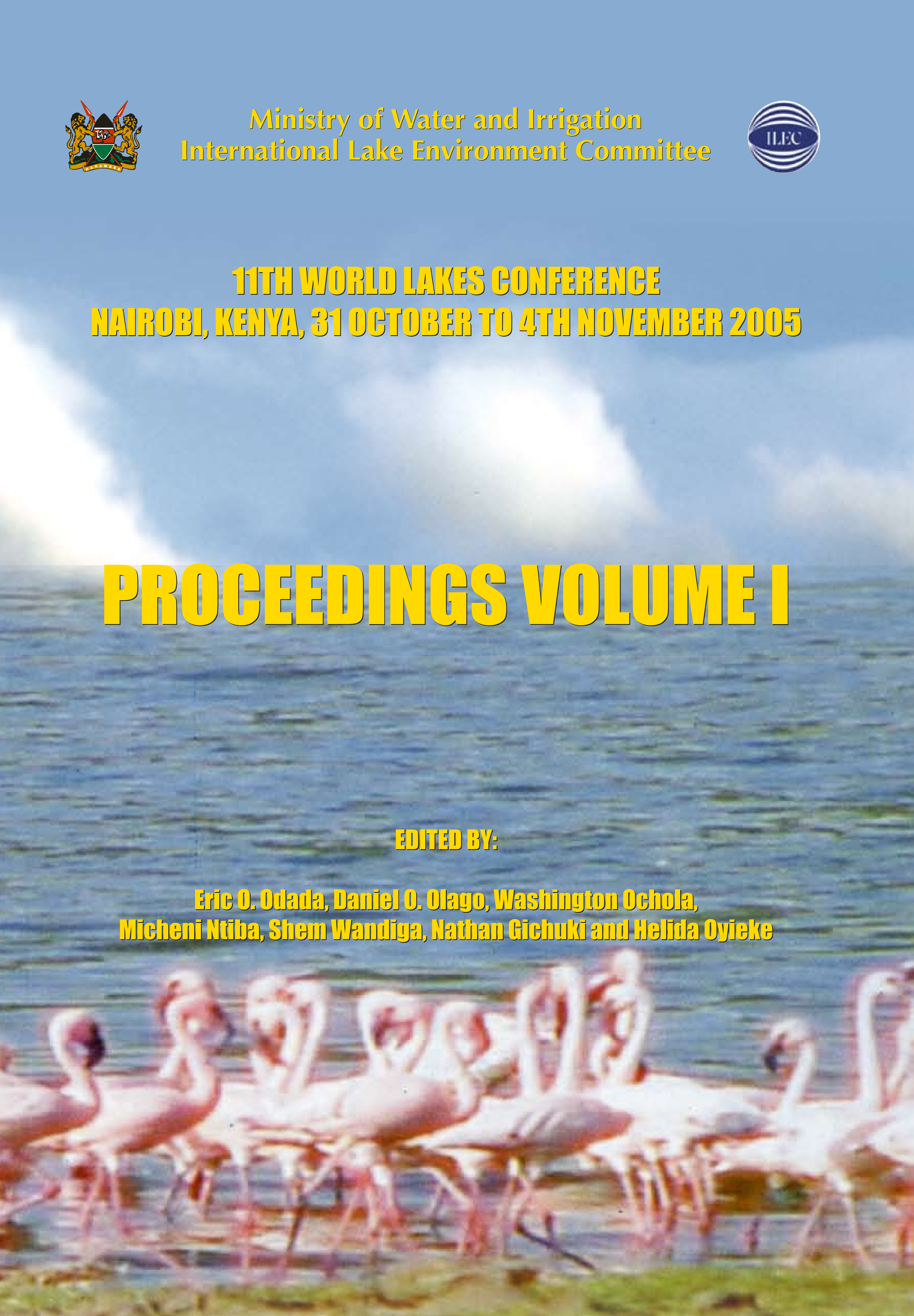
Ministry of Water and Irrigation
International Lake Environment Committee



11TH WORLD LAKES CONFERENCE
NAIROBI, KENYA, 31 OCTOBER TO 4TH NOVEMBER 2005

PROCEEDINGS VOLUME I

EDITED BY:

Eric O. Odada, Daniel O. Olago, Washington Ochola,
Micheni Ntiba, Shem Wandiga, Nathan Gichuki and Helida Oyieke

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FOREWORD

The International Conference on the Conservation and Management of Lakes (World Lake Conference) is a biennial conference co-organised by ILEC and a local host. Previous conferences have been held in Japan, USA, Hungary, China, Italy, Argentina and Denmark. In 2005 the Conference moved to Kenya and was held in Africa for the first time. This conference was held from 31 October to 4 November 2005 in Nairobi, Kenya. The organisers of the conference were the Ministry of Water and Irrigation, Kenya; the International Lake Environment Committee Foundation, Japan; and Pan African START Secretariat, Nairobi, Kenya.

The main theme of the Conference was “Management of Lake Basins for Their Sustainable Use: Global Experiences and African Issues”. The principle objective of the 11th World Lake Conference was to bring together diverse groups of people and organizations dealing with lakes to provide a rich forum for exchange of knowledge and experiences on the management of lakes in general and African lakes in particular, noting that African lakes contribute significantly to socio-economic development of the African region but are subject to high levels of rapid population growth, urbanization, industrialization, mining development, growth of irrigated agriculture, and impacts of climate change. These pressures have altered ecosystem processes and resulted in several threats on the lakes including: loss of biodiversity, over-fishing, eutrophication, proliferation of invasive weeds, siltation, toxic contamination and over-abstraction of water. To ensure their sustainable use, these important but fragile ecosystems need to be managed properly. The Conference reviewed progress on ongoing lake basin initiatives as well as set future goals for lake basin management.

The Conference Proceedings have been produced in two volumes: the first largely captures the socio-economic aspects of lakes and lake management, while the second volume deals more with the biophysical aspects of lakes and their basins. They offer a very rich and diverse range of new information and detail in all these aspects, and cover all parts of the globe. From them, very many useful lessons can be drawn for the better and sustainable management of the world’s lake basins, from the smallest to the largest. Below, a synopsis of the various themes under which the papers are grouped are presented, and these themes can be tracked by the reader with reference to the Table of Contents. The Statement of the 11th World Lakes Conference is also presented in full below.

The Editors would like to acknowledge all the effort put in by the numerous authors and reviewers without whom this volume would not have come to fruition. We would like also to acknowledge the critical funding and other support provided by the Ministry of Water and Irrigation, ILEC and the all the co-sponsors of the 11th World Lakes Conference that has enabled the production of the Conference Proceedings.

SYNOPSIS OF THE VARIOUS SESSIONS THEMES

Session 1: Governance and Water Resources Management
1A Governance and lake management; Lake management and corruption in the water sector
1B Lakes, IWRM and the Millennium Development Goals
1C Management of transboundary lakes; treaties and agreements on transboundary basins

This session focused on governance and management of lakes and their basins, their use and the related policy, economic and political implications from local, regional as well as international scales.

Session 2: Scientific Research and Monitoring
2A Scientific research and monitoring; technology and lake management
2B Harmonisation between research and sustainable management; education, research and training

Papers on scientific research, monitoring and improved technologies and the manner in which they have contributed to better and sustainable lake management were presented. However scientific, gaps that exist need to be bridged and mainstreamed in national and international policies and activities.

Session 3: Poverty Reduction and Cross-Cutting Issues
3A Poverty reduction and cross cutting issues
3B Lakes, sanitation and health issues
3C Lakes and agriculture/food security
3D Economic returns from lakes and their basins

Poverty is both a cause and result of degradation of lakes. The session dealt with poverty reduction as a means to enhancing environmentally sustainable livelihoods, particularly in areas where the population is largely dependent on land/lake-based resources. It also addressed natural, socio-economic, health, development and political factors that might enhance or mitigate poverty levels.

Session 4: Effects of Emerging Issues on Lake Management
4A Lakes and persistent organic pollutants; Emerging issues and lake management
4B Climate change and lake management

This session examined critically the emerging threats to lakes as a consequence of disasters, persistent organic pollutants and climate change. In a wider sense the session explored issues related to emerging disaster risks and vulnerability, and the new paradigms in Lake Management and research that need to be considered and effected in view of these emerging changes.

Session 5: Public Participation in Lake Management
5A Public participation, local communities and lake management; Confidence building and stakeholder participation in lake management
5B Gender issues in lake management
5C The role of education; awareness raising in the management of lakes

This session addressed issues of public participation in lake management from both a holistic point of view where all stakeholders are included; to a group or community focused approach, including aspects such as gender, youth, education and awareness building in participatory lake management.

Session 6: Lake Basin Initiatives
6A International Lake Basin Initiatives; Development aid and lakes
6B Lakes and water for African cities; Lakes and transportation issues
6C The role of international organisations and NGO's in lake management

This session dealt with experiences and lessons learned in the many lake basin initiatives that have been carried out throughout the world, including the role of international organizations and NGO's in Lake Management. It also emphasised lakes as water sources for African cities and as important transportation media.

Session 7: The Lakes Ecosystem Health

7A Lake ecosystem health
7B Lakes and biodiversity; Lakes and fisheries
7C Lake pollution, including eutrophication; Impacts of industrial and agricultural development on lakes
7D Comparative limnology: tropical verses temperate

This session focused on ecosystem health, particularly the lakes vitality, resilience, as well as their functional and structural components. It also highlighted the role of human activities that either promote or degrade the health of lake ecosystems.

Session 8: Threats to Lakes: With Special Emphasis on the African Realities
8A Lakes and land use change issues
8B Threats to African lakes
8C Invasive species

This session encompassed two major threats to lakes in general, i.e. land use change and invasive species, as well as other threats specific to African lakes.

Session 9: Cultural Issues
9A Cultural Traditions and Lakes
9B Modern Lifestyles and the Health of Lakes

This session included all aspects of culture that influence perception and uses of lakes and natural resources within the lake basins. Aspects of interest included cultural values and beliefs, traditional modes of environmental stewardship, resource use and gender, and modern lifestyles and their effects on the environment.

Special Plenary Sessions: There were several such special sessions. ***The Youth and Young Water Professionals Conference*** gave voice to the concerns and actions of the youth with respect to the conservation and sustainable management of lake basins. Young water professionals discussed and shared with the youth their experiences in the management of lakes and the provision of water supplies and related services in diverse lake settings. Major issues such as the implementation of integrated land and water management programmes, as well as obstacles to the implementation of such programmes, were discussed. The strengthening of capacity of water professionals to sustainably manage the lake basins was an important consideration. ***The Mayor's Special Session*** allowed municipality managers to share experiences and lessons learned in relation to the urban lakes that are under their management or jurisdiction. ***The World Lakes Vision*** brought together various stakeholders to share experiences and lessons learned in managing lakes for their sustainable use. ***The Lake Victoria Environmental Management Programme*** and the ***Nile Basin Initiative*** special sessions reviewed progress on ongoing activities and set future goals for the lake management programme. The ***Launching of the Lake Basin Management Initiative Report*** prepared by ILEC, World Bank (WB) and Global Environmental Facility (GEF) was officially launched at the 11th World Lakes Conference, formally placing the lake agenda on the global strategy. Finally, the ***Ministerial Round Table Discussion*** which was convened by Kenya Ministry of Water and Irrigation and UNEP, provided a rich forum for the exchange of knowledge and experience on the management of lakes in general and African lakes in particular, and was attended by Ministers and high –ranking government officials from around the world.

STATEMENT OF 11TH WORLD LAKES CONFERENCE 4 NOVEMBER 2005: NAIROBI, KENYA

Lakes, both natural and artificial, provide a wide range of important values, such as water resources and fisheries, both to sustain human livelihoods and to support economic activities. As particular wetland features, they also provide habitat for biodiversity, buffering capacities against hydrologic and climate fluctuations, and receptor functions for inflowing materials collected across their basins. Small or large, fresh or saline, ancient or transient, they are among the most dramatic and picturesque features of our global landscape, offering important aesthetic and spiritual values to many. On the other hand, they are among the most vulnerable ecosystems on earth, and are easily subjected to a variety of stresses originating from within and outside their drainage basins.

In view of their importance to human well-being and ecosystem health, as expressed in the Nairobi Statement of the 11th World Lake Conference, Kenya, October-November 2005, the management challenge of lakes and their basins must be addressed, recognizing that the future of lakes depends on our understanding and appreciation of their wider connections:

- With the surrounding landscape and human activities taking place on it;
- With the linking water system of rivers, groundwater, and wetlands;
- With the winds that carry nutrients and contaminants in from far distances; and
- With the rapid human changes to the Earth's atmosphere that are driving climatic instability.

The World Lake Vision, launched at the 3rd World Water Forum in Japan, March 2003, and the lessons learned from the Lake Basin Management Initiative launched at the 11th World Lake Conference held in Nairobi, Kenya on 31 October 2005, highlight these issues and suggest ways to achieve sustainable use of lakes and their resources, including a lake basin governance framework that involves;

- Adequate *institutions* implementing change;
- Efficient, effective and equitable *policies;*
- Meaningful *participation* of all involved stakeholders;
- *Technical measures to* ameliorate certain lake problems;
- Appropriate *information* about current and future conditions; and
- Sufficient *financing to* allow all the above to take place.

For the above governance framework to be successfully pursued, we must, first of all, recognize the primary importance of the people who directly use lake resources and therefore immediately experience damaging consequences of their misuse or degradation. These lake dwellers, both men and women, carry the cultural memory of the community and the lake through time, often having the best knowledge about the underlying causes of lake problems and viable solutions. This long-term perspective is essential because lakes have long memories when abused, and harbor many secrets in their complex dynamics. For these reasons:

- We must consider local knowledge and insight in making management decisions; and
- We must use available resources to build institutional capacity and scientific understanding at the community level, and to enhance the power of local people to find solutions, thereby bridging the gap between scientists, decision-makers, and society.

At the same time, however, local people on the front line must assume responsibility along with power, since local behaviour is often the source of damage to lakes. They must recognize that a healthy lake comes at a cost, and also that an unhealthy lake has its costs. As pointed out in the Kampala Declaration of the 9th Ramsar Convention, 12th November 2005, new innovative efforts to assign economic value to ecosystem services derived from lakes represents a powerful tool for identifying and justifying lake management interventions directed to conserving these important aquatic ecosystems; the accompanying increasing loss of lake - and wetland - dependent biodiversity also has major implications for local well-being and indigenous economies in many parts of the world; and that this degradation is occurring most rapidly in locations where populations are experiencing the greatest increases, thereby requiring increasing quantities of freshwater to meet human and ecosystem needs, especially being the case in developing countries, which often have limited availability to technological solutions to these problems.

National institutions also are vital for fostering awareness, promoting participation, and bringing together diverse interests within lake basins. When capable and effective, they provide the arena for developing broad management efforts that consider the lake basin as a whole, and its broader connections with the linking water systems and atmospheric influences. They also provide a forum for addressing the often conflicting needs of those who inhabit lake basins and who depend on lake resources. Without such an overarching framework and comprehensive perspective, there are few means for resolving conflicts over water or lake resources, or for integrating local efforts to maintain lake health into national programs and development plans. In setting these policies, national authorities must consider lake communities, as well as ensuring that the widest range of interests dependent on lakes enjoys their benefits. Experience around the world demonstrates further that effective lake management requires a cross Sectoral approach directed to maintaining wetland ecosystem services within the context of achieving sustainable development and improving human well-being.

National leaders also act in the international arena, where they can illuminate problems - -such as transboundary management, long distance air pollution, and climate change - -, and press for viable solutions.

International collaboration, including assistance from technical collaboration and funding programs, can provide a vital impetus for lake management efforts. Experience around the world shows that international technical collaboration and funding can plan a catalyst role in the management of lake basin activities, although in the longer term, individual citizens, local communities, and local and national governments must work to ensure that the ultimate goal of sustainable use resources is fully appreciated and pursued by all stakeholders, while also introducing a variety of policy tools, including innovative financing approaches.

These lake management experiences, which scientists and managers have gathered, analyzed and synthesized, provide important lessons for sustaining the health of both natural and manmade lakes that provide water for humans and nature, with one of the major lessons being that, where lakes exist, lake basin management is critical for sustainable development and responsible economic growth. It is imperative to embrace these lessons and build on them if we are to meet our pressing water needs in the decades ahead, as emphasized in the high-level African Water Ministerial Dialogue at the 11th World Lake Conference, which recommended that integrated management of lake basins be a long-term element of government and public priorities, planning and financing processes, habitat and biodiversity programs, and economic and development programs. The Ministerial Dialogue also recommended that the United Nations establish an International Year of Lakes, which would provide a global forum for the dissemination of these study results as guidance for lake stakeholders and decision-makers.

Over recent decades, we have been slowly learning how to manage the interactions between human activity and these living water systems. This experience underscores not only the key role of lakes in integrated water resources management, IWRM, but also the key contributions from the experience of Integrated Lake Basins Management or ILBM that provides many subtle, but crucial, dimensions of basin system management that have generally been neglected in the past. Indeed, the core elements of virtually every lake basin system are the flowing water with impounded water pools; namely, the lakes of natural or artificial origin that serve as the focal reserves of resources, as well as the barometers of basin vulnerability. Water also underpins virtually all the Millennium Development Goals, as recognized in the commitments of 170 heads of states and governments at the 2000 Millennium, and subsequently reinforced by world leaders at the 2005 World Summit, and achieving them depends on mainstreaming lakes and wetland issues into the overall global water agenda.

As fossil footprints in ancient lake bends dramatically testify, the rich resources of lakes were a magnet for early humans tens of thousands of years ago in Africa, and have continued to be so throughout human history to our own day. The challenge now facing us is to preserve the world's lakes, these complex life-supporting ecosystems that contain more that 90 percent of all the liquid freshwater on the earth's surface, so they can continue to provide physical and spiritual support for the generations that follow us.

Roles of government, scientists and NPOs in the development of Indonesia Lake Vision

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Abstract

Indonesia has a lot of lakes, which are distributed from lowlands to top mountains. It is estimated that the total number of lakes in Indonesia is more than 500. Indonesian lakes are very important for community livelihoods, biodiversity protection and development, research, and environmental services. In general, most Indonesian lakes are under rapid degradation. Major threats on Indonesian lakes are water pollution, habitat destruction, species extinction, and livelihood decline that put much greater pressure on lake resources. This problem is deeply rooted in the present government policies on lake management. A rapid population growth is also associated with the decline of lake resources.

A group of stakeholders, including the government, scientists, national and international NGOs, have paid major concerns on developing sustainable management of lakes. Indonesia Lake Forum and Indonesia Lake Foundation (Yayasan Danau Indonesia, YDI) have been established, in 2003 and 2004 respectively. In this phase, in collaboration with ILEC, we carried out a national workshop to disseminate the translated World Lake Vision. The World Lake Vision has been translated into Indonesian language by YDI in collaboration with the Ministry of Environment through a grant from LakeNet. We also developed a preliminary version of a database on Indonesia lakes, identified specific problems, and encouraged cooperative work among stakeholders that have major concerns or authority on the development of sustainable lake management. Stakeholder participation is absolutely necessary in order to create an inspired vision and effective missions.

Key words: Indonesia Lake Vision Development

Introduction

Indonesia has hundreds of lakes, which are important for livelihoods, freshwater supplies, agriculture, fishery, power generation, biodiversity, research and environmental services. To name a few, Indonesia famous lakes are Danau (lake) Sentani, Danau Toba, Danau Singkarak, Danau Maninjau, Danau Kerinci, Danau Tempe, Danau Limboto, Danau Poso, Danau Tondano, Danau Batur, Danau Kelimutu, Danau Sentarum, Danau Semayang, Danau Jempang, and Danau Melinau. In general, these lakes have important functions as major sources of freshwater, and fishery. The beauty of the lakes is also important to the tourism industry. In addition, several lakes, such as Danau Tondano, Singkarak and Maninjau, are used to generate hydropower. In Kalimantan, floodplain lakes, such as Danau Sentarum and Semayang, are important for water transportation, flood control, and fish breeding. In addition to natural lakes, Indonesia has built several dams in order to maintain freshwater supplies, to provide irrigation water, and to generate power. Large dams are mainly found in Java. To mention a few, these include Cirata, Jatiluhur, Saguling, and Sutami.

Major threats

In general, both natural lakes and dams in Indonesia suffer from anthropogenic impacts. These include erosion and sedimentation, pollution, eutrophication, timber extraction in the catchment areas, land use conversion, aquaculture and over-fishing (Table 1). For example, the development of aquaculture has had a strong impact on nutrient enrichment in Saguling Dam. In 1995, the total organic sediment from aquaculture was 1,830 tons with about 268 tons N and 122 tons P (Kartamiharja, 1995). At Sutami Dam, the average sedimentation rate from 2000-2005 was 1.1 million m^3/yr. High sedimentation rates are also common at Lake Tondano, and this problem has lowered the depths of the lake (Figure 1).

At forested lakes, for example Danau Sentarum National Park, illegal logging has become a major problem since 1998, after the collapse of President Suharto's regime. A new political condition has created more opportunities and also less control that drives local communities in cooperation with timber tycoons from Malaysia to illegally cut the forest in frontier areas. Over-fishing, poison, the use of electric shock, aquaculture, pollution, eutrophication, and high population pressures have also caused fish decline in many lakes.

In most cases, management plans that would ensure the conservation and sustainable use of lake resources are still lacking, or if it does exist, the plan is not well implemented. In addition, poor implementation of management plan drives lake users to put greater pressure on lake resources. Lake users are varied, and many have different interests and views on how to use lake resources. Table 2 describes an example of different interests, roles, functions, and problems on the use of natural resources in Danau Sentarum National Park. The most common problem is lack of expertise, and good cooperation and collaboration. Among government groups, cooperation and collaboration are difficult to achieve because the authority of this protected area is solely under the central government (i.e. the Department of Forestry). In general, in cases of non-protected lakes, both local and regional governments have paid little attention to lake management, particularly regarding the conservation of lake resources.

Table 1: Major threats on lakes and man-made reservoirs in Indonesia.

No	Lake Name	Size (Ha)	Location	Major Threat
1	Danau Laut Tawar	5,965	Central Aceh Regency, Sumatra	• Alien species • Over-exploitation
2	Danau Sepabegu Danau Bulusoma	2 2	Batang Gadis National Park, North Sumatra Province	• Over-exploitation • Timber extraction
3	Danau Toba	110, 260	Sumatra Utara Province	• Pollution • Aquaculture • Timber extraction • Erosion and sedimentation • Alien species
4	Danau Maninjau	9,950	West Sumatra Province	• Pollution • Aquaculture • Timber extraction • Erosion and sedimentation • Alien species
5	Danau Kerinci	4,000	Jambi Province	• Eutrophication
6	Danau Dendam Tak Sudah Danau Tes	50 300	Bengkulu Province	• Over-exploitation • Timber extraction
7	Danau Rawa Pening	2,660 (wet season), 650 (dry season)	Central Java Province	• Erosion and sedimentation • Eutrophication • Alien species • High evapotranspiration
8	Danau Sentarum (A series of Kapuas lakes)	40,000	West Kalimantan Province	• Over-exploitation • Timber extraction • Pollution • Erosion and sedimentation • Over-fishing • Forest fire
9	Danau Bangkau	535	South Kalimantan Province	• Over-exploitation • Over-fishing
10	Danau Melintang Danau Semayang Danau Jempang	11,000 13,000 15,000	East Kalimantan Province	• Erosion and sedimentation • Eutrophication • Alien species • Timber extraction • Forest fire
11	Danau Tondano	4,638	North Sulawesi Province	• Erosion and sedimentation • Eutrophication • Land conversion • Timber extraction
12	Danau Tempe	14,200	South Sulawesi Province	• Erosion and sedimentation • Floods and drought • Land use conversion • Aquaculture
13	Danau Limboto	3,000	Gorontalo Province	• Erosion and sedimentation • Land use conversion • Aquaculture
14	Danau Batur Danau Beratan Danau Buyan Danau Tamblingan	10, 535 1,340 2,440 920	Bali Province	• Land use conversion • Pollution • Erosion and sedimentation • Alien species

No	Lake Name	Size (Ha)	Location	Major Threat
15	Danau Kelimutu	105	East Nusa Tenggara Province	• Earthquake • Impact of tourism
16	Danau Laguna	185	North Mollucas Province	• Erosion and sedimentation
17	Danau Sentani	14,000	Papua Province	• Development of water power • Aquaculture • Alien species
18	Cirata Dam	6,200	West Java	• Timber extraction • Pollution and Eutrophication • Erosion and sedimentation • Aquaculture
19	Jatiluhur Dam	8,300	West Java	• Timber extraction • Pollution and Eutrophication • Erosion and sedimentation • Aquaculture
20	Sutami Dam	790	West Java	• Timber extraction • Pollution and Eutrophication • Erosion and sedimentation • Aquaculture

Source: FDI and ILEC, 2004.

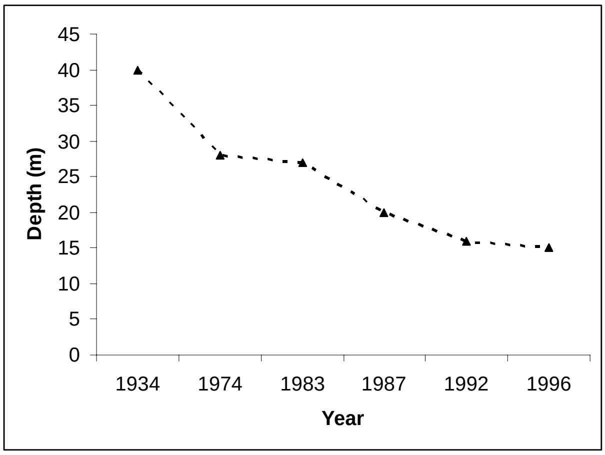

Figure 1.The depth of Lake Tondano, showing a decrease in 25 m from 1934 – 1996 (Source: Kumurur, 2002).

In practice, both protected and non-protected lakes are barely managed by the authority. It is essential to mention that NGOs and local communities have a lot of worries about the sustainable use of lakes. As a matter of facts, both NGOs and local communities do not have legal power to take care of lakes. Although local communities have potentials to conserve lake resources, without formal recognition on community rights many lakes appear to be open access (Anshari *et al.,* 2005). As resource becomes scarce, and local communities have lost their institutional mechanisms to enforce the long term view on the use of lake resources. Such condition causes rapid destruction of many Indonesia lakes. Due to the natures of the problem are too varied, finding quick solution is almost mission impossible to achieve in short term. Hence, from management point of view, it is urgent to develop Indonesia Lake Vision that could be nationally implemented in both natural lakes and man-made reservoirs.

Table 1.Stakeholders and their major problems on the realization of sustainable lake management (A case from Danau Sentarum National Park).

No	Stakeholder	Stakeholder group	Major interests	Role and function	Major problem
1	Local community	Malay community Dayak Iban community	The use of wetland resources The use of forest resources in the buffer zone	The steward of core zone The steward of buffer zone	Poor local capacity High population growth rates Resource decline that affects livelihood security
2	Government	Department of Forestry (Central Government) The department of ocean and fishery (Provincial Government) Kapuas Hulu Regency (Local government) The department of tourism (Provincial and local governments)	The authority of all protected areas Aquaculture The source of revenue Tourist destination (Scenic beauty)	Patrol, services and control An increase of fish production Socio-economic development Tourism development	Difficulties in coordination and sharing power Focus more on executing project activities than achieving long term development goals Poor local participation at all project stages Poor services and bad distribution on information High competition to take a lead as a project executor Lacks of expertise
3	Non Profit Organization (NPO)	Non Government Organization University and research institutes	Community development Research and publication	Mediator Public awareness campaign Capacity building Science and technology development	Poor human resources Small budget and under-staff Poor strategic planning Lacks of expertise High competition in gaining project assistance from donor agencies
4	Private sector	Fish trader/collector Timber tycoon Tour operator	An increase in income	Distribution in goods and services	Unsustainable extraction of natural resources from aquatic and forest ecosystems
5	International Agency	International donor agency International NGO International research center	An increase in regional income Community development Research and publication	Funding assistance Information source Expertise source Public awareness campaign for international community	Different interests Difficulties in cooperation and collaboration among agencies
6	Other community	Regional, national and international communities	Freshwater sources; Biodiversity protection	Beneficiaries of Environmental services and goods	Poor or small commitments to provide direct assistance/payment

Source: Anshari, 2005.

Developing Indonesia Lake Vision

The development of the Indonesia Lake Vision is based on inputs from many stakeholders. These include local communities, NGOs, scientists and governments. In 2003, the first national workshop on Indonesia lake conservation was conducted in Jakarta. This meeting was administered by the Ministry of Environment in collaboration with NGOs (e.g. LakeNet), and attended by 189 participants, who came from governments, NPOs, private sector, and scientists. The purposes of this meeting were to build commitments on sustainable use of lake resources, to develop Indonesia Lake Vision, and to establish national networking on lake management. The International Lake Environment Committee (ILEC) presented the World Lake Vision in this workshop. The Indonesia Lake Forum was formed in order to accommodate the flow of communication among stakeholders (Radiansyah *et al.,* 2003). At present, a yahoo mailing-list group called 'Indolakes' has been created and actively facilitating discussions on lake issues.

In the following year, a second workshop on sustainable lake management was again held in Jakarta. This meeting was sponsored by ILEC. The number of participants, who came from governments, NPOs, private sector, and scientists, were more than 100 persons. Presentations came from ILEC, Lake Laguna Development Authority, Philippines, Lake Biwa Research Institute, Kosho Net, The University of Shiga Prefecture in Japan, Wetlands International, LakeNet, as well as the Ministry of Environment, the Department of Forestry (i.e. the Directorate General of Forest Protection and Nature Conservation), and Indonesia Science Institute. At the end of the workshop, all participants agreed to a declaration on sustainable lake management, and to commit on fulfilling the following tasks:

1. to develop Indonesia Lake Vision,
2. to accomplish the mission on the practice of sustainable lake management
3. to increase capacity in the implementation of sustainable lake management schemes
4. to develop cooperation and collaboration among regional, national and international stakeholders

Local views on how to practice sustainable lake management schemes were sought from relevant stakeholders. Currently, most information is not yet directly sourced from local communities. This occurs because the cost of collecting first hand information from local communities is very expensive. In many cases, the location of lakes is quite remote. However, views submitted by local stakeholders, such as local governments and NPOs, are well represented, and in line with the needs of local communities.

For local communities, lakes are important places to live and are major sources of livelihood security. When lakes are inhabited by local communities for centuries, there are strong interactions between local communities and lake ecosystems. For example, local communities in Danau Sentarum have built local institutions that govern the use of lake resources according to traditional or customary laws (Anshari *et al.,* 2005). In many other lakes, local stakeholders have paid great concerns on the sustainability of lake resource uses. As the main direct user, local communities should be given rights to exercise community based lake management, preferably with some assistance from governments and NPOs.

It is important to note that each lake has different characters and specific needs. As a result, the lake vision could not be singly developed, without full participation of relevant stakeholders at local level. Having realized the variety of problems on lake management, the Indonesia Lake Forum, and Yayasan Danau Indonesia (YDI) will focus on public awareness campaign, capacity building, and finding alternative income generating activities that would help local communities to reduce human impacts on lake resources.

Concluding Remark

In the last few years, governments, NPOs, and scientists have put more effort to address the problems on the sustainable use of lake resources. The role and functions of local communities in the management of lakes are absolutely essential in order to accomplish the missions of sustainable lake management. More participatory access will be availed to local communities, who are directly dependent upon lake resources, to take part in the development of sustainable lake management in Indonesia. It is a great hope that the governments, local communities, and NPOs would build strong cooperation and collaboration in order to formulate Indonesia Lake Vision.

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Water information management as a limit of water governance in sub-Saharan Africa: the case study of the Republic of Benin

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Abstract

Reducing poverty and enabling people to improve their lives should be the central focus of any discussion of Integrated Water Resources Management (IWRM) in developing countries, mainly in sub-Saharan Africa. But to complement this challenge, countries are faced on one side with the need of developing other economic sectors which requires mobilization and efficient use of water in agriculture, energy, cattle breeding, industry, and so on, and on the other side with the need to preserving natural resources. To tackle this series of problems, African governments create several ministries and agencies related to water, energy, agriculture, etc., without serious co-ordination. While, integrated water management requires integrated information. In this complex system, a well-organized water resources database is extremely difficult to create. It results in highly fragmented approaches to the management of the sectors. Researchers and managers, striving for integrated approaches including the development of indicators, are on the horns of the dilemma of either spending too much time searching and retrieving fundamental data or alternatively omitting relevant information. The present paper, which based on the case study of the Republic of Benin (west Africa), shows how the multiplicity of institution and the sectoral fragmentation of water and related water management constitutes serious constraints to good water governance in the sub-Saharan Africa by limiting access to data and indicators that are indispensable for rational decision-making and cost-effective management.

Introduction

Recent researches on the attainment of water security have increased attention given to the role that effective governance plays in achieving Integrated Water Resources Management (IWRM). Water governance is, however, a multifaceted issue: it covers many sectors –economic and financial, law and justice, public and private. Managing this multifaceted issue needs proper and efficient information that is dependent on the management of water institutions that provide and constitute the source of information. But the integrated information source management needs to be promoted by water and related water institutions. Unfortunately, the water and water-related environment, in the Sub – Africa, is characterized by the fragmentation of water institutions. This situation constitutes a serious constraint on the availability of information for the development of indicators and data for decision-making and, thus, is a crucial constraint for water governance. The case study of the Republic of Benin, demonstrates how overcoming fragmentation of institution and providing a good information system should be the most effective ways of improving water governance in the region.

Overview

The deteriorating living conditions of million of people in Africa serves as a constant reminder to African governments to exercise caution in predicting the future possibilities and accomplishments of the present theories and approaches to development. As solutions, they (government) do create several institutions such as ministries, agencies related to different economic and social sectors: water, agriculture, energy, fishery, and industry. The development was seen with a sartorial vision. The price tag included environmental problems such as pollution, water scarcity, erosions, and climatic crisis. But, in the last two decades, global efforts to seek integrated approaches and sustainable solutions to human development problem have increased. The world has debated the main issue related to human development problems, and there is a consensus that water is a key factor in sustaining human life. Furthermore, it is now accepted that Integrated Water Resources Management (IWRM) is essential to address the problem of security and pollution of water resources. But IWRM and good governance of water promotion are based on integrated information on water resources. The information provided should be linked to water resource development.

Information is provided by the organizations involved in the water and water related domain. Consistent and relevant information on the status of water resources is indispensable for its national and cost-effective management. But, how does one access information and indicators when water monitoring is conducted by a wide variety of organizations with different missions in the same country? The ministries of agriculture, water, environment, etc., intervene in the water sector without any coordination. In this complex system, a well-organized water resources database is extremely difficult to achieve, whereas it constitutes a limiting access to information and a serious constraint to water governance.

Background to the importance of information on water

In 1992, the governments assembled at the Earth Summit in Rio de Janeiro, Brazil, called for access to information in Principle 10 of the Rio Declaration. Also, there is a wide consensus that the key elements of effective water governance include accountability and transparency. And the transparency is linked to the quality and access to information, integrated information, which also depends on the institutional environment.

Benin and water governance

The Republic of Benin is a small country with about 6 millions inhabitants and situated in West Africa. The country is very watered and shared between tropical climate in the south (rainfall 1300mm per annum) and sahelian climate in the north (700 mm of rain per annum).

The water resources availability could be summarized as:

- Surface water: 31.725 millions m^3
- Seven catchments
- Nokoue lake: 180 km^2
- Aheme lake: 100 km^2
- Groundwater:
- Sandy clay (80 – 90% of the territory): 1120million m^3
- Coastal Sedimentary basin: 600 millions m^3
- Kandi Sedimentary: 125 millions m^3
- Niger and Pendjari basin: 25 millions m^3
- Total annual availability per capita (1995): 5.625 m^3
- Total annual availability per capita (2025): 2.293m^3

Altogether, the country is not confronted with the problem of availability but with an efficient management of the resource. This management supposes a good allocation of the resource. Then, water allocation depends on relevant information regarding actors, resource availability, users needs etc

Now, in all system, institutions of management play the main role in information supply. Then, relevant information depends on a good institutional organization, and integrated water management supposes then integrated information from integrated institutional organization. But, like all sub-Saharan Africa region, the republic of Benin is characterized by a fragmented institutional organization in the water resources sector, which limits access to relevant information and constitutes then a crucial problem for good governance.

Institutional assessment

With regard to the institutional aspects of water management in the Republic of Benin, an essential lesson should be learnt: the institutional environment is very fragmented with no coordination.

In the fact of matter, the water institutional environments are dominated by the public sector. They are:

Ministry of Mines, Energy and Hydraulic (MMEH). The MMEH has under one wing the Hydraulic Department (DH) and the Benin National Water Supply Society (SONEB). The DH is in charge of water and water related activities regulating. It is in charge of inventory, evaluation and mobilization of water resources and securing rural areas with drinkable water. The SONEB is in charge of water supply in urban areas.

Ministry of Public Health (MSP). The MSP has under one wing the Hygiene and Primary Sanitation office (DHAB). It is commissioned to implement sanitation programs, to define sanitation plans and standards, and to control water hygiene and pollution.

Ministry of Environment, Habitat and Urbanism (MEHU). The MEHU is in charge of defining the national policy related to environment, habitat, urban sanitation, and land management. The control and the promotion of renewable natural resources management is another mission of MEHU. Its main institutions concerned with water resources are: (i) the Environment Department which secures protection to rivers, soils, and coasts; (ii) Urban and Sanitation Department in charge of conception, program planning and coordination of government interventions related to sanitation.

Ministry of Agriculture, Breeding and Fishing. Here, three departments are distinguished: (i) the department of Rural Engineering charged to elaborate the national rural hydraulic program and to conduct studies and experiments in pastoral, agricultural and villages; (ii) the Forestry and Natural Resources Department intervenes in rationalizing the exploitation of water, soils, forests, flora and fauna, (iii) the Fishing Department is commissioned to determine the economic and technical conditions for fishing.

Ministry of Transport is in charge of the National Meteorological Service, which is commissioned in collecting, transmitting and managing of meteorological data. Regarding the international basins, the Republic of Benin is a riparian country with four (04) international basins: Niger River basin, Volta basin, Mono basin and Oueme basin. The Niger River basin is managed by the Niger Basin Authority (NBA), but there is no common management structure between the Republic of Benin and its bordering states relating to the other basins.

Results and conclusions

The evaluation of the institutional environment that provides information on water resources shows the fragmentation and the duplicity of institutions' abilities. Institutions under different Authorities share same prerogatives. The analysis of responsibilities and function of different institutions show, unfortunately, that the diversity of actors aids duplicity and compromises effective management.

Although the information available today is more comprehensive than at any time previously, it falls far short of management and policy needs. Information is being collected in abundance but the efforts are often poorly coordinated. Scales diverge, baseline data are lacking, time-series data are incomplete, differing measures defy integration, and different experts may not know of each other's relevant findings. To overcome this situation and ensure effective water governance, some needs and challenges should be identified. Some challenges are to: (i) correct inappropriate legislative framework; (ii) overcome fragmentation of institutions, (iii) improve on transparency.

Recognised needs include: (i) Reform / enhance existing institutional set-up, (ii) Revise national policies, strategies and plans to provide for smooth integration (iii) clearly delineate responsibilities and mandates to avoid domination by single sector entities (iv) strengthen river basin level management systems.

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Water quality management in Nigeria: Environmental regulatory enforcement and compliance

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Abstract

Water Quality Management (WQM) is a tool which enables governmental authorities to set objectives to achieve and maintain clean water and reduce the impacts on human health and the environment. Environmental regulatory enforcement and compliance continue to be the main problems in controlling the rapid depletion and degradation of environment in Nigeria. The paper discuss the Federal Environmental Protection Agency (FEPA) which has statutory responsibilities for overall protection of the environment, and its initial functions and priorities implementing the national policy on environment. Also, FEPA is initiating a monitoring programme to ensure that the set standards are met. This paper therefore aims to facilitate law enforcement, to inform, educate and strengthen stakeholder participation in all aspects of water quality management in order to prevent and reduce the impacts of water pollution, and to include or strengthen the concept of water quality management in relevant policies and legislation in cities in Nigeria. The paper gives recommendations on policies, standards and regulation which is a strategic framework for water quality management in Nigeria. In conclusion, Clean Water Implementation Plans (CWIPs) in Nigeria are a means of improving urban water quality and are a convenient way of reporting on the different activities in water quality management.

Key words (Water quality management, Environmental regulatory Enforcement and compliance]

Introduction

Nigeria has abundant water resources although they are unevenly distributed over the country. The highest annual precipitation of about 3,000 mm occurs in the Niger Delta and Mangrove Swamp areas of the south-east where rain falls for more than eight months a year. There is a progressive reduction in precipitation northwards with the most arid north-eastern Sahelian region receiving as little as 500 mm annual precipitation from about 3-4 months of rainfall. Widespread flooding occurs in the southern parts of the country, while the northern parts experience chronic water shortages during the dry season when rainfed springs, streams and bore holes dry up. Nigeria is located approximately between latitude 4º and 14º north of the equator and between longitudes 20º20" and 140º30" east of the Greenwich Meridian. The climate which affects the quality and quantity of the country's water resources, results from the influence of two main wind systems: the moist, relatively cool, monsoon wind blows from the south-west across the Atlantic Ocean towards the country and brings rainfall; and the hot, dry, dust-laden Harmattan wind which blows from the north-east across the Sahara desert brings with it dry weather and dust laden air. The mean temperature is generally between 25-30ºC, although because of the moderating influence of the sea the mean daily and annual maximum temperatures increase from the coast towards the interior. In the dry season the temperatures are more extreme, ranging between 20 and 30ºC.

Materials and methods

There are five basic categories of water use. Public water supply, mainly destined for human consumption water use in agriculture, in industry, for recreation and for fisheries and wildlife. Globally, water withdrawals for irrigation are nearly 70% of the total withdrawn for human uses – 2,500 of 3,800 cubic kilometres, withdrawals for industry are about 20% those for municipal use are about 10% (Cosgrove and Rijisberman, 2000). Although globally, we are withdrawing only 10% of renewable water resources and consuming about 5%, they are still problems for human use. Water is unevenly distributed in space and in time and we degrade the quality of much more water than we withdraw and consume (Cosgrove and Rijisberman, 2000). Available estimates of consumption in irrigation range from 30-40% for flood irrigation, while drip irrigation is 90%. Also available water for agriculture is 80% while each for industrial and domestic purposes is 10% (Martins, 2001). The turning point of water resources development and management in Nigeria occurred after the severe drought of the 1960s. In the 1970s and early 1980s, water resources management in Nigeria was faced with a lot of problems which slowed down the development of the resource.

Results

Some of these problems included:

(a) The deficiency of the resource itself

(b) Unnecessary duplication and overlap in organizational structures and functions of the relevant bodies

(c) The ill-defined and uncoordinated roles of the federal, state and local government agencies responsible for water resources development.

(d) Failure to recognize the inter-relationship between surface and ground waters, and between water resources and land use

(e) Lack of effective water and environmental protection laws and the means to enforce the already existing laws. In the late 1980s, Nigeria began to make serious efforts to address these problems, although in the mid-1970s Nigeria had created the Federal Ministry of Water Resources and the River Basin Development Authorities. These institutions were further strengthened in 1981 by the establishment of the National Committee on Water Resources by the water boards at the state level. These bodies were charged with taking an inventory and ensuring rational and systematic planned management and conservation of the country's water resources. A national body was created to co-ordinate all environmental protection activities in the country (The Federal Environmental Protection Agency) The Federal Military Government placed great importance on the environment and established the 1988 (FGN, 1988a). A comprehensive national environmental policy was formulated which, among other things, addressed the issue of water resources (The National Policy on Environment).

Discussion

The National Policy on the Environment was launched by the president in Abuja on 27 November 1989 (FEPA, 1989). The goal of that policy was to achieve sustainable development in Nigeria. The Hazardous Waste Decree was promulgated with the intention of discouraging reckless and illegal dumping of hazardous and harmful wastes on land and into water courses (FGN, 1988b) Strategies under the National Policy on Environment Implementation of the Nigeria National Policy on Environment depends on specific actions directed towards major sectors and towards problem areas of the environment (FEPA, 1989, 2001). The strategies put forward for effective water resources management in Nigeria include:

(a) Promulgation of a national water resources law to co-ordinate water resources development

(b) Formulation of a water resources master plan

(c) Improvement of water use efficiency for sustainable development

(d) Implementation of water conservation measures including inter-basin water transfer

(e) Establishment and enforcement of national water quality and emission standards to protect human health and aquatic ecosystems and species

(f) Continuous data collection for resource monitoring and management

(g) Introduction of economic incentives.

The on-going programmes to assess the available water resources of the country are being strengthened to provide, among other things, data on:

(a) Hydrological features affecting surface water resources

(b) The location of ground water resources and their characteristics in terms of depths, yields, permeabilities, storage and recharge

(c) Per capita water use and requirements

(d) Changes in hydrological regimes resulting from Human activities, such as water use or extraction, pollution and the effects of mining and lumbering

(e) The management of small and large dams

(f) Irrigation problems with regard to crop water requirements, salinity, drainage and pollution from fertilisers, pesticides and cultivation activities

(g) Existing fresh water living resources.

As part of the strategies for the implementation of the National Policy on Environment in the water sector, a comprehensive national water resources master plan has now been drawn up with support from the government of Japan, through the Japan International Cooperation Agency (JICA), with the purpose of:

- Promoting the optimum planning, development and use of Nigeria's worker resources
- Ensuring the co-ordination of such activities as are likely to influence the quality, quantity, distribution, use and management of water
- Ensuring the application of appropriate standards and techniques for the investigation, use, control, protection, management and administration of water resources.
- Facilitating technical assistance and rehabilitation for water supplies.

Conclusion

Towards the end of the 1980s, Nigeria began to place a high priority on environmental matters, particularly water-related issues. This is reflected in recent environmental policy, legislation, action plans and programmes introduced by the Government. In all these programmes, environmental monitoring activities, especially water quality aspects are given strong consideration. With the creation of the FEPA as the central co-ordinating body for all environmental matters under the federal ministry of environment within the country, the new integrated water resources management concept adopted by the Government will improve all aspects of water use and conservation within the conservation within the country if the political will and financial will resources for the implementation are sustained.

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The Japanese New Law for Preservation of Lake Water Quality

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Abstract

Lakes and reservoirs are very important property for people's life, industrial activities, etc.. However, since lakes and reservoirs are closed systems, pollution tends to accumulate there. And, eutrophication hurts all types of water use. There are many factors for lake / reservoir pollution, from the activities of business operating in lake catchments, to the activities of people in their daily lives. In light of the fact that conventional strengthening of regulations through the Water Pollution Control Law by itself is not sufficient to conserve lake and reservoir water quality, the Law Concerning Special Measures for the Preservation of Lake Water Quality was enacted in 1984 to introduce pollution quantity control. Since then, 10 lakes and reservoirs have been designated under this Law, and many activities to preserve water quality are being carried out in accordance with the Water Quality Preservation Plan for each lake and reservoir. In spite of the devoted various efforts to preserve water quality, achievement of Environmental Quality Standard in lakes and reservoirs is lower than in other water areas. In 2005, taking account of this situation, the Japanese Government decided to amend the Law concerning Special Measures for Preservation of Lake Water Quality, introducing some new measures such as to: designate the district in lake catchments, in which non-pointed-source pollution is intensively controlled; designate the district in lakesides, in which plants with pollution absorbing function such as reeds are intensively preserved; introduce water pollution quantity control to the existing industrial facilities. With this new Law, the Japanese Government sector together with other sectors will do various activities for the further preservation of lake water quality.

Key words: Lake, Quality, Water

Introduction

Current situation and problem of lake water quality in Japan

Lakes and reservoirs are very important for people's livelihoods, industrial activities, etc. Lakes and reservoirs provide various benefits to humans, such as securing water resources for drinking, agriculture and industrial use, fishery resource, flood control functions and ecosystem integrities. However, since lakes and reservoirs are closed water systems, pollution tends to accumulate there, and once water is polluted, it is difficult to improve the water quality. In addition, population increase and development pressures increase pollution stress on the lakes.

According to the Fiscal 2003 Measurement of Water Quality in Public Waters, the achievement of the Environmental Quality Standards for water pollution (BOD or COD) is 87.4%, 76.2% and 55.2% in the river, in the sea area, and in the lakes and reservoirs respectively (Figure 1).

The national and the local governments are advancing measures to conserve public waters, such as the drain restriction (pollution concentration regulation) to the factory and the business place based on the Water Pollution Control Law. However, not only the drain from the factory and the business place but also household wastewater, the pollutant load from non-pointed sources such as farmlands and urban areas, etc., are the cause of the water pollution of lakes and reservoirs (Figure 2). Therefore it is necessary to execute comprehensively various measures corresponding to each cause of the pollutant load.

The Law concerning Special Measures for Preservation of Lake Water Quality

In light of the fact that the conventional strengthening of regulations through the Water Pollution Control Law by itself is not sufficient to preserve lake and reservoir water quality, the Law concerning Special Measures for Preservation of Lake Water Quality (hereinafter "Lakes and Reservoirs Law") was enacted in 1984.

1. The main content of the Lakes and Reservoirs Law:

   a. The National Government establishes and publishes the basic policy to preserve the water quality of lakes and reservoirs throughout the nation.

   b. The Minister of the Environment, at the request of the Prefectural Governors, designates lakes and reservoirs, in which the Environmental Quality Standards are not attained or are about not to be attained, in particular need of comprehensive measures to meet the Environmental Quality Standards for lakes and reservoirs (designated lakes and reservoirs) and watersheds contributing to/ affected by water pollution in designated lakes and reservoirs (specified watersheds).

   c. Prefectural Governors, with the approval of the relevant authorities, establish plans for the preservation of lake water quality (the Water Quality Preservation Plan for Lakes and Reservoirs), in keeping with both the natural and social conditions in the watershed areas. The Plan must be approved by the Minister of the Environment through consultation at the

National Conference on Environmental Pollution Control.

d. Measures are carried out to preserve the water quality of designated lakes and reservoirs in accordance with the Water Quality Preservation Plan for Lakes and Reservoirs. These measures include treatment of household wastewater and measures to purify lakes and reservoirs, such as dredging bottom sludge and aeration. And pollution quantity regulation of drain is applied to the factory and the business place in addition to the pollution concentration regulation of drain based on the Water Pollution Control Law.

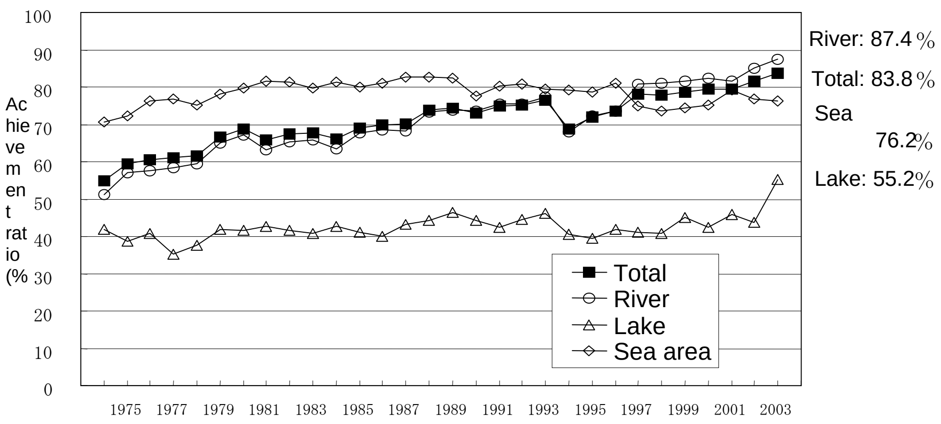

Figure 1: Transition of environmental standards achievement ratio of BOD/COD.

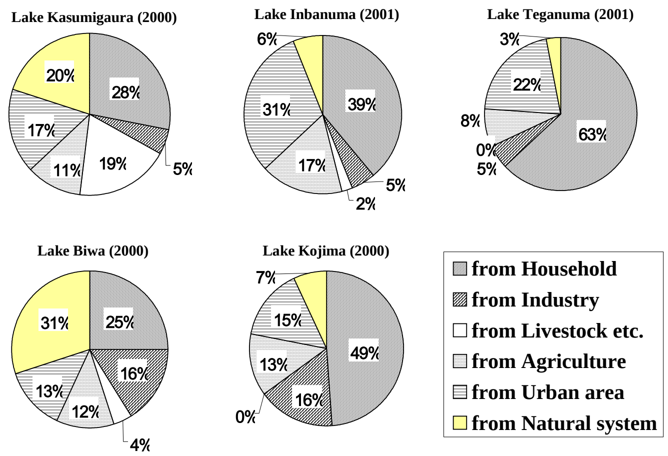

Figure 2: Examples of pollutant load ratio according to source. (Note) The percentage is not 100% in total because of the half-adjust necessarily. 0% means less than 1%.

From Household	• Pollutant load from drainage, rural community sewerage, septic tanks, and by gray water etc.
From Industry	• Pollutant load from factory and business place
From Livestock etc.	• Pollutant load from livestock raising and fishery system / barns and net pens
From Agriculture	• Pollutant load from rice field, upland field and unplanted agricultural land
From Urban area	• Pollutant load from roads and such as roofs of house in urban areas
From Nature system	• Pollutant load of natural origin such as forests and lake side rainfalls etc.

2. The main content of the Water Quality Preservation Plan for Lakes and Reservoirs:

a. The basic policy concerning the preservation of the water quality of the designated lake and reservoir, the plan period and the water quality value at the last year of the plan period (when the measure is implemented and when the measure is not implemented) are shown in the Plan.

b. The building and maintaining of drainage system, the other household wastewater treatment facilities, the animal manure waste treatment facility, the waste disposal facility, and the purification measures of lakes and reservoirs, river water, etc., are shown as projects contributing to the preservation of the water quality in the Plan.

c. The restriction to the pollutant load from the factory and business place drain, the household wastewater, and a livestock industry, fish culture, and the measures to control the non-pointed-source of pollution, and the conservation of green area and the other natural environment in the vicinity of the lake, etc. are shown as restriction measures for the preservation of the water quality in the Plan.

d. The measurement of water quality in public waters, promotion of the research study, and securing the cooperation with local residents, the adjustment with the related regional plans, and the promotions to the business sector, etc. are shown as concerning necessary measures in the Plan.

3. Situation since the Lakes and Reservoirs Law was put into effect 10 lakes and reservoir (Figure-3) have been designated based on the Lakes and Reservoirs Law. In these designated lakes and reservoirs, the Water Quality Preservation Plan for each lake and reservoir was established, and the Plan is updated every five years up to now. And various measures to preserve the lake water quality such as building and maintaining of drainage and septic tanks for household wastewater and the pollution quantity regulation of drain from the factory and the business places are being carried out based on the each Water Quality Preservation Plan.

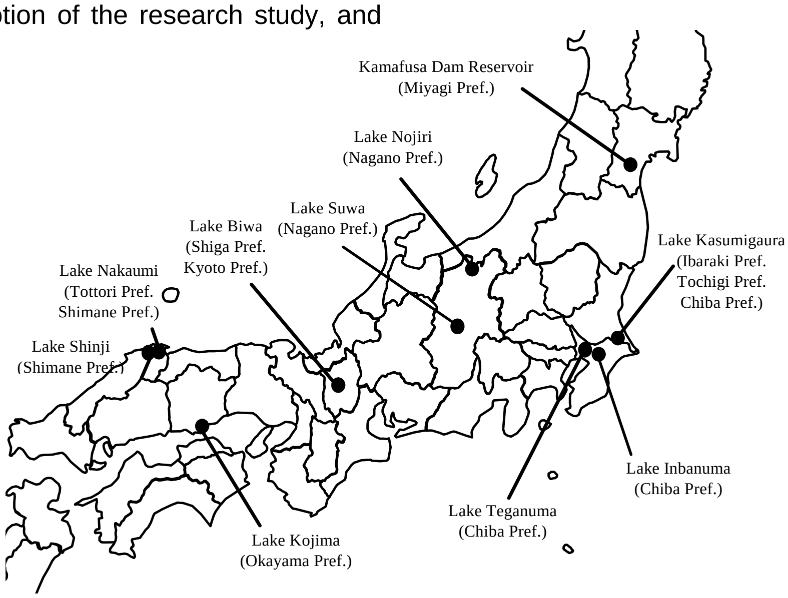

Figure 3: Ten designated lakes and reservoir positional chart.

Moreover, the effluent standard of Nitrogen and Phosphorus is provided as a prevention of the eutrophication of lakes and reservoirs, and the drain restriction has been applied since July, 1985. The target lakes and reservoirs for this restriction are reviewed every five years.

At present, in 1,329 lakes and reservoirs, effluent of Phosphorus is restrained and in 277 lakes and reservoirs effluent of Nitrogen is restrained. As a result of these measures, the pollution load from the business place etc. that flow in lakes and reservoirs has been reduced. In spite of the devoted various efforts to preserve lake water quality, the Environmental Quality Standards have not been achieved yet even in most designated lakes and reservoirs (Figure 4).

Central Environmental Council Report "What should be of lake environment preservation system"

Under the current situation of water quality of lakes and reservoirs, the Ministry of the Environment consulted the Central Environmental Council about what should be of the lake environment preservation system in October 2004, and received the Report from the Council in January 2005. In the Report the measures and the system that have to be promoted for the water quality preservation of lakes and reservoirs in the future was shown as follows.

1. Promotion of measures to meet non-pointed-source pollution

   It is important to reduce the outflow load by the improvement of the water management and proper manure etc. in the farmland and the under seepage and the storage of rain water etc. in the urban area. Therefore it is appropriate that the measures to induce the reduction of the pollutant load are intensively carried out in the specified areas under the understandings and cooperation of people concerned. And the effect of the measures should be checked.

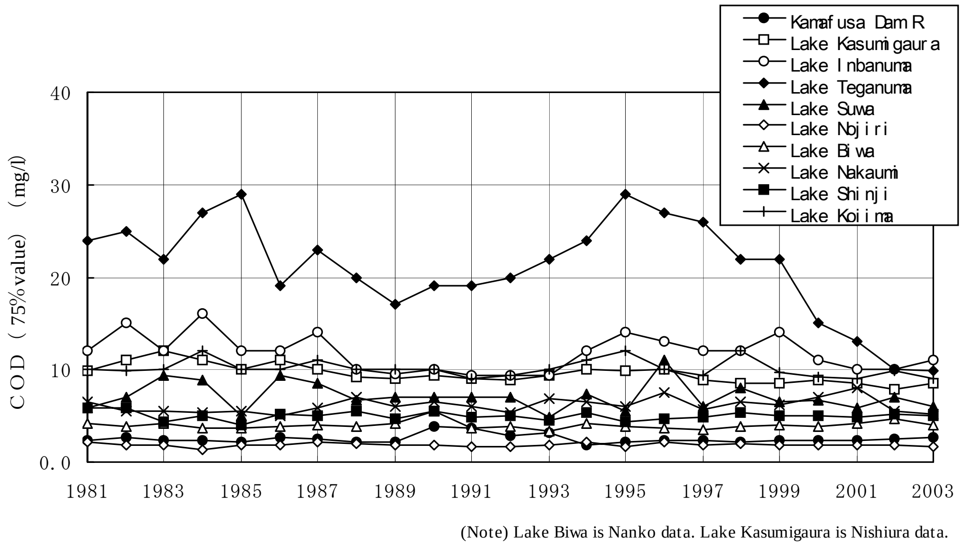

Figure 4: Variation of COD (75% value) of designated lakes and reservoir.

2. Promotion of use of natural water purifying function of plants

   Aquatic plants have the water purification function by the absorption of Nitrogen and Phosphorus, and it is important in the water purification of lakes and reservoirs to use the function of the aquatic plants. Therefore it is appropriate that the measures to maintain the aquatic plants properly and to restrict any activity to damage the water purification function of the plants are implemented under the cooperation of local residents in the specified area where the plants in lakeside should be conserved.

3. Promotion of measures to pointed-source pollution

   Regarding the household wastewater treatment measures, it is important to promote the connection to drainage systems, to change the septic tank from the single processing type to the Nitrogen and Phosphorus removal type, to maintain the septic tank properly and to enlighten local residents on the household drainage. In addition, it is also important to promote the advanced sewage treatment of Nitrogen and Phosphorus in a drainage system.

   Regarding the factory and business place measures, in order to reduce the pollutant load by proper control of the pollution quantity, it is appropriate to apply the pollution quantity regulation to the existing factory and the business place. Moreover, it is important to request possible measures to a small-scale business place which is unrestricted.

4. The comprehensive plan-making

   It is necessary for plan-making to put the entire valley in view, to obtain the resident's participation, to see from a diversified aspect that contains the water cycle and the ecosystem, and to settle on the plan by the long range perspective. Moreover, it is necessary to evaluate and review the plan in the same manner.

5. Appropriate evaluation of water environment of lakes and reservoirs

   It is necessary to monitor the pollutant load properly and to clarify the pollution mechanism of the water environment. It is also necessary to install a supplementary index which is comprehensible to the local residents.

Amendment of the Law concerning Special Measures for Preservation of Lake and Reservoir Water Quality

The Ministry of the Environment submitted a bill that amended a part of the Law concerning Special Measures for Preservation of Lake Water Quality to the 162nd Diet based on the Report of the Central Environmental Council. This bill was passed on June 14, 2005 as shown in the original bill, and promulgated on June 22. The main content of this amendment is as follows.

1. Revision of the Water Quality Preservation Plan for Lakes and Reservoirs

   a. The plan period of the Water Quality Preservation Plan for Lakes and Reservoirs can be set according to the situation of each lake and reservoir. Formerly the period was five years uniformly.

b. When the Prefectural Governor establishes the Water Quality Preservation Plan for Lakes and Reservoirs, in order to obtain the understanding and cooperation of the local resident, it is necessary to take measures to reflect the opinion of the resident to the plan such as holding of the open hearing beforehand, when it is necessary.

2 In order to reduce the pollutant load from factory and business place further, the pollution quantity regulation of drain is introduced to the existing factory and the business place, which were exempted from the regulation formerly.

3. New establishment of the designated district system in lake catchments, in which non-pointed-source pollution is intensively controlled to attempt reduction in pollutant load that flows out from non-pointed-sources such as farmlands and urban areas and flows into lakes and reservoirs.

a. The Prefectural Governor should be able to designate the district in lake catchments where the execution of measures (runoff water measures) to contribute to the improvement of the quality of the runoff water from non-pointed-sources to attempt the preservation of the water quality of designated lakes and reservoirs should be promoted.

b. The Prefectural Governor should set the plan (runoff water measures promotion plan) to promote the execution of the runoff water measures in the designated district in the Water Quality Preservation Plan for Lakes and Reservoirs, when a district in lake catchments, in which non-pointed-source pollution is intensively controlled, is designated.

c. When the thing causes the pollution of the runoff water remarkably, the Prefectural Governor should be able to do necessary guidance, advice, and recommendation to the owner of the thing etc. to execute the runoff water measures if it is necessary.

4. New establishment of lakeside environmental protection district system to protect plants such as reed fields in which it contributes to improvement of water quality of lakes and reservoirs.

a. When it is necessary to protect the natural environment of the district where the plants to contribute to the improvement of the water quality of lakes and reservoirs grows among the waterside ground etc. of lakes and reservoirs, the Prefectural Governor should be able to designate a district concerned for a lakeside environmental protection district.

b. The person who tries to do the act of the collection of the plant which contributes to the improvement of the water quality of lakes and reservoirs etc. in the lakeside environmental protection district should report the kind, the place, and the time etc. of the act to the Prefectural Governor.

c. The Prefectural Governor should be able to prohibit, limit an act concerned and command necessary measures in a necessary limit to the person who tries to do/did the act that requires the written report in the lakeside environmental protection district when there is a necessity to protect lakeside environment.

Approach from now on

The amended Lakes and Reservoirs Law is to be put into effect on the day set by the government ordinance, which is not exceeded one year from the day of promulgation of the Law. Moreover, it will be studied to promote the introduction of advanced sewage treatment that removes Nitrogen and Phosphorus from household wastewater. With the amendment of the Lakes and Reservoirs Law, the cooperation between the local residents, the municipalities and each related ministry will be deepened, and a further effort will be exacted to preserve water quality of lakes and reservoirs.

Conservation and management of Bhoj wetland, India

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Abstract

The Bhoj Wetland is a wetland of international importance. The Upper Lake basin comprises of a submergence area of about 31.0 sq. km and a catchment area of 361 sq. km., whereas the Lower Lake basin comprises of a submergence area of 0.9 sq. km and catchment area of 9.6 sq. km. While Lower Lake is surrounded on all sides by dense urban settlements, only about 40% of the fringe area of Upper Lake has dense human settlement and the rest is sparsely populated having cropping as the major land use. The Upper Lake is the major source of potable water for Bhopal city of 1.4 million people. Increase in anthropogenic activities in the catchment during the second half of the last century resulted in environmental degradation of the lakes. Consequently, a comprehensive project on integrated water resources management was implemented with financial assistance of 7055 million Yen from Japan Bank for International Cooperation (JBIC) during 1995-2004 for the ecological restoration of the lakes. Project action involved both preventive and curative measures like diversion of sewage from the lake catchment, its treatment and disposal outside the catchment, catchment area treatment, fringe area management, removal of silt and weeds, providing aeration systems etc. and the application of locally suited design solutions, low energy, low cost technologies, as well as planned environmental education cum awareness programmes to ensure stakeholder participation in project implementation. As a result, the ecological condition of the lakes has improved. A Lake Conservation Authority has also been created to ensure post project management of the lakes based on the wise use concept.

Keywords: Wetland, ecological restoration, stakeholder participation

Introduction

Bhopal, the capital city of the state of Mahdya Pradesh, India is famous for its numerous lakes. Of these the most important are the Upper and Lower Lakes, which have commonly been designated as Bhoj Wetland. The Upper Lake was created in the 11th century by constructing an earthen dam across Kolans River, the main feeding channel of the lake with the objective of supplying potable water for the city dwellers. The lake is an Important Bird Area (IBA) as well as a Ramsar site declared by the Government of India in 2002. Besides being a major source of water supply, the lake is also very rich in bio-diversity. The population of the city by the turn of the last century was merely 77,023 (1901), which grew at slow pace till the first half of the century. But after Bhopal became the capital of Madhya Pradesh, the city has expanded as a result of various economic activities, and has experienced on exponential population growth during the 2nd half of the century (about 0.1 million in 1951 to about 1.3 million in 2001) mainly due to influx of people seeking employment opportunities/ livelihood (Anonymous, 1994).

As a result of rapid urban development around Lower Lake and on the eastern and northern fringes of Upper Lake especially during the 2nd half of the last century, both lakes were subjected to various environmental hazards resulting in deterioration of their water quality. Since these two lakes are considered to be the life-line of Bhopal, the 'Lake Bhopal Conservation and Management Project' was implemented during 1995-2004 with 7005 million Yen financial assistance from JBIC of Japan. The paper elaborates on the management action plan and the achievements.

Objective of the Project

The primary objective of the project is to upgrade the overall environmental condition of the Bhoj Wetland and to improve the water quality of the two lakes, particularly Upper Lake, which is being utilized as the main source of the water supply to the city of Bhopal.

Location and basic features of the lakes

Both the lakes are located in Bhopal, the capital city of Madhya Pradesh of India. The Upper Lake spread over longitude 77°18'00" to 77°24'00" E and latitude 23°13'00" to 23°16'00" N, whereas the considerably smaller Lower Lake is spread over 77°24'00" to 77°26'00" E and latitude 23°14'30" to 23°15'30" N. The basic features of the lakes are provided in Table 1.

Table 1: Basic features of the Upper and Lower Lakes (Bhoj Wetland), India.

Lake Sub-basin	**Upper Lake**	**Lower Lake**
Lake Origin	Man-made (11TH Century A.D.)	Man-made (Late 18th Century)
Climatic Region	Warmer humid (Humid subtropical)	
Drainage Basin Type	Open	
Salinity Type	Fresh	
Altitude	503.5 m	500 m
Surface Area	36 Km^2	1.29 Km^2
Drainage Basin Area	361 Km^2	9.6 Km^2
Volume	0.117 Km^3	0.004 Km^3
Maximum Depth	11.7 m	9.5 m
Average Depth	6 m	
Population	0.5 million	
Population Density	1350 persons/km^2	

Environmental issues

The major issues concerning the environment of the lakes are as described below:

Problems	**Causes**
1. Reduction of storage capacity of lakes	• Inflow of silt and organic materials from urban and rural catchments along with monsoon runoff and dry weather flow. • Addition of clay and non-biodegradable materials through immersion of idols.
2. Obstruction to smooth flow through the spill channel of the Upper Lake resulting in a threat to the stability of the earthen dam.	• Constriction of the spill channel due to deposition of silt.
3. Increase in seepage through the earthen dam of Upper Lake	• Improper maintenance and growth of vegetation over the dam had caused dislocation of stone lining of the dam
4. Deterioration of water quality	• Inflow of untreated sewage from habitation. • Dumping of Municipal wastes not collected by the Municipal Corporation. • Dissolving of paints in water during immersion of idols. • Run off of chemical fertilizers from the catchment. • Activity of washing of cloths by people resulting in release of detergents. • Leakage of oil during motor boating.
5. Flourishing growth of invasive aquatic plants	• High Nutrient load of lakes due to inflow of sewage and agricultural wastes.
6. Reduction of water spread area.	• Encroachment on the lake fringe area which gets exposed when water level falls after rains.

Implementation of the Project

Inception

Efforts to manage the lakes were implemented in a piecemeal manner since 1988. A State government initiated public awareness generation programme of manual weed removal called ‘Sarovar Hamari Dharohar’ (Lakes are our Heritage) was implemented in 1989. Considering the deterioration in water quality on account of aggravated pollution load and environmental degradation of the lakes, the Government of Madhya Pradesh prepared an integrated plan for the Conservation and Management of both the lakes and requested financial assistance from the Govt. of India (GOI) in 1989. The GOI provided grant in aid of Rs. 16.5 million for conservation works during1989-92. On account of the high project cost the plan was posed by GOI for external financial assistance to the Government of Japan in 1991. The Environmental

Clearance from the Ministry of Environment and Forests (MOEF) and the concurrence of Planning Commission was obtained for the implementation of the project through foreign funding.

The Japan Bank for International Cooperation (JBIC) sent a study team under Special Assistance for Project Formation (SAPROF) to India in 1993 to assess the feasibility of the project. On their recommendations, the JBIC agreed to provide financial assistance in the form of a soft loan of Yen 7055 million, out of the total project cost of 8033 million Yen. It was decided that the balance of 978 million Yen, i.e. 15 % of the project cost, would be shared by the GOI and the State Government equally. An agreement between the JBIC and the Government of India (Ministry of Finance, Government of India being the signatory) was executed for the implementation of "Lake Bhopal Conservation and Management Project" (also known as Bhoj Wetland Project) to be executed over a period of 5 years, starting from April 1995.

The Project envisaged tackling various issues of conservation and management of the Upper and Lower Lakes of Bhopal in an integrated manner. Although the issues are interrelated and interlinked but for operational and management ease, these issues have been divided into various subprojects albeit with the undercurrent knowledge and understanding of the related issues and interconnectivity with each other. The Project initially envisaged 14 subprojects under the major heads of:

- **Desilting and Dredging**
- *(Desilting and Dredging of the Lakes, Deepening and Widening of the Spill Channel and Restoration of the island)*
- **Catchment Area Treatment**
- *(Afforestation, Creation of Buffer Zones, Construction of Check dams, Silt traps, Toe walls and Cascading and Garland drains).*
- **Prevention of Pollution**
- *(Sewerage schemes)*
- **Shoreline and Fringe Area Management**
- *(Construction of Link road from Retghat to Lalghati, Solid Waste Management, Prevention of Pollution from Dhobi ghats), and*
- **Improvement and Management of Water quality**

(Deweeding, Biological Control (of weeds) through Acquaculture, Installation of Floating Fountains, Monitoring of Water Quality)

Considering the importance of Public Awareness in successful project implementation, Public Participation and Environmental Awareness activities were added as the 15th sub-project. Later more works, namely, Lake View Promenade and Protection of Lake Fringes (both for Shoreline Management), Bridge across the Bhadbada Spill Channel, setting up of an Interpretation Center for increasing environmental awareness and Control of Seepage from the Earthen dam of Upper Lake were subsequently included as additional subprojects in the period from 2002-2004.

Project Planning

An integrated lake conservation plan was prepared after identification and investigation of issues related to the lake conservation and its sustenance. The environmental, ecological, economical, legislative, administrative and technical issues were incorporated in the project for the conservation and management of the two lakes.

Implementing agencies

A Government controlled society called the Environmental Planning and Coordination Organization (EPCO) was made the coordinating agency among JBIC, the state government and the implementing agencies namely Bhopal Municipal Corporation (BMC), State Public Health Engineering Dept.(PHED), Water Resources Department, Forest Department, Capital Project Administration (CPA) and MP Fisheries Development Corporation (MPFDC). EPCO was the executive and advisory arm of the Environment department on statewide environmental issues. A project cell was set up within EPCO, which had the role of coordination amongst various implementing agencies (IA) and the Project Management Consultant (PMC). At times the IA showed an indifferent attitude towards completing the project on schedule. The progress of the project was tardy for the first two and half years on account of lack of coordination between the implementing and coordinating agencies as well as the PMC.

A project cell was set up within EPCO, which had the role of coordination amongst various implementing agencies (IA) and the PMC. At times the IA showed an indifferent attitude towards completing the project on schedule. The progress of the project was tardy for the first two and half years on account of lack of coordination between the implementing and coordinating agencies as well as the PMC. The speed of execution of the project improved in May 1998, when the state government decided to bring most of the subprojects except for the ones being executed by the Bhopal Municipal Corporation and the CPA under a single umbrella called the Bhoj Wetland Project Directorate by upgrading the project cell within EPCO. Experts from different discipline were inducted in the project and kept under the one umbrella for the smooth implementation of identified works.

Administration of the Project

Following committees were constituted for the Project management:

Empowered Committee: Being a large investment project, sanction of the major works were falling under the preview of the State cabinet. For ensuring speedy disposal, the State Cabinet delegated its financial powers to an Empowered Committee under the Chairmanship of the Chief Secretary of the State Government. The committee was constituted in February, 1996. The Committee had the secretaries of all the concerned departments of the state government, which had a stake in the project implementation, and the MOEF, GOI as members.

Technical Evaluation and Tender Approval Committee (TETAC): A major decision was taken by the government in May 1998 for speeding up the tendering and sanctioning of the project works. In the government system authority for sanctioning of works depends upon the magnitude of the estimated cost. The time required for such sanction are often quite high having to pass through several levels, which create a bottleneck for smooth progress for the time bound projects. Such departmental delays needed to be avoided if the project was to be completed in the remaining 2 years. A Technical Evaluation and Tender Approval Committee (TE and TAC) for the project was constituted in May 1998 under the chairmanship of the Secretary of the Environment Department having Chief Engineers of the Public Health Engineering, Water Resources, Public Works as well a representative of the Finance departments as members. It was the competent authority for according approval to the Detailed Project Reports of various works under the Project, evaluation of tenders and technical matters and sanctioning works upto Rs. 15 million for all IAs.

High Level Committee

The Minister of Housing and Environment Department, Government of Madhya Pradesh was the Chairman of the Committee and Public representatives, Media persons, and reputed persons of the society were also included as the members of the Committee. This committee reviewed the works executed by the Bhoj Wetland Project regularly, and resolved issues related to the people as and when required.

Achievements of the project

Implementation of the project by the Housing and Environment Department, Government of Madhya Pradesh was started in 1995 but could not be completed within the five years due to change in scope of the work during the implementing of the project. The project was ultimately completed in June 2004 and the assets created under the project were transferred to the government agencies for their post project operation and maintenance.

Under Conservation measures various activities were implemented for improvement of the water quality of the two lakes. The achievements are briefly described below:

Desilting and Dredging: 5000 Cum silt from Lower Lake by Dredging and 2.7 million m^3 silt from Upper Lake by dry excavation was removed, which resulted in increase in lake capacity by 3%.

Restoration of Takia Island: Two rows of retaining walls and pitching around the Island were created to prevent erosion of the island of religious importance and siltation of the lake. Development of greenery has become an added attraction for the visitors and avifauna.

Deepening and Widening of Spill Channel: This activity through removal of 0.987 million cum of silt from 2.6 km of Bhadbhada spill channel was carried out to accommodate a discharge of 566 Cum/sec from the lake in the event of flood threat. The silt removal caused another 1% increase in storage capacity of the lake.

Fringe Area Protection: The Bhopal Development Plan 2005 prohibits construction within 50m of the Full Tank Level (FTL) of Upper Lake and 33 meters of Lower Lake. Accordingly, a “No Construction zone” located up to 50m from the FTL of Upper Lake has been demarcated by putting boundary stones. Besides a physical barrier in the form of arches along the Lower Lake has been constructed to prevent direct access to the lake.

Creation of buffer zones between the lake and the human settlements:

Physical Barrier: A 5.4 km Link road on the north-east and a 2.5 km long Lake View Promenade on the south east fringe of the lake was constructed which served the dual purpose of preventing encroachment of the lake fringe area as well as reduction of the traffic pressure through the city. The promenade has become a recreational site for the city dwellers as well.

Buffer Zone Plantations: In order to prevent encroachment by human settlements as well as cultivation and grazing within the lake area and prevent siltation buffer zones of plantations have been created particularly in the Western, Southern and Northern fringe of Upper Lake. Besides this, intensive plantation has been carried out in the watershed area of the lake to control soil erosion. The species (51 in member) selected are either biomass producing or having medicinal properties and are tolerant to both flooding and drought conditions. About 1.7 million plants have been planted in over 10 sq. km land over a period of 12 years. In the program under social forestry, farmers were encouraged to raise fruit yielding trees along their crop fields and marginal lands. The results were quite encouraging.

Catchment Area Treatment: The catchment area of Upper Lake covers about 361 Sq. Km., in most of which agricultural practices is being undertaken. During rainy season run off from the catchment carries a lot of silt and organic debris to the lake. The urban catchment run off and sewage enters the lakes through various drains causing not only siltation but water pollution. In order to mitigate inflow of silt, agricultural residues and other wastes into the lakes from various points, 75 check dams of loose boulder/gabion structures and 2 silt traps having a cumulative silt trapping capacity of 0.36 million cum have been constructed across 31 inlet channels.

Sewerage System: 14 drains carrying 15 MLD of Sewage and 28 drains carrying 50 MLD of Sewage enter the Upper and Lower Lakes respectively. This is one of the major causes of pollution and deterioration of water quality of both the lakes (Anonymous, 1998). The estimated pollution load to the two lakes through this process as per quantification of pollution load during 2000-01 is presented in Table 2.

Table 2. Estimated pollution load through inflow of untreated sewage per year (in MT).

Parameter	Upper Lake	Lower Lake
Nitrate	22.20	43.90
Total Phosphorus	97.09	217.44
BOD	270.47	4590.42
COD	80.51	22,952.00

Infrastructure laying of an 86.7 km pipeline through congested human settlements and construction of 8 sewage pump houses and 4 treatment plants for diversion and treatment of the entire domestic sewage has been developed. The systems are at trial stage and expected to be fully operational within a period of 6 months. However, the connectivity of individual households to the main sewage pipeline is still to be done.

Solid Waste Management: Before the implementation of the project, the municipal corporation could only collect 96 tonnes of garbage daily as against the generation of 131 tonnes of garbage from the project area (18 wards of the city) due to limited infrastructure. The infrastructure of Bhopal Municipal Corporation was strengthened from the project funds by providing dumper placers, refuse compactors, a sewer cleaning machine and containers. At the dumping site an electronic weigh bridge was installed to monitor the efficiency of the each vehicle. These measures resulted in the additional collection and disposal of 70 metric ton of solid waste from the 18 municipal wards located in the urban watershed of the lake.

Prevention of pollution due to washing activities: Along the Lower Lake there are unorganized settlements of washermen. The sewage from these settlements used to flow directly into the lake. The cloth washing activity was also done by these washermen in the Lower Lake directly to the lake. The sewage inflow and washing activities resulted in drastic deterioration of the water quality of the lake. In order to ameliorate the situation the washermen have been shifted outside the catchment of the Lower Lake. Rehabilitation sites for 250 washermen families outside the catchment of Lower Lake having all facilities for living and washing were constructed. The resettlement of the washermen families has been completed in February 2004. The washer-men families were provided with cash compensation and sufficient time to built their own houses on the allotted developed plots at the new sites.

All these processes were accomplished through several rounds of talks with the washer-men, individually as well as through there authorized representatives. The washer-men did not change their activity. Only there was shifting of location of the washing activity out side the catchment of the Lower Lake. The vacated land has been developed as a buffer zone having gardens and parks. These have resulted in reduction of pollution problems of lake water.

Weed removal: Nutrient enrichment of lakes due to inflow of untreated sewage, run off containing organic wastes from urban areas in both the lakes and agricultural residues from and rural areas in Upper Lake caused excessive growth of aquatic vegetation within the lake area. With a view to offload nutrients and prevent accelerated evapo-transpiration of lake water, controlled weed removal operation in about 90% of the submergence area of Upper Lake and almost entire area of Lower Lake was carried out. Removal of different types of weeds such as shoreline (Ipomea fistulosa), emergent (*Scirpus roylie* and *Cyprus rotandus, Polygonum glabrum* and *Ipomoea aquatica*), floating weed (Water hyacinth) and an assemblage of submerged weeds were started in a systematic manner from January 1999. Maintenance operation is still continuing, though magnitude of weed growth has reduced considerably.

Installation of water oxygenation systems: Injection of ozone to improve water quality of an urban lake has been tried out for the first time in the world in the Lower Lake. However, for the Upper Lake (a potable water source) only fountains with provision to expose the hypolimnetic water to the atmosphere, have been installed. A total of 15 aeration units (1 ozonizer, 1 ozonizer cum fountain and 4 fountains in Lower Lake and 9 fountains in Upper Lake) have been installed to oxygenate the hypolimnetic water. This has not only caused improvement in water quality but become a tourist attraction.

Aquaculture: Herbivore grass carps along with Indian Major carps were introduced in the lakes to control submerged weeds such as Hydrilla, Najas and Vallisnaria as well as to maintain ecological balance. This has resulted in the reduction of density of aquatic weeds upto 50% and increase in fish production by 130%. Thus there has been improvement of lake water quality as well as economic conditions of fishermen.

Construction of high level bridge across Bhadbhada spill channel: In view of the development on the south-eastern part of Upper Lake and to reduce traffic pressure over the age old Bhadbhada bridge cum spillway, a 4 lane bridge across Bhadbhada spill channel has been constructed. This is expected to divert the development outside the catchment of the Upper Lake.

Control of seepage through earthen dam of Upper Lake: The earthen dam of Upper Lake was constructed in the year 1005 A.D. This dam was reportedly constructed between 2 dry masonry walls field with murrum (small pebbles mixed with red soil) and boulders. Subsequently a tunnel (gallery) was constructed to release water from Upper Lake to Lower Lake and for supply of potable water to the city. The upstream retaining wall of the earthen dam, upstream toe and the tunnel inside the earthen dam were damaged for want of proper care over the years. Consequently through out the length of the body of the dam and through the tunnel water was seeping through. A proposal to stabilize the retaining wall of the dam and to prevent wastage of water was included under the project at a later stage. The remedial measures include construction of col-crete of existing stones masonry wall, grouting of retaining wall, construction of bell-mouth inlet and outlet structure of the tunnel and shot-creting in two layers on the inner wall of the tunnel. A vertical shaft has been provided to facilitate the inspection and treatment of tunnel in future. For inspection purposes a pathway has been laid on the upstream of the dam and the area beautification of the area has been done through providing planters and lighting. The work is in its last stage of completion.

Water quality monitoring: Water Quality monitoring of both the lakes were conducted on a regular basis, i.e. monthly at 18 points in Upper Lake and 14 points in Lower Lake since 1998. Before that water quality of Upper Lake was conducted at a single location by the Public Health Engineering Department for the purpose of treatment of raw water before supply for potable purposes. A comparison of surface water quality of both the lakes as recorded during 2003 (Anonymous, 2004) is presented in Table 3.

Table 3: Water quality of Upper and Lower Lakes of Bhopal during 2003.

Parameters	**Upper Lake**	**Lower Lake**	**Remarks**
PH	6.29-10	6.9-10.5	In general water is alkaline
Transparency (cm)	clear-267	25-74	In Upper Lake except in rainy season transparency is good indicating a meso-eutrophic status. In Lower Lake transparency is poor indicating eutrophic condition.
Total dissolved solids (mg/l)	17.9-443	175-335	
Hardness (mg/l) as $CaCO_3$	40 – 212	96-220	Soft to hard
Chloride (mg/l)	9.9 – 49.9	22.0 – 75	High values have been recorded mainly near the inlet channels
Total phosphorus (mg/l)	0.22-3.24	1.7-17	High values in Lower Lake was due to use of phosphorus rich detergents for washing of cloths at the washing bay
Total nitrogen (mg/l)	1.33-4.3	1.34 – 6.0	
Dissolved oxygen (mg/l)	1.2-15.6	0.8 – 24	Except near the confluence points of waste water DO levels were good.
BOD (mg/l)	0.4-20	1.2-28	Except near the confluence points of waste water BOD levels were acceptable
COD (mg/l)	8.0-340	12 – 372	Except near the confluence points of waste water COD levels were acceptable

Over the years there is deterioration in water quality of both the lakes, specially near the confluence point of waste water. Adequate data for the pre project period for these points are not available for comparison. There are some changes in values of some parameters, indicating positive impact of desilting, deweeding, shifting of idol immersion site and operation of aeration units. The sewerage system is yet to be made fully operational and the washer men have shifted from the fringe of Lower Lake recently. Therefore naturally it would take some time before the water quality of the lakes would really show some improvement.

Public awareness campaign

During the implementation of the project, it was felt that there is a need to educate the public of Bhopal about the need of the project and to make them aware about the deterioration in the lakes environment. Therefore it was decided to organize a well-coordinated awareness programme. Before doing that a survey was conducted to assess the people is response regarding the conservation efforts and management of the lakes. Based on this study the people of all walks of life were involved through the awareness programme. For its implementation, the cooperation of selected NGOs were solicited. Various education awareness materials were developed to create public awareness (Table 4). The details of activity/awareness programme is given in Table 5. Most of these programmes were organized through active involvement of NGOs.

Table 4: Public/educational materials developed/used for public awareness programme.

S. No.	Type
1.	Hoardings at Strategic locations
2.	Publications of special bulletin (Tal Sandesh to create awareness regarding diversion of Idol immersion activities).
3.	Advertisement in news papers regarding project actions.
4.	Communication through TV/Radio.
5.	T-Shirts/Caps showing massage of "Save Bhopal Lakes" used by the students/volunteers involved in awareness campaign.
6.	Stickers having various slogans for lake conservation were used sparingly to communicate the massage.

Table 5: Public awareness programme/educational materials developed.

S.No.	Particular	Total (No.)
1.	Workshop	37
2.	Seminar	7
3.	Training	22
4.	Public Meeting	54
5.	Recreational programme/Field Visit	20
6.	Open Forum	18
7.	Rally	20
8.	Eco-camp	24
9.	Street Theater/Puppet Show	20
10.	Lecture 20 and Audio-Visual show 50	103
11.	Competition	43
12.	Exhibition	20
13.	Participatory Programme	18
14.	Bird Watching	4
15.	Science Fair	4
16.	Festival Fair	1
17.	Film Festival	-
BIG EVENTS		
18.	Mera Taal Mera Bhopal on World Environment Day 5th June 2001	1
19.	Public Hearing on 10th October 2001	1
20.	Lake Festival 22nd – 25th December 2001	1
21.	Human Chain on World Wetland Day – 2nd February 2002	1
	TOTAL	**419**

Below are the areas where the public directly cooperated with the project:

(i) Shifting of idol immersion from traditional site to the new site. Various public awareness campaigns and promotional drives for idol immersion at the new site were organized. Promotional drives included various prizes/trophies for construction of environmental friendly idols, which include small size and idols made up of biodegradable materials. At the public hearings, besides religious and political leaders, the general public participated and agreed to cooperate with city administration.

(ii) Participation in weed and silt removal operation in Upper Lake. People of all walks of life came in big numbers to give their hand in removal of weeds (water hyacinth) and silt from strategic locations of the Upper Lake time to time before the start of the project i.e. in 1988 and during the project implementation especially during 1999-2002 as a token of solidarity with the project. In these cases NGOs, and School/Colleges of the city played a big role.

(iii) Promotion of environment friendly agricultural practices. Intensive cropping with use of inorganic fertilizers is being done in the rural watershed of Upper Lake. Through monsoon run off, a significant part of these nutrients find their way into the lake, causing growth of aquatic vegetation in the lake. With a view of discouraging the practice of inorganic fertilizers, a drive for promoting the use of organic manure was launched in the villages located at the fringe of the lake. The manure was produced by the farmers themselves using farm waste and cow dung. These include hands on training to the farmers for making high quality compost using bacterial innoculum. The farmers found the method acceptable since crop yield was higher as compared to the conventional method and there was considerable saving on account of non-purchase of inorganic fertilizers. Now Lake Conservation Authority of Madhya Pradesh (LCA) in collaboration with Winrock International India (WII) is promoting this activity with a view to encourage more and more farmers to adopt organic farming through a mechanism of providing incentives to compensate the loss the farmers might incur for adopting organic farming.

Interpretation centre

To create awareness among the people of all walks of life, an Interpretation Centre depicting the origin of the Bhoj Wetland, ecosystem structure and functions, conservation principles, the project activities and the future course of action for the wise use of the lake ecosystem has been developed on the shore of Upper Lake. This museum is expected to be a common meeting point for stakeholders as well as an attraction for tourists.

Benefit to the Stakeholder

About 3000 fishermen families depend on the lake for their livelihood. As a result of the project, they are harvesting better fish crop and their monthly income increased from Rs.1500.00 to Rs.2600.00. Therefore, socio-economic condition of the Fisherman is improved. Before implementation of the project their monthly income was Rs.1500, which was increased to Rs. 2600.

The farmers of the catchment area have benefited with the creation of a buffer zone around the lake. About 1.7 million plants were raised in the fringes of the lake that provide food, fodder, fuel, and fruits to the farmers. The involvement of people through social forestry has helped in development of apiculture, sericulture and silviculture and has also provided job opportunities to the villagers.

- The silt excavated from the lake was spread over the wastelands where the villagers are now growing crops under rain fed conditions. Therefore, the land, which was unproductive become a source of income for the marginal farmers.
- The facilities provided to the washermen at the rehabilitation site are much better than the area where residing earlier. This area is located within the busy city area and has access to the market. Thus their business has increased side by side with superior living conditions for them.
- The weeds harvested from the lake where deposited in the crop fields in the fringe of the lake. This provided an opportunity to the farmers to use the weeds as green manure in their fields. Due to this process, the humus and trace element content in the soil increased causing increase in crop yield.

Establishment of Lake Conservation Authority of Madhya Pradesh (MPLCA)

For post project conservation and monitoring of water quality of Upper and Lower Lakes, Madhya Pradesh Lakes Conservation Authority (LCA) has been established. The expertise developed under Bhoj Wetland Project and experiences learned are being utilized for the conservation and management of lakes and water bodies of the entire state through Madhya Pradesh Lake Conservation Authority. The Environmental Research Laboratory developed under the Bhoj Wetland Project is providing analytical services to monitor the post project status of the lakes. Besides this, LCA is instrumental in involving stakeholders in resolving their problems and issues.

Conclusion

In the developing countries, where financial resources are limited for infrastructural development, implementation of conservation plan for the conservation of a wetland system is unique. It has tried various innovations both in case of application of technology and for administration for accelerating the project implantation. Involvement of the public with the project, in part to solve the religious and social issues, is worth emulating in other parts of the world.

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The practice and probe on integrated management of Poyang Lake Basin

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Abstract

Jiangxi province is situated in the mid-low reaches of Yangtze River in China, having a population of 42 million and an area of 167,000 km^2. Such activities as transferring forest land to farming land, reclaiming the wetland for paddy land in the lake area and over-fishing took place for short-term benefits in the history of Jiangxi Province because of the great increase of population and unreasonable traditional development approach. Those activities resulted in serious water and soil erosion in the mountain and hilly areas, frequent flooding disasters in the lake area, environmental degradation and the retarded economy of the province. The Mountain-River-Lake Programme of Jiangxi Province, commenced in the early 1980s, developed its strategy of "to manage the lake, the river must be harnessed; to harness the river, the mountain must be developed; to develop the mountain, the poverty must be alleviated" and adopted the principle of "based on ecology, having economy in mind, developing the Poyang Lake (The largest fresh-water lake in China) Basin in a comprehensive way" on the basis of the law of substance-recycling, energy-flow, information-delivery and value-increasing in the river basin, and the inter-relationship among the population, resources and environment. With the aim of the balanced development of society, economy and environment of the Poyang Lake Basin, the Mountain-River-Lake Programme made an overall development planning for the basin, and developed agriculture, forestry, husbandry and their by-products by considering the sustainable use of natural resources and environmental protection. This paper attempts to summarize the successful experience and methods of integrated river basin management accumulated by the Mountain-River-Lake Programme in the past 20 years for reference of regions with a similar situation.

Key words: Poyang Lake, Integrated Management, Mountain-River-Lake Programme

Background

Jiangxi Province is located in the southern bank of middle and lower reaches of Yangtze River in China. Its topographical feature is hign in the south and low in the north, with hills and mountains in the south, hills alternating with basins in the middle and the Poyang Lake Plain in the north. The Poyang Lake within its boundaries - the largest freshwater lake of China, the five big Rivers of Gan, Fu, Xing, Rao and Xiu flowing into it and their catchment basins are called the Mountain, River and Lake Region for short (that is the Poyang Lake Basin) (Figure 1). This is a relatively complete and unique water system. The area covered by the whole basin is 162,200 km^2, accounting for 97.2% of the total land area in the Province.

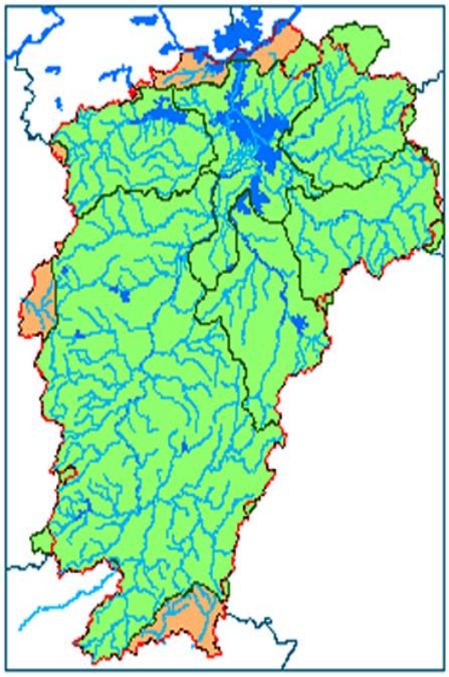

Figure 1: Sketch map of Mountain-River-Lake region of Jiangxi Province.

Due to various reasons, in the history of Jiangxi Province, there were such short-sighted campaigns as transforming forest land into farming land, unplanned reclaiming of wetland for paddy land around the Lake and over-fishing, which resulted in the deterioration of the ecological environment. In the early 1980s, only in the southern mountainous area of Jiangxi Province, the annual sand and soil erosion amount and area affected had reached 53.35 million tons and 1.1 million hectares respectively, accounting for over 35% of the total land area there. The forest coverage of the whole Province was reduced from about 60% to 31.5%. The serious water and soil erosion has quickly reduced the navigable waterway in the whole province from 12,000 kilometres to 5,000 kilometres. The deposited mud and sand has made the Poyang Lake, the largest freshwater lake in China, unbearable and has caused the water body to shrink, has reduced the function of the Lake and created serious flood disasters around the lake. In addition, such problems as land degradation, declining biological resources, worsening environmental pollution, enlarging epidemic area of snail fever around the lake and increasing number of poor population are becoming more and more severe.

Methodologies and measures

In order to solve such problems as severe ecological imbalance, environmental deterioration and backward economic development, as well as to make rational use of limited resources, protect ecological environment and promote the regional economic development in the Poyang Lake Basin, Jiangxi Provincial People's Government has carried out following measures:

Organize scientific investigations on the Basin and identify the development strategy

Since 1983, in cooperation with China Academy of Science, the Jiangxi Provincial Government has jointly carried out three full-scale integrated scientific investigations on the Poyang Lake and Gan River Basin so as to determine its resources, ecology, environment as well as the socio-economic status and seek the root causes of its main problems. It was discovered after investigations that the key to control the Poyang Lake lay in solving the mud and sand deposition problem beginning from the mountainous areas and river sources. The common view of "mountain is the source, river is the current, lake is the storage, and the mountain, river and lake are interrelated to jointly constitute an interdependent ecological and economic system" has been reached. This scientific point of view has singled out the inalienable inner law among the mountains, rivers and lake and has embodied the philosophy of their systematic development and management. Based on this view, the Mountain, River and Lake Development and Management Strategic Conception has been formed The Conception is "to bring the Lake under control, the problems of the rivers should be tackled: to tackle the problems of the rivers, the mountains must be managed, and to manage the mountains, the poverty should be eliminated".

Establish the Mountain, River and Lake Program and set up a comprehensive Basin management and coordination body

On the basis of repeated studies and discussions on the Mountain, River and Lake Development and Management, Jiangxi Provincial Government decided to establish the Mountain, River and Lake Program in July 1985 and to pay special and close attention to the Mountain, River and Lake development and management by regarding it as the cornerstone program to revitalize Jiangxi Province and enact a policy to spur harmonious social, economic and environmental development. Jiangxi Provincial People's Government Mountain, River and Lake Development and Management Leading Group (it has been upgraded to Jiangxi Provincial Mountain, River and Lake Development and Management Committee) was specially set up for this purpose. The provincial governor acts as director general of the committee and executive directors of more than 20 relevant departments and bureaus as members. The Committee undertakes the overall management and coordination responsibility for the Mountain, River and Lake development and management. An office has been established under the Committee. In order to guarantee a scientific, pace-setting and comprehensive Mountain, River and Lake Program, the Academic Committee of the Mountain, River and Lake Development and Management, comprising over 30 celebrated experts and scholars in and outside the province, was formed at the same time. The Committee has been providing scientific consultation and technological support for the major decision-making issues of the Mountain, River and Lake Program. The administration, coordination and implementation agency systems for the Mountain, River and Lake development and management covering the whole province have been formed.

Carry out strategic research and work out the overall Basin development planning

A macro strategic research on the Poyang Lake Basin has been carried out based on comprehensive scientific investigations on its resources and environment and drawing on the domestic and foreign planning and practical experiences relevant to integrated basin development and management. Jiangxi Provincial Overall Planning Outline of the Mountain, River and Lake Development and Management (It is called the Planning Outline hereafter) has been worked out in accordance with the sustainable development principle and the characteristics and development status quo of the Poyang Lake Region as well as under the guidance of integrated basin management and ecological economy theories. It has been reviewed and legislated by Jiangxi Provincial People's Congress as a binding law to govern the Basin development and management planning. According to the features of different development stages of the Poyang Lake Basin, Jiangxi Provincial Mountain, River and Lake Development and Management Committee Office has drawn up the Five-Year Plans for the Mountain, River and Lake Program by using the Planning Outline as guidelines. These Plans have been incorporated into Jiangxi Provincial Social-Economic Five-year Development Plans by Jiangxi Provincial Government, and have been guiding and coordinating the development and management efforts of various agencies, regions and a large number of farmers in the Poyang Lake Basin.

Rectify the environment according to laws and protect the ecology and natural resources in real earnest

In line with such major problems as worsening ecological environment and irrational resource development initiatives etc. existing in the Poyang Lake Basin, the Mountain, River and Lake Program has, in accordance with the arrangements of the Planning Outline as well as the national policies, rules and regulations on environmental protection and resource development, strengthened the establishment of a series of local laws and regulations suited to the local conditions. The purpose of all these laws and regulations is to ensure that the resource development and ecological environment protection in the Poyang Lake Basin follows a legal basis. On the other hand, it has strengthened the law enforcement in conserving the ecological environment and developing the resources in a reasonable and feasible way. The major specific works done are in the following three aspects:

Afforestation to control water and soil

The Mountain, River and Lake Program has been making great efforts in all-out afforestation and closing forest campaigns, and has been implementing full-scale water and soil conservation projects. The water and soil erosion area in the whole province has dropped from 36% to the present 21% of its total land area, which is far below the national water and soil erosion area accounting for 38.2% of the national total land area. The annual mud and sand amount flowing into the Poyang Lake has reduced from 50.00 million tons to 24.00 million tons. Jiangxi has become an advanced province in the national water and soil erosion control campaign.

Orderly development and sustainable use of resources

For the purpose of conserving the natural resources in a feasible way, 111 natural reserves and over 5,000 natural protection sub-areas were set up by the end of 2001. The total area of natural reserves and natural protection sub-areas amounts to 961,600 hectares, accounting for about 5.76% of the total land area in the province.

Regular and irregular special rectification of harmful fishing tools and methods in the Poyang Lake area has been made. The practice of banning off-season fishing and harbouring in the Poyang Lake have been in force for 16 years. All these practices are conducive to improving the ecological environment and to recovery of the fishery resources in the Lake area.

Concentrate on crucial points to rectify and control the environment

A combined multi-sector environmental inspection team was established and it conducted environmental inspections on nearly 1,700 enterprises, placed 299 enterprises on file for investigation, and prosecuted and closed several tens of enterprises violating the rules. These endeavours have effectively prevented and controlled environmental pollution and ecological destruction and have promoted the sustainable social and national economic development

Foster sustainable development model to promote local industrial development

In the course of working out the Planning Outline, the Mountain, River and Lake Program has established and improved 26 experiment and demonstration bases and 127 extension stations of 9 categories, and supported 112 high yield, high quality and high efficiency agricultural commodity production bases and enterprises. It has executed over 10 large-scale integrated resource development projects in all the typical regions of the Poyang Lake Basin. In the process of all these efforts, it introduced new development ideas, technologies and methods used at home and abroad and adopted the working methodologies of "paying attention to both hardware and software, actual implementation and publicity campaign simultaneously, assembling domestic resources and attracting foreign funds and demonstrating by examples". All these have provided examples for the harmonious social, economic and ecological development in various regions of the Poyang Lake Basin and have become the fostering bases of local industrial development.

Strengthen the human resource development to promote the sustainable agricultural development

The Mountain, River and Lake Program has been attaching great importance to rural human resource development while conducting the pace-setting experiments and demonstrations. By taking Jiangxi Provincial Mountain, River and Lake Rural Regional Development Centre as the nucleus, three sustainable development training centres in the mountainous, hilly and lake areas and extension service stations in various project areas have been set up one after another, constituting the training, technical extension service and information networks. It has, according to different natural resources and socio-economic conditions in various regions, provided training support for over 120,000 person times of various trainees[4] and disseminated more than 200 appropriate new technologies and methods through classroom lectures, workshops/ seminars and field guidance etc.

The effect of the Mountain, River and Lake Program

The Mountain, River and Lake Program has carried out the scientific practices of integrated Basin management and has achieved gratifying achievements following the principle of sustainable development. In the last 20 years, 2.30 million hectares of mountains have been afforested, which has basically covered all areas suitable for forests on the mountains; the water and soil erosion area has decreased from 3.30 million hectares to 1.30 million hectares; the forest coverage has risen from 31.5% to 59.7%, the green coverage in urban areas reaches 23.48%; the annual average mud and sand flowing into the Poyang Lake has decreased from 53.35 million tons to 24.00 million tons; water area of the Poyang Lake has basically recovered to that of the year 1954, with its flood water storage capacity increased by 4.6 billion cubic meters and the wet land area largely enhanced; the main levees in the Lake areas have been heightened and consolidated, thus the flooding prevention capability has been improved; water quality in the water bodies has been improved, with the main one of the Poyang Lake meeting the water quality standard of category II water body, and water quality of 70% of the monitored channel segments in the province meeting the water quality standard of category III; air quality in the urban areas meets the standards of grade I and II. In 2002, the annual net income per capita of rural population increased from 287 Yuan in 1985 to 2,458 Yuan in 2003 and 4.5 million of people eliminated poverty. The philosophy adopted by the Mountain, River and Lake Program has aroused enthusiastic echoes from home and abroad. The Mountain, River and Lake Program was selected by the Chinese Government to attend the Technical Exposition of the World Environment and Development Conference in June 1992; it was listed as the first priority projects of China Agenda 21 in July 1994; it was selected to participate in the World Expo 2000 held in Hanover, Germany; it was invited to join the South-South Cooperation Network in 2001; and it took part in the activities of the Sustainable Development Summit held in the Republic of South Africa in 2002. Wide and close attention at home and abroad is being paid to the Mountain, River and Lake Program.

The basic experience of the Mountain, River and Lake Program

The Mountain, River and Lake Program regards the mountains, rivers and Lake as an interrelated catchment ecological and economic system, and takes the sustainable development as its objective. It uses science and technology as the pace-maker, and promotes development by opening up. It organically combines mountain, river and Lake management with poverty elimination, thus pushing the regional sustainable development forward. Its basic experience lies in the following 6 aspects:

Abide by the sustainable development principle

The development strategies, working guidelines and development and management models of the Mountain, River and Lake Program embody features of sustainable development. The Program makes an overall planning, rational allocation and systematic development to the resources in the Poyang Lake Basin to ensure that the development can satisfy the interests of both the present and future generations and the two can be unified. In the course of social and economic development, the Program takes full consideration on promoting the harmonious regional social, economic, resource and environment development. The third aspect is the unification of mountain development, water control and poverty alleviation, to improve the natural environment through mountain management and water control; to heighten the technical standards of local farmers, make rational use of local resources and foster local characterized industries through training interventions and technical consultations.

Abide by the principle of systematisation and comprehensiveness of river basin management

Considering the whole Poyang Lake Basin as an interrelated and inalienable ecological and economic system at macro level, the program also cuts across the regional administrative boundaries and takes the small catchment as a control unit to make overall planning, arrangements, systematic development and integrated management at micro level. The multi-sectors of agriculture, forestry, etc and multi-disciplines of ecology, environment, resources, economy and society etc., are jointly involved. Each of the development models and management examples under the Mountain, River and Lake Program are by practice uniting the joint participation of managers, experts, scholars from relevant line agencies and disciples and local farmers. Their results embody the collective wisdom of natural and social science workers.

Establish an efficient and open catchment basin management and coordination agency

By establish an effective management network at multilevel in the basin, it mobilizes various sectors and masses to efficiently conduct ecological environment management and rational use of resources in the entire Poyang Lake Basin under the unified leadership and arrangement of the Mountain, River and Lake Program Development and Management Committee.

Abide by the principle of relying on technology and strengthening technological innovation

The Mountain, River and Lake Program has been implementing the principle of guiding the project practices by scientific theories from the beginning to the end. Guided by overall catchment development planning based on the integrated catchment management ideas and ecological economy theories, and in the process of specific experiments, demonstrations and model development, a technological network involving multi-disciplines, multi-sectors and multi-level joint cooperation has been formed. When considering the actual local situation, the technology and methodology innovations have been continuously incorporated to speed up the implementation progress of the Program.

Concentrate force on solving the major water and soil erosion problems in the Basin

It was found, after investigations and experiments by the Program, that water and soil erosion is the root of such problems as land degradation, river and lake silting up and frequent drought and flooding disasters etc. Through both biological and water conservancy engineering, measures have been taken to prevent and control water and soil erosion. In terms of economic factors, the Program aims to arouse the enthusiasm of the people for controlling water and soil erosion by sustainably utilizing and developing resources to increase farmers' incomes. The implementation of "pig raising, biogas production and fruit planting" project - a local eco-agricultural project, has brought forest vegetation destruction and ecological environment deterioration, which is caused by local farmers' cutting firewood and grasses as fuel regardless of ecological conditions, under permanent control. It has also changed the rural energy structure and ameliorated rural ecological surroundings, helped farmers get rid of poverty and become rich, thereby leading rural areas to a sound development approach, which highly unifies social, economic and ecological benefits.

Strengthen international exchange and cooperation to attract funds and talents

The Mountain, River and Lake Program has always been abiding by the guidelines of promoting development through opening up. It has established close exchange and cooperation relations with over 20 countries, regions and international organizations to continuously introduce advanced ideas, technologies and methods for application, extension and innovation according to conditions in the Poyang lake basin. All these have obtained obvious comprehensive benefits. As an inland province, the fiscal inputs of Jiangxi are very limited. Only by opening up, can one look at it not from the views of Jiangxi but from the insight of the world, thereupon learning from the experience of many countries and getting support and assistance from multiple fields.

Reflection and outlook

The practices of the Mountain, River and Lake Program in mountain development, water regulation and poverty elimination in the past twenty years have made some fruitful probes into integrated catchment management and regional sustainable development. However in the new development situation, the Mountain, River and Lake Program is faced with new problems and challenges, which are how to shift it from the development and rectification stage to the full-scale operation stage and how to change the ecological benefits of the Poyang Lake Basin into economic benefits, thus helping farmers in the Basin shake off poverty and get rich. In order to fulfil this great mission, great efforts must be made in the following aspects from a scientific development point of view.

Renew conception to form and implement scientific development views

In accordance with the practical requirements of the Mountain, River and Lake Program, the harmonious catchment social, economic and ecological environment development can only be realized by encouraging and organizing people to study the scientific development views in the wide range, publicizing and popularising the scientific knowledge of integrated catchment management and sustainable development, raising the masses' awareness of participation in catchment management continuously, and building up the protection and construction of catchment ecological environment incessantly.

Establish a resource-saving national economy system and a recycling economy of sustainable resource use and development

In the long run, the pressure of economic development and population growth in the Poyang Lake Basin will cause high demands for resources, so the increasingly outstanding problem of resources supply and demand contradiction will emerge. In this situation, the strategic countermeasures of resources in the Poyang Lake Basin should be to set up a resource-saving national economy system and a mechanism of sustainable resource uses and to develop a recycling economy in great efforts, thus creating conditions for the realization of the long-term objective of zero growth rate of resource and energy consumption.

Consolidate the control of water and soil erosion and waste gas, water and material pollution to improve stress tolerance of the Basin

The environmental and ecological levels of the Poyang Lake Basin are relatively high, ranking at the front row of the whole country, but its stress tolerance index is low, ranking, relatively at the back row of the whole country. Therefore, the management of the Poyang Lake Basin should focus on controlling water and soil erosion and industrial waste water, gas and material and aim at increasing the stress tolerance.

Strictly control the population growth and improve their quality to fundamentally alleviate the contradiction among population, resource and environment

The sustainable development of the Poyang Lake Basin confronts heavy population pressure. Hence, a more effective population policy shall be executed, modern population awareness shall be popularised, and efforts in human resource development shall be strengthened, thereby fundamentally controlling population growth and improving their quality.

Implement industrialized and urbanized development strategy to improve the sustainable development capacity of the Basin

It can be seen from the national sustainable development capacity evaluation that the weak and fragile function of the support systems for the Poyang Lake Basin development constraints the improvement of catchment sustainable development capacity as a whole. The main gap lies in the low level of industrialization and urbanization and delayed development. Therefore, to accelerate the industrialization and urbanization is the major task of economic development of the Poyang Lake Basin in quite a long period in the future.

Strengthen domestic and international cooperation and exchange to speed up development of the Poyang Lake Basin

The Poyang Lake Basin should actively participate in the regional cooperation at home to realize mutual supplements and promotion. It should at the same time bring the talent and technical advantages of its own and the famous brand influence of the Mountain, River and Lake Program into full play, thus further strengthening international cooperation and exchange and hastening its full-scale development.

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Sustainable management of sediments at reservoirs – A comparative study from Asia, Africa and Europe

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Abstract

The concept of water management is getting increasingly important as the situation of water scarcity is growing at an alarming rate. The management of natural and artificial reservoirs are important for sustainable development. It is estimated that 0.5- 1% of the world reservoir volume is lost from sedimentation annually. The world commission on dams knowledge base indicates that, while sedimentation potentially undermines the performances of a large dam project, the conditions and therefore the frequency of occurrence of this phenomenon are project and site specific. In natural reservoirs, sedimentation problems often arise due to soil erosion processes in the catchment and thus, its management requires a more comprehensive approach. Often the problems on sedimentation leads to water shortage and non utilization of reservoirs and leading to depletion of the resource base of a country. This, then leads to scarcity of water which thereby affects the livelihood of common man and in certain cases, leading to conflicts. The objective of this study is to look into factors leading to sedimentation and to bring together suggestions for management of natural and artificial reservoirs from Africa, Asia and Europe thereby integrating a code structure of good practices for sustainable development. The cultural and economic aspect would also be looked into apart from the national and international policies on water applicable to the region. The study would be focusing on management practices from Danube basin in Europe, the Narmada river basin in India and the Abaya lake basin in Ethiopia.

Key words: sedimentation, reservoirs, Lake Abaya, Danube, Narmada river, world commission on dams.

Introduction

Sediments originate in the catchment through erosion processes and are transported in river systems in the direction of the coast, with oceans being the final sink. As such land use, hydrology, geology and topography determine erosion and transport processes. In the river system temporary deposition can take place. Important in this respect are floodplains and lakes. In many regulated rivers, sediments are trapped behind dams and reduce sediment supply downstream.

Though reasons for sedimentation can be anthropogenic, there is also a strong reason to prove that climatic variations can be one of the factors that may cause an increase in sedimentation in rivers and reservoirs. For example, in temperate areas, the sedimentation of a reservoir is usually a slow process. A study by Dr. Cyberski of the State Hydrological-Meteorological Institute, Warsaw, for instance, reviewed sedimentation rates at 19 reservoirs in Central Europe. Cyberski found that their storage capacity (which ranged between 120 and 183,000 acre feet) was depleted by sedimentation at an average rate of 0.51 percent per annum (Glymph, 1973).

Another study at the USDA's sedimentation laboratory looked at the sedimentation rates of small, medium and large reservoirs in the United States (Dendy *et al.*, 1973). That study found that the rate of sedimentation in 1,105 reservoirs with a capacity of less than 10 acre feet was approximately 3.5 percent a year. In the case of medium-sized reservoirs (with a storage capacity of more than 100 acre feet) the annual storage loss was 2.7 percent per annum and the median rate of sedimentation was 1.5 percent. For reservoirs with a storage capacity of more than a million acre feet, the rate of sedimentation was only 0.16 percent per annum, with the mean rate coming out at 0.11 percent a year (Dendy *et al*., 1973).

Whereas, the sedimentation rates in the tropics are much higher and can be explained with the devastating effect which deforestation has had on tropical soils. In those areas where forest cover has been depleted, however, the rate of soil erosion increases dramatically: the organically poor soils of the tropics are particularly vulnerable to erosion and although the Monsoons only last for a short time, they can quickly wash away the soils from deforested slopes.

Given the present rate of deforestation in the tropics (10 hectares of rainforest are lost throughout the world every minute of the day) it is hardly surprising that rivers in the region carry enormous quantities of silt. Indeed, in many areas, the increased sediment load of rivers is clearly visible to the naked eye. In this study we would be looking at three case studies and the management practices for sediment management in Danube Basin in Europe, the Abaya lake basin in Ethiopia and Narmada river basin in India.

Water reservoirs in the Danube basin

Damming has become a practical necessity and has provided huge benefits to agriculture, industry and urban development. The report of the World Commission on Dams (WCD, 2000) has highlighted the scale of human intervention of ecosystems by the construction of large dams. Dams, inter-basin transfers and water withdrawals for irrigation have fragmented over 60% of the world’s rivers and changed the sediment load of rivers to the coastal sea.

In Western and Northern Europe reservoirs can be found in many catchments depending on their main purpose: hydroelectric reservoirs are common in Scandinavia and in the Alpine range from France to Slovenia, as well as in medium-high mountains (Tatra, Carpathians). Reservoirs of various sizes have been constructed in the Vistula, Elbe, Seine and Danube catchments.

Most of the reservoirs in Danube are human-made sediment traps in which more than 90% of the sediment transport of an incoming river can be stored when the residence time of the water exceeds two months. For the impact of damming on the global water and sediment flux, quantitative estimates have recently been made. The large reservoirs in the Danube basin intercept more than 40% of water discharge and approximately 70% of this discharge maintains a sediment trapping efficiency of more than 50% (Sednet, 2004). It is estimated that about 25 to 30 % of the sediment flux to the coastal sea is trapped behind dams (Sednet, 2004). One of the positive environmental effects is the trapping of contaminants associated with sediments and in this way protecting downstream areas. For example, in the territory of Slovakia, Danube basin area is around 48,950 km^2 and is divided into 10 sub-basins (9 belonging to the Black Sea basin and one to the Baltic sea basin). The most serious problem in these reservoirs are the quality of water for most of these reservoirs do not meet the standards required for sustainable quality use of water.

Management of sediments in the Danube - Danube River Protection Convention (DRPC)

Under the Danube River Protection Convention (DRPC) and within its organisation, the MLIM/EG (Monitoring, Laboratory and Information Management Expert Group) is responsible for "operating" the Trans National Monitoring Network (TNMN) for water quality in the Danube River Basin (Figure 1). One of its tasks is to set up programmes to improve laboratory analytical quality assurance. It also facilitates the preparation and exchange of (in-stream) water quality and quantity data among the contracting parties (Transnational Monitoring Network, 2001). The MLIM was set up in December 1992 as a Sub-Group of a former Task Force of the EPDRB with the aim to strengthen national and international capacity to provide reliable information on surface water flows and the quality of waters in the Danube river basin, to improve the comparability of sampling techniques and laboratory analysis, and to develop compatible information management systems for the exchange of information at the international level. Three MLIM's working groups were set up for Monitoring, Laboratory Management, Information Management.

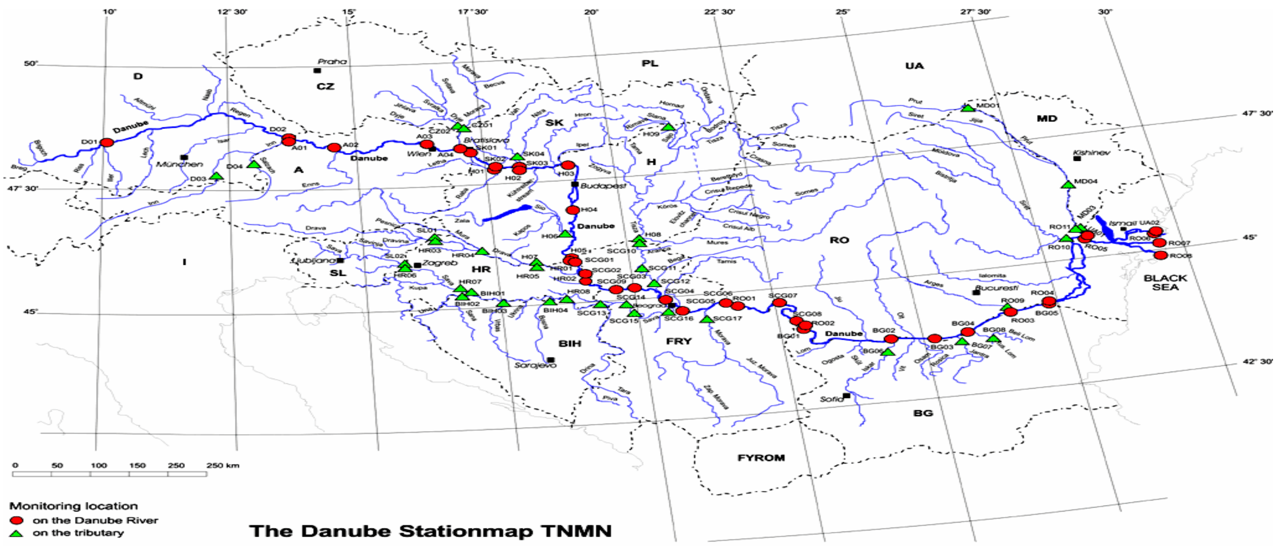

Figure 1: Sediment Monitoring locations in the Danube (Transnational Monitoring Network, 2001).

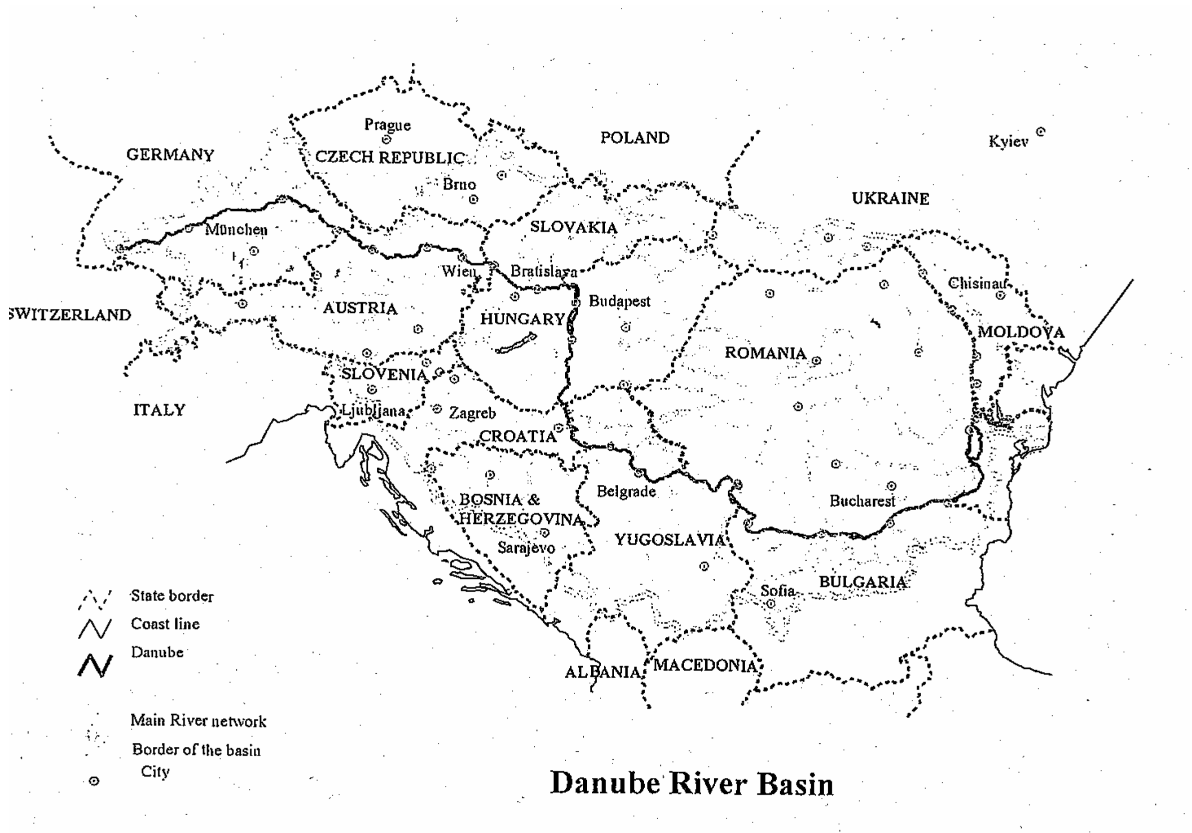

Figure 2: Hydrological catchments of the Danube (Source; International commission for the Protection of Danube River, 2005).

An important task of the Monitoring group has been to develop a Trans National Monitoring Network (TNMN) which also enhances the Bucharest Declaration monitoring network. In order to provide data for TNMN, a National Reference Laboratory Network (NRLN), with equal technical (equipment) and methodological capabilities (practices for sampling and analysing) in each participating country has been created under the working group of Laboratory Management. A National Information Centre Network (NICN) was created to exchange data in a common format between countries and international bodies. (Transnational Monitoring Network, 2001).

The Danube Water Quality Transnational Monitoring Network (DWQ-TNMN) is officially operating, starting June 9, 1999. The fully participating countries at present are Germany, Austria, Czech Republic, Slovak Republic, Hungary, Slovenia, Croatia, Romania and Bulgaria. Developments are under way to fully include Moldova, Ukraine, and Bosnia and Herzegovina.

The aim of the DWQ-TNMN is to enable the International Commission for the Protection of the Danube River as well as national authorities from the Danubian countries to manage and improve the quality of water resources in the whole region (Figure 2). Such management is based on the data and information obtained from the monitoring activities carried out.

The Transnational Monitoring Network has sampling and measuring locations in all countries starting from the river source in Germany and down to the three mouths in the Danube Delta where the river discharges into the Black Sea (Figure 1). There are 61 sampling stations in the present structure of the TNMN which were selected from the national monitoring networks. The selection was made based on criteria and objectives agreed between the countries. Other monitoring parameters like the list of determinants, sampling frequencies, analytical procedures were also agreed by the countries on basis of the advice given by the Expert Groups and Expert Subgroups.

Starting with 1996 on an annual basis data is provided by the Danube countries to the Central Information Point (CIP) where TNMN data are assembled in a well defined structure using rules of reference integrity.

Sedimentation of reservoirs in Danube basin – a case study from Slovakia

Water-management operation of reservoirs and dams are related with many issues and consequences, which are to be maintained at the minimum sustainable level. The common problems noticed in Slovakian reservoirs are, sedimentation, wave abrasion, and changed hydrological regime in the water course downstream of the reservoir. Problems caused by sedimentation are rather difficult in case of reservoirs with low regulative capacity, i.e. Krpeľany, Hričov, Nosice, Drahovce on the Váh river. In case of dredging these sediments, additional problem arose regarding their classification as “waste material”, requiring special storage. The most extensive sedimentation occurs at the reservoir Veľká Domaša with average specific disposal of 990 m of material from the catchment.

Another problem noticed was of wave abrasion occurring at large reservoirs with extensive flooded areas, where certain wind conditions creates intensive wave regime. Wave motion induces wave abrasion especially where the reservoir banks are constructed as sloppy structures of clay detritus, or easily erodable rocks (slates, claystones, etc.). These factors were experienced at 6 largest reservoirs: Orava, Veľká Domaša Liptovská Mara, Starina, Nová Bystrica, Vihorlat.

There are also many small reservoirs in Slovakia serving useful functions and improving the total water balance. Official standards define small reservoirs as basins with a capacity of not more than 2 million m^3 of water, a maximum depth of 9m and a hundred year peak discharge no greater than $60m^3/s$. Nationally, there are around 350 such small water reservoirs in Slovakia with a total surface area of 1910 ha and a design capacity of 45 million m^3 (Haigh *et al.,* 2004).

Sedimentation studies in this area have revealed that the amount of sedimentation ranges from 4.8% to 83.6 % of the total storage capacity which directly decreases the storage volume by 0.32- 9.3% with an anticipated design life of 100 years. Hence, maintenance clearance would be required on an average of every 15 years (Haigh *et al.,* 2004)

Sedimentation studies in Lake Abaya

Lake Abaya is the largest lake of the main Ethiopian Rift Valley (Figure 3). The area in which the lake lies is mainly volcanic in origin while the waters of the lake are permanently turbid due to a heavy colloidal suspension of ferric oxide. One interesting factor in the sedimentation of lake Abaya is that, prior to 1970’s, the major reason for sedimentation was attributed to climatic factors, but, since 1970’s it is noted that as well as changes in cultivation methods,caused a dramatic increase in sediment yield of Lake Abaya tributaries, thus, influencing basin bathymetry and volume (Schütt *et al.,* 2005) Because of its shallow depth (max. depth of 26 m) the lake level of Lake Abaya reacts sensitive to changes of water and sediment input (Schütt *et al.*, 2005).

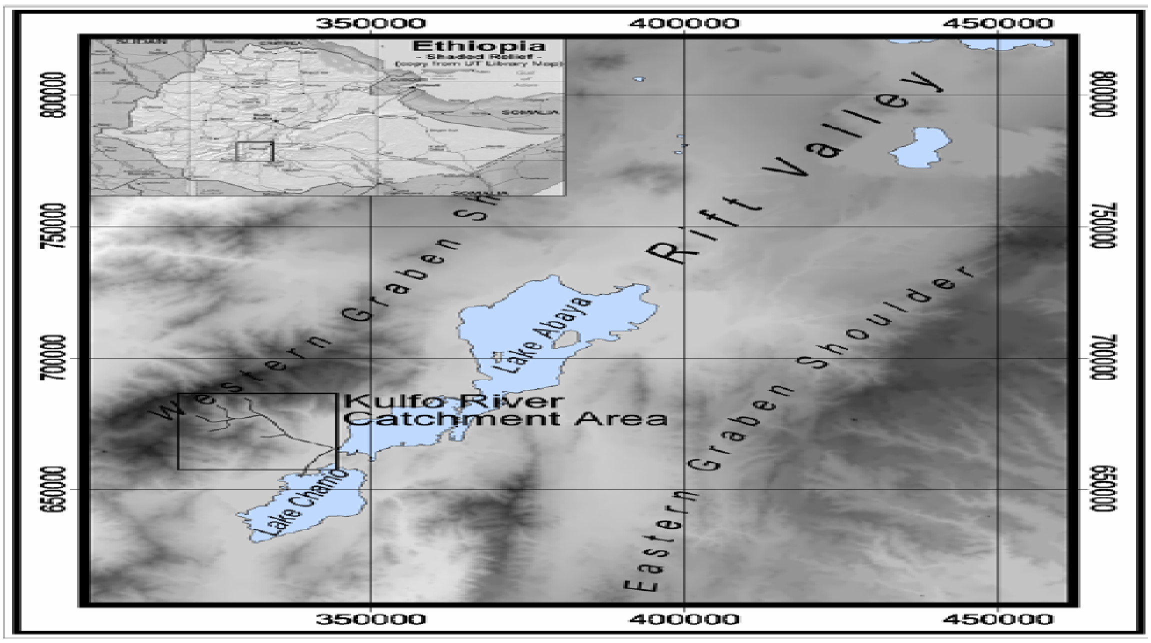

Figure 3: Topographical map of the Lake Abaya-Lake Chamo basin. (Source: Schütt *et al.,* 2005).

Earlier investigations on sediment management studies has proved a distinct differentiation between sediments incoming from 2 different tributaries discharging directly into the bottleneck of central Lake Abaya, one with a non anthropogenic influence and the other tributary with heavy human interaction. This clearly helped in identifying the results of sedimentation due to man made factors and climatic interactions. Furthermore, the characters of the lacustrine sediments indicate an existing interchange between the waterbodies of the northern and the southern Lake Abaya sub basins (Blumberg and Schütt, 2005).

Causes for sedimentation in Lake Abaya

There are two major reasons associated with sedimentation of lake Abaya. These are ;

- Due to Climatic and paleogenic changes
- Due to human interference

Climatic and paleogenic changes

High concentrations of quartz, silicates and iron-oxides point out that lake-floor deposits of lake Abaya bottleneck are predominantly allochthonous (Jones and Bowser, 1978). According to the high erodibility of soils in the catchment area Lake Abaya tributaries bring in high quantities of suspended load (Krause *et al.,* 2004, Schütt and Thiemann, 2004). Quartz and feldspar are primary formed in magmatic rocks. In the Lake Abaya drainage basin they occur area wide as well in the Tertiary volcanic rocks as in the underlying Palaeozoic sediments (Mohr, 1961). Correspondingly, both minerals were also recorded area-wide in the lake-floor sediments from Lake Abaya bottleneck. They have a high alteration resistance in the given limnic environment (Hakanson and Jansson, 1983). Distinct differences in the distribution Hematite is a mineral formed by pedogenic processes under tropical and subtropical environmental conditions (Schwertmann and Taylor, 1989). It occurs prevalently as a weathering cover, especially around clay-minerals (Berner, 1971). Thus, due to the ubiquity of clay minerals in the Lake Abaya bottleneck, spatial pattern of hematite is linked to the occurrence of clay minerals.

As for the drainage basin of Lake Abaya calcite deposits do not occur (Mohr, 1961), calcites detected in Lake Abaya's lacustrine sediments have to be of autochthonous origin (Flügel, 1978). Calcium derives from weathering of calcium-bearing feldspars (hydrolysis) while carbon is made available by decomposition of organics (Meyers and Ishiwatari, 1993). High water temperature as well as high pH values cause a decrease of the calcium carbonate's solubility product and afford its precipitation (Sonnenfeld, 1984). Thus, in shallow water areas like in the coves south of the Shope and Gelana River deltas calcite precipitation is improved by the local environmental conditions.

Due to human interference

In Lake Abaya typical topset beds are most recent deposits and correspond to soil-sediments and their mobilization and final deposition is due to soil erosion processes (cf. Schütt *et al.,* 2002, Schütt and Thiemann, 2004). In the Shope River drainage basin high accessibility causes a high population density – especially along the major traffic routes – and, thus, high land use intensity. Correspondingly, expected soil erodibility in the Shope River drainage basin is high and results in high deposition-rates of topset-beds. In contrast, accessibility of the Gelana River catchment area is poor as main roads are lacking. In consequence, population density and land use intensity are low, thus, also expected soil erodibility remains relatively low (Lal 1990) – resulting in relatively small input of suspended load into Lake Abaya. Accordingly, it can be confirmed that volume of topset beds is controlled by the input of suspended load and indicates intensity of soil erosion processes in the hinterland.

Sediment management practices in Lake Abaya

One of the major problem regarding the management of lake basin in developing countries is that, they do not have a strong sediment management system. In the case of Ethiopia, there is a practice of strict limitation of grazing and prohibition of tree felling in eroding areas, which appear to be meeting with some success.

The necessity of a more rational distribution of land use is also evident, but several factors hamper its realization. A physical constraint on changes in land management is the pressure to maintain, or better increase, total production levels, to support growing population and livelihood expectancies. A social and political constraint is the present land tenure regime, in which land belongs to the Kebelé; these institutions have proved a very effective framework for land management in their interior, but have caused a significant rigidity towards any shift involving more Kebelé. As the Kebelé are usually quite small, land reallocation on any larger scale is practically impossible.

Narmada River Basin sedimentation concepts

The South Asian region accommodates the population of 1.4 billion people, which is more than one fifth of the global population. The Ganga, Brahmaputra, Indus, Narmada, Krishna, Godavari, Padma, Irrawadi and Salween are the major rivers in the region. Most of these rivers are well known for high sediment concentration during the months of summer monsoon. In particular, the rivers originating from the Himalayas are known as some of the highest sediment laden rivers of the world. These large rivers along with other medium and small rivers of the region transport a significant amount of sediment in addition to other riverine materials towards oceans. The region contributes almost 15% to 20% of the global sediment flux towards the oceans (Milliman and Meade, 1983; Milliman and Syvitski, 1992; UNEP, 1995). The sediment received by the oceans at river mouths has created some of the largest deltas of the world (Coleman, 1969) such as the Ganga-Brahmaputra delta (50,000 km^2) and the delta formed by the Irrawadi River in Myanmar(30,000 km^2).

Narmada is one the major rivers draining towards Arabian Sea. The region consists of volcanic areas and ancient rocks with less than two percent recent deposit areas. Biksham and Subramanian (1988) and Chakrapani and Subramanian (1990) indicate that the geological formation within the region is the major controlling factor of sediment transport. Archaean rocks occur on either side of the Narmada river and include granites and gneisses and several outcrops of Bijawar rocks.

From Table 1 it is well understood that high soil erosion and tectonic factors have lead to heavy sedimentation in the Narmada river.

Sediment management in Narmada

Information on sediment in the region is far less than adequate and significant uncertainties lie in the proper understanding of its behavior. Educational and research do activities must be promoted in the field of soil erosion, soil conservation, sediment transport, and river morphology. Similarly, methods for monitoring sediment transport must be standardized for obtaining reliable and standard data for the assessment of sediment flux. Major sources of sediment data were the publications on reservoir sedimentation. However, there was inadequate information about the trapping efficiency of the reservoirs. Besides, the data on reservoir sedimentation not provide other essential information such as the hydrological and geographical data. Inclusion of such information would provide a lot of scope for the assessment of sediment transport characteristics.

Table 1: Various parameters measured at the Narmada Basin.

Various parameter measured at the Narmada Basin					
Physical parameters	**Specific run-off mm/km/yr**	**Rainfall (mm)**	**Length (km)**	**Molar Ratio**	
	531.5	1000	1312	0.71	
Chemical parameters	**Fe**	**Mn**	**Cu**	**Ni**	**Zn**
	7.6	1125	128	70	125
Denudation rates	Chemical Denudation rate	Total denudation rate			
	12.11	19.1			

Source: Comparative studies on trace metal geochemistry in Indian and Chinese rivers - R. Alagarsamy and J. Zhang, 2005.

Conclusions

This paper describes the various trends in sedimentation in lakes, reservoirs and rivers and also explains reasons for sedimentation. It is also understood that, climatic and human interactions have a big role in building up sediments in basins and catchments.

It would also be ideal to have strong policy measures to control sedimentation due to human factors. Another important feature we notice by comparing the regional studies (Danube, Lake Abaya and Narmada) is that, the developed nations have a more stricter rules and measures for monitoring and control of sediments, whereas, in developing countries, though sedimentations studies are carried out intensively, management practices are quite weak and do not answer critical problems.

The size of the watershed and basins also plays a decicive role in sediment management. We see from examples from the Danube river, the size of the network catchments is quite big and hence the sedimentation load into the river is also high though most of it get deposited into the artificial reservoirs in the catchment. In Narmada river, sediment deposits are carried from the tectonic regions in Himalayas and is brought down to the river thus causing heavy sedimentation down stream. Whereas, in the case of lake Abaya, the sedimentation is caused mainly by erosion from its tributaries.

Sedimentation is also a natural process and we can reduce the sedimentation rates into the rivers and reservoirs by managing its catchments in a sustainable manner. Policy initiatives taken to afforest catchments has always proved right in controlling erosion and thus managing sediments.

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Current status and challenges in managing the upper rural areas of world lake basins: preliminary implications from the GEF-project Lake Briefs

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Abstract

One of the foremost issues in the sustainable lake management agenda is to formulate guidelines that give rise to the realization of integrated lake basin management (ILBM). Within the context of ILBM, the importance of integrating activities in upper basin areas have been recognized but received relatively less attention compared to lakeshore and in-lake activities and concerns. In this study, we preliminarily examined current status and challenges related to the management of upper rural areas of 28 lakes that were of particular interest under the GEF-funded lake basin management initiative project with a global comparative perspective. Two major anthropogenic activities commonly listed as a potential lake environmental stressor in upper basin areas were: 1) deforestation associated with timber harvesting or land use conversion, and 2) agricultural practices including grazing. The stress-inducing processes highlighted through these two activities were the alteration of hydrological processes (i.e., reduction of groundwater recharge), excessive soil erosion, runoff of agrochemicals applied to cultivation fields. Furthermore, water abstraction was also identified as a cause of concern particularly in the African lake basins. Key areas suggested being in need of immediate actions related to the environmental threats in upper basin areas are: (1) technical advancements and improvements in water and soil conservation measures, management of agricultural chemicals, and forestry operations, and (2) establishment of socio-political systems in which cooperative and coordinated efforts for lake management can be effectively made with cross-boundary participations of various stakeholders within the basins. Importantly, the implication was ubiquitous that the lack of environmental monitoring of inflowing rivers and upstream land use information hinder the proper evaluations of upper basin activities, suggesting little documentation is likely due to unavailability of data rather than negligible influences.

Key words: sustainable management, environmental stressors, processes

Introduction

Lakes are by far the most important liquid freshwater storage accounting for approximately 90% of its quantity existing on earth. The fundamental values of lakes for humans are the provision of water supply and storage for drinking, household and industrial usages, provision of fishery resources, and also esthetic characteristics. Being as a public commodity, lakes play numbers of important roles in economic developments of local community, and are also deeply integrated into the foundation of community's cultural and social characteristics (e.g., ILEC, 1991; Krings and Platte, 2004). Thus, any deterioration of lake environments will have immediate and substantial influences on living environment of adjacently residing communities. Furthermore, these concerns are not limited to the areas whose environment is directly connected to the respective lakes, but also concerned to the rest of the world which indirectly depend on the world lake resources perhaps with a greater distance and more complex and subtle ways.

Despite well recognized importance of lakes at global scale, it is alarmingly suggested that lakes around the world particularly in the developing regions are facing various environmental issues, requiring an urgent attention and immediate actions (ILEC, 1997; Dudgeon, 2000; Everard and Harper, 2002; Odada *et al.,* 2003). The problems include, deterioration of water quality, reduction of water volume, increased toxicity of inhabiting organisms, losses of biodiversity, decline in fish catch, and potentially dwindling quality of livelihood of people whose dependence on lakes' economic values is direct and high (e.g., Claig, 1992; Cohen *et al.,* 1993; Flower *et al.*, 2001; Oyebande, 2001; Peters *et al.,* 2001; Becht and Harper, 2002; FAO, 2003). These problems largely arise from the cumulative impacts of human activities taking place within lake basins in excess of the lakes' capacity to buffer and negate the adverse effects.

Scientific methodologies for examining lake characteristics and, thus, our understandings of lake ecosystems have considerably advanced in the last couple of decades (Carpenter and Lathrop, 1999; Birks *et al.,* 2001; Odada *et al.,* 2002; Jørgensen *et al.,* 2005). Nevertheless, in many regions in the world, it has become apparent that development of water resource management approach in which political, legislative, and administrative systems are coordinated in an integrated manner is the necessity in realizing sustainable management in addition to firm scientific information as a prerequisite (e.g., Dudgeon 2000; Everard and Harper, 2002; Odada *et al.,* 2003; World Lake Vision Committee, 2003). One of the foremost issues in the lake management initiative agenda is, therefore, to formulate rather concrete guidelines that give rise to the realization of sustainable integrated lake basin management. Although the cumulative influences of anthropogenic activities in upper areas of lake basins have been perceived as one of the critical environmental concerns in the context of integrated lake basin management, there is an apparent lack in our understandings of this issue particularly with a global comparative perspective.

This study attempted to help making a step farther towards the holistic understandings of environmental stressors in global lakes particularly concerning the management of upper rural areas of lake basins (hereafter referred to as upper basin areas) based upon the secondary sources. We preliminarily examined current status and challenges related to the management of upper basin areas of 28 lakes that were of particular interest under the GEF-funded project – Towards a Lake Basin Management Initiative (GEF-LBMI) (see GEF-LBMI main report for more details). The objectives of the present study were: (1) to summarize major human activities and processes taking place in upper basin areas of world lakes from the viewpoint of lake environment stressors, (2) to elucidate the potential causal relationships between upper basin activities and processes and downstream consequences in lake environments, and (3) to draw management implications particularly related to the upper basin areas in terms of both technical remedies and social dimension of lake basin management approaches based on the past experiences and currently-faced challenges in world lakes.

Materials and methods

The project "Towards a Lake Basin Management Initiative (LBMI)" was launched in 2003 and completed in June 2005 with Global Environmental Facility (GEF) and the World Bank as major co-financing donors, International Lake Environment Committee as an executing body of the project, and substantial supports from various governmental agencies and NGOs (refer to the main report of the project for details about contributions). The primary objective of LBMI project was *to strengthen the capacity for improved lake and reservoir basin management at the local, basin, national, and global levels* (GEF-LBMI main report). The core resources of the project output was the experience and lessons learned briefs (*lake briefs*) compiled and contributed for a total of 28 lakes across the world mostly by the stakeholders of the respective water bodies. 28 lakes were carefully selected out of the countless lakes across the world to properly address the project recognizing limited numbers of lakes that can be handled. Specific selection criteria were (a) lakes with on-going, proposed, or completed GEF projects (i.e., 14 lakes), (b) lakes that reasonably achieve geographic representation with an intentional bias towards lakes in non-temperate developing areas where disproportionately less attention has been paid in the past, (c) lakes facing drastic and rapid environmental changes and nearly in the state of environmental catastrophe, (d) lakes with relatively large volume and surface areas playing important role as freshwater storages, and (e) lakes where emerging challenges and experiences in integrated lake management approaches are nicely exemplified and highlighted (e.g., transboundary lakes). The lake briefs were prepared with several key unifying themes: the briefs were intended to provide experiences and lessons learned through the past lake basin management in each lake by describing not only biophysical conditions of the lakes but also socio-economic conditions and management experiences at each lake basin (GEF-LBMI main report). Then, the lake briefs were thoroughly reviewed by project members as well as third party individuals to maintain consistency of the contents and outlines.

We have thoroughly gone through the lake briefs and extracted information particularly related to the following issues:

- Major human activities in the upper basin areas that are demonstrated or suggested as a lake environmental stressor
- Major processes of great concern identified as a threat to lake environments in relation with activities listed in 1
- Process-based linkages that are inferred to exist between lake environmental changes and human-induced environmental changes in upper basin areas

After constructing a data matrix containing all the extracted information for the respective lakes, data was numerically analyzed to provide general statistics related to the above-mentioned information 1 and 2. Information related to 3 was logically put together only when linkages between activities and/or processes in upper basin areas and consequences in lake environments were clearly stated in the lake briefs. Furthermore, particular management experiences and technical remedies considered useful in the environmentally sound management of upper basin areas were noted, synthesized, and used in the discussion section to provide the examples of actions in the context of integrated lake management vision. Preliminary examination of the briefs indicated that Tucurui reservoir (Brazil) brief was prepared focusing largely on the impacts of newly constructed reservoir on the surrounding environments rather than the influences of surrounding areas on the water body and residing community. Therefore, Tucurui reservoir was excluded from further analyses, thus, leaving a total of 27 lakes.

Results

Human activities

Major human activities identified in upper lake basins as a potential threat to lake environments are the followings: deforestation, agriculture, and water abstraction. Agricultural activities were referred to in all lake briefs and were often identified as a major economic activity within the lake basins examined in the project. Deforestation and water abstraction were the second and third commonly cited human activities; deforestation, agriculture, and water abstraction were identified as potential threat to lake environments in 74, 100, and 23% of the lakes examined, respectively (Figure 1). The causes of deforestation appeared variable among the lakes as well as locations within the basins, including commercial timber harvesting for lumber production, land clearance for subsequent cropland development, and subsistence harvesting of tress to obtain fuel woods and building materials. Agricultural target plants were also diverse in locations, including maize, bean, cotton, rice, coffee, and so forth; furthermore, raising livestock and land use for animal grazing were also occasionally described in some cases and were included as a part of agricultural activities. Water abstraction of rivers was often accompanied by the construction of dams and resultant regulation of river flows. Importantly, five out of seven lakes for which water abstraction was identified as a threatening activity for the lake environments were located in the African continent: Lake Nakuru, Lake Baringo, Lake Naivasha, Lake Malawi, and Lake Chad. Furthermore, deforestation and agriculture were identified as co-occurring two major activities in 13 basins of the lakes examined (Table 1). Furthermore, also all three activities were described causing stresses to lake environments in seven lakes; among them five lakes are the same African lakes listed earlier where water abstraction problems are common (Table 1).

Environmentally concerned processes in upper basin areas

Three processes were identified as a potential threat to lake environments: exposure and/or compaction of subsoil, usages of agrochemicals (fertilizers and/or pesticides), and water consumption. Exposure and/or compaction of subsoil, usages of agrochemicals, and water

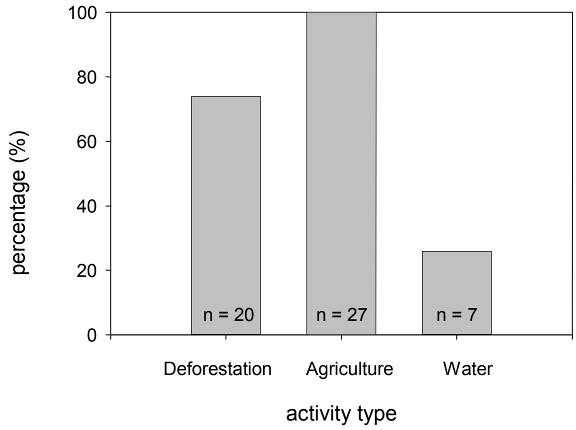

Figure 1: Major activities identified in upper basin areas as a potential threat to lake environment; it shows the percentage of 27 lakes for which respective activities were identified. *n* refers to the number of lakes counted for the respective activity type.

Table 1: Co-occurrence of activities in upper basin areas identified for 27 lakes; the processes are: 1 - deforestation, 2 - agriculture, and 3 - water abstraction.

identified human activities in upper basin areas	percentage (%)	number of lakes (n) †
1, 2, and 3	25.9	7 [1, 2, 3, 4, 6, 10, 11]
1 and 2	48.1	13 [7, 8, 9, 14, 15, 16, 17, 20, 21, 22, 23, 24, 27]
2 and 3	0	0
1 and 3	0	0
Only 1	0	0
Only 2	25.9	7 [5, 12,13, 18, 19, 25, 26]
Only 3	0	0

† Superscripted numbers denote the lakes for which respective sets of activities were identified particularly in upper basin areas: [1]Nakuru, [2] Baringo, [3] Naivasha, [4] Malawi, [5] Kariba, [6] Chad, [7] Victoria, [8] Tanganyika, [9] Xingkai,/Khanka, [10] Dianchi, [11] Toba, [12] Tonle Sap, [13] Bhoj wetland, [14] Chilika Lagoon, [15] Laguna de Bay, [16] Aral Sea, [17] Baikal, [18] Biwa, [19] Titicaca, [20] Cocibolca, [21] Ohrid, [22] Peipsi, [23] Issyk-kul, [24] Sevan, [25] Constance, [26] Champlain, [27] Great Lakes (Laurentian).

Consumption was identified as a potential threat to lake environments in 70, 85, and 30% of the lakes examined, respectively (Figure 2). Excessive exposure and/or compaction of subsoil poses a serious environmental concern as it promotes soil erosion in excess of natural rates by exposing subsoil directly to raindrop impacts and making ground surfaces more conducive to the occurrence of overland flow; this series of processes provide a source of sediment to the downstream areas. This process was attributed to deforestation in most cases but also to the combination of deforestation and agriculture in some case. Usage of agrochemicals have been identified most frequently as the environmentally most concerned process apparently reflecting the dominance of agriculture as a source of anthropogenic impacts in upper basin areas (see Figure 1). Water infiltrating to recharge groundwater or running off as overland flow during rainfall events likely pick up the residues of agrochemicals in soluble forms and reach to the downstream areas. Consumption of abstracted water is in general to meet water.

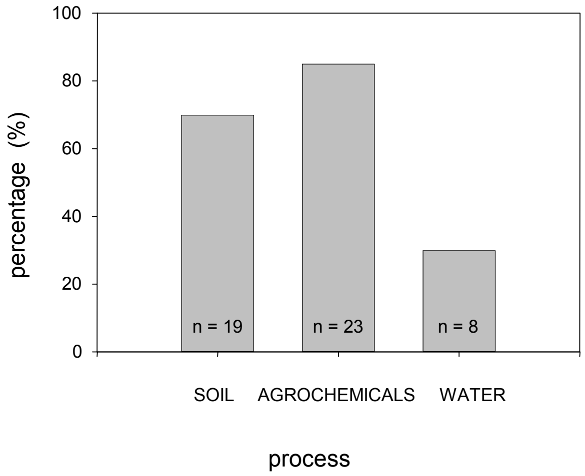

Figure 2: Processes in upper basin areas concerned as a threat to lake environments; It show the percentages of 27 lakes for which respective processes were identified. Process types are exposure and/or compaction of subsoil (SOIL), usages of fertilisers and/or pesticides (AGROCHEMICALS), and water consumption involving alteration of hydrological cycles (WATER). *n* refers to the number of lakes counted for the respective process types.

Table 2: Co-occurrence of processes in upper basin areas identified for 27 lakes; the processes are: 1 exposure and/or compaction of subsoil, 2 usages of fertilizer and/or pesticide, and 3 water consumption involving alteration of hydrological cycles.

identified stress processes in upper basin areas	percentage (%)	number of lakes (n) †
1, 2, and 3	18.5	5 [1, 2, 6, 15, 27]
1 and 2	33.3	9 [7, 8, 10, 13, 14, 17, 19, 20, 23]
2 and 3	3.7	1 [11]
1 and 3	3.7	1 [16]
Only 1	11.1	3 [4, 12, 24]
Only 2	25.9	7 [5, 9, 18, 21, 22, 25, 26]
Only 3	0	0
unclear	3.7	1 [3]

† Superscripted numbers denote the lakes for which respective sets of stress processes were identified particularly in relation with activities in upper basin areas; refer to the Table 1 for the lake identity.

Demands for the household and/or irrigation usages leaves less water available to downstream areas and changes hydrological regime of river flows through damming and flow regulation. In approximately 30% of the cases examined (nine lakes), combinations of soil exposure and usage of agrochemicals are identified as processes of environmental concern (Table 2). Overall, more than 60% of the cases reported the multiple processes as a threat to the lake environments.

Cumulative effects of human activities and relevant processes in upper basin areas

Impacts of human activities in the upper basin areas been largely related to the following adverse consequences in lake environments: water quality deterioration, decline of littoral zones and upstream habitat connectivity, changes in lake bed conditions, and changes in trophic structures of lake food-web (Table 3). All of such changes in lake environments are likely to negatively affect lake's values such as fishery resources, biodiversity, available water quality and quantity.

Table 3: Processes in upper basin areas related to their downstream effects and their consequences on lake environments identified from 27 lake briefs.

Causing processes in upper basin areas	Primary downstream effects	Consequences on lake environment †
Exposure and/or compaction of subsoil	• Excessive surface erosion rate in crop fields and cleared land, and sedimentation along river channels and within lake water • Reduction of groundwater recharge and alteration of river flow regime	• Habitat destruction through sediment deposition over lake bed [1, 2, 6, 7, 8, 10, 12, 13, 14, 15, 16, 17, 19, 20, 23, 24] • Changes in food-web structure through increased water turbidity that reduce light penetration and may decrease in phytoplanctonic activity [2] • Possible lake trophic environmental changes due to excessive input of nutrients and organic matter associated with eroded materials [7, 8, 10, 17 ,19] • Intensified seasonality in water availability and often scarcity [1, 2, 11, 15]
Usages of agrochemicals	• Excessive inputs of nutrients and toxic substances to lake via stream runoff and groundwater	• Increases in nutrient level and eutrophication of lakes that may deteriorate water quality and change trophic structure of lake [2, 4, 5, 7, 9, 10, 11, 14, 15, 17, 18, 20, 21, 22, 25, 26, 27] • increases in toxic substance level in water as well as lake bed possibly leading to bioaccumulation in lake organisms [1, 5, 9, 11, 18, 20, 21, 25, 27]
Water consumption involving flow regulation	• Reduction of river flow, groundwater, and lake water • Hydrological seasonality deviated from natural patterns	• Reduction of water volume and level that may result in habitat loss within lake in particular productive littoral areas [1, 2, 4, 6, 9] • Blockage of reproducing cycles by shrinking and reducing access to upstream spawning areas [1, 2, 18,] • Water scarcity [6, 10, 16]

† Superscripted numbers denote the lakes for which respective consequences were reported particularly in relation with upstream activities; refer to the Table 1 for the lake identity.

Discussion

The findings of this study suggest that excessive inputs of sediment and agrochemicals caused by deforestation and agriculture to downstream lakes are the most commonly recognized concerns in the upper rural areas of lake basins examined for the GEF-funded Towards a Lake Basin Management Initiative project. Furthermore, a relatively less commonly cited environmentally stressful activity - water consumption - appeared pronouncedly threatening in lakes of the African continent where rainfall input is inherently limited, seasonal, and adversely affected by recent climate patterns. However, it has to be reminded that these results were extracted from the already-condensed briefs that were prepared for the respective lakes with a particular emphasis on socio-economic and management issues. Therefore, interpretations of the findings have to be carefully made because the absence of references to upper basin activities in certain lakes does not necessarily indicate the absence of threats related to upper basin areas.

Importantly, sediment and agrochemical inputs from upper basin areas are the pollution of water body originating from distributed or non-point sources, meaning that sources of pollution are spatially widespread in surface and/or subsurface (in the case of agrochemicals) pathways and relatively invisible compared to point sources such as effluent spewing from industrial factories and sewage plants (e.g., Omernik *et al.,* 1981; Jordan *et al.,* 1997). Technical approaches to reduce the adverse effects of non-point pollution can be largely classified into the following two: direct controls of the pollution source activities, and preservation and amelioration of capacity of land-water ecotones in buffering pollutant loads (see Chapter 4 in Jørgensen *et al.,* 2005). Examples of direct controls include the encouragement of good practices in terms of agrochemical applications (e.g., types and concentration), and preparation and management of croplands (e.g., types and rotation of crops, manure management, and methods and areas for cultivation) in the agricultural sector. In deforestation activities, better practices in road and trail designs and layouts (e.g., gradient and drainages), harvesting intensity and frequency, and identification and preservation of critical areas from the perspective of sediment and water management (e.g., riparian zones and steep hillslopes) can be recommended. The importance of consideration of such good practices is emphasized in many of the lake basins examined (Nakuru, Baringo, Malawi, Chilika Lagoon, Cocibolca, Peipsi, Issyk-kul) although one will have to look into other literatures to examine to what extent and where such measures are being undertaken, and how successful they are in their respective environmental settings. Furthermore, efforts to revegetate the degraded land surface through reforestation have been also reported in some areas (e.g., Lake Toba and Bhoj wetland).

The most feasible, effective, indirect means to prevent and reduce non-point source pollution is perhaps to maintain vegetative strips along water bodies; excessive nutrients and eroded soil can be trapped without reaching to water bodies (e.g., Peterjohn and Correll,1984; Haycock *et al.,* 1997). Practices of riparian buffer strip conservation were reported in few of the project lakes. In Lake Naivasha (Kenya), for example, a guideline set aside by Lake Naivasha Riparian Association (LNRA) advocates the preservation of buffer zone of 100 m from the lake shore (cited in Everard and Harper, 2002). In Bhoj weltlant (India), also, reconstructions of wetlands are being promoted to increase buffering capacity of the basin to land activities. In Lake Victoria, on the other hand, loss of the vegetated buffering zones between croplands and surface water are pointed out as one of processes by which nutrient loadings to water body substantially increased. Thus, it appears that the recognition of vegetative buffer strips as an effective and economical management tool for non-point pollution controls has become common although the indications of its actual practices, particularly in upper basin areas, remains scarce. Non-point source pollution has long been recognized as one of the greatest concerns in lake environments of the developed regions, and measures including vegetative buffer zones along water bodies are being well incorporated into management guidelines and practiced (e.g., Warback *et al.,* 1990; USPC, 2002; Lake Champlain Steering Committee, 2003). Moreover, several recent studies conducted in agriculture-dominated mountain areas of Southesast Asia demonstrated the effectiveness of riparian vegetative strips as sediment traps (e.g., Afandi *et al.,* 2002; Ziegler *et al.,* in press). Therefore, transferring the techniques and knowledge already established in other regions and modifying them suitable to the biogeoclimatic, socio-economic conditions unique to the respective lake basin environments likely provide one of the promising approaches to tackle the non-point pollution sources in upper basin areas.

Another pressing concern related to the management of upper basin areas particularly for the African lakes is the reduction of water quantity to the lakes due to water abstraction for household and irrigation purposes. This issue is particularly serious as water scarcity to downstream areas not only lead to the reduction of water supply for household and industrial usages in downstream communities including those along the lakeshore, but also a host of environmental problems such as reduction of habitat important for rearing and spawning, which may result in fish resource decline and loss of ecosystem functions though biodiversity loss (see Table 3). Important management implications were drawn from the cases of Lake Chad and Aral Sea in dealing with water scarcity problems. The Lake Chad case pointed that the extremely low efficiency in irrigation water usage (i.e., 11%) provides rooms of improvement in irrigation planning and systems and, thus, increasing water available to downstream areas. Furthermore, it is also suggested that well planned allocations of water among the stakeholders within the Lake Chad Basin is a key to maximize the efficiency of water consumption and minimize the disruptions of hydrological cycles. These two approaches are also suggested in Aral Sea as realistic measures to ease water scarcity problems; but the Aral Sea case probably stands as an extreme example where the importance of transboundary coordination of reservoir operations and water usages is highlighted in the face of rapidly shrinking water body. These issues related to water allocation exemplify the challenges of lake basin management where technical improvements and advancements may be of limited value because what is equally needed is an integrated lake basin management system that allows efficient and thorough cooperation and coordination of efforts among various stakeholders in wise usages of limited water resources. Even in the lake basin without international borders, the similar point was highlighted in Lake Baringo. In this case, despite that the upper areas of lake basin is the main supply of water that stably recharges the lake system, the controls of human activities in upper basin areas and potential downstream threats are extremely difficult because administrative body of upper basin areas is not associated with that in charge of lake and its shore.

The common situations of upper basin areas where various human-induced processes deriving from both agriculture and forestry activities are often concerned as a potential threat to lake environments also should receive some attentions from the viewpoint of integrated lake basin management. The reason is that agriculture and forestry industries likely to be under supervision and controls of different government agencies or different sectors within government agencies who are in charge of natural resource management and, thus, may lack the system that allows efficient exchanges of information related to land development planning and monitoring of various environmental impacts to the downstream systems. This further underscores the importance of cooperative and coordinated efforts in managing lake basins at all levels within and among the stakeholders including government agencies, private sectors, NGOs and local communities. In-depth reviews and summary of experiences and lessons learned, and recommendations related to such efforts toward integrated lake basin management are provided in the main report of the project (GEF-LBMI main report). Although the present study was based on secondary, rather qualitative sources, we preliminarily conclude that sustainable lake basin management related to the activities and processes in upper basin areas should focus on, technical improvements in water and soil conservation practices in agricultural and forestry activities, promoting maintenance of riparian vegetative strips, and adjustments of administrating bodies in charge of water resources, agriculture, and forestry sectors in such a way that lake basin management can be done in an integrated manner with sufficient information exchange, cooperation, and stakeholder involvements. Importantly, there are frequent indications that sufficient scientific data is not available to conclusively relate lake degradations to the upper basin activities, alarmingly calling for monitoring and dissemination of scientific data on in-lake environments as well as land use activities in upper basin areas.

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Towards sustainable development of the environmentally degraded Lake Chad basin, central Africa

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Abstract

Global climatic change and changes in development over the 40 years have led to significant environmental and hydrological changes in the Lake Chad basin. Flows in its major tributaries (Komadougu Yobé, El beid, Logone, Chari) have dropped significantly due to changes in rainfall and temperature. Hydrological changes have resulted in (1) reduction of the lake surface area from 25 000 km² (before 1964) to 2500 km² (in 1976), (2) degradation of biodiversity and aquatic habitats (fish production is 100,000 to 200,000 Tons/annum), (3) Many people lost their traditional livelihood. The analyses of water balance show that the volume of water stored in the basin has decreased from 40 - 100 x 109 m^3 (before 1964) to 7 - 45 x 109 m^3 (in 1990). The reasons for this variability were the rainfall characteristics that control the runoff from the watershed and bad management practices (irrigated agriculture in different countries surrounding the lake Chad). Solving these problems requires massive and long-lasting concerted efforts. At the LCBC (Lake Chad Basin Commission), the discussion about an Inter-Basin Water Transfer (IBWT) from the River Congo to Lake Chad emerges again and again. The UNESCO Virtual laboratory project aims to conserve the remaining natural areas and to achieve the sustainable use of the resource, above all of water.

Key words: Lake Chad, sustainable development, IBWT, virtual laboratory

Introduction

The recent persistent drought in the Sahel, as well the continuing concern over the effects of global warming, have drawn attention to the fragility of the natural environments of semi-arid regions and especially to the availability and sustainability of water resources (Edmunds *et al*., 1999). In the last four decades, the hydrological regime of Lake Chad (Figure 1) has changed. The changes apparently reduced the water supply security for the population and economy (fishery and food production) in the Chad basin.

In view of the increasing water shortage in the Lake Chad basin which could ultimately lead to complete disappearance of the Lake and other wetlands in the basin, national and foreign organisations developed numerous water resources managements projects, with the highest priority given to the restoration of water level of Lake Chad. In order to filter out the relative importance of the factors which are specific to this problem, the general purpose of this work is the creation of a reliable data base for efficient decision support water management and ecological protection of the Chad basin.

Figure 1: A view of the Lake Chad (June 2003 by Ngounou Ngatcha).

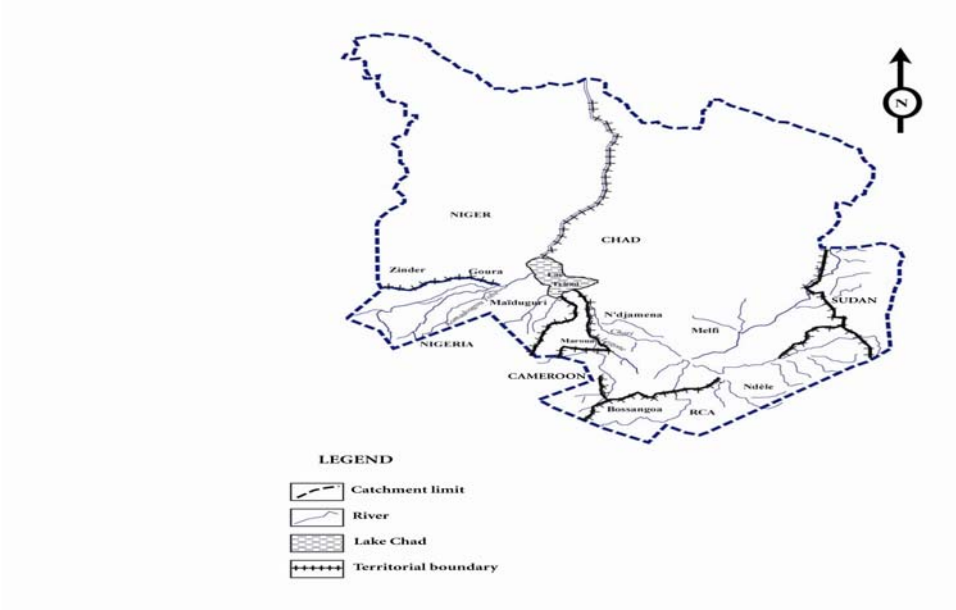

Figure 2: Lake Chad hydrological basin

Setting of the Lake Chad and its hydrological characteristics

The hydrological basin of Lake Chad (Figure 2) situated in the heart of sahara-sahel-sudanian Africa covers a surface area of 2,381,635 km². The lowest point of the lake is Bodele depression, about 320 km north-east of Lake Chad and approximately 100 m lower than the lake level (Olvry *et al*., 1996). Lake Chad is connected with the Bodele depression by an ephemeral stream, Bahr al Ghazal, which carries overflow to the depression during high lake levels. The hydrological basin of Lake Chad is shared between Algeria, Cameroon, Central African Republic, Chad, Niger, Nigeria, Sudan and to some extent Libya. Lake Chad and its active basin constitute an important water resource shared between Cameroon, Central African Republic, Chad, Niger and Nigeria. Lake Chad is, by surface area, one of the largest inland basins in the world, and fourth largest in Africa after Lakes Victoria, Tanganyika and Nyassa. The Lake is fed by two major tributaries namely the Chari and Logone Rivers which originate from Central African Republic and Cameroon to the south west of the lake, respectively. These rivers jointly contribute over 90% of the total water in the lake. They were thought to have an average of 40 billion cubic meters per year between 1930 and 1960 but this has now been reduced by about 50%. Other minor contributors include the El-Beid (from Cameroon), the Komadugu-Yobe and Yedseram systems (from Nigeria). They flow only during the rainy season. About 90% of the rains fall between June and September but the lake suddenly rises in November. Highest lake levels are in December, tapering off slowly for several months.

The soils in the Logne-Chari basin are predominantly heavy clays with a high shrink-swell potential, so that water runs off as rapid sheet wash rather than slow percolation.

Environmental consequences associated with climate change

Lake levels

Lake levels are important for regional hydrological investigations (Masson *et al*., 1994). Lake Chad is very shallow with an average depth of 11 meters and maximum water level of about 283 meters above sea level. The Lake Chad area is particularly sensitive to small changes in its average depth and therefore shows a trend of seasonal fluctuations in size. During the recent drought, Lake Chad receded to below 10% of its maximum modern area, corresponding to below 2% of its volume and water level at 277 above mean sea level (amsl) as compared with 283 m at its modern maximum (Durand, 1995). During the last millennium lake level maxima are considered to have reached 286 m (Servant and Servant-Vildary, 1980). In the early Holocene the levels of Lake Chad were probably significantly higher and with greater variation in extent than today. There is general agreement that this maximum extent was around 9 ka BP in the mid-Holocene (Edmunds *et al*., 1999). A maximum of *c.* 320 m has been proposed (Olivry *et al*., 1996) although this is challenged by Durand (1995) on the basis of neotectonic analysis and suggesting a maximum of *c.* 290 m, around 10 higher than its modern level.

The decline in the lake level is attributed to reduced rainfall (as result of the recent climatic change), and droughts [according to Nicholson (1980 in Goni, 2002)]. From the historical record there are records of droughts from 1680-90, 1730-60 and 1820-40 in addition to the recent drought during the 1970s and 1980s], as well as abstractions from influent rivers, excessive evaporation (2000 to 3000 mm/year), and greatly increased amounts of irrigation water being drawn from the lake.

Riverflow

River flow varies with the volume of water, precipitation, surface, temperature and other climatic factors. Land use in the drainage basins also strongly affects river flow. River flow directly reflects climatic variation. River systems play a key role in the regulation and maintenance of biodiversity. Changes in river flow are indicators of change in basin dynamics and land use.

In the 1960's, the Lake Chad had an area of over 25,000 sq km and by the year 2000 the total area had reduced to less than 1500 sq km. This translates to a recession rate of about 500 sq km per annum. The Lake is very responsive to fluctuations in rainfall. In years with no or little rainfall as characterized by 1972, the lake can drop rapidly because about 20-85% of the lake's volume is contributed by annual inflow (Olivry *et al*., 1996). It should be noted that the water balance of the Lake Chad is still negative; the losses (evaporation) exceed the gains (inflow of surface and groundwater, as well as precipitation). As a result, the water level of Lake Chad continues to drop rapidly. The drop of the Lake Chad level aggravated the water supply situation in the region.

Others impacts

The resultant disastrous consequences on the environment of the basin have negatively destabilized the ecosystem in the sub-region. After the drought in 1970s, there was a shift by the herders from grazing animals (cattle and camels) to browsing animals (sheep and goats), which affected the area's vegetation by consuming the woody plants. Poor water quality is also affecting the health of the population around the lake (Figure 3).

The actual man-made ecological disaster of the Lake Chad basin has impacted the active basin. The main cause has been the exploitation of natural resources, especially water, above the ecologically permissible level. This has disturbed the natural equilibrium and caused lasting damage to all the ecosystems. At present, violent sandstorms regularly rip through the basin, carrying away an estimated 50,000 tons of sand each year. Fishing and navigation have completely decreased and agricultural yields have plummeted.

Figure 3: Lack of adequate water service for a large part of the population around the Lake (June 2003 by Ngounou Ngatcha).

Condition and forecasts aimed for restoring the hydrological system of the Lake Chad basin

Inter-basin Water Transfer (IBWT) project

In 1964, four riparian countries of Lake Chad (Cameroon, Chad, Niger and Nigeria) created the Lake Chad Basin Commission (LCBC) in order implement sustainable and integrated water resources management for equitable exploitation of its active basin (Conventional Basin, 427 300 km²) and to promote regional cooperation and integration and regional security. The Central African Republic became the fifth member State in 1997 and the Conventional Basin extended to include pools upstream of Chari-Logone and Komadugu-Yobe sub-basins to form a new Conventional Basin which now covers a surface area of 967 000 km².

In 1985, the Heads of State of LCBC member countries expressed their serious concern about the drying up of Lake Chad. Convinced that the degradation of natural resources in the basin is not irreversible and that the mobilisation of human and financial resources can remove all obstacles to sustainable developments in the basin, the issue of the Inter-basin Water Transfer (IBWT) was discussed extensively at the tenth Summit held in N'Djamena in July 2000. However, implementation of such a proposal with high-cost technical solutions is a major challenge to the riparian countries which have poor economies. Without it, the opportunity to fully develop the economic potential of tourism and to solve the chronic regional water crises in the Chad basin will be lost. The proposed Inter-Basin Water Transfer may be viable and hence the need for a detail study of the project. For a start, the key parameters on which data will be collected for this project include:

- A literature search on inter-basin water transfer in the world such as the best technology/method of transfer to be used;
- Information on the physical characteristics of the River Congo such as its size/extent, topography, hydrology regime and geology;
- An environmental impact assessment to determine the possible impact of the project on the population and the environment;
- Evaluation of possible conflict (political, socio-cultural and economic).

During the inauguration of the Regional Parliamentary Committee of Lake Chad Basin (RPCLCB) in Abuja in March 2004, President Olusegun Obasanjo declared Nigeria's intention to pay the balance of 5.00 million USD needed to implement the feasibility studies of the IBWT Project from Oubangui River in Congo Basin into Lake Chad.

UNESCO virtual laboratory project

In light of the major ecological problems confronting the region and beyond, UNESCO proposed in 2002 (2-5 November) during a workshop held at Amman in Jordan, a project on Virtual Laboratories for drying lakes in Africa, the Middle East and Central Asia. The conditions of three lakes (Lake Chad, Dead Sea and Aral Sea) and ongoing and planned research were presented and discussed by the researchers and authorities represented from the respective regions. The drying-out of the large inland Chad, Aral and Dead Seas is deemed as a global environmental catastrophe. To solve the issue, scientists worldwide shall join efforts to enable the information exchange. The virtual laboratory is a new manner of working. It provides and experimental setting to scientists and engineers by making optimal use modern information-technology. It enables a group of researchers located around the world to work together on a common set of projects for the Sustainable Development and Environmentally Sound Management of the Resources of the Lake Chad, Dead Sea and Aral Sea. The components of a virtual laboratory include: computer servers capable of handling very large-scale simulations and data reductions; scientific instruments connected to the network (for example, satellite data, ground motion and air quality sensors), and collaboration tools, sometimes including tele-conferencing.

In June 2003 at N'djamena in Chad, African scientists from the countries sharing the basin, in cooperation with LCBC, held an international seminar funded by UNESCO following which the participants agreed to establish the Consortium in the context of the UNESCO project. The following steps were proposed: the establishment of two UNESCO focal points at the University of Ngaoundere (Cameroon) and the University of Maiduguri (Nigeria); equipment and connectivity for the two focal points with computers for data collection, network exchange and the attraction of African Scientifics into the project. Until today, UNESCO funds efforts to study the water balance of Lake Chad.

Environmental benefits of IBWT and virtual laboratory projects

The Lake Chad represents a significant cooperative step among Cameroon, Chad, Niger and Nigeria. The IBWT and Virtual Laboratories projects needs to be accomplished soon to maximize their benefits to the region and to the word at large. Seeking donor support for the inter-basin water transfer and virtual laboratory projects would help to promote the much needed regional cooperation and economic integration as well as social security. The primary purpose of the IBWT project is to save the Lake Chad and its active basin from environmental disaster and allow the economic benefits of a restored Lake Chad to flourish. LCBC proposed that by reconstructing the water supply systems, the water surface of the lakes should be restored with a total surface area of 15 000 km², i.e. 12,000 km² over it present extension. It is expected by the planned reconstruction of the Lake level that fish production (Figure 4) would increase up to 200,000 tons per year, 500,000 ha of hay-production fields could be irrigated, as well as 100,000 ha of pastures. The rich ecosystem surrounding the lake Chad could be brought back into balance. Raising of the lake Chad level will represent significant preservation of the precious fresh water resource of the region and open up countries in the region through navigation (Figure 5), electrical power generation and distribution. All this would considerably raise the employment level and living standards of thirty million people who depend on the activities carried out on the Lake and its active basin. It could also increase tourism revenues.

Virtual laboratories project will also help the creation of a reliable database for efficient decision support to water management in the Lake Chad basin.

Figure 4: Fish production along the Lake Chad (June 2003 by Ngounou Ngatcha).

Fig. 5: Exchange between the riparian through navigation (June 2003 by Ngounou Ngatcha).

Conclusions

The most precious commodity in the Lake Chad basin is fresh water. Because of its scarcity, water is a key to development and survival. Water is also a source of conflict in the region. A solution to save the Lake Chad exists. At present, the IBWT represents the only viable measure to mitigate all the negative environmental impacts of the declination of the Lake Chad. The IBWT project is a true opportunity to take a step towards peace in the region and peace in the world. The project would gradually promote an increase in the lake level back to historic levels.

While the above-mentioned projects would provide a strategic solution towards the preservation of Lake Chad, their implementation would require large amounts of funds. Under the present economic conditions of the countries surrounding the Lake Chad, such an undertaking seems to be questionable in the foreseeable future. Therefore, it seems to be more realistic to make efforts for better efficiency of the existing water, involving the co-operation of local researchers and non-governmental organisations.

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The ecosystem state of Yilong Lake Basin and its sustainable development management in the Longitudinal Range-Gorge Region (LRGR) of Southwest China

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Abstract

As a famous plateau lake in the LRGR of Southwest China, Yilong Lake Basin has attracted more and more researchers in China and in the world to pay attention to its ecosystem. The aquatic ecosystem of the lake and its catchment ecosystem characters are analyzed in this paper. The preliminary conclusion are as follows: 1) the inflow was less than outflow because the water supply river changed from Zhujiang River to Honghe River, and the extremely unbalanced rainfall allocation and non-ecological water use increased; 2) water quality degradation and eutrophication caused by the nutrient-rich wastewater increasingly discharged into the lake, arising from rapidly increasing agricultural non-point pollution and the tourist population, and oversupplied fishing feeds; 3) the decrease of indigenous fish and the increase of exotic commercial fish resulted from overwhelming fish culture, over-fishing in the lake, decreased lake surface area/catchment area ratio and reduced lake water depth 4) declining ratio of the catchment vegetation area to the catchment, and increased soil erosion as a result of serious catchment vegetation damage during the last few decades. Several sustainable development management options were proposed as follows: recovering and protecting the catchment ecosystem structure and function, and establishing an effective catchment management system; comprehensive lake water treatment approaches including remedying the water body in situ, strengthening the wastewater treatment and discharge supervision and modifying the structure and method of fish breeding; assuring optimal ecological water use by enforcing laws and regulations; reasonable water resource and catchment land utilization and development.

Key words: Yilong Lake; Ecosystem state; Sustainable development management; Aquatic; Catchment

Introduction

Lakes are vital for the life and health of people and ecosystem in the plateau (high-altitude) region especially in the Longitudinal Range-Gorge Region (LRGR) of Southwest China where rivers flow from North to South including the basins of four major international rivers, which are the Yuanjiang (Red) River, Lancang (Mekong) River, Nujiang (Salween) River and Irrawaddy River. Yilong Lake basin, with a total catchment area of 360.4 km^2 is located in Yunnan Province dominated by the LRGR of Southwest China (Figure 1). As one of the nine largest plateau lakes in the LRGR including Dianchi Lake, Erhai Lake, Fuxian Lake, Chenghai Lake, Lugu Lake, Qili Lake, Xiyu Lake, Yangzong Lake and Yilong Lake, it was well known for its scenic beauty and richness of aquatic life. Yilong Lake lies in the watershed of Honghe River and Nanpan River, a branch of Zhujiang River, between 23º28' and 23º42' N and 102º28′ to 102º38' E. A branch of Nanpan River named Lujiang River originates from the lake. There are three main rivers including Cheng River, Chengnan River and Chengbei River flowing into Yilong Lake, and most of them are seasonal streams except Cheng River. There are five towns, Baoxiu, Yilong, Maohe, Baxin and Taocun and more than 130,000 people live in this region.

There has been a remarkable population growth in recent years in Yilong Lake Basin, accompanied by intensive urbanization and an increase of industrial activities as well as higher exploitation of cultivable land and the lake water body. These transformations have brought about an increase in water demand, and there is a large quantity of discharges and wide diversity of pollutants discharged into the lake. These pollutants and ecological damage have undesirable effects on the Yilong Lake ecosystem. There were no reviews in the international journals on the state of Yilong ecosystem, although several related papers have been reported in Chinese (Chou, 1997; Zhang, 2003; Jing and Zeng, 2003).

Analysis and prediction of lake ecosystems is necessary because the pollution of reservoirs and water streams will result in the degradation of the ecosystems (Silow, 1999; Haberman and Laugaste, 2003). Up to now, several lake ecosystem state assessment methods have been proposed and used (Vollenweider, 1975; Krivtsov *et al*., 1999; Xu *et al.*, 2001a, 2001b; Pei and Ma, 2002; Pei and Wang, 2003). Most of them were studied to make clear the state of various lakes in low altitude regions (Machiwa, 2003; Mwanuzia, 2003). However, many studies have been established only considering several water quality parameters or aquatic organisms as one unit and they cannot, therefore, reveal the real state of lake ecosystem.

On the basis of the aquatic ecosystem and its catchment ecosystem character, the pertinent sustainable development management of the lake ecosystem state is analyzed and proposed in this paper. Its conclusion is important to improve Yilong lake ecosystem health in the future.

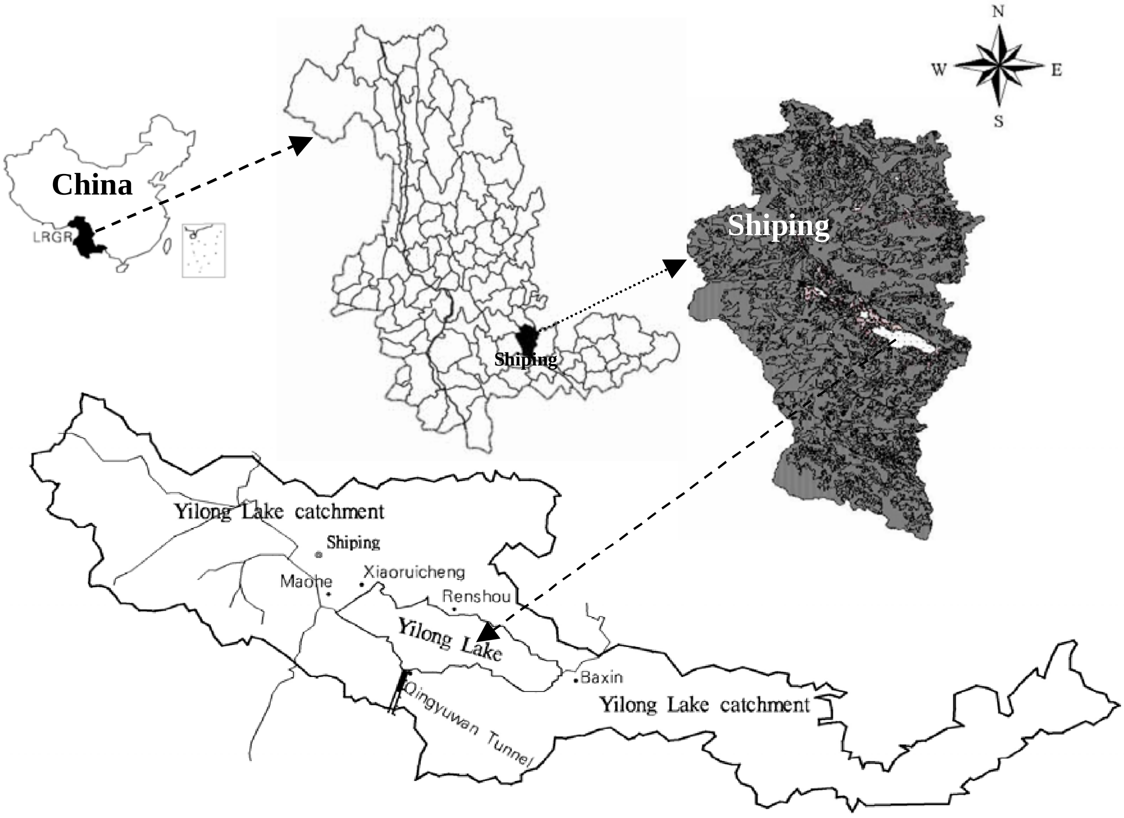

Figure 1: Location of the Yilong Lake and the study sites.

Data Description

The data reviewed here largely consists of water quality monitoring data and statistical reports by the Shiping County Government technical staff and its websites including Environmental Protecting Bureau (EPU), Forestry Bureau (FU), Tourism Bureau (TU), Yilong Lake Management Bureau (YLMB) and so on.

Yilong Lake Ecosystem State

Some Attributes of Yilong Lake

The water surface area in Yilong Lake has greatly decreased from 52.6 km^2 to 31 km^2 since 1952 due to the reclamation of land and extensive planting of crops. It had a length of 13.8 km, width of 3 km, shoreline of 86 km, and an average depth of 3.5 m (maximum 7.0 m) several decades ago. Yilong Lake substrate sludge deposits are severe, amounting to 9 x 10^{7}m^3, of which the western part of the lake is particularly seriously affected so that part of the lake bed is above the water surface and 133 ha swampland has come into being. The average thickness is 3.4 m (minimum 0.8 m, maximum 5.9 m).

Yilong Lake kept its nature before 1952 when water altitude was 1416.2 m, water capacity was 2.28 x 10^{8}m^3 and water surface area was 52.6 km^2. Then, water level and water capacity declined continuously. They lowered to 1412.78 m (asl) and 0.72 x 10^{8}m^3 in 1960, respectively. The annual average outflow water was 3648 x 10^{4}m^3 in 1971-1978 due to dredging of Qingyuwan Tunnel. Since then, the water flows into Hong River system. Moreover, continuous dry climate in 1979-1980 resulted in drying up of Yilong Lake for 20 days (April 28, 1981). Water level wasn't up to 1413.96 m until 1985 and was kept 1413 m to this day (Figure 2).

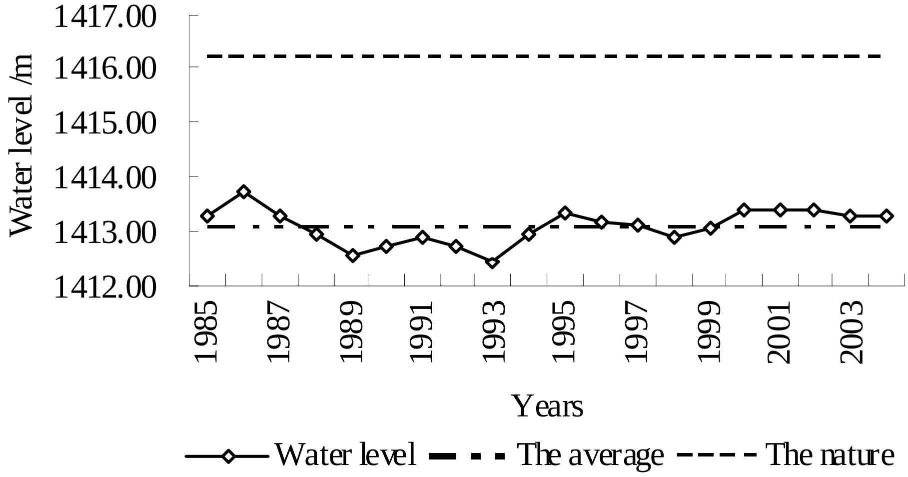

Figure 2: The monthly water altitude from 1985 to 2004.

Catchment ecosystem state

The average natural runoff volume in the whole catchment is 65.53 x 10^6 m^3, of which 26.03×10^6 m^3 was subtracted for the lake surface evaporation. The per capita consumption of water is less than 200 m^3, and the irrigated field per ha is less than 7,605 m^3. Thus, it can be seen that there is a shortage of water resources in this region. The runoff is strongly affected by its climate, rainfall, and seasonal weather patterns. The region has a generally subtropical climate characterized by a long, hot, and humid wet season (April-November) and a relatively mild dry season (December-March). The wet season is characterized by high humidity, intense solar radiation, and unstable atmospheric conditions. In contrast, the dry season is characterized by mild, dry weather. The lake surface water evapotranspiration losses are high in the whole year (from 1959 to 2000) averaging 1185.3 mm yr^{-1}. Moreover, the percentage of wet season and dry season is fifty-fifty in one year. The highest losses are from March to April, accounting for 35.7% of the whole year, and the lowest losses are from November to January accounting for only 17.5%.

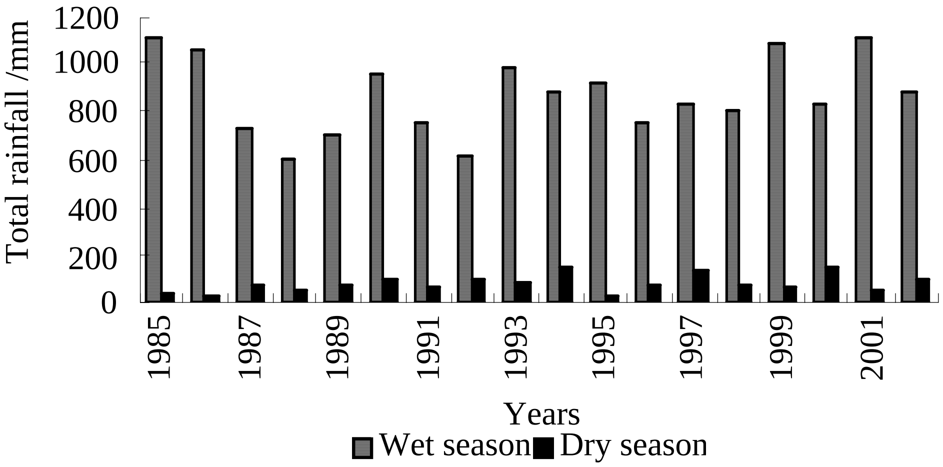

Figure 3: The rainfalls in wet season and dry season from 1985 to 2002.

Figure 3 shows rainfalls in the wet season and dry season from 1985 to 2002. The rainfall in dry season was only 5% or 10% of that in the wet season resulting in extremely unbalanced rainfall allocation. Most rivers flow between mid-April to November-December and then run dry. There are practically no inflows into lake during the dry season, especially in Match and April.

There exists 20,880 ha forestry area in the catchment in 2004, and its percentage of coverage is 17.58%, which is nearly 7% lower than that of Yunan Province. Forest area per capita is 0.14 ha, which is only 1/2 of the forest area per capita of the whole province. The commutative volume of forest trees is 673,630 m^3 and per capita cumulative volume is 463 m^3, which is 1/6 lower than the per capita in the whole province, and volume of forest tree consumption is almost 4 times as much as the volume of forest tree growth. Native vegetation is destroyed to a great extent and has resulted in single tree species and an unstable configuration. Especially, the area of large forest coverage and forest with water resources conservation activities around the lake is very low. The major tree species are *Eucalyptus globulus* and *Pinus yunnanensis franch* whose function of conserving water and soil is not good. Soil erosion area is 260.37 km^2, 72.24% of whole regional area. There is 100.03 km^2 of no soil erosion, 27.76% of the total area. Light soil loss area is 190.41 km^2, moderate soil loss area is 56.47 km^2, and severe soil loss area is 13.49 km^2, 73.13%, 21.69% and 5.18% respectively. Figure 4 shows the percentage of different soil erosion intensity.

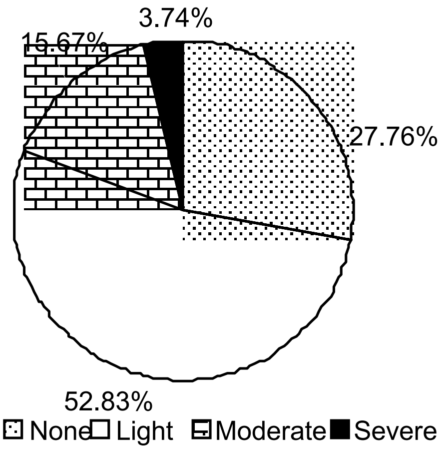

Figure 4: The percentage of different soil erosion intensity.

Primary Pollution Sources

Point pollution sources

Industrial and manufacturing works were major sources of contamination. The five largest bean-process industries produced large quantities of different kinds of pollutants. 0.86 x 10^6 t a^{-1} wastewater was discharged to Cheng River, containing 317.14 t a^{-1} COD_{-Cr-}, 113.29 t a^{-1} SS, 17.25 t a^{-1} total nitrogen (TN) and 0.45 t a^{-1} total phosphorus (TP), respectively.

The secondary pollution source was domestic and tourism wastewater discharging to Cheng River by underground canal and flowing into Yilong Lake. There are more than seventy excursion vessels and 200×10^3 person-times visitors, increasing sanitary waste and human generated rubbish entering the water. The wastewater amount was 1.642×10^6 t a^{-1} including 426.92 t a^{-1} COD_{-Cr-}, 180.62 t a^{-1} BOD_{-5-}, 49.26 t a^{-1}TN and 4.93 t a^{-1} TP.

Other associated industrial pollution sources included vintage and bean product assistant process industries discharging wastewater at 94×10^3 t a^{-1}, including 188.0 t a^{-1} COD_{-Cr-}, 14.1 t a^{-1}TN, and 0.012 t a^{-1} TP.

Non-point pollution sources

Non-point pollution sources were mainly rural domestic wastewater, rainfall, surface runoff, and agricultural effluent. Rural domestic wastewater was discharged at 1.211×10^6 t a^{-1} producing 314.86 t a^{-1} COD_{-Cr-}, 133.21 t a^{-1} BOD_{-5-}, 36.33 t a^{-1} TN and 3.63 t a^{-1} TP. TN of 1.0 t a^{-1} is and TP of 3.63 t a^{-1} were brought by rainfall into the water surface due to the average utilization efficiency of only 30％ (nitrogen 40-50％ and phosphorus 10-20％). A quantity of nutrient substance flows into Yilong Lake by rain wash because of uncontrolled fertilizer application and low utilization efficiency. Surface runoff in Yilong Lake mainly came from the west, south and north. Pollutants flowing into the lake by surface runoff include 170.12 t COD_{-Cr-}, 93.02 t BOD_{-5-}, 49.23 t TN and 5.59 t TP every year. Fishing intensity in Yilong Lake has been increasing on an annual basis in recent years. Fishing takes place in the four seasons. There is 1,152 m^3 of water exchanged between 270 ha of fish ponds around the lake and Yilong Lake, which brings 861.7 t COD_{-Cr-}, 118.6 t BOD_{-5-}, 42.60 t TN and 2.6 t TP into Yilong Lake. Table 1 shows the quantities of primary pollutions into Yilong Lake.

Endogenous Pollution

The results of monitoring substrate sludge indicate that the maximum for TN content is 6584mg kg^{-1}, which is in the west of the lake; the next for TN content is in the center of the lake. Organic content in the west and center of the lake are both above contrast cross-section and the average value in the west is higher than in the center. The maximum for TP content is 566 mg kg^{-1} which is in the center of the lake; the next is in the east of the lake, where both TP contents are above contrast cross-section; arsenic content has been decreasing gradually from the east to the west in the lake, which is above the contrast cross-section in the east and center of the lake.

Table 1: Quantities of primary pollutants into Yilong Lake.

Items		Pollutant /(t aPPP^{-1PPP})		
		TP	TN	CODBBB$_{CrBBB}$
Point sources	Industrial	0.45	17.25	317.14
	Domestic	4.93	49.26	426.92
	Other	0.01	14.10	188.00
Non-point sources	Rural domestic	3.63	36.33	314.86
	Rainfall	1.0	39.84	
	Surface runoff	5.59	49.23	170.12
	Agricultural	2.6	42.60	861.7
Total		18.21	248.61	2278.74

Water Function State

The functions of Yilong Lake are water supply, aquatic culturing, aquatic tourism, pollutant acceptor and air accommodation etc. The Third Class in the Chinese Surface Water Environmental Quality standards (GB3838-2002) was executed according to the function of fishery and irrigation judged by the Yunnan Province Government. The state of water quality and water quantity available could demonstrate whether the water state could be satisfied with the determinative functions or not.

Water Quality

The monthly values of surface water temperature, pH, DO, CODBBB$_{MnBBB}$, TN and TP from January 2003 to December 2004 were analyzed. Figure 5 A-D show monthly values graphs of the later four parameters.

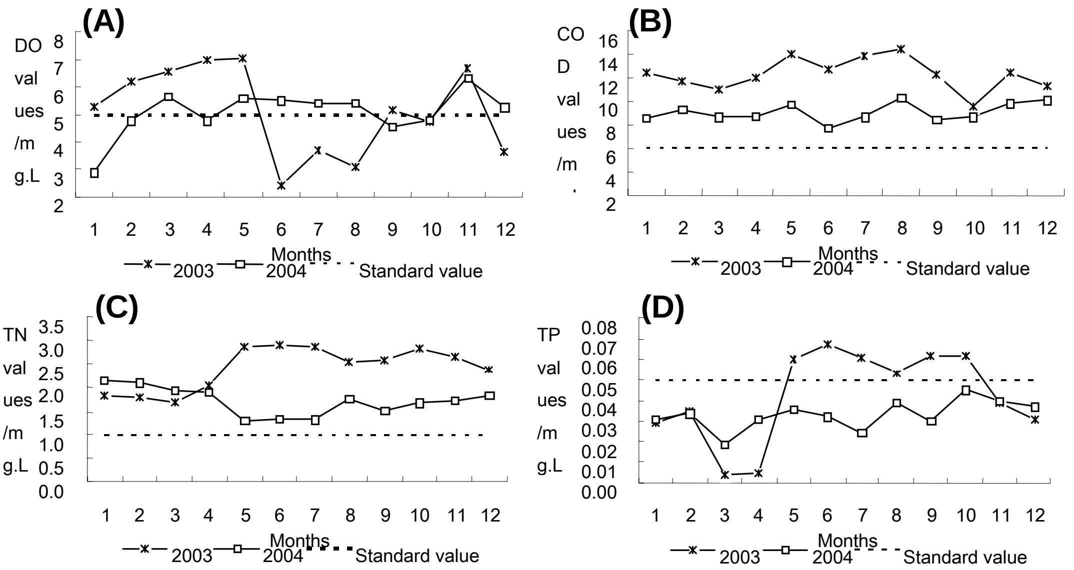

Figure 5: Monthly values of water quality parameters in 2003 and 2004: (A) DO, (B) CODBBB$_{MnBBB}$, (C) TN, (D)TP.

(a) Temperature

The temperatures were between 16.2 and 26.9ºC by measuring of water surface. The highest temperature was 27.9ºC and the lowest is 12.0ºC. The differences in temperature were presumably due to differences in rainfall among the months. As the lake is shallow, the temperature stratification should not be considered.

(b) pH

Generally, the pH values in all months were slightly/modest alkaline at the surface. The pH values were between 8.37 and 9.09 in the dry season and between 7.87 and 9.04 in the wet season, which exceeded the standard value of 6-9 for 3 or 4 months in one year. The figures of pH in the dry season were more alkaline because of the higher evaporation and less rainfall.

(c) DO

The DO values were between 2.44 and 7.07 mg LPPP^{-1PPP} at the surface. Generally, higher values of DO were observed in the dry season. The state of 2004 was better partly than of 2003, which could attributed to pollutant control measures carried out in recent years. (Figure 5(A)).

(d) CODBBB$_{MnBBB}$

The CODBBB$_{MnBBB}$ figures were between 7.68 and 14.51 mg LPPP^{-1PPP}. The mean values of two years exceeded the standard value of 6, but monthly average values in 2004 were lower than the contemporaneous data in 2003 (Figure 5(B)). The decline rate was from 10% (in December) to 40% (in June), of which decline in the wet season was higher than in the dry season partly because of the more rainfall in the wet season. In sum, the values of DO and CODBBB$_{MnBBB}$ in the two years indicate that the water organic pollutant has been reduced gradually, although the water quality is not as good as human requirement.

(e) TN and TP

The concentrations of TN and TP could indicate the degree of eutrophication (Pereira, 2002; Cristofor, 2003; Kagalou, 2003). The figures for TN ranged between 1.30 - 2.92 mg LPPP^{-1PPP} while those for TP from 0.004 to 0.067 mg LPPP^{-1PPP}. The month values of TN in both years were as much as 1.3 to 3 times higher than the standard, while the values in 3/4 months of 2003 were higher than the contemporaneous data in 2004 (Figure 5 (C), (D)). The concentrations of TP were lower than the TP standard value except in wet season (from May to October) in 2003, whose tendency was decline. With respect to the TN concentration, the Yilong Lake is significantly eutrophicated.

Water Use Status

Water usages include agriculture water, rural human and animal drinking, urban industry and living water use which are 40.71x10PPP^{6P} P^{PPP}mPPP^{3PPP}, 1.94 x 10PPP^{6P} P^{PPP}mPPP^{3PPP}, 1.11x 10PPP^{6P} P^{PPP}mPPP$^{3\ PPP}$ and 1.79 x 10PPP^{6P} P^{PPP}mPPP^{3PPP}, respectively (in 2004). Farm field norm water use is 10,425 mPPP^{3PPP} haPPP^{-1PPP} and industry output value norm water use is 112 mPPP^{3PPP} per ten thousand Yuan. It is short of 4.65 x 10PPP^{6P} P^{PPP}mPPP^{3PPP} with extraneous water area diversion considered owing to high unit farm field and industry output value water use.

Aquatic Organism

Yilong Lake is a shallow lake where there are plentiful and diverse biological species associated with abundant light supply, enough oxygen and better nutritional conditions in the littoral area. However, the species and quantity of aquatic organisms has decreased in the past twenty years.

Euglogy is dominant in the Cheng river entrance to the lake and *Cyanophyta* is the dominant species in other places. Algology in the middle part is higher than in the western and eastern section in number. Part of the water area, along the lakeshore, algal bloom.

Emergent plants are distributed mostly in the western lakeshore and consist of *reed, Zizania caduciflora, arrowhead, lotus, bulrush* and *Alternanthera philoxeroides* etc. *Lotus* is widely dispersed and its area extends to 160 ha, mostly in the shallow water area of the west Yilong Lake and exiguously along the southern lakeshore.

Floating-leaved plants include Water Chestnut, *candock, banana-plant, azolla* (dominant species in the shallow water area of the west Yilong), *Salvinia, water hyacinth* (run rampant especially in the northwest part) and *grass-sickness* etc.

Submerged plants distributed widely include *Potamogeton pectinatus, Hydrilla verticillata, Myriophyllum spicatum* and *Najas Major Au.*

Zooplankton is abundant in species and quantity, in which *protozoa* and *rotatoria* are dominant and *copepod* is small in number. It has been investigated that there should be 40 kinds of *protozoa,* 45 kinds of *Rotatoria,* 7 kinds of *Cladocera,* 4 kinds of *Copepod* and 5 kinds of other classes.

Sustainable Development Management

Catchment ecosystem management measures

Returning land for farming to forestry should be carried out and economical fruit trees and tree species for water and soil conservation should be planted in the sites above 25º slope in Yilong Lake basin. The area of 31 km^2 has been occupied after finishing Gaochong reservoir, Qianyang Mountain and Yangguangcheng small watershed comprehensive management for soil and water conservation by taking a small watershed as a management unit. This has has achieved notable social and ecological benefits such tha that Yilong Lake sediment accumulation has been alleviated by reducing soil and water loss and the influence of drought or excessive rain upon agriculture has been decreased. The feasibility study reports that comprehensive water and soil conservation management of Wangjiachong and Mitaibai small watershed should be completed actively. The projects should be planned, based on comprehensive water and soil conservation management of small watersheds such as Caiying reservoir, Baoxiufengshan Mountain, Xiushan Mountain, Doudiwan, Xinhaizi, Dashahe and Banjing in 5 years.

The recovering Zhujiang River system and the outlet from the east of Yilong Lake flows into Lujiang River through Sinjiehaikou river gate; Qingyuwan Tunnel should be long-term in reserve to involve in flood discharge by way of ideal flood discharge exit when subjecting to abnormal flood. Cultivated land formed for land reclamation in history should be carried out re-submerging particular polders step by step so that the abnormal impounded level of Yilong Lake reaches 1414.2 m, corresponding impoundment reaches $113\times 10^6 m^3$, the lake area is up to 47 km^2 and the area of returning farm land to lake particular polders of 1394.3 ha. The lake shore environment and wetland will be recovered such that natural aquatic plant community including wetland plants, emergent plants, floating-leaved plants and submerged plants will be restored in lacustrine wetland and below 5 m depth of shoal water, and the coverage of submerged plants should above 40%.

Pollution sources management and control

The 1x $10^6 m^3$ substrate sludge will be dredged and 400 ha a^{-1} hyacinth will be salvaged, then hyacinth, substrate sludge and agriculture waste castoff should be multi-utilized by recycling to make compost.

Sewage disposal project and related supporting facilities involves Shiping County sewage disposal plant whose processing capacity would be 10000 t d^{-1}. 80% sewage will be handled to realize compliance with emission standards in Shiping country after the project is finished, which will reduce the 1044 t COD_{Gr}, 576 t BOD_5 and 828 t SS discharged into Yilong Lake; auxiliary blow-off pipe net projects will implement separate systems in Shiping County. Processing capacity would be 1000 t d^{-1} in Baxin town sewage disposal project which may remove 89 t COD_{Cr} and 59 t BOD_5 The complete monitoring will be constituted to forbid waste water from being released without emission standards.

Regional management on excursion steamers should be implemented and integrated into ground management. Marine enterprises should rationally plan tourist lines and voyage intervals, choose proper ports of call and lay out self-contained ground restaurants and sanitary fixtures. The service of shipping internal management should be strengthened and be connected with supervisory departments to prevent pollutants from entering the water body.

Fire damp should be actively spread and constructed to abate the need for firewood. 6° - 25° slope of cultivated land will be fulfilled by building a low bank of earth between fields and creating land to increase the capacity of water, soil and fertilizer conservation and reduce silt input to the lake. The control measures should be carried out with increasing organic fertilizer, extending biological fertilizer and pesticide use and controlling chemical fertilizers. The villagers should be directed about how properly use fertilizers and pesticides through monitoring and information exchange.

River channel comprehensive management project

The Hai (Cheng) river with 18 km length lies between Baoxiuchirui Lake and Yilong Lake, which is the main river into Yilong Lake. The upstream surface runoff and sewage flow into Yilong Lake by Cheng River with severe sediments pollution in rainy season. It is necessary to dredge Cheng river watercourse, build sand banks, and reinforce river channel. Some plants should be planted in river channel to improve its water quality.

Fish culturing adjustment and management

Natural fishes including *Carp*, *herring* and *megalobrama* which should be cultured in the lake and whose quantity are 60 kg ha^{-1}, i.e. 1200 pieces per hectare water surface area, will be put into improved nature fishing production capacity. *Chub* and *bighead* may be put in to purify water quality. The proper quantities of fish fry should be put in on an annual basis to promote fishing cultivation health development.

Water resources utilization

The Yilong Lake aquatic ecosystem has been threatened since the water resources development range and intensity were increasingly extended in the past twenty years with the increased population and expanded industry. Water resources utilization in the watershed includes agricultural water use, urban and rural domestic consumption, and industrial utilization, and there is a shortage of $4.65\times 10^6 m^3$ with extraneous water area diversion resulting from impropriate the ecological water use. When natural water level is recovers to 1414.2 m the water resources will have $1.49\times 10^6 m^3$ surplus due to the decrease of $6.14\times 10^6 m^3$ in agriculture water use and decline of the other water uses as a result of returning farm land to the lake. So, the ecological water use of Yilong Lake basin ecosystem should be reasonable to improve its ecosystem health and sustainable development.

Conclusions

Within the frame of this study, the first comprehensive survey on the Yilong Lake ecosystem state is carried out. Decreasing water supply, increasing water use and wastewater effluent, water quality degradation and eutrophication, overwhelming unreasonable fish culture and tourism, and serious catchment ecosystem damage during the last few decades are identified as the major problems affecting the ecosystem state in the Yilong Lake basin. The problems of Yilong Lake should be identified and improved, although the ecosystem state has ameliorating year-by-year to some extent. The available sustainable development management to improve Yilong Lake catchment and aquatic ecosystem health should be considered.

The results of the study allow a more precise implementation of measures to improve and protect the lake basin ecosystem in the Yilong Lake. Within the resources available to the Shiping County

Government, the importance of good sustainable development management will be understood and the ecosystem in Yilong Lake basin would gain in health.

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Improved management of existing man made lakes

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Abstract

Achieving the development goals internationally agreed at the Johannesburg World Summit on Sustainable Development, particularly those related to water and energy supply, in the context of IWRM as fostered by the Johannesburg Plan of Implementation, involves, among other relevant measures, to get the best from existing infrastructure. Man-made lakes or reservoirs and its dams outstand for their importance as key elements of water resources management. Over 45000 large dams and reservoirs have been built to serve different water uses. Most of them require specific efforts to improve performance and safety conditions as well as to resolve or improve outstanding environmental and social issues. Moreover, it is accepted that in general there is lack of appropriate systematic monitoring and assessment of their performance and status. In this regard addressing existing dams is one of the strategic priorities for improved dam decision-making, planning and management that the UNEP Dams and Development Project is promoting. This involves not only optimising their performance through structural and non-structural measures and paying due attention to dam safety issues but overcoming the barriers for regular technical, environmental and social performance assessment. Each of these crucial issues has been addressed by a multi-stakeholder audience at the International Workshop on Addressing Existing Dams convened by UNEP-DDP in Nairobi on June 2004. The objective of this paper is to discuss the main conclusions of the meeting from the perspective of lake management and conservation and in the context of integrated water resources management at the lake basin level.

Keywords: Man-made lakes, optimising performance, environmental and social aspects

Introduction

Reservoirs are man made lakes built with the purpose of storing water and regulating flows to serve various water uses like water supply, irrigation, hydropower generation, navigation, flood control and recreation among others. Reservoir and lakes have differences and issues in common. Differences are related to a major extent to their configuration, flow circulation pattern and retention time. Like lakes they are part of the major water elements in the river basin system that should be dealt with within an integrated water resources management approach (IWRM). Reservoirs are in many aspects more challenging than natural lakes as regards river basin management. Volume, water level and outflows can be tailored to a given extent in terms of the requirements of the water uses. Frequently these requirements are conflictive among the various uses. Thus reservoirs may have better capacity to manage inflows in terms of quantity and quality but also to have a larger impact in the downstream ecosystems and the livelihoods that depend on them. Environmental and social issues associated with the dam construction and reservoir impoundment continue to condition the management of the reservoir management for long periods until they are resolved properly becoming integrated into a situation of new equilibrium, different and, expectedly, better than the initial one.

Management of reservoirs is also more challenging from an institutional point of view. In most countries the various water uses have sectoral regulatory frameworks that the developer and operator have to respond to, in addition to complying with, those ruling environmental and natural resources use and protection. These complexities enhance the need for an integrated water resources management approach. In the case of reservoirs such a comprehensive approach is direly needed given that significant interactions take place between watershed management, river regulation, the reservoir and the upstream and downstream areas of the basin, involving ecosystems and associated livelihoods.

The achievement of the internationally agreed development goals rests to a large extent on the sound management of water resources and energy. In particular, halving by 2015 the population without basic water supply, sanitation and electricity supply. At the World Summit on Sustainable Development, Johannesburg 2002, it was agreed that such goals would be achieved in the context of an integrated water resources approach. To this end the governments established as a target to have in the pipeline by 2005 IWRM and efficiency plans. The specific reference made to efficiency plans highlighted the relevance given to improving the performance of existing facilities and the efficiency in the use of resources in order to increase their productivity and minimise unproductive losses. While an important effort to this end falls within the range of non structural and demand side measures, optimising the performance of existing facilities is also a major component of the effort needed, which would allow expanding the access to the unserved population (contributing to the development goals) reducing the need for additional infrastructure (contributing to lessen the financial burden to achieve them).

Because of their scale and long operation life span, optimising the performance of reservoirs and associated dams is a key element in the improvement of water resources and energy efficiency. Further, it is recognised that such approach should be consider as one baseline option when planning new dams to cope with ever growing water and energy demands. The importance of optimising such performance in technical, safety, economic, environmental and social terms in response to the changing conditions has been highlighted by the World Commission on Dams (WCD) incorporating "Addressing Existing Dams" as one of the seven strategic priorities that it recommended as a new decision making framework for dams' planning and management. It should be noted here that, despite the diverse positive and negative reactions generated by the WCD report, published on November 2000, the seven strategic priorities have gained wide acceptance and are considered an appropriate framework to achieve "sustainable" outcomes, meaning projects that effectively contribute to sustainable development. However their implementation is still matter of discussion and providing guidance on how to address it at the national and regional level is the focus of the UNEP-Dams and Development Project (UNEP-DDP).

Precisely on June 2004, UNEP-DDP convened in Nairobi a workshop on "Addressing Existing Dams", within the context of the DDP work programme component on supporting global dialogues. 41 participants representing a wide range of stakeholder groups involved in the dams and development debate attended the meeting. The overall objectives of the workshop were to:

- Identify the current practices and constraints concerning the systematic assessment of the performance of existing dams, including systematic monitoring and safety aspects;
- Identify principles and criteria concerning structural and non-structural approaches for the optimisation and efficient production of dam benefits under changing contexts (climatic, socio-economic, policy and regulatory);
- Discuss the role of stakeholders, especially government agencies, beneficiaries and affected peoples, in the monitoring of dam performance, including safety issues; and
- Specify approaches for closing the gap between aspiration and reality.

The output of the workshop was a set of recommendations and issues to be discussed in the context of national and regional multi-stakeholder dialogues and workshops, with a view to influence policies and procedures aiming to improve decision-making on dams and their alternatives. The following sections present and discuss some of the issues and recommendations identified by the participants dealing with a wide range of aspects concerning the assessment and management of existing dams/reservoirs.

Key issues concerning the management of existing dams/reservoirs

Dam safety, including climate change, regular assessment and optimisation of performance and solving outstanding social and environmental issues summarise the main topics addressed by the meeting.

Reservoir/dam safety

Regarding dam safety, a theme of major concern was the absence of adequate flood warning and evacuation programs for communities downstream of the reservoirs. The need to ensure that dam safety and emergency preparedness and response programs are put in place was highlighted. It was felt that responsibility was in many cases diluted between developers, governments and multilateral lending institutions that being involved in the construction and operation of the reservoir often do not take responsibility for dam safety once construction is completed and the loans have been repaid. Climate change was identified as a potential threat to the safety of existing dams. Conclusions concerning dam safety dealt with the following main issues:

Assessment and Implementation of Dam Safety Programs: The workshop participants stressed the need to pay increased attention to the prevention and prediction of dam failures. It was recommended that governments should put in place legislation requiring dam safety programs where not available and that the costs of the projects should include the costs of dam safety programs and their payment from project revenues. Particular relevance was given to transboundary rivers and multiple dams situations. River basin organisations were encouraged to use of scenario-based models to address trans-boundary safety issues.

Emergency Preparedness and Evacuation: They were considered a fundamental element of dam safety programs. It was stressed that emergency preparedness and evacuation plans should be put in place operated by the lowest, feasible level of government for every dam involving risks to downstream populations. In their preparation and implementation it is crucial that local people, especially those who would be affected by a dam failure, is involved in the drafting of the disaster management and evacuation plans and strategies for communicating risk and recommended actions to communities. In this regard it was agreed that the provision of relevant information to potentially affected communities, as well as receiving demographic and other information from such communities, was fundamental in planning emergency warning and evacuation procedures. The design of emergency preparedness and evacuation plans should be done in the context of the river basin considering the interaction of multiple reservoirs/dams.

Climate Change: Climate change is one of the main forces currently driving water resources and energy management. Therefore it was underscored the importance of considering the impacts of climate change in dam safety assessments and programs.

In this regard it was recommended the elaboration of an international study to predict the effects of climate change on dam safety, including the use of storage for mitigating those effects.

Regular assessment of performance of dams/reservoirs

It was widely recognised that there is little practice in many countries concerning the regular assessment of performance of existing reservoirs/dams. The participants debated the value of regular and participatory performance assessments and identified several potential purposes of assessments including improving performance, identifying and remedying outstanding social and environmental issues, applying lessons learned from old projects to new projects, and evaluating development effectiveness. The institutional implications of carrying forward those assessments were discusses including the question of responsibility when in many cases operating decisions are made by organizations that have little or no responsibility for water resources management. The need for inter-sectoral assessments and inter-agency coordination was flagged.

Legal, political, administrative and financial barriers to regular performance assessments were also addressed, including the need to go beyond assessments towards political responsibility and accountability. It was agreed that there was little awareness of the benefits of evaluations to owners, in terms of improving dam performance, and that these should then be publicised. At the same time it was recognised the need to establish laws mandating post-project evaluations and that countries adopt consistent standards for these assessments. As regards the scope of the assessment the participants considered that there should be comprehensive review and assessment of existing dams/reservoirs, their use and the distribution of benefit streams, environmental and social impacts and outstanding social concerns. The evaluations should assess overall impact of water resources strategies (e.g. on poverty alleviation), development effectiveness and cumulative impacts. It was recommended that the assessments give every constituency an opportunity to articulate their own issues and interests and therefore participation of multi-stakeholder groups would be encouraged.

Optimising performance

It is important to ensure that an adaptive management approach is implemented to optimise the performance of reservoirs/dams in response to evolving needs and technological, environmental and social changes. Not only change of operation rules but upgrading and new facilities and even reviewed objectives for the reservoir might need to be considered along time. In doing this the availability of regular assessment of performance was highlighted. Since optimisation involved adapting the features and operation of the facilities to evolving needs, it was stressed the role that stakeholders should be given in taken decisions about what aspects of dam operation are to be optimised. Obviously this flagged as an important issue to identify the roles, responsibilities and needs of various stakeholders involved. The challenges raised by the institutional and organisational complexities involved in the decision making process were highlighted.

Thus the participants concluded that public participation be given importance in deciding what is to be optimised, about issues of resource management and how various benefits and services serve different needs. They also agreed that the optimisation of dam/reservoir performance should be carried out at least at the river basin level, considering the economic, environmental and social aspects. In particular it was stressed the consideration of both water quality and water quantity issues, including the provision of downstream flows for ecosystems, and taking measures for sediment evacuation and sedimentation prevention and water losses/wastage reduction to optimise the system performance and prolong the safe life of a dam.

Addressing environmental and outstanding social issues

A great deal of attention was given to addressing environmental and social issues outstanding in many reservoirs as unsolved issues derived from the construction stage. As regards environmental aspects the major point that emerged during this session was the dependence of community livelihoods on river ecosystems and the importance of hydrologic patterns and habitat connectivity emerged as important factors for them. Discussions also dealt with the value of local knowledge of the dynamics of a river system in protecting and restoring aquatic ecology and the need to integrate disciplines, such as engineering and biology, as well as planning frameworks, such as water resources and human developments.

In this context, the establishment of environmental flows were given high significance. The participants concluded that a legislative mandate should be created for environmental flows – quantity and quality – as well as for addressing other environmental issues associated with dams/reservoirs. The establishment of financial mechanisms to fund environmental releases in trans-boundary river basins was considered fundamental. In the context of addressing environmental aspects in general, it was suggested that environment funds to address outstanding environmental issues associated to existing dams be established through seed money provided by multilateral banks and that governments will eventually sustain. Re-licensing was seen as an opportunity to be used to address environmental issues.

Regarding outstanding social issues a great deal of discussion during this session revolved around issues of identification, adjudication and financing of reparations for social issues. The difficulty of garnering detailed information on the impacts of a project on communities and who was responsible for them, who should bear the burden of the proof, who should pay for reparations and for which types of damages reparations should be paid, were addressed by the participants. Thus it was stressed the need to implement by governments and funders of clear, consistent policies to deal with unresolved social impacts and, in this context, the establishment of multi-stakeholder committees that include the participation of dam-affected people.

It was emphasised the inclusion in the evaluations of cumulative impacts of projects on collective, community rights; the investigation of need for both financial and non-financial reparations and the coverage of psychological and physical suffering and indemnification for loss of lives. Regarding operational and financial aspects it was recommended the establishment of legal venues and mechanisms for addressing outstanding social issues and that a percentage of revenues from services provided by the dam be allocated for reparations.

Conclusions

While still general, the discussions at the workshop, the issues raised and the recommendations produced highlighted the more relevant aspects that governments should address in strengthening their policy/legal/regulatory frameworks in order to optimise the performance of existing reservoirs/dams, including the consideration of environmental and outstanding social issues. This outcome has the added value of resulting from the interchange of views of a multi-stakeholder group including government, private sector and civil society.

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An overview of the law of non-navigational uses of International waters with lessons from Africa

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Abstract

Adoption of the convention on the Law of the Non-Navigational Uses of International Watercourses under the aegis of the United Nations on 21st May 1997 ushered a new epoch in centuries of efforts to conclude a global treaty on the subject. Early efforts started with what has been referred to as water law in hydraulic civilizations. The early adjustments were predominant in Middle East and the Orient, the latter prevailed largely in Western Europe where they were followed by treaties for both production of hydroelectric power and those for the control of water quality.

North America followed the latter concerns in the 20th century, especially with the spectre of Hormon Doctrine and the Boundary Waters Convention of 1909. But the modern trends in Latin America followed the oriental approach of integrated basin management. In Africa, where approximately 54 internationals basins cover about 50 per cent of the area of the continents, systematic management of the waters has generally faltered leaving over 90 percent of the waters to flow to oceans while the continent languishes in draughts and in adequate exploitation of arable land and inordinate reliance on costly imported hydrocarbons. There are lessons for Africa to learn from the Orient in utilization of international waters. Early, treaty arrangements on different watercourses could facilitate such processes and would strengthen development of international water law and, to every extent possible, promote implementation of the 1997 Convention.

Keywords: Watercourses; Equitable Utilization

Introduction

Issues in non-navigational uses of international waters and which require legal intervention are often rendered intractable largely because they arise from fundamental national interests such as agriculture and human consumption. The significance of every problem assumes local exigencies. Therefore, it is an enormous task setting out to provide a global overview of the trends in the theory and practice in international waters within the few pages allowed by this conference.

In its synoptic way the paper will describe some of the early adjustments in regulation of consumptive utilization of water resources in ancient civilizations. These aspects of early adjustments will be followed by key characteristics and scope of international waters including issues of delimitation of scope of each water. In other words, should law concern itself with the obvious physical limits of a river or should it be concerned with the catchment thereof? This discussion will also summarize the dominant doctrines which influenced reasonable or equitable access to international waters.

The history of evolution of legal principles in the field is long and complex. A summarized section III therefore takes an institutional approach of the dominant learned societies. The institutional approach will suggest to the reader where detailed information on development and codification of law of non-navigational uses of international waters can be obtained. The Institute of International Law and the International Law Association have had global influence. But the thoughts of the Asian-African Legal Consultative Committee are introduced for completeness of African experience highlighted in the title to the paper. The Bellagio Draft Treaty is introduced in the discussion because it is arguably the only comprehensive effort at developing a draft treaty on international groundwater law.

Section IV summarizes regional trends and makes the point that treaties on international waters in Europe were preoccupied with either hydroelectric power generation or water quality. This is where the Danube treaty and eventual World Court adjudication stands out. The preoccupation with water quality and pollution control will also be evident in North America. There is a distinct difference in South America and Asia where the approach of integrated managements is adopted.

African trends are outlined in the distinct section V deliberately because the Conference being in Africa should receive a brief report of the continental trends.

Section VI then crowns the discussion by providing a brief outline of what may be described as the global framework treaty on non-navigational uses of international waters. The 1997 UN Convention on Non-Navigational Use of International Waters was concluded after decades of preparatory work by International Law Commission.

Final comments are offered in section VII, making suggestions for possible progress towards universal adoption n of provisions of the 1997 U.N. Convention.

Early adjustments and background: contributions from ancient civilizations

This section outlines early adjustments in water utilization and some theoretical perspectives that have influenced the development of non-navigational uses of international waters. What seems evident is that the development of legal regimes has been influenced by absolute or relative water scarcity. Thus, organized water utilization that carried the semblance of legal regimes seem to have taken root in what the distinguished Dante Caponera (1978) has called "hydraulic civilizations i.e. civilizations which grew and developed around water points or natural irrigated valleys".

In that article, Caponera analyses the social organizations found in Egypt, Mesopotamia, India and China. His historical account of the early adjustments covers the Mediterranean and Asian regions. For Egypt he found water organizations as far back as the First and Second Dynasties, about 3400-2980 B.C. In Mesopotamia he traces water organizations to 2492 BC when King Gudea constructed a new canal and maintained in an excellent state of repair the irrigation system from smaller canals. He finds prolific works in policy and actual codes where in the introduction to Hammurabi Code the latter describes himself as "the gracious arbiter who has allotted …. Watering places to Lagash and Girsu …." (ibid, 97). This is a point to note in a place where, as we shall see shortly, was the scene of the oldest water dispute in history.

Caponera does not specify the exact era of water codes under the Indus hydraulic civilization. But he finds documents relating to water law in Manava-Dharm-Shastra or Laws of Manu which were prompted by recurring annual floods, large bureaucratic water administration, large-scale networks, and the divine character of water.

In another text Caponera and Alhe'ritiere' (1981) say that written water laws in China became clearly established during the Ch'in Dynasty (249-207 BC). Efforts at that time was to find flexible rules, based on human judgment and on circumstances, rather than immutable and legalistic prescriptions typical of Confucianist thought. It was the search for flexibility which led the Chinese to the concept of "equalization of water" and hence "Agreements for equalization of water" (p.31). These principles were engraved on stones and placed in the fields "to prevent strife". This practice which is evident in Chinese practice by 35 BC. was the first time that the concept of equalization of water use appears. It was to reappear in contemporary water laws as "equitable apportionment of water." The Chinese were clearly ahead of their time in striking a practical and theoretical balance in water law.

The pillar of their approach to water law must be seen in the effort to prevent strife because access to the relatively or absolutely scarce water was evidently prone to strife. Professor McCaffrey (1997:43) says that the earliest known war over water was in 3100 BC when the governor of Lagash in Mesopotamia, led his people to a victorious but bloody battle against the neighbouring city state of Umma, in a dispute over water supply. Tables were later turned on Lagash in a subsequent water war when their governor was killed by Umma fighters, who are also upper riparian dwellers in the river basin. Thus, these are water-related violent incidents which subsequently persisted in the region. Upper and lower riparian states asserted claims to water often ignoring mechanisms for conflict avoidance which have been mentioned above. Although the conflicts in this instance were between city states, analogous situations arise in international waters under contemporary situations.

Nature of International Waters

A river or a lake is characterized as international if it traverses two or more independent states. Where a river is navigable, the boundary between the riparian countries is the *thalweg* or the centre of the navigable channel. On the other hand, where a river is not navigable then the middle of the river stream will constitute the boundary between the riparian countries.

There may be exceptional instances where there is a shift in the channel of the river. In that case the boundary and title to land tract left by the changes will depend on the language of the boundary treaty between the riparian states as was the consequence of Rio Grande and Chamizal Tract between United States and Mexico in the 19th Century (Mueller 1975).

It is an important question whether reference is to a river, basin, catchment or watercourse. In which case, a river may refer simply to the flow channel, pure and simple. A drainage basin and catchment have generally been used interchangeably to mean the some concept, namely, "a geographical area extending over two or more states determined by the watershed limits of the system of waters, including surface and underground waters, flowing into a common terminus" (International Law Association 1966). It is arguable that this definition, generally applied, may lead a basin organization, where one exists, to infringe on wide areas of territorial sovereignty of a riparian state. Yet for management purposes, which carry legal consequences, it would be artificial to ignore that catchment area. This dichotomy my well have led to adoption f the concept of "watercourse" in the 1997 U.N. Convention on Non-Navigational Uses of International Watercourses discussed later in this paper.

Contending Theoretical Concepts

As will be evident from the proceeding sections conflicts in utilization of international waters arise from the theoretical position from which each state asserts its interests. A state may selfishly claim a right to use the waters without consideration of the interests of others. The other extreme is where the respective states may accept that there is a community of interests worthy of collective protection and management.

For purposes of this presentation it is sufficient to rely on the seminal analysis by Jerome Lipper

(1967: 15-40) and a summary by Okidi (1980: 395, 403-406). Although the titles of the theoretical positions do not immediately suggest what they mean, we take them for what they are and have been in common usage.

a) Territorial integrity:

This is analogous to the old common law doctrine of private water rights whereby a lower riparian demands continued natural flow of river waters but that state for its part did not accept to permit the continuation of the natural flow through its territory. The closest instance of analogy would be the claim of Spain over the waters of River Carol, the dispute which ended up with *Lake Lanoux* Arbitration. In this case Spain had insisted that France, the upper riparian on River Carol, would be acting contrary to her treaty obligation if it constructed a dam for hydroelectric power up stream. Although France submitted that the quantity of water would not be reduced, Spain objected to the very fact of human intervention in the flow even regime if the quantity would be enhanced. The Tribunal adjudged Spanish claim as unreasonable. (12 UNRIAA, 1957:281; Green 1978: 318-328).

Some have argued that the doctrine might apply to relationship between Egypt and Sudan (Lipper, 1967). But then that relation is governed by the 1959 Agreement for the Full Utilization of the Nile Waters and Egypt has not been known to veto irrigation or other project of utilization of Nile waters in Sudan.

b) Absolute territorial sovereignty.

Under this theory a riparian state assumes the right to dispose of the water of a river or lake, totally ignoring the interests of other riparians, so long as the water is on its territory. On the other hand, the theory presupposes that such a state does not have a right to demand unimpeded flow of the water to it.

This extreme, and rather unpopular position is associated with a 1895 Opinio of Judson Harmon, then Attorney General of the United States, towards Mexican claim to a share of waters of Rio Grande. The so-called Harmon Doctrine has been described as “the most notorious theory in all of international natural resources law”. (McCaffrey, 1996). From Professor McCaffrey’s statement it is clear that the doctrine has commanded neither respect nor state practice.

c) Limited Territorial Sovereignty

This theory urges for mutual consideration of the interests of all riparians without either joint planning or cost sharing. It rejects the principle of absolute sovereignty without implying community of interests. In other words, it implies good neighbourliness, obligation not to cause harm, co-existence and prior consultation without the necessity of cooperation. The core of the principle may be constructed to be the age-old doctrine of *sic utere tuo ut alienum non laedas.*

d) Community of Coriparian States in the Waters of an International river

This theory characterizes the exceptional situation where all riparians regard the basin as an economic and, presumably, ecological unit, irrespective of the boundaries of the riparian states. The water therein would be vested wither in the community, through a joint institution or divided among the co-riparians by agreement. An example which is closest to this concept is the management of Senegal Basin under the 1972 Treaty of the Organization for the Management and Development of Resources of Senegal Basin whose French acronym is OMVS (Okidi, 1987). The second example, also from Africa, is the Agreement for the Management and Development of Kagera Basin or KBO as evidenced by the 1982 plans of implementation, (Okidi, 1986). Both treaties provided for projects that are essentially national but in addition there are provisions that are common and with shared financial and management responsibilities. That the KBO projects were never implemented is a different issue.

e) Equitable Utilization

This is the doctrine which avoid the extremes discussed above. It presupposes consideration of equity or an arrangement which considers the share due to each state and a determined through a bundle of conditions and attributes. Although the determination of what is a equitable and reasonable share of water is still a matter of some debate, the items to be taken into account have been identified, as we shall see again in discussion of The Helsinki Rules and the 1997 U.N. Convention.

Recall now that the first time the doctrine of equitable utilization was used, according to these studies was during Ch’in Dynasty in China, (249-207 BC) and it emerged as a principle for finding a formula for equalization of benefits from water use and therefore to prevent strife.

Contributions from learned societies

Introduction

The discussions so far have largely focused on the build up of custom through practice of states. The present section presents a quick review of selected learned societies, which have contributed to development of legal principles in this important area of law. It would, indeed, have been good to review all existing soft and hard law instruments, including case law. That, of course, is not a practical proposition for this paper. Instead, a select number of learned societies that have made special contributions or reflective of the key regions of concern for this study may offer sufficient illustration.

For purposes of this discussion four works of learned societies of which three are global, reviewed here are: Institute of International Law; International Law Association; Asians African Legal Consultative

Organizaiton; and the authors of the Bellagio Draft Treaty.

Institute of International Law

This is one of the oldest and respectable global learned societies in international law field. At different times since 1887 they have adopted four resolutions on international water law but two are on navigational issues, and therefore not of concern to this paper. The other two, one was adopted at Salzbourg in September 1961 is on international non-maritime waters; the second resolution focused specifically on pollution of international rivers and lakes.

The Salzbourg resolution showed a broad scope by recognizing first and foremost the economic value of the use of water and the evolving impact of modern technology in such applications. The preamble also took note of the interest of immediate riparians and their neighbours, presumably those which are within the catchment.

The term watershed, which is analogous to catchment or basin, is used but is not defined, leaving the impression of a rather restrictive meaning in this particular context. Such an interpretation is enhanced by repeated reference only to the right of a state to use water flowing through its territory or along the borders.

The resolution is clear that any disagreement among the riparians as to access to and use of the waters should be settled using principles of equity. Both the needs of the states and the prevailing circumstances should be taken into account.

There is a requirement for prior notification by any riparian which plans any work using the river water. No riparian may construct works or embark on the use of an international water without considering the impact on states sharing such a watershed. If other riparians object then the parties are obliged to open negotiation with or without technical expertise, as may be deemed necessary. All negotiations should be done in good faith and any construction likely to prejudice the final resolution should be suspended.

The states concerned may also proceed to arbitration or judicial settlement, but if the objecting party is opposed, then the other one remains free to proceed with the work. Finally, the resolution urges riparian states to establish joint organizations for planning and utilization of the water for economic development settlement of disputes.

The second relevant one, the Athen resolution of September 1979 focused on pollution of rivers and lakes. This is a surprisingly narrow move considering that Salzbourg covered the broad development issues without any mention of pollution. A developmental and evolutionary approach would have broadened the scope to combine the 1961 development component with the concern with pollution.

It would appear that Athens resolution was prompted by the increasing volumes of industrial wastes that had caused concern with, for instance, pollution of the Rhine. So the emphasis is on cooperation in preventing new pollution and taking measures to abate any existing ones, especially where hazardous and ultra-hazardous pollutants are in evidence. They also called for mechanisms for compensation to victims of pollution, including systems of compensation funds.

The resolution also urges for a duty to cooperate and to notify other basin states of any pollution incidents. In addition, basin states are urged to set up basin-wide regional cooperative frameworks and to evolve environmental standards for common application.

There is a unique provision as the resolution calls for technical assistance and resource support to developing countries.

This resolution recalls the Salzbourg one and makes the significant advance by defining pollution and also urging for rational and equitable utilization of resources, without providing factors to consider in implementing equity and reasonableness.

International Law Association (ILA)

This is the most prolific of learned society when it comes to matters of international waters, even though it started only in 1956. They adopted at least twelve resolutions by 1980. But their single most important contribution and which has had far reaching impact on development and codification of international water law is The Helsinki Rules on the Uses of the waters of International Rivers adopted at their 52nd conference at Helsinki, Finland on 20th August 1966.

The ILA prepared a comprehensive document of 37 articles, clustered under six chapters, and an annex on Model Rules for the constitution of the Conciliation Commission for the Settlement of Disputes. Each of the articles is accompanied by commentary to explain its purpose and the contents.

The first article explains that the rules are applicable to waters of international drainage basins, as may be provided for in international binding instruments. There is a definition of international drainage basin as a geographical concept referring to a watershed but including groundwater flowing to a common terminus. The concept of basin state is construed to refer to these located in or straddling the watershed.

The most crucial provision is in Chapter 2 comprising four articles and entitled "Equitable Utilization of Waters of An International Drainage Basin". The provision rejects the extremes of national claims and requires that every state is entitled to a reasonable and equitable share in the sense prescribed in the Ch'in Dynasty of China as we saw earlier. But this chapter goes a step further to prescribe what to take into account in the determination of what is equitable and reasonable.

Eleven indexes comprising geographical, economic and political factors are listed. In essence this leaves parties negotiating the legal regime for a given drainage basin to give weight to contending (uses) and users. The draft articles submit though, that no particular water use enjoys preference over others but in the ensuing commentary, domestic use is said to be preferable. The articles make clear though, that a state must not be denied reasonable use of the water to reserve such water for future use by a co-basin state.

Conditions for existing uses, and circumstanced under which they may be qualified, are spelt out, to include the circumstances of protection of such uses as well as the conditions of their creation and termination.

The problem of pollution is given prominence in a chapter of its own. It is defined in terms of any detrimental change resulting from human conduct. That phraseology alone confirms preoccupation, at that time, with fixing of liability *ex post facto* and lack of concern with the modern preventive and precautionary paradigms. Basin states are, nevertheless enjoined to prevent any new forms of pollution and any increase in existing pollution. It is to be noted, too, that pollution of the water is inconsistent with equitable and reasonable use and perpetrators are expected to pay compensation to the victims.

There are two chapters on navigation and floating of timber, respectively with focus on reasonable use, protection of water quality and requirement to desist from jeopardizing other users.

The last chapter, comprising ten articles, presents rather detailed requirements for prevention, management and settlement of disputes.

Up to 1997 when the United National Convention was adopted The Helsinki Rules remained the single most authoritative and influential instrument on international water law. In fact, the Rules heavily influenced the work of International Law Commission, which evolved the 1997 Convention, through its mandate to undertake progressive development of international law and its codification.

Asian-African Legal Consultative Organization (AALCC)

This organization is an intergovernmental forum responsible for review and development of legal matters of interest to Asian and African Governments. The first time it tabled a discussion on international waters was in 1967 and agreed that The Helsinki Rules were a useful guide on the subject (Okidi, 1978).

Subsequently, the AALCC initiated its own work on the subject and issued draft Propositions on the Law of International Rivers at its meeting in New Delhi on 18th January 1973. It will be noted that their reference was to "Propositions" rather than "articles" they had only ten such propositions (Caponera, 1980).

The first three propositions are on general legal obligation as they relate to conventions: the definition of drainage basin; the concept of basin state and the principle of equitable and reasonable utilization. In each case, the provisions are similar to corresponding ones in Helsinki Rules. It is curious though that the title refers to "international rivers" but the propositions refer to "drainage basin".

All the other propositions borrow directly from The Helsinki Rules, which confirms our earlier submission that the Rules have had immense influence on development of international water law.

The Bellagio Draft Treaty

The document called "Transboundary Groundwaters: The Bellagio Draft Treaty" was an initiative of a number of professors associated with University of New Mexico Law School and who solicited the input of about 15 experts in water law from around the world. (Hayton and Utton, 1989). The two professors had been involved as leading authors of The Helsinki Rules of ILA but their centre of scholarly work was New York University. They were convinced that very little attention had been paid to the issue of groundwater and wanted the gap sealed. The work started with a small group which produced the Ixtapa Draft which was improved upon by the retreat of fifteen experts at Villa Serbelloni in Bellagio, Itay.

This draft treaty as the output of dedicated scholars, was prepared with the same diligence as The Helsinki Rules. It contains twenty draft articles, each with explanatory comments. Topics include definition, and several terms here are also applicable to surface water.

The dominant theme in these draft articles is the idea of "reasonable and equitable development and management" of transboundary groundwater. There is also a special emphasis on institutional framework in form of a joint commission to ensure joint decision-making, planning and utilization. Functions of the commission include enforcement of qualitative and quantitative standards; maintenance of database; establishment of conservation area; comprehensive management planning; planning the rate of depletion; planning for drought and inquiry in the public interest.

The joint commission, as a common forum is enjoined to seek peaceful mechanisms for accommodation of differences. There is, in addition a provision on rights and obligations under existing agreements. There is the all important provision of resolution of disputes before the final clauses. As we shall see later the legal regime for groundwater is a topic which Africa, specifically in the Sahel in region.

Non-African regional trends

Introduction

The purpose of this section is to highlight the existence of regional agreements, bilateral and multi-lateral, on utilization of international drainage basins. As will be evident in each of the regions, the numbers of such agreements is vast; an analysis of any of the regions is beyond the scope of this paper.

An overview will be presented for each: Europe, North America, South America and Asia.

European Trends

The Food and Agriculture Organization of the U.N. (FAO) has listed 105 Treaties concerning the non-navigational uses of international watercourses (Burchi, 1993). We note that they opted for the term "watercourses" rather than "drainage basins" which has gained common usage. Out of that total 94 treaties are bilateral while eleven are multilateral. Nine out of the eleven multilateral agreements are on pollution control leaving only two for what may be considered as consumptive uses.

Out of the remaining agreements 34 deal largely with frontier issues while 18 have some aspects of consumptive and quantitative matters. Eleven agreements deal primarily with hydroelectric power generation. The rest of the treaties, approximately 31, focus primarily on protection of water quality in international waters.

It is interesting that the relative majority of the treaties should be concerned with frontier issues. On the other hand, it is not surprising that the second largest number should be concerned with qualitative issues given the impact of European industrialization on environment.

One hardly hears of conflicts or confrontations over implementation of the numerous European treaties. No wonder the disputes arising from diversion utilization of Denube waters attracted widespread global attention as evidenced by diverse professional commentaries (Kiss, 1997; Schwaback, 1996; Eckstein, 1995). In fact, the Danube case with its environmental issues including sustainable development, is unique in international water law and its adjudication by International Court of Justice (I.C.J. Reports, 1997; UNEP/UNDP Compendium, 1998).

North American Trends

According to the recently produced Atlas of International Freshwater Agreements published by United National Environmental Programme (UNEP, 2002) there are 92 international agreements on drainable basins, in North and Central America. Twenty-five agreements are essentially environmental, dealing with qualitative issues. Twenty-nine agreements are primarily concerned with border questions even though they may also encompass some matters of water utilization. Hydroelectric power generation is a primary concern of three agreements. Issues in quantitative or consumptive uses of water are covered by twenty nine agreements.

Rarely does one hear about issues in quantitative or other uses of water in North America except problems of pollution of international waters. The most notorious problems of pollution are on boundary waters between Canada and the United States, which are discussed in details by Professor Richard Bilder (1972) or the perennial problem of salinity of Colorado River discussed by Herbert Brownell and Samuel Eaton (1975).

South American Trends

UNEP's Atlas of International Freshwater Agreements has listed some 35 agreements, both bilateral and multilateral, so far concluded in South America. Out of that total, five have generation of hydroelectric power as their primary objective. Nine other agreements deal primarily with demarcation of boundaries. Quantitative or consumptive use of international waters is strongly covered by 19 agreements while one bilateral agreement, between Chile and Peru is only for settlement of disputes that may arise over their two boundary waters: Tacna and Africa.

Trends in Asia

With 67 agreements, Asia competes North America and Europe in the total number of drainage basin agreements. But these are striking features in Asian basin agreements. A total of 47 agreements, make specific provisions for qualitative and consumptive use including integrated management and utilization, including irrigation. Within that category five agreements provide for hydroelectric power generation. Sixteen agreements make provision or are predominantly for boarder related matters. Four agreements have significant provisions for settlement of disputes.

Irrigation also feature strongly with the agreements on consumptive and quantitative uses. This explains the report elsewhere (Okidi, 1988) that southwest Asia cultivates 110 percent and Southeast Asia cultivates 83 percent of arable land area. This, we shall observe later, is a lesson to Africa where only 24 per cent of arable land.

African trends

The purpose of treating African trends separately is to allow up to flag a few salient points to suggest that the continental drainage basins require a special legal, institutional and management arrangements to enable them to contribute to sustainable development. In the first place, we know Africa has some 54 drainage basins which are international. The total catchment of these basins cover approximately half the area of the continent.

According to UNEP's Atlas of International Freshwater Agreements (UNEP, 2002) there are 77 agreements ranging in age, from 1885 to 1999.

Thus, some of the treaties are colonial outcomes of the 1884 Berlin Conference on partition of Africa. We therefore, find 21 treaties were explicitly concerned with boundary demarcation of colonial spheres of influence. It is kept in mind that demarcation of spheres of influence was not an empty romantic matter. Its purpose was exploitation of natural resources of Africa. Therefore, there is a thin line between agreements on common boundaries and the early agreements, which are part of the 45 agreements, which are identified as concerned with quantitative and consumptive uses. Similarly, there are definite overlaps with the eight agreements, which highlighted production of hydroelectric power.

In this respect treaties relating to Nile waters, with implications for Lake Victoria, are unique because of the continuity of statehood for Egypt and Sudan as primary beneficiaries. It is rather certain that the only treaty that is definitely valid is the 1959 Agreement for Full Utilization of the Nile Waters and its 1969 Protocol, both between Egypt and Sudan. The status of the 1929 agreement is arguable as between the two. But none of these sets of treaties have any definite binding effect on other riparians (Okidi, 1994 and 1980). The way is clearly open to the nine or ten states falling within the Nile and Lake Victoria basins to negotiate a fresh treaty in good faith and voluntarily contracted among themselves. Such an agreement would reject the discredited Harmon Doctrine or the inverse theories and focus on acceptable terms for reasonable and equitable access, participation and utilization.

This is why a considerable hope and encouragement is given to the current negotiations within the Nile Initiative which we believe is being conducted in good faith.

The one basin agreement which showed promise for Africa is the Senegal Basin organization under 1972 OMVs treaty and in companion convention in 1978. It reached implementation stage in early 1980's (Okidi, 1987) with comprehensive planning and management in irrigated agriculture, hydroelectric power generation, navigation, projects common to the parties – with their legal status and country specific projects. They include all consequential issues such as environmental impact, resettlement plans, wildlife management, public health issues and problems of sedimentation. These initiatives have been frustrated by political relations among the parties but we suspect the problems are not fatal and this basin would be a useful case study.

The Kagera Basin enjoyed a comprehensive development and management plan by 1982 (Okidi, 1986). Unfortunately, implementation was frustrated by the tragic regional political instability. It is understood that the four contracting parties: Burundi, Rwanda, Tanzania and Uganda have resolved to place the project under the confidence-building programme of the Nile Initiative. This would be a good chance to implement sound projects.

There is a lot of hope in Africa focused on future implementation of water agreements in Southern Africa under Southern Africa Development Community (SADC). The eskewed water demand and consumption in favour of South Africa have potentials for future conflicts, if cooperative framework under the Revised Protocol on Shared Watercourses in Southern African Development Community, signed on 7th August 2000 is not implemented in full (Okidi, 1994a).

Africa stands in a unique position. The data we have show that there are 54 international river basins with catchment areas totalling half of the area of the continent (Okidi, 1988). According to that information Africa consumes approximately two percent of the total water available, leaving 98 percent to replenish oceans. The water in these rivers is also ill-distributed by seasons and geographical areas, making it necessary to create cooperative agreements control the flow and effect transfers to deficit areas. Along with the vast hydroelectric power potentials, of which Africa has harnessed only 5.6 percent, implementation of basin agreements can add considerable value to development in Africa.

The 1997 United National Convention

The Convention on the Law of Non-navigational Uses of International Watercourses was adopted at U.N. Headquarters on 21st Many 1997 having been developed under aegis of the United Nations, by International Law Commission (ILC). But the history of its development is long, dating back 1970 when the U.N. General Assemble directed the ILC to commence the task. Needless to say, that technical and long task is beyond the scope of this paper and has in any case been competently narrated by Professor Stephen McCaffrey who was special rapporteur for the subject at the critical stage in 1991 – 1992 (McCaffrey, 1996a).

This may now be considered as the global framework instrument providing the concepts, rules and principles to be applied, with whatever rationalization, to every specific treaty negotiation for different basins or watercourses. One of the key principles subject to such rationalization is that of "equitable and reasonable utilization and participation" which is in Part II of the convention. The convention enjoins parties to utilize a watercourse equitably and reasonably to ensure sustainability of benefits.

When it come to "Factors Relevant to Equitable and Reasonable Utilization" the list is reminiscent of that provided by The Helsinki Rules. In this case, seven items which would vary with each participating state and the particular situation are listed. Supplementing these factors are obligation not to cause significant harm; obligation to cooperate; regular exchange of data and information; and ensuring a careful balance between different kinds of uses.

The convention also makes a series of provisions with respect to planned measure. These include exchange of information on such measures, whether on not they are likely to have significant effect; what happens before, after or in absence of a reply; and instances of urgent implementation. Rather elaborate provisions are made for environmental concern including the requirements for prevention, reduction or control of pollution; introduction of alien species; protection of marine environment; and the call for bilateral or multilateral organizations for specific watercourses.

Specific provisions are made for harmful conditions and emergency situations with the requirement for individual or collective initiatives, depending on the nature of the problem. Besides, specific rules are provided for situations of armed conflict and those involving national defence.

Provisions for settlement of disputes, outlining requirements for mediation, conciliation and arbitration, are backed by an Annex outlining conditions and procedure for Arbitration.

A key issue where the convention left grave ambiguity is in the concept of "watercourse". It will be recalled that previous discussions, including The Helsinki Rules, used the phrase "drainage basin" for the scope of application. This convention opted for watercourse which may ordinarily be construed narrowly to mean that course followed by the river alone. However, the definition of watercourse in the convention is identical with that of drainage basin or catchment in Helsinki Rules (Hayton, 1992).

So there will be considerable room for interpretation of this convention as it provides guidelines for negotiation of different specific agreements.

Final comments

Development of international water law, from legal doctrines of ancient communities has been long and with diverse participants. Adoption of the 1997 Convention is, in actual fact, a culmination of that process and should be considered as the most advanced stage in development of law in that field. But the politics of water resources and its utilization, especially in international context will create a very slow process for general acceptance, entry into force and actual implementation of the treaty.

For that reason, the beginning must be in encouraging widespread adoption of agreements specific to different watercourses and to see the incorporation of principles from that convention. But that process must begin with a general recognition of the necessity for organized and collaborative management of international watercourses as an approach to sustainable development.

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Management of a shared lake ecosystem: A case study of Lake Victoria

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Abstract

Lake Victoria is the largest freshwater lake in Africa and it's the most important shared natural resource that defines the East African Community, which is presently constituted by Uganda, Kenya and Tanzania. The management of Lake Victoria resources, which are abound, is challenging and complex because of the different competing multi-stakeholders at national and regional levels.

The management of the Lake Victoria Ecosystem has transitioned from the traditional methods into national and regional mechanisms. The latest regional management approaches in Lake Victoria were introduced in 1996 under the auspices of the East African Cooperation and following the designation of the lake as a 'Regional Economic Growth Zone' and 'an Area of Common Economic Interest' for people of East Africa and that it be exploited in a coordinated process so as to maximize its economic and social benefits as well as the environmental concerns. The Treaty for the Establishment of the East African Community provided the required legal basis for the cooperation

To realise the aspiration as set out in the Treaty, a Lake Victoria Development Programme was established at the East African Community Secretariat in 2001 with a mandate to coordinate the multi-stakeholders and Partner States initiatives in the Lake Basin with a focus on economic development, poverty reduction and environmental protection. National Focal Points have been established in each Partner State to support the Unit. Furthermore, five Development Partners entered into a Partnership Agreement with the East African Community to support development in the lake.

In addition, a shared Vision and Strategy Framework for the Management and Development of the Lake Victoria Basin is now in place together with the Protocol for Sustainable Development of Lake Victoria Basin. A Lake Victoria Basin Commission as an apex and independent institution of the Community responsible for Lake Victoria Basin affairs became effective on 1st July 2005.

The management strategy has started yielding positive impacts in areas of conflict prevention and resolution, investment, projects development, harmonisation of relevant laws, networking and sharing of information and research

Keywords: East African Community; Lake Victoria Development Programme; Protocol for Sustainable Development of Lake Victoria.

Introduction

East African Community (EAC) is an intergovernmental regional economic organisation that is currently involving three countries (Partner States) namely: Kenya, Uganda and Tanzania. It was established by a Treaty signed in November 1999 and ratified in July 2000. The main objective of the EAC is to widen and deepen cooperation among the three Partner States in political, economic, social and cultural fields, research and technology, defence, security and in legal and judicial affairs for their mutual benefits: (EAC, 1999a).

The Lake Victoria and its Basin is one of the main focal areas, which the Partner States have prioritised in their cooperation efforts because of its uniqueness and significance to the people of East Africa.

Lake Victoria is the mother-nature main link between the three Partner States and it constitutes therefore the single most important shared and treasured resource of the region. This value is further enhanced when considering the whole catchment, which extends to the Republics of Burundi and Rwanda. The baseline description of the Lake and the whole of it drainage area is given in Table 1 and Figure 1.

The socio-economic importance of Lake Victoria to the Eastern Africa region is associated with the fact that it is:

- i The largest inland water fishing sanctuary
- ii A major inland water transport linkage for the three E A countries
- iii A source of water for domestic, industrial and commercial purposes
- iv A major reservoir for hydroelectric power generation
- v A major climate modulator in the region and
- vi Rich in biodiversity

Considering the whole basin, the socio-economic importance widens to include the vast natural resources such as wildlife, forests and minerals together with fertile soils that sustain the main economic activity of the region – Agriculture. However, despite these stated potentials, investments by both the local and international entrepreneurs are still low. The approximately 33 million people living within this basin are still bedevilled with poverty with average per capita incomes of between US$ 90- 270: EAC (2003a).

Table 1: Description of Lake Victoria and its basin.

Country	Lake Surface area		Catchment Area		Lake Shoreline	
	Km2	%	Km^2	%	Km	%
Tanzania	33,756	49	79,570	44	1150	33
Uganda	31,001	45	28,857	15.9	1750	50
Kenya	4,113	6	38,913	21.5	550	17
Rwanda			20,550	11.4		
Burundi			13,060	7.2		
Total	**68,870**		**180,950**		**3,450**	

(Adapted from the Lake Victoria Environmental Management Project document, 1994).

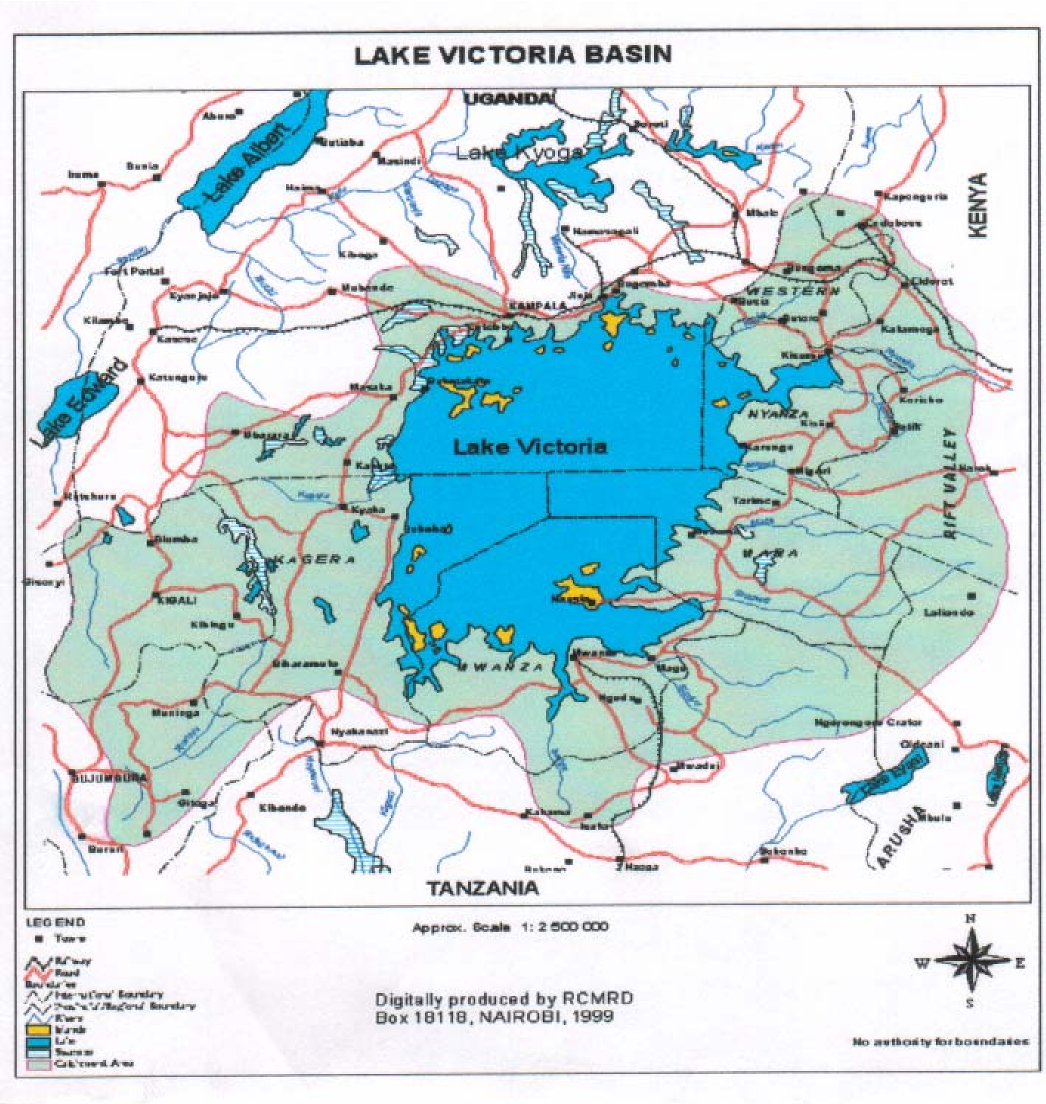

Figure 1: Map of Lake Victoria Basin.

Environmental concerns

The Lake has in the last four decades experienced very enormous environmental changes that have largely been influenced by both human activities and anthropogenic causes. Typical examples include; the prolonged spells of lack of oxygen (Hecky, 1993); increase in algal concentrations and changes in the abundant species (Mugidde, 1993); the reduction of the fish species diversity, the emergence of water hyacinths in the Lake (Twongo, 1996) and the pollution loading from the municipal and urban centres spread in the entire basin (Okurut *et al.,* 2003). In the catchment, the major environmental and conservation shocks have arisen out of the deforestation rates, poor agricultural practices and drainage of critical wetlands and silt loading to the Lake has increased by two-fold (LVEMP, 2001)

Management concerns

Arising from the rich natural resources base of the entire Lake Basin, many stakeholders have been attracted to this region and most of them have diverse interests especially in the Lake itself. The motive of those involved in the Basin is driven by the need to maximise exploitation of the natural resources in whatever manner but with minimum or no regard for the impact of their activities. A survey undertaken in the Lake region showed that there are several programmes and projects that are being implemented by individuals, associations and Non-Governmental Organisations (NGOs) with or without assistance from development partners and other interest groups and most of them did not effectively contribute towards the attainment of the common goals (EAC, 2003, unpublished data).

Another characteristic feature that existed in the Basin was the minimal interaction between and among the various groups/ associations/NGOs implementing various projects in the Lake Basin and often acted as adversaries to each other. This state of affairs was not healthy and as a result, most of the projects/programmes implemented are often duplicated within the same areas and most often in the different Partner States. The concept of *'a starting syndrome'* was in play where each project was initiated as if no other one has existed before it and to learn from. Often donor funding is sought from same sources. It is therefore not surprising that poverty and degradation of the environment are still endemic in this region in spite of the interventions and the funding quoted.

Management Approaches

Regional Management Initiatives

Following the conclusion of the World Earth Summit of 1992, the three Partner States of the East African Community initiated mechanisms for addressing the concerns of poverty and environmental degradation in the Lake Basin. One first such mechanisms was the establishment of the Lake Victoria Fisheries Organisation (LVFO) in 1994. The key objective of this Organization was to harmonize measures for sustainable utilization of the living resources of the Lake and to develop and adopt conservation and management measures thereof (LVFO, 1996). The second major intervention was the development and joint implementation of a regional project: the Lake Victoria Environmental Management Project (LVEMP), (LVEMP, 1994). The implementation of this project started effectively in 1996 with a holistic approach in environmental management for the Lake Victoria Basin. Both LVFO and LVEMP have contributed enormously towards the knowledge base of the Lake Victoria environment as well as contributing towards poverty reduction in various ways.

The achievements and challenges gained from LVEMP and LVFO propelled conceptualisation of a framework for a coordinated management of this shared ecosystem. In addition, the experience learnt from management scenarios from other shared water bodies, such as the Baltic Sea and the American Great Lakes indicated that there is a need for establishing a central coordination body for the activities in the Basin at the EAC level.

EAC Management Strategy

The strategy adopted for the management of the Lake and its Basin was based on the identification of critical requirements that must be put in place to support all the initiatives. Critical among these are:

i Sustained political commitment at the highest levels for the Lake Basin affairs;

ii Establishment of a regional institutional mechanism to coordinate the process of development;

iii Strengthening existing organizations that have overlapping mandates in the Lake Basin affairs;

iv Involvement and participation of the multi-stakeholders in Lake programmes in a coordinated manner;

v Partnerships with interest parties – local and international and;

vi Funding by the Partner States governments

Results and Actions

To date the EAC Strategy for development and management of Lake Victoria and its Basin has revolved around responding to these critical factors as highlighted above. The sections below show the results of response to each of these factors.

Political Actions

The Political commitment by the EAC Partner States in the development and rationale management of the Lake and its Basin has been demonstrated and sustained from 1996 to date. This is clearly evident from the several decisions taken by the Summit (Heads of State) and the Council of Ministers at their various meetings that have been the Basis for undertaking various interventions in the Lake. Typical examples of these include:

i The designation of the Lake Victoria and its Basin in the 1977-2000 EAC Development Strategy as an '*economic growth zone'* and '*an area of common economic interest'* to be exploited jointly in a coordinated implementation process in order to maximize its economic and social benefits, while taking into consideration the need to provide an effective environmental management regime for posterity. These provisions were further crystallised in *The Treaty for the Establishment of the East African Community* (EAC, 1999a) under various chapters and more specifically in Chapter 19. Arising from this decision several follow up actions have been undertaken in the development of the management framework for the Lake ecosystem.

ii The Establishment of Committee for Lake Victoria Development Programme (CLVDP) in 1999 (EAC, 1999b). This Committee is composed of Permanent Secretaries from the relevant sector Ministries and is charged with the responsibility of providing the necessary policy guidance for the activities of the projects and programmes related to the Lake Victoria Basin. This Committee has actively steered the development initiatives of the Basin through their effective consultative fora.

iii The Establishment of the Sectoral Council for Lake Victoria Basin in 2002 (EAC, 2002) to provide overall policy directions for the development and management of the Lake Victoria Basin in accordance with the provisions of the Protocol. The Sectoral Council is now the top policy organ for the newly created Lake Victoria Basin Commission.

iv The signing and ratification of the Protocol for Sustainable Development of Lake Victoria Basin in 2003 and 2004 respectively by all the three Partner States (EAC, 2003b; 2004b). The Protocol provides the legal status of the Lake Victoria Basin Commission and policy guidance to the national initiatives related to the Lake Victoria Basin management. The application of this Protocol has already begun at both national and regional levels.

v The Adoption of the Shared Vision and Strategy Framework (SVSF) for the Management and Development of Lake Victoria Basin and its use as a Planning Tool by all stakeholder in 2004 (EAC, 2004). The SVSF clusters priority areas for intervention under five policy areas. The use of this document by the various stakeholders is now gaining momentum among government, stakeholders and development partners.

vi The preparation and development of a single legislation for regulation of transportation in Lake Victoria from 2002-2004. The Bill is due for consideration by the East African Legislative Assembly in the last quarter of 2005 and the actual implementation of the Lake Victoria Transport Act is expected to be operational at the beginning of 2006.

Regional Institutions and Mechanisms

As noted earlier on, the management of Lake Victoria and its Basin is very complex because of the different stakeholders undertaking different activities. The EAC Strategy was the sequential establishment of regional management mechanisms notably:

1. The Lake Victoria Development Programme (LVDP) Unit established within the EAC Secretariat 2001. Since 2001, the LVDP has effectively implemented its mandate of promoting, coordinating and facilitating the socio-economic growth and Environmental management initiatives within the Lake Basin.

2. The National Focal Points for the Lake Victoria Basin were established in each Partner State in 2002 (EAC, 2002) for purposes of coordinating all National Sectoral initiatives in the Lake Victoria Basin and to provide linkages to the EAC Secretariat. The National Focal Points are hinged in the Ministry of Water, Lands and Environment in Uganda; Ministry of Environment and Natural Resources in Kenya and, Ministry of Water and Livestock Development in Tanzania.

3. The Lake Victoria Basin Commission (LVBC), which is established as per the provision of the Protocol on the Sustainable Development of Lake Victoria Basin. The LVBC started its operations in 2003 but it formally became effective in July 2005. The establishment of LVBC is a clear manifestation of the determination of the East Africans to put in place a management mechanism for Lake Victoria and its Basin that will guarantee its productivity for now and for posterity.

Strengthening existing Institutions

There are several national and regional institutions with mandates extending to the Lake. Since 1996, the EAC has strongly collaborated with these institutions in various ways but more so in promoting networking and data sharing. The most significant aspect for the national institutions was the strengthening / building up of the human resource and infrastructure capacity through the Lake Victoria Environment Management Project from 1994- 2005 (LVEMP, 1996 – 2004, unpublished data).

The Lake Victoria Fisheries Organisation (LVFO), which is an institution of the EAC responsible for Fisheries management on Lake Victoria, has been strengthened in its working ethics especially in financial management and legal aspects.

The East African Development Bank (EADB), which is also an institution of EAC has provided critical funding to the LVDP through the Partnership Funding and through this interrelation, EADB is now poised to fund a number of investment ventures in the Lake Basin.

The Inter University Council of East Africa Inter-University Council (IUCEA) is an institution of the Community responsible for higher education and research. Its capacity has been enhanced through fund mobilisation from the government of Sweden for specific research activities focussing on the Lake

Victoria Basin (VicRes). This programme started in 2003 and is operational to date. This programme is of great significance to various stakeholders who need research outputs for informed decision-making process.

EAC has strategically also supported the Nile Equatorial Lakes Subsidiary Action Program (NELSAP) which is responsible for implementation of three River Basin Integrated Water Resources Management Projects covering Kagera; Mara and Sio-Malaba-Malakisi. The implementation of these projects does now have the necessary political clout to successfully drive the entire process.

Partnership and cooperation with other Stakeholders

The role played by other stakeholders in the development of the Lake Victoria Basin, is an undisputable factor that is recognised by the EAC. To tap on the resource base from these Partners, as well to refocus their initiatives to the same priority areas of LVDP, the EAC, entered into Partnerships with the following governments and institutions:

1. The Governments of France, Norway and Sweden, the World Bank and the East African Development Bank through a Partnership Agreement on Sustainable Development of Lake Victoria Basin (Partnership Agreement, 2001, unpublished data). The Agreement provides for a partnership to promote sustainable development in the Lake Victoria Basin on the basis of agreed objectives and principles as spelt out in the Agreement.

2. The World Conservation Union, Eastern Africa Regional Office (IUCN-EARO); the World Wide Fund for Nature (WWF) ,Eastern Africa Regional Programme Office (WWF-EARPO) and the International Centre for Research in Agroforestry (ICRAF) through Memoranda of Understandings (MoUs) concluded in 2002 and 2003 (MoUs: EAC- IUCN, 2002; EAC- WWF, 2003 and EAC-ICRAF 2003, unpublished data). Under the partnerships, these international NGOs are now able also to plan and develop their interventions in the different communities in a coordinated manner and along the same priority areas of the EAC with minimal duplication.

3. The Governments of Republics of Rwanda and Burundi concluded Memoranda of Understandings with EAC in 2004 (MoUs: EAC-Rwanda, 2004 and EAC Burundi, 2004 unpublished data). Rwanda and Burundi are part of Lake Victoria Basin but are not yet members of the East African Community but through this MoU, the two have now been enable to fully participate in the development and management agenda of the Lake Victoria. For instance, they are jointly involved in the preparation process of the 2nd phase of the Lake Victoria Environmental Management Project. This was not possible in the 1st phase.

Funding by EAC Partner States

The political commitment highlighted earlier needed to be backed up by funding directly coming from the Partner States and not only from the donors. With regard to the development of the Lake Victoria and its Basin, the EAC Partner States have since creation of the LVDP Unit in 2001 fully funded the Recurrent Expenditure of the Unit. The countries contributions have steadily been increasing on annual basis starting from USD 66,950 in 2001 to USD 913,029 in 2005 (EAC Budgets, 2001, 2005, unpublished data). Besides, the Partner States have allocated budget lines towards meeting the costs for the National Focal Points offices in each country.

This funding commitment is the critical indicator of the support the Partner States are giving towards the management modalities of Lake Victoria and its Basin.

Involvement of stakeholders

As indicated in the previous sections above, there are many stakeholders in the Lake and its wider Basin and many more who are directly or indirectly influenced by the actions taking place in the Basin. In order to ensure ownership and commitment of stakeholders in the regional management arrangement described above, the EAC has systematically involved as many key stakeholders as possible in the planning and development of the major policy instruments and projects such as:

1. The Protocol for Sustainable Development of Lake Victoria Basin;

2. The Vision and Strategy Framework for the Management and Development of Lake Victoria Basin;

3. The Lake Victoria Transport Bill

4. The Lake Victoria Environmental Management Project and;

5. Outreach programme activities.

The LVDP works very closely with the regional Private Sector and Civil Society Organisations whose interests have a bearing in the development of the Lake Victoria and its Basin. Notable among these are: the East African Business Council (EABC) and the East African Communities' Organization for Management of Lake Victoria Resources (ECOVIC), the East African Law Society and the Lake Victoria Regional Local Authorities Cooperation (LVRLAC). The cooperation with LVRLAC for instance has culminated into the development of a joint project proposal with the EAC on water and sanitation. This proposal has now been concretised with cooperation with UNHABITAT under its realm of Lake Victoria water and sanitation initiative.

Discussion

The above management and coordination mechanisms that the EAC has developed and put in place for the Lake Victoria and its Basin has started bearing the expected fruits although to differing extents. For instance, the coordinated involvement of the community and other strategic stakeholders in the management of lake that is coupled with the political commitment exhibited by the directives of the Council of Ministers has resulted into the a significant reduction of conflicts related to the fishery resources. The conflicts over fishing in the Lake had been a sore spot in the overall integration efforts of the EAC. Often, fishermen were arrested and charged in courts of laws within the Partner States for various offences. The coordination efforts of EAC have culminated into the harmonisation of the Fisheries Acts in the three partner States and a dialogue mechanism in the border areas. These interventions positively impacted on the fisheries management in the lake and this model will soon be extended for conflict prevention and resolution for other shared resources in the region as well.

The need to build synergies in the various interventions in the lake has been concretised through the management approaches described above. The partnership established with the main donors and the international/regional NGOs and coupled with the cooperation with the governments and local NGO's has contributed to preparation and execution of projects that focus to the priority issues. Further, it has ensured sustained Development Partners interest in the lake. The Mt Elgon Regional Ecosystem Conservation Project and the 2nd phase of Lake Victoria Environment project are two such projects developed with all stakeholders, governments and the EAC (*MERCEP, 2005 unpublished data*).

Cooperation in research and data sharing among researchers, administrators and institutions has been greatly enhanced in the EAC region over the last ten years. Much of this is attributable to the revival of the Community in general but the initiatives in the lake Victoria have been the main drivers of these changes. The first phase of LVEMP, the LVFO and the IUCEA- VicRes programs in the lake have entrenched cooperation among the researchers and institutions in the region. At the EAC, a Lake Victoria Resource Centre will soon be on line as a one spot centre for all information on the lake and its basin.

The Lake Victoria management strategy has hastened the process of harmonisation of laws, policies and regulations among the three Partner States. For example, the laws regulating water transport on the lake were different in the three countries and moreover, in each country, there were multiple registration authorities. In this circumstances regulating the vessel was a problem nationally and worse regionally. Based on the new management strategy, the national laws have all been harmonised and resulting into development of a single law to govern transport of Lake Victoria and which is to be enforced in all Partner States. (EAC Lake Victoria Transport Bill, 2004 unpublished data).

Conclusion

The experiences from the EAC activities in the Lake Victoria and its Basin indicate that the management of a shared Lake System requires a very committed and focussed management body to coordinate all initiatives therein with a view to building synergies among different stakeholders. On the other hand, for this to be achieved, a High-level of Political commitment is a prerequisite since it creates and stimulates a sense of ownership among the different actors as well as gaining the stakeholders willingness to cooperate in managing the resource.

Strengthened institutions play a crucial role in developing and implementing shared programmes in the Lake. For these institutions to operate effectively, a funding mechanism from the governments is a necessity so as to justify and attract additional support from development Partners. Finally, it is worth noting that the management of a shared lake ecosystem is not restricted to country administrative boundaries. A partnership with countries that benefit from or contribute to the destruction/ disturbances of an ecosystem is an important commitment to ensure all countries are fully involved.

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The influence on the water resources management of the Lake Chad from national policies of member states of Lake Chad Basin Commission

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Introduction

Lake Chad and its active basin constitute an important freshwater resource for riparian countries, Cameroon, Central African Republic, Chad, Niger, Nigeria and Sudan as Member State Observer which involved within the lake Chad conventional basin, the jurisdiction of the lake Chad basin commission created in 1964. Indeed, The lake Chad Basin conventional currently covers 1 053 455 Km^2 of surface area of the hydrographic basin where about 22 million people earn their living from socio-economic activities.

The initial mission assigned to the commission, included the following: a) collect, evaluate and disseminate information on projects prepared by Member States and recommend plans for common projects in the Lake Chad Basin, b) Establish a link between Member States in order to ensure optimum use of water and other natural resources in the basin, c) follow up and implement studies including progress of activities undertaken in the basin and inform Member States accordingly, d) examine complains and settles disputes and e) security coordination with the basin.

The current situation in the Member States and activities at the Executive Secretariat of Lake Chad Basin Commission is marked : poor decision-making, short term development policies, unsustainable development decisions, lack of water and environment management policy, poor coordination mechanism due to low participation by all actors within the basin and badly constituted institutional framework, poor economic situation all the Member States and explosive population growth leading to considerable pressure on all available resources in the Lake Chad Basin.

This paper particularly is interested to explore the influence on the water resources management of the Lake Chad from national policies of Member States of Lake Chad basin commission.

Lake Chad Basin context

The Lake Chad (GIWA region 43) situated in Central Africa between 6° - 24°N and 8° - 24°E is a vast expanse of land of several catchments. The geographical basin covers an area of 2 434 000 Km^2 which represents 8% of the surface area of the African continent. This geographical basin is shared between the countries of Algeria, Cameroon, Central Republic (CAR),Chad, Libya, Niger, Nigeria and Sudan with area coverage per country (Eros Daba Centre, 2002) as followed.

	Geographical basin area	**Geographical basin area (%)**	**Convention Basin area**	**Conventional Basin (%)**	**National territory (%)**
Algeria	91 000	3.74			
Cameroon	47 400	1.93	56800	5.39	12.12
CAR	216 000	8.87	197800	18.78	31.75
Chad	1 123 000	46.14	361980	34.36	28.42
Libya	5 100	0.210			
Niger	674 800	27.72	162375	15.41	12.70
Nigeria	179 300	7.37	205500	19.51	22.15
Sudan	97 700	4.01	69000	6.55	

The necessity of regulating and controlling the utilization the bulk of water and other national resources of Lake Chad basin that Lake Chad Basin Commission (LCBC), an intergovernmental Agency has been established by the Fort-Lamy (now N'Djaména) convention signed on 22 May 1964 by the Heads of states of the four countries (Cameroon, Chad, Niger and Nigeria) which shared the Lake Chad. LCBC now is composed of five members states. Cameroon, CAR, Chad, Niger and Nigeria, Sudan was admitted in 2002 as observer country. The LCBC comprises a conventional Basin about 1053455 Km^2.

Physical situation

The region is bounded to the north by the Ahaggar Mountains in Algeria. From this summit, the border descends southwards towards the Tibesti highlands that forms the border between Libya and Chad, and continues to about 19°N near the Djebel Mara volcanic mountains in Sudan. The southern border is defined by the Mongos Hills in CAR and the Adamawa Mountains at about 6°N and further west by the Mandaras in the northern Cameroon at the proximately 10°N. The Jos plateau marks the western boundary in the Nigerian sector of the basin and further north the Air plateau in Niger

Climate situation

The conventional Basin of Lake Chad area is divided in three climatic regions:

- Saharan zone at the North is desert climate with low animal rainfall (less than 200 mm) and variables temperatures (maximum 47°C and 12°C minimum);
- Sahelian zone between the 12-16th North parallels with rainfall from 200-700 mm
- Sudanese zone characterized by a semi and to humid climate. The rainfall varies between 700-1200 mm and the mean temperature is about 28°C, lowest humidity is 51% while the highest is 96%.

Morphological , hydrological and hydrogeological situation

The Conventional Basin is the greatest hydrological unit without outlet of the African continent. The water of Lake Chad are supplied by the Chari-Logone (95% of the total input by southern pool), the Komadugu-yobe and Yedserama Ngadda Systems less than 2.5 % into the northern pool.

The Komadugu-Yobe river basin with area about 148 000 Km^2 is located in Nigeria and Niger and is formed by various tributaries, in the particular the Hadéjia, Jama're and Misan rivers that flow from the Jos plateau (northern Nigeria). The Komadugu-Yobe river is the only river supplying the northern pool of the Lake Chad.

The Chari-Logone River basin with area about 600 000 Km^2 is located in CAR, Cameroon and Chad and contains various rivers that flow from the Mongo Hills (CAR), as well as the Addamawa plateau and Mandara Mountains (Cameroon). The major tributaries are the Pendé, which become the Logone oriental on entering Chad and the Tandjilé. There is seasonal flooding in both the Chari-Logone and the Komadugu-Yobe basins, which feed the extension Waza-Logone floodplains and Hadejia-Nguru wetland repectively.

The Yedseram and Ngadda sub. System and its tributaries rise in the Mandara Hills and loses most of its water while flowing northwards through a floodplain. From Sudan in the East, flow seasonal Wadis (Wadi Kaya and Wadi Azum) whereas from the north there is virtually no surface flow.

The area of the Lake is variable (25 300 km^2 with 105 x109 m^3 as volume in wet period and less than 20 000 km^2 with 65 x 109 m^3 as volume in dry period. Tilho created a classification at the beginning of the 20th century:

- The « Grand-Tchad » with an area of 25 000 km^{2}in 1962-1965,
- The « Moyen-Tchad »was seen in 1917 and 1919, then from 1967-1969. The area was between 15 000 and 20 000 km^2. But, there were two basins (one in the north and one in the south). The northern basin is supplied by the Komadugu which come from Nigeria and Niger and it does now have any contact with the southern basin.
- The Petit-Tchad has been described just in 1915 and exists nowadays. The northern basin is not supplied anymore. The Lake Chad area is only 2 000 km^2 (photo satellite of the Lake Chad).

Hydrogeological viewpoint: the conventional Lake Chad basin falls within the tectonic zone which also witnessed sedimentary depositions during the tertiary and quaternary ages. Four major aquifers are found within the basin :

- The phreatic aquifer of quaternary age, widely exploited because most accessible and because by nature the most affected by climatic fluctuations
- The perched or artesian aquifer at great depths;
- The lower Pliocene aquifer formed by 20-70 m thickness of sand deposits between 200 to 400 m depth, separated from the phreatic aquifer by a clay layer 100 to 200 m thick;
- The Continental Terminal aquifer formed by 40 to 60 m sand deposits, located between 400 and 600 m depth. This aquifer is exploited more in Nigeria than in other countries within the basin.

The annual recharge of the aquifers within the basin is estimated at between 60 and 70 billion m^3.

Socio-economic characteristics

The main activities predominant within the conventional basin are, notably: i) agriculture, animal husbandry and fishery. All these activities are closely tied to the water resources within the basin. The agriculturists are sedentary whereas traditional animal husbandry is mainly nomadic. The number of animals within the conventional basin increases continuously. The fishery is mainly traditional and is practiced on the rivers and streams, the Lake Chad, ponds and floodplains.

The lake Chad basin contains numerous ethnic groups, whose language, legal and administrative systems based upon traditional pre-colonial culture and the English and French colonial covers. The population of the lake Chad basin has experienced rapid growth in the last decades is 2.6 in average and is currently estimated to over 37 million.

The country member states of LCBC are among the poorest in the world and are characterize by extremely slow and variable economic growth (e.g. Chad was ranked 155th out of 162 countries according to UNDP's human Development index, with per capita income of only 200$ US.

Institutional and organizational context

The Lake Chad Basin Commission (LCBC), an intergovernmental Agency, was established by the Fort Lamy (now N'Djamena) conventional and statutes on 22 May 1964 by the Heads of four countries that share the Lake Chad. This old conventional basin (427 000 Km^2) did not include the CAR and excluded the large desert expanses of Algeria, northern Niger, northern Chad and Sudan, and in particular excluded the upstream part of the active basins of the Chari-Logone and Komadugu-Yobe. In March 1994, CAR was admitted as the fifth member state leading to the new conventional thus increasing the conventional area. This enlarged the conventional basin to include the Upper basins of the Chari-Logone and Komadugu-Yobe sub-systems while Sudan was admitted into the LCBC in June 2000. With the admission of Sudan, the conventional area is now at 1 035 000 Km^2.

Briefly, the institutional arrangements is as follows- the Summit of heads of states of member states, the council of ministers (2 commissioners per member staff) and executive secretariat with its staff and 5 departments (planning, project monitoring and evaluation, agro-sylvo-pastoral production, administrative and financial affairs, water resources and environment, publications and information)

Major problems of the Lake Chad Basin

Rainfall pattern

The rainfall pattern in the Basin is of the sahelian climatology thus making it highly variable and unpredictable. For instance, in a period of two decades, isohyetal contours of mean rainfall have shifted to the south by about 180 km. As a result of this areas that have experienced a mean rainfall of 320 mm now receive 210 mm.

Water balance

The overall water balance in the basin is affected by the close interaction between rainfall, evaporation, the generation of lateral inflow to the Lake and the ground water leakage under the body of the lake.

Soil types

The properties of the soils in the basin vary considerably throughout the region and this affects the vegetation in the basin.

Drought and desertification

Rainfall deficits first noticed in 1972 have continued unabated till now, although there are occasional overflows of short duration. The cumulating effect droughts have led to the systematic shrinkage of the lake.

Environmental degradation

The natural cause highlighted above together with man-made causes such as upstream dam construction, land degradation, soil erosion, deforestation and bush burning have created serious environmental degradation problems.

Population

Population growth is another major problem in the basin. By the year 2025 the population of the basin is projected to be over 36 million from the current figure of 22 million. Population explosion and migration in pursuit of means of livelihood by the pastoralists, fisherman and environmental refuges as a result of desertification lead to competitions for scare water resources in the basin resulting into conflicts.

Poverty level

The cumulative effect of all the problems listed above is poverty. The five countries of the Basin are classified amongst the poorest in the world.

Absence of legal instruments to enforce the statues of the convention

No allocation clause in the provisions of the statutes of the convention

Absence of water policies in member states; thus transboundary water policies are implicit rather explicit.

Lack of clarity in the institutional relationship between LCBC and water, environmental institutions in member states. What are the role and responsibilities of the various institutions in the integrated water resources management in the Lake Chad Basin?

Institutional weakness

- Poor Management
- Negative competition for resources
- Diminishing resources base (natural constraints)
- No legal instrument to facilitate transboundary management
- Inadequate funding

National water policies analysis of Member States influencing water resources management in LCBC

National sector and environmental plans exist in each riparian country. At national level, the relevant environmental institutions are:

- **Cameroon**: the national Consultative Committee on the Environmental and Sustainable Development (CCNUDD, 1997), which includes the Prime Minister, various ministers, professional associations and NGOs
- **Chad**: the National High Committee on the Environment, which includes the Prime Minister and Various ministers (HCNE, 1995)
- **Central African Republic**: Information not available
- **Niger**: the National Council Committee on the Environmental and Sustainable Development (CNEDD, 1997), which includes the Cabinet leader, various ministers, civil society, universities and NGOs
- **Nigeria**: The federal Environmental Protection Agency (co-ordination of ministers) backed by the National Advisory (Government organizations, private sector, NGOs, community

organizations, university) by the National council on the Environment (States). Almost all the states in the federation have prepared a long term Environmental action Plan.

National water policy existing

Let us examine the national water policy in the riparian countries, the practical water management setting.

Cameroon

- Type of national water policy:

The national Consultative Committee on the Environmental and Sustainable Development (CCNUDD, 1997), which includes the Prime Minister, various ministers, professional associations and NGOs;

Main institutions in charged of water resources management

- National Hydraulics Directorate of civil engineering and Villager hydraulics
- Ministry of Mining, water and energy
- Ministry of Agriculture
- SEMRY

Central African Republic

- Type of national water policy:
- Main institutions in charged of water resources management
- Ministry of Energetic and Mineral Resources
- Ministry of Water and Forest, Hunting, Fishing, Tourism and Environment
- National Water and Sanitation Committee
- CHAD

Type of national water policy:

- The National High Committee on the Environment, which includes the Prime Minister and Various ministers (HCNE, 1995)
- Water Code promulgate by the Law N^{o} 016/PR/1999 of 18 August containing 183 articles
- Main institutions in charged of water resources management
- Before 1978
- Ministry of Agriculture and the Struggle against Natural Calamity on behalf of Ministry of Livestock and Animal Resources
- Ministry of Public Works, Mining and Geology
- Ministry of Communication and Transportation
- After 1978
- Ministry of the Environment and the Water

Some general observations from the available national water policy in the riparian countries influencing on the regional water resources management:

- In the most of riparian countries except in the CAR where the data are available a part time, the practical law texts are not yet elaborated;
- In all of the countries, the integrated water resources management concept is absent as the water management type, neither management of hydrological drainage basin;
- The water management does not adapt to drainage basin approach;
- The participation of interest groups is not clearly defined or need to define, there is not the consensus on their roles, responsibilities and priority actions
- There is a necessity to modify the current law related to national water policy in order to adapt it to the international context of integrated water resources management and the shared water resources for all riparian countries;
- In all riparian countries, there is not the implementation of the integrated water resources management processes;
- Each of these riparian countries apply its own legislation related to water without the upstream – downstream consultation
- The lack of application and monitoring of the various regional or bilateral agreements have leaded to the conflicts between States or revering population upstream/downstream or left/right side for the use of water in scarce period notably: Between the Chad and Cameroon 1985 - 86 on surface water of Logone river opposed revering population left/right side.

Between Chad and Nigeria in 1986 related to the marking off the lake Chad water in LCBC agreement:

- Absence of legal instruments to enforce the statues of the convention
- No allocation clause in the provisions of the statutes of the convention
- Absence of water policies in member states; thus transboundary water policies are implicit rather explicit;
- Lack of clarity in the institutional relationship between LCBC and water, environmental institutions in member states. What are the role and responsibilities of the various institutions in the integrated water resources management in the Lake Chad Basin?

From all above observations related to national water policy existing in riparian countries of Basin, which water vision for the sustainable development for the population in shared water resources management context for the transboundary River basin like the LCBC?

For this, it will better to enumerate the ideal opportunities we like to have particularly those related to institutional, management, legal instrument to facilitate transboundary resources management and inadequate funding.

Future outlook

What ideal opportunities for common vision for Lake Chad Basin for future generations? Adoption of the integrated water resources management by Member states and the Reorientation and harmonization of LCBC mandate with national water polices of member States was recommended.

For the Sustainable/integrated Management of resources for future generations, the needs to be done are like institutional, management, funding was formulated by the institutional, financial audit of LCBC, 1998.

Institutional

1. Establish at national an inter-ministerial committee close link to LCBC
2. Reviewing existing conventions and status from the best practices from elsewhere and facilitate approval by member states;
3. Formulate regional framework for water policies (including of roles and responsibilities and harmonization)
4. Restructure LCBC to oblige it with its new mandate as determined by the vision of the region;
5. Revise rules and regulations governing the operations of LCBC

Management

1. Develop framework (+ protocol) for data collection
2. Develop capacity for collection(at member states level) and processing and management(at LCBC level) of data
3. Devise and promote framework for institutionalised participatory management
4. Devise and promote framework for institutionalised integrated impact assessment
5. Develop and implement a human resource capacity development program

Funding and mobilisation

1. Promote development of financial strategies at regional level;
2. Develop mechanisms for revenues generation at national level (e.g. polluter pays principle)
3. Develop bankable projects with potential for cost recovery and/or income generate
4. Establish mechanism for dialogue between LCBC and member states on implementation of poverty reduction programs, etc.

Conclusion

The LCBC, a key player in shared water resources management, regional economic integration and cooperation, regional security coordination as well as conflict prevention in the western and central African regions, needs a robust political commitment. This is why, there is an endeavour to reshape LCBC and transfer it to a modern organization with a shared vision program and strategic action plan which must be harmonized with national water policies of member states. This is in order to satisfy present and future demands and challenges. All of the needs to be done are contained in the adopted LCBC Framework for cooperation, GTZ workshop, N'djamena, 2004.

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Distribution of economic benefits from the fisheries of Lake Victoria

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Abstract

The Lake Victoria fishery contributes immensely to the socio-economic development of the riparian states. The East African Community has designated the lake basin as an 'economic growth zone', with the potential to develop into a major economic region. The fisheries are vital in creating employment opportunities, mostly rural-based, thereby helping to reduce rural-urban migration. Fish is also a rich source of animal protein for human consumption and provides raw material (fishmeal) for processing animal feeds. The fish industry contributes to GDP and has continued to be an important source of foreign exchange earned from fish exports. Besides, the fish industry contributes to the national and local government revenues through levying of various taxes, levies and license fees. The sector has also contributed directly and indirectly to the improvement of physical infrastructure and social facilities, such as roads, schools and hospitals, particularly in remote fishing communities.

Based on current stock estimates, the lake has the potential to yield fish valued at over US$ 800 million annually on a sustainable basis. Further processing and marketing the fish in the local and export markets could provide opportunity to generate additional earnings. Currently, however, only about 500,000 tonnes of fish is landed annually, with an average landing value of approximately US$ 600 million. However, the distribution of these benefits at the regional, national and individual levels is often not equitable. High disparities in distribution of benefits is considered undesirable as it creates a sense of social injustice among the beneficiaries; can be an obstacle for self-sustaining growth; is a limitation in uplifting the resource users out of poverty; leads to low compliance to fisheries regulations and hinders attaining sustainable fisheries exploitation.

The paper assesses the distribution of economic benefits from the fisheries, using selected indicators. It reveals disparities in the benefits at the regional as well as at the local levels, with more benefits accruing to the upper levels of the fish marketing chain. The disparities are attributed to unequal distribution in production assets such as capital, skills and credit facilities; free-market price determination mechanisms; inadequate access to market and other useful information; limited investment horizon and opportunities among fishers; inadequate policies to deal with disparities in distribution and insufficient data for distribution analysis to feed into the policy process. In order to streamline distribution, the paper proposes, among other things; establishing suitable savings and credit schemes, empowering BMUs to organise fishers for marketing, improving market information flow through electronic and print, operationalising the Fish Levy Trust Fund for infrastructural and social facility development, improving policies and improving data availability.

Key words: Economic benefits, Disparities, Distribution, Equity, Poverty, Gross domestic Product

Introduction

The Lake Victoria fishery contributes immensely to the socio-economic development of the riparian states. The East African Community has designated the lake basin as an 'economic growth zone', with the potential to develop into a major economic region. The fishery is vital in creating employment opportunities, mostly rural-based, thereby helping to reduce rural-urban migration. Fish is also a rich source of animal protein for human consumption and provides raw material (fishmeal) for processing animal feeds. The fish industry contributes to GDP of the riparian states and has continued to be an important source of foreign exchange earnings through fish exports to the regional and international markets. Besides, the fish industry contributes to the national and local government revenues through the various taxes, levies and license fees. The sector has also contributed directly and indirectly to the improvement of physical infrastructure and social facilities, such as roads, schools and hospitals, particularly in remote fishing communities.

Lake Victoria is estimated to produce 500,000 tonnes annually, valued at US$ 600 million, with export value of US$217 in 2001 (LVFO, 2005). Based on current stock estimates, the lake has the potential to yield fish valued at over US$ 800 million annually on a sustainable basis. Further processing and marketing of this fish in the local and export markets can generate an additional value of about US$ 57 million.

Various goals have been considered to guide the utilization of Lake Victoria's fisheries resources. These goals derive from the definition of the concept of sustainable development in relation to fisheries, as provided for in the Agenda 21 of the Rio Conference. The Millennium Development Goals (MDG) of the United Nations provide for reduction in the number of people in extreme poverty and suffering hunger by half by the year 2015, eliminating gender disparity, ensuring environmental stability and developing global partnership for development, among others. Relevant elements of the Code of Conduct for Responsible Fisheries (CCRF) are also incorporated into national fisheries development and management plans (FAO, 1995). At the regional level, the development strategies of the East African Community (EAC) identify Lake Victoria and its basin as an "economic growth zone" to be exploited in a co-ordinated manner to maximize economic and social benefits and at the same time provide environmental management and protection. LVFO's mission statement spells out its goal for Lake Victoria as "restoring and maintaining the health of its ecosystem, and assuring sustainable development to the benefit of the present and future generations" (LVFO, 1999). The draft Lake Victoria Fisheries Management Plan (FMP) seeks to contribute to development of sustainable fisheries by establishing a viable system for the management of the lake fisheries (LVFRP, 2001). These goals are re-echoed in the national development programs and fisheries policies of the individual riparian states as spelt out in the Policy Mandates and Organizational Review Report for Kenya, the National Fisheries Policy for Uganda and the National Fisheries Sector Policy and Strategy Statement for Tanzania (MAAIF, 2004; MARD, 2000; MNRT, 1997).

However, available information highlights the concern that the distributions of the benefits from the lake are not equitable within the riparian states, between communities, households and individuals.

Problem statement

There has been concern that the benefits from the fishery of Lake Victoria are not fairly distributed among the players. High disparities in benefits creates a sense of social injustice among the parties concerned, especially since fish is viewed as a common resource to be exploited for the common good of the people. The danger with such disparities is that they can be an obstacle to self-sustaining growth of the region and may be a limitation in the uplifting of resource users out of poverty. Often they lead to low compliance to fisheries regulations by the fishers and hinder attainment of sustainable fisheries exploitation.

Effective interventions to address these problems requires sufficient information on the extent of the disparity, the people affected and their status, the types of benefits accruing from the system and how these are distributed among sub-sectors, gender and individuals and their policy implications. This paper, therefore, sets out to provide the necessary information by addressing a selection of key questions reflected in the study objectives.

Objectives

The overall objective of the paper is to provide information to facilitate formulation of policy to address disparities in the distribution of economic benefits from Lake Victoria. The specific objectives are as follows:

i) To identify the main economic benefits from the fisheries of Lake Victoria.
ii) To explain the concerns with disparity in distribution of the benefits.
iii) To show how the benefits are distributed between the riparian countries of Kenya, Uganda and Tanzania.
iv) To show how the earnings are distributed between boat owners and crew, between the sub-sectors and by gender.
v) To identify the challenges in ensuring equitable distribution of economic benefits on Lake Victoria.
vi) To recommend the way forward in improving the distribution of benefits.

Methodology

The information presented in this paper has been generated through different methods. Secondary data search was conducted by reviewing records of fishery related institutions at the local, national, regional and global levels. Literature review was carried out, involving reports from various studies in the region. Expert consultations were conducted with key informants at the different levels.

Definition of economic benefits

Generally, the benefits to the region, riparian states, communities, households and individuals accruing from the fisheries can be grouped under the following categories:

a. Economic
b. Social
c. Institutional, and
d. Environmental.

This paper is concerned with the economic benefits. These are defined as the gains in relation to wealth acquisition and its distribution to the nations, households and individuals.

At the national level, the economic benefits include:

i Production, and its contribution to GDP, through primary, secondary and tertiary activities within the fisheries.
ii Balance of trade as given by the difference between foreign exchange earnings and expenditures in fisheries, compared to the national levels.
iii Public revenues less public expenditures in fisheries, compared to national budgets.
iv Employment and job creation as indicated by the numbers directly and indirectly involved in the fisheries.
v Food supply, given by the per capita fish quantities as well as the contribution of fish to animal protein at the national level.

At the household level, economic benefits include:

i Earnings from fish production, processing, marketing and ancillary activities.
ii Jobs accessed by communities by category of activities.
iii Fish consumption as contribution to food security and protein intake.

At the individual level, the benefits are very much the same as at the household level. However, distinction needs to be made concerning access to the benefits by gender and age group.

Results

Regional distribution of economic benefits

The major types of economic benefits are distributed between the riparian states in various ways. These distributions are to some degree related to the proportions of water surface area of Lake Victoria within the different countries, namely Kenya 6%, Tanzania 51% and Uganda 43%. However, there are other factors influencing the distribution of economic benefits as discussed later in the paper.

Table 1: Distribution of selected economic benefits by state.

Types of benefit	Distribution		
	Kenya	Uganda	Tanzania
Production (US$ Mill.)	115	156	180
Contribution to GDP	0.5%	1.5%	1.8%
Employment of fishermen (2002)	54,163	41,674	80,053
Foreign Exchange Earnings (US$ Mill)	50	88	112
Per capita Fish Consumption (Kg/year),	5	12	12
Contribution to Animal Protein (1994-97)	10.6%	29.7%	32.6%
Balance of Trade	N/A	N/A	N/A

Sources:FAO records, MAAIF, MARD, MNRT LVFRP, LVEMP, Bureau of Statistics.

Table 1 provides the indicators of distribution of the economic benefits between the riparian states, namely Kenya, Uganda and Tanzania. The highlights are as follows:

i Production values relate closely to distribution of the lake between Uganda and Tanzania. However, in the case of Kenya, it is rather out of proportion with the water area within the country. Cross border fishing, fish trade and variations in fish prices are among the factors influencing production values of the countries.

ii Contributions of fisheries to GDP data show similarity between Uganda and Tanzania but are much less in Kenya. This shows that fisheries contribute much less significantly to the national economy in Kenya than in the other riparian states.

iii Recent frame surveys show that Tanzania has the highest number of people engaged in fishing, followed by Kenya and Uganda has least.

iv Foreign exchange earnings are highest in Tanzania, followed by Uganda and then Kenya. However, it was not possible to make a comparison on the Balance of Trade due to lack of data on import of fishery inputs and repatriation of profits by investors in fish processing.

v Per capita fish consumption is comparable between Uganda and Tanzania but much less in Kenya. This is attributed to the population size relative to fish catch.

vi Similarly, contribution to animal protein is least in Kenya compared to Uganda and Tanzania. This shows that there could be more important sources of animal protein in Kenya than in the other two countries.

Distribution of earnings by sub-sector

Different people are involved in different activities within the fisheries. Table 2 indicates differences in the earnings accruing from fish production, processing and marketing.

Table 2: Average monthly earnings by sub-sector.

Sub-sector	Earnings (US$)
Fishing	
Motorized	257
Non-motorised	110
Processing	
Smoking	179
Sun-drying	126
Trading	
Bicycle trader	25
Market stall-holder	24

Source: Odongkara 2001.

The table generally shows the following:

i Fishing earns highest incomes to the operators, followed by fish processing while fish trading earns least.

ii Within fishing, motorized fishing generates more earnings than non-motorised fishing.

iii Among processors, those engaged in sun-drying earn more that those in smoking.

iv In fish trading, earnings of bicycle operators and market stall-holders realize similar earnings.

As a result of inadequate data, other sub-sector enterprises could not be compared.

Distribution of earnings by type of fishers

As mentioned above, different types of fishers earn different levels of income, depending on the facilities influencing the prices they receive and the species they target. Table 3 gives indications of the disparities in earnings of fishers of different species operating at beaches served with different transport facilities. The table reveals that: truck beaches are sources of higher earnings to fishers than non-truck beaches, mostly due to the more readily available market and higher prices of fish. However, there is little impact on the earnings of tilapia fishers as much of it is ferried away by bicycles rather than trucks.

Table 3: Average earnings (US$) by target species.

	Truck beach	Non-truck beach
Nile perch fishers	473	384
Tilapia fishers	97	102
Dagaa fishers	296	93

Source: FIRRI 2002.

Figure 1 shows disparities in earnings by species targeted. The figure shows that fishers of Nile perch earn highest incomes, followed by those of dagaa while fishers targeting tilapia earn the least.

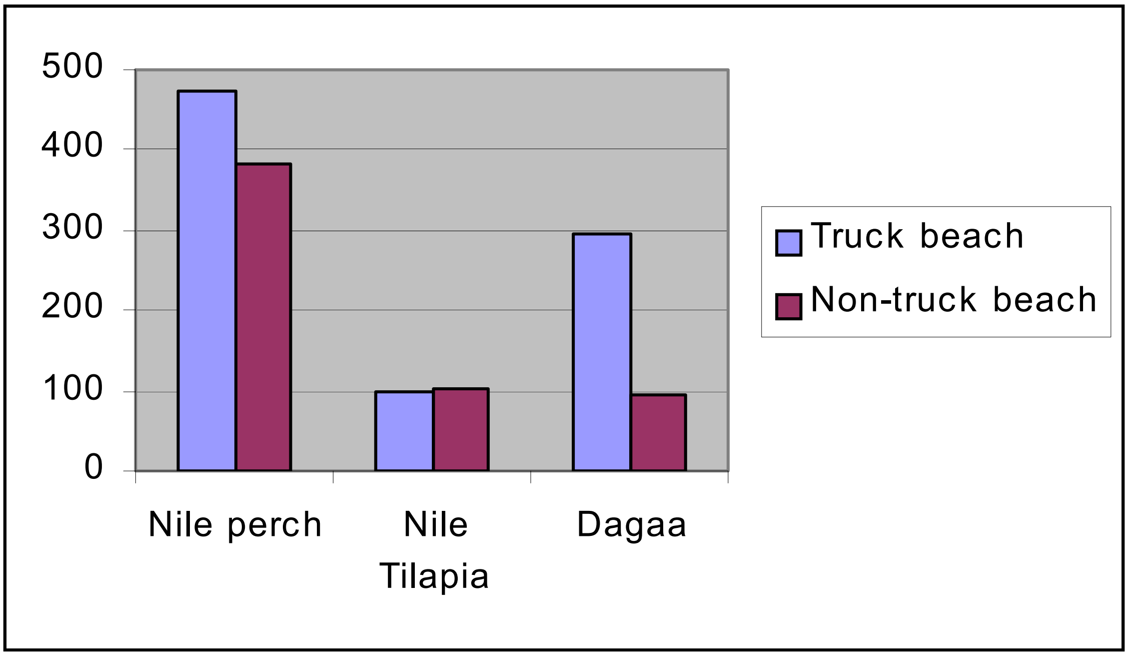

Figure 1: Mean monthly incomes of fishing enterprises by species (US$). Source: FIRRI 2002.

Distribution of earnings between boat owners and crew

An important distinction occurs in fishing between the boat owners and the crew. Fishing unit (boat) owners provide the investment, management and maintenance of the fishing units, also taking the risks involved. They normally await the return of their boat(s) on beaches where they check on catches, oversee catch sales and payment of the crew, and consider input needs such as fuel, net or boat repair. An average of 3 crew members work on a boat. The most common method of paying crew is to divide the catch value into agreed upon portions after deducting the expenses.

Table 4 gives the average proportions within which the net earnings from fishing operations are shared between boat owners and crew members. It should be noted from the table that although on average the earnings are shared equally between boat owners and crew, the share for crew has to be divided between 3 crew members, on average. That leaves each crew member with little earnings, thus explaining why the crew are among the poorest group within the fisheries.

Table 4: Share of earnings from fishing.

	Boat owners	Crew members
Proportion of net earnings	50%	50%

Source: FIRRI 2002.

Distribution of Nile perch value along the market chain

In order to assess the distribution of gains from Nile perch by the various players involved, prices were examined along the Nile perch market chain as presented in Table 5.

Table 5: Prices received along the Nile perch market chain.

	Price (US$/kg)
Fishermen	1.0
Middlemen/ Factory agents	1.1
Processing plants (FOB fresh fish equivalent)	2.1

Source: Various records.

The table shows that there is no evidence of undue disparities in the earnings of any particular group along the chain as fishers, middlemen and processing plants are paying/receiving prices, which are moderately different.

Contribution to national economies

Fisheries have made important contributions to the social and economic development of the riparian states through linkages and externalities. In the absence of data, comparison is not possible. However, some of the areas of contribution are highlighted in Table 6.

Table 6: Key areas of national contribution of fisheries.

Industrialisation	US$ 150 million investments in fish factories
Infrastructural Development	Rural infrastructure (roads, landing facilities, water supply etc)
Social Development	Schools, health centres and recreational facilities

The table shows that development of the fisheries has stimulated development in the areas of industrialization, infrastructure and social facilities.

Challenges in achieving equity in distribution of benefits

In order to identify the challenges in overcoming the disparities in benefit distribution, the major underlying factors were identified and analysed. They included:

i Unequal distribution in production assets of fishermen, fish processors and traders. These include capital, equipment and skills.

ii Free-market price determination mechanism, where the poor are subjected to unfavourable trading conditions and low prices.

iii Inadequate access to sufficient market and other useful information, limiting the opportunities and choices among fishers.

iv Lack of fishers' organizations to strengthen their market bargaining power and support their activities.

v Limited investment horizon and opportunities among fishers, which hinders their capability to re-invest the surplus earnings from the fisheries most profitably.

vi Lack of access to credits especially to fishermen to enable them improve on their operations and invest in alternative income sources.

vii Lack of appropriate savings avenue and a savings culture among fishers for better utilization of earnings and saving for the future.

viii Poor physical infrastructure to the fishing villages that limits the market for fish and results in low prices to the producers.

ix Inadequate post harvest handling facilities and skills to ensure quality maintenance for better market and prices.

x Inadequate policies to deal with inequitable distribution of benefits, for the good of the disadvantaged groups.

xi Insufficient data and skills for distribution analysis to support the policy process.

Conclusions and recommendations

The main economic benefits from the fisheries of Lake Victoria at the regional level are production and contribution to GDP of riparian states, employment, foreign exchange earnings, contribution to diet. At the household and individual levels, the benefits take the forms of earnings, employment and consumption.

Disparities in income distribution is considered undesirable because it creates a sense of social injustice among the beneficiaries; can be an obstacle for self-sustaining growth; is a limitation in uplifting the resource users out of poverty; leads to low compliance to fisheries regulation and hinders attaining of sustainable fisheries exploitation.

Based on the findings presented above, disparities have been observed in the benefits between the riparian countries of Kenya, Uganda and Tanzania. Furthermore, earnings are inequitably distributed between the fisheries sub-sectors, between different fishery enterprises and between boat owners and crew. Due to insufficiency of gender-disaggregated data, the distribution of benefits by gender was not conclusive. Factors responsible for the disparities have been identified.

In order to re-dress disparities, the following interventions are recommended:

i Develop suitable savings and credit schemes run by micro-finance institutions, which are tailored to suit working conditions of fishermen.

ii Empower BMUs to organise fishers for marketing as well as fisheries management.

iii Improve mechanism for market information flow, covering prices, quantities landed at various beaches and number of buyers, through radio announcements and weekly newsletters produced by the Fisheries Departments/Divisions.

iv Operationalise the Levy Trust Fund and utilize part of it for infrastructural development and provision of landing facilities such as fish banda, holding facilities, portable water and latrines.

v Make provisions for fishermen to be trained in financial management and investment skills.

vi In order to maintain quality, fishers' organizations should collect fish from their members by use of insulated boats, and provide them with ice.

vii Improve policies at the national and regional levels to ensure that high disparities in the distribution of economic benefits do not arise.

viii Improve data availability and analysis skills to support the policy process that ensures equitable distribution of the benefits from lake Victoria.

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Restoration initiatives of Rupa, a small hill lake, through forming a cooperative: A suitable strategy for lake conservation in poverty-laden areas in developing countries?

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Abstract

This paper describes the case study of a restoration initiative, through community participation, for a small lake of about 100 ha in Central Nepal. The lake is situated in the mid foothills with rich biodiversity and poor traditional fishing community. A notion that smaller natural water bodies such as lakes, swamps generally ≤500 ha ultimately disappear and turned into grassland due to "lake succession" seems a common perception. However, even small lakes possess a multitude of social, environmental and ecological benefits and their disappearance reduces opportunities for jobs and income. This loss might ultimately fuel social chaos and disorder in areas already suffering from having to cope with rapid change.

To restore this lake a cooperative was formed prioritising traditional fishers and women for equity. Since then, local biodiversity and fisheries have been improved; encroachment of the lake margins halted and water hyacinth infestation controlled. Numerous lakes of this type exist throughout the world with several at the verge of disappearance. This work implies that cooperatives could be a powerful mechanism to save small lakes in a sustainable and economically viable manner in alike socio-economic setting by connecting communities with their integrity, equity and social justice.

Key words: cooperative, biodiversity, social justice, small lake, win-win, equity

Introduction

Human social dynamics and their involvement in understanding environmental degradation and restoration have been central to studies of sustainability (Janssen & Carpenter, 1999; Cairn, 2003; Leigh, 2005). Here, restoration is "the act of restoring to a former state or position" (Bradshaw, 1996). A notion that small lakes, generally ≤500 hectares, ultimately disappear and turned into grassland due to "lake succession" is a common perception. However, even small lakes possess a multitude of social, environmental and ecological benefits and their disappearance might create social chaos and financial deprivation to sections of the community least able to cope with change.

Nepal is rich in biodiversity; traditions, ethnicity and well known for its community based forestry management (Shrestha, 1996; Gautam & Shivakoti, 2002). However, community based natural resource management may cause serious social conflicts (Leal 1996), notably where social discrimination exists on the basis of different ethnic caste (Chakraborty, 1998), there is economy with inequitable sharing of ownership, or the benefits are overwhelming (Upreti, 2002).

Sustainability of small lakes and wetland resources is a growing problem in Nepal. It is generally thought that government supported efforts in sustainability of environmentally degraded small lake could be more effective, if a legal framework of 'ownership' or 'management rights' could be realized and vested in local communities. This framework might be of critical important to societies where water bodies are used as common resources with unrestricted access for livelihood of surrounding communities having low economic activities and literacy (Gurung, 2003). In such situations restoration of demised lakes and their sustainable management become highly desirable from multiple of perspectives.

In general, flat land has always been in scarcity for agricultural use, especially in hill and mountain regions of Nepal. For a population of some 26 million, there is an almost insatiable desire for suitable flat land for both crop production and human settlement. The formation and evolution of the Kathmandu valley is a very good example, derived from the draining of a large lake (Sakai *et al.*, 2004; Gongah, 2004). This trend still continues and several lakes, wetlands and other form of water bodies are being drained for different purposes in several parts of the country (Bhandari, 1998; IUCN, 2004). Another factor that might have induced the destruction of lakes and wetlands in the past may have been associated with attempts to control the spread of malaria, especially in tropics (Elizabeth, 2004).

The current tragedy for most small lakes in Nepal is their rapid sedimentation associated with high rainfall, traditional agriculture in catchments, deforestation, landslide, flood, eutrophication, draining for agriculture use and encroachment (Bhandari, 1998; IUCN, 2004). Mostly, all Asian lakes are known for extreme human activity in their catchments areas (Groombridge & Jenkins, 1998). However, owing to a recent increase in population and poverty, the sustainability of small water bodies has been questionable in Nepal. The growing trend of converting them into intensive aquaculture or agriculture systems is to be viewed with caution because of the impacts on the environment and the socio-economic problems created. Intensive aquaculture is essentially a capital-intensive activity undertaken by corporate houses or industrialists aiming to make a quick profit, and the profit generated is often shared by a few. However, it is recognized that community run fisheries can avoid the "tragedy of common", where tragedy is – of it being a common resource, i.e. it is everyone resources to exploit but no one's property to sustain (Leal, 1996; Buyali, 2001).

Generally, deprived and economically poor communities subsist on natural wetland, lakes, ponds, and rivulets for their livelihood by collecting food, fishing, hunting, and boating in Nepal (IUCN, 2004). Affluent people mostly benefit from using water for irrigation and other corporate uses leading to conflict of interests where the resource is limited.

Here, it is stressed that common property should mobilized into a participatory approach involving citizen and stakeholders throughout the planning and management process (Borre *et al*., 2001). Decision should use a grassroots approach on a novel manner forming cooperatives for employment and income generation activities suitable to the environment and its people (Leigh, 2005). Any community aiming for social justice has to reduce social tension emerging from skewed distribution of wealth generated from common resources. Many countries have realized that it is wiser to encourage extensive fisheries which are more compatible to the traditional practice of sharing nature's wealth among many (Syampaku, 1998; McConney, 1998), even if it means that less income is generated.

It is assumed that for the management of common resources without social conflicts in heterogeneous societies: a *win-win* situation is essential, which is a situation where the outcome benefits everyone. This solution is possible by developing criteria judiciously prioritising the traditional knowledge, occupation, skill and economic status of members of organization. Such wise assembling could be the real strength for the sustainable management of common resources in society composing of people from different ethnic backgrounds, economic status and faith. It is interesting to note that the question of sustainable development is, therefore, a way to stimulate a sustainable co-evolution of human activities and environmental change (Janssen & Carpenter, 1999).

Often lake management is viewed from biophysical perspectives, but more crucial and central to balance for sustainability: the social values are often forgotten (Klessig, 2001; Klessig *et al.,* 2004). To achieve the former state, restoration of Rupa Lake was initiated through the formation of a cooperative of local households. Hereafter, the cooperative, an autonomous association of villagers united voluntarily to meet their common economic, social and cultural aspirations through a democratically controlled enterprise as stated by Groves (1985) and University of Wisconsin, Center for Cooperative (UWCC, 2004).

Recently, a seminal work by Leigh (2005) has described community-based restoration as a best instrument to cure ecological crisis. This approach should also be helpful for peaceful and rapid co-evolution of human activities and environmental changes in societies with weak economic support system. Moreover, it delineates a bottom up social mechanism for restoration of natural resource management for sustainable development. There are limited studies on the conservation of small lakes through the participation of local community cooperatives. The present paper aims to describe how equity and social justice based cooperative in a heterogeneous society could play role in the restoration of small lake ecosystem for sustainability.

Methods

Background and location of the project

Lake Rupa watershed is located between 28^{O} 08' N to 28^{0}10' N latitude and 84^{o} 06' E to 84^{o} 07 E longitude, at 600 msl in central Nepal with an estimated water surface area of about 100 hectare (Figure 1). The total catchment area of the lake is about 30 km^2. The lake is elongated from north to south and is surrounded by hills on east and west, while immediate north are rice field followed by hills. The outlet opens at southern end into rice fields. The lake was known to originate by depression and blockage on its outlet. The main threat of this lake is dangerously low water level with heavy aquatic vegetation leading to transitional stage from a lake to swamp formation (Table 1).

Ethnic community living around the lake

The total human settlement estimated in the catchments area is nearly 15, 000; primarily comprises of *Brahmin, Chettri, Gurung, Magar, Newar, Damai, Kami, Sark and Pode* communities. Among them, *Pode* solely depended on fishery, while, *Gurung, Magar, Damai* and *Sarki* in the vicinity were also involved as one of means of their livelihood.

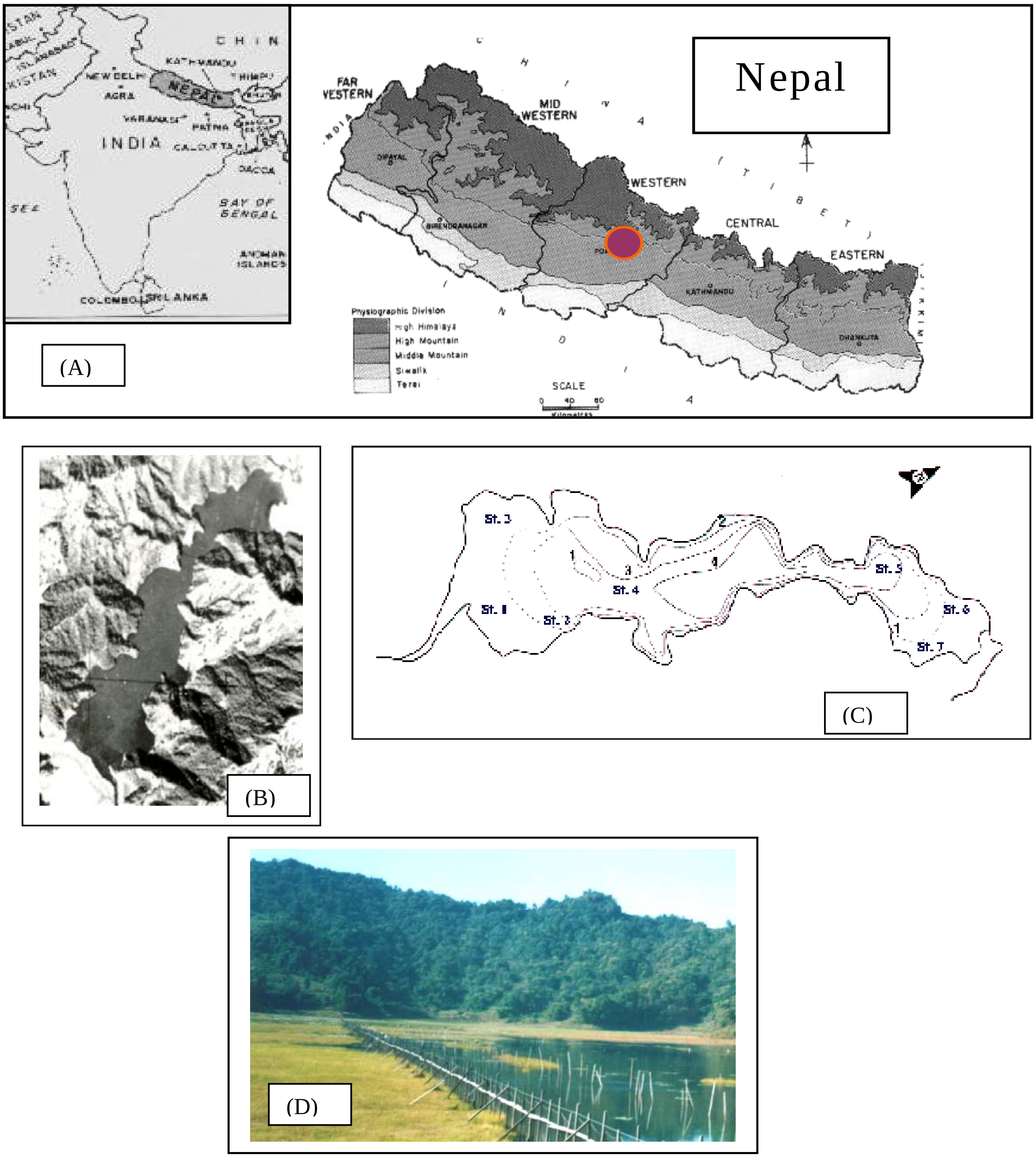

Figure 1: (A) location, (B) an aerial photograph taken around 1978 (C) bathymetric map after Ferro and Swar (1978), (D) Net screen at outlet of Lake Rupa.

Table 1: Change in some features of Lake Rupa in last four decades.

Description	After Ferro & Swar (1978)	After Rai *et al*. (1995)	Present features
Surface area (ha)	117	135	100 roughly
Maximum depth (m)	6.5 m	6 m	4 .7 m
Mean depth (m)	2.3	3	2.7
Vegetation coverage	Nearly 5%	Nearly 65%	Nearly 35%
Volume (x10^5 m^3)	-	32.5	31
Length (m)	-	2800	2700
Breadth (m)	-	400	-
Surface Water temp (^{0}C)	-	14-30	15-28
pH	-	5.6-7.8	6.9-8.5
No. of fisher family	5	6	6
DO (mg/l)	-	5.0-8.9	1.6-11.3
Fish catch (ton/year)	3.0	-	18.0

The initial situation: the issue of lake conservation and approach

Besides traditional fishing, a plankton feeding based cage fish culture in the lake was started around 1975. Cage fish culture production peaked around 1990 with nearly a yield of 50 mt fish per annum from about 500 cages occupying about 25,000-m^3 and involving more than 150 families of the surrounding hills. However, gradual sedimentation from the catchments area led to nutrient load, decreased depth, low water level and heavy infestation of aquatic plants. Upon the seasonal demise and subsequent decomposition of aquatic plants, oxygen is depleted (Rai, 2000) causing collapse of the cage fishery since early 1990s in the lake.

Before the start of the present activities, there remained a number of obstacles. As it is often, lack of mutual trust and respect among the villagers was one of the main factors. Coordination, led by the Fisheries Research Station Pokhara, developed a number of draft regulations on sustainable restoration of the lake, in participation with the people living up and downstream. To sustain the restoration of rich biodiversity of the area (Oli, 1996), it becomes critical to consider fish restocking into the lake. Fish could be a reliable source of income to sustain the cooperative and would enhance diversity as they are they are the food of cormorants, otters and mammals. For these reason main function of the cooperative becomes fish stocking enhancement in lake. However, the involved community has demanded that the local government improve lake water quality by damming the outlet of the lake. Since this is a costly and environmentally sensitive proposal a decision on such a matter would justifiably take several years.

Establishment of the co-operative

The present study refers to an ongoing community-based whole lake restoration program started in 2002 to address problems in Lake Rupa, situated at the mid hill region of Central Nepal. It was designed by the Fisheries Research Station, Pokhara in cooperation with District Development Committee, local Municipality and near by Village Development Committee, authorized by District Cooperative Office, Kaski. The author assisted in the designing and implementation of the program and has been involved with local participants. To resolve the impasse, several workshops were and public meetings were held involving fisher, village chiefs and senior government officials. For restoration of the lake, the villagers took the strategy of co-operative establishment incorporating about 329 local households within the established “Rupa Lake Restoration and Fisheries Co-operative”. The major goal of the cooperative is conservation, protection and enhancement of fisheries and wildlife for the continuing benefit to the society and the environment. The immediate objectives were:

- To prevent the dry and shallow parts of the lake from encroachment;
- To increase the income from the lake through management of recapture fisheries;
- To implement restoration measures from the funds generated from fish production.

Result & discussion

The expected outcome of the cooperative is the resumption of a gainful fisheries enterprise while simultaneously achieving restoration of a degraded environment and the enhancement of biodiversity around Lake Rupa through community participatory approach. Some major outcomes achieved by the restoration can be outlined as follows:

Organization of the Co-operatives

An eleven member Executive Committee heads the cooperative. The members of general assembly elect the President, Secretary, Treasures and other members of the Executive Committee. The general assembly also formed a Management Committee and Advisor Committee. Management Committee governs the Finance Committee, Lake Conservation Sub Committee and Staff Management and Fisheries Committee.

Legislative Support and Framework

The cooperative has been approved from District Cooperative Development Office, Ministry of Agriculture and Cooperatives, HMG. Ministry of Forestry and Soil Conservation has recently formulated a "National Wetland Policy-2002 (2059)". The primary goal of the policy is participation of local people for wetland biodiversity conservation through wise use and management. The policies of the cooperatives are in agreement with the guidelines of this National Policy.

Highlights of the Constitution of the Co-operative

i. The cooperative is established based on the sub-Article-14 of Co-operative Regulation-2049 using the right of Article 18 of Co-operative Law 2048.

ii. The goal is livelihood improvement of people living around Lake Rupa through fisheries activities in the lake.

iii. It is expected that the cooperative could substantially prevent shoreline encroachment and develop eco-tourism in the area

iv. The cooperative shall pay tax to government from income generated through different activities in its command areas.

v. Provide free schooling up to class 10 in government school for the children of the traditional fisher family depending on fishing in Lake Rupa for their livelihood.

vi. Displaced traditional fisher community member will be provided with the job created under the cooperative. Outsiders shall not be allowed for employment in the project.

vii. The traditional fisher and members who cannot pay their share will be offered to pay their share in instalments or through the working in the cooperative.

viii. Importantly, out of two posts of vice-presidents and two members in the Executive Committee of the cooperative. One of each are reserved for women and deprived member respectively.

Awareness

The most striking achievement of the present project is an increased awareness among the local community of how to set a goal and undertake their objectives, as the cooperative has generated awareness throughout the country. Media coverage has given high priority on the success story of lake restoration. This has brought the cooperative restoration efforts in the limelight (Figure 2).

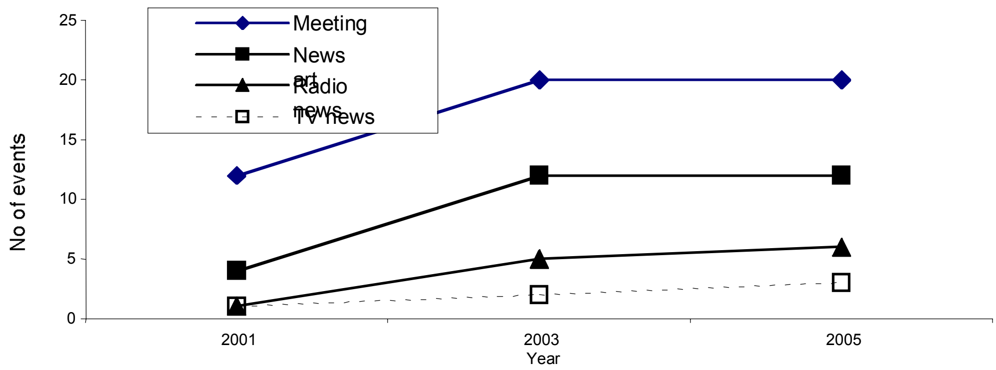

Figure 2: Annual events of Lake Rupa in brought in different media.

People and communities living near other lakes, wetlands and swamps have been sensitised to conservation needs. Several others 'endangered' lakes and wetlands are expected to be restored and vitalize through participatory approaches. However, it is not particularly necessary to establish fisheries cooperative, instead, it can be based on the need of the locality, the members and specific biodiversity conservation.

Control on encroachment

Sedimentation is the major factor for demise of the lake, with the dry parts of the lake has been rapidly converted into the paddy field by local inhabitants. With the initiation of the cooperative, the encroachment has been surprisingly curtailed. The lake margin encroached for paddy cultivation has recovered by the cooperative.

Biodiversity

In general, biodiversity has been improved in lake and surroundings after establishment of the cooperative. Previously, the region attracted illegal hunting and fishing activities resulting in the killing of birds, fish and wild animals. Presently, however, the hunting has been stopped and fishing by non-cooperative members is banned. This change has resulted an increase in visiting and migratory birds. The detail of biodiversity of the lake and surrounding area is underway in separate paper by the author.

Weed control

Before the project most of the lake surface was covered with the macrophytes such as - the invasive water hyacinth (*Eichornia* sp). Now with the efforts of the cooperative the water hyacinth has been cleared. As part of their campaign, the cooperative has announced to reward Rs. 75 (nearly 1 US$) for every kilograms of water hyacinth collected from the lake. This strong incentive for removing the water hyacinth is believed to prevent re-colonization. Occasional fishing by drag net has also been instrumental to remove the weeds. Other aquatic weeds, like water chestnut (*Trapa sp.*) and *Hydrilla* have been uprooted with the movement of stocked fish into the lake. It was speculated that a combination of different fish would control the spread of weeds in the lake and this has been borne out by the 40% decline in weed cover.

Fisheries

The annual fish catch has tripled over 3 years to approximately 17 mt in year 2004 (Figure 3). Fisheries have been enhanced after restocking the lake with carp (*Aristichthys nobilis*: bighead, *Hypophthalmichthys molitrix*: silver, *Ctenopharyngodon idella*: grass and indigenous carps, such as *Labeo rohita*: rohu, *Cirrhinus mrigala*: Naini; and *Catla catla*: bhakur)). Undersized live fish accidentally caught are released into the water. These efforts are expected to enhance the biodiversity of the surrounding areas, as these could be the attractive natural foods for many birds, reptiles, amphibians, and wild mammals.

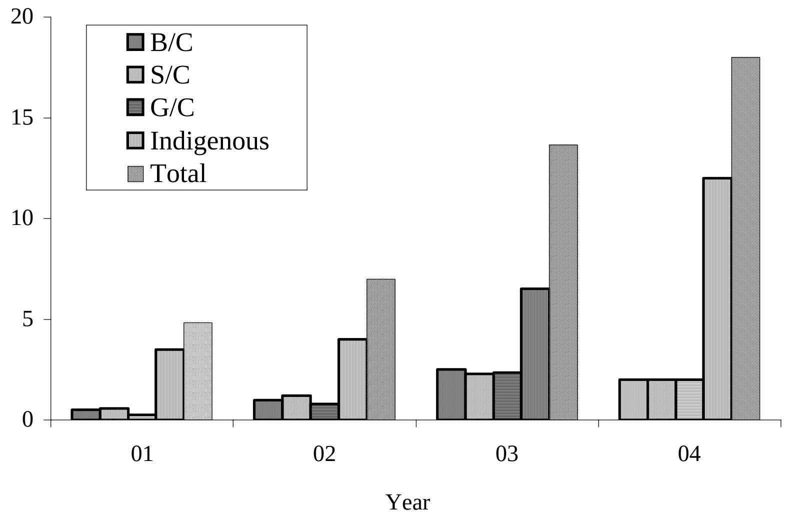

Figure 3: Annual capture fisheries yield in Lake Rupa, B/C, S/C and G/C represents bighead, silver and grass carp species.

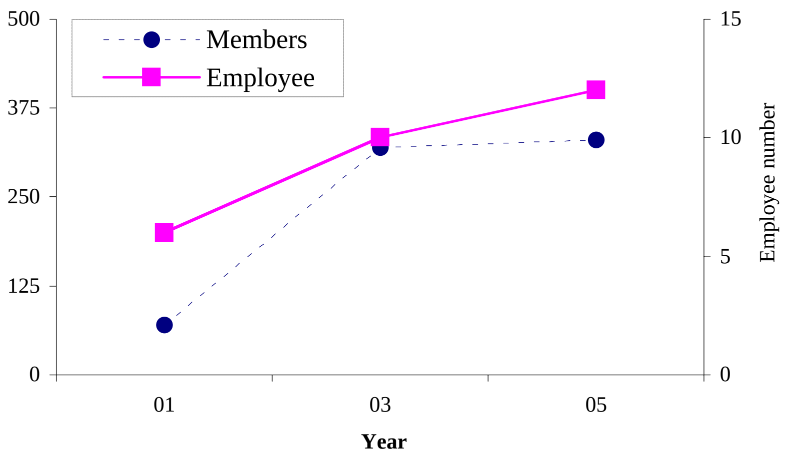

Figure 4: Number of direct beneficiaries from the lake restoration.

Income

The main sources of income generations in the cooperative are through capture fisheries. Initially, each member had invested about 5000 NRs (approx. 71 US$) for net purchase and lake restoration. Poor fishers who could not afford to pay the investment cost had contributed in the project through their labour. This cost has been already reimbursed through marketing of fisheries product as an outcome of the project.

Before, only few fisher families benefited from the lake, but now the lake has become a reliable source of income for all members of the cooperative. The income shows an upward trend in past years with an increase in captured fish. It is assumed that volume of the captured fish will be reach more than 100 mt per annum as the efficiency and the skill of the fishermen is enhanced over the coming years.

Employment

The cooperative offers job opportunities to its member. Earlier, only few fishers had the job, now, it provides opportunities to hundreds of other farmers (Figure 4). It is now, the source of temporary jobs to several people for weed removal, fish harvest, value addition and marketing. Members from the fisher, deprived communities and women who were involved in the lake for their livelihood have been employed permanently for fish harvest, security and office assistant in the cooperative.

Conclusion

Fish and wildlife resources around Lake Rupa correspond to a mosaic of interconnected aquatic and terrestrial habitats. The Lake Rupa ecosystem plays an important role along the Himalayas as critical stopovers migratory birds during spring and fall. Many other songbird and waterfowl also use the lake, forest, and riparian areas as feeding and breeding habitats. Since, the objective of the cooperative is the conservation and enhancement of fisheries, wildlife and important habitats. Therefore, the answer to the question posed in the title is "yes", because this approach can save hundreds of small lakes from being drain every day around the world – especially in under developed countries, where such loss can have dire consequences. The approach of establishing legally constituted cooperatives to manage small lake resources; and foster livelihood of local people through environmental sustainable mechanism is possible through creating an equity based *win-win* situation in conflict prone societies. This is being successfully implemented as part of the strategy for poverty reduction, utilizing human social dynamics in understanding small lake restoration; and is advocated for countries having similar socio-economic settings.

Acknowledgement

Thanks to Dr. William Stewart-Jones, UK, Professor J. R. Jones and D. Obrecht for reviewing the manuscript. Mr. S. K. Wagle and all members of Rupa Lake Restoration & Fisheries Cooperative, Fisheries Research Station, Pokhara, and LI-BIRD (Local Initiatives for Biodiversity Research and Development) are thankful for their generosity. Partial fund for this study was supported through Project No: 62359001 of NARC (Nepal Agricultural Research Council).

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Hydroponics - an effective tool for management of lake basins and poverty reduction in developing countries: experimental evidences

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Abstract

Wastewater coming from town, city and food processing plants contain essential nutrients such as phosphate, nitrogen and carbon that may act as a wealth or waste depending upon the management. Hydroponics – soil-less cultivation of vegetables or economically important water loving plants is a useful low cost option for management of lake basin by integrating the phenomenon of nutrient removal from eutrophic lakes and production of value added crops that will generate income among the rural poor people and utilize water resources in a sustainable way. This is especially true in tropical developing countries where plants grow fast and make resource uses sustainable. The concept of biological reclamation coupled with production of value added crops was examined by performing two experiments using different dilutions sewage water upon which tomato and marigold seedlings were grown using artificial floating bed. The growth performance of tomato plant was markedly different in response to strength of wastewater. Though tomato plant survived in all the strengths of wastewater used, best growth was observed with 100% wastewater having flowering stage after two months. The initial value of orthophosphate of water in all the treatments tended to decline gradually as the strength of wastewater increased with the per cent of removal being 33 - 50%. The responses of nitrate were almost opposite to that of phosphate, being highest at 25% wastewater and minimum at 100% wastewater. The uptake of both phosphate (0.11 to 0.4 µg/l per day per plant) and nitrate (0.4 to 1.6 µg/l per plant per day) tended to increase as the percent of wastewater increased and vice versa. Nitrate reductase activity in root of tomato plant was found to be highest at 50% wastewater and lowest at 100% wastewater. All tomato plants have died before flowering in all but 100% wastewater. It is concluded that hydroponics with right selection of plants would become an effective tool for management of eutrophic lake basins and providing valued added crops for poverty reduction.

Key words: Hydroponics, Tomato; Wastewater reclamation

Introduction

Soil less cultivation of agricultural crops has become increasingly popular in recent years due to its immense production potential under controlled nutrient condition. The process of hydroponics practice goes back about a century. It is as ancient as the Pyramid. The hanging garden of Babylon, be one of the seven wonders of the ancient world, has been stated to be maintained using the hydroponics. A primitive form of this method has been used in Kashmir for centuries.

Hydroponics is now defined as the science of growing plants without the use of soil, but by use of an inert growing medium, such as, gravel, sand, peat, rockwool, perlite, vermiculite, coconut fiber, sawdust, and other more exotic medium, such as, crushed rock or bricks, shards of cinder blocks and even Styrofoam, to which is added a nutrient solution containing all essential elements needed by the plant for its normal growth and development.

Generally, the home hydroponic system consists of a few basic parts: a plant growing tray, a nutrient reservoir, a simple timer controlled submersible pump for watering and an air pump and air stone to oxygenate the nutrient solution. Basically, it is a type of hydroponic gardening known as nutrient film technique (NFT). There are several variations of NFT around the world. In the modified of nutrient film technique (NFT), balanced micro and macronutrients are supplied to the plants for their growth.

A large number of vegetables are grown hydroponically, such as, beets, radishes, carrots, potatoes, cereal crops, fruits, ornamentals and flowers. The most spectacular development was achieved by Dr. William F. Gericke of the University of California who succeeded in growing tomatoes to the heights of 25 feet, using water culture in large tanks.

Though hydroponics has been primarily aimed at increasing the crop production under controlled conditions of balanced nutrients that are supplied in solution for the growth and development of plants, this concept may be profitably extended for the reclamation of nutrient rich wastewater by integrating hydroponics and wastewater reclamation, which will reduce the cost of nutrients and conventional wastewater treatment processes. The rationale behind this idea is that plants selected for hydroponic gardening are water loving plants and have nutrient removal of potential and therefore they may be used for removal nutrients from the nutrient rich wastewater as well as from eutrophic lakes, because both contain all the essential elements required for plant growth. The advantages of such integrations are that the production cost of hydroponically growing plants will be greatly reduced, as there will be hardly any requirement of nutrient film prepared by mixing fertilizers and water and being environment friendly, the technique will reduce the cost of wastewater treatment. The reclaimed water may be used for various demand driven activities.

A large number of wetlands and water bodies are highly eutrophic and rich in all essential nutrients necessary for plant growth. It is proposed that if the hydroponic culture is made successful in a more prudent way in the overlying waters of eutrophic lakes and wetlands, such water bodies will be reclaimed by the economy driven processes and the resulting wetlands may be used for many other purposes such as for fisheries, irrigation, and drinking water source of domestic animals, and pollution free habitats and integration of other processes. The purpose of the present study is to demonstrate experimentally to what extent the nutrients are removed by tomato hydroponics from nutrient rich sewage water and also the growth performance of tomato plants under conditions that simulate natural eutrophic lakes and wetlands using the artificial island concept. This may reflect its potential use for nutrient removal from lakes.

Materials and methods

Experiments were performed in 300 l fibre glass tanks placed in the yard under natural light and dark conditions using domestic sewage effluent as the source of nutrition to the hydroponically growing plants. A sewage treatment plant in the township of Kalyani treats household wastewater collected from nearly 100,000 population in the Kalyani township in West Bengal. The sewage effluent in extremely rich in nutrients (phosphate –P: 0.46 mg/l, ammonia –N: 0.730 mg/l, nitrate-N: 0.85 mg/l, pH: 8.1) was used in the study. The collected sewage water from the sewage treatment plant was diluted in different grades with tap water (0%, 25%, 50%, 75% & 100%). The prepared diluted sewage water of each grade was transferred to 300 l fibreglass tanks in triplicate and kept in the yard under natural photoperiodic conditions from December 2004 to February 2005.

Growing medium was prepared by using dried coconut coir anchored with floating system that did not leach any nutrients or toxicants. Each floating bed (0.148 m^2) was implanted with three seedlings of tomato plants and kept for 2-3 days for establishment. Three such floating beds were transferred to the 300 l fibreglass tank containing different grades of diluted sewage water. The plants were allowed to grow under natural conditions of light and dark for the period until the plants attained the flowering stage in some experimental conditions.

Nutrient removal capacity of the test plant was examined by monitoring the nutrient parameters of tank water (PO_4-P, NH_4-N, NO_2-N and NO_3-N) at weekly intervals following the standard protocols (APHA, 1995). The samples of water were also examined for the qualitative and quantitative analysis of plankton and other biota that developed during the growing period of the plant.

The growth performance of the test plant was examined at regular intervals by recording the growth parameters (root length, root number, stem length, shoot -root ratio).

The experiment was terminated when some growing plants developed flowers in some dilutions. At the time of harvest, the roots of the tomato plants grown in each dilution were assayed for their nitrate reductase activity following the standard protocol (Hageman and Reed, 1980).

Results

Water quality

Hydrogen-ion- concentration

Implantation of tomato seedlings in the artificial growing medium that floated on the surface of raw sewage resulted in decline in the values of pH of water by 0.72 units within 10 days of plantation. Decline in the values of pH was further accentuated as the volume of sewage added to the tank decreased gradually (Figure 1).

Total alkalinity

The responses of total alkalinity to tomato plantation were similar to that of pH of sewage water. The concentration of total alkalinity was reduced by 70% when tomato plant was grown on the raw sewage water (100%) (Figure 1). This shows that growing tomato plants utilized the total alkalinity as carbon source and removed substantial amount of total alkalinity from the sewage water by their root system mediated through root absorption.

Phosphate –P

The concentration of phosphate, after two months of plantation, ranged from 0.028 to 0.058 mg/l in different sewage dilutions (Figure 2). The concentration of phosphate in the tank water was the direct function of the strengths of raw sewage added to the tanks. As a result, the concentration of phosphate was maximum in the 100% waster water followed by 75%, 50%,25% and 0%. This shows that removal of phosphate by the growing plant was reciprocal with the concentration of raw sewage.

Nutrient uptake

Phosphate uptake

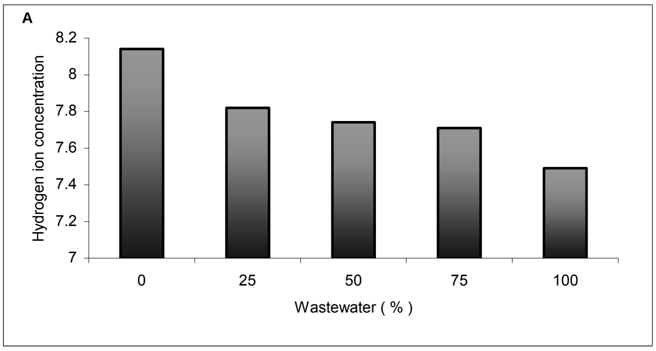
The phosphate uptake by the tomato plant per day was found to increase almost linearly with rise in the strength of raw sewage and vice versa (Figure 3). This shows that tomato plants are capable of removing high concentration of phosphate from the lake water enriched with high concentration of phosphate.

Nitrate-N

The responses of nitrate-N to tomato plantation in these sewage dilutions were similar to that of phosphate level of tank water (Figure 4). The variability in the concentration of nitrate-N of water was the direct function of the per cent of raw sewage added to the tank water indicating the pattern similar to that of phosphate.

Nitrate Uptake

The pattern of nitrate uptake by the tomato plant followed the trend similar to that of phosphate, being maximum and minimum in the 100% and 0% wastewater, respectively.



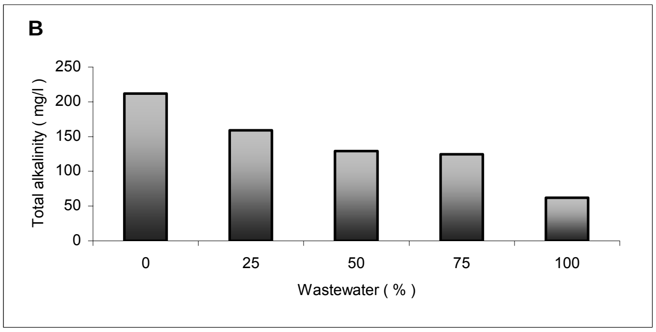
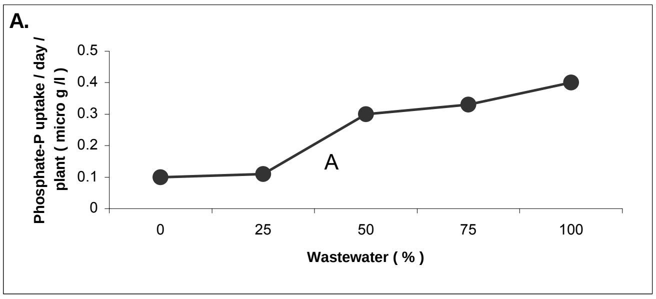


Figure 1: Responses of water pH (A) and total alkalinity (B) to tomato hydroponics after two months of plantation.



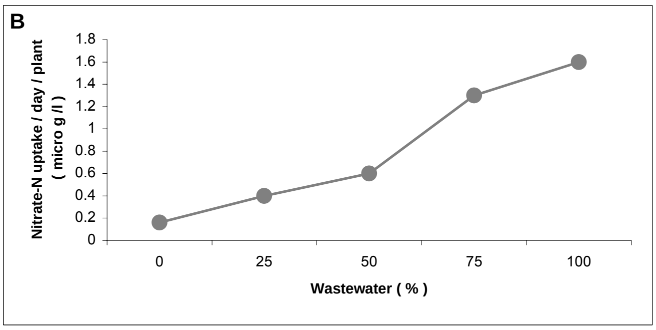


Figure 2: Uptake of Phosphate-P uptake (A) and nitrate-N uptake (B) in tomato hydroponics after two months of plantation.

Comparison of per cent wise uptake of phosphate and nitrate by the plants revealed an opposing trend with each other. While the phosphate uptake tended to rise with rising in percent of wastewater till 50%, the nitrate uptake followed an opposite trend. Thus, the uptake of phosphate and nitrate was maximum and minimum at 50% wastewater.

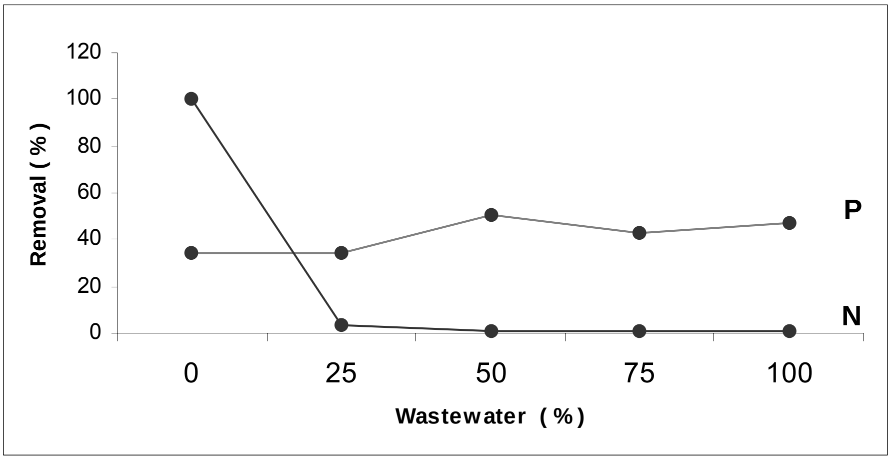


Figure 3: Removal of Phosphorus (P) and nitrogen (N) by tomato plant.

Uptake of N:P

The nitrate uptake by the tomato plant tended to increase at a higher rate than phosphate as the strengths of sewage increased. Thus the nitrate uptake was maximum at 100% and minimum at 0% wastewater, respectively. This suggests that nitrate uptake by the plant was the direct function of the ambient concentration of nitrate in water.

Nitrate Reductase

The nitrate reductase activity of the root system of tomato plant showed a rising trend with increase in the strength of sewage till 50%, followed by downward trend. The trend was similar to that of per cent of phosphate uptake by the test plant.

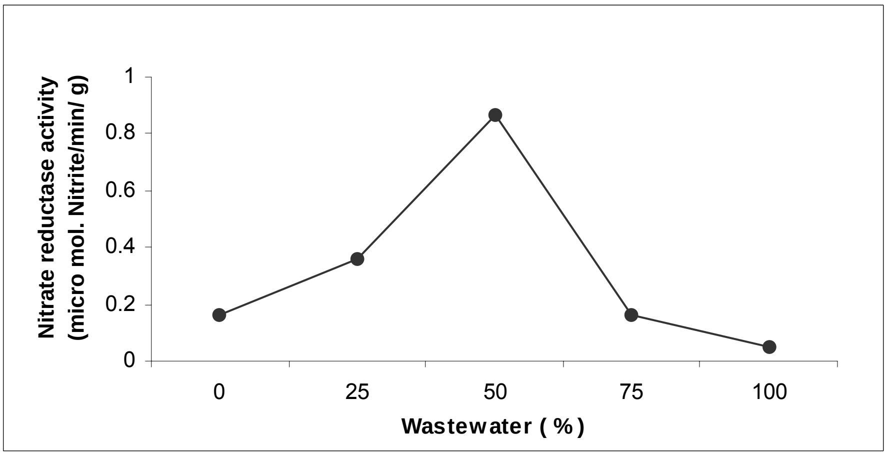


Figure 4: Responses of Nitrate Reductase in root of tomato plants.

Biological parameters

Root length: Root of tomato plants lengthens up to 50% strength and then tended to reduce as the strength of sewage increased.

Root number: The number of root in tomato plant tended to rise as the sewage strength increased.

Shoot length: The stem length of tomato plant increased from 11.81 cm in 0% wastewater to 16.8 cm in 100% wastewater.

Shoot-root ratio: Shoot-root ratio in tomato plants increases with the rising of the strength of wastewater.

Discussion

The experimental results revealed that cultivation of suitable water loving plants, such as tomato plants as experienced in the present study, would be a useful proposition for the removal of nutrient from the wastewater. This can be profitable extended for reclamation of eutrophic lakes, wetlands and other water bodies. The resulting reclaimed water would be used for various economic driven activities. This approach has several beneficial effects. Firstly, there is no need of artificial nutrients, which is the prime consideration in the conventional hydroponics resulting in substantial reduction in the cost of hydroponically produced crops. Secondly, after cultivation the nutrient rich water has achieved the level of improved water quality as the maximum concentration of nutrients have been removed and resulting water could well be reused for aquaculture and other economic driven activities. Thirdly, it is of great importance from the perspective of water conservation as the treated and discharged water can be repeatedly used or integrated for various activities such as irrigation, animal consumption, industrial use, building construction, etc..

There were clear-cut evidences of reclamation of wastewater due to hydroponic cultivation of tomato plants. This was due to the fact that the total alkalinity of water has been reduced by 71% in the raw sewage; the phosphate removal was maximum (50%) in the 50% diluted sewage water where the removal of nitrate was found to be less. As there was no requirement of nutrient solution prepared by mixing fertilizer and water the production cost of hydroponically produced crops is likely to be reduced. Since these trials have been aimed for experimental studies, up scaling of the system was necessary for its commercial application or further improvement of plant growth. Further trials are in progress in the field**.**

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Water pollution and social construction of health risks in urban Uganda: community perceptions, water use and burden of disease in Murchison Bay area, Kampala City

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Introduction

This study has been carried out in 4 parishes in Kampala City – Murchison Body catchment area, in order to assess and describe water use, community perceptions and social construction of health risks due to water choice and exposure to water pollution, and the perceived household's Burden of Disease (BOD) suffered due to exposure to water pollution among the urban community in Murchison Bay-Kampala District. This study has been carried out in four parishes: Buziga, Ggaba, Butabika and Luzira all located in the down stream area of Nakivubo channel and adjoining the Murchison Bay are of Kampala district. This qualitative study was carried out through Focus Group Discussions (FGDs) and supplemented by a review of related literature[1]. Two FGDs; one for adult females and other for males, were carried out in each parish. The study area preliminary readings for Kampala indicate that, 90% of the fisher folk around the fish landing cites don't have access to clean water (NEMA-DSOR, 1997). They depend on the lake water for drinking, washing and waste disposal. Also, many households especially those in the suburbs of Kampala city obtain domestic water from the wetlands directly or from shallow wells. Piped water is the major source of water supply in Kampala district. According to the National Water and Sewerage Corporation (NWSC, 1994), 75% of the district's population has access to piped water, up from 50% in 1991 although only 8% of the households actually have running tap water in their houses. About another 47% of Kampala's population are served by protected (36%) and unprotected (11%) springs. By 1997 approximately 1.4% of Kampala district population were using streams, rivers, lakes, ponds, etc., as sources of water supply (NEMA-DSOR, 1997).

Water source and water use

Common sources of domestic water in the study area are: stand water pipes/tapes, protected wells/springs, unprotected wells/springs, lake water and at times rainwater. Some of the household bought water from water vendors who collect it mainly from protected and unprotected springs, and some from the lake. Very few households have tap water connected to their residences. Several of the households which collected water from open stand pipes mainly used it for drinking largely due to cost implications. Protected and unprotected springs were commonly used in all the parishes especially in the less affluent cells (administratively, a cell in urban areas is equivalent of a village for rural areas in Uganda) for all domestic purposes. Lake water is predominantly used when tap water supply is off, when there is over crowding at the springs, and among households near the lake for mainly washing of clothing and utensils, for and bathing. Sometimes lake water was used because of convenience (next to wetland were some households cultivate food, one can also purchase fish or do the fishing when you go to collect water from the lake. Tap water is paid for in all areas, while water from protected springs in some areas is also paid for. Other water sources were free of charge. Some households from across Murchison Bay islands in Mwanga use lake water for all domestic purposes.

Water use and accessibility

Restriction of access to tap water was mainly described in terms of; ability to pay, opening time (mainly open during day time), when the owner/agent/operator of an open stand pipe is available and when there is sufficient pressure and supply. Distance was not mentioned as a strong restriction factor. In one cell, restriction was in terms of divided labour, where a person fetching water from the well had to fetch one jerry can for the landlord where the protected water source was located In some cells, households using a both protected and unprotected springs had to routinely provide communal labour to clean the water source. Water was collected mainly by children, women, housemaids and water vendors. Other determinants and risks associated with accessing water include: children crossing busy roads to fetch water, going to the inshore of the lake to collect water was risky and several water vendors collect water from protected and unprotected springs and from the lake. Some of the wells were located down the slope, and this is very risky, especially for children during the rainy seasons, due to the slippery nature of the slope. Household size influenced volume and water source used, with bigger households using less costly or free water sources.

Perceptions and construction of health risks due to water source and use

Community members perceived tap water as being relatively safe – although they questioned the presence of some particles in the water, and the public health messages that tap water should be

[1] This qualitative study was also intended to develop proxy indicators to guide the sampling process for the wider household survey in the same area, and identify variable categories for designing the household questionnaire.

boiled before drinking. Some community members argued that tap water is also contaminated.

"Even tap water is contaminated, they (water authority) put in drugs/chemicals to kill the germs…..they tell us to boil it to kill the remaining germs" (adult male FGD participant)

"Why does it (tap water) sometimes change its colour to brown…it shows its also sometimes dirty and not good (Female FGD participant)

Most of the FGD participants perceived water from protected springs as being safe for human consumption and domestic use. Perceived health risks from using water from protected springs was low among the FGDs participants, who argued that; water from protected springs is very clear/colourless, its free of particles, its always scentless, the smell is natural and good, the taste is natural, and its always flowing (it does not hold up or accumulate contaminates since its always flowing and its filtered by sand through which it flows. Community members also argued that protected springs could be accessed any time and some of them were near other people gardens making it more convenient to draw water for home use after cultivation. However, a more recent study by Tonnessen (2004) established that some of protected springs in Kampala had counts of *E. coli* ranging between 5/10o ml-120/100ml, with protected springs in highly congested areas having more concentrations than springs in less congested areas. The unprotected springs had *E. coli* counts ranging between 1500/100ml to 1830/100ml. Tonnessen (2004) also noted that several of the protected and unprotected springs were located at breaks of slope between hill sides and flat land, and are routinely exposed to contamination, particularly after rainfall. Poor disposal of garbage, also leads to seapage of pollutants to ground water. Some of the protected springs in Kampala were found to be near garbage dumping sites, and some of the protected springs were poorly constructed offering little or no filtration protection (Tonnessen, 2004). A study done by Nabiwemba (1997) in peri-urban Kampala made similar observations.

Water from unprotected springs was perceived as being of more health risks especially during the rainy season due to surface run off, plant and animal waste contamination. During dry season, it was observed that water form the unprotected springs was relatively safe for consumption and domestic use. Unprotected springs were largely used because the water was free, more convenient, and the taste and smell of water was good. Some of the FGD participants argued that if a person stays in the area for long, you become used to this kind of water (immunity strength) and you no longer fall sick due to continued use.

"Its normally new comers/immigrants who are affected…but if you stay for long, you become used to it" (Male FGD participant).

Lake water from the off-shore (a small distance inside the lake from the shore) was considered as relatively safe, while lake water at the shoreline was considered unsafe for domestic use. Lake water was mainly collected (a small distance inside the lake) in the morning when the water was perceived to be clearer, more settled and less likelihood of algal blooms or avoiding areas where algal blooms were more prevalent. Some people used lake water because others (neighbours) have been using it (lake water) without any major health condition affecting them. Community members' awareness about algal blooms was generally high and associated it with itching of the skin. Rainwater was preferred and perceived as very safe but the process of trapping it was described as sometimes unsafe.

Perceived burden of disease due to exposure to water pollution

Health conditions suffered due to exposure to water pollution include: typhoid, dysentery, stomach aches, skin rash, skin itches, and cough. Some respondents mentioned bilharzias as more common among children than adults. Few respondents mentioned, eye infections and cholera. Opportunity costs for health conditions suffered included: foregoing school, foregoing domestic responsibility, defaulting on rent to pay for treatment and missing out on gainful activities.

Preventive behaviour

Common preventive measures mentioned were: boiling drinking water, using tap and protected spring water for drinking purposes only, using unprotected spring and lake water for washing and bathing, regularly cleaning wells/springs, and fetching water from the inner-shore of the lake. Some people working at landing sites have bought gum boots to prevent direct water contact; some were smearing their legs with petroleum jelly to prevent possible infection from algae. For school children, it was difficult to monitor the kind and source of water they use or consume while at, or going to school, thereby minimizing the efficiency of preventive measures at household. In public places like markets, the use of lake water in eating houses had been outlawed by the area local council leadership. Treating water for washing, bathing and cooking was not considered as a worthwhile practice.

" Why should I boil or treat water which am going to use for bathing or washing clothing…because it will eventually be dirty and disposed off" (Male FGD participant)

Conclusion

This qualitative study shows that community perceptions and social construction of health risks are powerful determinants of choice of water source and water use at the household and community level. This study demonstrates that improving access to water through expansion of tap water systems and price regulation is not sufficient without addressing the community perceptions and construction of health risks due to exposure to water pollution. This study was informed by the cultural theory of health risks perception describes forms of social solidarity which shape views and influence individual and group attitudes and judgments about health risks associated with different types of water sources and water use at the community and household level (see Langford *et al.*, 2000).

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Biofilms in constructed wetlands for wastewater treatment: Their distribution and potential use as indicators of treatment efficiency

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Abstract

Vertical up flow systems of Constructed Wetlands contain gravel and macrophytes through which the wastewater flows. The aim of this study was firstly, to quantify for biofilm concentrations associated with different gravel sizes in the water column, gravel and root zone of a vertical up flow wetland with and without macrophytes, and secondly, to correlate the generated information on biofilm concentrations with the treatment efficiency of the different macrophyte-gravel type combinations in nutrient removal. Total Kjeldahl Nitrogen (TKN) method was the technique used to measure the protein content in the three wetland compartments. Protein was shown to be a meaningful indicator of biofilm biomass and revealed that there was a significant difference in the water column, gravel and root zone. There was a variation pattern between biofilm biomass in the sections with and without macrophytes. 18 laboratory scale bucket reactors (6 controls, 6 *Carex pendula*, 6 *Phragmites australis*) were placed in fine, medium and coarse gravel types to determine nutrient transformations. The different plant-gravel type combinations and controls were dosed with Artificial Waste Water (AWW) containing carbon source, micro- and macro-nutrients. Results indicated that the root zone had significantly higher biofilm biomass compared to the gravel and water column compartments respectively. In addition, the best performers in both COD and BOD Removal Efficiencies (REs) were *Carex* Coarse (80%. 94%) and *Phragmites* Coarse (64%, 93%), while the worst performers were *Carex* Fine (54%, 89%) and *Phragmites* Fine (49%. 88%) respectively. Furthermore, there was a positive correlation between COD (r^2=0.60) and BOD (r^2=0.66) REs with biofilm biomass.

Keywords: biofilm biomass; constructed wetland; removal efficiency

Introduction

Constructed Wetlands for wastewater treatment have been receiving sewage effluent for over 30 years. Their treatment functions rely heavily on the metabolism of biofilms. The water column, gravel and root zone of macrophytes in vertical up flow systems provide large surface area per unit volume respectively, which would enhance the development of biofilms. Most biofilm-based systems for water quality improvement utilize the interactions between biofilms and macrophytes in the removal of wastewater pollutants. In recent years, there is growing interest in making use of biofilms to improve the performance of constructed wetlands in wastewater treatment. Vertical up flow systems of constructed wetlands and biofiltration systems use substrates of gravel and clay, which are used to treat municipal and industrial effluent.

The mechanism of pollutant removal in constructed wetlands includes biofilm transformations, plant uptake, sedimentation, filtration, and chemical precipitation (Brix, 1993). The role of macrophytes in wetlands has been well documented (Bruggen *et al.,* 1994; Okurut, 2000; Kansiime and Nalubega, 1999), but a few studies have quantified for the role of biofilms (Ragusa *et al.,* 2004; Larsen and Greenway, 2004) in wetlands. This study will quantify for biofilm biomass and relate it to the treatment efficiency of the constructed wetland.

The aim of this study was twofold:

- Determine the distribution of biofilm biomass within the different wetland compartments (water column, gravel and root zone) by comparing the biofilm biomass in buckets with and without plants.
- Assess if biofilm biomass has a positive correlation with the treatment efficiency of the different plant-gravel substrate in the constructed wetland.

Materials and methods

Site description

A laboratory scale vertical up flow wetland was constructed in the UNESCO-IHE laboratory to polish Artificial WasteWater (AWW). The wetland comprised of controls (6), and planted buckets with *Carex pendula* (6) and *Phragmites australis* (6). The substratum used was gravel which was previously washed before being placed in the bucket reactors. The diameter was determined using the sieve method and density using the displacement method. The diameter and density values of each gravel size were as follows respectively: Fine gravel (1-2.5mm, 2.56 g/l), Medium gravel (3-5mm, 2.43 g/l) and Coarse gravel (6-8mm, 2.39 g/l).

Biofilm sampling in the three different wetland compartments

Biofilm samples were collected every two weeks in both the unplanted and planted buckets. Water column samples were taken using syringes and for the gravel big forceps were used in the unplanted and planted buckets. Root zone samples were carefully harvested using a grab sampler in the planted buckets only.

Quantification of biofilm biomass

Protein was the indicator parameter used for the biofilm amount. Total Kjeldahl Nitrogen (TKN) was the analytical technique used to measure the biofilm biomass in the water column, gravel and root zone of *Carex pendula* and *Phragmites australis*. Nitrogen content of distillate was determined according to standard methods for NH_4-N.

Nutrient sampling

Water samples were taken from both the influent and effluent every two weeks.

Analytical methods

The following parameters were measured according to standard methods: COD, BOD, NH_4-N, TN and TP. Physico-chemical parameters such as pH, temperature and DO were measured in-situ using WTW microprocessor electrodes when the water samples were collected every two weeks.

Total Nitrogen (TN) and Total Phosphorus (TP)

Plants were harvested at the end of the experiment after 10 weeks. Since the macrophytes were relatively young, the whole plant was taken, cut into small pieces (shoots, roots and rhizomes), folded in aluminium foils and oven dried at 70^{o}C for 3 days. After drying, the dry weight was measured. The samples were then stored in the desiccator for N and P analysis.

Accuracy of techniques

This section explains the reliability and efficiency of the extraction and digestion methods used for quantification of Protein content and removal of accumulated TN and TP from the digested plant samples.

Total Kjeldahl Nitrogen (TKN)

An intermediate NH_4-N Standard of known concentration was treated the same way as the samples. At the end of the digestion process, the known and unknown concentrations were determined of the standard and samples respectively. The digestion efficiency ranged from 80% to 95%.

H_2SO_4/Se/Salicyclic Acid and H_2O_2 Method

Reference samples of known concentrations of N and P were dried as the plant material and later digested. At the end of the extraction process, the known and unknown concentrations of the reference and plant samples were calculated respectively. The extraction efficiency ranged from 90% to 100%.

Data analysis

Statistical analysis was done using MS EXCEL and SPSS (Single factor ANOVA) to ascertain whether there was a significant pattern in the variation of the means between the controls and plant-gravel combinations. Spearman's coefficient was used for correlation tests between biofilm biomass and the removal efficiencies of the different plant-gravel combinations in the constructed wetland.

Results and discussion

One-way ANOVA with post-hoc tests showed that the root zone was significantly different from gravel and water column. The biofilm biomass in the root zone was highest in both *Carex pendula* and *Phragmites australis* planted in coarse gravel, compared to fine and medium planted gravel as shown in Figure 1. It implies that there was a preference for coarse gravel with large size for biofilm growth due to the presence of large void fraction for biofilm development, and there existed less hindrance to root growth of both plants compared to fine and medium gravel. In comparison to the root zone, biofilm biomass decreased with increasing grain size from fine, medium and coarse respectively in gravel and water column. It is probably due to the available surface area on the different grain sizes.

The changes in biofilm biomass in root zone, gravel and water column were probably caused due to the porosity, availability of nutrients and surface area for biofilm attachment and development. In the root zone, biofilm biomass showed a much higher build up as compared to gravel and water column due to the presence of limiting nutrients and more macrohabitats in the rhizosphere for biofilm attachment and growth.

There was a general decreasing trend of biofilm biomass with increasing depth in the different plant-gravel type combinations as shown in figure 2 above. It is most probably attributed to availability of nutrients and surface area on gravel. The decreasing trend of biofilm biomass with depth in the gravel profile was probably due to access of dissolved nutrients occurring at the top of the gravel profile.

The variation of biofilm biomass with depth profile in gravel has crucial information with regards to purification of wastewater as it flows through the constructed wetland. The results revealed that most probably there are preferred depths for the biofilms. This has implications for biofilm sampling within wetlands where wastewater purification occurs at one site within the wetland.

One-way ANOVA with post-hoc tests was used to investigate for TN and TP differences between shoots, roots and rhizomes of *Carex pendula* and *Phragmites australis* in different substrata. The results indicated that there was a significant difference ($p=0.001, df=2, F=13$) between shoots, roots and rhizomes of both plants at $p<0.05$ level between the groups. Multiple comparisons showed that the roots and rhizomes were similar with respect to both TN and TP concentrations, but the shoots differed significantly from both roots and rhizomes.

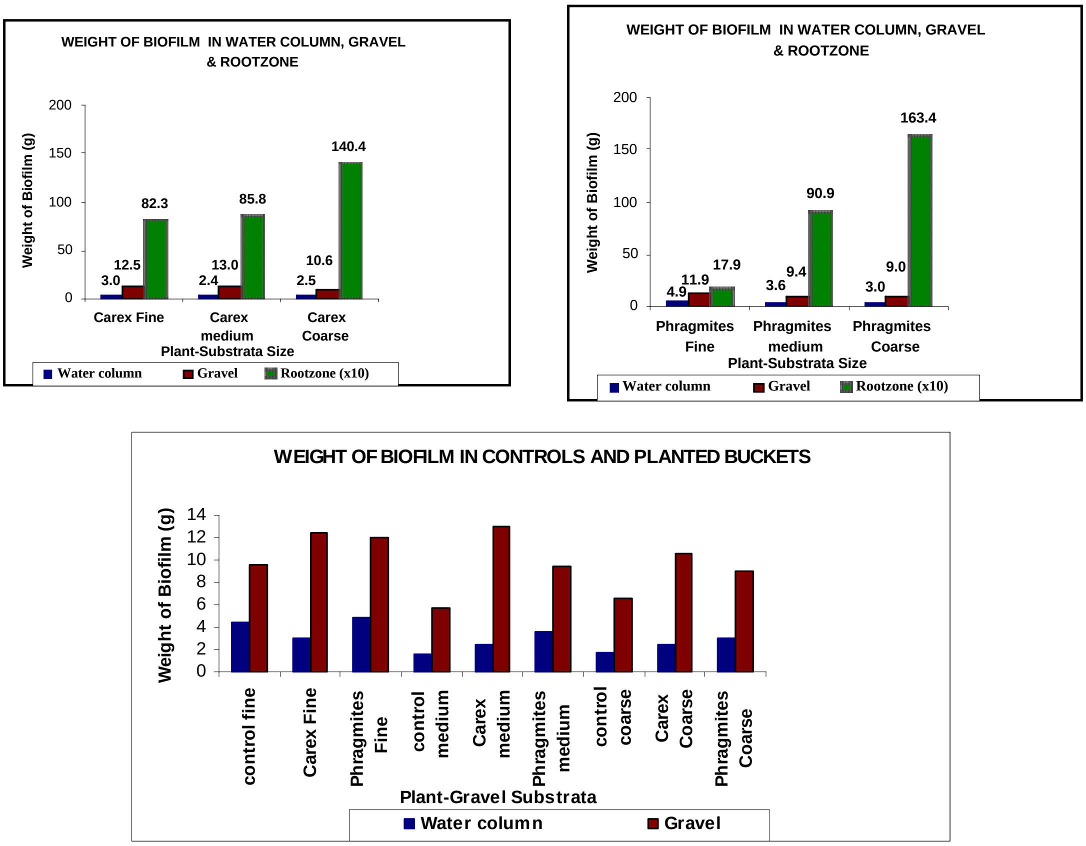


Figure 1: Trends of biofilm biomass in *Carex pendula* and *Phragmites australis.*

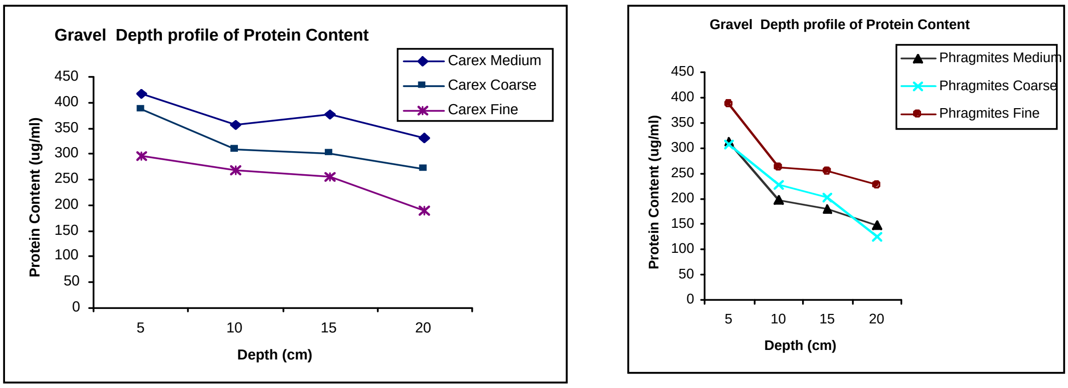
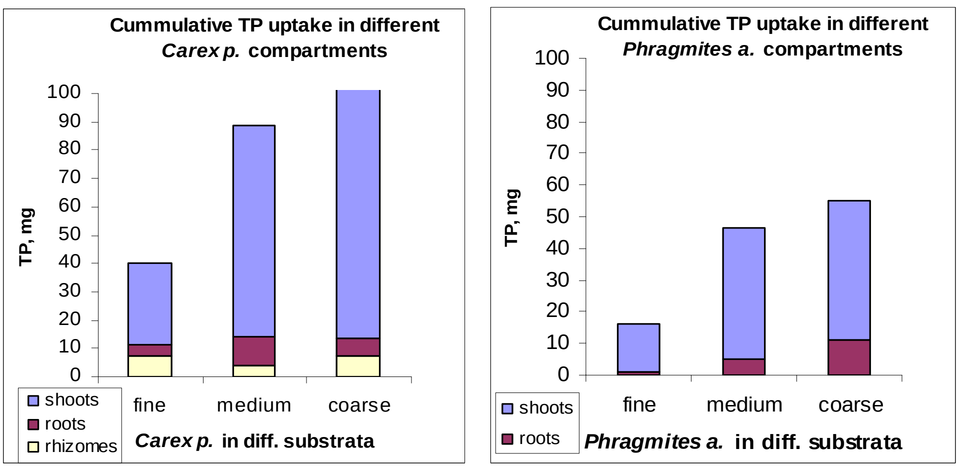


Figure 2: Biofilm biomass changes with depth in *Carex pendula* and *Phragmites australis.*



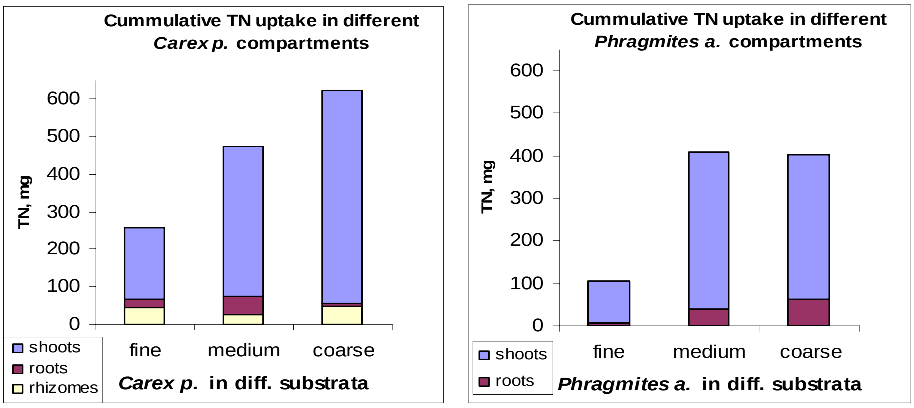


Figure 3: TP and TN Accumulation in shoots, roots and rhizomes of *Carex pendula* and *Phragmites australis.*

The findings as shown above in Figure 3, shoots accumulated more TN and TP compared to roots and rhizomes in both *Carex pendula* and *Phragmites australis*. It is probably because the plants were harvested during their active growing phase when there was translocation of nutrients to aerial parts to be incorporated into plant biomass. TN and TP uptake was higher in *Carex pendula* than in *Phragmites australis.*

Table 1: Annual biomass in dry weight to be harvested for each plant-gravel type.

Plant-Gravel type	**Dry weight in Kg yr^{-1} ha^{-1}**
Carex fine	15,120
Carex Medium	19,694
Carex Coarse	21,408
Phragmites Fine	6,477
Phragmites Medium	13,879
Phragmites Coarse	14,254

Table 1 shows estimates of biomass in dry weight assuming complete area coverage of the buckets by the emergent macrophytes that have to be harvested annually in the constructed wetland.

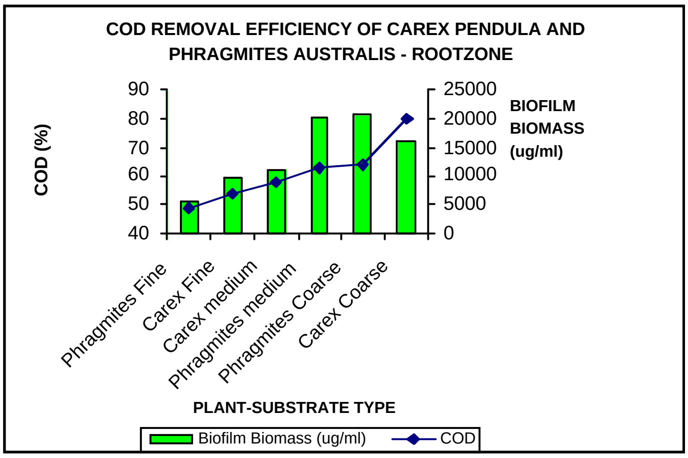
The highest amounts of harvest per year were in *Carex pendula* for the three different gravel types. *Carex pendula* and *Phragmites australis* planted in coarse gravel had the highest amounts of biomass in dry weight from the harvests compared to the fine and medium gravel.

Phragmites australis planted in fine gravel had the least harvest indicating a preference for medium and coarse gravel. Most probably there was hindrance to root growth in the fine gravel, which resulted in the low harvest, and its similarly reflected in the low TN and TP amounts accumulated in plant biomass.

From the measurements of TN and TP Removal Rates per year in table 2 below, there was general increase in both *Carex pendula* and *Phragmites australis* with increasing gravel size from fine, medium and coarse gravel respectively. Nutrient removal rates of TN and TP per year indicated that *Carex pendula* and *Phragmites australis* in coarse gravel were significantly higher than those of *Carex pendula* and *Phragmites australis* in fine gravel. Furthermore, *Carex pendula* had significantly higher TN and TP removal rates than *Phragmites australis* in the three different gravel types. Therefore, Carex Coarse and Phragmites Coarse were the most influential plant-gravel type in the transformation of nutrients from the constructed wetland and the most suited emergent macrophyte-gravel type for use in the management of constructed wetlands for wastewater treatment.

Table 2: TN and TP removal rates of *Carex pendula* and *Phragmites australis.*

Accumulated Nutrients (mg)	**Gravel Type**	***Carex pendula***	***Phragmites australis***
		Nutrient Removal Rate	**Nutrient Removal Rate**
		Kg N yr^{-1} ha^{-1}	Kg N yr^{-1} ha^{-1}
		Kg P yr^{-1} ha^{-1}	Kg P yr^{-1} ha^{-1}
TN	Fine	260.76	102.53
	Medium	493.73	428.10
	Coarse	651.51	419.23
TP	Fine	41.06	15.83
	Medium	92.48	47.88
	Coarse	118.94	56.92



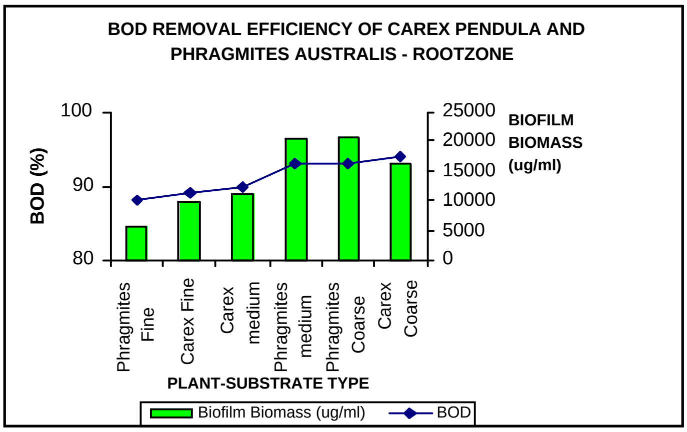


Figure 4: The relationship between biofilm biomass and removal efficiency.

In Figure 4 above the best performers in both COD and BOD removal efficiencies were Carex Coarse and Phragmites Coarse, which had the highest biofilm biomass, while the worst performers were Carex fine and Phragmites fine which had the least biofilm biomass.

Furthermore, the results of Spearman's correlation coefficients indicated a positive relationship (r^2=0.6) between biofilm biomass and COD removal efficiency (p=0.001, n=6). It is because 60% of the relationship explains the occurrence of high COD removal efficiencies in the plant-gravel types with higher biofilm biomass.

Similarly, the results of Spearman's correlation coefficients indicated a positive relationship (r^2=0.66) between biofilm biomass and BOD removal efficiency (p=0.037, n=6). It is because 66% of the relationship explains the occurrence of high BOD removal efficiencies in the plant-gravel types with higher biofilm biomass.

From the results above, it is revealed that the plant-gravel types with the highest removal efficiencies for COD and BOD corresponded with higher biofilm biomass. This supports a mechanism of enhanced nutrient removal in those plant-gravel types with the highest biofilm biomass.

Conclusions

The study assessed the potential use of biofilm biomass as an indicator for the efficiency of a constructed wetland for wastewater treatment. The study demonstrated that the biofilm biomass is a potential indicator for the wetland efficiency.

Research findings of this study revealed that there was a significant difference between the biofilm biomass in the three different wetland compartments (Water column, Gravel and Root zone) of the constructed wetland. Root zone had a significantly higher biofilm build up compared to gravel and water column.

Furthermore, there was variation in biofilm concentration in gravel bed with depth in the constructed wetland. This has important implications for biofilm sampling within wetlands where wastewater purification occurs at some localized sites supporting high biofilm biomass within the constructed wetland. It is equally crucial information for modelling such systems.

The different plant-gravel systems influenced the performance of constructed wetland. The best performers in both COD and BOD removal efficiencies were Carex Coarse (80%, 94%) and Phragmites Coarse (64%, 93%) while the worst performers were Carex fine (54%, 89%) and Phragmites fine (49%, 88%) respectively.

From the experimental results, there was a positive correlation between COD (r^2=0.6) and BOD (r^2=0.66) removal efficiencies with biofilm biomass. Carex Coarse and Phragmites Coarse plant-gravel type systems had high biofilm biomass and hence better COD and BOD removal efficiencies in the constructed wetland. Therefore, biofilm biomass can be used as an indicator in the management of constructed wetlands for monitoring and evaluating the wetland's efficiency.

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Meanings and possibilities of ecological toilets to lakeshore village communities at Lake Malawi: (1) Sanitation issues and people's attitudes towards toilet

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Abstract

Out of the total population of 6.4 billion on the earth, 1.2 billion people are said to be without access to safe and clean water due to water pollution. These people live in the countries that have not been industrialized yet. The main cause of water pollution in these countries is human waste or faeces. This means safe water issue is directly related with the lack of waste disposal facilities, especially toilets.

Located in southeast Africa, Lake Malawi occupies most of the Malawi country's eastern border. Twenty percent of the country's area is occupied by Lake Malawi, which is one of three large lakes along north-south Great Rift Valley. By visiting many lakeshore communities along the Lake Malawi since 1995, we have identified the following social and ecological issues as common concern of the lakeshore community.

1. Recent population increase has resulted in the spread of infectious diseases such as Cholera and Bilhalzia, which are commonly transmitted through water by human waste.
2. Increased demand for lake fish has resulted in over fishing, especially large fishes like Chambo (*Oreochromis spp*.) and Mcheni (*Rhamphochromis spp*).
3. The yield of maize, which is the staple food for the communities, is often badly affected by natural climatic factors, such as drought and floods. Acute shortage of maize is often observed during the period before the crop is harvested.
4. The introduction of hybrid type of maize, aiming at eradicating the shortage of maize, has been forcing farmers to spend more cash for the purchase of expensive seeds, chemical fertilizer and agro-chemicals.
5. Deterioration of land fertility resulted due to the repeated use of chemical fertilizer for a long period of time, and the Government and the villagers have begun to realize the needs for organic fertilizer.

After discussing these issues with local residents and some researchers from Malawi, we have found that the introduction of ecological toilets, which are able to utilize human waste as organic fertilizer will be one of the plausible measures for the solution of the multiple social and ecological issues of lakeshore communities. This presentation shows the result of attitude research about sanitation and toilet issues at a lake shore village namely, Chembe in southern west part of Lake Malawi and discuss the strategic vision for the future.

Keywords : Ecological Toilet, Sanitation, Lake Malawi

Problem of sanitation in a developing country and treatment of human waste

Located in southeast Africa, Lake Malawi occupies most of the country's eastern border. Twenty percent of the country's area is occupied by Lake Malawi, which is one of three large lakes scattered along the north-south Great Rift Valley. Malawi was formerly called "Nyasaland", meaning 'Lakeland' of Africa. Malawi for its supply of protein food heavily depends on freshwater fish from Lake Malawi. Out of 206 nations of the world, it was ranked 199th in GNP per capita in 1999. More than 60 percent of the populations are living below the poverty line.

The writer and her team of students have regularly paid visits to villages along Lake Malawi since 1995. During the visits we have been conducting basic study of social and ecological issues involving water and living environment. The writer is honoured to have had cooperation from many local residents as well as Professors and students from University of Malawi in this study. Out of the many villages we have visited, Chembe Village, also known as Cape Maclear by tourists, located in the south of Lake Malawi National Park and inhabited by Bantu tribe speaking Chewa dialect, is especially noteworthy. The population of the village in the beginning of 20th Century was merely 500, but it has now grown to estimated 10,000 residents in 2005. This rapid growth has resulted in many and related problems as explained below.

First, the high population growth has resulted in the spread of infectious diseases such as Cholera and Bilhalzia, which are commonly transmitted through contaminated water by human waste.

Secondly, the yield of maize, which is the staple food, is often badly affected by natural climatic factors such as drought and floods. Acute shortage of maize is often observed during the period before the new-crop is harvested.

Thirdly, the Government of Malawi, with an aim to eradicate the threat of shortage of staple food, encouraged the farmers to plant hybrid. It has become common practice of farmers to plant hybrid replacing the local maize. Hybrids come as a package and require optimum conditions to realize bumper yields. Farmers have to spend more money for the purchase of expensive seeds, chemical fertilizer and post-harvest-chemicals.

Fourthly, deterioration of land fertility resulted due to repeated use of chemical fertilizer for a long period of time, and the Government and villagers have begun to realize that it is now necessary for them to take up and use organic fertilizer in place of chemical.

For every villager, the utmost concern is to ensure constant supply of food. Interviews conducted by us in August 2002 with 20 women in Chembe Village revealed that over 90 percent of them wanted constant supply of maize as the most important concern. The same interview conducted at the same time with primary school children revealed that more than 50% of them had only one meal a day. The problem of hunger has not been alleviated despite the introduction of hybrid maize. Introduction of hybrid maize has automatically necessitated the more use of expensive seeds, and chemical fertilizers.

During our visits to Malawi, the writer and her team had thorough discussion with youngsters of the villages regarding water environment, sanitary problem, shortage of food and use of fertilizers as is shown in Chart 1. We have come to a conclusion that the exhaustive utilization of every inch of natural resources available around the household, forest and lakeside just like the historically-proven farming method of Japanese farmers is most recommendable. Farmers in Japan have for a long time made use of forest leaves, dried fish and human waste as their main source of fertilizer in enriching their land. But the use of human waste as organic fertilizer for farmers in Malawi is completely out of their imagination; as such an idea has never existed in their cultural background. In addition Chewa dialect does not have any vocabulary for 'manure' nor 'fertilizer', and those words are borrowed from English.

We have a long way to go before the villagers are convinced of the necessity of organic fertilizers in enriching or tilling their land properly. The writer intends to discuss the problems underlying the globalisation of economy together with the results of the fact-finding research conducted on the environment of life and the agricultural production in the Chembe Village. The writer also intends to touch on the problems encountered during the introduction of ecological toilets in Chembe, along with the problem of assuring constant supply of food and that of fertilizer by the next presenter G. Mwale.

Globalisation of economy now progressing in this world is forcing the developing countries to depend more and more on the supply of essential materials from other countries. Self-sufficient survival nowadays seems to be impossible in the global economy. The writer venture to seek a solution for economic survival within local region where natural resources are limited and scarce like in the case of Malawi.

International policy that regulates the lives of lake shore villagers.

The life environment in Chembe Village is greatly regulated by international structure, where rapid globalisation is progressing. One of the problems is that of conservation of environment is synonymous with keeping "Biodiversity". The other is the problem of so-called "Structural Adjustment Programme" being carried out by such organizations as The World Bank and IMF.

Not Enough Toilets Available	**Water Pollution + Sanitation Problem**	**Food Shortage Problem**
⇩	⇩	⇩
• Expensive to build. • Require strong foundation as the ground is sandy. • Danger of collapse due to rain. • Building toilets is gender related as only men can build toilets. • Matrilineal society (more than half of families are matrilineal)	• Diseases like Cholera & Diarrhea, Bilharzia. • High rate of infants' mortality. • High rate of population increase. • Lack of Natural Resources, what about the lake, trees etc.	• Increase of population • Limited land available • Introduction of hybrids • Increased use of chemical • fertilizer • Deterioration of land • Fertility for agriculture • Dependency on chemical port fertilizers which are imported. • Devaluation of Malawi currenc • Sharp increase in price • of fertilizers.
Strong sense of TABOO---Culture of feces-phobia		

Figure 1: Structural Problem of Water in Lake Malawi.

By looking at the example of Chembe Village, it is easy to see how the policies of IMF and The World Bank directly affect the lives of the villagers. We have to consider seriously the direction to which the local society is forced to take. Important theme for us is to find a solution to the "survival economy" in relation to the problem of environment, where almost all of household income must be spent for its food.

Chembe Village is one of the five enclave villages of Lake Malawi National Park. The Park was established in 1980 in order to conserve the important species of fish called mbuna and the surrounding forest. The Park is designated as one of the World Heritage Sites in 1984 by UNESCO. It is one of the most important hot-spot for the study of mbuna. Cutting trees in the forest within the area of the Park, and fishing within 100 meters of the lakeshore is strictly prohibited.

The National Park deprives the villagers of their daily resources of fuel and food by placing restriction on getting woods and fishing in the lake. The villagers depend solely on the forest and the lake for their supply of fuel and food. For the authorities of the National Park, the villagers are a menace to them, invading illegally into the prohibited forest to cut trees and entering restricted water area to fish. The cash income is constantly decreasing due to the decrease of catch of fish from the lake.

The conflict between conservation of National Park and securing the livelihood of residents is becoming a big problem in Malawi as in most of the African countries. Efforts have been made by such organization as WWF in order to create new method to let the villagers earn livelihood with new way by "Substitute Economic Approach".

The British protectorate of Nyasaland became the independent nation of Malawi in 1964. After three decades of one-party rule under President H. K. Banda the country held multiparty elections in 1994. The New Government attempted to "liberalize and democratize" the nation and it resulted in the loss of national support for agricultural system. Farmers have been directly exposed to the capitalist economy. Introduction of hybrid maize meant that the farmers have to purchase every year new seeds. Seeds of hybrid cannot be produced domestically, and chemical fertilizers for hybrids must be imported. For instance, Monsanto, which is a multi-national chemical enterprise, has taken over National Seeds Company of Malawi in 1990s. Not only those African countries such as Republic of South Africa, Zimbabwe and Egypt are exporting Chemical Fertilizer to Malawi but also Greece is aggressively seeking to join the market.

The Agricultural Development and Marketing Corporation (ADMARC), who supplied Fertilizer and Seeds to all farmers even in remote country-sides of Malawi, went half private in the name of 'commercialisation'. Thus, economic efficiency has come as first priority, and inefficient activities are shaved off. In the rural areas where public transportation is not readily available, the shrunken service of ADMARC necessitated all farmers to transport heavy seeds and fertilizer themselves for a long distance from the market. As a result of cutting down the various services of ADMARC previously available in the village of Chembe, villagers now have to carry a bag weighing 50 kg of fertilizer from a town some 20 km away from the village. Malawi depends 100% on imports for the supply of chemical fertilizer, the prices are going up continuously at an enormous rate as currency of Malawi is devalued.

Looking into the problem of making toilets in Chembe-

It is not customary for the villagers of Chembe to build toilets. In 1990's an Aid Organization from Denmark (DANIDA), in an effort to stamp out contagious diseases like Bilhalzia transmitted through human waste, run a campaign to build toilets in Malawi. As a result increasing number of people built toilets within their premises. However more than half of residents in Chembe remain without toilets and once the toilets become full most people cannot afford to make new one. Heaps of human faeces are built around lakeside, riverside and underneath large trees hidden from the public eyes. These faeces are drained into the lake during the rainfall. This lake is the place for children to bathe and for housewives to draw water for daily living.

In August 2003, we conducted interviews with villagers of Chembe to find their opinion about building toilets. Thirty-nine adults and 42 elementary pupils of higher grades were directly interviewed. We asked them (1) places where they excrete (discharge), (2) if they are troubled or feel uncomfortable without toilets, (3) why they do not try to build toilets, and (4) if they know anything about turning human wastes into fertilizer.

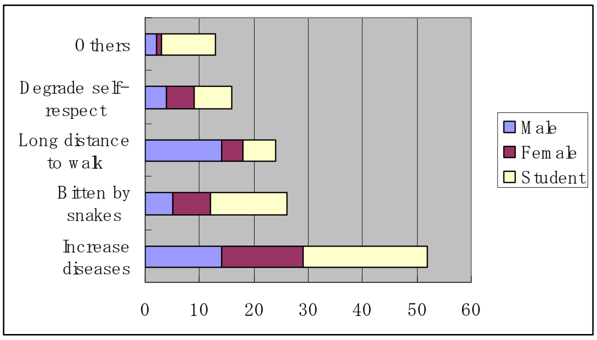

Figure 2: If it were not for toilet, what troubles the villagers?

For our question if they are troubled or feel uncomfortable without toilets, they answered mostly that the spread of diseases is feared without toilets. Male and female adults and pupils alike feared the spread of diseases. Fear of being bitten by snakes came next before a long distance that they must travel to reach a place. Some others mentioned the necessity of pocketing the self-respect by discharging in the wild fields.

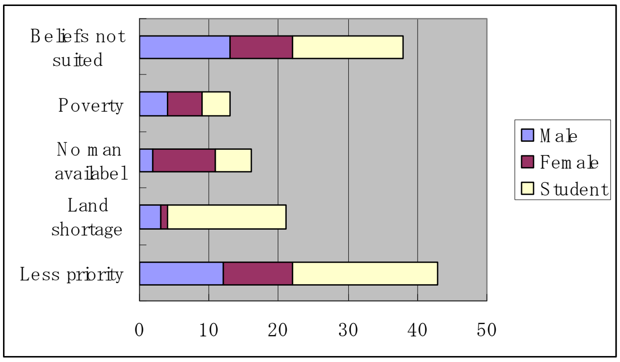

Figure 3: Why do they not set up toilets?

To our question of why they do not build toilets, most of them answered that it is their "less priority" or "laziness'. We understood, however, that they are not building toilets simply because of their laziness, but because toilet comes less important in its priority of other essentials of life for them. "Limited availability of land", "Unavailability of funds" came next as reasons for not building toilets. Building toilets on the sands by the lakeside in Chembe requires a large quantity of cement, which costs lots of money for the villagers. The cost of building a toilet is in on average 1400 Kwacha for necessary materials only. This is very expensive for a villager because monthly salary of a teacher at elementary school is not more than 2,000 Kwacha per month. Toilet making is gender related and it is the job of the male to build toilets. If a male is not available for work, even though the materials could be obtained, toilets cannot be built. Lack of male labour was the main reason for not being able to build toilets in households where females are the head of the family. This region of Malawi is traditionally matrilineal, and there are many households where females are the head of household.

Even if a toilet were built, the pit is easily filled up with faeces within a few years. Soon another pit is required to be dug. There are many remains of such pits left unused, and we can see how easily they are used up and disposed of. Seventy percent of the villagers are Christian, and thirty percent are Islam. And yet, they believe in anathema (malediction) or practice of cursing. Villagers fear that their faeces are the targets of anathema. In order to avoid someone cursing on their own faeces, it is important not to be identified by others whose faeces they are. By building toilets, it becomes easily identified whose faeces they are, and they become an easy pray for the curser. This cultural background where they believe it is safer to discharge at unfixed unknown places makes it difficult to set-up toilets in the village.

We learned that the villagers are not easily motivated to set up "easily filled up" toilets around their houses due to economic and cultural reasons. Despite our efforts to inform them of the urgent need to improve sanitation of water for the well-being of the public in general; it does not directly motivate them to build toilets. Everybody is aware of the desirability to improve sanitation and of the danger of spread of diseases due to no toilet. Yet each one of them is thinking that it is neither he nor she to be victimized by the disease, and they continue to go out to the lakeside and bushes to discharge. Many villagers complain that the water of the lake is now so polluted and it is not fit to drinking. Yet his or her complaint does not directly lead to the building of toilets.

"Sanitation" is in a sense "a public asset". People are not motivated to build new toilets unless new social and economic motivations are placed.

As we mentioned DANIDA once assisted the villagers to set up toilets, but those facilities were abandoned after a while. There is no guarantee that the habit of using toilets persists among the villagers. Enormous expense and labour are necessary to build new toilets after old toilets are abandoned. It is important for us to find a condition where the villagers themselves recognize the value of toilets as their essential necessities for life both economically and culturally.

If we look back on the history of toilets in Japan, it was the farmers' ingenuity that led them to makes the most of human faeces for fertilizer. Farmers' psychology and tradition of making the best use of whatever resources available in their household resulted in the sustainable upkeep of toilets in Japan and eventually sustainable maintenance of life economy. The problem of sanitation of toilets is equally important as the problem of fertilizer and of food and of economy, and they are closely related to each other.

Therefore, we have added the following question to our interview to the villagers: "In Japan, we have long used human faeces as fertilizers. What do you think about it?" Nearly eighty percent of the adults and 60 percent of school children expressed their opinion "for" the use. This does not automatically mean that they are themselves willing to make the use of toilets. They expressed their willingness to build toilets by themselves only if we can prove to them that human faeces can be effectively used as fertilizer and that toilets can improve sanitation of the village. These problems of toilets, water pollution, environment of life and agriculture can be summarized into Chart No.5 as below. The big obstacle for setting up toilets comes from economic and social reasons.

We can conclude that sanitation problem alone would not provide the sustainable solution for 'necessity of life'. It would be necessary to solve all those necessities of life such as food, sanitation and environment according to the order of urgency as the villagers feel necessary in their daily system of life. Again we would like to emphasize that persuading people to make toilets for health reasons alone was not sufficient. In the past various organizations failed to dig toilets for the disposal of human excreta because the bushes and river and lakes around homes would simply provide that service, the economic values attached to the faeces and urine is too attractive to ignore. Attaching an economic value to toilets and faeces and urine has important possibility for improving the food shortage when a lot of African farmers cannot afford fertilizer.

Sanitary conditions in selected lake areas of Uganda: Case study of Kiribairya – Lake Kyoga and Lubajja – Lake Wamala

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Abstract

A research into sanitary conditions in two selected fish landing sites of Kiribairya on Lake Kyoga and Lubajja on Lake Wamala was carried out in November 2003 and April 2004. The study was guided by four objectives: (i) to find out the coverage of sanitary facilities like pit-latrines and washrooms; (ii) to examine people's sanitary practices in the two sites; (iii) to assess the quality of the adjacent Lake water to the landing sites by using faecal-coliform; (iv) to find out how sanitary conditions have affected people's health in the two sites. Both qualitative and quantitative data collection methods were used.

In both Kiribairya and Lubajja, it was found that the coverage of sanitary facilities was low; in Kiribairya, the coverage was 43%, 40%, 42.5% for latrine, wash rooms and rubbish holes respectively. Consequently, people often use open spaces or the bushes along the lakeshore as "toilet" and dumping areas. This is dangerous because when it rains, the filth is washed down into the lake by runoffs. The water samples that were taken from both case study areas during the dry and wet seasons indicated high levels of *Escherichia coli* in the adjacent lake water to the landing sites - which is evidence that the poor sanitary conditions at the landing sites are affecting the quality of the water in the lakes. The lakes are the main source of water for people who use and drink it largely unboiled – for instance 82.5% in Kiribairya drink unboiled water thus affecting their health.

Key Words: Sanitation, Sanitary conditions

(For this study, sanitation refers to the management and handling of human body wastes while sanitary conditions refer to the availability of sanitary facilities like pit latrines, hand-washing facilities and waste disposal facilities at house hold level).

Introduction

This research was carried out in Kiribairya and Lubajja fish landing sites on Lake Kyoga and Lake Wamala respectively. Kiribairya village is found on a flat land on the southern shores of Lake Kyoga, Kamuli District, Eastern Uganda (Figure 1). It is dry – with only one major rainfall season in May-June and a mild one in October – November. The village has an estimated population of about 600 people, and it has about 201 households. It is ethnically diverse with 5 tribes namely: Bakenye 44%, Basoga 27%, Banyoro 18%, Iteso 8%, and Jaluo 3 % (Ellis and Bahiigwa, 2002).

Lubajja is found in Mubende District on the shore of Lake Wamala, Central Uganda (see map 1).The area has an estimated population of about 1000 people and about 377 households. The main ethnic groups in this area are: Baganda, Basoga, Batoro, Banyarwanda, Bakiga. It receives rainfall throughout the year with two peaks in April-June and October-November (Scullion, 1997).

Kiribairya experienced floods in 1998 after the El Nino rains while Lake Wamala (Lubajja site) experienced shrinking and recovery of lake levels in early 1990s and late 1997 and early 1998 respectively. These changes seem to have led to an increase in livelihood opportunities such as an increase in fisheries and fish related businesses following the recovery of the lake levels. Consequently, there was an increase in human population which contributed to the deteriorating sanitary conditions.

Materials and methods

In order to get a broader understanding of some key topics vital to the research such as village and lake environmental history, problems of the area and problem ranking, changes in livelihood activities, village well being, and wealth ranking Participatory Rural Appraisal (PRA) and in-depth interviews methods were used between November 2003 and March 2004. There were also meetings held with a group of school going children (6 – 14 year olds) in each of the case study areas. This was aimed at capturing information on issues that are sensitive for adults to provide answers. In each of the fish landing sites, a total of 8 meetings were held with adults of 18 years old and above.

Questionnaires were also used to get more information from households that were stratified into wealth groups of rich, medium and poor in a wealth ranking exercise from village household lists and then proportional household samples selected randomly. This was done because there was a need to ensure that all the wealth structure of the communities was captured. In both Kiribairya and Lubajja, a total of 40 questionnaires were administered in each landing site.

For the water quality studies, samples were taken from each of the case study areas from the shore and approximately 100m offshore in each of four months of January and February (dry season), and April and May (wet season). APHA standard methods (1992) were used. The water samples were collected in plastic bottles of 500mls, immediately stored cooler boxes and transported from the field to the laboratory analysis within 24 hours of collection.

All laboratory work was carried out in the Busoga Trust laboratory or FIRRI laboratory in Jinja. Faecal coliform (*Escherichia coli)* was used as the main determinant of the water quality. It was determined using the membrane filtration method according to APHA 1992.

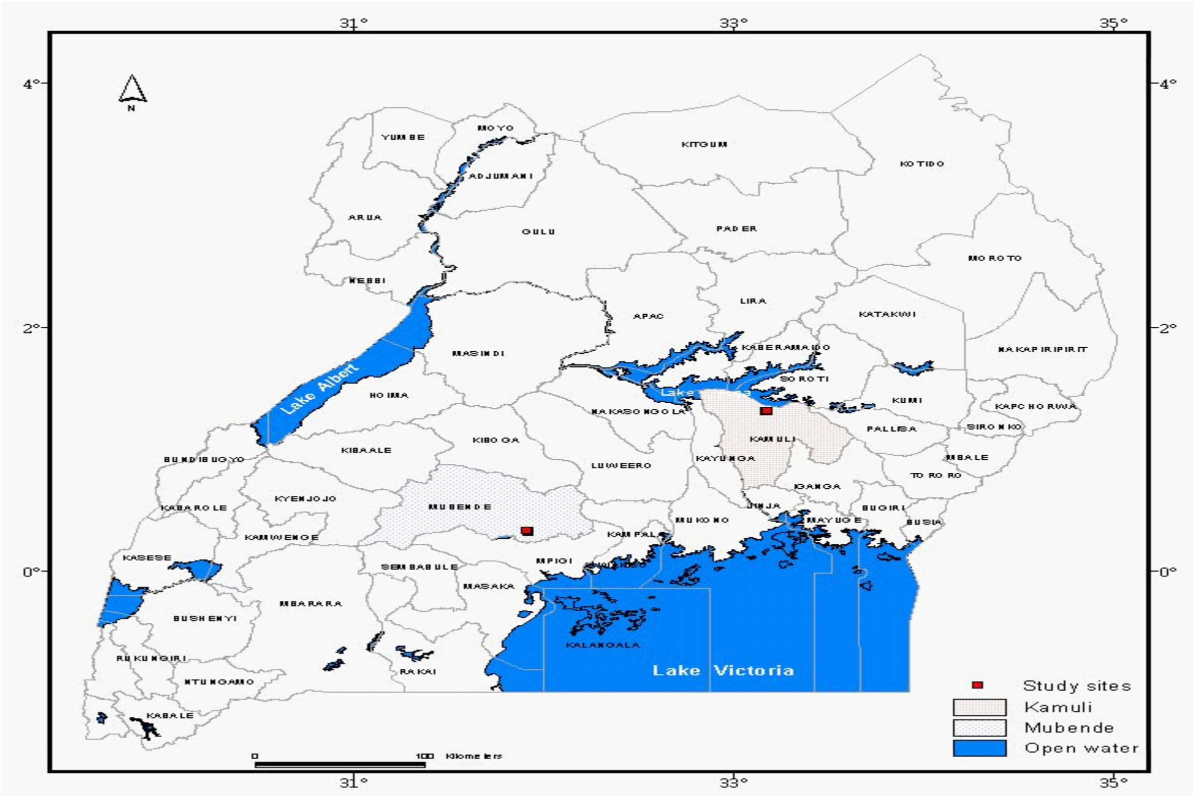

Figure 1: Map of Uganda showing the location of study sites on Lakes Kyoga and Wamala.

Table 1: Coverage of sanitary facilities.

1 Sanitary facilities in households surveyed in Kiribairya						
	Pit latrine		*Washroom*		*Rubbish hole*	
Presence of facility	*Frequency*	*Percentage*	*Frequency*	*Percentage*	*Frequency*	*Percentages*
Yes	*18*	*43.0*	*16*	*40*	*17*	*42.5*
No	*22*	*57.0*	*24*	*60*	*23*	*57.5*
No response	*0*	*0*	*0*	*0*	*0*	*0*
Total	*40*	*100.0*	*40*	*100.0*	*40*	*100.0*
2 Sanitary facilities in households surveyed in Lubajja						
	Pit latrine		*Washroom*		*Rubbish hole*	
Presence of facility	*Frequency*	*Percentage*	*Frequency*	*Percentage*	*Frequency*	*Percentages*
Yes	*36*	*90*	*27*	*69.2*	*16*	*40.0*
No	*4*	*10*	*12*	*30.8*	*24*	*60.0*
No response	*0*	*0*	*1*	*2.5*	*0*	*0*
Total	*40*		*40*	*100.0*	*40*	*100*

Results

Coverage of sanitary facilities

In order to assess the importance and use of sanitary facilities in Kiribairya and Lubajja, forty people were interviewed on the presence of a pit latrine, washroom, and rubbish hole at household level in each of the fish landing sites. the results about the coverage of these facilities are shown in Table 1 above. The results in the table above indicate that the coverage of sanitary facilities especially the pit latrine is low especially in

Kiribairya. Out of the 40 people who were interviewed in Kiribairya, only 43% had latrines, 40 % had washrooms and 42.5% had a rubbish hole. The low coverage of sanitary facilities especially the latrine in this case study area is due to poverty – people have no money to put up these sanitary facilities. Other factors include inadequate land and the culture of people.

For the case of Lubajja, the table indicates that the coverage of sanitary facilities is high as compared to Kiribairya (90%, 69.2%, 40%) for latrine, washrooms, and rubbish hole respectively. This is because there is an arrangement in the village whereby the authorities have encouraged people to construct these facilities or share with neighbours who don't have. Though this is the case, the sanitary conditions are still poor. It is common to come across faeces scattered along the lakeshore because the landing site is over-crowded. There are more people than the facilities available; there is also a problem of poverty and cultural rigidities.

Sanitary conditions and water quality

The water quality as measured by the faecal coliform is shown in Figures 2 and 3 below for Kiribairya and Lubajja respectively.

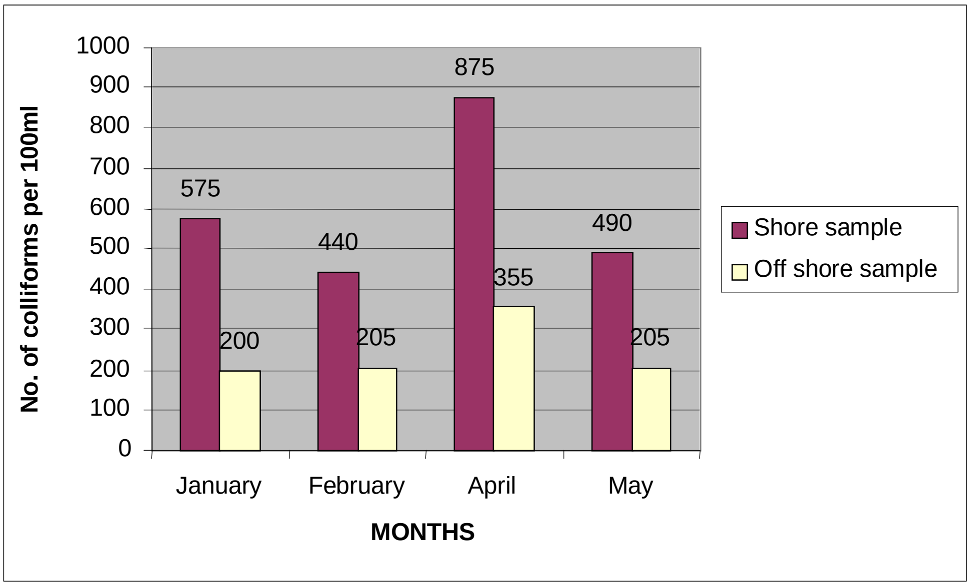

Figure 2: *Escherichia coli* levels in lake water adjacent to Kiribairya landing site.

From Figure 2 above, samples from the shore have higher *Escherichia coli* levels compared to those taken offshore. This is because the shoreline gets contaminated by faeces from the human settlements near the lakeshore, whereas dilution effects offshore disperses the bacteria thus reducing their abundance per unit volume. Samples taken in April during the rain season had *Escherichia coli* counts taken in January, February and May. This is because April was the peak of the rain season and so there was a lot of run off from the main land to the lake water. The January- February results are quite similar to May results partly because January was dry season and May was the end of the rain season. So, there was less run off into the water body during these periods.

In Figure 3, there are similar observation to Figure 2 in that shore counts of *Escherichia coli* are higher than counts off shore because of immediate faecal contamination and dilution effect respectively. Also, there are high *Escherichia coli* numbers in samples picked in April and May (rain season) as compared to samples picked in January and February (dry season).

Effect of poor sanitary conditions on people's health in Kiribairya and Lubajja

Assessing the effects of poor sanitary conditions on people's health was one of the objectives set for this study. Table 2 below presents results of the occurrence of sanitary related ailments from the household questionnaire survey in Kiribairya.

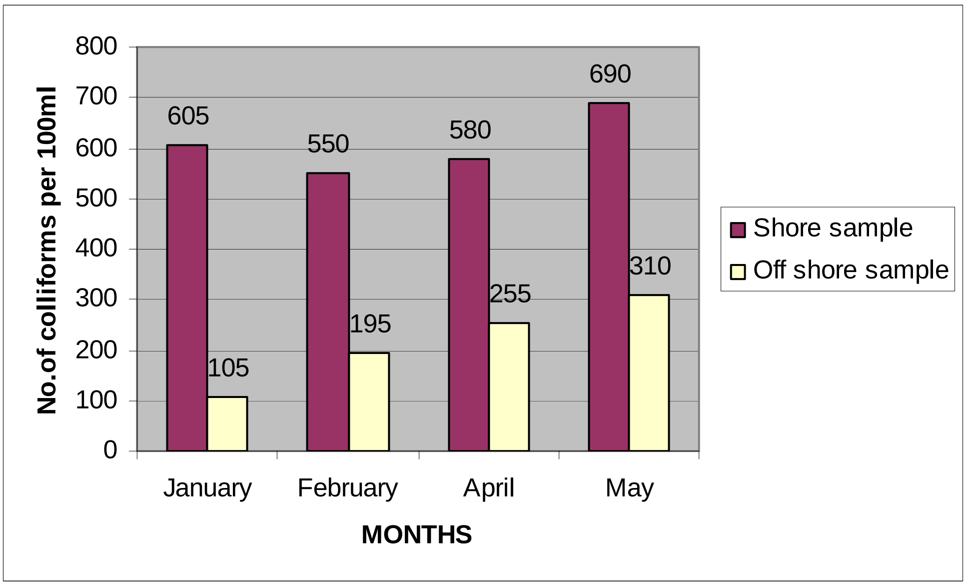

Figure 3: *Escherichia coli* levels in adjacent lake waters to Lubajja landing site.

Table 2: Occurrence of sanitary related diseases in households (period of 1 year).

	Kiribairya		Lubajja	
Health condition	Frequency	Percentages	Frequency	Percentages
No blood stained stool	11	27.5	21	52.5
Blood stained stool	29	72.5	19	47.5
Total	40	100.0	40	100

Table 2 shows that 72.5% of respondents amongst the people who were interviewed in Kiribairya admitted that they had suffered from blood stained stool (probably due to Escherichia coli) in the period of one year back from the time of data collection compared to Lubajja with 47.5%. The occurrence of the sanitary related diseases can be attributed to the low coverage of pit latrines and hence use of bushes as 'toilets' as shown earlier. When it rains, raw faeces get washed into the lake and yet people depend on the lake for water for domestic purposes. Some people boil their drinking water while others do not as shown in Table 3 below:

Table 3: Boiling lake water before drinking.

	Kiribairya		Lubajja	
Boil drinking water	Frequency	Percentage	Frequency	Percentage
Yes	*4*	*10*	*36*	*90.0*
No	*33*	*82.5*	*3*	*7.5*
Sometimes	*3*	*7.5*	*1*	*2.5*
Total	*40*	*100*	*40*	*100*

Table 3 shows that out of the 40 respondents who were interviewed in Kiribairya, only 10% boiled lake water before drinking it; 82.5% of respondents were not boiling water while 7.5 % of respondents admitted that sometimes they do boil lake water for drinking, sometimes they don't. Some people in Kiribairya don't boil lake water before drinking it because they think that lake water is safe as it is clear in appearance.

For the case of Lubajja, 90% of the people interviewed admitted that they boiled lake water before drinking it. 7.5% admitted that they don't boil lake water before drinking it and 2.5% of those interviewed said that they sometime do boil the lake and some time they don't boil the lake water before drinking it. The number of people who boil lake water before drinking is high because the local authorities in an effort to curb break out of epidemics due to poor sanitary conditions, they encourage people not drink un-boiled water from the lake.

A statistical cross tabulation between sanitary related illnesses (blood stained stool) and drinking un-boiled lake water was run using a chi square test at significance level of 0.05. For Kiribairya, the P value obtained was 0.008. This indicates that the result is significant at a 5% confidence interval. It also further means that there is less than 5% chance that the results obtained could be due to random chance alone. As such, there is a relationship between people's health - as far as sanitation is concerned, and the drinking of un-boiled lake water although there may be other dependent factors like poverty. However, because the sample size was small, it was not possible to meet all the assumptions of the test.

For Lubajja, the P value was 0.539. This means that the test is not significant at the 5% confidence level. In other words, because there were more people who boil lake water before drinking it, the results of a cross tabulation between sanitary related ailments (blood stool) and boiling lake water before drinking didn't produce evidence of a relationship between people's health and the drinking of un-boiled lake water. This interpretation is made on the basis that other factors like the sample size was small so that all the assumptions of the test were not met.

Discussion

The level of sanitation in Kiribairya and Lubajja is poor because sanitary facilities are not adequate. There are also cultural beliefs and fisherfolk practices that negate use of even the few facilities available. Consequently unsanitary practices like using bushes and open lake as 'toilets' leads to the contamination of lake water. The counts of *Escherichia coli* in the water used by the people for domestic purposes are rather higher than the recommended values for drinking water in Uganda as shown in Table 4 below:

Table 4: National Microbiological guidelines for drinking water.

Total coliform per 100ml	*Escherichia coli* range per 100ml	Comment
0 – 50	0 - 25	Satisfactory
50 – 100	25 - 50	Acceptable
100	50	Max. permissible

Source: RUWASA, 2001

Shortage of land and overpopulation are also other factors in the sanitary equation. In Kiribairya and Lubajja, there are areas that are extremely crowded and these are areas adjacent to the lakeshore. Landlords demarcate small portions of land to their tenants so as to obtain very high profits out of their land. These portions are usually just enough to put up a hut and no space left to put up a latrine or bathroom. In the less crowded areas away from the shore, land was relatively abundant such that people had space to put up the facilities and so the inventory on sanitary facilities registered more facilities in these less crowded parts of Kiribairya and Lubajja.

The culture and beliefs of people are other factors responsible for the low level of sanitation in Kiribairya and Lubajja fishing villages. For instance in Kiribairya, among the Bakenyi tribe who are the dominant at the landing site, it is a man's duty to dig a latrine for his family. Since most Bakenyi men have more than one wife, it becomes costly to build a latrine for all the wives. As such, it is easy to find households especially female-headed households without a latrine.

Also in the Bakenyi tribe, young children don't use pit latrine because the Bakenyi believe that human body excreta from a child are not harmful. As such, children are left to ease themselves in the open. In Lubajja, fishermen were reported to have a habit of defecating in the lake when they go to set their fishing nets. The fishermen do this because they have a belief that the lake is too big to be polluted by an individual who defaecates in the water at one end.

Lack of sensitisation is another factor that is contributing to the poor level of sanitation in Kiribairya and Lubajja. This is partly because the District health officials who are supposed to sensitize people on proper sanitation don't visit these areas regularly. As such, people don't have pit latrines because they don't know why they should have them. Also some of those who have latrines don't use them because they don't know the importance of having these facilities. People may put up pit latrines, bathrooms, and kitchens in order to impress or to avoid being arrested by health inspectors who come once in a while.

People at the landing site especially in Kiribairya attribute their failure to put up a pit latrine to the fact that underground water is very near the surface. Kiribairya is quite water logged. Residents say that underground water can be found within six feet when a latrine is dug. Because of this, when it rains, the water table rises even higher and the pit latrines flood and eventually the filth washes down into the lake. Due to the place being too water logged, some residents in Kiribairya have resorted to other alternatives like digging temporary holes that they use as pit latrines. The holes are usually not more than a meter deep and they are used for a short time after which they are filled and covered with soil when they are full.

Some people in Lubajja attribute their failure to have a latrine because of hard rock on the surface. The residents claim that the rock along the lakeshore is very hard; it is not easy to dig a pit that is deeper than a meter and if one tries it becomes very expensive to hire labour.

In Kiribairya, there is a situation of chronic and severe poverty. In other words, many people in this fishing village are living in long-term conditions of poverty brought about by a multitude of causes. For instance, the area is very dry and as such, there are few income-generating activities that can be done there and these activities lack diversity (Bird, 2001). Also, other factors like difficulty of access to markets, loss of assets due to conflicts in the Northern part of Uganda, increased seasonality in income of a household (Goulden, 2004) prolong poverty conditions.

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Water related disease prevalence and health risks in riparian region of Lake Victoria, Uganda

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Abstract

Studies to examine the prevalence of water-related diseases and other health risks in the Lake Victoria region of Uganda were carried out. Surveillance studies were done by the Water Resources Management Department (Directorate of Water Development) and the Fisheries Resources Research Institute. Other sources of data included review and analyses of findings from the Ministry of Health and other studies in the region. Faecal coliform counts in water samples were analysed for indication of faecal contamination. The coliforms were generally very high in most of the sampling sites indicating high contamination of waters. The riparian communities source their water for domestic consumption mainly from the lake. The wet seasons had significantly higher coliform counts than the dry seasons for all lakeshore sites. This seasonal variation in coliform counts correlated positively with waterborne disease incidences that were higher in the wet season.

The most prevalent diseases in the landing sites included malaria, dysentery, diarrhoea and bilharzia. Many people in the catchment disposed their wastes in bushes or in polythene bags, contaminating water sources with faecal material and leading to waterborne diseases. Lakeside communities' vulnerability to water-related diseases was further aggravated by low accessibility to health facilities and personnel.

In Lake Victoria, cyanobacteria (potentially toxic to humans and animals) dominate other algal species and contribute a larger fraction (>50%) of the biomass. Algal blooms were found to be frequent in Murchison Bay, a source of drinking water for Kampala and the surrounding urban centres. Algal blooms cause unpleasant odours and tastes in domestic water supplies, clog filters on pumps and machinery, increase chlorine demand, requiring more complex and expensive treatment process. Findings suggest that improvements in water quality, sanitation and hygiene behaviour change can significantly reduce prevalence of water-related diseases.

Key words: cyanotoxins, Lake Victoria (Uganda), water-related diseases.

Introduction

Like many developing countries, Uganda faces a high population density accompanied by a relatively poor infrastructure. In the urban centres and some rural settlements, the available sanitary facilities cannot sustain the population, leading to contamination of surface water sources with faecal material. As a result, waterborne diseases such as cholera and typhoid fever have become rampant.

Faecal pollution on top of introducing bacteria (coliforms) of faecal origin into the water body also accelerates eutrophication which causes explosive growth of algal species (Muthoka *et al*., 1998). Faecal pollution implies a high risk of contracting water borne diseases if the water is used for drinking purposes without treatment (Odada *et al*., 2004). Under the WHO guidelines, *Escherichia coli* must not be detectable in any 100 ml sample of drinking water (Havelaar *et al.,* 2001). It is very important that human faeces be safely deposited, in order to reduce the pathogen load in the ambient environment (Huttly *et al.,* 1997).

In Lake Victoria, cyanobacteria dominate other algal species and contribute a larger fraction (>50%) of the biomass (Mugidde *et al.,* 2003). Cyanobacteria are potentially toxic to humans and animals and also deteriorate the ecological and aesthetic values of water and have been found to poison wild animals such as fish, kangaroos and birds (Krienitz *et al*., 2003). The main three toxin producing blue-green algae in the tropics are *Anabaena, Microcystis* and *Cylindrospermopsis.* Algal blooms cause unpleasant odours and tastes in domestic water supplies, clog filters on pumps and machinery, increase chlorine demand, leading to increased trihalomethane precursors which lead to increased chloroform and other potential carcinogens in treated water supplies, increasing costs of operating water treatment plants.

Bilharzia (schistosomiasis), caused by a blood born fluke of the genus *Schistosoma* is the second most prevalent tropical disease in Africa after malaria. The intermediate hosts of the genus *Schistosoma* are snails. *Schistosoma mansoni* is responsible for all the cases in Uganda (Kadama *et al.,* 2001). Prevalence typically is highest near the lakeshore and along large rivers. No transmission occurs at altitudes >1400 m above sea level or where total annual rainfall is <900 mm, limits which can help estimate the population at risk of schistosomiasis (Kabatereine *et al.,* 2004).

Ninety three percent (93%) of the total population in Uganda is at risk from malaria. *Plasmodium falciparum* is responsible for over 95% of cases. Major vectors are *Anopheles gambiae s.l.* (and within the complex mainly *A. gambiae s.s.*) and *Anopheles funestus*. The number of malaria cases reported by the ministry has steadily risen over the past 14 years (MoH, 2005). It is estimated that up to 100,000 deaths occur due to malaria every year in Uganda, most of them in children below five years. The vector mosquitoes require access to standing water to complete their life cycles as eggs are deposited and larvae grow to adults in water. Malaria is transmitted in tropical and subtropical areas, where mosquitoes can survive and multiply and malaria parasites can complete their growth cycle in the mosquitoes.

The first HIV/AIDS case was diagnosed in Uganda in 1982, to date over 2.2 million people have been infected and about 838,000 have died, leaving behind close to 1.7 million orphans. HIV/AIDS has unleashed several impacts including straining of the health system, socio-economic disruptions, reductions in productive capacity, and it has also exacerbated poverty at household and community levels. The number of cumulative AIDS cases has continued to rise as a result of a large pool of HIV infected people who fall sick (UNICEF- IRC, 2002). The first two cases of AIDS identified in 1982 were from Rakai District on the shores of Lake Victoria. The relationship between water quality and human health in Lake Victoria basin is presented in Figure 1.

Materials and methods

In October 2002, we undertook a rapid survey of five landing sites, with water sampling and review of diseases from the nearest health centres. The study was intended to analyze the disease prevalence and sanitary conditions at selected landing sites. The landing sites studied were Kiyindi (Mukono District), Kasensero (Rakai District), Dimo (Masaka District), Bwondha (Mayuge District) and Dorwe (Bugiri District).

The study targeted local officials as key informants at the landing sites and health workers of the most frequently visited health centers in the communities. An interview guide was used to investigate the general population size, basic economic activities, health problems and existing health facilities, sanitary and hygiene conditions, water sources and waste disposal facilities, among others. On-site observations were used for data collection to verify responses from respondents on hygiene and sanitation, the water characteristics and waste disposal facilities. Water samples were collected from the available water sources and analyzed for physical, chemical and pollution indicator microorganisms (APHA, 1998). Water sources, which varied from site to site, included the lakeshore, springs, shallow and deep wells (where they existed).

A study on the prevalence of schistosomiasis around the riparian districts of Lake Victoria, Uganda, was also carried. The study addressed the intensity and spread of schistosomiasis in the fisher folk communities at the Lake Victoria shores in relation to the obligate snail populations. The study was carried out in six districts around Lake Victoria. These districts included Mukono, Jinja, Iganga, Bugiri, Busia and Kalangala. 271 adult respondents were randomly selected from 17 landing sites of Lake Victoria. Questionnaires were administered and samples of urine, stool and blood were analysed. The issues investigated included intestinal infestations, environmental public health, water and sanitation, and nutrition aspects. The symptoms covered included persistent abdominal complaints, stool stained with blood and bloody diarrhoea. While under the health and nutritional status, key issues were availability of latrines, clean water and food consumption.

Results and discussions

Findings indicated that generally the inhabitants on all the five landing sites were mainly migrants from different areas of Uganda, and immigrants from the region. High immigration to the landing sites is partly due to a high population growth rate in the riparian districts, resulting into less and less available land on the main land for farming, forcing many people to look for alternative livelihoods such as fishing and related activities. Many of the immigrants are also from war affected areas of Uganda (north and north east), while some are refugees from neighbouring countries (Rwanda, Democratic Republic of Congo and Sudan). Population instability makes information dissemination difficult and disease transmission more likely. It concentrates populations and creates problems for local infrastructure that becomes overwhelmed further aggravating the situation (Muyodi *et al.,* 2005, unpublished data).

The education level for most of the lakeshore communities was primary. The soils are basically sandy, making it very difficult and expensive for the local community to construct proper latrines. It was estimated that only half of the population had access to proper latrines.

The main prevalent diseases in these communities were basically water-related. They included malaria, dysentery, diarrhoea, skin-related infections and influenza. Cholera seems to be endemic in most of the landing sites. Recent studies show that lake water is the main source of water for the communities. Water for domestic purposes is drawn from about 1 to 2 meters from the shoreline. Domestic animals in the community also directly drink water from the same source. All the drainages in the settlement carry storm water and waste-washed water into the lake. The different sampling sites also displayed various microbial indicator levels. The total coliforms were generally very high for all the samples indicating that the waters were highly contaminated.

There is high variability between the seasons for coliform counts between wet and dry seasons. The wet seasons have significantly higher coliform counts than the dry seasons for all lakeshore sites (Muyodi, 2000). The wet season increases runoff of surface waters that mobilizes faecal material into the water courses and the lake. This seasonal variation in coliform counts correlates positively with waterborne disease incidences which are higher in the wet season.

Latrines, Ecosan toilets and boreholes were constructed in some districts by LVEMP. The success of these facilities varied from place to place. Some of the boreholes constructed are not being used because the water is either salty or coloured because it contains a lot of iron. The use of Ecosan toilets is estimated to be less than 50% on average because of several reasons. In fishing villages, people are too poor or reluctant to pay 100 Uganda shillings per visit to the toilets. Also, socio-cultural beliefs discourages their use. As a result, many people in the catchment dispose their wastes in bushes or in polythene bags, and therefore contaminate water sources with faecal material which in turn leads to waterborne diseases.

A total of 13 cyanobacteria species were observed in Lake Victoria. Cyanobacteria were dominant at sites which were deeper and eutrophic (Okello, 2004). Algal blooms were thicker and more frequent in Murchison Bay than Napoleon gulf. Highly toxic blue-green scum (*Microcystis* and *Anabaena* spp.) and water hyacinth congregated along the shore of Gaba water intake sites. Microcystin test kit results were lower than 0.5 ppb on all samples except for one station in the Napoleon gulf that showed a microcystin level of 0.5 ppb. In the inner Murchison Bay, some samples had microcystin toxin levels ranging from 0.5 ppb to 3 ppb. Microcystin levels observed were higher than the WHO guideline of 1.0 ppb in the inner Murchison Bay (CIDA, 2002).

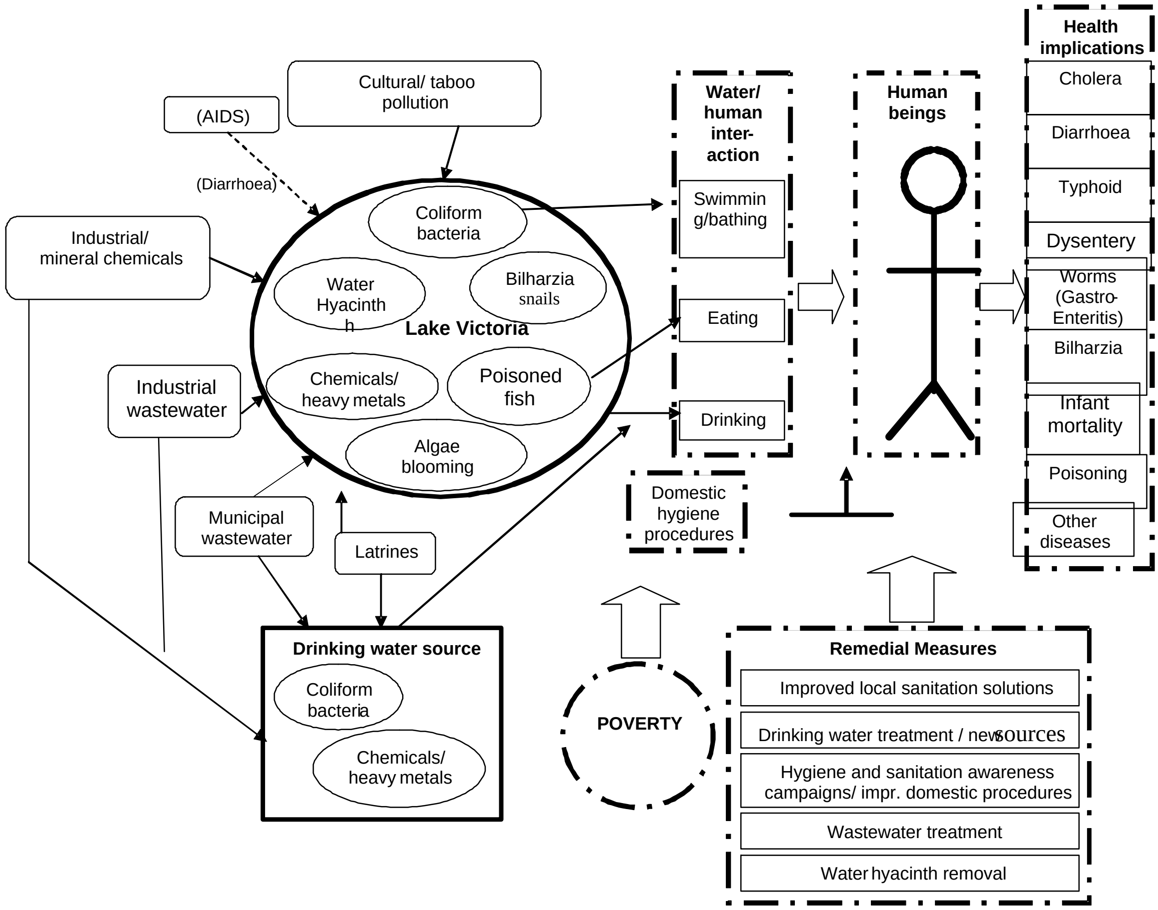

Figure 1: Simplified schematic relations between water quality in Lake Victoria (large circle) and human health.

The NWSC water treatment facilities at Gaba II were found to be adequate for removing cyanobacteria from their intake water. However, the age or stage of the particular cyanobacterial bloom was not determined. It appears that the cells had not yet lysed and the toxins were still contained within the cells. There is still a possibility that an older deteriorating bloom may rupture and release toxins, before or during water treatment. This would expose the residents of Kampala to moderate levels of microcystins.

Out of the 271 respondents screened for *S. mansoni,* 140 were infected, giving a prevalence of 51.6%. Collection of water from the lakeshore is mostly done by women (64%), making them more vulnerable to the disease. Fisher folk vulnerability to schistosomiasis was further aggravated by inaccessibility to both health facilities and personnel. The nearest health centres to most of the population were in a distance more than 1 Km while extension services by health workers were unsatisfactory. The findings suggested that lake water quality was deteriorating, a factor that supports the growth of the intermediate snail host. The Ugandan Government launched a campaign against Schistosomiasis in March 2003, and already about 500,000 people have received treatment (Schistosomiasis Control Initiative, 2005).

Figure 2 shows that the lowest prevalence of bilharzia is on the southwestern shoreline, close to the Tanzanian border, and increasing eastwards towards the Kenyan border. Results also show that bilharzia prevalence in school children is lower than that in landing sites communities in general indicating that the students may benefit from being in school and away from lake waters for prolonged periods of the day. The prevalence of bilharzia was generally <20% in the south-west of Uganda away from Lake Victoria, and >50% close to Lake Victoria (Kabatereine *et al.* 2004). The prevalence decreased as the distance from Lake Victoria increased; this is expected as contact with water decreases. *S. mansoni* infections were also found in children as young as 9 months old (Schistosomiasis Control Initiative 2005). There was a significant difference in bilharzia prevalence between those who used latrines regularly and those who did not have, as parasitic eggs of *S. mansoni* are released into the environment from infected individuals, rupturing on contact with fresh water to release the free-swimming miracidium (Takuhebwa 2001).

Figure 3 shows the trend in cases of cholera, dysentery and typhoid fever in the riparian districts for the first 13 weeks of 2003, 2004 and 2005 (MoH, 2005). Cholera cases were highest in Kampala for the three years. Cases of dysentery were high in most of the districts and highest in Wakiso followed by Kalangala.

Malaria was observed to contribute by far the major share of the disease burden in the country. There has been an increasing trend in malaria cases reported in governmental and non-governmental organizations health facilities (from 5 million in 1997 to 16.5 million cases in 2003) (MoH, 2005). Currently, malaria-prevention efforts in Uganda include control of breeding grounds of the mosquito vectors, the use of insecticide-treated mosquito nets, and anti-malarial drugs (especially for expectant mothers).

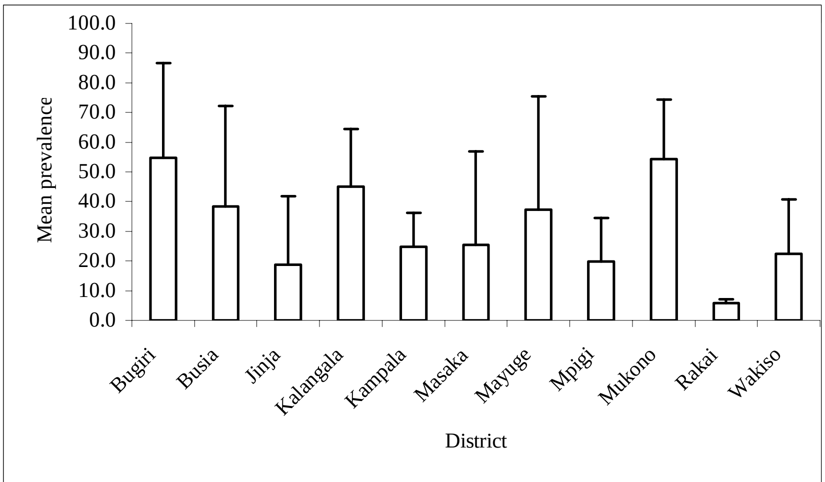

Figure 2: Prevalence of Schistosomiasis in Lake Districts of Uganda (MoH 2005).

The Ministry of Health is also proposing to use DDT as an indoor residual spray to kill the vector mosquitoes. DDT was initially introduced for control of vector-borne diseases, including malaria, however, it was banned in the United States in 1972 because of potential harmful effects on humans, wildlife and the environment (Jaga and Dharmani 2003). The use of DDT for controlling malaria should be carefully studied before its application as mosquitoes may become resistant to it and its non-specificity as a pesticide amongst other potentially environmentally harmful attributes.

Malaria causes ill health and deaths and also has a great impact on the economic developments of the individual, the family, the community and the nation at large. This is mainly through treatment seeking, treatment costs, and on prevention (MoH, 2005).

Kampala, Masaka, Jinja and Rakai were observed to have more than 500 AIDS cases per 100,000 residents (UNICEF-IRC, 2002). The large number of cases in Kampala and Jinja is attributed to the high concentration of urban residents whereas in Masaka and Rakai it is mainly due to the fact that HIV/AIDS was first identified in these districts. In the districts of Rakai and Masaka where the epidemic was first reported, HIV prevalence ranges between 10 to 13 percent. Alcohol selling is one of the income-generating strategies in Uganda being adopted by women, but it is also associated with risky sexual behavior. Alcohol consumption centered lifestyle is the observed lifestyle around most of the landing sites. The situation in landing sites is aggravated by the high mobility of the populations and high rates of immigration. AIDS and sexually transmitted diseases (STDs) were common at the landing sites due to the high rate of prostitution, lack of safe sex, and existence of migrant HIV-infected persons. The common STDs were sores in the genital parts, gonorrhea and syphilis.

Conclusions

Malaria continues to be the most prevalent water related disease for Uganda followed by dysentery in the riparian districts. Lowest prevalence of malaria and bilharzia is on the south western shoreline close to Tanzanian boarder, and increasing towards the east and Kenyan boarder. Of all the waterborne diseases, dysentery is the most common, followed by typhoid fever and cholera respectively. The most affected districts included Wakiso, Kampala and Kalangala.

Highly toxic blue-green algal scum congregate along the shore of Gaba water intake sites and microcystin levels observed were higher than the WHO guideline, posing a threat to human and other animal health. Water treatment for serviced communities can lower the risk but for un-serviced communities or those taking water directly from the lake, algal toxins pose a greatly increased risk as over-eutrophic conditions cause algal blooms dominated by toxic cyanobacteria.

AIDS and STDs were reportedly common at landing sites due to high rates of prostitution, lack of safe sex, and existence of migrant HIV infected persons. High mobility and high rates of immigration to landing sites contribute for the observed high prevalence of HIV/AIDS and STDs transmission.

Seventeen percent of Uganda's population had no access to toilets or latrines; and only 55 and 62 percent of the rural and urban populations respectively had access to safe water (UBOS, 2005). Some riparian districts have low water and sanitation coverage, for example, the district water coverage for Rakai is 42.6%.

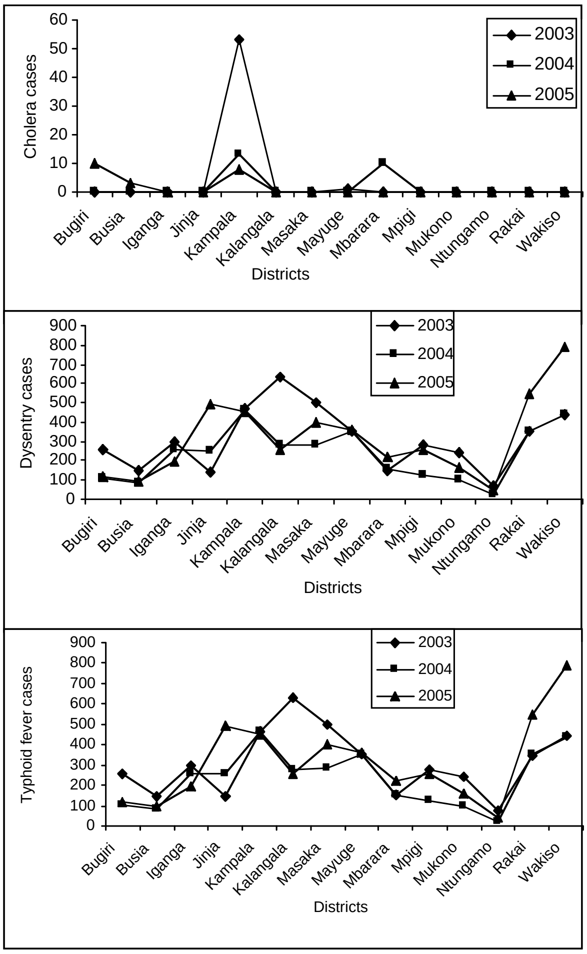

Figure 3: Trends in waterborne diseases in selected districts in the catchment.

Recommendations

Efforts should be geared towards reduction of waterborne and water-related diseases. This will largely contribute to improved health and standard of living for the riparian communities. There should be increased sensitisation / health education, combined with improvement of sanitary structures, as the main focus. Improved quality of domestic water supply in a number of selected locations could be included in such programmes. Low-cost locally initiated infrastructure development (latrines, and small water supplies) should be the starting and focal point.

The activities should primarily encourage changing peoples' hygiene habits and behaviour patterns and must have a long-term approach as changing peoples' minds cannot done overnight.

The use of cheap, sustainable home-based methods of purifying / treating water in particular should be researched upon, for example, the potential use of plants such as moringa (*Moringa oleifera* Lam).

The attendance of compulsory Universal Primary Education (UPE) for all

school-age children must be ensured to improve literacy level, which will in turn improve better hygienic and sanitary practices.

The exposure to algal toxins is an increasingly important but understudied risk factor for the health of lakeshore populations. Further study is needed to define the risk and solution to the eutrophication that is the cause of the cyanobacteria dominance.

Acknowledgements

We are very grateful to the following institutions, departments and individuals for providing support without which we would have not been able to produce this work. LVEMP funded the study. We are grateful to the staff of Water Resources Management Department of the Directorate of Water Development (Ministry of Water, Lands and Environment), FIRRI and NWSC where the actual studies were done. The Ministry of Health provided secondary data on diseases prevalence.

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Water contamination and its effects on the health of the people along the Lake Victoria shore areas (Tanzania)

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Abstract

Water can be considered as the food staff consumed in the greatest quantity around the world. Therefore, it comes as no surprise that the health risks associated with consumption of contaminated water are of great interest (McLellan, 2004). The objectives of this investigation, conducted over four years, from 2001 to 2004, were determined the water quality of Lake Victoria in near shore areas, and determined if any correlation exists between the quality of water and types of health problems experienced by those using the water for domestic and recreational activities. Additionally, local people living along the shore areas were interviewed to obtain their perspectives on how the decline in water quality has affected their health. The Water Quality Indices (WQI) indicated that the water was medium quality and acceptable for consumption. However in some stations, as much as 3×10^5 CFU/100ml of faecal coliforms levels were recorded; levels unacceptable for drinking and bathing water standards (WHO, 2001). Therefore, there is a need to ensure protection of the lake from further pollution.

Keywords: Water contamination, Lake Victoria.

Introduction

Many surface waters and ground waters in developing countries are contaminated by faecal pollution. For the past three decades Lake Victoria the second largest fresh water in the world and the largest of its kind in Africa has no exception. In Lake Victoria basin there is in creasing agriculture and urban runoff into the lake as well as direct discharge of raw sewage. The contamination with faecal materials results in degradation of recreational and drinking water quality as well as increasing health risks to persons exposed to the water (McLellan, 2004)..

The health hazards from water are evident from the fact that about 80% of infectious diseases throughout the world are water related. Since most of these diseases are transmitted through human faeces the condition is more serious in densely populated areas with in adequate sanitation and sewerage facilities (Tibbetts, 2000; Wu *et al*., 1999; Kravitz *et al*., 1998). Unfortunately this situation is more common in developing countries where the facilities to control a disease outbreak are limited.

On the Tanzanian side of Lake Victoria, several urban centres as well as village settlements are situated along the lakeshores. The major urban centres are Musoma to the east, Bukoba to the west, and Mwanza to the south. In Mwanza urban centre only 7% of its population is connected to the municipal sewers (current population is estimated at 447, 000). In Bukoba (66, 600 population) and Musoma (118, 000 population) urban centres there is no sewerage system at all. The most common sanitation systems in the major towns are pit latrine, bucket toilet or septic tank depending on the economic conditions of the households. Urban high income buildings such as restaurants, hotels, offices and rental accommodation have flush toilets connected to municipal sewers where available. Effluents from septic tanks are also discharged into the municipal sewers or on the ground. Open defecation is common in rural areas along the shores of Lake Victoria.

The common water borne and other water related diseases associated with poor water quality of the lake include cholera, typhoid, dysentery, diarrhoea, intestinal worms, amoebiasis, shigellosis and giardiasis. Knowledge on pollution levels in Lake Victoria could aid in the restoration of the water quality and reduce the danger of infectious disease resulting from exposure to contaminated waters.

Materials and methods

Study area

The study was carried out along the near shore areas of the urban centers of Mwanza and Musoma. Water samples were collected from fixed sampling stations along the Lake Victoria shore areas in Mwanza, Musoma and Bukoba urban centers, from 2001 to 2004. In Mwanza urban, water samples from public tapes were also collected.

Sample collection

Weekly sampling of water was made from various fixed impact sampling stations at a distance of about 100m from the shore, during the period from 2001 to 2004. Samples for bacteriological analysis were collected aseptically in sterile 250-ml wide mouth glass bottles. After collection, samples were kept in a cool box containing ice-bags and transported to the laboratory, where they were analysed within 3-6 hours of collection.

Data on the common water related diseases associated with poor water quality were also collected from dispensaries, hospitals, and health centres, as well as district and regional health headquarters within Lake Victoria region (Tanzania) using structured questionnaires and interviews (face to face and by telephone). Literature such also used to get data. Focus group discussions were also held to get view of water users on how the decline in water quality has affected their health.

Sample analysis

Faecal coliform counts

The detection and enumeration of faecal coliforms were done using Pour Plate Method and M-FC Agar as solid medium (APHA, 1995). With sterile pipette 1 ml of sample was pipetted in sterile petridish, followed by 10ml of the liquefied solid medium. Samples from heavily polluted stations especially during wet season were serially diluted. After the medium solidified, the plates were inverted and incubated at 44.5ºC for 24 hours. Blue colonies on M-FC Agar were counted as presumptive faecal coliform using a magnification of X15. Positive colonies were confirmed by EC medium which incubated at 44.5ºC for 24 hours (APHA, 1995).

Disease related to poor water quality

Data on the diseases associated to the use of contaminated water entered into Excel and processed. The diseases were intestinal diarrhea (cholera, typhoid fever and dysentery), intestinal worms, bilharzias and skin infections

Results

Faecal coliforms

Faecal coliform concentrations are reported in units of the number of bacterial colonies forming unit per 100ml of water sample (CFU/100mL) (Figures 1 – 3). The concentration of faecal coliforms ranged between 0 to 3 x 10^5 (CFU/100ml). The maximum value was measured in May 2002 in Mirongo station, Mwanza Urban.

Water related diseases

The present study shows that intestinal diarrhea (cholera, typhoid fever and dysentery), intestinal worms, bilharzias and skin infections are common in Lake Victoria shore areas, urban centres and in rural areas (Figure 3). Most of these diseases are caused by microbial-contaminated water supplies that are linked to deficient or non-existent sanitation and sewage disposal facilities.

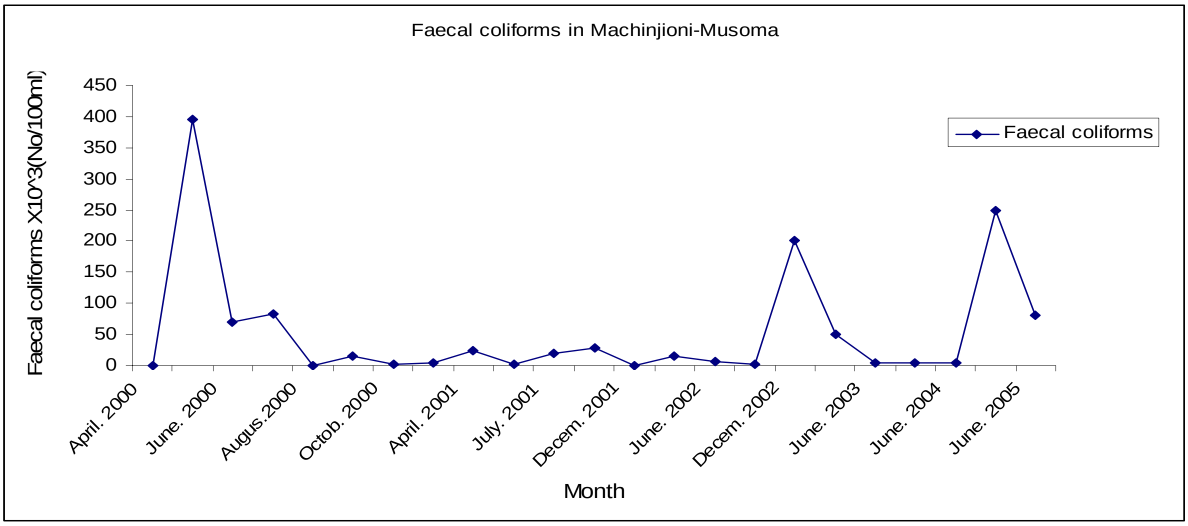

Figure 1: Monthly mean of faecal coliforms recorded in Machinjioni, Musoma urban.

People's perception on how the decline in water quality has affected their health

Ten focus group discussions were held in Mwanza and Musoma in 2002 and 2004. About 95% of the attendees admitted that decline in water quality has affected their health. Attendees from Ukerewe Island in Mwanza region said that they are no longer use water from the lake for drinking. They opt for well water. Students from Ngaza Girls Secondary School located in the outskirt of Mwanza City complained itching and eye infection whenever they take shower using tape water from the water. Mwanza Urban Water Supply Authority supply drinking water to the public places including Ngaza Girls Secondary School. However, the Authority has no complete water treatment facilities. Dominance of toxic species of blue green algae is a common phenomenon in Lake Victoria to date. Theses species are known for skin infection including itching.

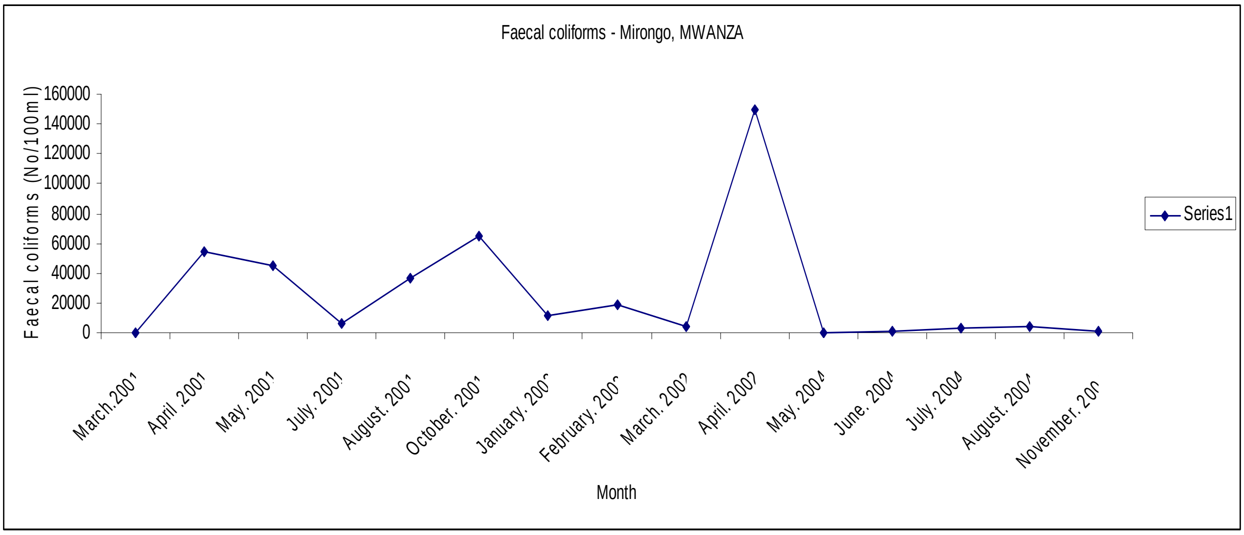

Figure 2: Monthly mean of faecal coliforms recorded in Mirongo, Mwanza.

Discussion

Over 300 million Africans lack access to clean water and 500 million lack adequate sanitation. Two million deaths occur annually from contaminated water and sub-standard sanitation and 50 percent of the population suffers from water-related disease. At least 17 African countries will become water-starved in the next decade as the continent's population explodes, while few of the 50 major international river basins in the continent have adequate basin conservation and management systems in place. Without doubt, Africans, and the aquatic ecosystems that sustain them, are at severe risk (Daley, 2003).

Lake Victoria, the largest tropical freshwater lake (68,000 km^2) in the world (Linda *at al*, 2003) is a resource shared by three countries of Tanzania (51%) Uganda (43%) and Kenya (6%). On the Tanzanian side of the lake, several urban centres as well as village settlements are situated along the lakeshores. The major urban centres are Musoma to the east, Bukoba to the west, and Mwanza to the south. In Mwanza municipality only 7% population is connected to the municipal sewers (current population is estimated at 447, 000). In Bukoba (66, 600 population) and Musoma (118, 000 population) urban centres there is no sewerage system at all.

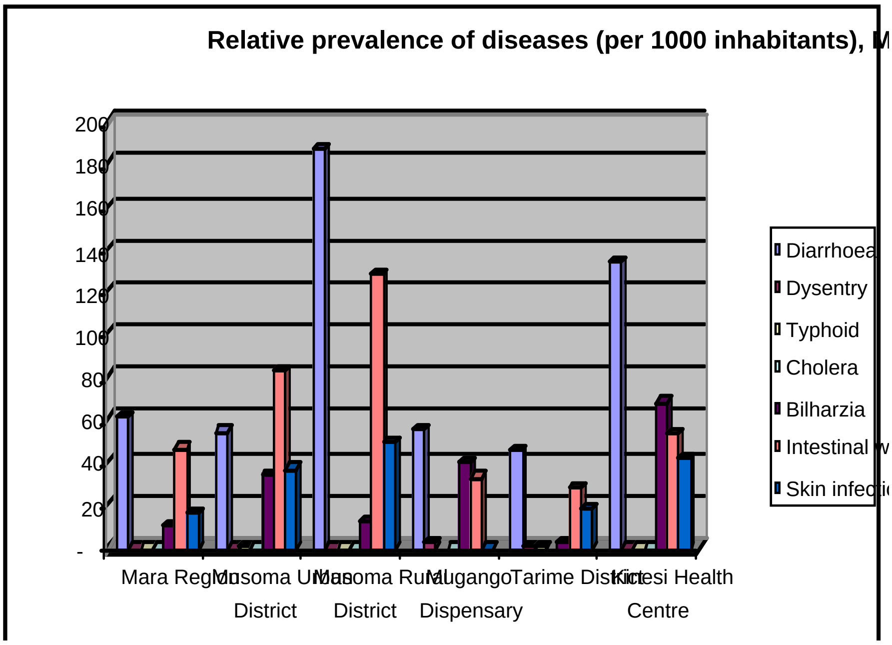

Figure 3: Relative prevalence of selected diseases (per 1000 inhabitants), Mara region (adopted from Tore Report-2004).

The most common sanitation systems in the major towns are pit latrine, bucket toilet or septic tank depending on the economic conditions of the households. Urban high-income buildings such as restaurants, hotels, offices and rental accommodation have flush toilets connected to municipal sewers where available. Effluents from septic tanks are also discharged into the municipal sewers or on the ground. Open defecation is common in rural areas along the shores of Lake Victoria.

Densities of faecal coliforms greater than Surface Water Criteria for Public Water Supplies of (2000 CFU/100ml) (Hammer, 1975) were observed throughout the course of this study at many stations (Figures 1-3). The presence of faecal coliform bacteria in surface waters indicates that faecal material of humans or other warm-blooded animal has been introduced into the water at some point. Potential sources are numerous - agricultural runoff, urban storm water, inadequate or neglected septic systems, sanitary waste from boats (less likely) and waterfowl and other wildlife. Beyond these actual sources, soils and aquatic sediments are reservoirs for faecal coliform bacteria (Heufelder, 1997).

Manjinjioni and Mirongo sampling stations are close to the City centres, therefore, Urban runoff was associated with elevated levels of faecal coliforms observed. Another explanation for higher levels of faecal coliforms measured at the three stations was suspected to be human activities like fish processing, washing cargo handling, and local boat making which carried out either at the lake shores or near the lake. Agricultural activities are carried out to the shore land in Mwanza gulf. In these areas farmers brought fertile soils to fertilize shore land and animal manures and pesticides are also used (Alley, 2002). This practice may probably contributed to the higher counts of faecal coliforms measured in stations located out of the urban centres (results are not shown in the paper). Capri-Point water intake (not shown) is surrounded by hills and no agricultural activities carried out in near by areas. This partly could be the reason of low levels of faecal coliforms (<2500 CFU/100mL) measured relative to the other three stations shown above.

Pollution caused by faecal contamination is a particularly serious problem, due to the potential for contraction of disease from the pathogenic (disease-causing) organisms found in faecal matter. *Shigella* (dysentery), *Salmonella* (gastrointestinal illness), *Pseudonomas auerognosa* (swimmer s itch), and certain *E. coli* species (i.e. 0157) are examples of bacterial pathogens. *Giardia* and *Cryptosporidium* are examples of common protozoan pathogens.

The present study shows that intestinal diarrhea (cholera, typhoid fever and dysentery), intestinal worms and bilharzias are common in Lake Victoria shore areas, urban centres and in rural areas. Most of these diseases are caused by microbial-contaminated water supplies that are linked to deficient or non-existent sanitation and sewage disposal facilities. However, the situation is more serious in rural areas where more people are poor, ignorant and have no access of tape water.

Observations of the data from the present study and earlier publications show positive correlation between water quality decline and prevalence of water related diseases.

In addition to implying health risks, the presence of faecal coliform bacteria in surface waters may also be an indicator of environmental concerns. Most often, faecal coliforms enter a water body through non-point source pollution (not from a single source, like a sewer pipe). This type of pollution can include silt, nutrients, organic material or toxins that are present throughout the watershed. A watershed is all the land around a stream, river, or lake that drains precipitation runoff to that water body.

Higher levels of faecal coliforms recorded in this study confirm the previous studies which reported degradation of water quality in Lake Victoria. (Kling *et al.,* 2001 Verschuren *et al*., 1998; Kandoro and Hamza,1998; Lowe-Mc Connell 1992; Bugenyi and Balirwa, 1989). This re-emphasizes the need for urgent action to take measures to control deterioration of the water environment for sustainable social and economical development in general and water supply in particular.

Conclusion

The study has shown that the levels of faecal coliforms (FC) in most samples exceeded the Criteria of Surface Water for Public Water Supplies found in the literature (Hammer, 1975). The study and published information also revealed that agriculture and urban runoff, and municipal raw sewage, domestic and industrial wastes are the major sources of pollution in Mwanza and Musoma urban centres. It was further noted that agricultural activities and destruction of wetlands aggravated the situation. Other human activities like fish processing, washing cargo handling, and local boat making which carried out either at the lake shores or near the lake are also significantly cause pollution in the gulf. This implies that without intervention measures the cost of water treatment would increase. It is also implies that the health of people using water from Lake Victoria prior treatment would be threatened.

Recommendations

Bacterial contamination is a serious concern in near shore waters of Lake Victoria. This presents a health hazard from pathogenic micro-organisms where water supplies are not disinfected. There is a need to ensure protection of the lake from further pollution.

Major population centers in developing nations without established waste treatment or water treatment infrastructures often suffer from epidemics of water borne diseases. In these areas raw sewage often directly contaminates the lakes, rivers and streams used for drinking, washing and cooking. It is therefore advocated that, sewerage systems be improved and sewage be treated before discharging into the lake.

It is further recommended that agricultural activities and human settlement should be stopped in shore land areas to minimize further pollution of the lake.

Launching a public education programme about non-point source pollution, including good agricultural practices, deforestation, bush/grassland burning, etc. This kind of education outreach is especially for those living and working in the shore land and stream bank areas.

Existing laws on proper disposal of domestic and industrial wastes should be enforced.

Water collected from Lake Victoria intended for domestic and industrial uses should be checked and necessary steps taken to disinfect it. At home, water collected from the lake should be boiled.

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Aquatic macrophytes infestation in relation to water quality status of a small tropical fish farm in the Nigerian savanna ecosystem

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Abstract

Maska Fish Farm is located near Zaria in the Nigerian Northern Guinea Savanna. The farm covers an area about fifty acres and is fed by a number of seasonal streams and tributaries. A study was conducted to evaluate the occurrence of aquatic macrophytes in relation to physicochemical characteristics and season in Maska fish farm, Katsina State, Nigeria. Total dissolved solids; conductivity and chloride ions, were significantly higher during the dry season than during the rainy season. On the other hand, dissolved oxygen and nitrate-nitrogen were significantly higher during the rainy season than the dry season. Other parameters such as pH, temperature and phosphate phosphorus did not differ significantly between seasons. Sixteen species of aquatic macrophytes belonging to thirteen families were encountered during the study. There were more species during the rainy season than the dry season. *Nymphaea lotus* and *Leersia hexandra* formed the major vegetation of the ponds during both the rainy and dry seasons. In the reservoir, *Helistropium ovalifolium* and *Polygonum lanigerum* dominated during the dry season, while during the rainy season, *Polygonum limbatum, Polygonum lanigerum, Torulinum sp*. and *Mimosa pigra* were co-dominant, as mainly emergent/terrestrial forms.

Key words: Macrophytes, Physico-chemical parameters.

Introduction

The development of aquatic macrophytes in both lentic and lotic habitats are of considerable importance in fishery operations. Aquatic macrophyte communities contribute positively to the productivity of fisheries operations when properly managed. However, they could become a nuisance under situations of improper management, posing problems to fishing and irrigation.

Water level fluctuations modify species content and the size and hydrology of water bodies usually determine the floristic composition of the developed communities (Ita, 1993).

Extensive human activities such as agricultural practices, fertilizers application over grazing in the catchments could result in marked fluctuations in the physicochemical parameters of lentic ecosystems of biotic communities (Ezealor *et al.*, 1999; Gbem *et al*., 1999)

Component plant species exhibit an annual seasonal activity rhythm that varies with species. Generally, rooted /floating-leaved plants dominate when water levels rise, and floating plants are more dominant at seasons when the water level is low (Ita, 1993). This applies especially to emergent or paludal weeds which are weeds whose roots grow in submerged soil or in damp soil but most of the stems, leaves, flowers and fruits grow out of the water (e.g *Phragmites communis*) and to floating weeds and in certain cases submerged weeds (Hough *et al*., 1989)

Excessive vegetation accelerates silting, makes difficult the movement of the fish and stops the water from warming. It also provides refuge for competitors seeking nourishment and to enemies of the fish and creates a bottom rich in cellulose and in general diminishes the productivity of the pond.

\Macrophyte structure and abundance in lakes depend on different factors, which include, trophic status, light penetration and water currents. For macrophytes, water current is the most important. The total pool of nutrients is less important than an amount of its exchangeable fraction. The amount of this fraction depends on ecosystem efficiency and to some extent on macrophytes occupying the water body as they both depend on and create a nutrient budget of their environment.

Siltation over the years has been a major problem of Nigeria lentic habitats. This seriously reduces the depths of lakes. Decrease in depth favours the occurrence of emergent species of macrophytes, which in turn displace floating types.

Uncontrolled development of aquatic plant communities in fish farming/fisheries systems has several undesirable implications (Balogun *et al*., 2000) These include further depletion of water volume through additional evapotranspiration from surface of plants (especially emergents), hindrance to navigation and fish cropping, clogging of machinery and turbines (where applicable and depletion of oxygen from the water column) especially during decay processes. All there factors will reduce the well being growth and reproduction of fish and consequently, lead to lowered production rates and poor returns from investment made on the fish farm (Bako and Oniye, 2004).

Materials and methods

Study area

Maska Fish Farm is located 65km from Zaria on the Zaria-Funtua Road. The farm covers an area about fifty acres and is fed by a number of seasonal streams and tributaries. The farm was constructed for the purpose of producing species like *Tilapia zilli, Tilapia nibitan, Tilapia salitea, Clarias lazera,* *Synodontis* spp. exotic species of carp (*Cyprinus carpio*) (Nkwatoh, 1989).

Field survey

This was done to cover two seasons (rainy and dry) of 2004. Surveys of aquatic plants in quadrats of 2 x 2 meters were done in five ponds, which were randomly selected. A similar survey was conducted in the reservoir using quadrats of 25 x 25 meters. An arbitrary scoring scale was used to compute the frequency of occurrence of plant species. Plants were identified according to texts such as Cook *et al*., (1974); Obot and Ayeni (1987) Temperature measurements were carried out in the field with a thermometer.

Water samples were also collected from the five ponds in water bottles analysed for other physicochemical parameters in the laboratories of the department of Water Resources and Environmental Engineering A.B.U, Zaria.

Analytical methods

Hydrogen Ion Concentration (pH), conductivity, and dissolved solids were measured in the laboratory using a pH meter. For pH measurements, the meter was standardized with buffer solutions of pH 7 and pH 9. Conductivity and Dissolved solids were measured with the same instrument after it had been adjusted. Chloride ions, Dissolved Oxygen, Nitrate Nitrogen, and Phosphate Phosphorous were determined according to standard methods (APHA, 1980). Morpho-edaphic index was calculated by dividing the total dissolved solids of each pond by its depth.

MEI = TDS/Depth

Statistical analysis

Differences in the physicochemical parameters between the ponds with regards to seasons were compared using the T- Test.

Results

Physicochemical profile

The physicochemical profile of water samples, are presented in Table 1. pH values showed no significant (P = 0.05) difference between the two seasons. Total dissolved solids were significantly (P = 0.05) higher in the dry season than the rainy season. Conductivity in the ponds was significantly (P = 0.05) higher during the dry season than the rainy season. Temperature showed no significant (P = 0.05) difference between the seasons. Dissolved oxygen showed no significant (P = 0.05) but the values were slightly higher in the rainy season than the dry season. Concentration of chloride ions was significantly (P = 0.05) higher in the dry season. Phosphate phosphorus concentration showed no significant (P = 0.05) difference but was slightly higher in the dry season than the rainy season. Nitrate concentration was significantly (P = 0.05) higher during the rainy season. Morpho-edaphic index was also significantly (P = 0.05) higher during the dry season.

Table 1: Physicochemical characteristics of selected production ponds and reservoirs of Maska Fish Farm during the dry and rainy seasons.

Pond No./ Season	pH	TDS (ppm)	Conductivity (µs)	Temp. (^oC)	D.O (mg/l)	Cl (mg/l)	PO_4 (mg/l)	NO_3 (mg/l)	MEI
1									
Dry Rainy	7.90	127	255	30	0.80	6.00	0.85	32	15.30
6	6.94	42	85	28	3.30	1.60	0.10	47	4.20
Dry Rainy									
7	6.90	199	400	30	1.20	11.30	1.80	41	29.83
Dry Rainy	6.54	64	127	28	1.40	2.20	0.25	45	6.41
8									
Dry Rainy	7.20	260	522	30	0.60	14.70	1.95	21	53.06
12	6.55	40	81	28	0.50	1.80	0.40	47	4.00
Dry Rainy									
Reservoir	6.70	279	559	32	1.70	15.10	0.90	26	45.60
Dry Rainy	6.54	47	94	28	1.90	1.40	0.25	45	4.70
	7.40	152	306	30	2.70	6.90	0.25	30	15.21
	6.68	78	157	28	1.20	3.20	0.20	47	7.81
	-	-	-	-	-	-	-	-	-
	7.02	45	90	29	4.30	1.80	0.80	51	3.37
Mean									
Dry Rainy	7.22	203.4	408.4	30.4	1.40	10.80	1.15	30	31.8
SE +	6.72	52.70	105.70	28.20	2.10	2.00	0.33	47	5.08
Dry									
Rainy	0.18	29.51	59.02	0.40	0.38	1.90	0.32	3.33	7.73
	0.09	6.15	12.26	0.17	0.58	0.26	0.10	0.89	0.69

Occurrence of macrophytes in the ponds

Table 2 shows the occurrence of aquatic macrophytes in the ecosystem during the dry season. Eight species belonging to 8 families were recorded. *Nymphaea lotus* had the highest frequency of occurrence (100%). This was followed by *Leersia hexandra* (80%), *Hydrolea palustris* (60%), then *Polygonum lanigerum* and *Ipomoaea aquatica* (40% each). *Oryza barthi, Hydrocotyl bonariensis and Alternathera sessilis* had the lowest frequencies of 20%. These were all emergent forms.

During the rainy season (Table 2) a higher number of species (13) belonging to nine families were recorded. *Nymphaea lotus* and *Leersia hexandra* had the highest frequency of occurrence with a 100% score. Next in frequency were *Ipomoaea aquatica* and *Maricus curatelifolia* with 80% score. *Hydrocotyl bonariensis* , *Alternanthera sessilis*__, *Oryza barthi* , *Nymphaea micrantha* and *Ludwigia erecta* had lowest frequencies of occurrence (20%) each. Species that were present in the rainy season but absent the dry season, were *Nymphaea micrantha*¸*Torulinum sp,* and *Polygonum limbatum.* The growth forms were mainly emergent.

Table 2: Occurrence of aquatic macrophyte species in the production ponds of Maska Fish Farms during the dry and rainy seasons.

S/no	Family	Species	Occurence (%) 1 Rainy Season	Dry Season	Growth form
1.	Nymphaeaceae	*Nymphaea lotus*	100	100	Emergent
2.	Poaceae	*Leersia hexandra*	80	20	Emergent/marginal
3.	Nymphaeaceae	*Nymphaea micrantha*	20	-	Floating leaved
4.	Cyperaceae	*Torulinum sp*	60	-	Emergent
5.	Convolvulaceae	*Ipomoea aquatica*	80	20	Emergent
6.	Cyperaceae	*Mariscus alternifolia*	80	-	Emergent
7.	Onagraceae	*Ludwigia errecta*	20	-	Emergent
8.	Polygonaceae	*Polygonum lanigerum*	40	20	Emergent
9.	Polygonaceae	*Polygonum limbatun*	40	-	Emergent
10.	Poaceae	**Oryza barthi**	20	20	Emergent
11.	Hydrophylaceae	*Hydrolea palustris*	60	20	Emergent
12.	Amaranthaceae	*Alternanthera sessilis*	20	20	Emergent/ terrestrial
13.	Umbelliferae	*Hydrocotyl bonariensis*	20	20	Emergent

Table 3: Occurrence of aquatic macrophyte species in the reservoir of Maska Fish Farms during the dry and rainy seasons.

S/No	Family	Species	Occurrence (%) 2 Rainy Season	Dry Season	Growth form
1.	Moluginaceae	*Glinus oppositifolius*	-	50	Terrestrial
2.	Boraginaceae	*Helistropium ovalifolium*	-	100	Terrestrial
3.	Polygonaceae	*Polygonum lanigerum*	100	75	Emergent
4.	Polygonaceae	*Polygonum limbatum*	100	50	Emergent
5.	Leguminoseae	*Mimosa* pigra	100	50	Terrestrial
6.	Acanthaceae	Hygrophila auriculata	-	25	Terrestrial
7.	Nymphaeaceae	*Nymphaea lotus*	50	-	Emergent.
8.	Cyperaceae	*Torulinum* sp.	100	-	Emergent.
9.	Poaceae	*Leersia hexandra*	25	-	Emergent.

Occurrence of macrophytes in the reservoir

Table 3 shows the occurrence of aquatic vegetation in the reservoir during both raining and dry seasons.

During the dry season 6 species belonging to 5 families were recorded *Helistropium ovalifolium* had the highest frequency of 100%, *Polygonum* *lanigerum* was next, and with 75% while *Hygrophila auriculata* had the lowest frequency of 25%. Species found only in the dry season and not in the rainy season are: *Gliinus oppositifolius*, *Helistropium ovalifolium* and *Hygrophila auriculata* They were mainly terrestrial plants.

During the rainy season, 6 species belonging to 5 families were recorded. Species observed to be present here and absent during the dry season were: *Nymphea lotus*, *Leersia hexandra*, *Torulinum* sp., *Polygonum limbatum*, *Polygonum lanigerum* and *Torulinum* sp. and *Mimosa pigra* had the highest frequencies of 100% each. *Leersia hexandra* had the lowest frequency of 25%. These species were mainly emergent forms.

Discussion

The aquatic macrophyte community of this ecosystem expanded in terms of species diversity during the rainy season. This could be as a result of enhanced content of plant nutrients such as nitrates. High levels of nitrogenous nutrients are known to encourage vegetative growth of plants.

Dilution from the rains during the raining season reduced the total dissolved solids concentration in the ponds and reservoir during the rainy season that is why it was higher in the dry season. Dilution also affected conductivity and phosphate concentration in the ponds resulting in a slightly reduced concentration during the rainy season.

Higher MEI values during the dry season implied that the ponds had higher productivity during this period. This may be as a result of higher water retention time, as very little influx of fresh water took place. It could also be that higher evaporation rates from the water surface and higher rates of evapotranspiration from leaf surfaces of vegetation reduced the water volume such that the over all depth profile of the ponds reduced significantly.

Most of the species encountered were emergent or terrestrial forms. This implies an encroachment of terrestrial vegetation into the ponds probably due to siltation processes, which have reduced the depths of the ponds. Siltation and infestation by aquatic macrophytes threatens many aquatic ecosystems in Nigeria, and commonly a pattern of succession is observed as these aquatic ecosystems transit into terrestrial ecosystems (Bako and Oniye, 2004). Urgent intervention measures to prevent the complete loss of this ecosystem, and the consequent economic loss are required.

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Analysis of post-jump lake Victoria daily water level time series by the theory of runs

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Abstract

Between 1961 and 1964 there was a sudden jump of 2.5m in lake Victoria daily water level, which was confirmed in all four gauging stations around the lake (Jinja, Entebbe, Kisumu and Mwanza). This sudden hydrologic jump was found difficult to explain in terms of the components of water balance and consequently introduced extra dimensions and coverage of later studies on the overall lake basin. In addition to pre-jump fluctuations, the lake levels have always reflected and contained the jump in whole or in part. But the overall tendency to increase, stabilise or decrease to pre-jump levels is not known.

This paper reports the results of the analysis of 21 years post jump daily lake Victoria water level time series for the period 1965 – 1985 by the theory of runs. The results show that the lake levels display a strong tendency to revert to pre-jump levels and that modelling the daily series would not be very practical due to the long memory of the lake.

Key words: Stochastic processes, Time series analysis, Theory of runs.

Introduction

Most of the agriculture along the Kenyan shores of Lake Victoria has been and still is rain fed. Combined with excess evaporation, the bimodal rainfall in the area is in most cases not adequate or reliable to guarantee all-year round good yields. Irrigation has therefore been recognized as an essential input for improved agriculture.

The lake is the only reliable source of water and drainage sink for any lakeshore irrigation undertaking. The waters of the lake are fresh and therefore possess no problem of quality. Before 1960, Lake Victoria levels in all the four gauging stations (Jinja, Entebbe, Kisumu and Mwanza) had not been known to be greatly variable but between 1961 and 1964 there was a sudden jump in level of 2.5m, which was confirmed in all four gauging stations. This sudden jump was found difficult to explain in terms of the components of water balance and consequently introduced extra dimensions and coverage of later studies on the overall lake basin (Kite, 1982). In addition to pre-jump fluctuations, the lake levels have always reflected and contained the jump in whole or in part. But the overall tendency to increase, stabilise, or decrease back to pre-jump levels is not known. These general tendency and fluctuations have a bearing on the siting (elevation) of pumping stations to avoid occasional submergence. They also have a bearing on the location (elevation) of the suction filter level of any pump works to be sure of reaching the water. While the suction filter elevation can be put at the lowest observed lake level and conversely the pumping station located at the highest observed lake level their relative elevation are important because:

(1) Practically suction head is limited and pumping lifts should be kept lowest.

(2) Bearing in mind the small slopes of the irrigable areas of the lake shores, small differences in the two elevations can translate themselves into very long suction lines further limiting the suction head due to friction head loss.

(3) Drainage of any such irrigation works would be back to the lake which would be expected to discharge by gravity at any time of the growing season.

The limiting depth at which drainage back to the lake is possible by gravity without having to introduce gates would be highly dictated by the expected level of the lake during drainage periods. In the design of small-scale irrigation projects along the lakeshores, the authorities charged with the responsibility are always faced with the question of what lake level to base the designs on. With an immediate decision to make, the compromise of a rapid purely frequency analysis has always been opted for without regard to the time and run aspect of the records with the result that some of the schemes have sometimes gone dry. For better design and control, knowledge of the lake level series is also often required for irrigation or drainage development along the lower reaches of river basins entering the lake. In these basins, the slopes become so small that the backwater effects in response to lake level fluctuations pose drainage and irrigation works protection problems.

The plans to dyke the rivers and consequently drain swamps would owe their operational success on an understanding of the lake level series. Therefore the decision to be made above in relation to irrigation or otherwise would heavily depend on the level of lake and what level of risk is to be expected. It is therefore of interest to analyze the time series of the lake levels in the post-jump years to reveal its structure and tendency for use as a planning tool for any works on the lake shore.

The data

Currently, the level gauging of the lake is done at four stations (Kisumu, Kenya; Mwanza, Tanzania; Jinja and Entebbe, Uganda).

In the succeeding investigation, 21 years of post-jump (1965 – 1985) Kisumu gauge data is used. The data, obtained from the Ministry of Water Development in Kenya are of maximum and minimum daily reading as extracted from a continuous level recorder. The data is not quite complete in that occasional holes of non-available observations exist in the series but where they occur, they run for less than a month except in 1980 where they occur longer than a month (for six months) and so frequently that the whole year has had to be ignored as a whole.

A feature of the daily continuous data of the level recorder is that the maximum and the minimum, which are extracted as the daily reading, occur twelve hours apart reflecting the daily oscillations. Such daily oscillations in water body levels are a notable common feature of hydrologic time series attributed to various astronomical events such as the phases of the moon and the rotation of the earth about the sun. In this respect, the available data can be seen as three time series of the same process, Namely Time series of the levels at 24 hr interval (maximum levels), Time series of the levels at 24 hr interval (minimum levels). or Time series of the levels at 12 hr interval (maximum and minimum levels). The structural analysis is done on the third series and results inferred to apply to the other two as well but where necessary as dictated by the question to be answered, the maximum and minimum series have been distinguished.

Literature review

The planning, design, operation and maintenance of water resources development require information in the form of various hydrological series. A thorough understanding of the structure of hydrologic time series is a pre-requisite for any reliable input data in the planning and operation of water resources projects. Apart from the stochastic variations of hydrologic quantities with time, diverse sources of inconsistency and non-homogeneity superpose their changes to the stationary and non-stationary deterministic variations. Therefore a hydrologic series observed for a sufficiently long time cannot generally be considered the sample from one population.

Kottegoda (1980) defines a stochastic process as a phenomenon whose outcome or occurrence is uncertain and a time series as a chronological sequence of observation of a specified variable of the process. Further, a process whose inputs are stochastic variables is itself stochastic. Recognizing lake levels as a reflection of the storage component in the basic water balance equation of the lake, and that inflow and outflow are stochastic variables, records of lake levels constitute a time series of a stochastic process. Ideally, lake level is a continuous process variable and only discretized for practical reasons.

Various definitions of runs have been proposed in literature. From a classic point of view, Moods (1940) defines a run as a sequence of observation of the same kind preceded and succeeded by one or more observations of a different kind. The runs of the continuous sequence of a stochastic variable or a combination of stochastic and deterministic component making a composite sequence can again be defined on the basis of various characteristics i.e. intensity, duration or surplus and/or deficit. The sample statistic to be studied differs according to the objective for which the run theory is to be used.

In the case of hydrologic application, the main characteristic which defines runs is the occurrence of series values above or below a certain level called crossing or truncation level. Figure 1 serves as the basis for various definitions of runs of a continuous or discrete variable X_t with X_0 (constant or variable) as the truncation or crossing level.

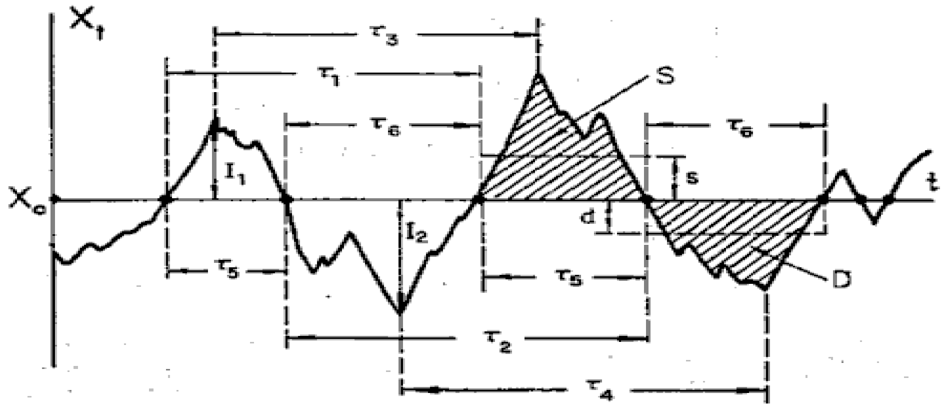

Figure 1: Various definitions of runs for a given crossing level X_0.

Where S and D are measures of surplus or deficits, I_i are measures of intensities and τ_1 are measures of duration. In employing runs theory for investigating time series, the best basic parameters for various reasons has been considered to be the run length (Saldarriaga and Yevyevich, 1970). The most commonly used characteristics are therefore τ_5 and τ_6 which define the positive and negative run lengths although run S and D defining surplus and deficit and run I_1 and I_2 called the run intensities are more appropriate to particular problems in hydrology and water resources. The narrower but adequate definition adopted in this analysis was suggested by Yevjevich (1972). He notes that run lengths as statistical properties of sequences represent the best basic parameter for objective definition of droughts or surplus (minimum or maximum lake level).

The number of total run lengths of a finite series is a random parameter and is a function of the process X and the crossing level X_0. Run analysis can thus be used either for time series structural investigations or as a decision-making criterion. On the second usage of run theory, the frequency of total run lengths as measured with respect to a given crossing level provides the estimates of probability. Restricting the analysis to irrigation, drainage and related works on the lakeshores the crossing level can be used to define low or high water levels on which to base the relevant designs at given safety levels.

Methodology

If X_0 determines the location (level) of the suction point of say an irrigation works or any design whose critical functioning depends on lowest levels reached, and the series for the minimum levels fall beyond X_0, then on the above definition a drought occurs.

Similarly, if X_0 determines the location level of the pumping station or drainage benchmark of an irrigation scheme and the series for the maximum level raises beyond X_0, then pump station flooding occurs. Empirical techniques for determining probabilities associated with various run lengths and crossing levels for stationary hydrologic time series use sample data to obtain the necessary information.

Using the maximum series for the positive run length statistic, and the minimum series for the negative run length statistics, the combinatorial probabilities of various levels and run lengths can be investigated. In either case, the interest would be the statistical risk that would be expected or associated with a certain level and/or run length.

In this approach the deficit or surplus level is first defined then the series of the hydrologic variable is plotted with the level as the truncation level. All durations as run length, equal to, greater or less than the truncation level can be counted and the relative frequency of each is an estimate of the risk associated with it.

Various run lengths probabilities and statistics that are particularly important for water resource management decision making have been calculated, namely (1) The probabilities of various run lengths (5, 10, 15, 20, 25, 30 days) for various crossing levels X_0 at any arbitrary time in the time series calculated as

$$P(X_0) = N_i/N_T \qquad (1)$$

Where N_i is the count of consecutive levels over a length and N_T = total length of the series (2) The average run length for various crossing levels X_0 calculated as

$$L = \frac{L_1 + L_2 + L_3 + ------}{N} \qquad (2)$$

Where L_1, L_2, L_3, etc are the various run lengths for a given crossing level X_0 and N is their count of occurrence. (3)The conditional probability that the (k + 1)th day is lower (minimum series) or higher (maximum series) than a crossing level X_0 given that the previous k days were lower or higher than the crossing level X_0 at any position in the time series calculated as.

$$P(X_{k+1} \mid X_k) = \frac{P(X_{k+1})}{P(X_k)} \qquad (3)$$

Where $P(X_{k+1})$ and $P(X_k)$ are the probabilities of the respective run lengths.

Probabilities as calculated above refer to the basic risk, which is understood as the probability of exceedence or non-exceedence of any critical design level, which is related to random phenomena as opposed to uncertainty, or total risk whose analysis is an economic optimization problem. The computations have been carried out with the help of the inbuilt statistical and logical functions of the computer.

Before analysis, the series were investigated and tested for trends and periodicities. If present, trends must be removed from the series so as to satisfy the stationarity condition in time series analysis. The periodic part of the series was approximated and fitted by the sine Fourier series following a procedure outlined by Yevjevich (1972)

In the procedure, if P is the length of the period and U is the statistic estimator of the sample in the period position j, then the smooth statistic $\overline{U}$ (j) is

$$\overline{U}\,(j) = A_o/2 + \sum_{k=1}^{k}\left[A_k\,COS\left|\frac{2\pi\,kj}{P}\right| + B_K\,SIN\,\left|\frac{2\pi\,kj}{P}\right|\right] \qquad (4)$$

Where

$$A_k = 2/p\sum_{j=1}^{p} U(j)\;COS\;\frac{2\pi\,kj}{P} \qquad (5)$$

And $$B_k = 2/p\sum_{j=1}^{p} U(j)\;SIN\;\frac{2\pi\,kJ}{P} \qquad (6)$$

are the smoothing coefficients of harmonic k. In practice, Kottegoda (1980) notes that periodicities can be represented by one or two harmonics in monthly series and by four to six harmonics in daily series. For the detrended series the smoothings for the mean and standard deviation of maximum series are shown in Figures 2 and 3.for the harmonics 3 and 4 respectively, which have been adopted through inspection as the best fit. The identified periodic part was however not removed from the series as it is considered a permanent part of the series imposed on the series by a cyclic phenomenon and does not affect the run analysis. It however gives a good insight into the structure of the series.

Another common feature of hydrological time series is the linear association of successive observations "k" time units apart. The autocorrelation statistic γ is a measure of the extent to which an observation tends to determine its successor reflecting the memory extent of the system. This time dependence can be measured in a manner analogous to that used to measure the degree of linear association between two sets of observations. The autocorrelation lag "k" that relates an observation at time i with an observation at time i + k is defined as

$$\gamma(k) = \frac{COV\,(X_1,\, X_{1+k})}{\sqrt{(VAR\ x_1,\ VAR\ x_{1+k})}} \qquad (7)$$

Statistical methods available for analyzing time series consider only the first and second order moments, that is the mean, the variance and covariance. Therefore any concern about the stationarity of a time series is generally confined to these moments. Matalas (1967) observes that if a time series is stationary with respect to these moments and the observations are normally distributed, then the series is stationary with respect to all other higher order moments since they depend only on the second order moments. The autocorrelation as defined in equation (7) are estimated by

$$rk = \frac{\sum_{i=1}^{N-K} X_i.X_{i+k} - \frac{1}{N-k}(\sum_{i=1}^{N-k} X_i).(\sum_{i=k+1}^{N} X_i)}{\left[(\sum_{i=1}^{N-k} X_i^2) - \frac{1}{N-k}\ (\sum_{i=1}^{N-k} X_i^2)\right]^{1/2} . \left[(\sum_{i=k+1}^{N} X_i^2) - \frac{1}{N-k}\ (\sum_{i=k+1}^{N} X_i^2)\right]^{1/2}} \qquad (8)$$

Where "k" is the lag and other parameters have meanings as used earlier.

With the deterministic component identified and where necessary removed, the data was investigated for serial dependence. The Kth order autocorrelation between X_i and X_{i+k} was estimated from the sample series by equation (8). For a serially independent series, the autocorrelation coefficients is equal to zero except for the trivial case (k = 0) where r_k = 1. Otherwise due to dependence or sampling errors, for a finite sample $-1 < r_k < 1$ and a significance test is necessary. Graphical representation of the result for the minimum series is shown in Figure 4 in the form of continuous lines. Similar correlograms for the maximum series can be inferred by virtue of the generating process being the same.

The most important questions facing a water resource manager that require explicit information are: What level is associated with what probability?, What probability of exceedence or non-exceedence is associated with what level? And what conditional probability is associated with one level in relation to another. Figures 5 to 8 shows the results of various run length probabilities and statistics of the series. Runs theory is particularly good for water projects operation and management because it explicitly brings out the most needed and easily understood information by water resource managers.

Results

The linear trend

T_t = 12.89 – 0.033 (9)

for maximum and

T_t = 12.62 – 0.033t (t in years) (10)

for minimum series were detected, fitted and removed so as to satisfy the basic requirement of stationarity in time series analysis. Other graphical results are shown below.

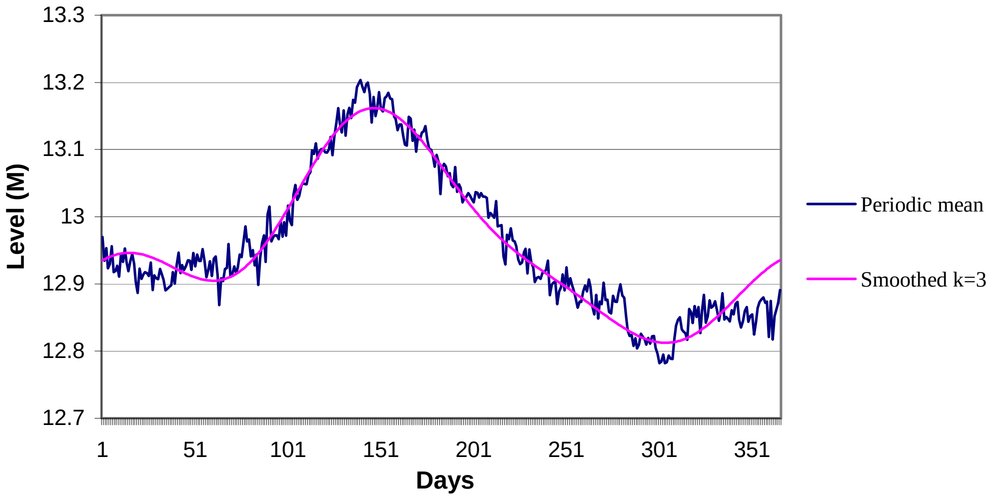

Figure 2: Annual periodic mean for the detrended maximum series (k = 3).

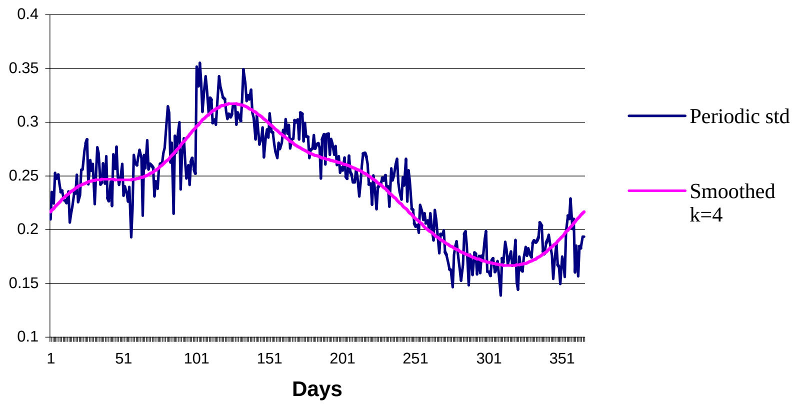

Figure 3: Annual periodic standard deviation for the detrended maximum series (k =4).

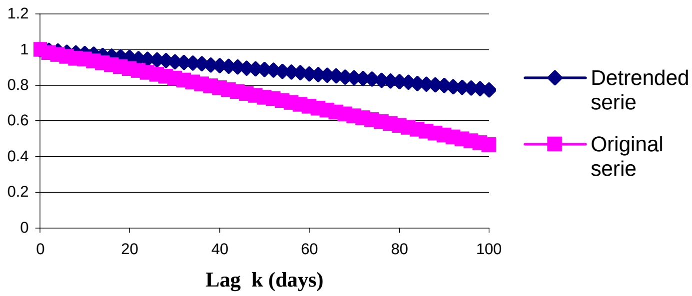

Figure 4: Correlogram of the original and detrended minimum series.

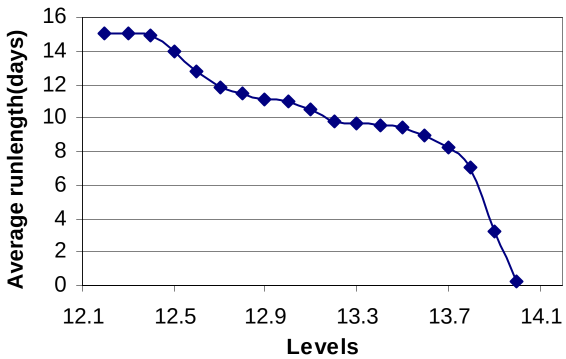

Figure 5: Average runlengths for various crossing levels for the maximum series.

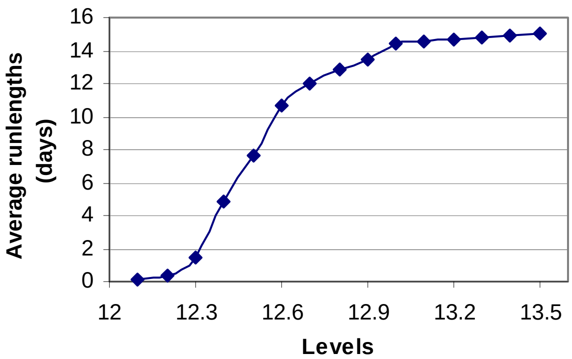

Figure 6: Average runlengths for various crossing levels for the minimum series.

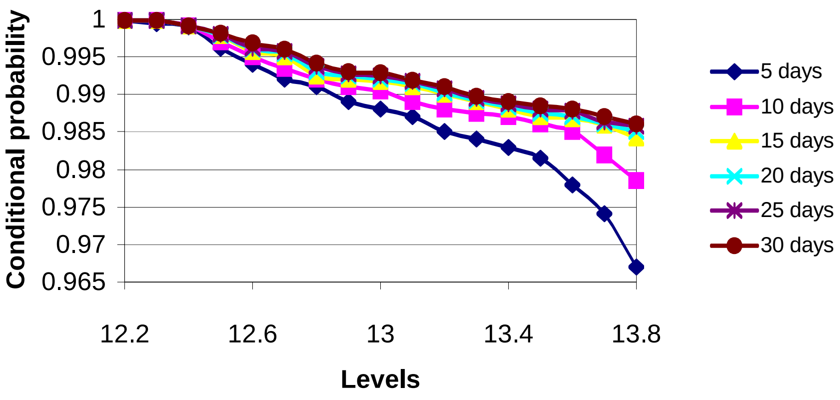

Figure 7: Conditional probability for various crossing levels for the maximum series.

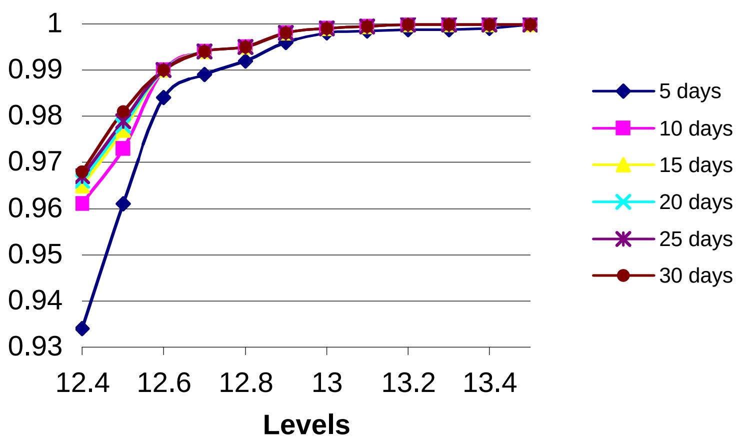

Figure 8: Conditional probability for various crossing levels for the minimum series.

Discussion

Post-jump Lake Victoria daily water level time series has been analyzed by the theory of runs for structural understanding of the daily variations in the general interest of lakeshore irrigation/drainage or other civil works. The lake time series has been conceived as being composed of deterministic and stochastic elements. The two elements have been identified to be present and combined in a linear manner. As of now until probably the 2.5m jump is undone, the deterministic element is constituted of a decreasing trend and an annual periodic part while the stochastic element makes up the smallest part.

The daily series is seen in Figure 4 to have very high autocorrelations upto large lags. This can be explained by the fact that the lake is a big reservoir whose volume is very large relative to the average input components of its water balance and therefore has a proportionally large memory. Another possibility is the existence of the fitted trend which may not have been fully removed. No attention or effort has been made to the modeling of the daily series but the relevant statistics have been presented and the large extent to which auto regression can go has been demonstrated.

Trend is usually thought of as a smooth motion of the series over a long period of time and for any given time series, the sequence of values will always follow an oscillatory pattern around the trend. However a word of caution about the fitted trend is worthy at this point. It is realized that trends are difficult to detect in an observed hydrological time series because theoretically no number of observations is sufficient (The 21 years of data used is nowhere near that number) to determine with no uncertain terms if an apparent trend is actually a trend or a periodic wave having a low angular frequency or even a chance event. Therefore although a linear decreasing trend has been identified, fitted and removed one cannot use this linear trend to make an argument on the time it will take to undo the 2.5 metre jump of 1960 – 1964 This is particularly so in that the trend is small and likely to take long time in which man induced hydrological changes in the whole basin may occur thus changing the generating process. However one can use it to safely report that since that size of sudden increase had not been known of over the total period of earlier records available and whatever the cause of the jump, it is not a permanent slippage and that the lake levels have a strong tendency to go back to the pre-jump levels. Figures 7 and 8 shows that on a daily basis, the level variations are quite small and the high persistence of the series renders the probabilities of run lengths shorter than 30 days not any different. Therefore the more practical range of run lengths (shorter than one month), probabilities of exceedence or non exceedence for various crossing levels may not be of much concern and the one month case is considered representative. For the shorter run lengths, the periodic fit of the maximum and the minimum series would be adequate as an indication of the relative range at any time of the year.

Conclusions

On the basis of the foregoing investigations and discussion of the daily maximum and minimum series of post-jump Lake Victoria levels at Kisumu station (KENYA), the following conclusions are ventured.

- The series displays a strong tendency (trend) to return to pre-jump levels.
- Modeling the daily series would not be very practical due to the long memory of the lake.
- On the long term, the presented levels and their probabilities for the maximum series may be used but for the minimum series, pre-jump levels would be safer.

Acknowledgement

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On-farm participatory assessment of the profitability of small-scale fish farming in Malawi: A case study of Mpalale Village, traditional authority – Kasumbu in Dedza District

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Abstract

Fish production on the Malawian smallholdings is generally limited by quantity and quality of pond inputs as by this on-farm participatory assessment of the profitability of the small-scale fish farming research that was conducted in Mpalale village in Dedza district (from May 2003 to December 2003) records. The timing of labour availability and other farm activities limit the amount farmers put into their ponds resulting in lower growth and yields. There is potential for improving production and yields in the project area through modifications of production schedules to accommodate other farming activities that farmers put much interest either. Limited material and labour inputs among fish farming, as business enterprises can be better allocated by considering seasonal availability of pond inputs and adapting the pond as a fish farming technology to the overall farming systems.

From a small preliminary survey that was conducted in the study area beefed up with a focus group discussion from the 23rd to the 26th of July 2003 on socio-economic status of the target groups which revealed that on general basis, most of the farmers in Mpalale fish farming area fit into the category of the low resource farmer, characterized by having the merge on-farm resources; a few livestock and some none, and only a small amount of maize, beans, Irish potatoes and sweet potatoes all mainly grown for their consumption and less for sale especially iris potato and beans and fish farming was mainly regarded as a complementally on-farm occupation despite its high potential in some parts of the area.

This case from Mpalale village in Dedza district demonstrates that fish faming technology that neglects the annual cycle of events and constraints on the farm will not easily achieve its optimum profits. Focusing on the fish farming technology adoption and facilitation rather than focusing on the maximization of fish production has been a feature aquaculture projects in the area and at large. Profitable fish farming research must identify niches and opportunities for system improvement for it to be worth stand as business enterprise venture and sound fish farming management can give better returns than other crops in Malawi.

Key words: On farm participatory assessment, Small-scale fish farming, On farm inputs, Business enterprise

Introduction and literature review

Fish farming in Malawi is a new farming system where crop and to a lesser extent livestock predominates. Fish farming research started in Malawi in the 1930s in order to develop fish farming in areas remotest from the lake, so as to address nutritional problems that were revealed by a nutritional survey of 1938 conducted by Blatt as cited by (Maluwa and Brooks, 1996).

Fish contribute about 60-80% of Malawi's animal protein supply *(ICLARM* and *GTZ*, 1996). However, fish consumption has declined from 16 kg/capita/yr to around 9 kg/capita/year as indicated by World Health Organization *(WHO*). The bulk of fish comes from capture fisheries with aquaculture contributing less than 1% to the total supply (Kaunda, 1994). Over the years, fish supply from capture fisheries has stagnated between 60,000-80,000 metric tons per year. At the same time the demographic studies show that Malawi is one of the most densely populated countries with growth estimated at a rate of 3.8% per annum. This means that if the current per capita consumption of fish is maintained, an alternative source of fish has to be identified. Aquaculture is the alternative. Aquaculture development or production is hampered by several constraints. These include, but are not limited to: lack of technical awareness, climatic and legal constraints, lack of skilled manpower, lack of suitable culture species, lack of artificial feeding, use low protein feeds, limited water supply and restricted availability of suitable soil.

Most of the problems have been addressed in several programs. For instance, studies have been conducted on indigenous species, small water bodies, integrated aquaculture and the role of women in aquaculture by the Central and northern Regions fish Farming Project (CNRFFP*)* and the International Center for Living Aquatic Resources Management (ICLARM) (Kaunda, 1994). However, these studies were conducted concentrating in the southern and Northern Regions of Malawi.

Although a number of constraints to fish farming development have been observed (and they include availability and high quality of animal feeds, fertilizer and poor knowledge base, since aquaculture is a new farming enterprise) fish farming continues to grow rapidly in Malawi in general, and the southern region of the country, in particular (Sloans et al., 1995).

Fish farming is increasingly becoming popular among smallholder farmers in Central Malawi, particularly Dedza and Lilongwe districts (Ng'ong'ola, 1992).

On farm failure of supposedly appropriate technology is a well-known phenomenon, and is at least partly due to researchers working on the experimental stations having used optimal, rather than realistic, conditions in developing extension packages. This is especially true for aquaculture research where the test situations due to the requirements of controlled experimentation, are usually drastically simplified parodies of real farming systems (Rendall and Brummett, 1995). The development of such systems in isolation from the complexities of the actual farm may have resulted in low applicability and consequently, the observed low adoption rate of new fish farming systems and other integrated technologies.

If extension is to be effective and successful it will to take knowledge, ideas, opinions and interests of their intended target groups as its point of departure (FAO, 1995). Aquaculture cannot be conceptualized as purely technical activity. Opportunities available to differentiate for aquaculture not only depend on environmental conditions, access to means of production, but also their social relationship within and beyond the household level.

The socio-economic environment of the rural population appears not fully understood, preventing most effective translation of the extension message to recipient population and monitoring impact of extension activities. Socio-economic consultants on a piecemeal basis have assessed socio-economic impacts of aquaculture projects in respective areas. These studies were time limited and have collected a range of information, which often does not allow comparisons between study areas. The main reason for this is that there is awareness of need for socio-economic inputs in extension approach, but there appears no clear identification in the nature of problems in terms of fish farming development *(*Draft paper, 1998)

Although much has been written about the techniques of increasing food production in the developing countries, little is known about the best combination of biological, technical, socio-economic and administrative functions for promoting integrated rural development for nations or their various regions. Further in most cases the ultimate beneficiaries of development policies have never been identified and their behavioral patterns and institutional practices are at best poorly understood.

This makes it difficult if not impossible to design an effective national and regional policy and program, or to determine the best mix of inputs required in a given location to ensure the success of an aquaculture development project

Rationale of the study

The potential for aquaculture development is far less infancy as regard to semi-intensive culture systems in the study area. The development of Aquaculture has not been made on assumption that farmers need fish for nutrition and not basically for sale (not on business culture). As a result not much has been done to inculcate business culture in the promotion of aquaculture. Once outputs are not conceived, farmers have ended leaving the enterprise. This research therefore was aimed at involving farmers to see the overall profitability of aquaculture venture. By involving farmers, it was argued here that this can lead to sustainability of fish farming, in the sense that on farm trials marry the technology in the farmer-working environment hence boosting technological uptake and user sharing.

On farm research, which can perhaps be termed '*adaptive field trial'* could be exceedingly valuable particularly in the study area and Malawi at large where on-farm experimental pond and farm facilities are in short supply. Hence in this case, on farm trials aimed at facilitating the generation of data and its use in technology development direct with farmer

In addition, the compilation of databases from this on-farm study will give the Ministry of Natural resources and Environmental Affairs, Ministry of Agriculture, Irrigation and food security and other stakeholders' involved in farming systems, valuable insights into the economic sustainability of semi-intensive aquaculture using on-farm resources, baked up with proper pond management skills.

Objectives of the study

Underlying objective

The overall objective of the study was to find appropriate intervention, involve farmers in proper fish farming and assess the profitability of the enterprise.

The following were the Specific objectives

To monitor the management of the fish ponds together with farmers

To assess returns from farmer own managed ponds.

To analyze the profit margins of aquaculture after proper management of fish farms (farmer-researcher managed ponds

Materials and methods

Place of study

This study was carried out in Mpalale village, T/A Kasumbu in Dedza district.

This place was chosen because it is one of the areas where semi-intensive fish farming is being practiced with the overall goal of boosting nutritional status of the rural community, and no on-farm research was conducted by then to investigate the profitability of semi-intensive aquaculture in this project area. The interviewed farmers thereafter, recommended that fish farming is the best option in farming systems because it involves less continuous hard labour of digging as compared to crop farming systems where farmers dig or cultivate annually.

Sampling design and data collection

This research was carried out on-farm (Mpalale village in Dedza District).

- Semi-intensive fish farmers were identified through questionnaires, interviews with sampled household heads and focus group discussions.
- Four fishponds had been selected for trials (stocked and non-stocked 200m^2 ponds)
- The sampled farmers were regularly visited for collaborative on-farm trials and discussions.
- The previously stocked ponds were harvested in farmer-researcher collaborative system and the fish were counted and valued in weight/monetary forms.
- The harvesting gear (fishing net) was brought to the farm by the researchers
- The harvested ponds were stocked using fingerlings brought by the researcher-and fingerlings were valued in monetary forms.
- Farmers were advised to manure their ponds and feed their fish using their own farm resources on 3% biomass to the ponds on daily basis for six months.
- Data on the used inputs were collected
- Key water quality parameters were tested on farm using water checker (e.g. DO, PH; Temperature, Turbidity). All data were recorded.
- After six months experimentation and monitoring process, the restocked and stocked ponds were harvested
- The harvests were valued on gross margin basis. The economic values of the two harvests of fish (farmer/farmer-researcher managed ponds) were compared to find the effect of farmer-researcher pond management over farmer own pond management.

Data analysis

The results from on-farm activities were discussed with the farmers before compilation.

Economic analysis of the gross margins were calculated using the following formula:

GM= TR-TVC

Where: GM = Gross Margin, TR =Total Revenue and TVC = Total Variable Costs

The quantitative data was analyzed using Microsoft Excel.

Results and discussion

Preliminary survey

From the pilot study that was conducted in the project area from the 23rd to the 26th of July 2003 with the overall aim of establishing the socio-economic status of the target groups, determination of farmers' perception to fish farming venture and farmer out come expectation from pond returns, came out with the results that are illustrated below:

Table 1: Farmers' name/description.

	M. Jamiton	S. Billy	Z. Moyo	M. Makwinja	H. Jamiton	K. Lostala	A Chisamba	D. Chabwer a
GD	Male	Male	Male	Male	Male	Female	Male	Male
MS	Widowed	Married	Married	Married	Married	Divorced	Married	Married
AG yrs	26	29	23	27	35	40	46	38
TS	Settler	Son in-law	Son in law	Son in law	Son in law	Land owner	Land owner	Land owner
EDL	Std 1-5	Std16-8	Std 1-5	Std 1-5	Std 1-5	Std 1-5	Std 1-5	Std 1-5
NFR	Piece work at MCF	None	None	Brick layer	Piece Work at MCF	Piece work at MCF	None	Casual labor
LZ (ha)	1-2	1-2	1-2	Un known	1-2	1-2	1-2	Unknown
LA	From parents	From parents and marriage	From parents and marriage	From marriage	From parents	From parents	From Parents	From parents
SI	Sale of crops and pond fish	Sale of crops and pond fish	Sale of crops and off farm employme nt	Sale of crops and pond fish	Sale of crops and pond fish	Sale of cash crops and tock	Sale of crops and livestock	Sale of crops and livestock
AI (K)	2000	1,000	Don't Know	1,000	3,000	1,500	Don't know	4,000

GD = gender of farmer, MS = Marital status of farmer, AG = age of farmer, TS = traditional status of farmer, EDL = educational level of farmer, NFO = non-farming occupation of farmer, LA = land acquiring method, SI = source of income, AV = average income level, MCF = Malawi College of Forestry.

Generally, most of the farmers in the project area proved to fit into the category of the low resource farmers as per their income levels (Table 1). The farmers are characterized by having merge on farm resources; a few livestock and don't have, and only a small amount of maize, beans, Irish potato and sweet potatoes all mainly grown for their consumption and less for sale especially beans and Irish potatoes are sold. It was identified that fish farming was regarded as just a complementary on-farm occupation despite their strong willingness to venture into fish into fish farming with a business perspective all due to lack of good advisory extension messages from aquacultural experts.

The isolated main problem in the preliminary studies was the lack of fingerlings for stocking the ponds were then provided to farmers by the researcher with an estimated value attached to it for farther pond out put analysis (farm 1-3).

Farm/pond characteristics and their impacts on pond profit margins

Farm 1: Owned by Mr. Jamiton Manuel.

The fish pond in this farm had plenty of water through the whole rain season and started drying in the early October but little amount of water was retained especially from the capillary rise which prompted the survival of the stocked fish to meeting the following rain season. Although the water source had some good supplies of water, the pond owner could not pump in extra energy for bringing water to the pond for refilling as he was always out for casual labor at the Malawi College of forestry (Table 1), as a additional source of income to an intermittent sells of cash crops which could not give out an income of more than MK3,000 per annum.The 200m^2 pond lies in the land owned by an uncle who takes charge in approving for land matters when need arises for pond/farm extension, an element that hinders the farmer's interest to accommodate an integration of vegetables and other crops to the pond surroundings.

The most important used household and agricultural by-products identified on the farm (Table2) and for all other ponds.

Fish stocking and harvests

The preparatory harvesting yielded no even single from pond 1 and was stocked with a total of 800 fingerlings making a stocking density of 4 fish/m^2 i.e. in a 200m^2 pond. The fingerlings stocked were valued at MK 3.00, each which gave to a total estimate cost of MK 2400 for pond 1 fingerling input.

Through incomplete harvesting due to the presence of a large number of fish fry and fingerlings of over 200 in number the pond was harvested. The incomplete harvesting was carried in avoidance of rendering the young fish being rendered to lethal conditions. The harvested fingerlings were valued at MK 6, 000 as by year 2003 (i.e. > 2000 fingerlings * MK 3.00).

A total number of 198 table-sized fish were harvested i.e. out of a total stocker number of 800, weighing approximately 5 kg with an estimated monetary value of MK 3, 300 as per Mpalale market prices of the 24th December 2003 in Dedza district Malawi, which were going at 5/6 flesh fish pieces at MK40.00.

Gross outputs and margin analysis from the pond returns

Where in this case gross out put is the preliminary measure of income that assessed the performance of the pond enterprise purely interns of benefits it yielded without considering the costs incurred in fish production.

A) Pond 1. Gross output;

= The value of table sized fish + estimated value of fingerlings.

= MK 1, 300.00 + MK 6000.00

=MK 7, 300.00.

B) Pond 1. Gross margin analysis – returns weighed with respect to expenses.

Gross margin

= Total revenue estimated – estimated variable costs (fingerling cost in this case)

= MK 7, 300.00 – MK 2, 400.00

= MK 4, 900.00

This did not take into account the cost of labour, pond inputs and fixed assets.

The disposable income was that from the sales of table sized fish and the short fall of table fish size from the stocked number represents a loss on gross out put which observably was due to predation, farmer own fish harvesting and fish mortality due to poor feeding regimes

Farm 1 pond 2. Owned by Mr. M.Makwanja, Mr. H.Jamiton and Mr. Z. Moyo.

The pond has almost similar hydrological characteristics as in pond 1 that tend to dry in the hottest season of the year and the management styles tend to tally with those in pond 1 too probably due to a reason that owners happened to have off farm occupations of doing casual labour at the Malawi college of forestry .The farmers reported to have an average income level of MK 1000 per annum.

The pond yielded 69 fish fry on preliminary pond harvest with the overall body weight of 1.7 kg and an addition of 600 fingerlings was carried out making a total of 669 fingerlings with an estimated stocking density of 3 fish /m^2 in a 200m^2 pond and the estimated fingerling value was MK 1, 800.

On harvesting a total number of 184 table sized fish was realized with an estimated value of MK 1500 and batch weight of up to 6 kg. A good number of fingerlings that on counting could number up to 1000 in total giving a monetary value of MK3, 000.00

Pond 1 Gross out put

=Table fish value + fingerling value

= MK1, 800.00 + MK 3,000.00

= MK 4,800.00

The management short falls, predation and calculation estimate considerations apply as in pond 1 despite the pond being owned by three farmers.

Farm 1.Pond 3. Owned Mr. Billy Mateyu a 29-year-old farmer by the year 2003.

The and obtained its water from the same source with pond 1 and pond 2,but it differed with the two in that it lost all its water in early October, which led all its fish transferred to a small well. The water losing tendency with no objection was due to the pond's poor construction as it levered on a very shallow depth into the ground hence had no access to capillary rising water as others had that led to some water retention. Being constructed on loose topsoil, seepage was at its peak and low retention.

The preliminary harvesting the pond yielded no fish and as a result of the complete pond drying no fish again was harvested on the day of project termination making pond out put estimation difficult if not impossible.

The farmers' incomes level as per annual basis was MK1, 000.00 that mainly comes from sell of food and cash crops (Table 1). It was observed that the farmer had little activeness towards fish farming activities and overall farming interventions no wonder he failed to channel the from the source to the close by fish pond.

The pond was stocked with fingerlings totalling to 600 which proved to yield failure due to pond dry up hence ended up in total loss (Table2).

Farm 2 Pond 4: Owned by Mr. Alick Chisamba a 46-year old farmer by year 2003.

This farm lies on the upper part of the farm 1, where water sure of good quality is through out the year no wonder the fish out put was he best. Being the village headman the farmer owned personal land that requires no consultations if pond expansion or pond number increment demands their ground. Despite the farmers old age he proved to be the most active colleague to work with regarding farming as the only source of household income with no known amount of money worth mention per annum but fish farming venture a realization of an approximate realization of a disposable income amounting to MK1, 500.00 after only six months from sales table sized fish at Mpalale Market which required no transportation costs.

The 180m^2 pond was stocked with 500 fingerlings at an estimated stoking density of 3fish /m^2 on a rough monetary value of MK1, 500. As a matter of interest, table sized fish sales have managed to pay back the cost of fingerlings stocked into the pond.

Regarding its favourable fish farming environment, no wonder the farm, despite low stocking density as compared to pond in farm 1, the pond produced the highest number of big marketable table sized fish which came up to a total number of 227 with an overall batch weight of 9 kg and a monetary value of MK1, 500.00 plus a very large number of fingerlings (>2,000) as well as a lot more fish fry. The farmer in this farm managed to adhere to the advice that the researchers advised them, as he constructed a separate fish-seed pond for keeping fingerlings unlike all other farmers.

Gross output for pond 4:

=Table fish sales + estimated fingerling costs

=MK 1,500 + >MK6000 = MK 7,500

Gross Margin

=Table fish sales + estimated fingerling value- Cost of fingerlings stocked

=MK 7,500.00-MK1500.00

=MK6, 000.00

The gross values not into account the fish numbers that were subjected to mortality, predation and other losses.

Farm 3 Ponds 5: Owned by Miss Kilida Lostala a 40-year old farmer as by 2003.

In general the farm/pond conditions are similar to that of Farm 2 pond 4, of Chisamba only differed in that was shallow a condition that favored excessive algal growth invasions during the hot season of the year i.e. when the season hits summer. There was no harvest that was realized from the pond out of the total number of 200 added fingerlings to the already existing ones in the pond due to the water channel sedimentation –that blocked the water flowing into the pond without the knowledge of the owner rendering almost all the fish to predation as the pond went dry.

The owner of the pond showed great interest in venturing into serious fish farming as she went round with the research team harvesting other farmers' ponds despite her zero harvest.

Another woman's pond that was formerly part of the research project program was harvested to have a fair comparison in gross out puts. The pond was initially stocked with 4fish/m2 but yielded only less than 10 table fish with lots of wild small river fish that are of no economic use, but this was after a fish-rearing period of three years. The low harvests were due to poor extension services from the aquacultural experts for guidance to the farmer who had a very promising water supply for fish farming.

The zero out puts were a result of complete dry up of the fishponds as explained in the farm characteristics above.

Pond inputs in the area and farming production cycle

The most used household agricultural by-products identified as pond inputs on the Mpalale fish farms (Table 3) below.

Table 2: Summarises the estimated gross out puts for the four farm enterprises, Mpalale village, and Dedza, Malawi, 2003.

Item	Pond # 1	Pond # 2	Pond # 3	Pond # 4	Pond # 5
Area (m^2)	200	200	200	180	200
Table fish size (number)	198	184	0	227	0
Table fish size (weight, kg)	5	6	0	10	0
Table fish size market price (MK)	6/7.00/ piece	6/7.00/piece	0.00	6/7 per piece	0.00
Fingerlings estimated number	>2000	>1000	0	>2000	0
Fingerlings estimated unit price (MK)	3.00	3.00	0.00	3.00	0.00
Gross output (MK)	7,320.00	4,800.00	0.00	7,500.00	0.00

Table 3: Pond inputs, their specific use, alternative use, season of year when common and their impacts on fish production.

Material	Specific pond use	Alternative use	Season common
Maize bran	Fish feed	Emergency food	Harvesting period
Vegetables	Fish feed	Household consumption, and Selling	When field are harvested and rain season
Maize stoves	Compost pond manure	Feed for livestock	Soon after maize harvesting.
Pumpkins	Fish feed	Human consumption	Soon after field crop harvesting
Chicken manure	Pond manure	Vegetable manure	Dry season
Goat/pig manure	Pond manure	Field crop manure	Dry season

From the table above, it is worth noting that seasonal availability of pond inputs in addition to already cited water availability and labour turn over plays an important role in constraining aquaculture as a business venture. Feed pond inputs except manure are not available in hot, dry season when fish growth would be highest. At this time when inputs are maximally available, farmers are engaged in production of garden/field crops hence much labour input allocated to the pond activities.

It was noted that to overcome these constraints, it would be necessary to better adapt the pond to and fish farming technologies to the whole farm farming systems. Vegetable production for example integrates with the pond than does with maize.

This also well supported by the higher gross out puts in the harvests of farm 2, pond 4 which had a labour that concentrated on the farming alone than that of farm 1, which had shared labour profiled (Table 1), with non farm occupations.

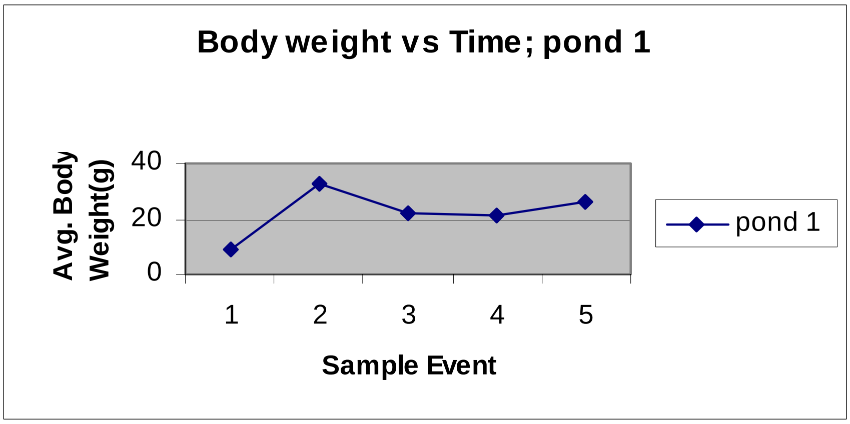
This simply entails that when a suitable niche is found, aquaculture plays an important role in the small farmer's productivity and profitability as cited by Chikafumbwa, (1994), that rice-fish integration has grown rapidly in southern Malawi because it takes advantage of the existing and well understood technologies associated with rice-production.

As the case of Mpalale village, demonstrates that fish farming that neglects the annual cycle of events and constraints on the farm will not easily turn into a profitable business venture.

It was purely observed that for such smallholdings that are making their transition from a primary subsistence to amore commercial focus, new technologies such as simple processing of feed materials would be very useful.

venture would *de facto* those with access to more reliable water supplies as was the case with farm 2,pond 4, no wonder the output was highest despite low stocking density.

Figures 1, 2, 3, and 4 show the fish growth trends in the four ponds at five samples that were made from July – December 2003. Computations made from



In Malawi, properly conducted fish production is more profitable than other crops but with a limit that farming transition towards fish farming business

the summarized averages (table of averages not shown).

Figure1. Fish growth trends.

The graph shows that there was a fast fish growth soon after fish acclimatization in the pond in the harvesting season of the year (June –August) due to the abundance of pond inputs such as maize bran for fish feeds i.e. samples (1-2). There after, the growth was decreasing due to the scarcity of feed pond inputs since maize bran which forms the basis of fish feed in small holdings tended to be shared as food for people and fish hence little could be prioritized for fish. The other reason and most important for mature females was that at this time fish had laid eggs which were being incubated, therefore loss of weight in that *Oreochromis shiranus* doesn't feed during this period (samples 2,3 and 4).

From sample 4, which was the fifth month after stocking, the fish had hatched and resumed feeding hence there was increase in the biomass again but still at a slow pacing due low pond inputs as stated above.

This can as well be used as a management tool in fish feeding by reducing the amount of feed given per time period with reference to the total biomass in the pond. The results are almost concurrent in all the four ponds (Figure. 2, 3, and 4), with very slight differences due to differences in management and environmental scalars.

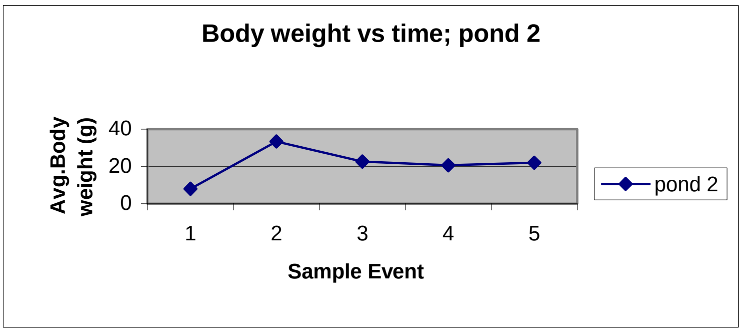


Figure 2: Fish growth trends for pond 2. Results from Pond 2; collarets with that of pond 1, (Figure.1) and the same description applies.

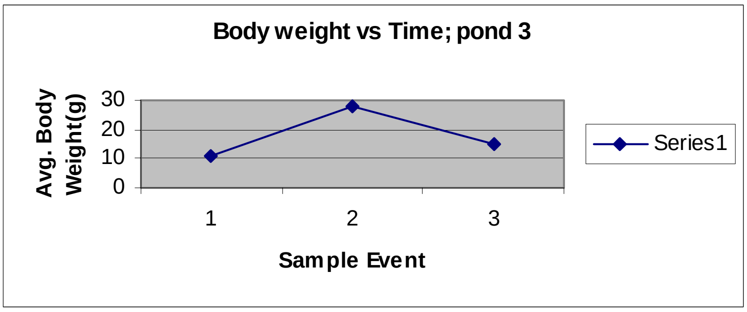


Figure 3: Fish growth trends for pond 3. This graph is explained similarly to Figures 1 and 2; samples (1 – 3) and the zero growth in samples (4-5) indicates that there was complete pond dry up and fish were transferred to a small well where sampling was impossible. No data was collected on these two sampling days on pond 3.

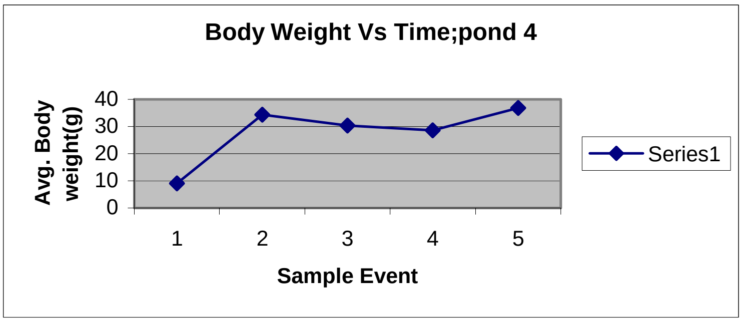


Figure 4: Fish growth trends for pond 4. The description in Figure.4; marries very well with those of Figure.1, but this pond had an upper hand in terms of fish growth because the farmer had a good amount of feed pond inputs despite the passage of time and the site has a very good high quality water supply all year round as opposed to ponds 1,2 and 3 above. There was a significant gross output from this pond despite its low stocking density (Farm 2, Pond 4) as compared to the other ponds (Figure 5).

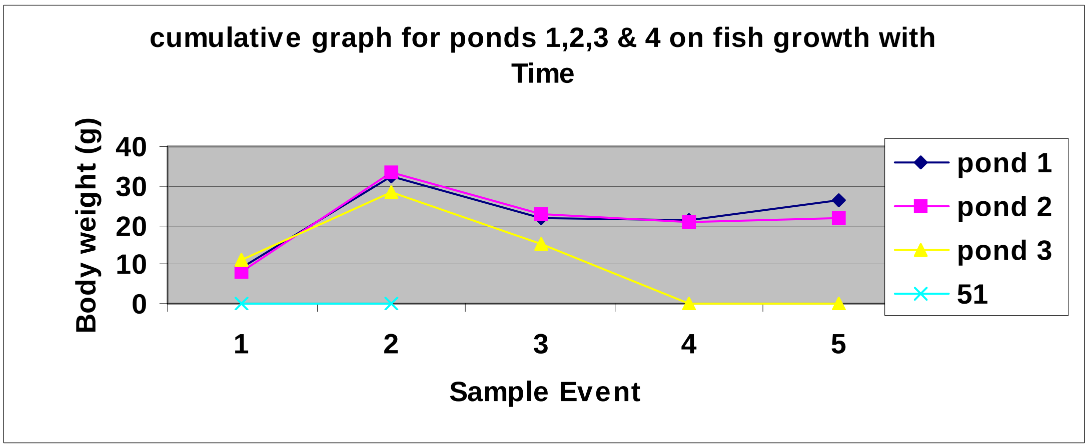


Figure 5: Cumulative fish growth trends for ponds 1, 2,3 and 4. Results from pond 4, explains the high productivity that aquaculture venture can give when good niche for its operation is found and pond input availability is adequate for the cultured *Oreochromis shiranus shiranus*.

Conclusion and recommendation

There are manifold interactions between fish farming and agriculture through common use of land and water resources, and concurrent production cycles that on overall, supports the rural village communities, therefore its vital that in-depth evaluation of the targeted farmers be conducted if aquaculture is to be exploited on a sustainable and profit making point. There is need for concerted effort to resolve production time conflicts between aquaculture and crop production and bear them as twins that can use the same resources at times (Table 2). Hence it is important to consider seasonal availability of inputs, availability of water and labour in the design of fish farming projects, as this plays an important role in boosting pond returns despite inadequate farm inputs on the overall (Farm 2,Pond 4), where fish farming has a high potential and a readily market as well.

It is in view of this that the report therefore recommends that fish farming research be continued in the Mpalale area on business approach, particularly in the upper course of the river (Farm 2 and farm 3) where water is plentiful through out the year, and women be given the first priority as they proved to have had the most spectacular interests towards the improvement of fish farming on business culture, in addition to that they have low tendency of going outdoors searching for casual labour leaving starving fish ponds at home as compared to men.

This primary research should stand as an eye opener to future on farm trials in the research project area and Malawi at large, in the sense that- there shall be a good understanding on the interlocking spurs that farming cycles form and the importance of handling them as one entity to maximize out puts on the farm in all individual enterprises that the farm the farm holds.

Acknowledgements

The author of this material claims that no one ever in the world attains very eminent success by simply doing what is required of him or her: It is the amount of excellence of what is over and above the required, that determines the greatness of ultimate distinction.

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In closing, may I extend my myriad greatness to the Canadian International Development Agency (CIDA)-Marine Institute (MI), through Aquaculture and Fisheries Science Department – Bunda College of Agriculture for funding the Research Project for on its own it was a total failure. May GOD blesses all the Aqua staff and Bunda College at large.

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Meanings and possibilities of ecological toilets to the lakeshore village communities at Lake Malawi: (2) Hybrid maize production and food shortage

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Abstract

Located in southeast Africa, Lake Malawi occupies most of the country's eastern border. Twenty percent of the country's area is occupied by Lake Malawi, which is one of three large lakes scattered along north-south Great Rift Valley. Out of 206 nations of the world, Malawi was ranked 199th in GNP per capita in 1999. More than 60 percent of the population is living below the poverty line and 80% of population is dependent on primary industry, that is, farming and fishing for their economic well-being. Malawi for its supply of food heavily depends on freshwater fish from Lake Malawi.

The largest source of protein is fish which mainly come from Lake Malawi. People's staple food is maize and their expenditure on food is more than 60% of the total household income. Food especially fish and maize are the utmost concern for local people. Interviews conducted by us in August 2002 with women in Chembe Village at lakeshore of Lake Malawi revealed that over 90 percent of them wanted constant supply of maize and fish. The same interview conducted with primary school children revealed that more than 50% of them had only one meal a day.

The problem of food shortage continues to escalate the introduction of hybrid maize. Since hybrid maize comes as a package of purchased seeds, chemical fertilizer, and agricultural chemicals, introduction of hybrid automatically necessitated the more use of outside resources. Among them cost for chemical fertilizer put biggest burdon on farmers economy, because Malawian KWACHA has been constantly devalued since 1990's against US Dollar as the foreign debt increases. Currency devaluation directly affects the price of fertilizer, and it is constantly rising sharply.

The local farmers household economy, however, have been seldom surveyed in Malawi, and thus we have conducted farm household economy survey at Chembe Village in 2004 and we have found that there is no return for the labor and land invested, and there remains a huge monetary loss by planting maize. The situation has been worsening since 2001 when the price of fertilizer started to shoot up sharply.

Thus, this paper focuses on the worsening farm economy based on our fact-finding farm household survey and also the economic and ecological legitimacy of the introduction of ecological toilets which will be able to utilize human waste as farm fertilizer. We also discuss the possibility of improving the lake water pollution issues by human waste. At the same time we have to discuss the mental and cultural barriers of the use of human waste as organic fertilizer for farmers in Malawi because it has been completely out of their cultural tradition and their imagination.

Key Words: Lake Malawi, Sanitation, Food Shortage

The attitude toward the introduction of high yielding hybrids

Introduction of Hybrids in Malawi started in 1970's. Figure 1 demonstrates the increasing tendency.

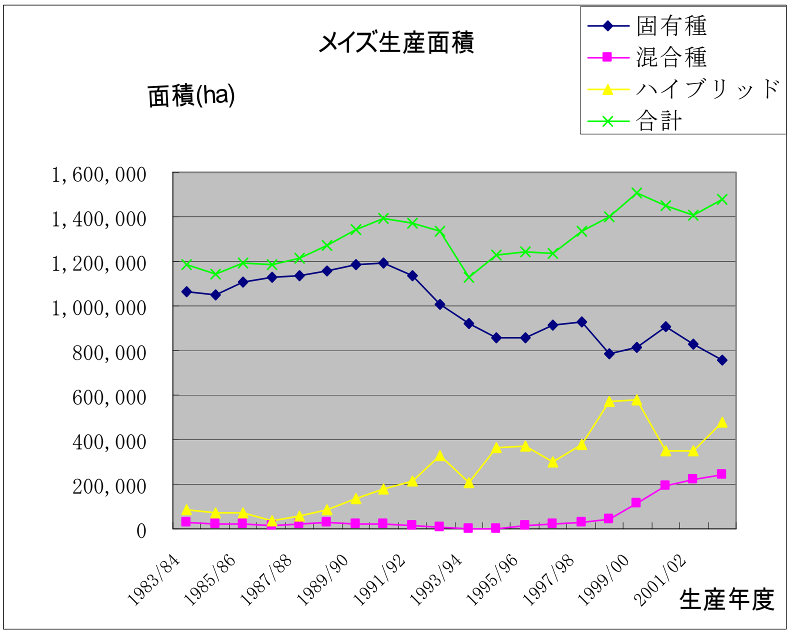

Figure 1: Introduction of Hybrids after 1980s. (Ministry of Agriculture and Food Security, Malawi).

Introduction of Hybrid and its penetration into farming can be divided into three stages according to its species of seed. The first stage is symbolic in CCA （Chitedze Composite A Grade） developed by Chitedze Research Station and in UCA (Ukiriguru Composite A grade） developed by Ukiriguru Research Station in neighboring Tanzania. Both types were not popular because of their poor taste and low resistance to diseases in spite of the fact that they were higher yielding than the conventional maize. Figure 1 shows that the spread of this type was curtailed in 1980's.

The second stage is symbolic in the movement in 1980's and 1990's, when 'NSCM41' was developed with nation-wide zeal under President Banda by National Seed Company of Malawi became popular. This type of Hybrid developed by national effort of Malawi was better than UCA and CCA with characteristics of high yielding crop and quick growth. Yet it was weak against severe weather condition such as drought and against insect pests. It also required chemical treatment after harvest to prevent from quality deterioration. It is the customs of the people of Malawi to mill the grain of maize into flour before they cook their food. This species was especially difficult to mill. For housewives, the heavy load of milling the maze was a great burden, which made this type unpopular not mentioning of the inferior taste in comparison to that of local species.

In the third stage, in order to overcome the shortcoming of NSCM41, "MH18", the Malawi Hybrid, was developed by NSCM. In Chart 1 this type was shown as "mixed bred". This type not only inherited the characteristics of high yield and quick growth of 'NSCM41' but also inherited such character as strong resilience towards drought and insect pests. It is easier to mill and has good flavor in taste.

Results from questionnaires to chemical firms including AGORA

Survey of 20 farmers in Chembe village in 2004 showed that 13 divided areas of farmland with a total of 21 division of land were planted with "MH18". Seven divisions were planted with "NSCM41". Local species occupied only one division. Introduction of Hybrids increased among farmers in 1990's. According to survey of farmers, three farmers took to Hybrids in 1980's, 17 farmers in 1990's. The main reason for them to take up the Hybrids is "High Yield of Crop" (8 farmers) and "Quick Growth" (9 farmers).

Questionnaires to Primary School pupils showed that they prefer Hybrids because they are "High Yield Crop" (26 pupils) and "Quick Growth" (20 pupils).

Local conventional species planted in December when the rainy season starts are ready for harvest only next April, whereas the Hybrids are ready in March.

This makes it easier for the people to cover the shortage of food during the period just before the new-crop of maze replaces the old. Most farmers welcome the introduction of hybrids, especially when we consider that 8 families out of 20 replied to our questionnaires that food supply is definitely improved with the introduction. Twenty-six elementary school pupils replied that their supply of food has definitely been improved.

Problem of rapid increase in the price of fertilizer

It was only in 1990's when the Hybrids started to be popular, chemical fertilizers came into use in large quantity for farming. The villagers of Chembe almost never experienced the use of any fertilizer. All 20 farmers who were interviewed by us answered that "Chemical Fertilizer is definitely expensive", which is the biggest problem that they are presently facing. Forty-nine out of 72 school children answered in the same context.

Figure 2 shows the price tendency of Chemical Fertilizer based on the records of one of the manufacturers of fertilizer. There is no domestic producer of chemical fertilizer in Malawi, and every single packet of fertilizer must be imported.

The local currency, Malawian KWACHA has been constantly devalued since 1990's against the US Dollar as the foreign debt increases especially due to conspicuous decrease of Tobacco export, which has been the main export item. Currency devaluation directly affects the price of fertilizer, and it is constantly rising sharply.

Figure 2 also demonstrates the market price of the fertilizer called locally as "23:21:0+4s" or "CAN", which is a mixed compound of fertilizer, and that of what is called as "UREA", which is a nitrogen fertilizer. In early 1990's both of them were priced at 30-40 Kwacha per bag of 50 Kilograms. In the middle of 1990's, the prices shot to 200-400 Kwachas. In the year 2000, the price of the same was over 1,000 Kwacha. In September 2003, farmers had to pay 2,500 Kwacha for one bag of fertilizer: this means advance of price in three digits.

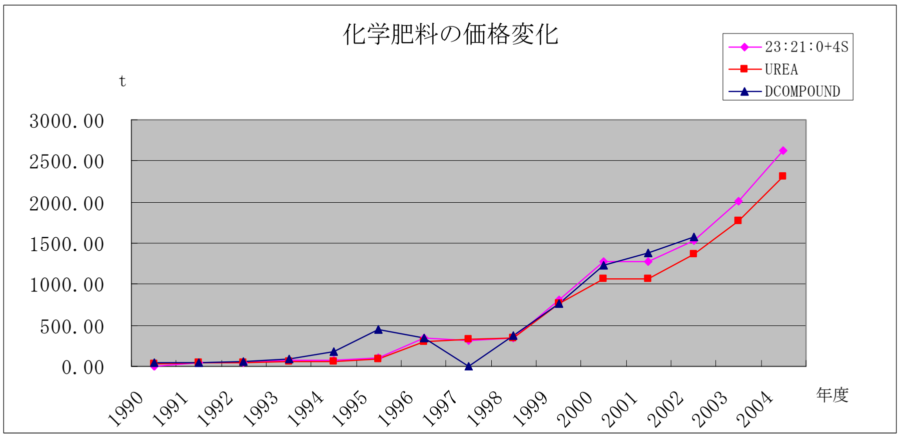

Figure 2: Price increase of chemical fertilizer.

The writer and our team started to visit Chembe in 1995, and it was around 2000 when the villagers started to complain about the sharp rise of the prices of fertilizer. We can observe that it was around the year 2000 when a bag of fertilizer reached to 1,000 Kwacha. The prices have been constantly advancing since then.

Now that ADMARC has gone half-public, the prices of Chemical Fertilizer are determined by this enterprise. The cost of transportation is added to the price, and therefore farmers in remote country-side are forced to pay higher price. Chart 7 shows the over-all nationwide tendency of price of fertilizer. List 1 below demonstrates the result of our interview of 20 farmers who answered to our inquiries as to the amount of fertilizer consumed and its price for the past 5 years. Average amount of fertilizer used and the resultant amount of crops are shown as per List 1. The amount of crops and that of fertilizer vary year to year. Largest harvest is recorded during 2003-2004, when the amount of crop is almost five times of the amount of fertilizer consumed. Whereas during 1999-2000, the amount of crop was only three times of that of fertilizer consumed.

Table 1: Amount of fertilizer input and maize harvest in Chembe (50 kg bags).

Harvest Year	Average Fertilizer Input (Bags)	Average Maize Harvest (Bags)
1999-2000	3.4	9.7
2000-2001	3.3	9.3
2001-2002	3.1	9.0
2002-2003	3.2	11.1
2003-2004	3.7	17.4

Table 2: Amount of money paid for fertilizer and proceeds from crop of maize in Chembe. Monetary units: Kwacha.

Harvest Year	Fertilizer price per 50 kg	Fertiliser cost for one farm	Maize price per 1 kg	Farm Income (KW)	Balance (KW)
1999-2000	700	2380	5	2435	55
2000-2001	1200	3960	4	3960	2100
2001-2002	1320	4090	8	4090	492
2002-2003	1770	5664	8	5664	1224
2003-2004	2005	7418	8	7418	538

The price of Chemical Fertilizer went up in the most recent five years by three times. Whereas the price of Maze rose only by 1.6 times, according to our survey conducted at Monkey Bay Branch of the sales office where most of the villagers of Chembe buy fertilizer and sell maize. It is apparent that the burden for the farmers to pay for the fertilizer is becoming heavier each year; List 2 indicates the result of our survey.

Up until 2000 the amount of money spent for fertilizer was less than the monetary value of the crop. Yet after 2001, money spent for fertilizer has always surpassed the monetary income from the crop. Even in 2003 when extra-ordinary good harvest was recorded, the gross amount spent for fertilizer was greater than the income from the crop. In 2001 when it was a year of bad harvest, the amount spent for fertilizer was greater by 2,100 Kwacha than the amount of income per farmer. In order for a farmer to harvest the crop of maze, it is required to spend many hours of labour and other chemicals, not mentioning the cost of seeds.

If we estimate the necessary cost of production for 2.5 acres (1ha) of farming area, which the average 20 farmers of Chembe tills, total cost sums up to 9,618 Kwacha. It can be broken down to 7,418 Kw for fertilizer, 1,730 Kw for 15 kg of seeds and 470 Kw for chemicals. If we estimate the average harvest of 17.2 bags in 2003 were sold at 8 Kw per kg, the income becomes 6,880 Kw, and it ends up with a loss of 2,738 Kw for a farmer.

In other words, there is no return for the labour and land invested, and there remains a huge monetary loss by raising crops of maze. This is serious after 2001 when the price of fertilizer started to shoot up sharply. And yet, 11 farmers out of 20 expressed their intention to spend more money for fertilizer if they can afford, believing that more fertilizer would bring them more harvest.

According to a booklet for farming instructors issued by the Ministry of Agriculture and Food Security, the condition of land around Chembe requires more fertilizer than average Malawian farming land. Chembe farmers are recommended to use 2 bags of mixed compound fertilizer and 3 bags of nitrogen fertilizer per one hectare. This means that present amount of fertilizer used in Chembe, which is 3 bags of compound and nitrogen fertilizer in total are definitely below recommended quantity of fertilizer.

It is economically more feasible to purchase Maize in the market than growing them under such situation of market. Villagers in Chembe, nevertheless, continue to grow Maize. In order to let the villagers know the simple arithmetic of such market situation, we have put up on September 7th, 2004 a lakeside exhibition, and asked the villagers of their opinion.

We have also held discussion with young local workers who volunteered assistance to this survey. The discussion led us to find that most of the farmers never calculated the cost of production of the maze or nobody is aware of how much expense is incurred for raising the crop. Some of them may be aware of the cost of production, but they are satisfied with the sense of safety by securing the supply of food. The heavy rain in the rainy season cuts off the routes of transportation to the village in the period just before the new crop of maze replaces the old, and thus the villagers often suffer from absolute shortage of food. The villagers are instinctively aware of the necessity to guard themselves against this shortage, which is aversion of risk or self-defence.

Psychologically, it is considered among villagers to be "idle" to buy the maze in the market, and spoils the reputation of the villagers. So long as there are healthy members in a family, it is expected that the family would grow maze enough to provide for themselves even on the borrowed land. This is a minimum condition expected of the villagers to live in the village as a full-fledged member.

We can observe here the decision making process in a "Survival Economy" as Chayanoff, the Agricultural Economist has analyzed. There exists an economic custom where commercial calculation of 'profit and loss' plays no part in a "Moral Economy" in an agricultural society. In a marginal condition of survival, the utmost priority is self-sufficiency of food for a family.

'Economic survival' in the past required almost no cash expenditures. It has long been an economic society where the goods and money cycled within its society. A big change in the structure occurred with the introduction of Hybrid, which has to be imported from abroad together with chemical fertilizer. So long as they all are imported, the effect of domestic employment cannot be created by the production of fertilizer. One-way flow of cash to over-seas suppliers creates unfavourable trade deficit of Malawi. Introduction of Hybrid and chemical fertilizer is accelerating the capitalistic control of agri-business in Malawi. There has long been an academic theory contending that small farmers of Africa cannot be captured by the principle of capitalistic economy due to their resilience by its unique farming method.

The writer doubts with great concern how long this unique resilience in survival economy can continue to exist taking the present socio-economic condition of farmers and their conducts into consideration.

Attitude of farmers towards farmyard manure (compost) and using human feces as fertilizer

In March 2004, Malawian Government announced, in order to cope with the problem of hiking price of Chemical Fertilizer, a policy to encourage the farmers to utilize farmyard manure as organic fertilizer. Eighteen farmers out of 20 showed their agreement to the policy. Sixteen farmers said that they would utilize the waste of farm animals such as chicken and goat as important sources of manure. Fourteen farmers replied that they would utilize the 'weed'. Ten would use 'leaves of trees'. School children also were aware of the importance of Organic Fertilizer, especially when they are available domestically and quite effective as fertilizer to improve the land.

We added to our questionnaire: "What do you think about the fact that a certain country has long used Human faeces as fertilizer. What do you think about it?"

In the questionnaire of 2003, we specifically mentioned that the country is Japan, but we avoided mentioning this specific country in the questionnaire this time. In 2003, over 70% of adult villagers replied in favour of using Human faeces. Whereas only 2 adults out of 20 replied in favour, and 18 replied in negative. Their reasons were 'bad to the health/fear of disease' (7), 'not imaginable' (6), and 'no previous experience' (1).

Seven male and 21 female school children expressed their willingness to accept Human faeces for fertilizer. It is evident that young children have less resistance to Human faeces than adults, and female children showed the least resistance.

Therefore it is important to target young people in the introduction of ecological toilets in order to utilize human faeces as composite manure to boost agriculture production with few inputs. It is a long process to change people's attitudes and perceptions but launching it with the youth, the writer believes that it is a viable option. It is noteworthy that some children and young people within the village have organized themselves and formed Ukhondo Youth Network and are working on the ecological toilets. This is the subject of the next presenter John Matewere.

The role of wetlands in lake ecological functions and sustainable livelihoods in lake environment: A case study on cross border Lake Jipe - Kenya/Tanzania

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Abstract

Wetlands are highly productive ecosystems. Their values and functions support other ecosystems and are significant to economic development. They once covered large areas of the world and are now among the rarest and most at-risk ecosystems. They are highly valued for their recreational, educational, scientific, aesthetic, spiritual and cultural values; and form an important component of lakes that provide critical functions influencing lake ecological functions. Despite the important roles in sustaining vibrant lake ecology, supporting economic development and elevating poverty, almost all wetlands in the world are threatened by diverse human induced factors.

Lake Jipe striding across the Kenya-Tanzania international boundary is an important ecosystem to both countries. It provides habitats for various biotic communities, regulates hydrology, stores and purifies water and has significant economic benefit to the local communities in the lakes' environment. The lakes' wetlands stabilize the shoreline, provide habitats for the Lake Fisheries, and remove sediments, nutrients and pollutants.

This paper reviews Lake Jipe and associated wetlands values, threats, policy effectiveness in Lake management and community involvement in the management and conservation of a cross border lake. The study show that lack of integration in planning, natural resource use in the Lake Catchment, weak policy enforcement and destruction of wetlands around the lake has lead to loss of biodiversity, increased siltation and diversion of the feeder River Lumi. Associated impacts of this diversion include change in the Lake water quality, decline in fisheries, poverty prevalence and migration of the local fishing community. This paper recommends institutionalization of integrated lake management taking into cognizance integrated land use, sustainable resource use, river basin management and community involvement that focus on sustainable livelihoods.

Key words: Buffering capacity, dynamic ecosystems, catchment and river basin management, community participation and involvement, cross border management initiatives, sustainable use.

Introduction

Lake Jipe traverses the Kenya-Tanzania border and has its catchment spanning the two countries. The lake originally covered 100 km^2, however over the years this area has declined to the present 30 km^2. For a long time, the lake had been the main fisheries source in the Taita Taveta region of both Kenya and Tanzania and a biological hotspot in a semi-arid area. The lake is threatened with demise due to threats as a result of catchment degradation leading to erosion and siltation; and the rapid growth and expansion of *Typha domingensis* and diversion of the major feeder river. The lake fish production has declined drastically adversely affecting the fish industry in the area (Taita Taveta District Fisheries, 2001). Invasion by typha weed and decline in fisheries has affected over 5,000 fish depended community, with some migrating to Nyumba ya Mungu reservoir in Tanzania and others changing into new live styles.

The lake and associated wetlands serve as a water reservoir for the Ruvu and Pangani river basins in Tanzania. They contribute significantly to socio-economic development through water supply for irrigation, domestic use, livestock and wildlife watering; and biodiversity conservation that supports tourism and recreation (KWS, 1998). Jipe wetland complex form a major source and storage of water for the Pangani River basin; the second-most important river in Tanzania for hydropower generation, water supply and irrigation. Whereas the lake and its wetlands are of international importance as a home to a diverse fauna and flora as well as providing support to many communities, it is beset with many management challenges including; accelerated runoff, increasing siltation, deteriorating water quality, a collapsing fishery and altered hydrology. The lake riparian land and its catchment are being used for agricultural development while the waters of the drainage basin are diverted for domestic supply and expansion of irrigated agriculture. These developments lack data on sustainability.

Lakes and associated wetlands are dynamic areas that are open to influence from natural and anthropogenic factors. In order to maintain their biological diversity and productivity and to allow wise use of their resources by human beings, an overall agreement is mandatory among the various owners, occupiers and interested parties. This can be provided for through wetland management planning process that is based on ecological studies and experience (Matthews, 1993).

The two countries Tanzania and Kenya have expressed the need for a cross-boarder watershed management approach as a measure towards wise use of the catchment, wetlands and other nature resources within the Lake Jipe region and shared by the two countries. This demands for cross-border collaborative management initiatives that impresses on the importance of wetland wise use based on ecological relationships, river basin management and catchment management approaches. This paper discuses the characteristics of the Lake Jipe - Lumi River Flood Plain ecosystem and significance to sustainable socio-economic development while proposing specific intervention mechanisms.

The Study Area

Lake Jipe, area 30 km^2, 12 km long and a maximum depth of 3m strides along the Kenya-Tanzanian international boundary at an altitude of about 700m a.s.l. It is located on the leeward side of Tanzania's North Pare Mountains on 3°31'-3°40'S and 37°45'E (Figure 1).

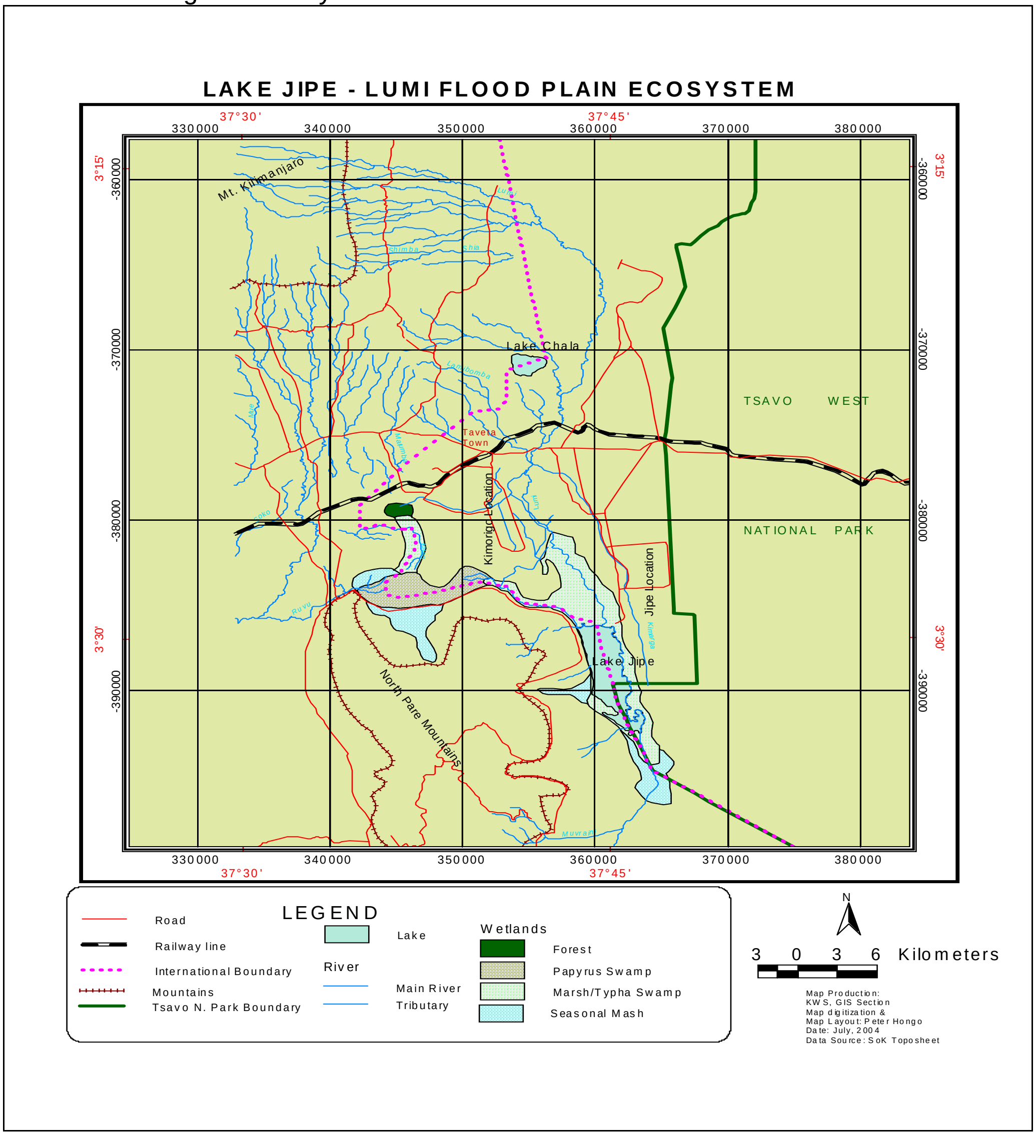

Figure 1: Study area map showing the Lake Jipe-Lumi flood plain ecosystem.

The international boundary divides the lake longitudinally such that the eastern half lies in Kenya and the western half in Tanzania. Unlike other lakes in the two countries, Jipe has its inlet and outlet in the northern edge Rivers Lumi and Ruvu respectively. The lake northern swamp has been expanding over the years especially towards the northern part as compared to 1906, when the northern swamps were approximately 5 km^2 expanding to about 14 km^2 in 1923 and 23km^2 in 1942 (Bear, 1955). This expansion and subsequent sediment deposition along River Lumi inlet is reducing the lake length in its northern end.

Hydrology

Lake Jipe is drained by River Lumi originating in the slopes of Kilimanjaro and along its course fed by several springs. From Ziwani to the Njoro Kubwa Springs, the river is 4m deeply eroded channel and the riverbed underlined by basalt except for the small area north-east of Worombo. The river flow is almost constant to the Njoro Kubwa Spring's confluence where it increases to about 230 m^{3}sec^{-1}. Several other springs join the river at this point increasing the flow to about 260 m^{3}sec^{-1}. Between the Voi-Taveta Road Bridge and the Njoro Kubwa, the banks of the river are approximately 4 metres high. Thereafter, the river profile flattens rapidly before entering the swamp, an area of the river that has been transformed extensively through irrigation.

River Lumi drainage basin is approximately 451 km^2, a quarter of which lies on the lower slopes of Kilimanjaro. In this area rainfall is heavy and runoff high. This subjects the river to occasional floods of considerable magnitude, a serious menace to infrastructure (railway, road bridges and irrigation projects down stream). The hydrology of the area indicates possible diversion of some of the rivers that previously discharged into the Tsavo River into the Lumi as a result of vulcanicity during the Tertiary period. Table 1 shows River Lumi mean annual water level, discharge and suspended load in 1950s, 1960s and 1980. The results show that river discharge has declined significantly. However it increased during the *el-nino* rains causing serious erosion and sedimentation blocking all the irrigation cannels, damaged water supply infrastructure and silted most of the springs. This diverted the river to discharge directly to Ruvu instead of the lake and progressive decline in water levels and increase in lake conductivity.

Table 1: Mean annual water level, discharge and suspended load for River Lumi in the 1950s, 1960s and 1980.

Year	**Water level (cm)**	**Discharge (m^3s^{-1})**	**Suspended load (ppm)**
1954	106	70	2442
1955	210	143	5473
1958	74	33	276
1959	54	12	30
1960	135	65	385
1961	158	-	1214
1980	-	1	23

Source - GoK-JICA (1992).

Lake Jipe outflows into the Ruvu River, which is a tributary of the Pangani River. It has a mean flow of about 130 m^3sec^{-1} near the source, increasing tremendously immediately below the lake and giving a strong indication of high subsurface input. The lake and its swamps are a storage basin for the Ruvu basin.

There are three groups of springs in the Lake Jipe area the most important being the Lumi Springs, comprising the Lenonya on the eastern banks of the river, and the Njoro Kubwa and Maji ya Waleni on the western bank. These springs increase the flow of the river from 5 to 300 m^3sec^{-1} in a distance of only 6-km. The largest of the springs is the Njoro Kubwa whose aggregate discharge is about 290 m^3sec^{-1}. The second cluster of springs forms the headwaters of the Njugini, Sainte and Njoro streams. The latter two unite to form the Tsavo River. The third cluster is the Kitovo Springs, discharge 42 m^3sec^{-1} and formed by the lavas and outwash gravels at the base of Kilimanjaro. There is a strong possibility of other springs discharging underground at the lakes' Northeast corner.

Geology

The geology of the area has caused an increase in Lake Level leading to an expansion of the lake to the south. The lake has sedentary soils of metamorphic origin while the northern and southern parts have a lot of sedimentary alluvium from the incoming rivers. Lake soundings indicate the deepest part to be about 2 m. Available evidence suggests that Lake Jipe is a recently flooded valley because high-level stradlines and lake beds similar to those around lakes in other parts of the country are absent. The superficial deposits surrounding the lake, excluding the sedentary soils are of fluvio-lacustrine origin and are represented by calcareous and ferruginous clays, greyish earthy limestone, and white gritty limestone, all mixed with carbonaceous material, and are fairly well sorted and relatively fine in texture.

Biodiversity

Jipe ecosystem is rich in biodiversity and the main watering point for wildlife in Tsavo West National Park. The lake is infested with crocodiles and hippos, with other wildlife species being various waterbird species, elephants, zebras, impalas and gazelles. Extensive cover of Typha and Cyperus swamps, which extend well up the Lumi and Ruvu Rivers, surrounds the open 4045 ha surface area of the lake. This swamp is habitat to several bird species and breading area for large numbers of *Oreochromis jipe* thriving in the lake and that supports the local fishing industry.

Socio-economics

Lake Jipe ecosystem is the main source of income in the region. It is used for tourism, irrigated agriculture, fisheries, domestic water supply, livestock and wildlife watering, and transport being the cross-border crossing point. Table 2 shows the main socio-economic activities in Lake Jipe and their environmental impacts especially with regard to the lake ecosystem. The lake has a high development potential whose realisation is hampered by poor access. Table 2 shows that most of the negative environmental impacts emanating from human land-use are concentrated within the northern and northeaster areas of the lake especially areas around Ziwani. Lumi sedimentation has collapsed irrigation activities and water supply in the area in the last ten years and a major shift in flow direction the river to Ruvu River instead of the lake. This transformation is probably caused by silt deposition at the floodplain, which is also said to be the cause of the collapse of small irrigation activities and permanent farm flooding.

Table 2: A summary of socio-economic activities and environmental impacts Lake Jipe, Kenya.

Activity	**Description and concentration area(s)**	**Magnitude and significance**	**Environmental impact**
Agriculture	Subsistence farming in the Lumi catchment and lower riparian area. This includes large-scale sisal production.	2	Accelerated soil erosion and sedimentation,
Small-scale irrigation	Subsistence and commercial irrigation in the lower riparian area	1	Impairment of hydrological systems, changes in water discharge and flow rates, lake surface area, water depth, water storage, water pollution and eutrophication
Large-scale irrigation	Commercial irrigation in the lower riparian area	2	Impairment of hydrological systems, changes in water discharge and flow rates, lake surface area, water depth, water storage, water pollution and eutrophication
Rural settlements	Kacheru and Mikocheni lake shore fishing villages, northern irrigation communities, scattered pastoral settlements	1	Negative changes in water quality including accelerated soil erosion and siltation, waste disposal and wetland contamination, resource over-consumption, overgrazing, river damming, loss of species, invasive species especially *Prosopis julliflora*, water pollution and eutrophication, illegal cross-border trade, cross-border resource utilization conflicts.
Urban settlements	Taveta town and other small urban centres to the northern area of the lake	1	Changes in water discharge and flow rates, lake surface area, water depth, water storage, water pollution and eutrophication, introduction of invasive species especially *Prosopis julliflora.*
Livestock husbandry and grazing	Northern and northeastern areas especially around Ziwani area.	2	Resource over-consumption, overgrazing, soil erosion and sedimentation, desertification, loss of species.
Mining	Mainly sand harvesting along the riverways especially River Lumi and tributaries	1	Impairment of hydrological systems, landscape alteration, accelerated soil erosion and siltation.
Forestry	Northern and north-eastern areas especially Ziwani..	3	Introduction of invasive species especially *Prosopis julliflora*.
Water supply and water harvesting	Northern and north-eastern areas especially Ziwani..	1	Impairment of hydrological systems, changes in water discharge and flow rates, lake surface area, water depth, water storage, water pollution and eutrophication.
Flood control, drainage and dyking	Northern and north-eastern areas especially Ziwani..	1	Impairment of hydrological systems, changes in water discharge and flow rates, lake surface area, water depth, water storage, water pollution and eutrophication, landscape alteration, river flow alteration and changes in river direction.
Dredging and channelization	Northern and north-eastern areas especially Ziwani.	1	Impairment of hydrological systems, changes in water discharge and flow rates, lake surface area, water depth, water storage, water pollution and eutrophication, landscape alteration, river flow alteration and changes in river direction.
HEP generation	Ruvu River, Tanzania	2	Impairment of hydrological regime, downstream ecological changes.
Commercial fishing	Tanzanian part of Lake Jipe and un-protected part in Kenya.	2	Over-exploitation of fishery resources.
Subsistence fishing	Tanzanian part of Lake Jipe and un-protected part in Kenya especially at Mkwajhumi, Kacheru and Mikocheni	1	Over-exploitation of fishery resources.
Sport fishing	Isolated areas of the lake.	3	-
Macrophyte utilization	Riparian shores in Tanzania and unprotected shores in Kenya	1	Over-exploitation of resources (90% of houses at the Fishermen Village with macrophyte roofing), trampling, overgrazing, burning, introduction of new species including invasive species *Prosopis julliflora*, water quality changes, habitat fragmentation and alteration.
Wildlife utilization	Riparian areas in Tanzania and unprotected areas in Kenya	1	Human-wildlife conflicts especially hippos and elephants.
Nature photography	Isolated areas around lake.	3	-
Bird watching	Isolated areas around lake.	3	-
Boating and canoeing	Isolated areas around lake.	3	-
Camping	Isolated areas around lake.	3	-

Note: (1=widespread and highly significant, 2=common and moderately significant, 3=rare and insignificant).

Results and discussions

African wetlands are primarily important due to the fish populations they support. This provide food for local populations and is a major source of income. Fisheries in Lake Jipe show a declining trend, which can be associated to changing water quality and decline in Lake Water Level. Wetlands and people are ultimately interdependent, with local community livelihood being highly dependent on local wetlands. The open-access systems, which characterize some of these areas also means that they are probably more vulnerable than other kinds of environments. Prolonged presence of water in dryland wetlands makes them suitable for farming and grazing, due to their ability to provide crucial ecosystem services like water and nutrients. In addition they support important economic activities thus creating a link between economics and natural resources, which acts as the driving force for wetlands transformation. Some loss of wetland due to missing economic signal to local people and policy makers regarding values of ecosystem goods and services are evident. Ruvu swamp on the Ruvu River as it leaves Lake Jipe in Tanzania is valuable as a water purifier (Howard, 1996). It is important in maintaining water quality in Nyumba ya Mungu dam and the entire river flow. This significance has increasingly created recognition on conservation importance of arid zone wetlands, which are particularly productive environments with high biological diversity. Unfortunately, their importance is generally not well documented or understood. This is primarily because of the difficulties of working in such areas and the concentration of arid lands in some of the poorer nations of the world.

There are a number of significant impacts on arid zone wetlands. These include pollution (including run-off from agricultural areas), over fishing, over grazing, erosion and climate change, which may affect flooding regimes. The most serious impacts are those that affect water quality and supply. Wetlands at the end of rivers are particularly vulnerable to the impacts of diversions or damming in their catchment. Likewise, water extraction from the water table threatens salt lakes and springs in many areas. Humans have significantly affected wetland ecosystems in the world's arid zone. Lake Jipe is no different from this scenario. A combination of decline in water level, increase in water conductivity, over fishing, over grazing within the riperian zones and increase siltation of the lake has reduce the lake’s economic potential. This has contributed to migration of fishermen to Nyumba ya Mungu.

Increased local demand on wetland resources including use of macrophytes for building material, mats making among other products as well as grazing have had a significant effect on their regeneration capacity and spatial distribution. While it is important to document the current macrophyte uses it is crucial also to investigate the forces behind the demand for these wetlands products and its effect on utilization. These efforts should be geared at examining avenues of maximizing bio-economic values especially of macrophytes while minimizing the impact of human activities. It is important to seek and have clear understanding of the past and future development scenarios in terms of macrophytes use, distribution and the factors behind these changes. This will facilitate better planning and management for the future in sustaining wetland water purification abilities in lakes and as a measure in reducing lake eutrophication.

Jipe ecosystem is under multiple uses and various jurisdictions in both Kenya and Tanzania. On the Kenyan side part of the lake is protected as a National Park setting in phase resource use conflicts. Similarly various institutions Ministry of Water and Irrigation, Ministry of Agriculture, Ministry of Fisheries and Livestock development, Kenya Wildlife Service, Coast Development Authority, Fisheries Department, several NGOs and CBOs on the Kenyan side and those in the Tanzania side have conflicting interests on the ecosystem. To harmonize resource use and ensure sustainability, there is need to establish institutional framework that promotes collaboration and synergies.

Conflicts within Lake Jipe ecosystem

Conflict in this ecosystem has been aggravated by lack of an ecosystem integrated management plan and cross-border issues in a situation where the two countries are under different policies and legislation despite the ecosystem serving local communities with similar socio-economic and cultural e background and interests. Declining resources, water diversion, wildlife habitat loss, declining fisheries, poverty prevalence, land tenure system and community access to natural resources are the main causes of conflict, which have been accelerated during the last two decades by other factors like poaching and the burgeoning human population that has precipitated major conflict. To mitigate these conflicts and promote integrated ecosystem conservation, there is need to undertake studies to establish the magnitude of the issues and problems, and identify alternatives that will minimize such conflicts for sustainable socio-economic development.

Within this ecosystem conflict is mainly due to decline in natural resources especially water, collapsing fisheries, lack of wildlife watering points within and outside protected areas, human settlements within wildlife corridors, diminishing natural resources base, increased agricultural activities and limited community rights and access to natural resources. Other forms of conflicts are upstream versus downstream water users due to water abstraction, fishers versus agriculturists due to eutrophication and fishers versus livestock keepers due to erosion and siltation into the rivers and the lake. A list of alternative conflict resolution strategies is available but these need to be evaluated through community involvement and participation so as to address all the conflict issues within the ecosystem of the lake. The conflict issues therefore, should be addressed depending on the most appropriate community acceptable mitigation measure.

Lake Jipe ecological significance

Jipe ecosystem values and functions are significance and critical for socio-economic development of the area. These include:

- Transportation acting as a cross-border crossing point between Kenya and Tanzania
- Support to commercial and subsistence fisheries
- Tourism and recreation
- Water supply for domestic use, livestock watering and agriculture
- Provision of building materials like bricks for building and typha for thatching, palm for mat and basket making, fish traps, fencing and building posts.
- Biodiversity conservation. The lake and its swamps are important refuge and breeding sites for local and migrant bird species and a major water source for wildlife in Tsavo West National Park in Kenya and Mkomazi Game Reserve in Tanzania.

Lake Jipe ecosystem conservation and management challenges

This ecosystem has high potential, which is threatened by various issues. The situation is compounded by lack of adequate scientific information to support policies and conservation. These challenges are compounded by cross-border policy variations and include:

- Poverty and conflict prevalence
- Change in course of River Lumi to drain directly to Ruvu instead of flowing into the lake thereby reducing water levels, declining water quality and quantity
- Increasing siltation
- Declining fisheries and over fishing
- Increasing water abstraction for domestic, urban and agricultural use
- Lack of integrated management plan for the site
- Cross-border issues and policy conflict as it relates to natural resource use
- Lack of institutional arrangements
- Inadequate scientific data
- Over grazing, destruction and over harvesting of riparian vegetation
- Inadequate local community involvement in conservation and access to natural resources

Lake Jipe - current problems and management needs.

The current ecological changes in lake Jipe are linked to community involvement in conservation, policies and water regimes, where poor land use has led to a decline in natural resources and changing water quality setting in phase several events like:

- Siltation has probably led to increase in salinity as evidenced by virtual disappearance of water lilies and the pigmy Geese
- Increase in area covered by typha and a decrease of the open water
- Disappearance of water lilies and dominance of typa as the main wetland plant
- Reduction in fisheries, fish size and increased poverty leading to migration of the fishing community
- Changing water quality and quantity
- Prevalence of water-borne diseases.

Soil erosion is the main causative agent for siltation and has been accelerated by loss of soil cover due to poor land use, deforestation and over stocking. The situation has been aggravated by poor farming activities within the lakes' catchment area. The interference of water flow from the upper catchment on Mt. Kilimanjaro and the Pare Mountains has resulted into river seasonality affecting the Lake Water quality and quantity. To restore the ecological integrity of Lake Jipe ecosystem, integration and harmonization of human activities within the ecosystem is prudent. This can be achieved through joint integrated management planning that involves the communities living on both sides of the international boundary and integration of management and conservation activities of both countries.

Analysis of Lake Jipe cross-border wetland conservation and management issues

This ecosystem strides across international political boundary of two countries under different administrative regimes and conservation legislation. Sustainable management of such an ecosystem demands the two countries to integrate conservation and wise use principals into national, provincial and local planning and decision-making processes on land use, ground water management, catchment and riverine planning under the concept of Trans Border Natural Resource Management (TBNRM) principles.

TBNRM is a holistic approach to natural resource management, which incorporates the principal of overall natural resource management required across international political boundaries. It is a process or form of cooperation across political boundaries that facilitates or improves the management of natural resource base to the benefit of all concerned, affected or interested parties, especially the local communities separated by the political boundary. TBNRM aims at securing the provision of goods and services, while maintaining wetland ecological integrity in perpetuity. Cross-border Wetland managers and users need ability, skills and knowledge on the function, ecological processes, structure and wise use principles on this ecosystem and its resources to effectively manage and conserve it

Strategies for Lake Jipe cross-border wetland management

This will involve various stakeholders inform of local communities, institutions and wetland users, who have various roles like policy makers, managers, facilitators, trainers and users. Management between the two countries may be developed and implemented through Management Agreements which could take the following forms:

- Equal funding and joint Commissions and Management Committees.
- Memorandum of Understanding between the states and conservation agencies.
- Reciprocal Agreements on Emergencies
- Co-operation in pollution, over exploitation and other forms of land use activities that threaten wetland role in socio-economic development.
- Coordination through a regional conservation agency like East Africa Community and international NGOs like IUCN, WWF and EAWS.

Recommendation

The following research issues are outstanding in the Lake Jipe ecosystem**:**

Lake fishery

Lake Jipe supports an important subsistence and commercial fishery. However, the opportunities, potential and constraints of the fishery are not clearly known and documented and will require a comprehensive scientific study. Such a study should focus on the viability, constraints and development potential of the lake fishery.

Transboundry socio-economic interactions

Different communities along the Kenya-Tanzania border share Lake Jipe. The communities are characterised by a wide range of socio-economic interactions, which can drive conflict and co-operation between the two countries. A comprehensive study of common human activities in the Lake Jipe area can provide important information for transboundary natural resources management for which the area is an outstanding laboratory.

Socio-economic impacts of hydrological transformations in the Lower Lumi

One of the key environmental changes in the Lake Jipe area is the recent hydrological realignment of the Lumi floodplain. This realignment has seriously affected agricultural activities in the area thereby disrupting traditional livelihood systems. The human role of this transformation has not been well investigated neither have the actual impacts of the hydrological changes been documented.

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Impact of agricultural development on the levels of total nitrogen and phosphorus in Lake Qarun, Egypt

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Abstract

Lake Qarun, a closed elongated salty basin lying in the western Egyptian desert, receives continuously huge amounts of agricultural drainage waters, controlling its area and volume. The agricultural development in the last decades at the southern and southeastern sides of this lake following the successive increase in population affected its nutrient levels. The vertical and horizontal distribution of total nitrogen and total phosphorus in the lake was studied to illustrate their levels and sources. The total nitrogen vertical and horizontal distribution showed irregularity, according to the amounts of its main constituents; dissolved organic nitrogen and particulate nitrogen. Total nitrogen showed highly significant direct associations with dissolved organic nitrogen ($r=0.93$, $p\leq0.001$) and particulate nitrogen ($r=0.69$, $p\leq0.001$. The higher surface total nitrogen values coincided with spreading of total nitrogen enriched drainage waters over the denser bottom lake water. The trend of total phosphorus vertical distribution followed the same pattern of the different phosphorus species. The higher total phosphorus averages were obtained in the surface layer in the southern lake region, directly affected by drainage water discharges, as confirmed from its indirect association with chlorinity. The total phosphorus averages showed irregular distribution pattern in the middle lake region; the surface total phosphorus fluctuations coincided with variations in dissolved inorganic phosphorus uptake, excretion of dissolved organic phosphorus and the amount of particulate phosphorus. These assumptions can be confirmed from the high significant positive correlations between total phosphorus and dissolved inorganic phosphorus ($r=0.88$, $p<0.001$), dissolved organic phosphorus ($r=0.93$, $p<0.001$), particulate phosphorus ($r= 0.78$, $p< 0.001$). In the northern lake region, however, the higher surface total phosphorus content was in accordance with the air born dust particles blowing from the northern desert and containing phosphate, as well as the phosphate excretion by surface organisms. The total phosphorus distribution showed an increase southward and eastward, conforming the direct effects of drainage water discharges. Similar to total nitrogen, the seasonal distribution of total phosphorus followed that of total dissolved phosphorus.

Key words: Agricultural drainage, closed lake, total nitrogen and total phosphorus.

Introduction

No detailed physico-chemical studies on Lake Qarun have been carried out since Naguib (1958, 1961) and El-Belbisy (1973). After those two studies, only scattered investigations on Lake Qarun, dealing mainly with some physical, geochemical and biological features, were carried out. Lake Qarun was subjected in recent years to external and internal events, such as the increase in agricultural land at the eastern and southern sides of the lake and elevation of salinity inside the lake, affecting markedly its environment and biota. This attracted the attention of the authors to conduct a research project on the water and sediments of this historical lake to investigate its environmental and chemical characteristics for illustrating man's impact. The present study, a part of this project, deals with the regional and monthly variations of total nitrogen (TN) and total phosphorus (TP) in this lake.

Study area

The present Lake Qarun is an enclosed salty basin lying in the deepest part of the Faiyum Depression at 80 km Southwest of Cairo (Figure 1). Its mean water depth, area and volume are 4.8 m, 243 x 10^6 m^2 and 923 x 10^6 m^3. These Figures were lower than those recorded in 1968, confirming shrinkage of the lake during recent years. Two peninsulas divide the lake into the shallower eastern basin and the deeper western basin. Lake Qarun is feeding with large amounts of contaminated drainage waters from Bats and Wady Drains, discharging into its eastern and southern sides, respectively, beside other small drains (Figure 1).

Material and methods

Water samples were collected monthly from June 1987 to May 1988 at 13 stations covering different ecological regions in Lake Qarun and from Bats and Wady Drains (Figure 1). The surface water samples were collected at 20 cm below the lake water surface to avoid floating matter and the bottom samples at 40 cm above the bottom to avoid disturbance of the sediments.

TN and TP were determined in 30 ml portions of unfiltered lake water samples, according to Valderrama (1981). Simultaneous oxidation was obtained using, an oxidizing agent (sodium peroxodisulfate, boric acid and sodium hydroxide). Four ml of this reagent were added to each of the 30 ml water samples and autoclaved for 30 minutes in a pressure cooker. After complete oxidation and cooling at room temperature, all nitrogenous compounds became oxidized and were determined as nitrate and all phosphorus compounds became oxidized and were determined as reactive phosphate. Both nitrate and reactive phosphate were determined according to Strickland and Parsons (1972).

Results and discussion

For simplicity in presentation and discussion of the data, it was found most appropriate to divide Lake Qarun into three horizontal regions; Region A representing the southern lake area is covered by stations I, II, VI, VIII and XI and is directly affected by huge amounts of drainage waters from cultivated lands; Region B is covered by stations III, V, IX and XIII and represents the central part of the lake; and Region C, representing the northern lake area is covered by stations IV, VII, X and XII. Besides, the lake is distinguished by the eastern basin, which is represented by the stations from I to VI and the western basin, covering stations from VII to XIII (Figure 1).

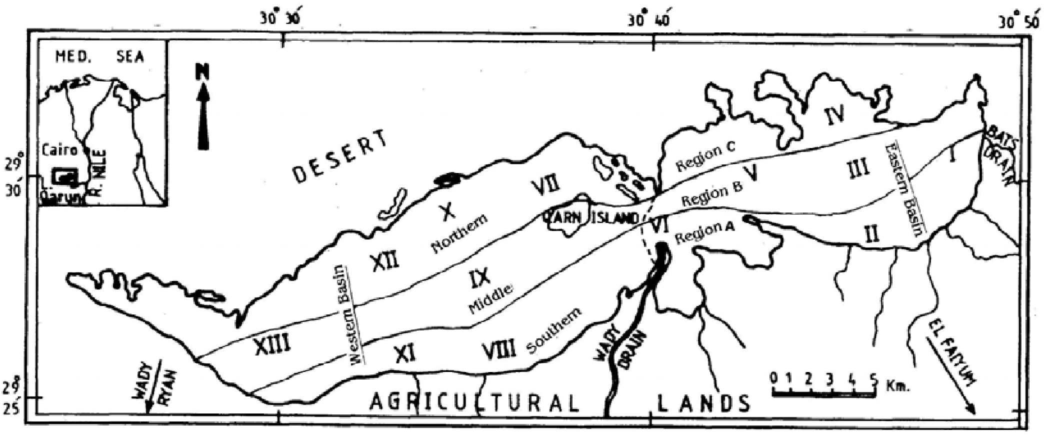

Figure 1: Map of Lake Qarun showing position of stations and the horizontal Regions A, B and C, as well as the Eastern and western lake basins.

Total nitrogen (TN)

The trend of TN vertical distribution showed generally irregularity in most surface and bottom waters. The higher surface TN values might be attributed mainly to spreading of the drainage waters relatively enriched with TN over the denser bottom lake water before mixing with it. However, the lower surface TN values are related mostly to the increase in the settling rate of the nitrogenous containing materials. As stated by Jenkens and Kemp (1984), the large net losses of nitrogen from the water column were probably attributed to sedimentation and denitrification in the sediments. Generally, the levels of all nitrogen containing compounds are determined by the net effect of fixation, assimilation, denitrification, regeneration and other processes in the complex nitrogen cycle.

Following the irregular vertical distribution of the absolute TN values, the horizontal variations of the surface and bottom averages of TN in Regions A, B and C (Figure 2) also showed an irregular distribution pattern. This is coincided with the concentrations of dissolved organic nitrogen (DON) and particulate nitrogen (PN) constituting the main fractions of TN. This can be justified from the highly significant direct associations of TN with DON ($r=0.93$, $p\leq 0.001$) and PN ($r=0.69$, $p\leq 0.001$), as pointed out by Hemeda (1996). These horizontal TN averages fluctuated between 211.68 µg-at.l^{-1} in the surface of Region B in July and 418.30 µg-at.l^{-1} in the surface of Region A in November. The horizontal distribution of TN average values in the three regions showed that Region A amounted the maximum values and Region B the minimum values during most of study period. Hemeda (1996) found the same results for PN reconfirming that PN contributed a main portion of TN.

The distribution pattern of TN in the eastern and western lake sides showed some irregularities; higher values were found in the eastern side in some months and in the western side in the others (Figure 3). The eastern basin gave the minimum and maximum TN average values of 226.2 and 405.7 µg-at.l^{-1} in July and November, respectively. Based on the mean averages calculated during the study period, the TN content in the eastern side (326.9 ±54.17 µg-at.l^{-1}) was slightly lower than that in the western side (331.9±51.01 µg-at.l^{-1}). Generally speaking, the variations of TN content in the eastern and western lake sides were in correspondence to the variations in DON, PN and also dissolved inorganic nitrogen (DIN) contents of the two sides, reconfirming that the concentrations of these nitrogenous species were the main constituents of TN (Hemeda, 1996). The minimum (234.8 µg-at.l^{-1}) and maximum (403.5 µg-at.l^{-1}) TN monthly average values in July and November were accompanied with the lowest (243.6 and 270.0

µg-at.l^{-1}) and highest (434.6 and 425.3 µg-at.l^{-1}) TN values in Bats and Wady Drains in the same months, respectively, reflecting the great influence of drainage waters on the TN in the lake water.

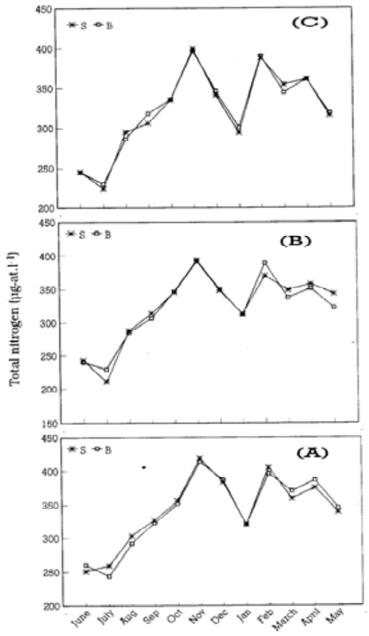

Figure 2: Monthly variations of the surface and bottom average values of total nitrogen (TN) in Regions A, B and C in lake Qarun.

Saad and Hemeda (2005) came to the same results and conclusion concerning the influence of drainage waters discharges on the levels of total dissolved nitrogen (TDN) in Lake Qarun. The relatively lower TN values observed in summer might be due to the increased uptake rate with the expecting increase in standing crop of phytoplankton in this season. As stated by Meybeck *et al.* (1988), primary production was responsible for the remarkable summer depletion of nutrients. Deposition of organic materials carrying nitrogenous compounds during stagnant conditions of the water column in summer is expected to be responsible for the decrease in TN content in the water column during this season (Fisher *et al.,*1988). On the other hand, Vegelia and Vaissiere (1984) stated that the water column in early autumn, from the beginning of the vertical mixing process and until the end of winter was enriched with nutrients.

During the study period, TN recorded an extremely high mean concentration of 329.6±23.2 µg-at.l^{-1}. Most of this nitrogen budget of the lake (90%) was in the dissolved form. PN formed an average of 10% of the TN. Of the dissolved forms, DON was the dominant species and constituted about 98 % of TDN in the lake water. However, DIN constituted 2% only of the TDN.

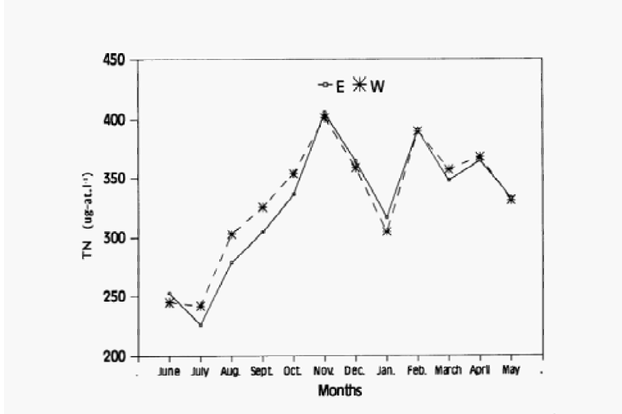

Figure 3: Monthly variations of the average values of total nitrogen (TN) in the Eastern (E) and Western (W) sides in Lake Qarun.

In Lake Qarun, nitrate was the most abundant DIN species forming 75%, followed by nitrite 18 %, while ammonium constituted about 7%. (Hemeda, 1996). This author stated that the annual mean percentages of the different nitrogenous compounds (DIN, DON and PN): TN for Lake Qarun calculated during the period of study was 1.8, 88.5 and 9.7, respectively. These indicate clearly that DON was the main constituent of TN and DIN was the lowest one in the water of Lake Qarun.

The data of TN, as a dependant variable, were statistically treated against the different parameters affecting its distribution (environmental parameters and nitrogenous forms). The following equations of multiple regressions were obtained, using data from Hemeda (1996):

(1) *TN* = - 390.148 + 11.809 *Cl‰* (chlorinity) + 2.180 *POM* (particulate organic matter)

+1.475 *TSM* (total suspended matter) + 51.389 *pH* (r^2= 0.469, p< 0.001)

(2) *TN* = - 16.701 + 1.175 *TDN* (r = 0.93, p < 0.001)

(3) *TN* = 310.112+ 3.1637 *DIN* (r = 0.40, p < 0.001)

(4) *TN* = -5.835 + 1.156 *DON* (r = 0.93, p < 0.001)

(5) *TN* = 221.7 + 2.978 *PN* (r = 0.69, p < 0.001)

Total phosphorus (TP)

The trend of TP vertical distribution followed the same pattern of the different phosphorus species; the higher values were obtained from the surface rather than from the bottom water layers at most stations during majority of study months (Hemeda, 1996). These high values originated in the main from the brackish land drainage effluents floating over the denser lake water. The horizontal variations of the average values of TP fluctuated between 1.25µg-at.l^{-1} in the bottom of Region B in December and 12.76 µg-at.l^{-1} in the surface of Region A in August (Figure 4). The higher TP average concentrations were obtained in the surface water layer in majority of months in Region A, which was directly affected by the drainage water discharges than Region B and C. The indirect association between TP and Clorinity ‰ (r= -0.17, p< 0.05) is supporting this evidence. The average values showed generally an irregular distribution pattern in the lake middle (Region B), far from the direct influence of drainage water discharges. The TP fluctuations in the surface water of this region coincided with variations in reactive phosphorus uptake by phytoplankton, excretion of dissolved organic phosphorus (DOP) and the amount of particulate phosphorus (PP), whereas the bottom water fluctuations are related mostly to the amount of TSM and consequently the variations in adsorption and desorption processes influenced by the prevailing environmental conditions. These assumptions can be confirmed from the high significant positive correlations between TP and dissolved inorganic phosphorus (DIP) ($r = 0.88$, $p < 0.001$), DOP ($r = 0.93$, $p < 0.001$), PP ($r = 0.78$, $p < 0.001$) and TSM ($r = 0.40$, $p < 0.01$), as pointed out by Hemeda (1996). In the northern lake area (Region C), however, the higher TP content observed in the surface water layer was in accordance with the air borne dust particles blowing from the northern desert and containing phosphate, as well as phosphate excretion by surface inhabiting organisms. The horizontal distribution of TP in majority of months showed maximum content in the southern area (Region A) and minimum in the northern area (Region C), as shown in Figure 4.

The eastern lake side harbored noticeably higher TP average values than the western side (Figure 5), giving overall means of 6.77±2.43 and 5.01±2.75 µg-at.l^{-1} for the two sides, respectively. These average values fluctuated between 1.94 µg-at.l^{-1} in the western side in March and 11.52 µg-at.l^{-1} in the eastern side in August. The highest regional TP averages were obtained at stations I and VI, situated in the vicinity of Bats and Wady Drains, while the minimum was found at station XII, located in the northern area of the western side far away from the direct effect of drainage water discharges. TP was subjected to monthly variations, giving lowest and highest averages of 2.72 and 11.09 µg-at.l^{-1} in December and August, respectively. Such increase in TP content is due mainly to the corresponding increase in dissolved inorganic and organic phosphorus forms, which might be originated from decomposition of the organic matter accumulated in considerable amounts in summer. The strong direct relationship between TP and water temperature ($r= 0.50$, $p< 0.001$) and POM ($r=0.42$, $p<0.01$), as pointed out by Hemedan (1996), are justifying the present assumption. The lowest monthly average TP value in December reflects the lowest DIP, DOP, total dissolved phosphorus (TDP) and PP monthly averages in the same month (Hemeda, 1996)).A stepwise regression model is in support to this assumption:

(1) *TP* = - 3.700 + 0.269 *Wt* (water temperature) + 0.059 *TSM* + 0.067 *POM* - 0.012 *SD* (transparency) (r^2=0.403, $p< 0.001$)

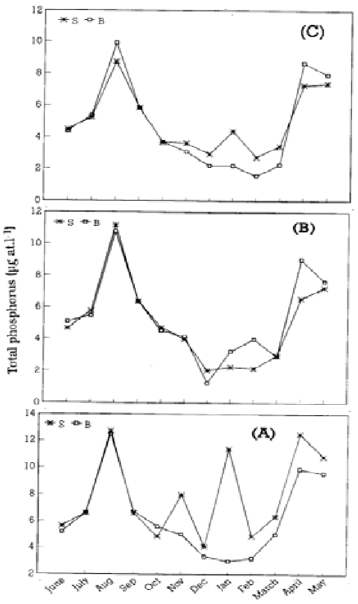

Figure 4: Monthly variations of the surface and bottom average values of totalphosphorus (TP) in Regions A, B and C in lake Qarun.

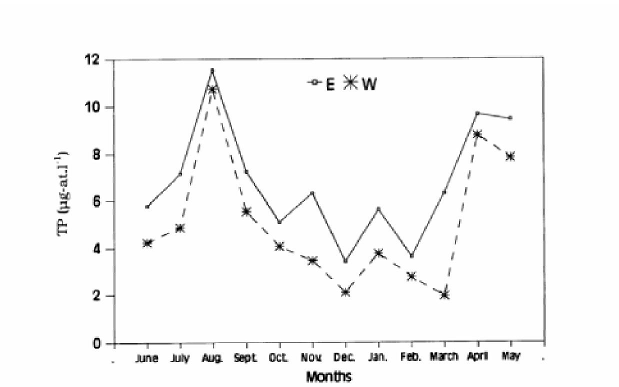

Figure 5: Monthly variations of the average values of total phosphorus (TP) in the Eastern (E) and Western (W) sides in lake Qarun.

Lake Qarun sustained relatively higher TP content, giving an overall mean of 5.82±1.75 µg-at.l^{-1}. Most of this phosphorus budget (72.2%) was found in the dissolved form. PP formed an average of 27.7% of the TP. Of the dissolved form, DOP was the more abundant and constituted about 64.5 % of TDP in the lake water. However, DIP constituted about 35.5 % of the TDP (based on annual mean concentrations), as pointed out by Hemeda (1996).

The TP data were statistically treated against phosphorus species, giving the following regression equations and correlations:

(1) *TP* = 0.3813 + 3.6854 *DIP* ($r = 0.88$, $p < 0.001$)

(2) *TP* = 0.4600 + 1.9735 *DOP* ($r = 0.93$, $p < 0.001$)

(3) $TP = 1.9215 + 2.4167\ pp$ (r = 0.78, p< 0.001)

Bierhuizen and Prepas (1985) found that the ratios of TN:TP in 20 saline lakes in south eastern Alberta varied from 0.5:1 to 68:1. Also, in another three Alberta saline lakes, the TN:TP ratios were low, ranging from 0.9:1 to 1.7:1 (Compbell and Prepas, 1986). These authors attributed the lower ratios of TN:TP in the Alberta saline lakes to the extremely high levels of both TP and TN, since these compounds were not effectively utilized by the algal communities in these saline environments. However, the TN: TP ratios in Lake Qarun water gave a high mean of 87.1:1, reflecting the considerable high concentrations of TN accompanied with ordinary TP concentrations. This high mean ratio might indicate that considerable concentrations of TN were not effectively utilized by the algal communities and thus were accumulated in the different lake compartments.

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Sediment management of Sukhna Lake by social fencing

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Abstract

Sukhna Lake was artificially created in Chandigarh (Punjab) primarily for recreation. Due to denudation of hills in the catchment the lake started silting up at an alarming rate and within a period of 15 years only it lost about 60% of its storage capacity. During summers, many small shoals would appear and create hindrance to boating activities. Subsequently three small earthen dams were constructed for controlling sediment from the gullies. These made a total of 8.33 hectare-metre of storage available which could be used for enhancing agricultural productivity. A novel people-oriented management programme was devised. In India water rights are appendix to land, but in this case water was first allocated to 'people' and only secondarily to 'land.' Under this management, called 'haqbandi' (arrangement based on right), every family, irrespective of land owning and crops grown, had equal share of water. A coupon system was introduced to get water. The coupon could be traded or sold if the family failed to use water of its share. This helped in creating stake for everybody in the project. 'Water Users Association,' subsequently renamed as 'Hill Resource Management Society,' was constituted and each family living in the command has a member on it. It was made mandatory for the villagers not to graze their animals in the hilly watershed and not to indulge in illicit cutting of vegetation. This is what is called 'social fencing.' This proved highly effective and helpful in soil conservation and reduced sediment inflow to Sukhna Lake significantly. The model is recommended for adoption in other such cases

Key words: lake, management, sedimentation

Introduction

The man made Sukhna Lake was created in Late 1950s primarily for recreation. Its catchment lies in Shivalik hills of Northern India, which have been worst affected by severe soil erosion. Ever increasing population pressure and consequent uncontrolled grazing accelerated the processes of deforestation and denudation of the hills. As a result the sediment inflow increased and the lake started silting up at alarming rate. During summers may shoals would appear in the lake bed and would create serious hindrance to boating activities. Dry dredging and desilting of the lake were tried, but they proved to be recurring affairs and highly expensive. Earlier a number of Acts were legislated prohibiting grazing and tree felling in the hills, but they would not be effective due to socio-economic reasons. There are six main gully heads in the catchment of the lake which are the problematic areas from sedimentation point of view. Out of these the worst area is located near village Sukhomajri from where starts the Kansai choe (stream) which is main tributary of the Sukhna choe (Figure 1). The elevation of the area is 50 to 620 metres (m) above mean sea level. The average annual rainfall is 1,137 millimetres (mm) out of which 792 mm occurs in monsoon months (June to September). Rainfall of long duration and high intensity is rather a usual feature of the tract. Geologically the rocks are young, soft and loose. They are highly susceptible to erosion.

With a view to reducing sediment inflow to the lake, catchment area treatment was done and also three small earthen dams were constructed on the gullies draining to Kansai Choe. The reservoirs so created trapped sediment and also made a total of 8.33 hectare metres (ham) available which could be utilised for irrigating crops. It was though desirable that stakes should be created for all people in the project so that the chances of sabotage by the locals by reverting to the old practices inducing denudation of the hills were obviated. It was decided to distribute the available stored water among all the families of command on equal share basis irrespective of the fact of their being land owning or landless. This system is called 'haqbandi' (rule of right) and includes provision that the landless family can sell its share of water to others. Under the situation the villagers have voluntarily agreed not to graze their animals in the hilly areas and also not to indulge in illicit cutting of vegetation. This is what is called 'social fencing'. These measures have greatly helped by giving the twin advantages of reduction in sediment inflow to the lake and increase in agricultural productivity of the area.

Problem of sedimentation

The catchment of Sukhna Lake is more than 3,000 hectares. Once this region was covered with dense forest replete with wildlife. Due to deforestation caused by ever growing population and overgrazing by more and more cattle brought in by nomadic herdsmen the dense forest started giving way to boulders, deep gullies and chasms since the beginning of the last century. The catchment area is absolutely devoid of vegetative cover. The average cover is less than 5% in most parts of the hilly terrain. The soil is erodible, rainfall is high and ground slope is steep. The average slope of sub-watersheds, feeding the main stream is 30 to 40%. The slope of the main stream itself is 6%. The drainage density, on the average, is 9 kilometres per square kilometre of the catchment. The channels of the sub-watersheds, feeding the main channel, have slope of 20 to 30%. All these factors led to high rates of soil erosion and sediment inflow. The problem was so serious that even 4 to 6 centimetres (cm) of topsoil would sometime disappear with one heavy shower. Several agricultural fields were thus converted into 20m deep and as much wide gullies. Most of the monsoon rains ended in runoff and brought down with it huge quantity of sediment. Consequently, Sukhna Lake lost about 60% of its storage capacity within 15 years of its functioning. This created an alarming situation and called for urgent and effective remedial measures.

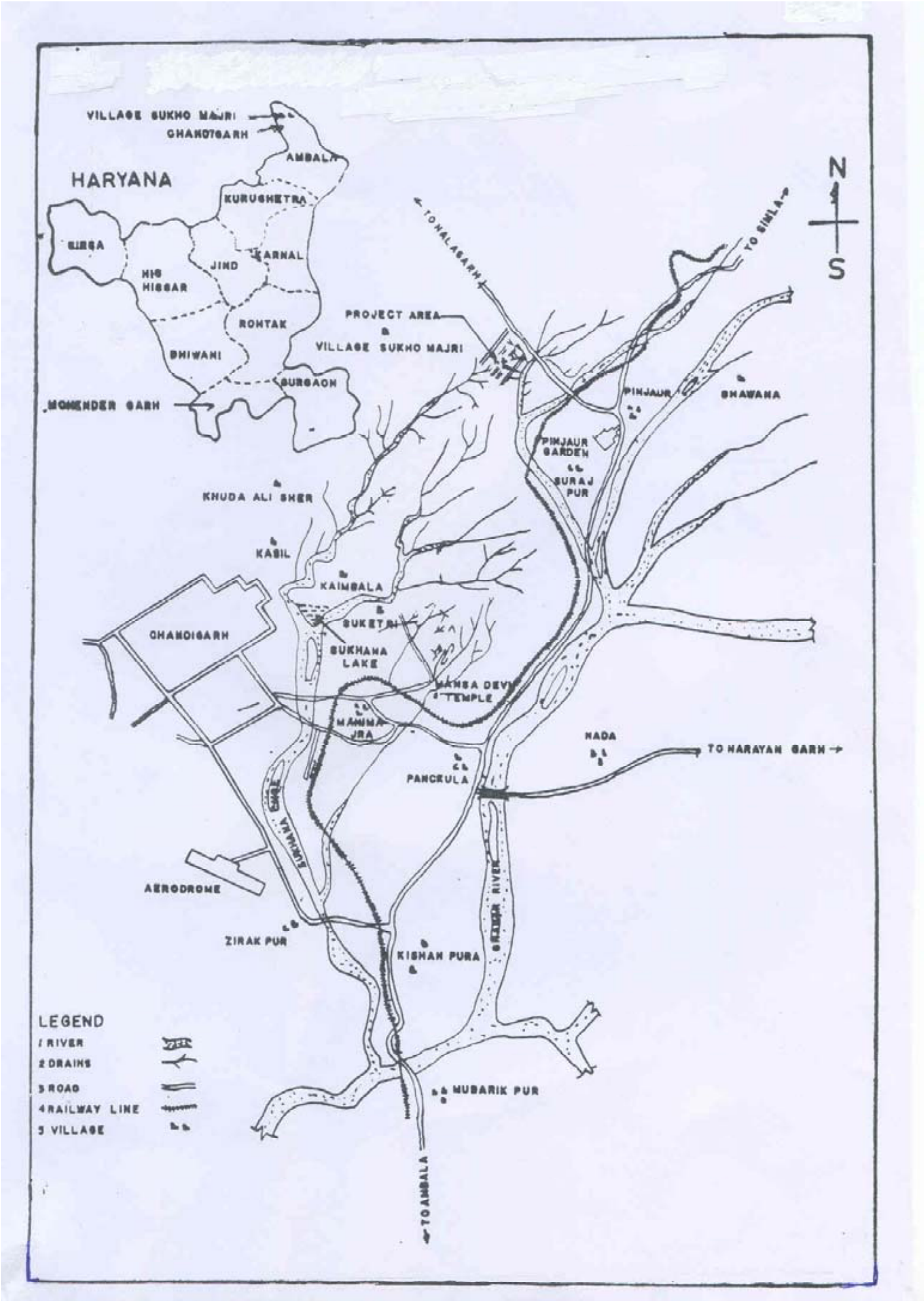

Figure 1: Location of the project area.

The erosion of soil is a double-edged weapon. It deprives the hilly people of their life giving and non-replenishable resource and simultaneously threatens the people of plains with unwanted sedimentation and flooding. Poverty in the hills is an endemic and multidimensional problem. Failure to prevent the loss of soil by erosion and inability to provide irrigation facilities in hilly areas are the two basic causes for this situation. Since soil erosion is a corollary to rainfall, it may be said that water alone is the root cause.

Needless to say that a two-pronged approach to solving the problem was necessary, and was implemented. Catchment area treatment along with water resources development and management provided much needed relief from sedimentation and low agricultural productivity.

Remedial measures

For effective control and management of sediment both agronomic and engineering measures were adopted. While doing so it was thought, until and unless the interest of the local people was strongly tied up with the hilly area, there was little scope for sustainable result. The possibility of storing rainwater and in the process reducing sediment inflow within permissible limits was explored. Further utilisation of stored water for irrigation was also considered and it was found feasible. With this immediate, direct and visible benefit the farmers could be motivated to protect the hilly areas. A development plan was accordingly chalked out.

After detailed survey and planning three earthen dams of 6.0m, 12.0m and 6.5m height were constructed at suitable sites at gully heads. Together they created storage of 8.33 ha. which could be used for irrigation for enhancing agricultural productivity. In this project of runoff harvesting and recycling it was important to conceive a system of vegetation that by and large induced more water while safeguarding against rapid siltation of the storage reservoirs. Accordingly maximum emphasis was given on raising grass rather than thick cover of trees and bushes (Figure 2). To stabilise bare slopes shallow contour trenches, 2.5m x 0.3m x 0.3m, were dug out and 'bhabhar' grass (Eulaliopsis Binata) was planted on their ridges as well as on other slopy areas where construction of such trenches was not possible. Check dams were provided in the gully bottom to stabilize the gully and thereby to stop its widening and deepening. The area was completely protected against grazing and illicit cutting.

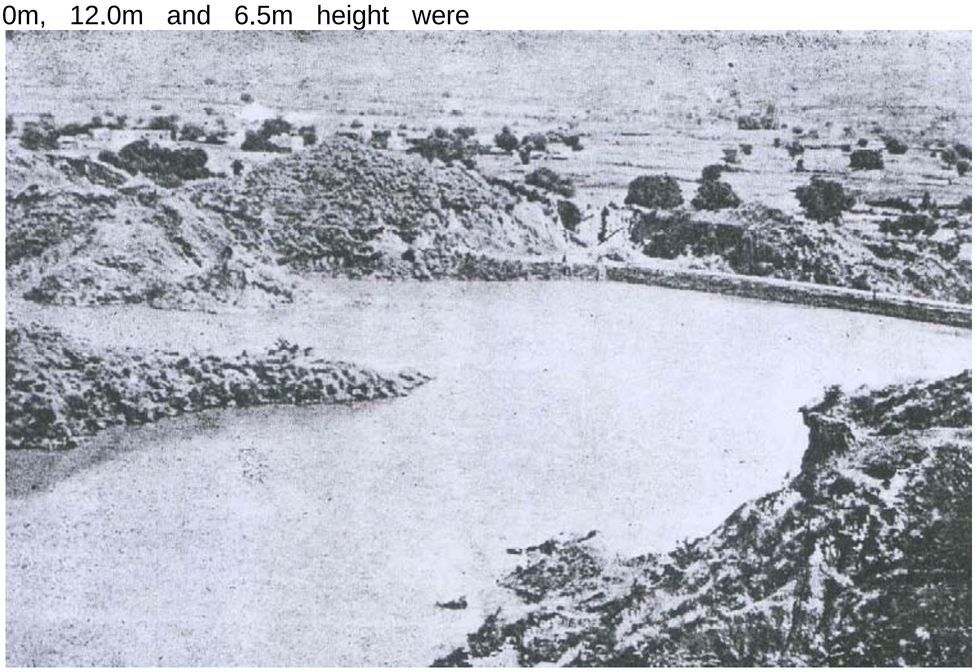

Figure 2: Site showing catchment, an earthen dam, reservoir and command area.

In order to minimise seepage loss and also to have better control over irrigation water in undulating fields the water conveyance system was constructed with 15cm diameter cast iron pipes laid under ground 0.8m to 0.9m below the surface. Suitable command area development including land levelling and grading was also carried out for which the cost was shared between them and the government on a 50:50 basis. Improved seeds and fertilisers were provided to the farmers on payment basis in the areas where irrigation water was made available. The total food grain production in the village went up from 450 quintals in 1975 to 1824 quintals in 1986 from the same area. The average net sediment inflow rate in the lake reduced from 141 to about 15 tonnes per year per hectare of the catchment. The economic viability of the project was found to be high with benefit cost ratio of 2.75:1.

Management by social fencing

A novel management strategy was formulated and adopted in this project for making the impressive result lasting and sustainable. This was meant to ensure people's involvement and participation. Initially a bargain was struck with the villagers to allow them to collect dead and dry wood and pruned branches for their domestic consumption rather than chopping the whole tree. They were also allowed to cut grass from the forest area for feeding their cattle but not to graze their animals in hilly watersheds and indulge in illicit cutting of vegetation. The villagers voluntarily and happily did so. This is what is called 'social fencing'.

Available stored water was used as a tool for further strengthening and consolidating the system. In India water right is appendix to land. Irrigation water in this country is traditionally allocated only to those who own agricultural land. Thos having more land automatically get more water and the landless remain totally deprived of it. In this project a departure was made from the traditional system and it was decided to allocate water first to 'people' and secondarily to 'land'. A new method was designed to ensure water right for every family including landless one living in the command. Under the system each family gets equal share of water and is given a coupon for fixed quantity of water to be drawn in a certain period. If any family is unable to utilize a part or whole of such water, it can sell it back to the society that manages the system at a fixed price or to any other family at a price mutually agreed upon. All such sales have to be decided before the sowing of a crop starts. This method has been named 'haqbandi' (rule of right) and has made every family a stakeholder in the project providing adequate incentive to safeguard and protect the project.

The project is managed and run by 'Water Users Society' subsequently renamed as 'Hill Resource Management Society'. Every family living in the command has a member in this society which looks after protection of hilly areas from grazing and illicit cutting of vegetation, distribution of irrigation water among its members and maintenance of dams as well as all appurtenant works (Figure 3). It has a board of directors including some specialists. The system has worked wonderfully well and fully deserves replication elsewhere.

Figure 3: Water Users Association deciding to distribute water equally amongst its member families.

Conclusion

Sedimentation of Sukhna Lake was taking place at an alarming rate. Desilting by mechanical and other means proved to be recurring and highly expensive affairs. Catchment area treatment was found effective. For its sustainability people's involvement and participation were ensured through social fencing. A novel method of water allocation (called haqbandi) was introduced which provided equal share to every family living in the command. This every family became stakeholder in the project and voluntarily worked for its protection and safeguard.

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What is the socio-economic value of the wetlands fisheries? The case of Yala Wetland in Kenya

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Abstract

Wetlands in most parts of the world are under threat of over-exploitation partly because their socio-economic value is not well known. Yala Wetland, the largest fresh-water wetland in Kenya, with a large part of it bordering Lake Victoria's shoreline, faces even greater threats of extinction. This wetland measures about 17,500 ha and is host to a number of indigenous fish species, animals and plants which are exploited by the local communities for subsistence and commercial purposes.There has been pressure to reclaim portions of this wetland for agricultural activity. So far, 2,300 ha has, indeed, been drained for commercial agriculture. Furthermore, it is difficult to control effort in the exploitation of the remaining wetland resources since the economically sustainable yields are undetermined.

This study was undertaken to close down the information gaps and generate relevant data for managing the wetland. Data for the study were collected in two phases, first a rapid appraisal exercise, then a monitoring program for 6 months in 2004-2005. Several variables were monitored during the study period, including; fish catch and composition, commercial yield of macrophytes, demand and price levels of wetland resources, levels of effort for exploiting wetland resources and other relevant ecological variables.

This paper presents the results of the study including, the composition and fish catch levels, the quantities of harvested and marketed macrophytes and other resources. Using these, the annual economic values of the Yala Wetland resources is determined. In addition the paper gives determinants of exploitation effort and the characteristics of wetland exploiters. The paper proposes management options under which the wetland can be managed.

Introduction

The Yala Swamp is located in Siaya and Busia districts in Kenya, with its western end bordering Lake Victoria. The swamp, which presently measures approximately 17,500 ha, is largely as a result of outflow of the Yala River. Three lakes add to the water mass in the Yala wetland, namely; Kanyaboli (10.5 square Km), Sare (5 square Km) and Namboyo (0.01 square Km). Yala Swamp is Kenya's largest fresh water wetland; it is one of several wetlands in the Lake Victoria basin, which include the wetlands of Nyando River, Sondu-Miriu River, River Nzoia and Kuja-Migori River.

A number of studies on the Yala Swamp since the 1950s have recommended that the swamp could be reclaimed and developed so as to establish a smallholder settlement scheme on the reclaimed swamp area, that would provide increased food and cash crop production (Gibb *et al.*, 1955; ILACO, 1975). This has been an issue of great controversy, particularly between the 'pro-development', mainly government officers who regard the swamp as a potentially rich agricultural ground, and the 'environmentalists', who see the swamp as an important ecosystem for various species of plants and animals (OSIENALA, 1998; Aloo, 2003). Some of these studies have further suggested that the reclaimed land could support commercial fish production in fish ponds, and in cages in running water channels, which they estimate could produce up to 60 MT of fish per year (JICA, 1987).

Despite those controversies, the first reported reclamation actually took place in one part of the swamp, commonly known as area 1, from the mid 1960s to early 1970s, in which 2,300 ha of swamp was drained, under a project sponsored by UNDP and FAO (Government of Kenya, 1987; OSIENALA, 1998). Reports, though, indicate that swamp reclamation resulted in ecological problems, such as lower water quality in Lake Kanyaboli, decreased species diversity and increased pressure on resources of the remaining wetland (OSIENALA, 1998). Investigations by Schuijt (2002) and Abila (1998) further indicated that the local community was the net loser from the reclamation; the benefits forgone from their use of wetlands far outweighed what they obtained in the new situation. Despite this, new proposals have been developed and feasibility studies conducted for further reclamation and development of parts of the remaining wetland (Government of Kenya, 1987; OSIENALA, 1998).

Improved commercial fish production was not one of the outputs of the first reclamation project, and has not been considered in any of the proposed future projects. In spite of the low priority given to enhanced fish production in Yala Swamp's development plans, fishing has been repeatedly rated among the most important income earning activities for the swamp community. Most reports have ranked fishing behind agriculture (cereals and horticulture crops production) and livestock keeping as leading sources of cash and for subsistence, while some (such as Abila's, 1998) considered fishing as the most important economic activity, with average incomes nearly four times that attainable in agriculture. Other economic activities in the swamp include hunting, tourism, fuel wood collection, brick making, papyrus exploitation, transport, salt lick supply and water supply for domestic use (Abila, 1998). In addition, fisheries is regarded as the highest supplier of animal protein in the area (Lihanda *et al.,* 2003).

Despite the importance of fish in nutrition, employment and as a source of income to the local communities, not much has been documented on the socio-economic aspects of the swamp fisheries. This is easily understandable considering that Lake Victoria, with its dominant commercial fisheries, is just adjacent to the Yala Swamp, which makes the swamp fisheries to be of comparatively insignificant commercial value. Thus, the main interests for managing the swamp fisheries seem to be for conservation, rather than commercial, goals. Admittedly, the swamp fisheries are important for biodiversity, but also have great socio-economic value to the local community, which need to be put in adequate perspective.

This paper investigates into the socio-economic aspects of the Yala swamp fisheries. It gives a profile of the wetland fishers and the distribution system for Yala Swamp fish. In addition, it assesses the status of the fisheries, using socio-economic approaches, to get an estimate of the yield and, using market prices, to determine value of the catches. Unlike other wetland products whose markets are underdeveloped, it is assumed that fish markets are sufficiently developed and the prices reflect the economic value. The catch and effort levels are estimated and cost of effort derived.

Sources of data for the report

This report has obtained data and information from both primary and secondary sources. The main source of primary data was a survey conducted in November 2003, in which fishermen of Lake Kanyaboli and Lake Sare were interviewed using questionnaires, key informant interviews and participatory methods. A total of 40 fishermen and other key informants, randomly selected in the two lakes, participated in that study. The primary information is complemented with data from relevant published and unpublished papers, technical reports on Yala Swamp and some historical data from KMFRI databases.

Review of literature

Yala Swamp fisheries and fishing activities

Fishing in the Yala Swamp is semi-commercial and takes place in lakes Kanyaboli and Sare, while hardly any fishing takes place in Lake Namboyo. The fish species composition in the Yala Swamp lakes is now well understood following studies by Okemwa (1981), Government of Kenya (1987), Opiyo (1991), Kaufman and Ochumba (1993), Aloo (2003), among others. These studies have revealed that the lakes' fisheries are dominated by cichlids, particularly *Oreochromis esculentus* in Lake Kanyaboli and *Oreochromis niloticus* in Lake Sare (Table 1). Okemwa's (1981) results, in particular, showed that *O. esculentus* composed about 65% of Lake Kanyaboli fisheries, while in Lake Sare, *O. niloticus* constituted nearly 60% of the catch. Kaufman and Ochumba (1993) reported that various species of haplochromines formed the second most important group of fishes in Lake Kanyaboli after the *Oreochromis* species.

Table 1: Percentage catch composition from experimental data.

Species	% catch composition from experimental data			
	Lake Sare		Lake Kanyaboli	
	(Okemwa, 1981)	(Government of Kenya, 1987)	(Okemwa, 1981)	(Government of Kenya, 1987)
Oreochromis esculentus	0	0	64.4	30
Oreochromis niloticus	58.6	31	24.7	30
Oreochromis variabilis	0.4	<1	0.5	6
Oreochromis leucostictus	9.6	20	0.2	<1
Tilapia zilli	0.1	<1	0.6	<1
Haplochromis spp.	16.2	30	8.6	30
Clarias mossambicus	0.4	<1	0.7	<1
Protopterus aethiopicus	7.5	18	0.2	1
Xenoclarias spp.	-	0	0.1	<1
Synodontis afrofischeri	6.3	7	0	0
Synodontis victoriae			0	0
Barbus spp.	0.2	<1	0	0
Gnathonemus spp.	0.7	<1	0	0

Adapted from Okemwa, 1981; Government of Kenya, 1987.

The main difference between the fisheries of the two lakes could, in fact, be attributed to Nile perch. It is known that Nile perch has already penetrated Lake Sare through a natural channel linking it to Lake Victoria. As a result, certain species, such as *O. esculentus*, which are very vulnerable to predation by Nile perch, are not found in significant quantities in Lake Sare. The same species are dominant in Lake Kanyaboli, which is still free of Nile perch (Government of Kenya, 1987: Opiyo, 1991; Aloo, 2003; Lihanda *et al.,* 2003).

Aloo (2003) and Opiyo (1991) explained that some of the fish species that disappeared from Lake Victoria occur abundantly in both lakes. The fishery of Lake Kanyaboli has particularly been of interest to conservationists, who see it as a replica of the situation in Lake Victoria before the introduction of Nile perch. In fact, some reports have called Lake

Kanyaboli a 'living field museum' of Lake Victoria (Government of Kenya, 1987; Mavuti, 1989; OSIENALA, 1998). The swamp lakes, therefore, are potentially important nursery grounds for many species of fish.

Okemwa (1981) reported that fishermen in lakes Kanyaboli and Sare mainly used canoes in shallow and deep water, in which the main gears were monofilament nylon gillnets, beach seines, purse seines and long lines. Some fishermen used fishing rods and operated in deep water which they accessed using papyrus stem rafts. The fisheries of Lake Sare, though, depended largely on seasonal rains, which stimulated the ascent of migrant fish from Lake Victoria. Fishermen took advantage of this migration and used traditional traps to catch fish on their ascent.

OSIENALA (1998) and Abila (1998) reported that most fishermen in Lake Kanyaboli used gillnets of between 1 and 2 inch mesh sizes. As evidence, most tilapia fish landed were below 25 cm long.

Previous estimates of fishing effort and fish values

Okemwa (1981) estimated the average catch of tilapia per canoe per day in Lake Kanyaboli to be 20 Kg for tilapia. Using this result, the commercial yield of tilapia in Lake Kanyaboli was estimated at 100 MT, and that of all fish in the lake at 250 MT in 1981. Other results obtained by Okemwa (1981) showed that the catch per net was higher in Lake Kanyaboli for the smaller mesh sizes (less than 4 inches), while the catch per net for mesh sizes above 4 inches were higher in Lake Sare than Lake Kanyaboli. Opiyo (1991) estimated the catch per canoe of *O. esculentus* in Lake Kanyaboli to be 26 Kg per day. OSIENALA (1998) indicated that gillnet fishermen in Lake Kanyaboli had an average of 3 nets per boat, but other effort statistics were not given.

Lihanda *et al.* (2003) revealed that there were about 130 fishermen in Lake Kanyaboli operating 56 fishing vessels, mostly of "sesse" type and a few dug out canoes, the main gear being hooks, gillnets and traps. The authors estimated that fishermen in Lake Kanyaboli landed about 21,807 kg (per month), valued at about 1,033,230. These estimates could be used to derive the average price for all fish species at about Ksh 47 per Kg. Furthermore, the authors estimated that the catch represented about 60% of the lake's capacity; indicating that with due care, the lake could yield up to 36 tonnes per month, and earn as much as Ksh 1.7 million.

Abila (1998) estimated the average income per day for each fisher at Ksh 143, and there were other income generating activities associated with fishing, such as net repairing (Ksh 100 per person per day) and making traditional fishing gear.

Results of socio-economic survey

The profile of Yala Swamp fishers

The typical fisher in Lake Kanyaboli and Lake Sare is a male adult, commonly in age range 25 – 45 years, although in recent years, there has been increased entry by people below 25 years. Most new fishers enter as crew with no gear, who fish for boat owners. (In the olden days, most fishers would be boat owners fishing in their own boats). It was estimated that there are about 3 new boats in the two lakes each year, indicating additional 6 fishermen. Women have little role in fishing. It was indicated that in some seasons, women do involve in a type of fishing called 'Kitenga', in which they scare and drive fish into set basket traps. This takes place in shallow waterways in the lake wetland.

Most fishermen in the lake have many direct dependants (Figure 1). The survey revealed that the number of people directly supported by each swamp fisher was in the modal range of 4 - 7, followed by the range 12 - 15. The mean number of direct dependants was 9.

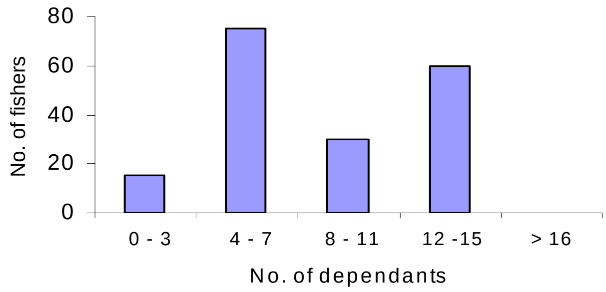

Figure 1: Dependence ratio on Yala Swamp fishers.

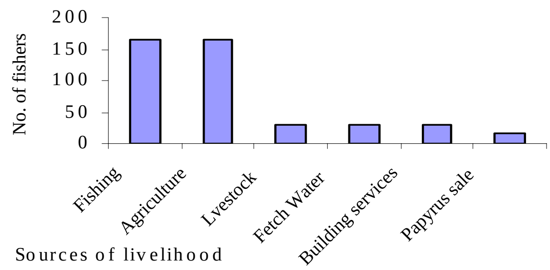

Figure 2: Fishers' main alternative sources of livelihood.

Fishing is the main source of livelihood for the swamp fishers, although agriculture has almost equal importance. The fishers also raise livestock (mainly cattle, goats and sheep) and provide various services, listed in Figure 2, for which they get additional income. To most fishers, fishing is the principle employment. However, when not fishing they engage in a number of activities, either for extra income or for recreation (Figure 3).

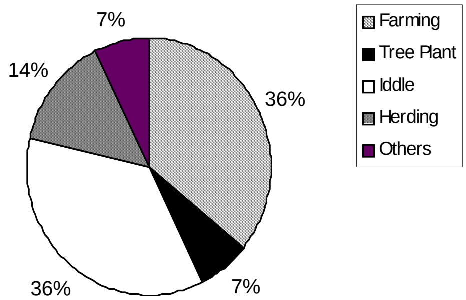

Figure 3. What fishers do in their spare time.

Main fish species targeted

\The survey revealed that fishermen of lakes Kanyaboli and Sare target mainly six groups of fish species, namely; *Protopterus aethiopicus* (mud fish, 'Kamongo'), *Clarias* spp*.* (Cat fish, 'Mumi') and three *Oreochromis niloticus* (*O. variabilis, O. esculentus, and O. niloticus*,) and the *Haplochromis* spp. ("Fulu"), the latter which is mainly targeted for bait. In Lake Sare, however, some fishermen also indicated that they often catch Nile perch, thought to drift into the lake from Lake Victoria. Results further indicate that the fishermen mostly prefer to target *P. aethiopicus, C. Gariepinus, O. esculentus* and *O. niloticus,* a decision that is probably based on the market value of each fish species, and their relative abundance (Figure 4).

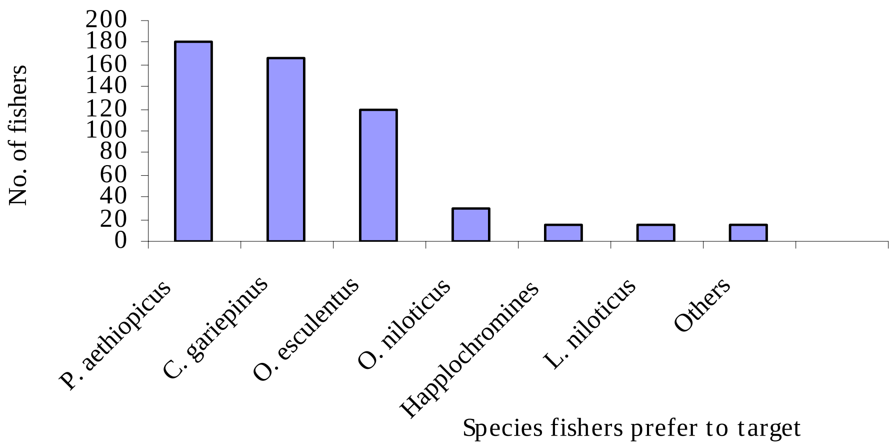

Figure 4: Fish species targeted.

The species type, their quantities, and average size caught depend on gear used, the season and location. For example, long lines with *Haplochromis* spp*.* baits are used to target *Clarias* spp*.* and *Protopterus* spp., while the various *Oreochromis* spp*.* are mainly caught using gillnets, most commonly of about 2 inches. As the lake water recedes during he drier months (for example, December – February), fishermen tend to get higher catches of *Protopterus* spp. and *Clarias* spp*.* These species usually tend to hide in the papyrus vegetation that surround the lakes, and are thought to come out in the open water when water level recedes, making them easier targets.

Up to very recently, a number of fishermen in Lake Kanyaboli used a kind of seine net, but the Fisheries Department confiscated most of these in August 2003. These seine nets indiscriminately scooped a lot of small size *Oreochromis* spp*.* ('dwela') and *Haplochromis spp*, and were regarded by the Fisheries Department, as well as the lake community, as an unsustainable and destructive fishing practice.

Markets for swamp fish

Fishing in the swamp has become largely commercialised. At least 93% of fishers sell a portion of their catch; the quantity taken home depends on the catch level, availability of buyers and the fisher's domestic need for fish.

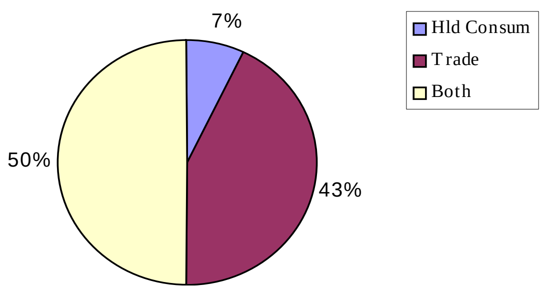

Figure 5: Use for fish.

On some days, like when a fisher has visitors in the household, more of the catch may be consumed at home. About 43% of fishers principally fish for trade and would ordinarily sell all the catch, while only 7%, mainly found in one beach in Lake Sare, admitted to completely fishing for subsistence (Figure 5). In overall, over 85% of respondents took home less than half of what they caught.

The first point of trade was at the immediate landing, where fishermen sold fish to consumers or buyers from outside markets (Table 2).

Table 2: Fish distribution pattern.

Market level	Location Fish seller	Fish seller	Fish buyer
1st level markets	Beach site	Fishermen	Local consumers, women traders, bicycle trader
2nd level markets	Nearby market centres e.g. Nyatworo and Harambee	Women traders	Consumers in neighbouring villlages
3rd level markets	Farther market centres e.g. Siaya, Boro, Ugunja, Hawinga, Mwer	Bicycle traders, women traders	Consumers in those centres

Source: Survey results.

There is a gathering place in the main landing centres, where traders and fishermen bargain until they reach an agreeable price. There is no weighing of fish in any of the landings, so prices are based on sizes and quality of fish as perceived by buyers and sellers, and the demand versus supply on a given day. Consumers from the neighbouring villages buy some of the fish, especially the very small sizes. Women traders also buy fish from the beaches and take to small market centres that they can reach on foot, for example, Nyatworo and Harambee. However, there are approximately 12 bicycle traders who come to the beaches and buy much of the fish, which they take to markets outside the swamp, for example, Siaya, Boro, Ugunja, Hawinga, and Mwer. Gang Beach on Lake Kanyaboli is particularly popular with the bicycle traders.

Estimation of fishing effort

This survey established that there were about 65 fishing boats in Lake Kanyaboli and 25 in Lake Sare, giving a total of about 90 boats in the two lakes. Each boat had an average of about 2 fishers; the estimated total number of fishermen was actually 195 for the two lakes. About 54% of all fishers fished for each day of the week, although the mean number of days fished per week was about 5.5. On average, fishermen would be expected to fish for about 70% of the possible number days in the year, which allows for any planned or unexpected disruptions. This gives a total fishing crew-days of 38,766 days in a year (Table 3).

Table 3. Estimated number of fishing crew-days.

Fishing days per week	Projected no. of fishers	Effort (Crew days)
1	0	0
2	0	0
3	60	180
4	0	0
5	30	150
6	0	0
7	105	735
Total no. of fishers	**195**	
Total fishing crew-days per week		**1065**
Total fishing crew-days per year (at 70% of total possible time)		**38,766**

Source: survey results.

The time spent on fishing by each fisherman was also obtained and projected for the entire lake (Table 4). According to the time ranges provided, most fishermen in the two lakes carried out each fishing operation for 4-7 hours. This included the entire period spent by fishermen in the water, for setting the gear, in case of passive gears, inspecting gear, for removing trapped fish and eventually, landing it.

Table 4. Fishing time (source: survey results).

Hours mostly spent per day	Projected no. of fishers	Fishing hours per day
0-3	0	0
4-7	107	589
8-11	0	0
12 –15	88	1188
≥16	0	0
Total no. of fishers	195	
Total no. of fishing hours per day		**1,777**
Total no. of fishing hours per day at 70% probability of fishing		**1,244**

In Lake Kanyaboli, some fishermen occasionally stayed for 12-15 hours in the water, especially as a result of blockages by floating 'islands'. The result of the number of fishing hours could, though, have large daily variations depending on the local situation and the fisherman's intentions. Fishermen spent a total of about 1,244 crew hours fishing in the two lakes each day.

There was a variation in the amount of fish caught by different boats. The least was an average of 2 Kg per day, while the highest reported a mean of 40 Kg per day. Table 5 gives the estimated mean catches per boat. The Figure s show that the modal catch rate was about 5-9 Kg per boat per day, while the mean was about 15.2 Kg per boat per day.

Based on these Figure s, the total catch of the two lakes per day was estimated as;

Mean catch per boat per day x No. of boats in both lakes x 70% probability that a boat goes fishing.

= 15.24 x 90 x 70% = 960 Kg

Based on above estimates, the annual catch for the two lakes is;

= 960 x 5.5/7 x 365 =275,314 Kg

Table 5. Estimated catch levels (source: survey results).

Kgs per boat per day	**No. of boats**	**Catch (Kg)**
0-4	14	28
5-9	21	147
10-14	14	168
15-19	7	119
20-24	14	308
25-29	14	378
$\geq$30	7	224
Total no. of boats	90	
Total catch		**1,372**
Total catch in the two lakes per day (at 70% probability of boat fishing)		**960**
Mean catch per boat per day		**15.2**
Total annual catch (at 70% probability)		275,314

Valuation of swamp fisheries

To obtain unit fish prices, actual weights of the units which fishermen usually use for selling fish, and the related prices, were determined. This involved taking samples of each unit of fish and weighing it, then recording the actual price of fish in that unit on the day of survey, and adjusting it to take account of the 'usual price range' as perceived by fishers.

This Survey estimated an average price of all fish species in the two lakes at about Ksh 40 per Kg. There was, though variation in prices between landing sites and species (and obviously, on different days and seasons). The highly priced species such as *Protopterus aethiopicus* and *Clarias* spp. fetched an average of about Ksh 50 per Kg, while the small sized *Oreochromis* spp. was sold at about Ksh 35 per Kg. Using the mean price above, a swamp fishing boat, on average, could receive;

= 15.2 x 40 = Ksh 608.

In line with the existing remuneration system, 50% of this amount would go to the boat owner, while the crew would share out the other half. (In a few of the beaches, there was a different remuneration system where boat expenses were subtracted and the balance shared out between boat owner, taking 40%, and crew, 60%). Thus, a boat and gear owner expected to receive about Ksh 300 daily, and crew, Ksh 150 each, if all fish were sold out. This gives an average income per person (one boat owner and 2 crew for each boat) of Ksh 200. Since some fish went for subsistence, the actual amount received in hand by boat owners and crew would be less than these Figure s.

To countercheck the validity of this Figure , fishermen were directly asked to state, in confidence, how much they normally expected to receive in a day. The stated Figure s had a mean of 187 (usually fishermen are more likely to state a lower income if asked directly). Hence the average income level of Ksh 200 per person as derived above may be within acceptable range.

With the above Figure s, it is possible to derive an overall annual value for the fisheries of the two swamp lakes. The fish market price at landing is taken to represent the value of the traded fish as well as the economic value of the fish for subsistence. Hence, value of annual fish yield is derived as;

$\sum$ (traded fish + subsistence fish) x mean price of traded fish

= 275,314 x 40

= 11,012,560

Thus, the total annual fish yield from Lake Kanyaboli and Lake Sare is about Ksh 11 million.

The average returns per boat, therefore;

= 11,012,560 / 90 = Ksh 122,362

Cost of fishing effort

The main effort components are the fishing boat, its components and gear, as well the fishing labour, all represented in Table 5. The wage rates have been used to represent the cost of labour, while the depreciation cost of boats, estimated using the straight-line method, represents the annual cost. A new canoe costs about Ksh 15,000, and has a life span of about 5 years, giving an annual cost of Ksh 5,000.

Most boats had 3 nets, each costing Ksh 700, giving a total cost of Ksh 2,100 per boat at a time. A net had a lifetime of 3 months (a possible distortion is that fishers would go on using an old torn net for several more months, when its efficiency had greatly reduced). Assuming fishers would replace nets about 4 times a year, then the annual cost of gillnets per boat per year would be about Ksh 8,400. The other components such as oars (each Ksh 200, for three oars two times a year), plastic basin (each Ksh 50, for four per year) and plastic rainproof sheeting ("capera") costing Ksh 170 two times a year.

The long line fishing boat had all the above components, except gillnet, but instead had lines and hooks. On average long line fishermen had 200 hooks, each costing approximately Ksh 3, replaceable four times a year, thus an overall annual cost of Ksh 2,400. The line thread capable of supporting 200 hooks costs Ksh 250 and would be replaced about thrice a year, giving a total annual cost of 750. Labour constitutes the greatest cost in fishing. The wage rate per boat per year, calculated at about Ksh 300 (for 2 crew per day), is about 60,225 (at 70% boat operation days a year and 5.5 days a week). The costs of fishing effort are estimated in Table 6 for both gillnet and long line fisheries.

Table 6. Estimated cost of effort (source: survey results).

Effort item	Total cost per year per gillnet boat	Total cost per year for per long line boat
Boat	5,000	5,000
Nets	8,400	
Long line thread		750
Hooks		2,400
Other components (e.g. oars, 'capera')	1,740	1,740
Fishing labour (wages)	60,225	60,225
Estimated total cost of effort per boat per year	**75,365**	**70,115**

Conclusion and recommendation

Besides giving a socio-economic assessment of the fisheries of the Yala swamp fisheries, this report has attempted to estimate the catch effort level, effort costs and value of the fisheries of Lake Kanyaboli and Lake Sare, using mainly socio-economic valuation approaches. In the situation of complete lack of statistics, other established methods of estimating catch could be attempted, and probably may provide varying results. The results presented here should, therefore, not be seen in the context of providing absolute Figure s, but as a basis for comparing and validating results obtained from other biological estimation methods.

Results show that the two fisheries are of immense economic value, as demonstrated by the actual and potential incomes established in this report for annual yields. There are additional socio-economic values obtained from the fisheries. It is, therefore, important that management of the swamp lakes be given priority in the plans to develop the Yala Swamp. There is also need for long time monitoring of swamp fisheries, and to determine the stocks sizes of the important fish species in the two lakes.

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Seasonal variability of nutrients supply into Pulicat Lake, east coast of India: Implications for economic health

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Abstract

Pulicat lake, one of the largest salt water lakes in India, is situated between 13° 22' 04" – 13° 22' 04" N and 80° 02' 00" – 80° 20' 00"E. The lake has a spread of 400 sq. miles with an average depth of 4 m and connected to the Bay of Bengal at the southern top by a small inlet of width of about 1 km. A detailed study of the nutrients supply have revealed that the Northern and Channel parts differ considerably in the way that nutrients are supplied and regenerated. The Channel part is rather closer to the influence of the Bay current and is affected both by upwelling at the shelf-break, and by the advection of warm, nutrient-poor surface water from perturbations along the land ward edge of the current. This leads to the establishment of two layer system for much of the year, with the thermo clines intensifying during the summer. The Northern part in contrast, is more away from the upwelling region of the Bay. Here deep mixing during monsoon is favored by the fresh water inflow, wind stress and thermo cline formation during the summer is less intense. Bottom water supply appears to be from the Bay rather than the fresh water inflow from the land and localized patches or oxygen – depleted waters are formed as a result of lowered advection. The variability in source waters and the forcing fields over the two regions of the Lake leads to differences in the nutrient concentrations in the surface waters. These in turn, affect the productivity of the region and the attendant biodiversity in general and fish stocks in specific. This paper attempts to delineate the nutrient abundant zones and nutrient-depleted zones in the Lake settings.

Key words: Recent foraminifera, Lake environment, Ecology, Diversity and density

Introduction

Knowledge of the ecology of recent benthic foraminifera has application both in modern and past environmental studies. Lagoonal environments are often the most polluted marine habitats. Foraminiferal studies provide the potential for a quick, cost effective method of assessing the impact of pollution on the biota, for monitoring change and for comparing the modern fauna with that of the unpolluted recent past. Study of foraminiferal distribution patterns also provides an efficient method of investigating water circulation patterns in lagoons and enclosed harbors and the interplay between the sea and freshwater inflow.

An understanding of modern foraminiferal distribution patterns can be used in interpreting fossil foraminiferal faunas and allow us to make relatively accurate assessments of paleosalinity and paleo environments. Fossil benthic foraminiferal faunas are of special relevance to modern methods of determining rates of Quaternary uplift, changes in sea levels and climate (Bhalla, 1968; Reddy, 1973; Reddy and Reddy, 1983; Nigam and Aradhana Rao, 1987; Hayward and Hollis, 1994). Now the present study shows that, it is possible to recognize a foraminiferal species / assemblage characteristics of brackish environment. Recognition of this assemblage in quaternary sediments provides an assessment of former sea levels and evolution of the lake itself.

The Lake Pulicat: its general setting

As an example we are using benthic foraminiferal affinity with ecological controls from Pulicat Lake (Figure 1), which represents an approximately 110 km long and 45 km wide. The lake is marked by steeply rising ridges, having a height of about 17 m from the mean sea level (MSL) and composed of quartzites of Cuddapah group (Proterozoic Era). The steep and plain topography may be due to the great difference in age between the Archeans of the plain country and the Proterozoic of the high lands and also due to the greater resistance for erosion offered by quartzites compared to gneisses. The important ephemeral rivers that join the lake include Arani, Kalangi and Rayalavagu (Figure 1). Enormous quantities of fresh water influx along with sediment load are discharged into the study area during monsoon. The Pulicat lake is a particularly attractive small marine basin for studying the interaction between hydrography and the underlying sediment cover because of its proximity to the Bay of Bengal, its wide water depth range, its hydrography and its apparently homogenous fine grained modern sediment cover.

Material and methods

Foraminiferal samples

A total of 30 surface sediment samples were retrieved using hand – hauled dredge for four seasons each viz., premonsoon (August, 1996), monsoon (November, 1996), post monsoon (February, 1997) and summer (May, 1997). The sampling was done starting from the evening on 6th day of the month and continued till the morning of 8th day of the month. Sampling stations were located mainly in the central part of the lake by fixing at least two permanent land marks (Figure 1).

Immediately after collection, a 200 ml sediment sample from the upper 1-2 cm of the sample was preserved in ethanol with Rose Bengal stain (1 g/l). Assuming that water content of the sediments was approximately 50%, the alcohol concentration was diluted to about 60-70%. Most of the samples were stained for four weeks, with a maximum of two months for some (Hald and Korsun, 1997).

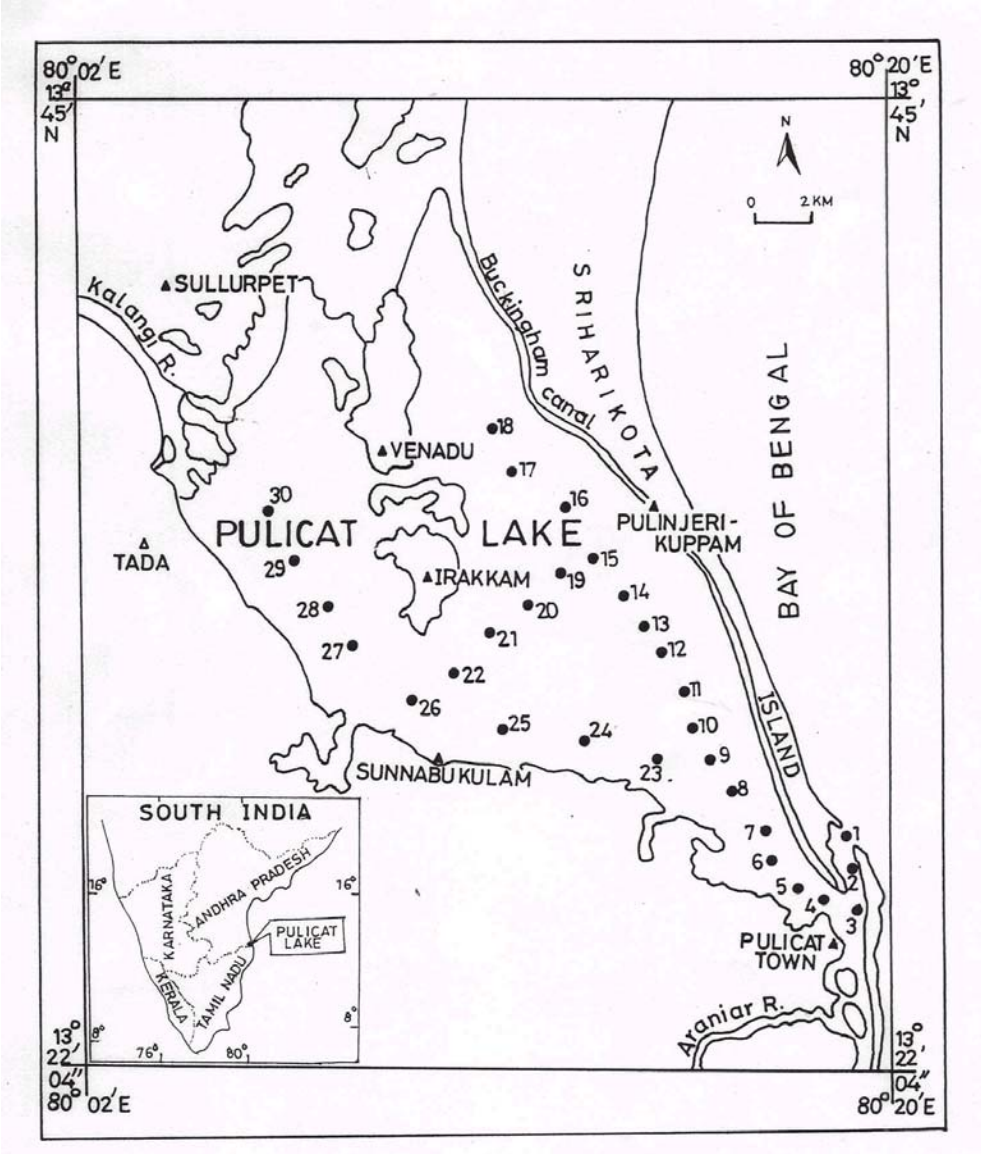

Figure 1: The study area and sampling stations.

Each sediment sample was subsequently dried and weighed. After soaking in water, samples were washed in a solution of water and sodium pyrophosphate through sieves with much openings of 1.0 mm and 0.1 mm. The residue on the 0.1 mm mesh was dried and foraminifera were concentrated by floating in carbon tetrachloride / bromoform (Meldgaard and Knudsen, 1979). A counting plate with vertical and horizontal rulers living a checker – board pattern was used for microscopic examination. To obtain more accuracy in the faunal data each processed sample was splitted into fraction containing around 300 foraminiferal specimens. And all the foraminiferal specimens from the entire split sample was counted. Only samples with undisturbed sediment surface, denoted by a high water content and a brownish oxidized surface, were used for analysis. Live macrobenthos such as sponges, worms and starfish were occasionally found on the sediment surface.

The sampling procedures, especially sieving and drying, reduce the number of the most fragile arenaceous foraminifera. However, they are not directly comparable to studies using the > 63 μ fraction, which is used commonly in investigations (Hayward and Hollis, 1994).

The present study attempts for total crop, that is dead plus live (stained) individuals of the benthic foraminifera. Both living and total faunas are good indicators of modern conditions (Murray, 1991).

Ecological variables

Bottom water parameters viz., salinity, dissolved oxygen and organic matter, were measured in the field itself by using Elico water Analysis kit. Sounding pole was used to measure the depth of the lake. Water depth is rather erratic due to fresh water inflow from rivers into the lake. Water depth was negatively correlated to salinity and temperature. Although no direct measurements of turbidity was made in the water column, on-site observations during sediment sampling typically showed highly turbid water and very soft sediments in the central part (stations 10-25) of the lake.

Foraminiferal species distribution

Cushman (1959) considered the foraminiferal fauna of the Bay of Bengal to be typically a warm water assemblage represented by an admixture of East African and Indo -Pacific fauna. According to Bhalla (1968) the mixed nature of the fauna of the Bay of Bengal was due to the entry of East African fauna during South-West monsoon and the entry of Indo-Pacific fauna during North-East monsoon.

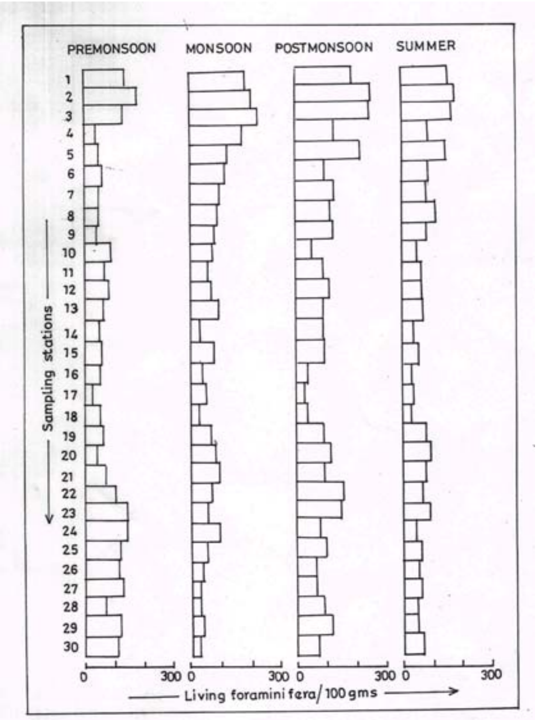

Figure 2: Living foraminifera 100gms against sampling stations for four seasons.

We have recognized 50 species, out of which 38 species have already been reported by earlier workers from Indian waters (Reddy, 1973; Reddy *et al.,* 1983; Jayaraju and Reddi, 1995). The remaining 12 species reported by the authors for the first time from the Bay of Bengal region include : *Criboelphidium sp, Elphidium discoidale, E. milletti, E. sp, Flintina sp, Haueriana fragillissima, Quinqueloculina hadai Q. inca, Sigmoidella pacifica, Trochammina sp., T. inflate and Weisnerella auriculata.* Of these, only *Haueriana fragillissima* and *Sigmoidella pacifica* have not been represented in living condition in all the four seasons. These might have lived in the lake in the recent past and in part dead tests transported into the lake from the Bay of Bengal through channel part (Stations 1-9).

Foraminifera found in all the samples collected during all the four seasons (Figure 2). The number of total populations was generally higher near the Bay in the channel part (Stations 1-9). This trend was noticed in all the four seasons (Figure 2).

A similar pattern was observed for living crop. The highest mean ($\bar{\times}$) is 385 at station 30 in Kalangi estuary with CV as 12%. There is no much significant difference in variability for all the four seasons with CV ranging from 41-46%. The dominant genera were represented by *Ammonia, Elphididum, Quinqueloculina* and *Trochammina*. Among these, *Ammonia beccarii* and *A. tepida* occurred in all the sampling stations in all the four seasons. Other significant species include: *Quinqueloculina agglutinans, Elphidium hispidulum, E. excavatum Quinqueloculina seminulum* and *Trochammina* sp. Certain species, viz., *Asterorotalia dentate, Cibicides lobatulus, Cribroelphidium* sp. *Elphidium crispum, E. incertum, Haphophragmoides* sp, *Quinqueloculina parkeri, Spiroloculina communis* and *Triloculina tricarinata* which occurred abundantly in only channel part (stations 1-9) and were totally absent in other parts of the lake.

Live and dead ratio

It is a matter of observation that living and dead assemblages from the same sediment sample are commonly different to a greater or lesser extent. There is nothing surprising in this for the living assemblage represents only the time of sampling whereas the dead assemblage represents many generations added over a long period of time (Murray, 1984). It has been demonstrated that standing crop of living assemblage through life processes and postmortem changes become dead assemblages (Murray, 1976). The same dead material is known to take place by various transporting agencies predominantly by water. The main difference between live and dead associations are due to the combined effects of a slow sedimentation rate and a period of rising sea level leading to mixing of faunal assemblages aided by bioturbation (Murray, 1979). In the present study, premonsoon recorded high L/D ratios (21-55% stations, 23-30), with other stations (10-21%) summer recorded a very low (6-8% stations 27-30) L/D ratios (Figure 3).

The lake recorded relatively meager number of living crop and high values for dead fauna. This is due to the transport of dead tests from the Bay of Bengal into the lake during high tides. It is also possible that the lake receives substantial quantities of brine spring waters, which contain little dissolved oxygen and more anaerobic bacterial that reduce sulphate to sulphide (Reddy, et al., 1983). Under such conditions, it is not conducive for benthic foraminifera to live and survive in the lake. They very low L/D ratios (4.3 – 54.7% with an average of 8.2%) obtained in the Pulicat Lake to that of the Pennar River estuary (10-100% with an average of 26%, Reddy, 1973) and Araniar River estuary (0-92.3% with an average of 12.12%, Reddy et al., 1983) may also be accounted by considering most of the dead tests to represent sub-fossils.

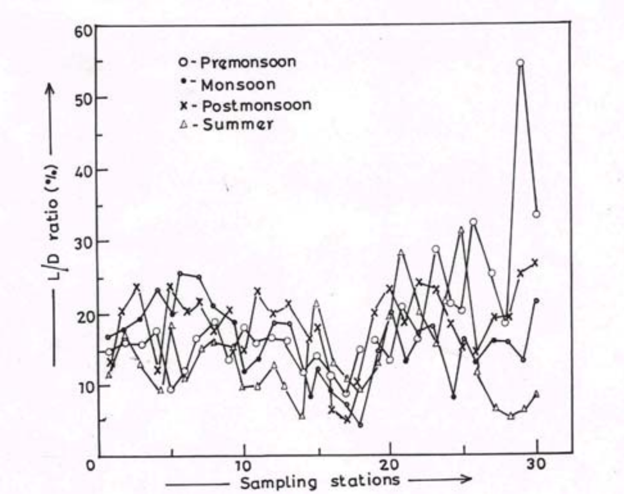

Figure 3: Sampling stations vs L/D ratios for four seasons.

From the on-site observation of the substrate of the lake is composed of subfossils of marine invertebrates like molluscs in abundance with no living representatives at present. It may be inferred that the lake was once part of the sea and had an environment favourable for the growth of those macro-organisms (Raman et al., 1975). It is possible, when conditions are conducive for to flourish of macro-organisms, foraminifera will also flourished in large scale.

Relationship between Foraminifera and ecological controls

The ecology of Pulicat Lake is influenced by the environmental variables viz., tropical subhumid climate, its connection with the Bay of Bengal bringing considerable freshwater influx and brine waters from surroundings (Doraswamy Naidu et al., 1976). Computations for correlation co-efficients between water parameters and living fauna were calculated on TDC 316 Computer at the Computer Centre, National Institute of Oceanography, Goa.

The level of significance was determined (Fisher and Yates, 1964). After computation, the relationship of depth, water temperature and pH with living crop were found insignificant as their correlation co-efficient values were found well below the significance value (0.36) and hence the above parameters were not considered for discussion. The correlation co-efficient values for dissolved oxygen (γ = 0.19, γ = 14) organic matter (γ = 14, γ = 18) and salinity (γ = -0.17, γ = -0.62) in pre-monsoon and post-monsoon respectively, are well below the significant level, hence, the relationship of living foraminifera with above parameters is insignificant except the salinity (γ = -0.62) which shows inverse relationship in post monsoon (Figure 3). The co-efficient correlation values for dissolved oxygen and living foraminifera in monsoon (γ = 0.33) and in summer (γ = -0.26) are slightly below the significant level (0.36) at 95% confidence level. The scatter gram reveals a positive correlation in monsoon and negative relationship in summer (Figure 3). As the co-efficient correlation values are below the significance level inferring that dissolved oxygen may be an important factor controlling the growth and distribution of foraminifera in monsoon and summer.

The correlation co-efficient values for salinity and organic matter are found to be above the significance value. Hence these two parameters may be ecological controls of farminifera in the Pulicat lake.

Salinity versus living Foraminifera

The salinity regime in the coastal lagoons is strongly dependent on the entrance condition, rainfall and evaporation rates (Yassini and Jones, 1995). In the main body of the lagoon, where mixing occurs, the surface and bottom layers exhibit a similar salinity. During the extended periods of rainfall, fresh water run off and direct precipitation dilute the surface salinity to levels as low as 16.2%. Conversely, during drought periods, reduced stream flow and increased evaporation result in the salinity of the lagoons exceeding ocean salinity (Hadgson, 1979). In this study the correlation co-efficient values for living foraminifera with salinity in monsoon (γ = 0.43) and in summer (γ = -0.75 i.e., negative relationship) are above the significance level (Figure 3). It is demonstrated that salinity is the most important single factor that governs the distribution of foraminifera in both time and space (Murray, 1968; Nigam and Aradhana Rao, 1987; Jayaraju and Reddi, 1995; Rijik, 1995). In Pulicat Lake, salinity ranges from 16.2-39.0% during monsoon and from 35.2-52.5% during summer. The lower salinities (16.2% station 30) during monsoon are attributed to the supply of freshwater into the lake by the River Kalangi (Ellison and Nichols, 1970). During summer the lake water is mainly hypersaline and the highest (52.5%) is recorded at station 18. The variation in salinity in different parts of the lake may be due to the differences in the rate of evaporation (Reddy et al., 1983; Frey and Basan, 1985). The living foraminiferal assemblages range from 22-228 / 100 gms during monsoon and from 23-177 /100 gms in summer. The living foraminifera show a positive relationship with salinity in monsoon (Figure 4).

In this season, the living foraminiferal counts gradually decreases from channel part (station 1-9) towards the other parts of the lake and the number of reaches minimum (16.2%) near Kalangi estuary (stations 26-30) where the salinities are also at a minimum. This indicates that the fauna could not adjust to this sudden lowering of salinity levels (Goldstein et al., 1995). So their number has reduced showing low positive correlation. The minimal number of living microbiota in summer may be because of less inflow of fresh water or fresh ground water into the lake. It is possible that this lagoon receives substantial quantities of brine spring waters, which contains little dissolved oxygen and more anaerobic bacteria that reduce sulphate to sulphide (Doraswamy Naidu *et al.,* 1976). Under such adverse conditions, the benthic foraminifera record a meagre crop (L/D ratio 5.2%) as they can not adjust to this radical fluctuations in salinity levels, hence the negative correlation (γ = -0.75). From the study, it appears that the fauna of the lake neither adjusted to extremely high values (54.7%) of salinity in summer nor low values (16.2%) in monsoon.

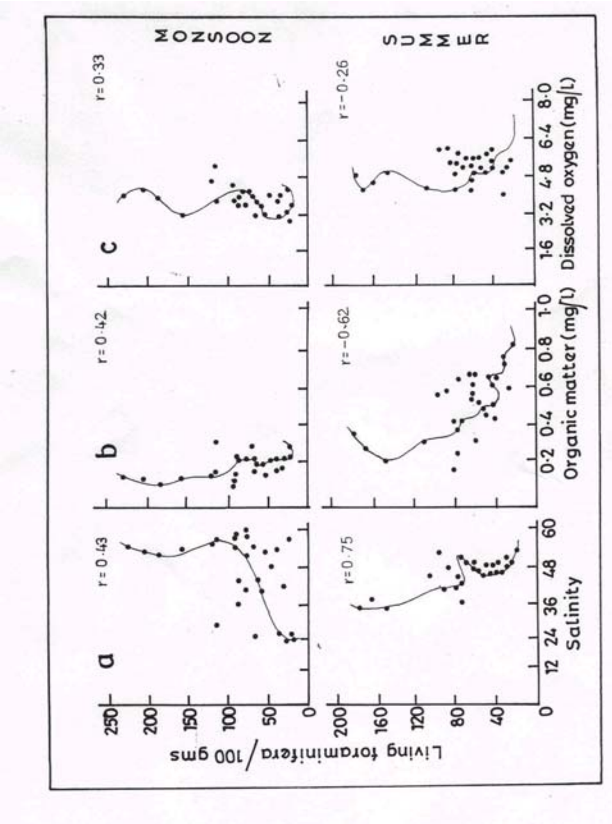

Figure 4: Some ecological parameters against living foraminifera / 100 gms for two seasons.

Organic matter versus living Foraminifera

The influence of organic matter inputs on the abundance and distribution of species and populations of benthic foraminifera is a topic of considerable current interest (Gooday, 1994; Murray, 1991). The negative correlation (-0.62; -0.42) in summer and monsoon respectively between organic matter and living foraminifera may be explained in both the seasons. The organic matter increases from channel part (station 1-9) towards the Kalangi estuary part (station 26-30). With the increase of organic matter, foraminiferal abundance decreases (Figure 4). In general, the correlation co-efficient values for living foraminifera with organic matter in monsoon (γ = -0.42, an inverse relationship) and in summer (γ = -0.62 an inverse relationship) are above significant value. In fact, organic matter showed wide variations in relation to space and season.

Paleocological implications

Studies of foraminiferal distribution in lagoon such as the Pulicat Lake enable one to recognize and better interpret ancient lagoonal deposits. Most of the species now living in the lagoon range back to the middle Tertiary of the East African and Indo-Pacific fauna (Cushman 1959). Bandy (1956) also realized that Rappahannock estuary is mostly represented by fauna of Atlantic and Gulf coasts. These species should be valuable paleoecological guides, if one can assume that their environmental preference have not changed and that the distributing fossil tests faithfully parallel that of the once-owing foraminifera (Gooday, 1994). Paleoecological interpretation is facilitated by combining other faunal and sedimentary characteristics with features of the foraminiferal distribution (Ellison and Nichols, 1970).

Like Foraminiferal faunas in bays, lagoons, and around deltas, estuarine faunas have few species, with one or two dominants. There are more species near the bay coast than the estuary. Although populations vary widely in size, they are commonly largest in the gradient zone of linear reaches where the salinity range is great. The faunal composition changes the Bay ward from one that is arenaceous foraminifera in the 16.2-20% salinity range to chiefly calcareous foraminifera at a salinity that is greater than 20%.

Lagoonal faunas are subject to modifications arising from addition or removal of certain species. In a stratigraphic section, lagoonal faunas may be expected to show marked vertical changes in abundance and composition. With long terms sedimentary aggradation, salt water intrusion will be limited, stratification reduced, and the more marine *Elphidium* fauna will be less widespread in younger than in older sediments. The facies boundary along the longitudinal axis would shift seaward as one proceeds stratigraphically up the section and the sequence would have the general appearance of a marine regression.

Conclusions

1. The channel part (station 1-9) recorded the highest average number of both total and living foraminifera. On the other hand northern part (station 16-18) documented the lowest number of foraminifera. An analysis of variations suggests that the low variability is found for the pre-monsoon and high variability for summer.

2. Out of 50 species recognized, only 35 species had living representatives, while the rest occurred as dead representatives which might represent in part sub-fossils lived in the lake bottom in the recent past and in part dead tests transported into the lake from the Bay of Bengal by wave action. *Ammonia beccarii*

occurred in all 120 sediment samples hence, cosmopolitan species.

3. In the total and living (stained) assemblages *Rotaliina* was dominant followed by *Miliolina* and *Textulariina.*

4. A high positive correlation and a high negative relationship have been noticed between salinity and foraminifera in monsoon and summer respectively. On the other hand, inverse relationship was observed between organic matter and foraminifera in both the seasons. In monsoon, the living foraminifera decreased from channel part towards Kalangi estuary where it showed minimum values and it may be attributed to the effect of flood waters. In summer living foraminifera decreased from channel part towards interior of the lake. This may be due to the extremely high saline conditions in central (stations 10-25) and Northern parts (station 16-18) of the lake. The various environmental variables were not independent and the importance of any particular environmental variable was relative to the others. The significance of the set of environmental variables of this study and the lack of significance of any individual variable testified to this fact (Buzas, 1968). Based on the above discussion, it appears that out of four seasons (pre-monsoon, monsoon post-monsoon and summer) pre-monsoon and post-monsoon appear to be congenial for growth and distribution of foraminifera. In conclusion, it may be inferred that in the Pulicat Lake as a whole, the environmental variables are moderately favourable for the growth and survival of foraminifera.

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Fishing and poverty levels around Lake Victoria (Kenya)

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Abstract

Fishing is known to be one of the oldest occupations of mankind and in Lake Victoria; it has been largely practiced at artisanal levels. Despite this, poverty amongst the fisher folk remains high. Why the fisher folk remain in perpetual poverty was the key research question for this study. Sampling was conducted on 12 landing beaches between June and August 2004. Data was obtained using survey questionnaires; personal interviews were made using open-ended questions and beach observations.

Results from this study indicates that 179 fishers sampled earned an average income of Ksh. 107,063 each in a year with modal income of Ksh. 57,600 while in a day they earned an average income of Ksh. 518 each with modal income of Ksh. 200. Fishers perceived that with the decline of Kenyan economy, income they get from fishing cannot sustain them because of increased daily expenses, exploitations on fish prices, strict laws and regulation as well as decline in fish catches by about 88 %. Fishers live in isolation and far from urban centers but near markets or beaches 55.3% while 35.2% lived in remote areas with primary level of education forming 60.9%.

Results indicate that fishers are always vulnerable to diseases like Diarrhea, Amoebae, typhoid, Malaria, cholera and Aids. They own an average of 4.2 acres of land and cultivate only a small portion of their land 41.3%. Majority of fishers are men who are self-employed but always exploited by middlemen on fish prices; they live in isolation in grass-thatched houses and eat three meals a day. Poverty amongst them was due to lack of capability of efficiently participating in the industry.

Key words: Poverty, isolation, vulnerability, physical weakness and powerlessness.

Introduction

Lake Victoria is the second biggest lake in the world with a surface area of 69,000 km^2. The lake is shared between three countries, Tanzania constituting 49% of the area of the lake, Uganda 45% and Kenya 6%. Lake Victoria dominates Kenya's fishing industry whereby in 1995 it accounted for 94% of the total catch of 193,789 tones of fish while 3% was from the marine fishing.

Ikiara (1999) reported that due to the expansion of the Nile perch export Kenya's fishing industry contributed 0.2% of the annual GDP between 1971-1981 while in 1990 the contribution rose to 2% and 4.4% of the non-monetary and monetary GDP. In 1995 fish export earned Kenya Ksh.15 billion in foreign currency while in the same period fishermen earned a total of Ksh.. 5.2 billion from fishing, less than 30% of the value of the retail trade (Ikiara, 1999).

In Kenya the fisheries department recently estimated that a total of 798,000 people were directly or indirectly supported by the fishing industry compared to 720,000 in 1995 whereby there were 34,000 fishermen, 238,000 dependants and ancillary services such as trade in fishing inputs, fish handling, processing and marketing. In 1995, for instance, 560,000 people were estimated to have been employed in Kenya's fishing industry accounting for 25% of the country's total employment in the employment in the informal sector and 14.5% of the country's total employment.

According to (Reynolds *et al.,* 1992) Lake Victoria fisheries produced a total value of US$ 280 million between 1975 and 1989. Employment increased from 158,000 employees in fishing and ancillary activities in the entire lake to 422,000 by 1992 when Nile perch fisheries was at the peak (Wilson, 1993)

Ikiara (1999) reported that the value of fish produced from Lake Victoria has grown since 1980 from Ksh. 0.2 billion to about 22 billion in 1995. The commercialization of Lake Victoria fishery has been increasing since late 1970,s and this has yielded substantial benefits to the Kenyan economy in terms of foreign exchange earnings, income earnings to the owners of fish processing and animal feeds manufacturing factories, tax income to the government, fisher incomes, and creation of employment opportunities. C. Bokea and M. Ikiara (2000) estimates that the government of Kenya collects at least Ksh. 131.6 million (US$ 1.9 million) annually from the Lake Victoria fisheries, most of which can be attributed to fishery transformation. Annual per capita fish consumption in Kenya increased from 2kgs in 1963 to 8kgs in1992 (Kenya Fisheries Department). Ikiara (1999) estimated that the average monthly income for boat owners was Ksh. 6,000 while crewmember earned between Ksh. 1000-2000 per month but the fish-processing sector, processors earned slightly more than the fishing crew. The income distribution from the fishery is increasing skewed in favour of the owner of fish processing and animal feed factories against the fishers, factory employees and fish consumers.

Ikiara (1999) also reported that the highest levels of malnutrition in Kenya are now found within fishing communities because fisher folk consume very little of what they harvest and yet they have no access of supplementary sources of protein. The high poverty levels that exist among the fishing communities contribute to high fish pressure even with rising real prices, poor fishers strive to increase their fishing intake as much as possible. World bank (1972) defined poverty as hunger, lack of shelter, being sick and not being able to see a doctor, not able to go to school and not able to read, not having a job, fear for the future and living one day at a time. World Bank (2002) defined poverty as loosing a child brought by unclean water, powerlessness, lack of presentation and freedom.

According to the Danish Association for International Cooperation, poor people are prevented from acquiring basic needs like shelter, health, and education. They are often deprived of dignity, live insecure lives and are vulnerable to risks and crisis, have little access to vital knowledge and information, are denied rights, are excluded from access to productive resources, and have few possibilities of influencing the political environment.

The Poverty Eradication Plan (1999-2015) identifies the poor as the landless, the handicapped, female-headed households, households headed by people without formal education, and pastoralists in drought areas (arid and semi -arid areas of the land), unskilled and semi-skilled casual laborers, Aids orphans, street children and beggars.

Sen. (1983) pg 153 describes absolute poverty as a condition characterized by severe deprivation of basic human needs, including food, safe water for drinking, sanitation facilities, health, shelter, education, and information.

The aim of this study was to establish why fishers of Lake Victoria keep on remaining trapped in the state of poverty and they are the owners of the fish caught. Fishing in the Lake Victoria is a major activity for people within the lake basin with an estimation of 124,000 fishers and estimated fish production capacity of 400,000-600,000 metric tones per year with a value of US$ 300-600 million at the beach level (LVFO 1999).

Objectives of the study

- Examine the poverty levels of fishers of Lake Victoria

Specific Objectives

- Find out why the fisher folk always remain in perpetual poverty.
- Examine main indictors leading to poverty
- Establish main reasons hindering the improvement of their standard of living.

Methodology

Data collection was carried out between June and August 2004 covering 12 landing beaches within Busia, Suba and Homabay Districts. Data was obtained using structured survey Questionnaires and secondary data sourced from literature review. Personal interviews and beach observations were made.

Random sampling method was used to select the respondents for the interview e.g. boat owners, crewmembers, gear owners and boat renters. A stratified random sampling method was used to the select the beaches for fieldwork. Data was analyzed using SPSS package.

Results and discussions

Characteristics of fisher of Lake Victoria

Studies done by (SEDA WOG II, 1999) revealed that fishers of Lake Victoria were dominantly men with the age bracket of 21-45years. This study also confirms the above results where 97.8% of fishers involved in actual fishing activity were men while women were only owners of fishing equipment and were mostly involved in beach seining. Their average age was 34 years with a mode age of 28 years. However, minimum and maximum age ranged between 15-64 years. This result indicates that now younger people have joined the fishery. On marital status 88.3% of fishers were married with at least one spouse per fisher forming 69.2%. They had 6 dependants per fisher indicating a large family size to feed.

Education being one of the most important indicator of poverty shows that literacy level amongst fishers is high where 60.9% of fishers had attained primary level of education, 38% secondary level, 0.6% had attained university level while 0.6 % had not gone to school.

Knowing the fisher's parent educational background was important to establish whether their present educational level was due to their family educational background. However results indicate that 57% of fisher family members had attained primary level and 1.1% university level. Fishers family members could not attain the required educational level due to lack of funds 67.6% This shows that most fishers being in remote areas with few educational facilities have little access to vital knowledge and information.

Out of 175 fishers interviewed, 36.7% had family members who were involved in other activities that contributed some income to the family.

Poverty amongst fishers of Lake Victoria

(i) Income earned from the fishery

Fishing is an important source of livelihood for many Kenyans for many years. It is also an important source of animal protein, especially for most people living around the lake. In theory fishers of Lake Victoria are regarded as the poorest group of people in all sectors of the economy. Looking at the way they live, the way they look, assets they own, saving habits and their family sizes one wonders. When one enters at the beach and look at the fishers, most of them look weak, poorly dressed, drunk and live in poor housing structures. They have many dependants, wives, orphans and widows to feed.

Results from the study indicate that 89.4% of fishers around the Lake Victoria (Kenya) have no other sources of income except fishing. This shows clearly that poverty amongst the fishers was due to lack of alternative income sources. Fishers sampled around Lake Victoria earned income from the fishery totaling to Ksh. 20,331,160 in a year, with an average income of Ksh. 107,063 per fisher per year.

In a day a fisher earned an average income of Ksh. 518 per fisher per day with a modal of Ksh. 200. Their daily income ranged between Ksh. 40-20,000 and yearly income ranged between Ksh. 7,200-1,404,000. From all these earnings can we say that the fishers of Lake Victoria are poor? This is evident that fishers get good earnings from the fishery but they are not able to mobilize their earnings properly and lack the culture of saving and investing.

(ii) Kenyan economy and job satisfaction

The Kenyan economy has declined; money has become scarce and not changing hands. From the survey carried out, out of 179 fishers interviewed, 88.3% perceived that the income they get from fishing activity could not sustain them because of inflation in the country, daily expenses have increased, scarcity of fish in the lake, exploitation on fish prices by factory agents, strict laws and regulation in the fishery and they feel that fishing was their only source of livelihood.

(iii) Shelter and Food

The standard of living of majority of fishers around Lake Victoria is very low. Shelter and food are the most important basic needs of mankind but looking at the landing beaches around the Lake, fishers live in poor housing structures with inadequate social amenities and inadequate food supply. Most of the houses they live in are muddy thatched houses with few semi-permanent ones.

The results confirm that 63.7% of fishers at their homes live in grass-thatched houses while 26.8% live in semi-permanent houses showing that fishers lack good shelter as shown in Figure 1.

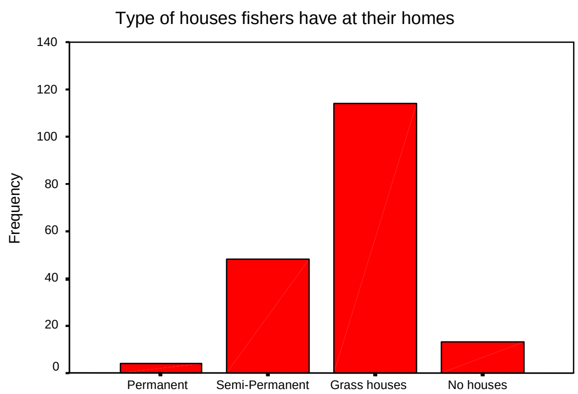

Figure 1: Types of houses fishers have at their homes.

Food being a necessity for ones life, there is malnutrition along the sampled beaches because majority of fishers depend on fish earnings to buy food that is also scarce. This has affected their nutritional status leading to eating unbalanced diets.

From the results got, 43.6% of the sampled fishers around the Lake and their families take three meals a day while 42.5% take two meals a day. The changes in daily catches of fish determine the number of meals one can take in a day but there is a possibility of missing a meal in a day (Figure 2).

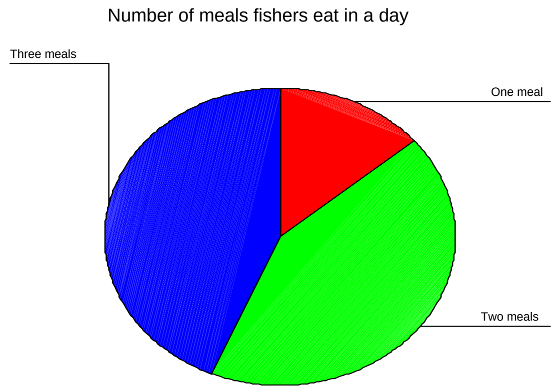

Figure 2: Number of meals taken by fishers in a day.

When fishers were asked whether they ever lacked food to eat or stayed hungry with their families, 77% indicated that sometimes they lacked food to eat especially when they don't catch any fish, poor yields from their farms, draught seasons and when fish prices are low, 12.3% had not lacked food at all and these were mostly fishers who own many boats and gears, 6.7% often lacked food and 3.4% had always lacked food especially workers in the boats (crewmembers).

Fish prices have increased and fish has become increasingly inaccessible to the local fishing communities that have placed other poor Kenyans seriously threatened by food insecurity. Although fish export earnings to Kenya is a bout 7 million a year, the fishermen who bring in the catch are so poor that they cannot afford to eat it.

Fishers residency and local politics

(i) Locational position of fisher's residency:

Fishers of Lake Victoria are isolated from most facilities that are found in the urban centers. Locational factors on their residency affect fishers on education, health, information gathering and communication.

Results show that 55.3% of fishers live in homes situated near a market s or beach while 35.2% live in remote areas with little access to vital knowledge and information (Figure 3).

In those areas there are few good schools, lack of teachers, modern equipments e.g. computers. Schools that were situated near to the lake had a lot of school dropouts due to the influence from the fishery and the few good schools were very far from their residency.

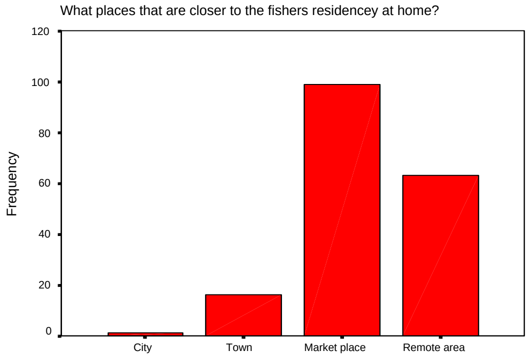

Figure 3: Places that are closer to the fisher's residency at home.

(ii) Political meetings

Fishers feel that they are not properly represented in the fishery. Any decision made concerning the fishery they are never consulted, they are rarely invited to the management meetings. They cannot have their kinsmen representing them in high position in the government.

When asked how often they meet with their political leaders for advice or to know what the others are doing in other areas, 58.7% indicated that they had not met with their political leaders at all since they were elected but some had sometimes made with their leaders 31.8%.

Majority of fishers revealed that their leaders only came to the beaches during campaigning period, launching government directives, or funeral and have nothing to offer the fishers.

Powerlessness of fishers in the fishery

(i) Fishers involvement in the fishery

Fishers involved in fishing activity were composed of boat owners, boat renters, gear owners and crewmembers. Fishers lacked enough capital to buy efficient fishing equipment like effective fishing gears, boats, and outboard engines. From that they felt that they earned little money from fishing as compared to 10 years ago.

Due to lack of cold storage facilities to store fish and sell at better prices they have experienced big losses from the sale of catches.

One big problem fishers have around the lake was middlemen who have captured the whole market. A lot of money is got from the fish sale but the fishermen still remain poor. At times the fishermen are forced to sell their fish at a throw away prices because they cant store it for a long period (perishable).

Although Lake Victoria is a major foreign earner to the tune of 7 billion from fish export, the huge industry does not help to improve the living standard of the fishing communities or raise the economic status of the fishers due to large number of middlemen in the fishery.

Once fish is landed on the landing beaches, the fishermen cease to play any significant role in the trade also the cooperative societies which could benefit the local fishermen and fishmongers, have totally failed due to corruption.

Although majority of fishers perceive that the income they get from fishing cannot sustain them, the majority also tend to be spend thrifts. They do not save any of their income from the sale of fish, many tend to reason that there is always more fish in the lake and their motto is "Drink today for tomorrow we fish". Fishers also have other various constraints in their activities. Gears required by the government are very expensive and theft of equipment is very rampant around the lake. Most fisher's fish at shallow waters where they get low catches while those with engine and bigger boats fish in the open waters and get more catches thus getting high income. Thus they feel that low earnings from the fishery put them in a state of poverty.

Among the employers in Lake Victoria fishery 67.6% were self employed, 26.3% boat owners, 5% employers who paid wages on daily basis, 1.1% foreigners who own fishing boats and nets.

(ii) Exploitation of fishers in the fishery

In the course of carrying out their fishing activities majority of fishers perceived that they are totally exploited. Fishers have a weak bargaining power in their interaction with fish purchasers. Locally based fish agents of processing factories dominate the market. Most purchasers of fish no longer avail credit to fishery, several factors also influence where fishers sell their fish, including prices, distance to the market, availability of fish, costs of other commodities and domestic goods at the market points. 45.7% of fishers were always exploited in one way or the other Figure 4).

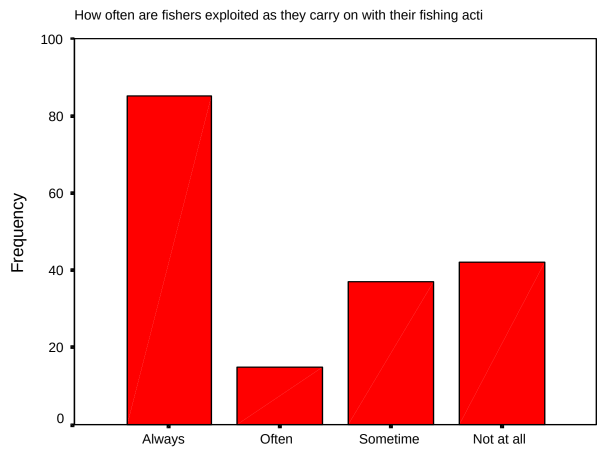

Figure 4: How fishers are exploited as they carry on with their fishing activities.

- Middlemen exploited fishers on fish prices
- Boat owners exploited crewmembers on daily wages and mistreatments

- Government officials solicit for bribes and confiscate their gears
- Unnecessary contribution to the BMUs.

(iii) Government assistance or aid

Fishers of Lake Victoria feel that they are always powerless when carrying out their fishing activities. Famine, floods and droughts that affect them greatly always strike them and they don't have any alternative way for survival. During the period under review the government of Kenya was distributing relief food to the communities that have been stricken by famine, droughts or floods.

When asked whether they had ever received any government aid like relief food in time of famine, 73.2% had not got any relief food at all and 52% didn't have any idea why they didn't get relief food but 16.2% felt they were powerless to receive food and felt distributing agents were exploiting them. This result shows that fishers are powerless when it comes to government aid.

(iv) Discrimination in schools

About 42.5% of fishers sampled indicated that they were not discriminated by school head teachers in securing a vacancy for their children in good schools after passing national examinations. However the few who were always discriminated indicated that they were discriminated because of ethnicity, by clan or village 21.8%.

In school fees payment, 33.5% of fishers were sometime able to pay school fees promptly especially when there was good catches and better prices while 22.3% could not afford fee payment at all. The most common group affected were crewmembers due to low earnings.

Diseases and other risks threatening fishers of Lake Victoria

(i) Diseases affecting fishers of Lake Victoria

Fishers around Lake Victoria are always vulnerable to diseases and other risks due to lack of medical facilities, ignorance, culture and poverty etc. Most of the hospitals or dispensaries available at the landing beaches lacked medical facilities and enough qualified doctors. Waterborne diseases are the major problems to the fishers forming 83.2%. Malaria, typhoid, amoebae, cholera and aids related diseases were identified as the most frequent diseases affecting the fishing communities. Poor health status of the fishers has resulted to poor production of fish and increased poverty amongst them.

Apart from the killer malaria, the lake region has been occasioned by the high prevalence of the HIV/Aids due to adulteration of cultural practices such as wife inheritance where many have succumbed to the scourge, leaving only the young and the old to take care of one another.

The diseases have reduced life expectancy, high child mortality and substantial amount of money is used to treat diseases rendering them poor.

Results of the study indicates that 66.5% of the fishers got treatment and their families at the health centers while 16% got at private clinics. Apart from dispensaries or health centers, which were nearer to the fisher's homes 64.8%, complicated cases were referred to the District and Provincial hospitals which were very far from the fishers' residency. The unclean water for drinking and poor sanitation hinders the health status of the fishers around the lake. Results indicate that although there is poverty amongst the fishers 53.6% were sometimes able to meet their hospital bills when they took their families to the hospital and among them the most hit were the crewmembers who earns low wages. Boat owners, renters and boat managers did not have many problems in paying hospital bills because they owned many boats and gears.

(ii) Sources of water for domestic uses:

Fishers around Lake Victoria require water for drinking and for other domestic uses. About 75.4% draw water for their daily uses from Lake Victoria while 10% used piped water Figure 5.

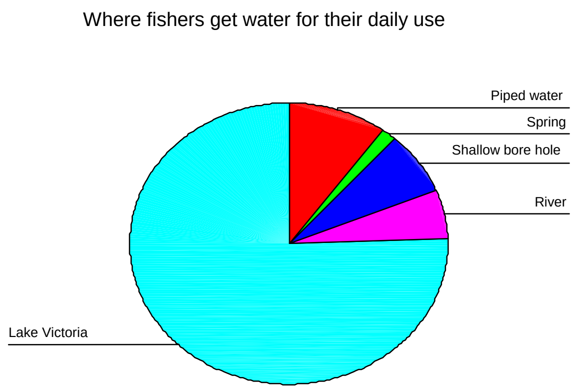

Figure 5: Where fishers get water for their daily use.

Although Lake Victoria is a fresh water Lake, the water is not safe for drinking. There are several reported cases of the outbreaks of many waterborne diseases. From our results 43.6% always boil water before drinking, 33.5% do not boil water at all while the remaining group use chlorine or water guard to purify water. Majority of fishers take their cattle to drink water in the Lake while a few took to dams, rivers and boreholes. Other results also indicates that fishers travel a long distances in search of water but those living at the beaches draw water from the Lake directly.

Farming activities

Size of land fishers cultivate in a season

Apart from fishing activities fishers also do farming activities as another alternative means of livelihood.

Out of 150 fishers interviewed one fisher owned an average of 4.2 acres of land with a modal of 2 acres. The size of land owned by fishers ranged between 1-60 acres but 29 fishers were landless.

The above results indicates that fishers have alternative means of earning income from farming thus the case of poverty amongst them does not arise. The survey shows that 41.3% fishers cultivate a small portion of land during farming season while 29.6% cultivated a big chunk of land (Figure 6).

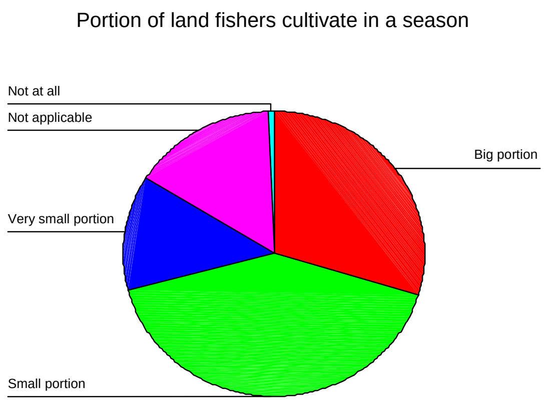

Figure 6: Portion of land fishers cultivate in a season.

Majority of the fishers complained of unpredictable climatic conditions, low rainfall, poor soils and lack of farming equipments. 41.9% of fishers perceived that all the produce from their farms were little or less due to poor climatic conditions. They also indicated that earnings from their produce were low. In the course of cultivating their farms 58.7%, of fishers set aside 3 hours and above in cultivating activities in a day, 15.6% had set aside 2-3 hours in a day, 7.8% could take 1-2 hours a day, 1.7% would not cultivate any land at all and 16.2% did not set aside any hours because they were landless.

Conclusions

- Fishing activities on lake Victoria is dominated by men
- Fishing is the main source of income for the fishers
- Fishers live in isolation and are prevented from acquiring basic needs such as shelter, health and education
- Poverty amongst the fishers is due to lack of being capable of efficiently participating in the industry
- Majority of fishers sampled are literate but have little access to vital knowledge
- Fishers get a lot of income from fishing activities but have poor business management skills
- Middlemen on fish prices heavily exploit fishers.
- Fishers Live in grass thatched houses and eat three meals a day on average
- Fishers are physically weak; they live insecure lives and are vulnerable to risks and diseases
- Fishers have few possibilities of influencing the political environment
- The fishers lack proper representation and freedom
- Their standard of living is poor.

Recommendations

- Harness the money in the fishery sector for development e.g. NGOs.
- Education a must so as to upgrade fisher's standard of living.

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Primary study on evaluation of wetland ecosystem's services of Poyang Lake in China

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Abstract

The wetland is a particular eco-system with multi-functions. The evaluation of wetland ecosystem's value is a basis for wetland protection, conservation and reasonable development. This paper presents the primary study of wetland ecosystem's value of Poyang Lake with the methodologies of Eco-economics and Resource Economics. The total economic value of Poyang Lake wetland eco-system services was about 1381.006×10^8RMB/a. The main services include water conservancy and flood-homogenized, soil protection, culture and scientific research, wild species habitat, purification, CO_2 fixation & O_2 release, and organic matter production. Among these services, the water conservancy and flood-homogenized had the maximal value which reached 1173.084×10^8RMB/a. The following one is soil protection which had 136.531×10^8 RMB /a. The values of culture and scientific research, wild species habitat, purification, CO_2 fixation & O_2 release, and organic matter production were 31.533×10^8 RMB/a、20.665×10^8 RMB/a、9.696×10^8 RMB/a、7.05×10^8 RMB/a and 2.477×10^8 RMB/a respectively. The organic matter production had the minimal value, which only made up 0.179% of total value of Poyang Lake wetland ecosystem. Therefore, the importance of Poyang Lake should be fully considered and the researches on Poyang Lake have to be conducted roundly and actively. Meanwhile, the decision-makers should consider the trade-off of the wetland ecosystem services of Poyang Lake in order to reach the balance of the ecology and economic development of the region when selecting the development options.

Key words: Evaluation, Poyang Lake, Wetland Eco-system service

Introduction

Ecosystem services are the environmental condition and the avail formed and preserved by the ecosystem and its process which humankind live upon. It not only contain the food, medicine and the raw material used in industry and agriculture, but also sustain and preserve the supporting system of the earth, keep the biology cycle and the water cycle of the living material, protect the organism diversity of species and heredity, sustain the chemical balance and stability of the air.

Wetland is a special nature complex taken shape by the reciprocal effect of land and water. It can bring us many kinds of beneficial results; it is the very important ecosystem on the earth with great use value that we should protect. The evaluation of the value of the ecosystem services is the foundation and precondition of the rational use and protection of the wetland. For this reason, there are lots of specialists and organizations study on the ecosystem services and its value of different kinds of wetland in different areas both internal and aboard.

The study area and methodologies

Poyang Lake is located in the north of Jiangxi province, in the south bank of the point where the middle reaches associate with the lower reaches of the Changjiang River, P. R. China. Its geographical coordinate is 115° 49'-116° 46'E; 28° 11'-29° 51'N. It is China's biggest freshwater lake, which has the headwaters from the Ganjiang River, Fuhe River, Xinjiang River, Raohe River and Xiushui River, and flow in the Changjiang River. So the water level of Poyang lake is controlled by the above five rivers and the Changjiang River. The surface area of the lake has great difference between the high-water season and the dry season. During the dry season, the water level decline, the shoal and the sands shows, and the water return to the groove. It has profuse water resources; the yearly average rate of flow is $1525\times10^8m^3$. It takes 16.3% of the Changjiang River's average rate of flow in the Datong station.

Poyang lake area has a subtropical moist monsoon climate. It has warm weather, plenty of rain and sunshine, long frost-free period, so it is a suitable place for many kinds of living things. There are many kinds of water plant, fish and other animal annularly distribute over the Poyang lake water area. According to the definition of the wetland, the total area of the Poyang lake wetland is 8,190km^2. Among which, 4045 km^2 is natural wetland and 4145 km^2 is manmade wetland.

Poyang Lake has many important functions of wetland and typical characteristic of freshwater lake wetland. This paper synthetically used the methods of ecological and resource economics to estimate the value of nine main ecosystem services in the Poyang lake wetland, expect to provide some references for the decision-making of sustainable development and the environmental protection of this area.

This paper adopts such following methods of research to estimate the value of ecosystem services of the Poyang lake wetland.

1. Market Value: It is the way that evaluates the valuable ecosystem products and services. It is mainly used here in estimating the substantial product of the wetland ecosystem.
2. Carbon and Oxygen Price Measure According to the equation of photosynthesis, we use the

output of dry matter to calculate the capacity of the settled CO_2 and the O_2 released. Based on the international current Carbon measure at the present and China's average cost of afforestation and the industrial oxygen price measure, we change the environmental standard into the economic standard, and then get the economic value of the settled CO_2 and the O_2 released in the wetland.

3. Shadow Engineering Method: It is the way to create a project by the manpower to substitute the expenses of environmental function or formerly destroyed environmental function. At the present time, one unit of capacity cost 5.714 RMB/m^3. And our research mainly used it to estimate the function of storing water resources and the value of the control and store the flood.

4. Substitution: Mostly using the value of the reduced fertility of soil on the wetland to substitute the value of protecting soil.

The results of the study

The value of producing organic matter

The wetland ecosystem has a very important function, utilize solar energy, and use the inorganic compound to synthesize the organic compound, sustain the whole ecosystem. The output and the biology capacity are the two important standards that reflect the production of organic matter. In the ecosystem of Poyang lake wetland, the primary producers are the phytoplankton, the hydrophytes and the self-supported bacillus. Due to the lack of datum, we can't estimate the output and the biology capacity of the self-supported bacillus. Therefore, the value of organic matter in the Poyang lake wetland can be calculated in the following way, the value of the phytoplankton can be reckoned by the potential of fishery that it supplied, the value of the hydropyte can be reckoned by its output, the bait material coefficient, and calculated together with the market price of the feedstuff.

$V = \Sigma (Y1*P1 + Y2* C2*P2/ C1)$

In the expressions, V represent the indirect produce value of the organic matter of lake, Y1 is the potential of fishery which it supply by the phytoplankton, Y2 is the output of the hydrophyte, P1 is the average price of fish market, P2 is the price of the feedstuff market (RMB/kg), C1 and C2 are the bait material coefficient of the hydrophyte and the feedstuff.

According to the record and narrate of related datum, the phytoplankton in the lake has an elementary fertility which can convert into the annual fresh weight output is 4513272t, it can provide the potential of fishery 15952t. In the lake there are 137200t hygrophyte, 394800t emerging plant, 3505600t submerged plant, 280000t floating leaf, the total biology capacity of the lake is 4317600t. Based on the fish market price 2 RMB/kg, fish mixed feedstuff is 2 RMB/ kg; calculate the hydrophyte bait material coefficient as 120, the bait material coefficient of normal. The mixed feedstuff is 3, consider the average price of mixed feedstuff market is about 2 RMB/ kg, we can educe that the produce value of the organic matter is about 2.477×10^8 RMB/a in the Poyang lake wetland.

The value of the fixed CO_2 and the O_2 released

To estimate the function of fixing the CO_2 and releasing the O_2, with the elements of Poyang lake wetland's biology capacity output, then according to the reaction equation of the photosynthesis and respiration, we can reckon that it needs 1.6296g CO_2 and will release 1.1914g O_2 to form 1g dry matter.

The annual fresh weight output of the Poyang Lake's phytoplankton is 4513272t. Because there are no plenty of related dates about Poyang lake, apply the production of the phytoplankton research in the lake Dong, the dry and fresh weight ratio is 1:7, so educe that the dry weight of the phytoplankton is 644753t, the total biology capacity of the hydrophyte in the whole lake is 4317600t in fresh weight, according to the dry and fresh weight ratio of the hydrophyte is about 1:20, the total dry weight of the hydrophyte in the whole lake is 215880t.

The regular amount of CO_2 at Poyang Lake mostly consists of two sorts of regular amount: phytoplankton and hydrophytes. In accordance with the reaction equation of photosynthesis and respiration, we can estimate that the regular amount of CO_2 of phytoplankton can reach 1050689.49t and the regular amount of CO_2 of hydrophytes can be 351798.05t in the marsh of Poyang Lake. Plus the two data above, we can educe total amount of CO_2 should be 1402487.54t. According to CO_2's molecular formula and atomic weight $C/CO_2=0.2729$. At present, the tax rate of carbon usually is Swedish tax rate of carbon: l50\$/t, it is absolutely a little high for our China, so here adopt 770RMB/t as a standard of the tax rate of carbon. It is an average of Chinese afforestation cost 250RMB/t and international tax rate of carbon. The functional value of receiving CO_2 absorption in the marsh of Poyang Lake's can reach 2.95×10^8 RMB/a.(1US dollar=8.3yuan)

Total amount of O_2 release at Poyang Lake is mostly the sum of phytoplankton release and hydrophytes release. On the ground of the reaction equation of photosynthesis and respiration, we can estimate that the total amount of CO_2 release by the marsh of Poyang Lake should be 768158.72t and the total amount of CO_2 release by hydrophytes should be 257199.43t.The sum of them is 1025358.15t. Apply shadow price measure which is often used in producing oxygen in industry to estimate economical value of O_2 release, Calculate its value according to the current price 400RMB/t in producing oxygen in industry, we can find that the value of marsh ecosystem of Poyang Lake's O_2 release is 4.1×10^8RMB/a per year. Total economical value of marsh of Poyang Lake's O_2 fixation and O_2 release should be 7.05×10^8RMB/a.

The value of water conservancy and flood-homogenized

The value of water conservancy of marsh of Poyang Lake is calculated by the amount of water conservancy. We usually use shadow-engineering method to calculate. The yearly average water lever of Poyang Lake is 14.01m (Duchang hydrometric station, Wusong base level). Accordingly its dimension is 2694.0km^2, its volume is 67.3×10^8m^3[2)]. Look Poyang Lake's dimension as its amount of water conservancy, We can get this kind of outcome that the value of water conservancy of marsh of Poyang Lake ought to be 384.552×10^8RMB/a. It is calculated by unit cost of warehouse capacity currently. And this value doesn't involve the value of Poyang Lake marsh's surface water.

The value of Poyang Lake's flood-homogenized also can be calculated by shadow-engineering method. First, calculate the flood-homogenized amount of Poyang Lake, Second, determine the value of Poyang Lake's flood-homogenized according to construction cost which is needed by storing so much flood's warehouse capacity. Poyang Lake's year average flood-homogenized amount was 138×10^8m^3.According to unit cost of warehouse capacity 5.714RMB/m^3 currently. We can get this kind of result that the value of Poyang Lake's flood-homogenized ought to be. 788.34×10^8RMB/a.

The total value of Poyang Lake's water conservancy and flood-homogenized should be 1173.084×10^8RMB/a.

The value of soil protection

Replace the value of reducing soil erosion with the value of soil abundance's chance, it means that when the marsh was destroyed wholly, these soil would be regressive and even be disused.

When we calculate the value of soil fertility's loss, we can work out the quality of losing soil first, and then multiply by the nutrient matter amount of unit soil, so we can get the nutrient matter amount of the soil, which was reduced. At last in terms of the data of State Statistical Bureau, we use the outcome above to make a conversion with our nation's average chemical fertilizer's price 2549RMB/t in 1992.

V=S*h*R1*R2*P

V means value of soil fertility's loss, it was produced by marsh reduction. S means abandoned earth dimension, h means the soil without vegetation's medium-degree erosion depth, R1 means bulk density of soil, R2 means the average content of unit soil nutrients, P means our nation's average chemical fertilizer's price.

According to the research findings of Chinese soil erosion, the medium-degree erosion of the soil without vegetation is 15-35mm/a. Toward the total amount estimation of soil erosion which was caused by reducing of the marsh, we can replace it with the average amount of meadow's medium-degree erosion. It is 25mm/a^2. The total dimension amount of Poyang Lake's marsh is 8,190km^2; the bulk density of soil is 1.2g/cm^3. The average content of unit soil's N-P-K nutrients is 2.18%. Then according to the average price of our chemical fertilizer (2549RMB/t), we can figure out the value of soil fertility's loss, which was produced by marsh reduction, should be 136.531×10^8RMB/a.

The value of contaminative degradation

Because Poyang Lake is the center of Poyang watershed, total dimension of all the drainage area is 162,225 km^2, it takes 97.2% of Jiangxi Province's territorial dimension. Provided 97.2% wastewater and garbage drainage of our province will input into Poyang Lake. It can be conclude that the drainage amount of all the drainage area was 4.213×10^8t in 2002, disposal rate was 90.1%, the rate of drainage that can reach the standard was only 54.0%, so the average drainage amount of industrial waste water which was not dealt with or can not reach the drainage standard was 2.163×10^8t yearly In 2002 the domestic sewerage drainage amount of all the drainage area reached 5.402×10^8t. So the amount of waste water which was let into Poyang Lake and the water was not dealt with or can not reach the drainage standard reached 7.353×10^8t. The cost to deal with the wastewater and sullage is 0.7RMB/t (It's a current average cost of dealing with sullage in Jiangxi). The cost to deal with these wastewater and sullage is 5.147×10^8RMB/a.

In 2002, the amount of chemical fertilizer's application in all the drainage area was 0.012×10^8t. But there's only 30–40% that can be used in fact, another 60–70% will enter into our environment, and will pollute our water and soil. According actual utilization ratio 35% and 97.2% to calculate, the amount of chemical fertilizer that input into Poyang Lake marsh per year should be 0.00758×10^8t. Refer to the cost to get rid of SO_2: 600RMB/t . The cost to deal with the chemical fertilizer, which was let into Poyang Lake, should be 5.147×10^8RMB/a.

To purify the wastewater of industry, domestic sewerage and the chemical fertilizer that didn't be used, it will cost us 9.696×10^8RMB/a. And the cost doesn't include the value to purify residual pesticide and industrial solid garbage.

The value of wild species habitat

The function as Wild Species Habitat refers to the function that the ecosystem can offer a place for the wild animals to roost, multiply, migrate and live through the winter. To estimate Poyang Lake's function as an organisms' habitat, we adopt Robert Costanza's researching outcome an American eco-ecologist. Robert Costanza estimated that the value amount of marsh sanctuary was 304\$/hm^{2}· a. Then according to the dimension of Poyang Lake: 8,190km^{2}, we can figure out the value of Poyang Lake's marsh as an organisms' habitat should be 20.665×10^{8}RMB/a.

The function of culture and scientific research

The research uses 3897.8RMB／hm^{2}as its unit value which is the mean value of 382 RMB／hm^{2} of Chinese average research value and 86l\$／hm^{2} of global wetland ecosystem research value estimated by Robert Costanza. Taking 8,190km^{2} as the area of Poyang Lake, we can figure out Poyang Lake's culture and scientific research should be 136.531×10^{8}RMB/a.

Conclusions

The study shows: In all the value of wetland ecosystem's services of Poyang Lake, water conservation and flood-homogenized have the highest value, it is 1173.084×10^{8}RMB/a. The next place is the value of soil fertility's reduction, it's 136.531×10^{8}RMB/a. The value of culture and scientific research, wild species habitat, 31.533×10^{8} RMB /a. The contamination's purgation, CO_2 fixation and O_2 release, and the productive value of organic substance are 31.533×10^{8} RMB /a; 20.665×10^{8} RMB /a; 9.696×10^{8} RMB /a; 7.05×10^{8} RMB /a; and 2.477×10^{8} RMB /a. The total value of wetland ecosystem's services of Poyang Lake can reach 1381.006×10^{8} RMB /a (Figure 1).

It can be concluded that the value of wetland ecosystem's services of Poyang Lake is great and comprehensive. The result of the research indicates that the value of organic matter produced only takes 0.179% of the total value of ecosystem services in Poyang lake wetland. Therefore, if we just attach the importance to produce substance while programming the using of ground, it can not avoid the losing of the ecosystem services' value, then there will cause the destroy of ecosystem and bring a series of kickback. The decision-maker must equably consider the items of ecosystem services in the area, while choosing the scheme of programming. In that way, we can develop our economic sufficiently and logically, in the meantime, protect our environment and realize the continuance development.

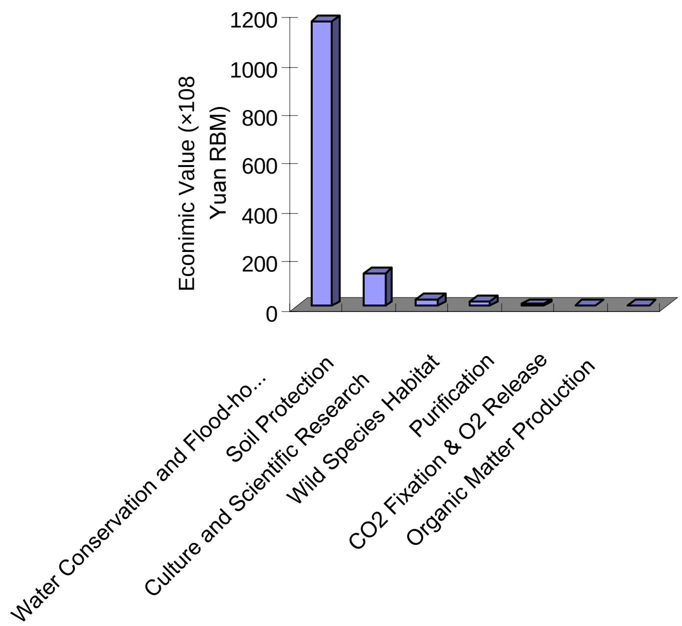

Figure 1: Wetland ecosystem's value of Poyang Lake.

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Biodiversity and sustainable management of a tropical wetland lake ecosystem: A case study of Lake Kanyaboli, Kenya

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Abstract

Lake Kanyaboli and the surrounding Yala swamp wetland has been recognized as an important biodiversity hotspot. Recent population genetic and phylogenetic studies confirm the evolutionary importance of Lake Kanyaboli in preserving the cichlid fish fauna of Lake Victoria. The adjoining Yala swamp harbours the endangered swamp antelope Sitatunga (Tragecephalus spekii) and several papyrus endemic birds. The lake and adjoining swamp play a critical role in the livelihood of the local communities who heavily depend on the wetland resources.

Current ongoing large scale land use changes within the swamp threaten the ecological integrity and functioning of this highly dynamic wetland ecosystem. It is therefore imperative that proper management and conservation measures be put in place to protect Lake Kanyaboli and associated Yala swamp wetland.

This paper presents a review of the biodiversity of Lake Kanyaboli and the associated wetland and the threats the lake ecosystem faces. Polycultural 'finger ponds' aquaculture, tourism and papyrus based industries as well as an all stakeholders driven management plan are suggested as a step towards achieving sustainable management, utilization and conservation of the Lake Kanyaboli ecosystem.

Key words: Biodiversity, Conservation, Lake Management, Lake Kanyaboli, Land use changes, Yala swamp.

Introduction

Most developing countries depend heavily on the exploitation of its natural resources especially biological resources. Most of these resources are found among very poor rural communities whose livelihood depends solely on the exploitation of these resources. Sustainable conservation and development depend heavily on strengthening the capacity of local individuals and communities to implement conservation initiatives (IUCN, 1996).

The Yala swamp wetland, located along the northwestern shores of Lake Victoria in Kenya is one of the most extensive freshwater wetlands in Kenya. The wetland supports a large human population who derive income directly from activities like fishing, hunting, building materials production and agricultural production. These economic activities if not carried out sustainably can lead to destruction of the wetland. The Yala swamp wetland is important as a source of livelihood to the local community, as a potential area whose agro-industrial exploitation could lead to increased national food production and as an important biodiversity hot spot. How to reconcile and harmonize these three apparently conflicting interests posses a big challenge to the management of the wetland.

Currently, a large scale reclamation venture that will reclaim up to 40% of the Yala swamp, mostly around Lake Kanyaboli is underway. The short and long term ecological and socio-economic costs of such an undertaking will be enormous. This paper presents suggestions for sustainable utilization, management and conservation of Lake Kanyaboli and the adjacent wetland.

Ecology and Biodiversity of Lake Kanyaboli and the assosciated swamp

The Yala Swamp is Kenya's largest freshwater wetland habitat (Otieno, 2004). The wetland covers 17,500 hectares along the North Eastern shore of Lake Victoria in Siaya, Bondo and Busia districts in Kenya (Figure 1). Three sizeable peripheral lakes Kanyaboli (10.5 km^2), Nyamboyo, (2.0 km^2) and Sare (5.0 km^2) lie within the boundaries of the Yala swamp as do at least a dozen other smaller bodies of water (Otieno, 2004). Lake Kanyaboli is the largest and most economically and ecologically important of the Yala swamp lakes. A thick fringe of papyrus (*Cyperus papyrus)* completely surrounds Lake Kanyaboli (Figure 2).

Lake Kanyaboli is of great conservation interest. The lake contains relic populations of cichlids that have severely been reduced or almost extinct in Lake Victoria. Viable populations of the native Lake Victoria tilapias *Oreochromis esculentus* and *Oreochromis variabilis* that have virtually been eliminated from Lake Victoria due to Nile perch predation occur in Lake Kanyaboli. Secondly, Lake Kanyaboli acts as refugia for the following haplochromine species: *Lipochromis maxilaris*, *Astatotilapia nubila*, *Astatotilapia 'bigeye'* (Kaufman), *Pseudocranilabrus multicolor victoriae*, *Xystichromis phytophagus* and *Astatoreochromis alluaiudi*. *L. maxilaris* and *X. phytophagus* are critically endangered haplochromines (IUCN, 2002). A recent molecular phylogenetic study uncovered a very high genetic variation in the Lake Kanyaboli haplochromines (Abila *et al*., 2004). This illustrates that Lake Kanyaboli can act as a 'genetic reservoir' for the Lake Victoria species flock. Other fish fauna that are found in Lake Kanyaboli include *O. niloticus*, *O. leucostictus*, *T. zilli*, *Clarias mossambicus*, *Protopterus aethipicus* and *Xenoclarias sp*. (Aloo, 2003). The adjoining Yala swamp forms an important habitat to the endangered sitatunga (*Tragecephalus spekeii*) and the following bird species: the Blue breasted bee eater, the papyrus gonolek, the Swamp flycatcher, the Papyrus canary, the White winged warbler, the Great snipper and the Baillor's crane.

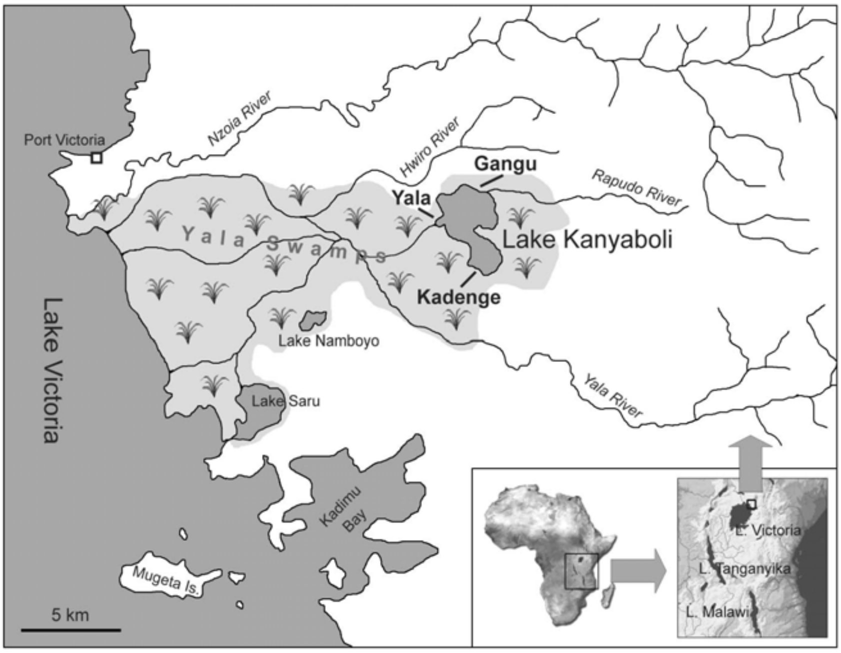

Figure1. Map of Yala swamp showing the position of Lake Kanyaboli and other associated lakes. Source: Re-drawn from S.A. Crafter, S.G. Njuguna and G.W. Howard (eds) 1992: Wetlands of Kenya, IUCN.

Figure 2: Part of the shore of Lake Kanyaboli. Note the dense papyrus fringed littoral zone. The lake is completely surrounded by such dense papyrus vegetation.

Patterns of utilization of the wetland resources

The major economic activities in Lake Kanyaboli and associated wetland are:

Fisheries: In Lake Kanyaboli, the main method of exploitation is by use of gill nets. Other methods of fishing include use of long lines, and, in areas bordering Lake Victoria, seine nets. Fish is the most important wetland product, and 98 – 100% of the residents are dependent on the fish, either commercially and/or for subsistence (Abila, 2002, Abila, 2003). The average income per day per fisher range between 140 – 150 Kenya shillings per day (approx. $1.8) (Abila, 2002, Abila, 2003, Table 1).

Table 1: Patterns of exploitation of the Yala swamp wetland, Kenya.

ACTIVITY	% People involved	Mean monthly income (Ksh.).
Grazing	49.3	*
Hunting	11.2	150, *
Fishing	80.6	5015, *
Fuel wood	66.2	984, *
Papyrus exploitation	21.0	1000, *
Agriculture	89.5	1263, *
Salt lick	35.0	*
Water for domestic use	97.0	*
Transport	70.0	3000
Brick making	5.6	2000
Papyrus building materials	28.0	2100

*Subsistence (Source: Abila, 2002).

Grazing: This is carried out in the swamp, which is a free access property thus grazing is not controlled. The wetland is particularly important for grazing during droughts. A special kind of clay containing minerals required by animals, and found only at particular spots, is used by cattle as a salt lick.

Agriculture: This is the second most important activity after fishing. Agriculture takes place on privately owned farms, based on traditional methods of land cultivation, with little use of fertilizer or biocides.

Mats 'industry'. Papyrus reeds are also used as a raw material to make a variety of products. Mats are used a s bedding materials or drying surfaces. They can also be useful substitutes as roof ceiling materials. Papyrus is also used to make chairs.

Current threats to the biodiversity of Lake Kanyaboli and the associated Yala swamp

One of the major threats Lake Kanyaboli currently faces is over exploitation of its fish resources especially the cichlids. It is currently estimated that there are over 65 fishing boats in Lake Kanyaboli (Abila, 2003). This has exerted considerable pressure on the lake. Majority of the fishermen use gill nets of between 1 and 2 inch mesh sizes. The result has been a rapid decline in the size of fish landed. The current fishing pressure in Lake Kanyaboli is certainly not sustainable.

Secondly, the on going swamp reclamation and conversion pose several environmental and socio-economic problems. The most immediate effect of reclamation is habitat loss and associated cascading environmental effects. Apart from directly destroying the habitats of the various swamp organisms, removal of swamp vegetation will result into several negative effects on the limnology of Lake Kanyaboli. The wetland has been shown to play an important role in the reduction of sediment loads and nutrients (Okungu and Sangale, 2003). The buffering effects of the swamp would be greatly reduced by removal of the swamp vegetation. Excessive nutrient and biocide loading to Lake Kanyaboli would greatly affect the water quality and functioning of the lake ecosystem. In a nutshell, the environmental effects of swamp conversion will be wetland degradation, water quality change and pollution and biodiversity loss.

Socio-economically, conversion of the wetland will bring to an end the several socio-economic activities carried out by the local communities. A critical examination of the Environment Impact Assessment study carried out by the project developers reveals that issues associated with wetland conversion have not been adequately addressed.

Future outlook: Towards sustainable utilization, conservation and management of Lake Kanyaboli and associated wetland

The foregoing demonstrates that like most tropical wetlands, the Yala swamp wetland is important for both biodiversity and is also of great socio-economic value to the local community. Long lasting sustainable utilization, conservation and management of this resource therefore hinges on addressing the seemingly conflicting demands of biodiversity conservation, community utilization and agro industrial development. The high economic potential of the Yala swamp wetland, the fact that the wetland is not a protected area and the lack of a proper wetland policy make the Yala swamp a very vulnerable ecosystem.

While reclamation has received immense political support, past studies indicate that this has been a source of conflict with the local communities. Conversion of the wetland, while it may give short term gains, will lead to long term economic, social and environmental problems such as inflated costs and reduction of yields after irreversible soil fertility exhaustion. Evidence on the ground indicate that other problems associated with conversion such as resettlement, compensation, sedimentation, eutrophication and habitat loss have not been adequately addressed in the on going Yala swamp irrigation development scheme.

In order to maintain the ecological integrity and environmental functioning of the Lake Kanyaboli Yala swamp wetland, the following alternative sustainable methods of wetland utilization should be pursued and if possible improved.

Papyrus based industry: This could involve formation of groups to make mats, baskets, seats etc. NGOs and development partners could be consulted to give technical assistance geared towards improving and diversifying the papyrus products and to explore better marketing strategies. Development of papyrus based industry have been attempted in the Nyando wetland of Lake Victoria, Kenya (Raburu, 2004).

Aquaculture: Aquaculture could be development by adopting the 'finger pond' techniques developed by Denny and Turyatunga (1992) for Ugandan Lake Victoria wetlands. This involves cutting wide channels into the swamp at right angles to the shore. The soil removed from the channels would be heaped between the channels to form raised beds (Figure 3). These channels could be used to raise *Clarias, Oreochromis niloticus* and the two native *Oreochromis* species. The fringe of the ponds could be used to cultivate papyrus or for horticulture. Fish culture would be based on polycultural techniques successfully used in south east Asia and now being developed in Africa. This technique is currently being tried in the Ugandan wetlands (Ssanyu, 2004). Aquaculture development would greatly reduce pressure on Lake Kanyaboli.

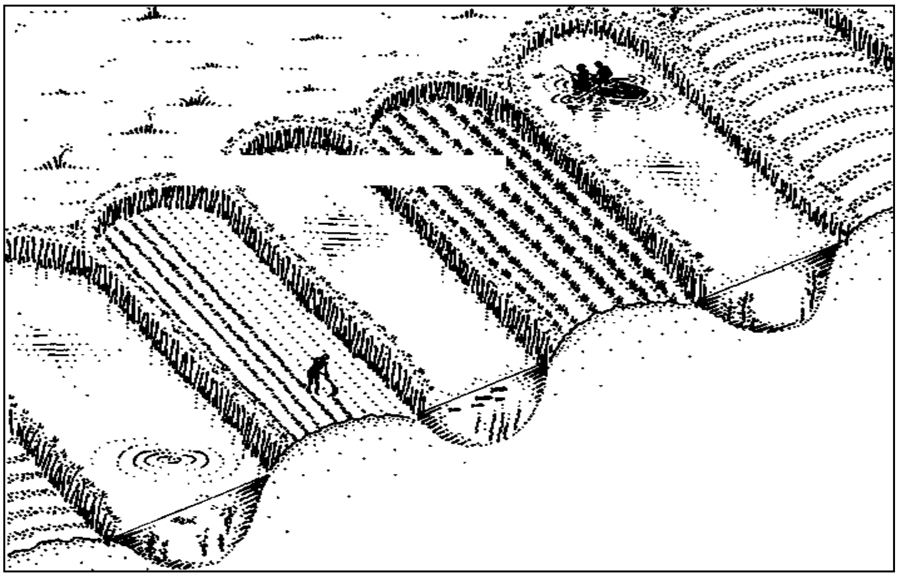

Figure 3: A proposed scheme for development of swamp fringes with 'finger ponds'. The fishponds will be bsed on polycultural management whilst the raised mounds between the ponds will provide for horticultural cultivation. (Adapted from: Denny, P. and F. Turyatunga (1992). Ugandan wetlands and their management. In: E.Maltby, P.J. Dugan and J.C. Lefeuvre (eds). Conservation and Development: The Sustainable Use of Wetland Resources. IUCN. Gland, Switzerland. Pp 77 – 84).

Tourism: Tourism is the least developed activity at present. Potential tourist attractions include birdwatching, sportfishing and boating. Further income could be obtained by charging the tourists visiting the wetland. The wetland could be promoted as a locally controlled, people – centered tourist destination and be included in Kenya's 'western circuit'.

Finally, the success of an integrated natural resource management depends on developing and implementing a comprehensive management plan drawn up by all the stakeholders. A major drawback to wetland conservation in Kenya has been the lack of clear policies guiding utilization. It is therefore important that the various stakeholders to Yala swamp wetland be identified and their needs assessed. Such a management plan would identify the various interest group needs and will spell out how the resources will be utilized to ensure sustainability and minimize resource access and use conflict.

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Gaining Public Acceptance

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Abstract

Participatory decision-making and gaining public acceptance are among the core values and strategic priorities, respectively, that the UNEP-Dams and Development Project is promoting to improve decision making, planning and management of dams and their reservoirs (man-made lakes). Although a wide consensus has been reached on these concepts, a road map to gain public acceptance has yet to be drawn. On the World Commission on Dams' perspective enabling the informed participation by all groups of people in decision making processes that result in the demonstrable acceptance of key decisions are fundamental elements of said road map. At the very onset it implies a careful definition and identification of stakeholders to ensure that all legitimate stakeholders are involved, including both beneficiaries and adversely affected groups. The establishment of norms for consultation and involvement of all stakeholders and of means for dispute resolution are also relevant elements of the process. It is further agreed that adequate and equitable compensation and/or benefit sharing for all affected stakeholders should be reflected in the outcome of the process if acceptance is sought. While transparency and involvement of all concerned stakeholders seems to be a common understanding, the means through which such involvement is achieved and the decision making process is carried on, have raised diverging views. These involve the issue of government's roles in decision-making and in participatory processes. The very concept of participatory decision-making is thus under scrutiny. In addressing these issues the paper will report on the efforts done by the DDP to further clarify the concept of "public acceptance" in the context of decision-making in water and energy development aiming at the identification of common basic attributes and/or characteristics of public acceptance processes that would gradually improve public participation in and ownership of public decisions.

Key words: Man-made lakes, decision-making, public participation and acceptance

Introduction

Reservoirs are man made lakes built with the purpose of storing water and regulating flows to serve various water uses like water supply, irrigation, hydropower generation, navigation, flood control and recreation among others. Reservoir and lakes have differences and issues in common. Differences are related to a major extent to their configuration, flow circulation pattern and retention time. Together with natural lakes they are part of the major water elements in the river basin system that should be dealt with within an integrated water resources management approach (IWRM). Reservoirs are in many aspects more challenging than natural lakes as regards river basin management. Volume, water level and outflows can be tailored to a given extent in terms of the requirements of the water uses. Frequently these requirements are conflictive among the various uses. Thus reservoirs may have better capacity to manage inflows in terms of quantity and quality but also to have a larger impact in the downstream ecosystems and the livelihoods that depend on them. Environmental and social issues associated with the dam construction and reservoir impoundment continue to condition the management of the reservoir management for long periods until they are resolved properly becoming integrated into a situation of new equilibrium, different and, hopefully, better than the initial one.

Management of reservoirs is also more challenging from an institutional point of view. In most countries the various water uses have sectoral regulatory frameworks that the developer and operator have to respond to in addition to complying with those ruling environmental and natural resources use and protection. These complexities enhance the need for an integrated water resources management approach. In the case of reservoirs such a comprehensive approach is direly needed given that significant interactions take place between watershed management, river regulation, the reservoir and the upstream and downstream areas of the basin, involving ecosystems and associated livelihoods.

Dams and reservoirs have played a role in water resources management worldwide and there are founded presumptions that they will continue to play it. Either positive or negative, their economic, social, environmental and social impacts are significant, particularly in the case of large dams. They have fuelled an intense debate characterised by polarised views in favour and against dams. Positions are usually entrenched, based in most cases on one-sided approaches to either benefits or negative impacts.

The question thus arises how to plan and manage reservoirs in a way that they contribute to sustainable development. A number of policy/normative frameworks have been established at national and international level dealing with planning and management of dams, specifically, or as a part of a more general approach to large infrastructure developments characterised by significant environmental and social impacts. On the light of standing criticism based on actual examples of social, environmental and even technical failures that continue to stir public opinion, one must concur that such frameworks are not comprehensive enough nor they are thoroughly enforced and complied with. The World Commission on Dams, drawing on an extensive knowledge base of experiences and lessons learnt, recommended a new framework for decision making that made emphasis on social justice, recognising rights and entitlements and meaningful involvement of the affected groups in project development. It should be noted here that, despite the diverse positive and negative reactions generated by the WCD report, published on November 2000, the WCD core values and seven strategic priorities have gained wide acceptance and are considered an appropriate framework to achieve “sustainable” outcomes, meaning projects that effectively contribute to sustainable development. However their implementation is still matter of discussion and providing guidance on how to address it at the national and regional level is the focus of the UNEP-Dams and Development Project (UNEP-DDP).

On the light of the above, it is concluded that achieving sustainable outcomes involves not only full consideration of engineering, environmental, social, economical and financial issues but also carrying forward a sound decision making process. This means a process that properly addresses the outstanding trade offs and risks associated with a dam project during planning and management, informs people, implements appropriate participatory mechanisms and seeks public acceptance.

The significance of the decision making process in project planning and management

The decision making process becomes then one of the substantive sustainability elements that should be addressed along the whole project cycle together with engineering, environmental, social, economic and financial aspects. This cycle is depicted in Figure 1, which attempts to put together the complex set of issues involved in sustainable dam planning and management. They refer to the so-called sustainability elements, the comprehensive project cycle, the overall water resources management context and the institutional or normative frameworks. A brief description follows:

Sustainability elements: Dams, particularly large dams, are characterised by the large scale of the interventions and their effects. Therefore engineering, environmental, social, economic and financial aspects all play a role and should be dealt with in way that they contribute to the sustainability of the outcome. This goal is catalysed by the decision making process, which ensures that these sustainability elements are properly dealt with, that trade-offs and risks are assessed, addressed and decided on the basis of participatory approaches appropriate to the planning level. The decision making process also deals with identification, information and participation of stakeholders. Appropriate participation mechanisms leading to public acceptance is a core element of the decision making process.

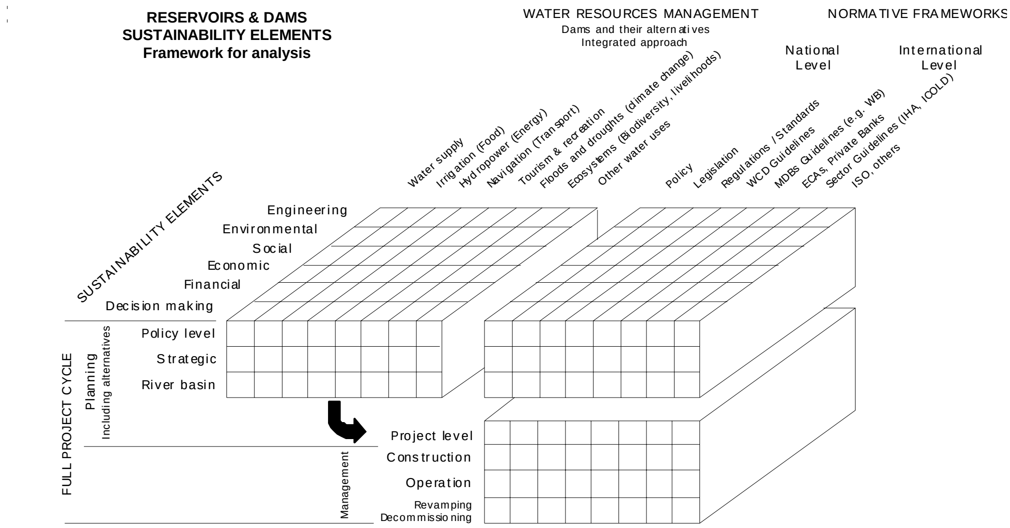
Project cycle: It is widely agreed that a decision to build a dam/reservoir should be the outcome of a planning process that considers development needs and the full range of option early in the planning cycle. Therefore a dam/reservoir project cycle should start at the policy planning level where basic decision regarding the development paths, use and protection of natural resources are set. The dams, including alternatives sources of water and energy, should be dealt with at the strategic and river basin planning levels where all sustainability elements should be given a similar stand. Once adopted as the best option the dam project is planned built and operated giving due consideration to the specific sustainability elements in compliance with the provisions of the applicable normative frameworks. The decision-making element plays a catalytic and substantive role along the whole cycle.

Water resources management: Being dams, and associated storage, a significant element of water resources management, capable of serving various water uses, the planning stage should be carried out in the context of a comprehensive and integrated water resources management approach that includes water demands emerging from all sectors, among which hydropower outstands. Alternative ways of providing the required water uses are considered in this context. The approach sought is integrated, meaning that dams and their alternatives are elements of a mixed solution that will be optimised rather than considering them as mutually excluding in a sectoral context. The conflicts between water uses are addressed at this integrated planning stage usually at river basin level giving similar standing to all sustainability elements.

Normative frameworks: They establish the criteria, procedures and standards that rule the development of the project cycle and the consideration of the sustainability elements, including enforcement and compliance elements. Because of the predominance of the national and local context in dam planning and management, the quality, comprehensiveness and enforceability of national normative frameworks are paramount to achieving sustainable outcomes. The financier sector, multilateral, bilateral and private, plays a substantive role through project selection, loan approval and conditionalities. Their safeguards complement national regulations filling gaps to a given extent and stage in the project cycle. Sector guidelines, in contributing to rule the behaviour of relevant stakeholders that self abide by them, can have a major decisive influence in achieving sustainability.

This presentation seeks to stress the importance of the decision making process in catalysing the way in which the other sustainability elements, i.e.

engineering, environmental, social, economic and financial aspects, ensure that the dam/reservoir contributes to sustainable development. Therefore its is proposed that the policy/legal/regulatory framework at country and regional level should rule about the nature and features of the decision making process concerning dams/reservoirs ensuring that it displays the needed attributes to achieve sustainable outcomes.



Decision making, public participation and acceptance

One key element substantiating the appropriateness of the decision making process is the public acceptance of the project, which can be interpreted as one indicator of sustainability. Public acceptance, meaning a reasonable degree of ownership by the stakeholders and in particular those negatively affected by the project, will reflect also that an acceptable level of compromise has been achieved between trade offs and risks from the perspective of the public. As stated above, the decision making process also deals with identification of stakeholders, providing information and appropriate participation mechanisms

The concept of Gaining Public Acceptance was publicised by the World Commission on Dams as its first strategic priority. Although large consensus has been reached on the concept, a road map to gain public acceptance has yet to be drawn. On the WCD's perspective, enabling the informed participation by all groups of people in decision-making processes that result in the demonstrable acceptance of key decisions is a fundamental element of said road map. Recognition of rights and assessment of risk to identify stakeholders, full access to information, negotiated agreements as the basis of demonstrable public acceptance of key decisions and guidance of decision on projects affecting indigenous and tribal peoples by their free prior and informed consent, are the underlying policy principles issued by the Commissioners. Reactions to WCD Report raised concerns on some of these principles, particularly regarding their implementation aspects, thus indicating that further discussion at the global and national levels was required.

The first Dams and Development Forum meeting, Nairobi July 2002, acknowledged the need to have transparency in decision-making. References were made to the need that information on needs assessment, options assessment, environmental and social impact assessment etc. is made available to all. Opportunity for all stakeholder groups to participate, fully and actively, in the decision-making process would thus be enabled. The need to carefully consider the definition of stakeholders to ensure that all legitimate stakeholders, including both beneficiaries and adversely affected stakeholders, are identified at the start of the process was raised. Establishment of norms for consultation and involvement of all stakeholders and of means for dispute resolution was considered necessary. Reference was made to factor in that the outcomes of the process should reflect adequate and equitable compensation and/or benefit sharing for all affected stakeholders if acceptance is sought The relevance of considering all these issues in the framework of the national contexts was pointed out. While transparency and involvement of all concerned stakeholders is widely agreed, the means through which such involvement is achieved and the decision making process is carried on, have raised diverging views. These involve the issue of government's roles in decision-making and partcipatory process. In order to clarify these issues decision was taken to convene a multistakeholder workshop on Gaining Public Acceptance.

Table 1: Proposed characteristics of a GPA process/procedure.

	Step/Components	Elements	Attributes/requirements leading to public acceptance
1	Stakeholder identification and involvement (appropriate to stage of planning)	Rights and risk approach Roles Responsibilities Accountability Support mechanisms to disadvantaged groups Interaction between groups International stakeholders Proactive involvement (keeping motivation)	Transparency Accountability Recognition of rights and entitlements Benefit sharing and community development (as opposed to compensation) Recognition of indigenous rights in the local context Adaptation to local culture and context. Time bound process
2	Access to information	Availability Language Formats	
3	Informed participation in decision making processes	Public participation mechanisms Participatory decision making mechanisms	
4	Demonstration of acceptance	Measures of success: Special Agreements Lack of conflict Ownership of process and outcomes	

The second Dams and Development Forum meeting, Geneva, 25-26 September 2003, provided additional direction for the proposed Gaining Public Acceptance issue-based workshop. The meeting stressed the need to further clarify the concept of Public Acceptance, in terms of common attributes or characteristics to be considered in the context of a decision-making process in water and energy development. When looking into the diversity of societies with different cultures, it is reasonable to state that “public acceptance” in one society will be quite different to another society. Therefore, there will inevitably be different approaches to implementation. Consequently a key expected output of the GPA workshop is to identify and agree on some common attributes and characteristics as well as the components of a public acceptance process that can then be an input for more detailed consideration at national levels and form the basis of appropriate policy formulation.

On the basis of discussions at the DD forum meetings the Table 1 was built summarising a proposal of components, elements and attributes of a gaining public acceptance process. Identification and involvement of stakeholders, access to information and informed participatory decision making are interrelated elements of a process geared to incorporate in the planning and management process the views, expectations and concerns of the stakeholders, particularly those negatively affected in order to reverse such condition. The flow of information is seen as a dialogue where information is provided in appropriate formats to the stakeholders and their views are acknowledged by the promoter, who informs the various groups how such views have been dealt with and incorporated into the project.

Table 1 only intends to provide just an example of the range of issues that should be considered when addressing the participatory element of the decision making process. It provides a kind of checklist of issues for discussion and clarification. Some of them are of procedural nature and project related. Others have to do with the existing local governance framework beyond the scope of dam planning and decision making. In any case their implementation will take place at country level through the various components of the policy/legal/regulatory framework. Further discussions and more refined elaborations are still needed, preferably in a multi-stakeholder context. The workshop on Gaining Public Acceptance that the UNEP-DDP is organising will be an opportunity in this regard.

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How can Web-GIS promote information sharing for participatory lake management?

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Abstract

Public participation to Lake Management can not be attained without information sharing throughout all stakeholders, especially local residents. However, it is often that environmental information, such as water quality, is monitored and evaluated by very limited researching specialists or governmental staffs. As a result, local residents tend to hold low-leveled awareness about lake environmental crises.

Web-GIS, one of the most promising IT tools, enables people to share environmental information beyond differences of geographic positions and study fields on the Internet maps in real time. Web-GIS can help local residents not only to understand environmental conditions but also to input environmental data by themselves, which raises their motivation to conserving action.

Mountainous Region Research Center, the first and only research institute for mountainous region in Japan, has developed various Web-GISs since 2002. Mountainous Region Research Center and the Environment Policy Section of Shimane Prefecture have opened the new Web-GIS called “Lake Shinji and Nakaumi Environment Information Station” which can collect water environmental data from local school students through the Internet-connected personal computers or mobile phones with global positioning system since 2004. Lake Shinji and Nakaumi Environment Information Station and the relating participatory research projects are expected to promote awareness about water environment and to evolve as a comprehensive information system about lake management.

Key words: Information Sharing, Participatory Research , Web-GI

Introduction

Need for our new “nervous system” for sustainable lake management

With the start of the 21st Century, also known as the “Century of the Environment,” each region is looking at new approaches to regional management in order to realize a sustainable society. The world is now in need of a “nervous system” stretching to every corner of the globe that will let us keenly recognize where, what and when crises of non-sustainability are happening. The World Lake Vision, launched at the 3rd World Water Forum, provides guiding principles for sustainable lake management and identifies the departure point of action with the Precautionary Principle, which needs sensitive nervous system based on wide-ranged information sharing (World Lake Vision Committee, 2003).

Information sharing crossing boundaries of regions, fields and time

The conventional framework of information sharing, whether it was environmental information or administrative information, was only advanced over limited regions, fields and periods. However, when one considers that the ecosystem is organically linked across such regional, field and time boundaries, it will be essential for the “nervous system” for sustainable lake management to realize information sharing that cross over these boundaries in a manner corresponding to the ecosystem.

Importance of information circulation originating from local residents

This kind of information sharing crossing over the boundaries of regions, fields and time cannot be realized by the conventional methods of information collection and one-way transmission of the analysis obtained predominantly by a small group of experts. Any approach that leaves out local residents will find it impossible to even observe local information on a continuing basis in the various fields of diverse regions.

Another, even a bigger problem, is that information collected and analyzed “over the heads” of local residents inspires no community motivation with respect to the vital elements of consensus formation and conservation actions.

Deployment of pioneering “participation-based survey”

A pioneering example of ordinary residents conducting survey of their local environment and sharing environmental information over a wide area was witnessed from the end of the 1980s in the “Hotaru-Das” movement around Lake Biwa. In this movement, residents living around Lake Biwa were called on to go down to conduct surveys at the water’s edge and present survey sheets including photographs and sketches concerning the habitat of fireflies. Hundreds of such survey sheets have since been collected every year, resulting in a significant research work that illustrates the waterside environment around Lake Biwa (Water and Culture Research Conference, 2000).

Appearance of web-GIS as an excellent information sharing tool

In recent years, GIS (geographic information system) have been attracting attention as a support tool for understanding regional information. Specialized GIS software enables maps to be expanded or reduced as desired and makes it possible to arrange, superimpose and compare differing layers of field-separate and time-separate data.

Web-GIS has brought such GIS functions onto the Internet, thereby enabling anybody from anywhere to acquire, input or view regional information from any place. This may be called an unprecedented information system realizing the real time sharing of information crossing over regional, field and time boundaries based on the initiative of local residents.

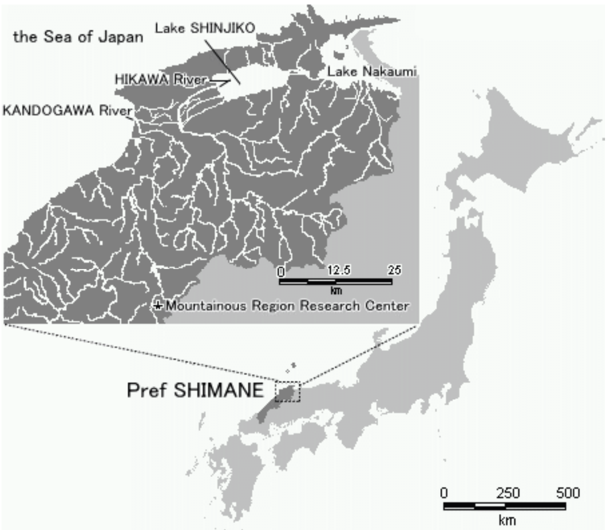

Figure1: Lake Shinji, Lake Nakaumi, Kandogawa River, Hikawa River.

Cases of lake environment information sharing utilizing GIS and Web-GIS

Towards the end of the 1990s, rapid technology development of GIS software and the Internet promoted environmental management projects in many lakes. For an example, Lake Tahoe, in the USA, started GIS-based data clearinghouse project, supported by the Executive Order of President Clinton in 1997. This clearinghouse, “the Lake Tahoe Data Clearinghouse”, managed by the US Geological Survey (USGS) in partnership with Federal, State, tribal, local agencies and groups, provides a wide range of GIS data such as Digital Elevation Model, Digital Orthophoto Quadrangle, Lake Tahoe Bathymetry, Landsat 7 data, land cover data, Census and Soil, in the website (USGS, 2005). In European countries, the Lake Peipsi / Narba River Catchment GIS database has been developed in the tri-laternal region shared between Estonia, Russia and Latvia from 2001 to 2002. This GIS database project for the transboundary waters have created 24 theme map in seven groups, namely hydrology, land cover, pedology, hydrogeology, topology, nature conservation areas and infrastructure (Hannerz et al, 2002). In Japan also, a research project for lake water quality management was operated around Lake Kasumigaura from 1995. Matsushige, Aizaki and Miura aggregate GIS data, which consist of administrative units, river network, lake area, land use, population, sewerage and water quality, to construct water quality management system for Lake Kasumigaura (2000). They made use of this system to select the target regions, counter measures and levels of water quality to attain. Taking an example of Web-GIS based on local people’s involvement, local people around Akanoi-Bay of Lake Biwa present maps about fire-flies and water quality on their Web-GIS from 2002 (Lake Biwa Research Institute, 2005). They intend to develop the Web-GIS as a tool to draw the image of present problems and to plan improvement measures.

Methods

New Web-GIS developed by Mountainous Region Research Center

Shimane Prefecture established the Mountainous Region Research Center (MRRC), the first institute of its kind in Japan in 1998. Moreover, following construction of a new building in 2002, MRRC has been operated both as a research agency conducting integrated research in the fields of society, economy, agriculture, forestry, livestock, and wildlife damage countermeasures, etc., and also as a center of local development support and information transmission in mountainous regions since April 2003. MRRC developed a new type of Web-GIS capable of responding to the issues that need resolving in mountainous regions at this time of transition.

Priority function of “participatory mapping system”

The Web-GIS of MRRC, called “Participatory Mapping System” (http://www.chusankan.jp/gis), has been developed on a platform of software based on the MapXtream of Mapinfo Co. and covers mainly within Shimane Prefecture, possesses the following priority functions.

Realization of maps based on people involvement

Anybody can input local information with photographs and can view findings in real time. When uploading information, improper inputting is prevented by requesting users to register in advance and obtain an ID and password.

Decentralized control of input information is possible

For each map, map controller authority is set so as to enable information inputted within groups and agencies to be renewed and removed. Therefore, decentralized control of the system is made possible.

Provision of research findings and administrative and statistical information on maps

Main theme maps (prepared by Mapinfo Professional) showing population data land use, etc., are uploaded onto the website in a format that enables data to be downloaded.

Enhancement of layer superimposition functions

Map images can be freely superimposed on each other. As a result, by superimposing resident-input maps and expert-analyzed maps and other maps of differing fields, types and years, it is possible to carry out comparison and linkage crossing over the bounds of status, field and time.

Flexible expandability conducive to residents' suggestions

In addition to inputting by people using the existing format, Participatory Mapping System is also open to suggestions for making new kinds of maps. Accordingly, new GIS databases including input item settings may be freely increased.

Project Examples of "Participatory Mapping System"

Making use of these functions, local people groups, NPOs and schools have operated their original Web-GIS maps. Picking up some projects relating to lakes and rivers, Hikawa River Club, a NPO for conservation of Hikawa River and Lake Shinji in Shimane Prefecture, have input the site data of Reed Recovering Project into their Web-GIS map. Joint Council for Water and Green, a NPO in the middle of Shimane Prefecture, have presented their watershed research of Shizuma River, focusing a variety of historical, cultural, landscape resources. Two elementary schools, Hata and Maki, have utilized Web-GIS maps to illustrate their outcome of firefly research in the rivers near their schools. These maps and its input item settings were arranged differently to meet the needs of NPOs and schools.

Environment Map Building in a River Basin

A representative project utilizing "Participatory Mapping System" is the "Kandogawa River Environmenta Map", which has been advanced in a joint effort by the boards of education of five municipalities in the Kandogawa River basin. In September 2002, 1,208 students and teachers of 29 elementary and junior high schools in the area conducted an aquatic organism survey in the river near their respective schools. Each school then inputted via the Internet the survey findings into the Web-GIS map. From 2003, river surveys have been carried out twice annually, spring and autumn, and the total participating students have reached up to 4,828 with 250 investigated points at the end of 6^{th} survey in spring of 2005.

Jointed Web-GISs based on MRRC's system

Started by "Participatory Mapping System", MRRC and the related section of Shimane Prefecture Government have developed 15 Web-GISs that shares the same servers and software in MRRC in 2005. These 15 sister sites consist of multi-thematic Web-GIS homepages as Table 1.

Table 1: 15 Web-GISs of MRRC and the related section.

System name (open year)	**Purpose**	**function**
Participatory Map System(2002)	Participatory Research (local people, NPO, school)	1
Forest Information Station(2002)	Forest Management (vegetation, zoning etc)	1,2
Wildlife Information Station(2002)	Wildlife Management (wildboar, bear, deer etc)	1
Gourmet Net(2003)	advertisement of foods, markets, restaurants, farmer	1, 3, 5,6
Recycling Facilities Search(2004)	easy search and navigation for the nearest facilities	6
Discover Creature(2004)	register discovering data of flora and fauna on the spot	4
Shinjiko & Nakamumi Environment Information Station(2004)	register water quality data and environmental monitoring data on the spot by participatory research	4
Water Environment Information Station(2004)	showing water quality data registered by local government	
Landslide Hazard Site Research(2005)	showing landside dangerous areas	
Afforestation Site Research(2005)	showing afforestation site by public corporation	
Child Raising Supporting System(2005)	researching facilities and activities for child raising	1,3
Communitiy Activity Research(2005)	researching good community activities	
Upper Watershed Guide System(2005)	guiding resources, land use, walking courses in upper watershed (all JAPAN)	1,3,4,7
Road Planning Support System(2005)	showing road network and effects of new roads	6
Comprehensive Land use Planning(2005)	land use planning map system for small communities	

Function 1: participatory data input, 2:two map showing, 3:accessible from mobile phone, 4: accessible from mobile phone with GPS function, 5:can input from FAX, 6:road map navigation, 7:3D showing.

With these jointed HPs, the Web-GISs of MRRC are building up multi-thematic GIS data and functions necessary for watershed management of lake and river.

Management Stuffs and Costs

The MRRC's and its jointed Web-GISs are managed by 3 staff, who coordinate participatory researches and train local people or maintain GIS database, collaborating with researchers in MRRC and the related sections of Shimane Prefecture Local government. The total running cost of MRRC's and its jointed Web-GISs is 100 thousand US dollars in 2004, including wages of 3 stuffs, maintenance of Web-GISs, renewal of GIS data, communication costs, trainings and symposiums.

Lake Shinjiko & Lake Nakaumi Environment Information Station

Lake Shinjiko and Lake Nakaumi, if both together the second largest blackish lake area in Japan, are located in the east of Shimane Prefecture and are needed to promote water quality improvement. In 2004, the Water Contamination Measure Conference for Lake Shinjiko, whose members are cities and towns surrounding the lake and Shimane Prefecture Government, decided to develop a Web-GIS for participatory surveys of water quality of the lake, which is named "Lake Shinji & Nakaumi Environment Information Station (SNEIS)". The Environment Policy Section of Shimane Prefecture Government (EPS) and MRRC cooperated to create the new Web-GIS that enable participants to input their survey data by GPS mobile phones on the spot and started a survey by elementary and junior high school students from December in 2004 as a system test.

From 2005, the participatory survey has been operated by following methods.

(1) Objecting rivers: 29 inflowing rivers into Lake Shinji

(2) Surveying months: February, May, July, September, November,

(3) Surveying items:

Elementary school: Transparency, COD, Aquatic organism, condition of river bank

Junior high school: Transparency, COD, Aquatic organism, condition of river bank, influx

Besides these items, both school groups send bottles of water at the site to the research institute which analyses T-N and T-P.

(4) Surveying flow

1. Registration: Volunteer groups of each school apply survey group registration.
2. Delivery of ID and Password: MRRC set and delivers ID and Password to registered groups by way of the executive office.
3. Preparation: The executive office sends survey equipments to each group and provides training courses if needed.
4. Execution of survey: Elementary students must be accompanied by adults.
5. Input of data: Each group inputs data into the Web-GIS from PCs or GPS mobile phones.
6. Annual report: Each group submits annual report to the executive office.
7. Commendation: Excellent groups are commended and make presentations.

(5) Executive Office: EPS

(6) GIS Technology Support : MRRC

SNEIS has another participatory Web-GIS map called "Lake Environment Monitor Map", which volunteer monitors input the results of sense check about lake environment of each site. The monitors check the conditions of their lake sites by their own 5 senses and pack test kits for COD. EPS and MRRC have also operated relating Web-GISs named "Water Environment Information Station (WEIS)", which open the water quality data investigated by governmental institutes.

Results

51 data sets of 19 sites by 19 schools, 222 data sets from 10 lake monitors

At the end of August in 2005, 51 data sets of 19 sites by 19 schools were registered in this SNEIS. Due to bad weather or busyness, some school groups failed to investigate every two months. However, this kind of wide and continuing river survey around Lake Shinji is unprecedented and one of the earliest projects in Japan that utilize Web-GIS jointed GPS mobile phones. Moreover, Lake Environment Monitor Map has collected 222 data sets from 10 sites.

Real time information sharing and mutual data comparison

As soon as each group input their data, SNEIS reflects such data renewal in real time. So, the survey participants can enjoy real time information sharing. They also can compare each data set with previous data of the same site or that of other group's. Such immediate data sharing can not be accomplished without Web-GIS technology.

No serious technical problems or accidents

No serious technical problems or accidents have been reported in this SNEIS. Most of participants, especially junior high school students have no difficulty in operating Web-GIS map or GPS mobile phones, once they are taught how to use them with simple training. At the same time, no malicious input data have been sent into SNEIS, because of the rule requesting users to register in advance and obtain an ID and password.

Discussions

Unprecedented information tool for participatory lake management

Web-GIS jointed GPS mobile phones is an unprecedented information tool for participatory lake management because of following 3 reasons. Firstly, it is almost the only one tool that enables ordinary people not only to operate wide and continuing environmental monitoring in real time but also to draw present condition clearly in maps which help themselves to understand without special theories or techniques. Secondly, GPS mobile phones are cheaper and easier information input tools than PCs, therefore monitoring activities can be shared by more people or groups as daily routine works. Thirdly, GPS mobile phones give great help to operate workshop in which groups of ordinary people research carrying the phones. With inputting data on the spot via GPS mobile phones, a research map is automatically drawn in Web-GIS. MRRC have already held this kind of workshops four times, in which citizens or students enjoyed participatory mapping process.

No alternative to human networks

Based on the author's experience in participating in the development and operation of Web-GIS, it should never be forgotten that Web-GIS is by no means something to take the place of "human networks," but is rather a system for actualizing and vitalizing the power of human networks that should already exist. For examples, the backgrounds behind the success of "Kandogawa River Environmental Map" and SNEIS are the network of relating conferences and schools.

Suspicion of data accuracy and the need of collaboration with specialists

Some people, above all some specialists, may cast doubts upon data accuracy of participatory surveys by Web-GIS. As a matter of fact, measuring skills of ordinary citizens or students are inferior to that's of specialists. However, this does not mean participatory surveys by Web-GIS are useless. If you find unusual data in a Web-GIS map, you can ask specialists to investigate the point again. Specialists can advise ordinary people how they made mistakes, or can rarely attest to the truth of the data. Both results lead us to better understandings about lake environment.

Establishment of joint Web-GIS center

If you start a new Web-GIS, it may cost over 100 thousand US dollars including hardware, software, GIS data and programming. Considering the operation cost, it is not wise to develop and manage Web-GIS independently by each institute or municipal office. The key to success of Web-GIS is the continuing employment of skilled stuffs who can coordinate information sharing among different fields, areas and time. The more fields and areas take part in Web-GIS, the less cost each field or area has to pay, the easier every stakeholder joins in participatory lake management. Just like many small streams join into one main stream, an establishment of joint Web-GIS center is necessary for each river basin or wider region such as a prefecture or a district.

Evolution to Web-GIS for comprehensive lake management

Web-GIS is one of the most promising tools for comprehensive lake management that can collect an enormous amount of data, put them into different map layers and make it possible for anyone including ordinary people to access those data. Besides data of participatory water quality investigation, MRRC have already started accumulating watershed management data such as land use, vegetation, wildlife and creature cooperating with joint Web-GISs of MRRC's. In 2005, Research Center for Coastal Lagoon Environments (RCCLE), a research institute of Shimane University, has started a joint research project of GIS database for comprehensive lake management. MRRC has joined this project and is going to cooperate with RCCLE in developing a Web-GIS for comprehensive lake management.

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Basin Community Initiatives for Environmental Protection of Lake Biwa

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Abstract

Thirteen basin organizations, called "Basin Consociation" (BC), have been established for the watershed management of Lake Biwa in Japan. BCs resemble, in terms of organization structure and organizing method, modern community-based organizations (MCBOs) that have been founded all over the nation as part of community building activities by the central government. Noting similarities between these two types of organizations, the objectives of this study were to clarify the features of BCs and consider their possibilities by comparison with MCBOs. As a result, it was revealed that BCs had resemblances to MCBOs in many aspects and, thus, BCs should be regarded as basin community-based organizations; BCs' activities had high affinity with ones for community development and aimed at not only environmental conservation but also building sustainable communities; and the form of BCs comprised of traditional community-based organizations, local organizations and people, and environmental non-governmental organizations (NGOs) was fit for Japanese society, and BCs could bridge between activities of communities and environmental NGOs as well as local people and environmental activists, and integrate the activities and people into efforts toward sustainable communities.

Key words: Basin management, Community initiatives, Lake Biwa

Introduction

Lake Biwa is the largest freshwater lake in Japan, with a surface area of 670 km^2. The greatest characteristic of the lake in terms of lake management lies in its geographical condition, in which its watershed including the lake itself is almost identical to the jurisdictional area of Shiga Prefecture.

In 2000, Shiga Prefectural Government drew up "Mother Lake 21 Plan", which is a comprehensive conservation plan for Lake Biwa of the 21st Century (Shiga Prefecture, 2000). The plan shifted the major focus of environmental protection policy for the lake from the conservation of entire catchment area to collective watershed management in each basin of major rivers flowing into the lake. To set this plan into action, thirteen basin organizations, named "Basin Consociation" (BC), have been established so far at each major river basin by the prefectural government (see Figure 1).

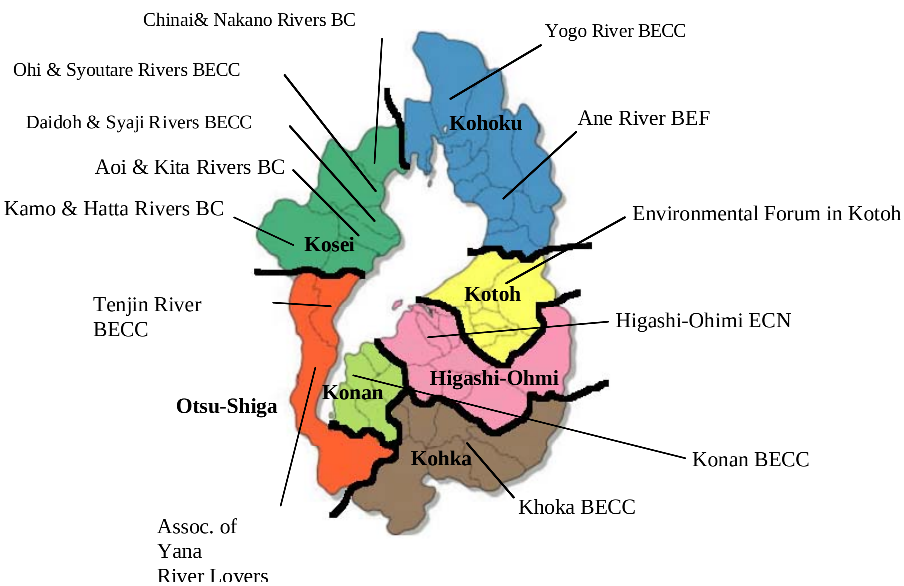

Figure 1: Basin consociations around Lake Biwa.

BCs are comprised of traditional community-based organizations (TCBOs), local organizations and people, and environmental non-governmental organizations (NGOs). In addition, Lake Biwa Basin Network Committee (LBBNC), a prefectural-wide network of BCs, was also inaugurated in 2004.

Basin Consociations are striving for comprehensive conservation of Lake Biwa through collective efforts and activities at each watershed. BCs seem to hold a great promise as a new vehicle to promote community initiatives for lake-basin management, but their abilities have yet to be revealed as they were just founded recently and have achieved little.

As described hereinafter, there are many similarities between BCs and modern community-based organizations (MCBOs) that have been created all over Japan as part of community building activities (CB activities) by the central government since the 1970s. Focusing attention on those similarities, the objectives of this study are to clarify the features of BCs and discuss their prospects by comparison with MCBOs.

To achieve these objectives, the history of CB activities in Japan and features of MCBOs and TCBOs are first to be reviewed by literature survey. Organization structure and activities of BCs are also to be elucidated with related documents and interviews with persons involved. Being compared to MCBOs, major characteristics of BCs are to be highlighted and BCs' potentialities are to be considered lastly.

Community-Based Organizations in Japan - History & Features

What is the community?

MacIver (1917) defines the "community" as that in which people live together in a specific locality, and community sentiment is fostered and common features can be observed consequently. Those features include:

(i) social likeness;

(ii) common social idea:

(iii) common custom; and

(iv) sense of belonging together.

His concept of community is counterparted with the one of "association", which is organized to pursue a specific interest(s). The community can be also regarded as a complex involving numbers of associations in a specific area.

In Japan, community building activities are quite strong all over the nation nowadays (Wu, 2002). CB activities have been promoted by Ministry of Home Affairs since 1970, in which a lot of modern community-based organizations (MCBOs) have been created. The concept and term of "community" was introduced to Japan from Europe and the United States. Current CB activities in Japan came under the direct influence of the same ones in the United States in the 1960s (Kurata, 2000).

On the other hand, Japan has had another type of traditional community-based organizations (TCBOs), which is called as "*Chonaikai*", "*Jichikai*", or so forth, from the very start (Ajisaka, 2000). As described later, a MCBO typically include numbers of TCBOs in the organization. Therefore there are two different kinds of community-based organization (CBO) today in Japan, one is western or modern style and the other traditional Japanese style, coexisting in a multi-layered and fostering an exceptional and complementary relationship in between.

Traditional community-based organizations (TCBOs) in Japan

The history of TCBOs in Japan can be traced back to "*Goningumi*" (quinternion) in the Edo-era, several hundreds years ago, or even a neighborhood group system brought in Japan from Ancient China more than one thousand years ago (Hasebe, 2001). The "*Goningumi*" system was devised as a control mechanism to rule farmers, and was also a mutual assistance system of farmers at the same time.

The "*Goningumi*" system or TCBOs were once abolished by the Meiji Government in the 1870s, but those TCBOs quickly made a comeback. In 1940 they were officially incorporated in local instruments of **municipal governments and** played a crucial role in the conduct of the World War II. As a result, TCBOs were again dismantled by the Occupation Authorities right after the war, but they again rose from the dead substantially in 1952 when the peace treaty came into force. Today *Jichikai* or *Chonaikai* can be found anyplace in Japan.

Main features of TCBOs (*Chonaikai* or *Jichikai*) are as follows (Kurata, 2000):

1. Comprehensiveness of function: it responds to any basic needs of local population;

2. Compulsory participation: all residents in a specific area must join the organization;

3. Household membership: a household is a unit of its membership;

4. Government subcontractor: it is always cooperative to governments and governments consign the organization with some administrative services; and

5. *Gemeinschaft* (of community).

A typical TCBO is composed of a few hundreds of households — some are less than one hundred and others greater than one thousand — and it is being operated by community members themselves and financially with membership fees and partly with subsidies from governments (Salamon & Anheier, 1994).

Why TCBOs could survive through the long history of Japan? In a ward, TCBO has been always needed as it is a fundamental organ for local society (Ajisaka, 2000). It ensures local security, beautifies and protects neighbor environment, cultivates mutual friendship of neighbors, provides emotional relief, goes between governments and local people, and acts as an autonomous and resistance body in case of community's crisis.

The community building activities in Japan

The community building activities (CB activities) in Japan started in 1970. At that time, a number of TCBOs were on the brink of collapse due to the concentration of the population into urban areas, urbanization of life style (individualism), and changes in family structure as a result of rapid industrialization in the 1960s (Wu, 2002). Some social problems emerged, such as juvenile delinquency and lessening local community's function of disaster prevention. People also needed some organ to tackle traffic and pollution problems and to meet their needs for higher quality of life. The community building activities were thus proposed for filling a void of traditional communities (Takahashi, 1997).

A major goal of CB activities was to create new local societies instead of collapsed traditional ones through organizing local people to form new community-based organizations and running such organizations by conscious and voluntary "citizen"s in an open and democratic manner. As a result of the activities, a lot of MCBOs and convention facilities as the centers of community activities have been established by governments across the country.

One of the main features of the community building activities is completeness of institutionalization (Kurata, 2000). To organize the population in these activities, a MCBO in a form of consociation is usually inaugurated, which is composed of all the major local organizations including TCBOs and Parent-Teacher Association typically in a primary school district. The activities also try to meet local people's diverse and high level needs such as cultural needs and human services whereas TCBOs try to meet their basic needs. The goals of MCBOs set up in the activities are very clear and stipulated as they are organized for specific purposes. In regard to this matter, such newly created MCBOs resemble "association"s rather than communities.

However, since MCBOs are typically composed of board members of local organizations, leadership cannot be manifested or is not strong enough in comparison with TCBOs, and thus they cannot act a key role in case of community's crisis.

Depending on the degree of TCBOs' involvement in the organization, MCBOs can be classified into the following three types (Takahashi, 1997):

1. (J)*ichikai*-Type CBO comprised of mainly TCBOs;
2. (C)onsociation-Type CBO of various local organizations including TCBOs; and
3. (N)etwork-Type CBO of voluntary individuals and organizations independent of TCBOs.

Basin Consociations at Lake Biwa

Thirteen Basin Consociations have been founded so far at each major river basin of Lake Biwa, as stated previously (see Figure 1 and Table 1). The major goal of BCs is to protect the water environment in respective basins, and achieve the comprehensive conservation of the lake collectively.

Table 1: Thirteen Basin Consociations at Lake Biwa.

Area	Name of consociation	Type of CBO	Date of Foundation
Otsu-Shiga	- Tenjin River Basin Environmental Conservation Consociation	J	2002/03/10
	- Association of Yana River Lovers	J	1984
Konan (South Shore)	- Konan Basin Environmental Conservation Consociation	N	2001/08/30
Khoka	- Khoka Basin Environmental Conservation Consociation	N	2001/04/22
Higashi-Ohmi (East Shiga)	- Higashi-Ohimi Environmental Conservation Network	N	2000/07/05
Kotoh (East Shore)	- Environmental Forum in Kotoh	N	2001/05/24/
Kohoku (North Shore)	- Yogo River Basin Environmental Conservation Consociation	C	2001/05/20
	- Ane River Basin Environment Forum	C	2002/08/07
Kosei (West Shore)	- Kamo and Hatta Rivers Basin Consociation	C	2001/06/29
	- Chinai and Nakano Rivers Basin Consociation	C	2001/09/24
	- Ohi and Syoutare Rivers Basin Environmental Conservation Consociation	C	2002/10/03
	- Aoi and Kita Rivers Basin Consociation	C	2003/09/08
	- Daidoh and Syaji Rivers Basin Environmental Conservation Consociation	C	2003/12/04

J: *Jichikai*-Type, C: Consociation-Type, and N: Network-Type.

Table 2: Activities of Basin Consociations and their constituent members.

Constituent Members	Activities
Basin Consociation	symposium, study meeting, environmental education, transmission of information, waste reduction & recycling, local production for local consumption, headstream exploration, water quality conservation, cleanup activity, eco-tour, environmental research (aquatic life, water quality, bird)
Local office of the prefectural government and municipality	Symposium
Jichikai or *Chonaikai*	cleanup activity, beautification campaign
Parent-Teacher Association	environmental education, cleanup activity
Junior Association	cleanup activity
Consumer group	use-of-soap promotion, local production for local consumption
Mizusumashi (Farmer's) Consociation	agriculture of environmental conservation type
Local organization	waste reduction & recycling, local production for local consumption, environmentally-sound fishery, headstream exploration, forest conservation, making bamboo charcoal, photograph exhibition, water quality conservation, cleanup activity, tree planting, transmission of information, organic farming, traditional arts, eco-village, eco-tour, environmental education, clipping reed, environmental research
School official	environmental education
Individual (forest instructor, bio-environment adviser, environmental initiative promoter, environmental conservation counselor)	environmental education, environmental research

Table 2 summarizes activities of BCs and their constituent members. As shown in the table, activities conducted by BCs and their members are quite miscellaneous. The variety of those activities can be attributed to the one of BCs' constituent members. When a BC is organized, all the major local organizations including TCBOs and environmental NGOs in the area are to be invited to join. BCs are also open to local residents and being operated in a transparent and democratic manner.

At the same time, activities of BCs and their members are not limited to the conservation of water environment, as shown in Table 2. Those activities include recycling, organic farming, forest conservation, and so on, all together aiming at comprehensive conservation of each basin environment. In addition, BCs even include such groups working for cultural-preservation. In short, BCs are striving to meet needs of local people, who ask for higher quality of environment and life, and realize sustainable communities in respective basins.

The method of setting up a BC is quite different from one consociation to another since it was left to the local office of the prefectural government at each region for adapting to the circumstances. The forms of organizations are thus fairly diverse. BCs can be also classified into the aforementioned three types of CBO depending on the degree of TCBOs' involvement in the organization.

Out of the thirteen BCs, the number of *Jichikai*-Type is two, Consociation-Type seven, and Network-Type four. For example, the Tenjin River Basin Environmental Conservation Consociation and Association of Yana River Lovers are both based on the southwest shore of Lake Biwa, which are typical *Jichikai*-Type BCs and made up with only several TCBOs.

Four BCs in Konan, Khoka, Higashi-Ohmi and Kotoh Areas are all Network-Type BCs. The Higashi-Ohmi Environmental Conservation Network in Higashi-Ohmi Area is a typical Network-Type BC consisting of eleven environmental preservation groups that have been very active in the area. Seven BCs in Kohoku and Kosei Areas are all Consociation-Type BCs composed of a wide rage of organizations including not only TCBOs but also other local associations in the areas.

Those areas with four Network-Type BCs are situated in the south to west shores of the lake, where it is densely populated and there are a lot of residents moved in from outside of Shiga. On the contrary, the other areas with *Jichikai*- and Consociation-Type BCs are sparsely populated and most of people have lived since their birth. People in the latter areas tend to be more conservative than ones in the former areas.

It should be, however, noted that even a Network-Type BC may include in the organization other types of BCs, which involve TCBOs. For instance, Akanoi-Biwako Environmental Citizens' Initiative (ABECI) is a Consociation-Type BC as well as a member of the Konan Basin Environmental Conservation Consociation (ABECI, 2003). ABECI founded in 1996 is the first BC created at Lake Biwa and one of the leading environmental protection groups in Shiga, working very hard for restoring to original state municipal rivers in Moriyama City and downstream Akanoi Bay situated on the southeast shore of Lake Biwa. The present number of membership is more than four hundreds including almost all TCBOs in the city, a farmer union, women's associations, and individual members.

While ABECI is a typical Consociation-Type BC, it has been, under the strong leadership of board members, developing remarkable activities such as clean up activities of municipal rivers, cultivation of fireflies (lighting bugs), making city maps of water quality and fireflies with a GIS system, and information dissemination through the Internet. Another feature of ABECI is active exchanges with overseas' lakes and activists. It convened two international sessions at the 9th World Lake Conference in 2001 and the 3rd World Water Forum in 2003. When environmental activists come to Lake Biwa from abroad, most of them visit this organization. Energetic PR activities to the world and international exchanges are a strategy for them to raise members and to bring together the organization as well as tools to appeal their activities.

Whereas ABECI is promoting activities with advanced IT technologies or international exchanges, it still emphasizes down-to-earth activities of TCBOs in the organization. Those TCBOs have been also very active in the environmental conservation of each area. Members of the TCBOs, namely local people, have protected the vicinal environment over the ages by themselves. Their activities are usually conservative, but very continuous and sustainable at the same time. Such TCBOs activities collectively back up the sustainability of ABECI's entire activities.

Discussion and conclusions

As described above, BCs have resemblances to MCBOs in many aspects. It is conceivable that BCs were created on the model of MCBOs particularly in terms of organization structure and organizing method. Environmental movements by BCs at Lake Biwa are nothing but CB activities by Shiga's people. Although the geographical area of activities by each BC is larger than a primary school district, it is still confined to a specific locality, the watershed of respective major rivers. In that context, the BC is a form of CBO and the one that should be called "basin community-based organization".

Owing to similarities between BCs and MCBOs, BCs' activities have high affinity with ones for community building or development as partly shown in Table 2. Environmental issues are quite diverse and demanding today, which can be hardly differentiated from ones concerning the quality of life. BCs' activities should be regarded as not only environmental conservation ones but also community initiatives toward realization of sustainable communities around Lake Biwa.

However, BC is not almighty as matter of course. Not all the BCs are as active or successful as ABECI are. There are still many problems remaining for BCs. What BC can do by itself is very restricted due to its human and financial resources. Furthermore, it can be functional and effective only for issues of its own basin. To address environmental issues related to wider areas, the roles of networking organization such as LBBNC come to be important.

The worst weakness of BCs is that they are financially dependent of the Shiga Prefectural Government. Fortunately we can see a silver lining today. ABECI, which was initiated with 100% financial support of governments, became an incorporated nonprofit organization and stood on its feet in October 2004.

The community building activities in Japan were adapted from the United State. However, MCBOs created by the activities have brought TCBOs in the organization and evolved flexibly, playing a crucial role today in Japan. BCs have a great potential also to fulfill an important role in society as well as environmental conservation. BCs are unique as an organization in that they are comprised of TCBOs, local organizations and people, and environmental NGOs, which is also a great asset for BCs. As is the case with MCBOs, BCs are gifted with features of both the community and association. BCs have the ability to bridge between activities of communities and environmental NGOs as well as local people and environmental activists, and integrate the activities and people into efforts toward sustainable communities

Community-based activities are essential particularly for environmental conservation of lakes and rivers (Avramoski, 2004). Local water should be protected by the local community. BC-type CBOs would play more and more important role in the conservation of water environment in Japan.

In this study, the author revealed main features of Basin Consociations (BCs) at Lake Biwa and discussed their possibilities. As a result, it is concluded as follows:

1. BCs resemble, in many aspects, modern community-based organizations (MCBOs) that have been founded in Japan as part of community building activities and, thus, they should be regarded as basin community-based organizations;
2. BCs' activities have high affinity with ones for community building or development and aim to not only protect the environment but also build sustainable communities in respective basins; and
3. Since BCs are comprised of traditional community-based organizations, local organizations and people, and environmental NGOs, BCs have an institutional form fitting for Japanese society. BCs have the ability to bridge between activities of communities and environmental NGOs as well as local people and environmental activists, and integrate the

activities and people into efforts toward sustainable communities.

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The Activities of the Environment Conservation for the Firefly: With the partnership between the Local Government, a case from Japan

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Introduction

Akanoi-Bay in Lake Biwa

Moriyama city, located in the Akanoi-Bay sub-basin of the Lake Biwa watershed, was once famous for fireflies (lighting bugs). However, the rich natural environment in which fireflies had thrived became degraded because of rapid population growth, urbanization and industrialization after 1965, and they disappeared from Moriyama (Akanoi, 2002). Also, there was an outbreak of blue-green algae bloom around the area of Akanoi-Bay, which was a very shocking change since it was the signal telling us how the lake water became polluted. We realized that we sacrificed the nature environment so much and that the price we paid for convenient modernized life was so large (Nagao, 2005).

From people's voice and movement

These phenomena caused the sense of crisis both in people's mind and the Shiga Prefecture. In 1970, housewives initiated the Soap Movement, a campaign encouraging people to use natural soap instead of detergent. The movement was powerful enough to have the Prefectural Congress declare the Eutrophication Control Ordinance in 1979 and enact it next year (Nagao, 2005). Akanoi-Biwako Environmental Citizens' Initiative was established in September 1996 in order "to bring back the natural environment for fireflies" and eventually "to make the Akanoi-Bay water environment better." (Akanoi 2002; Nagao 2005)

Footpath of AKANOI

Talks with the Local Government

To pursue these goals, at first, we needed to obtain the support and understanding of Shiga Prefectural government and Moriyama municipal government in terms of finance and practice. If it had not been the support from Shiga Prefecture and Moriyama city in the beginning, our organization would not have been established nor grown as it is today.

The start was not very peaceful as many NGOs/NPOs are established. At first, there was a sudden request to organize 4 cities in the Akanoi-Bay basin in order to make Akanoi-Bay environment better from prefecture officers in a meeting. It made the local people feel just like damped a big work with one utterance or only names and titles without any actions. We were bored of their rubber-stamped attitude toward the environment problems. However, the only one condition suggested by the government was "the Shiga Prefectural government and Moriyama City government provide the organization with financial support and no words." It was new and appealing to us, that is, it was a fresh idea that "all is undertaken within initiative of the local people" showing the new direction of the water environment conservation, with which we agreed (Nagao, 2005).

We also hoped to play a role as a hub for local people. The process of building the partnership with these stakeholders was not easy and there was even a time of confrontational relations between the local governments and us, among us. However, we did not give up building up the partnership in order to achieve the goals.

Main activities of AKANOI in the partnership with Local Government

In this section, we focus on our main activities implemented within the cooperation or collaboration with the local government among our all projects (all the project of our organization is given in Box.1). Some of them were also cooperated largely by local communities or supported by other enterprises1.

Firstly, we prepare a draft of our annual activity plan for the next fiscal year2, which is the same as that used by the local government. Secondly, we propose some plans, which are related to the city, to the city with their budgets. Before they are placed on the city council, we have to explain and discuss with city officials on them. Sometime they are cut down to a certain extent, as a matter of course. The plans approved by the city council are entrusted to us with their budgets. Thus, we have conducted the project in general cooperation with city government. In other words, it can be said that we have realized each step to our goals by having proposal approved by the city government.

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1 For technical support, we had many assists from Lake Biwa Environment Research Institute (former Lake Biwa Research Institute) of Shiga Prefecture and a few universities.

2 Fiscal year used in Japan is from April through March next year, e.g., the fiscal 2005 is from April 2005 through March 2006.

The detail of our activities within the partnership with Local Government

Water quality monitoring

There are 8 main rivers flowing into Akanoi-Bay, Lake Biwa, through Moriyama city and each river has many tributaries running through local villages. We have fixed approximately 100 observation points on those rivers and tributaries. The river water is monitored at each point 5 times a year and all the data are recorded.

We monitor the following items: water quality, potential of hydrogen (pH), transparency, water temperature, width, depth and flow velocity of the river and creatures living in the river. In terms of water quality, the figures of phosphorus, nitrogen and Chemical Oxygen Demand (COD) are used as indicators or measurement items (Table.1). In order to measure these items, we use “pack test”, a set of equipments with which people can check the above chemical items in the water.

Table1: Indicators and measurements Items.

Phosphorus: phosphoric phosphorus:	0.066 ～ 3.3mg PO_4^{3-}-P /litter
Nitrogen: nitric nitrogen:	0.23 ～ 10mg NO_3^--N/litter
Chemical Oxygen Demand (COD):	0 ～ 10mgO/litter
Transparency:	0 ～ 100cm
pH, BTB test paper:	6.2 ～ 7.8

Study and research of the firefly, *Genji-botaru*

One characteristic of our activity is that we use one of the fireflies as a biological indicator. There are around 2,000 kinds of firefly in the world and 46 in Japan. But one of them, which is called *Gennji-botaru* in Japanese, is found only in Japan, has special features in its growing process. Its scientific name is Luciola cruciata Motschulsky.

The eggs of it are laid just nearby a river around early June. One month later, they hatch and jump into the river. They can inhabit clear water only, as aquatic glow-warms, larvae, for about ten months till next April. Then they go on shore, get into underground, and become pupas. After one and half month, they come out on the ground, take off into the air lightning on and off.

It may be sound curious to you, but we, Japanese, like to see the fireflies flying at early summer evening. In the old days, before 1940, a lot of firefly inhabited in Moriyama City, and it was so famous, that the people living near our city came to see them. But they once died away because of environmental pollution. And now, most of Moriyama citizen are aware that they cannot inhabit in polluted river.

So we have taken up the firefly as one of the biological indicators, and been studying their inhabitable situation. Responding to our activity and citizen’s requirement, Moriyama City has enforced regulations protecting a firefly on 2001.

Environmental education

It is also important for us to promote environmental education and to raise awareness in both school children and their parents. For this objective, we have three activities implemented with understanding of Moriyama city: Akanoi-Bay Exploring Study Tour, River Watching, and a School on Waterside.

Firstly, as for Akanoi-Bay Exploring Study Tour, every summer we take children and their parents on Lake Biwa by several boats getting cooperation of Moriyama Fisherman’s Union. On the lake, we watch the condition of the lake, collect creatures and mud of bottom and draw water. After coming back to fishing port, we study the creatures and check the water quality receiving biologist’s guidance. We record the result of the year and compare it with the result before. We ask questions to biologist and/or exchange our opinions.

Secondly, as for River Watching, we hold this event twice a year. On the days, we walk down along a few rivers with them from upper stream to down stream observing the condition of the river, studying what kind of aquatic plants and animals are and their increase and/or decrease comparing with previous year.

Lastly, three times a year, we hold a one-day School on Waterside, where we show them what kind of environment is necessary for not only aquatic creatures but our life, and tell them the names of aquatic plants and fishes with their properties.

BOX.1: The Activities of AKANOI

Research and Betterment Group

Model Rivers
Monitoring Water Quality
Research of Aquatic Botany
Akanoi-Bay Exploring Study Tour
River Watching
Environmental Education Group

Community Information Network Project

Sharing information on the network among the community
Presentation of Outcomes

Expert Activity Group

Study and Research of the Firefly
Biotope
School of Medaka (Rice-fish)
Survey of Firefly / Guide for Firefly Watching

Publicity Group

Make Water Environment Saloon open and comfortable
Newsletters
Website (Japanese and English)
Publicity and Announcement in Events

Firefly Park & Ride Project
The 11th World Lake Conference, Moriyama Session (2001)
The 3rd World Water Forum in Moriyama (2003)

Information exchange and publicity

Publicity is also an essential part of our activities. We issue the newsletter four times a year and distribute them to each household in the city. The newsletter includes announcement of our activities, the result of water quality monitoring, other programs and etc., and they are reflected onto our web site. Some of the issues were written in English as well.

Outputs and outcomes

As the result of the activities above that were undertaken with understanding of Moriyama city government, we were able to gain some outputs and outcomes.

Improvement of water quality and firefly are back again

Thanks to many efforts by all the participant, members and to understanding by Moriyama city government, the water quality of river in the Akanoi Bay basin has become much better. In particular, the figures of COD, transparency and nitrogen show remarkable improvement compared to those in 1997 (Akanoi, 2005). Furthermore, the firefly once disappeared began to come back to the stream in our basin. This proved that our activity and continuous commitment paid, and it also meant that we were able to achieve one of the goals, "to bring back the natural environment for fireflies." Today, fireflies are seen in some streams in the basin in the early summer (from the beginning to mid of June). The number of fireflies are reported, recorded and uploaded in GIS map in the website (Akanoi, 2005). Regarding the report of the numbers, there were many efforts of the volunteer members of our organization and the local people.

The efforts of Moriyama City cannot be ignored in terms of the improvement of water quality regarding the two points. The first point is their effort for diffusion of the sewage system in Moriyama. The diffusion rate had increased to 95% in 2004 from only 53% in 1996 (Moriyama City, 2004), and this can be the largest contribution to better water quality. The second point is the Firefly Ordinance by Moriyama City government. This ordinance was adopted and enacted in 2001 by receiving the voice from the city citizens (Akanoi, 2002), and Moriyama City performed for their voice. This means that our organization contributed to the city planning by proving the Moriyama City government with information fitting to the people's needs for the nature environment. The partnership between Moriyama city and our organization is tied with citizens' needs, awareness and commitment.

On the other hand, the quality of water seems to be improved, we still have the problem that the figure of Biological Oxygen Demand (BOD)3 is not improved very much, and water quality of Akanoi-Bay has not improved yet either.

Higher awareness of people

Active involvement and actions are arisen from citizens autonomously. In a case of underground water pollution because of discharged water from a factory4, for example, the citizens in the area noticed it and reported to the city government. In

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3 Regarding BOD, AKANOI does not measure BOD in its water quality activity; however, AKANOI pays attention to the BOD and its figure/numerical data reported officially.

4 The wastewater from factories has been controlled by the Pollution Control Law and a more stringent ordinance, which was amended by Shiga Prefectural government based on the Pollution Control Law enacted in 1971.

another area of city, the residents who found that wastewater had been discharged from a launderette directly into the river without any treatment. They reported it to Moriyama City government, and the city government talked to the laundrette owner and persuaded to do appropriate treatment of wastewater from the laundrettes. The owner reacted quickly and it was not long before that the problem was solved after the talk between the owner and the city government.

Their autonomous actions were impeccable so that Moriyama municipal government responded them respectably and required those companies to take care of the wastewater with appropriate treatment. These actions were not occurred because we asked them to do so but emerged from their own awareness trying to make the environment better. In other words, our activity enabled people not only to have higher awareness of their own roles and responsibilities but also to become leaders in their areas or communities for environment conservation.

Meanwhile, we recognized each autonomous action by citizens and wanted people to share their information, knowledge, actions and activities with more communities. This brought our organization to establish "*Kawa zukuri Net* (River Networking)". In this network, AKANOI plays the role of hub providing people with information on activities in each community. The information and activities shared within the network is regularly uploaded on to the website so that it can be seen by the local government and all the citizens.

Model project consigned from the Ministry of the Environment, Japan

This year, fortunately, the accumulation of our activities was recognized by the Ministry of the Environment, Japan as one of the models for the lake basin management. AKANOI was selected and funded to implement a project of the participatory lake basin management. This was a big encouragement and made us proud of what we have pursued, i.e., our continuous small activities. The morale among the members has been more raised, and the project is now being carried out by the stakeholders inside and outside of the Akanoi-bay basin. Not only the members of AKANOI but also professors, experts, and young college students have been involved and committed deeply in this project. This is an asset of our organization for the next step in the future.

Way forward – quality improvement

We have achieved in raising awareness in the citizens and building the partnership with the municipal government. It can be said that we also succeeded in becoming independent as an organization in terms of planning and implementing projects. However, there are still two more important perspectives for us to overcome, which are 1) improvement of project quality and 2) financial independent.

Firstly, we need to improve the quality as a non-profit organization, that is, organizing and managing skills in the project. We hope to develop our project performance and to provide unique services and programs reflecting our experiences. This enables us to produce unique services or projects, which may have people eventually distinguish us pioneer for the water environment in Akanoi-Bay basin.

Secondly, financial independence needs to be taken into account when we think of the long-term future. Although one of the biggest assets of our organization is the volunteer, it is difficult to pursue the activities only with their power. We also need to have the finance management strategy as well as volunteers. We need to think of the matter of improvement of organizing skills vis-à-vis the matter of financial management skill, or vice versa. The output brought by human power in a project can be the indicator for society to assess the organization. When the result of assessment is good, it encourages the morale of people involved in it and strengthens the organization further. This cycle ultimately forms the basis of the financial independence for the next step (Nagao, 2005). We have hoped to establish an organization that is independent in project and finance by the initiative of local people or the participatory initiative, that cooperates with other various organizations, that speaks clearly and equally, and that build up and encourages the partnership among all of industry, government, academia, NGOs, NPOs and people/community (Nagao, 2005).

Mr. Iijima, the Director of NPO, Asaza Foundation, Japan, gives profound comments on this by claiming that few NPOs in Japan have management strategies. He also asserts that raising-awareness nor simple dissemination is not enough, and organizations should have the policy or business plan. Moreover, he adds that many people complain that they have little money, but actually, they just do not have idea come from creativity (Omi Environment Conservation Foundation, 2004)5.

We have succeeded in gaining the partnership with the local government and in bringing back the nature environment for fireflies in Moriyama although the dramatic change has not yet seen in water quality of Akanoi-Bay. However, the vision of the organization including skills and strategy can be important for us these days and it is the key for the next step. It is not very easy for a small non-profit organization to survive; therefore it should be very practical for us to become a visionary organization or to visualize our goals clearly in order to build up the continuous partnership.

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5 The original was published only in Japanese, and English paraphrase used here was done by the author of this paper, Naoko Kimura.

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The role of local communities in managing Lake basins

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Abstract

According to information available in literature, communities in many developing and developed countries have played a significant role in the management of lakes and their basins. The common findings and observations derived from reviewing the roles played by Kenyan and Japanese local communities in lake basin management are that; the communities feel attached to the values and functions being provided by the lake ecosystem, they are composed of community membership organizations which are run by conscious and voluntary "citizens" in an open and democratic manner and the community organizations aims at satisfying their members need for higher quality of life. On the contrary to the Kenyan situation, most of the community organizations in Japan were established based on traditional community organizations – *Chonaikai* or *Jichikai* – and are officially incorporated in local instruments of municipal governments throughout the country, they are operated financially with membership fees and partly with subsidies from governments, they respond to any basic needs of local population, they involve compulsory participation, a household is a unit membership of an organization and they are always co-opted into the government, which assign them with some administrative services. The paper concludes by generating information useful to planners, water resources managers and administrators in relating to the use of local communities in lake basin management in achieving national, regional and local goals

Key words: Community, Organizations, Lake Basins

Introduction

Lake basins have played an important role in sustaining people and other forms of lives through centuries. Social - economic and industrial development has occurred hand in hand with the availability of clean and reliable water resources; communities settled and were forced to migrate to areas where water was available. Caponera (1992) called these social groupings as hydraulic civilizations.

Lakes are natural entities in which fresh, brackish or saline waters and a mixture of interacting living and non-living components can be found. They play a pivotal role in the water cycle and in nearly all forms of life cycles as a source of bio-diversity. They are the reservoirs of the much needed freshwater and are repository of mankind's pollutants as well as from natural activities within and outside their basins. Far more serious in its effects has been the failure by developing nations to enforce adequate industrial pollution controls, where, in their desire to keep costs down and maximize profits, industries are content with standards, which would be unacceptable in the developed world (Cleary 1989). It is by this fact that their wise-use and good management in the 21st century has gained a lot of impetuous. In general, worldwide and especially in developing countries, communities living in lake basins are faced with severe poor water quality and water shortages for their uses. Therefore, how the lake inflow river waters are managed is critical in poverty alleviation, improving health standards and food security.

Key threats to most lakes include loss of forest cover in upper catchments and along inflow rivers, unsustainable agricultural and fishing expansion, population growth, poorly placed tourist facilities, urban settlements and agriculture, and failure of local, national and regional institutional structures. The results from these threats are some typical problems facing the world's lakes including; biodiversity loss, climate variability, eutrophication, diminishing exotic species, overfishing, pathogenic contamination, salinisation, siltation, toxic contamination and water level decline (WB/GEF, 2004). With the trends, which most African lakes are taking, the importance of the aquatic resources within the lakes, as well as the supply of fresh water from them, cannot be overemphasized.

Having said that, it is important to note that all is not lost because citizens and other stakeholders have been encouraged to participate meaningfully in identifying and resolving critical lake problems. For example, in Kenya, there are many groups named as friends of lakes and reservoirs whose aim is to protect these water bodies from severe degradation. The Friends of Lake Victoria – OSIENALA is one of the groups. Likewise, in Japan, lake protection movements are from the citizens, the Akanoi – Biwako Environmental Citizens' Initiative is one of such groups.

It can be concluded that managing lakes means managing people and peoples' behaviour at individual, household and community level determine the successes in managing lake basins. When people are involved, they provide individuals and groups with forums where their views are communicated to decision makers (bottom-up and consultative process).

This paper will therefore give an overview of the roles played by local communities in lakes management at their hydrological boundaries (lake basins). It will compare local initiatives by Kenyan and Japanese communities in lake basin management and show how these communities have been constituted. The paper concludes by generating information useful to planners, water resources managers and administrators in relation to the use of local communities in lake basin management. The reader will realize that the forms of decentralization processes are not discussed in detail

Communities and lake basins

Populations do not live in isolation, but rather live together in a particular area and often interact in various ways. It is now becoming clearer that people's lives and influences extend far beyond themselves. For example, communities living along lake shoreline have as much influence on the lake as those who live in the upper catchments and along rivers. In most cases, competition occurs when people make use of the same limited lake basin resources. However, in many cases, competing individuals do not interact with each other directly, instead they are affected by the reduction in the common resource (exploitation).

In lake basins, problems emerge between water and land-use interactions, environmental and social effects of water resources development schemes and problem of access to, and allocation of water resources among competing uses. Oya (2004) pointed out that although lake basin forms a convenient spatial unit for water resources development and management, the increasing use of land and water resources in the basins has pointed to potential conflicts. A good example is between upstream and downstream areas or between different sectors such agriculture, fishing, and industry. The major categories of such conflicts from a lake basin perspective include: contamination of water through upstream land-use activities adversely affecting downstream activities; excessive water extraction due to the upstream land use activities resulting in water shortages in the downstream areas; deterioration of watershed ecological functions owing to removal of forest cover through logging, land settlement and spontaneous expansion of agricultural land resulting in increased flooding, drought, and sedimentation in downstream areas; and increased pressure to construct dams and reservoirs in the upstream for the benefit of downstream communities, giving rise to adverse socio-economic effects on the upstream communities.



Continued deforestation of the Mau forest threatens people's lives with flooding and the drying up of River Mara; this has direct negative effects to Lakes Nakuru and Naivasha.

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Who should speak for lake basins?

There are few cases where governmental organizations have been effective representatives of lake basins. This could easily make someone to conclude that the answer to the above question is: No one.

In responding to the challenges posed by water problems, the Lake Biwa Comprehensive Management Plan and the Lake Victoria Management Environment Programme (LVEMP) were formulated in Japan and Kenya in 1972 and 1997 respectively. But it has since been realized that an effective strategy for water resources management requires some entity or entities – public-private, or mixed public and private – to speak for the lake basins interests involved. The Lake Naivasha Management Committee (LNMC), Friends of Lake Victoria (OSIENALA) and the Akanoi-Biwako Environmental Citizens' Initiative are examples of some of the public – private entities or association formed to manage basin crises related to water pollution, flood or drought control. The local communities within the lake basins have spearheaded most of these associations.

Institutional setting

Institutions are organizations or establishments founded for a specific purpose based on a set of working rules originating from an established custom, law or relationship in a society or community. In most cases, these organizations are formed after a series of sectoral conflicts on lake basin resources utilization, upstream-downstream water pollution, land degradation and extreme natural calamities like prolonged drought or flooding years with a substantial part of the population at the verge of perishing. From the afore mentioned reasons, it can be noted that the need for lake management on their hydrological boundaries is mainly triggered by the growing competition for water or by the need to co-operate in upstream-downstream relation for flood control or both.

In forming institutions, it is imperative to note that they should operate on hydrological boundaries, rather than on administrative boundaries; this is because water (both surface and ground water) simply tends to flow down and it does not stop at the boundary of the district or the region. If institutions operate on administrative boundaries, the following could result:

a) Cumbersomeness in conducting water allocation.

b) Cumbersomeness in setting water use priorities

c) Cumbersomeness in carrying out flood control measures.

d) The respective authority (e.g. province, District etc.), may be induced to monopolize the water supply sources within its area and transfer the problem of flooding or water pollution to downstream.

Lake basin management: Kenyan versus Japanese local communities: a case study

Most of the lake basin communities have an attachment to the values and functions that lakes provide to them. Lakes have in many generations provided cheap protein sources, building materials and are sources of interest and inspiration for people of all ages. By trying to protect these lake functions and values, communities living adjacent to lakes come up with informal or formal organizations that cater for their interests. It is after some time that other communities within the lake basin join hands to protect the basin at large. This normally occurs after sectoral conflicts on using the lake resources or polluting the lake itself.

The establishment of these organizations varies from one lake basin to another and from one country to another, depending on the ideals, culture and historical background of those communities. In Kenya, lake basin organizations have been due to both government policy directions e.g. Lake Basin Development Authority as well as individual / sectoral initiatives e.g. OSIENALA and Lake Naivasha Management Committee (LNMC). In most cases, membership to these organizations is voluntarily and is very formal. Where no membership registration fee is required, a member or membership sector will have to meet the cost of running the organization. All in all, the community organization will aim at satisfying its members need for higher quality of life and solve sectoral conflicts.

Contrasting the Kenyan situation with that of Japanese local community organizations, these organizations are established based on traditional community organizations (*Chonaikai* or *Jichikai*). The organizations are officially incorporated in local instruments of municipal governments through out the country and they respond to any basic needs of the local population. They are operated financially with membership fees and partly with subsidies from governments. They involve compulsory participation and a household unit is a member of an organization. The government has come to identify them as useful administrative organs and therefore it assigns them some administrative services.

Although it can be said that community organizations in Kenya have played a significant role in lake basin management, it is imperative to note that the local communities have come to identify them as elite groups and have therefore found it hard to sell their ideas and indigenous knowledge for the sustainable use of lake resources within and outside the basin. The National Wetland Policy 2005 has tried to resolve this impasse by incorporating indigenous knowledge in lake management. It has identified and outlined ways in which locals are encouraged to participate in creating an enabling environment for sustainable development and management of lakes. The Water Act 2002 and the Environmental Management and Co-ordination Act 1999 also support this Policy.

The activities that these community organizations undertake have resulted into positive changes. For example, a SIDA 1998 report quoted by Ong'ang'a *et al* (2003), painted a terrible picture of pollution from all sides of Lake Victoria Basin. Effluent released from Agroindustries had a BOD value of 95,000mg/l, far much higher than the recommended World Heath Organization value of 100mg/l. According to Ong'ang'a *et al* (2003) things improved with the efforts made by OSIENALA by campaigning to extol the virtues of waste treatment to the managers of major sugar factories and Agrochemicals and Foods industries.

In Japan, Yahagi River had murky waters problem due to rapid urbanization and industrialization (Ide 2005). To protect the river water quality, citizen's movement started with the initiatives of affected farmers and fishermen in 1962. In 1969, the river water pollution was at its peak, when the Yahagi Water Quality Conservation Consociation (YRWQCC) was established. The consociation conducted protest activities for protecting the river water quality. Later it realized that both downstream and upstream should understand each other and cooperate; because of that, the YRWQCC shifted its direction of activities to environmental conservation with dialogue and collaboration. In the end, a citizen's movement initiated by farmers and fisher folks in Yahagi River Basin has successfully motivated and involved local administration and other organizations and has increased people's consciousness that they must not dispose of polluted waters.

The formation of was a long and tortuous journey. It is a stakeholder representative forum established to address issues of Lake Naivasha and its environs. It has the mandate to implement the gazzetted Lake Naivasha Management Plan, which it has developed; and has been recognized by the Kenya Government as a legal instrument in Lake Basin Management. The Lake Naivasha Riparian Owners Association initiated the LNMC. The land below the arbitrary chosen lake level of 6,210 ft a.s.l (1892.8m a.s.l) was put into their custody in 1933 where no permanent structures are allowed to be built on. This proved to be a wise move, since it has protected the riparian/shore line from degradation. The committee has achieved a lot in bringing different stakeholders into a round table to discuss their interests and those of the lake basin.

From the above-mentioned examples, citizen participation can be considered to deepen stepwise from information sharing to consultation, collaboration and empowerment. UNEP (2000) stated that to achieve the objectives of eutrophication control, public participation throughout the period of decision-making is required. It is therefore important for decision makers to consider environmental education and community participation as a priority in their national and local environmental policies. This is because it is easier for people to accept policies, even difficult or controversial ones, when the importance and nature of the problem is properly presented to them.

Conclusions

Local lake basin community organizations in Kenya and Japan have been autonomous and implementation bodies for environmental protection in the basins. As a matter of course, these organizations are not almighty and what they can do by themselves is limited due to human and financial resources. The community organizations established in the community activities have same drawbacks. In order to address issues related to the environment from a wider perspective, roles of secondary stakeholders like the Non-Governmental Organization (NGO's) come to be important. In most cases, national opinion has backed issues raised by local community organizations though the national network of local NGO's.

The community activities in Kenya and Japan are potential pragmatically movement bodies, which combine advantages of both western and traditional style of community organizations. The worst weakness of these organizations is that they are financially dependent on other sources. Other organizations are already proving to be financially independent.

In conclusion, it is important that any country must have local community organizations for lake basin management. For the conservation of water environment with community participation, the Government must restructure and revitalize such local community organizations in line with modern society and by adapting good virtues from the western style community organizations. Governments should also strive to subsidize and even incorporate such community organizations into their administrative roles.

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Communication, education, awareness generation and community participation in management of Bhoj Wetland

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Abstract

The Upper and Lower lakes of Bhopal, also recognized as Bhoj Wetland, were subjected to pollution due to various anthropogenic activities. Therefore, an integrated conservation plan for the habitat restoration, water quality improvement and conservation of bio-diversity of the wetland was implemented during 1995-2004 with financial assistance of Yen 7055 Million from Japan Bank for International Cooperation. As a part of this conservation plan, a series of intensive awareness programmes were organized with the active participation of NGOs and educational institutions. An Interpretation Centre to educate and create awareness about water and wetland conservation has been created, which is only of its kind in India for urban wetlands.

Idol immersion is an age-old practice in India. The people of Bhopal had general preference for idol immersion in Upper Lake, a major potable water source than other water bodies. This practice being environmentally nonsustainable, a specially designed awareness campaign was launched in 1998 to ensure public participation in stopping idol immersion in the Lake, and ultimately succeeded in complete shifting of idol immersion to the alternative site in 2002 after continuous efforts of 3 years. It is the only example of regulating the religious activity for the wetland conservation in the country.

Use of chemical fertilizers in the 210 sq.km crop fields of 51 villages in the catchment of Upper Lake is one of the major causes of pollution of the lake. To address this problem, an organic farming promotion drive through capacity building of farmers was launched. Majority of the farmers of 15 villages located along the lake has adopted the organic farming technique. This has resulted in savings of the farmers without compromising with the crop yield.

The washing activities by the washermen residing in the fringe of Lower Lake was one of the major cause of deterioration of its water quality. Due to constant interaction and awareness ultimately all the 250 washermen families had been rehabilitated with mutual consent to the new site developed for the purpose in 2004 after a long sequence of efforts over nine years. This has resulted in improvement of lake water quality as well as living condition of washermen at the new rehabilitation site.

Key words: wetland conservation, community participation, idol immersion, organic farming, rehabilitation

Introduction

The water bodies especially in the urban areas are under severe anthropogenic pressures due to rapid population growth and urbanization. The Upper and Lower lakes of Bhopal, designated as Bhoj Wetland, are one such wetland. The Upper lake, perhaps the oldest among the man made lakes, was created in the 11th century AD, whereas, Lower lake was created on the downstream of Upper Lake in the 18th Century AD. While the Upper Lake was the principal water source for the people of Bhopal for centuries, the Lower Lake enhanced the beauty of the city. The urban development around the lakes and the increased anthropogenic activities in the catchment areas has subjected both the lakes to various environmental problems resulting in deterioration of water quality. Consequently, Bhoj Wetland Project successfully implemented a major project for the conservation & management of picturesque and ecologically important upper & lower lakes of Bhopal during year 1995 - 2004 with financial assistance of JBIC. The project involved several pollution control and environmental conservation measures for upgrading the water quality of these lakes and 21 sub-projects brought under five main categories such as desilting & dredging, catchment area treatment, sewage pollution prevention, shoreline and fringe areas management and water quality management had been undertaken for implementation. Public awareness programme was one of the major action programmes to ensure public participation in the in the implementation of the conservation programme. The paper elaborates upon the public awareness programmes , their successes through few case studies and the Interpretation Centre created to sustain the awareness activities.

Location

Both the lakes are located in Bhopal, the capital city og Madhya Pradesh of India. The Upper lake spread over longitude 77°18'00"to 77°24'00" E and latitude 23°13'00" to 23°16'00"N, whereas considerably smaller Lower lake is spread over 77°24'00"to 77°26'00" E and latitude 23°14'30" to 23°15'30"N.

Implementation of public awareness programme

The public awareness programme was started since 1998. In the programme implementation, NGOs numbering about 80 and various educational institutions numbering about 100 had actively participated. In all 450 awareness programmes and a large number of educational materials had been developed and published. The project has succeeded in creating general consciousness amongst the citizens about wetland conservation.

Some of the worth mentioning success stories of public awareness campaign are elaborated below:

Shifting of idol immersion activity for the prevention of pollution in the upper lake

Construction of idols of holy deities for worship every year and their immersion in water at the end of worship forms a traditional part of Hindu religion. This happens mainly for the worship of the deities Ganesh and Durga, both occurring during September-October. The idols have grown in numbers and size over the years and urban water bodies are facing an increasing nutrient load. For example Bhopal Upper Lake, the main source of potable water for Bhopal city, received more than 15000 Ganesh (370 tonnes) and 1300 Durga idols (99 tonnes) in 2000.

Idols are made of clay but non-biodegradeable thermocol and paints containing heavy metals such as chromium, nickel, cadmium and lead are also used. The immersion practice leads to degradation of water quality as well as siltation. Parameters like turbidity, BOD and COD became higher on immersion; increase in heavy metal concentration is low at present, but it is apprehended that continuance of immersions might cause built up of heavy metals in sediments plankton's and ultimately their bioaccumulation in fishes and in turn in human beings.

Religious issues are extremely sensitive ones and hence, even though the problem was serious, neither the administration nor the political leadership was willing to raise it in public. The project authorities decided to launch an extensive awareness campaign through the media in 1999 to convince the people regarding the need of saving the lake from pollution through idol immersion. One of the ways of reducing the quantities involved in immersion is to have smaller and environmentally friendly idols. Competitions for making Environmental Friendly Idols are one possible way to promote awareness of this aspect. In 1999 such a competition was organized in Bhopal by the project authorities to promote the manufacturing of idols with environmental friendly materials. A large number of entries for this competition were received which shows the increased awareness of the people.

An alternate immersion site at Prempura on the spill channel of the Upper Lake, which is well connected with roads was identified near the city. The selection o the site was on the premise that the flow of the spill channel being towards the outfall, the pollutants would not flow back to the main body. The site was developed by construction of an immersion bay and provision of other facilities. The construction work was completed just before the Durga idol immersion in 1999. To build a consensus amongst opinion makers, local legislators, corporators, NGOs (viz Sahyog, Vidhya Sagar Kalyan Samiti, Aarambh, Shuruat, Swablamban Mahila Parishad etc) and leaders of religious communities were taken to the site, their suggestions recorded and approval obtained. In 1999 during Durga festival 35% of idols were immersed at Prempura without a hitch. About 37% of Durga idols and 27% of Ganesh idols were immersed at Prempura in 2000, reflecting continues acceptance of the new immersion site. In 2002, a large number of public figures, including the mayor, corporators and legislators, and organizations came forward in support of the project and joined the efforts in persuading the Pooja groups to divert the immersions to the alternate site provided; the media also provided favorable publicity to these efforts. The participation of different communities and political groups ensured that the matter would not be given a communal or political colour. Complete shifting to Prempura took place during the Ganesh idols immersion in 2002 and this is now an accepted practice with the people of Bhopal themselves functioning as a pressure group for ensuring sustainability of immersion at the Prempura site. This difficult decision involving changes in age-old practices and attitudinal shift in mindset can be implemented by a consensus building approach involving stakeholders, illustrates how a sensitive religious issue concerning water pollution had been tackled by running a stakeholder awareness campaign and creating an environment of consensus building. The magnitude of the success is evident from Table 1 below.

Table 1: Diversion of Idol from Upper lake to Prempura Ghat (Weight in MT).

	Ganesh							
Year	**2000**		**2001**		**2002**		**2003**	
Location	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
Upper Lake	11282	288.00	12952	153.53	-	-	-	-
Prempura	4249	81.96	1766	29.80	9970	103.50	13899	109.73
Total	15531	369.96	14718	183.33	9970	103.50	13899	109.73
% Diversion	27.36	22.15	12.00	16.25	100.00	100.00	100.00	100.00

	Durga									
Year	**1999**		**2000**		**2001**		**2002**		**2003**	
Location	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
Upper Lake	1035	74.56	812	62.00	713	51.56	-	-	-	-
Prempura	573	50.74	489	37.17	407	34.65	851	65.97	1157	95.22
Total	1608	125.30	1301	99.17	1120	86.21	851	65.97	1157	95.22
% Diversion	35.63	40.49	37.59	37.48	36.34	40.19	100	100	100.00	100.00

Shifting washing activities for preventing pollution in the Lower Lake

The Lower Lake, being surrounded by habitation, had much greater pollution problems receiving the untreated city sewerage. A number of Dhobies (washermen) used the lake waters for washing clothes using detergents and soaps releasing chemicals into the water body. They had constructed their houses and shanties on the bank of the lake and even in the water itself at some places, resulting in the inflow of all the sewage, solid and liquid wastes along with several other discarded materials directly into the lake. The families also possess livestock i.e. donkeys, goats, buffaloes, and cows for professional and personal use with a sprinkling of poultry at places. A large quantum of nutrients thus entered into the lake directly. One of the subprojects identified under the Bhoj Wetland Project was to end these washing activities and relocate this community. The implementation was assigned to the urban local body, the Bhopal Municipal Corporation (BMC), which is the statutory body governing constructional & developmental activity in the city.

Right from the beginning it was decided to relocate the Dhobi community on a basis of voluntary agreement on their part. Initial surveys conducted over 1995 identified 128 families holding occupancy leases and another 120 'encroachers' without any such leases. Initially their union, the Dhobi Sangh (Union of Washermen), made exaggerated claims both with regards to compensation and the relocation site. However finally they agreed to relocate to the sites being provided in the middle of the city. Some of their conditions regarding leases for the new plots, financial help in construction of new houses and setting up a new washing bay as per their directions, were accepted and the Sangh gave a written consent in 1998.

A detailed project report was prepared over the next two years, with frequent consultations with the Sangh and land for relocation was also acquired. In the meantime consensus building was undertaken among the affected families, both as individuals and in small groups. Assistance of NGOs (namely Sahyog and Shuruat) was sought to create awareness among the Dhobies and convince them to shift voluntarily. They were also taken to the construction site to familiarise them with the new place and suggestions given by them were often incorporated. Regular monthly meetings were held by BMC officials to sort out problems. Compensation packages were worked out for various families and agreements signed between the individual and BMC. The compensation was paid in 3 installments to leaseholders and an ex gratia payment was made to the encroachers as well. All these efforts were intended to affect the transfer with goodwill on both sides. The final transfer was completed in 2004 after the long sequence of efforts over nine years. 72 additional families that had encroached in the interim period were also relocated. The new sites are certainly superior with roads, electricity and water connections so that the Dhobies now enjoy access to a better quality of life. The area vacated by them has been developed as a park adding to the aesthetic beauty of the lake in addition to reduction in pollution. With rapid urbanization, surface water resources are increasingly subjected to encroachment and pollution. This case study illustrates how unorganized human settlements around the water bodies and their life sustaining activities can affect the quality of water bodies and how sustained consensus building approach results in their shifting without any conflict.

Promotion of organic farming in the catchment area of Upper Lake

The intensive use of chemical fertilizers in agricultural practices not only reduces humus matter but changes soil texture too that brings down the crop yield. Farmers were looking for the better options and organic manure was a suitable alternate of it. The high demand of water after use of chemical fertilizer and its increasing cost reached beyond affordability of farmers. However the agriculture practice adopted in last few decades takes time to change from chemical fertilizer to organic manure. In case of Bhopal the promotion of organic manure in the catchment area of Upper Lake was started with definite aims and objective, which is the conservation of lake from the chemical pollution coming out of the intensive use of chemical fertilizer in the catchment of the lake. Bhoj Wetland Project Authorities targeted the catchment area of the Upper Lake Bhopal as organic farming zone and implemented programme. The major part of the wide spread catchment (361 sq.km.) is under the agriculture. The pollution load exerted through point sources and inflow channels have been trapped by providing gabion structures, check dams and cascades but agricultural waste, cow dung and dead organic matter joins lake through non-point sources accrued nutrient load in the lake.

The promotion of organic farming in 20 villages in the catchment area of Upper Lake has been successfully implemented through public participation to prevent pollution of the Bhoj Wetland due to intensive use of chemical fertilizer and for long-term benefit and sustainability of the programme without any government subsidy. About 250 farmers have started practicing in organic farming and about 200-hectare agriculture land had been converted in organic farming. Now efforts are being made to apply incentive based mechanism to encourage more and more farmers to try and adopt organic farming in the entire catchment of the lake.

Bhoj wetland interpretation center

An Interpretation center was established to disseminate the information and enhance visitors experience about wetland conservation, educate students and also create awareness among the people. It is only center of its kind in the country for conservation of urban wetland. This center is established as center of excellence for creating awareness and enhancing knowledge about wetland conservation. There are 3 exhibit galleries, a audio visual room and a meeting room in the Interpretation center. These galleries are furnished with the exhibits as follows:

Water tap exhibit at the entrance

Water coming out of a tap that is connected to nothing! Which reflects the ignorance and non-concern of people about what lies behind the tap.

Wetlands

Photo Panels depicts what are wetlands? What is a Ramsar Site? Worldwide distribution of Ramsar sites, also in India, Bhoj as a Ramsar site. Wetlands are among the, most endangered habitats in the world because they are close to human habitations and are easily destroyed as human population increases and development expands. Part of the distinctiveness of the wetlands lies in their ecological composition and character which arises form the fact that they are situated between land and water.

Riverine Systems of Madhya Pradesh

A working model depicts the major rivers of Madhya Pradesh and gives information on them to provide wider context for the water resources in Madhya Pradesh.

Bhoj Wetlands

The backdrop painting showcases the rivers leading to the Bhoj Wetland. The rivers on which the dams were built are Kolans, Betwa and Halali. Betwa on which Bhojpur dam is built leads to the formation to two lakes in Bhopal-Upper and Lower

The submergence and convergence of the lake areas

The Upper Lake is a source of potable drinking water to the people of Bhopal. The Upper Lake is subject to an erratic level of water spread. The working model depicts water level fluctuation in the upper lake to show the water spread area at the time of dead storage and full tank level.

Geology of the lake

Panels show the rock formation of the wetland area. The lake bottom is comprised of basaltic rocks, which form part of the Deccan Trap. These are very hard, igneous rocks, formed due to the cooling of lava.

Lake ecology

A longitudinal section of the lake explains the physical, hydrological, chemical and biological functions and the stratification of the Bhoj Wetland.

Avifauna of the lakes

The lake provides a good habitat for the various birds which visit it during winter months. Congregation of *Gras antigone*, a vulnerable species in the Upper Lake area are showcased in the form of diorama. The most interesting and fascinating aspects of birds are shown through life-size models. Visitors can hear the calls of these birds with the help of headphones.

Bird migration

The phenomenon of migration is dealt with through exciting models and interactive exhibits, illustrating the distance that the bird has traversed, the perils on the way, the number of days taken to cover the distance to reach the wintering site.

Fish life in the lakes

The development of aquaculture in the lakes aims at biologically controlling aquatic weeds, thereby improving the water quality. Harvesting of fishes enables the removal of nutrients from the lake, which causes eutrophication. Fish seeds of Grass Carp, Common Carp, Rohu and Mrigal are stocked. This also helps in providing livelihood for local fishermen.

Flora- land and aquatic vegetation

Tri-vision panels depicts land and aquatic flora of Bhoj wetland which supports mainly 3 types of vegetation consisting of more has 100 marshy plants, 10 aquatic floating forms, 14 submerged forms and 10 emergent forms.

Lake to homes

Do the people of Bhopal know the journey of the water that flows from the taps to their homes? The water supply to the city of Bhopal from the Bhoj Wetland through a maze of pipes – the engineering aspects- are brought to the light to the citizens. This highlights the departments involved and the responsibility of the people in managing their resources at the user's end. The Municipality is responsible for the distribution of drinking water. The lake has a certain capacity of withdrawal, beyond which it is not ecologically feasible to draw water. The people of Bhopal must be made aware of this. May be a change in the use pattern, or finding an alternative source of water for drinking purposes for Bhopal is the need of the our. The story of lake to home has been shown through working model.

Conservation Issues and measures

Touch screen depicts environmental problems of Bhoj wetland and conservation measures implemented under the project.

Children's corner

Children form an important target group. Making a child aware of the importance of Bhoj Wetland amounts to making his/her whole family aware. Themes on water, water-cycle, water-based life, life's beginning in winter, various uses of water, adaptations of animals, plants and humans to a life of inadequate water and conservation values have been presented with the help of Models, Photo Panels, Interactive Games, Voting Machines etc. in this section.

Conclusion

From the foregoing discussion it becomes clear that involvement of public is essential for the implementation of wetland conservation programmes. However, to ensure the same a plan is required. NGOs and educational institutions can play a significant role.

Dams in the Mekong Basin– Institutional and governmental policies and their Impact on the people and ecosystem of the region

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Abstract

International and national policies on energy and water have often taken a big cause on the environment. In many cases, economic influences of neighboring regions have a detrimental impact in the lesser-developed country and this is the same in the Mekong region. In this study, the influence of 2 major dams in the region Nam Theun 2 in Laos and, Yali Falls dam in Vietnam would be studied. In the case of Nam Theun 2, the role of international institutions like World Bank, Asian Development Bank and the European Union in pushing the process of the commissioning of the dam and, its impact to the biodiversity of Laos would be studied. The study on Nam Theun 2 is vital as it is said to affect the indigenous people, flora and fauna of the region. Yali Falls dam is another important case study where the upstream development process in Vietnam is causing environmental concern in downstream Cambodia. By a comparative study on Nam Theun 2 and Yali Falls dam, this paper aims to bring out the reasons for failures on policy decisions - both institutional and governmental and its effect on the people and ecosystem of the region.

Key words: Nam Theun 2, Yali Falls dam, Mekong River Basin

Introduction

Water and energy are two components that are in need for the developing world. As a matter of fact, lots of studies are carried out in the world to overcome the shortage of energy and water. In certain situations a solution to one problem can lead to the other. For example, construction of dams can help to reduce the water and energy scarcity of many regions, it on the other hand has severe ecological and human implications like displacement of indigenous community, sinking of forest zones and, in the aftermath of a siltation of the dam, the losses could be immense during decommissioning. In certain other situations like Yali Falls dam, the transboundary issue is often the problem.

Hence, to manage water resources, a long-term vision is required, priorities have to be set and sometimes hard choices are to be made. This is very much a political process. In the current debate on ‘water crisis’ better governance is generally advocated a major solution. However, even though it benefits of a very broad definition, the notion of governance fails to address political issues directly.

In this paper, the role of international and government policies are analysed on two major dams in the Mekong - Yali Falls dam in Vietnam and the Nam Theun in Laos.

Nam Theun dam

Background

Financing for the Nam Theun 2 Power Co (NTPC) hydro project in Laos closed on 3 May 2005 featuring a number of signatories to the sustainable lending pact, the Equator Principles. Sponsored by EdF International (35%), EGCO (25%), Electricite du Laos (25%) and Italian-Thai Development (15%) under a 25-year BOT concession from the Laos government, the $1.45 billion project involves the construction of a 1,070MW hydroelectric power plant and dam on the Nam Theun River, a tributary of the Mekong River, in central Laos. With the commissioning of the work of the dam, it has also sparked controversy regarding the environmental and social implications of the dam and sharing of electricity (Project Finance, 2005).

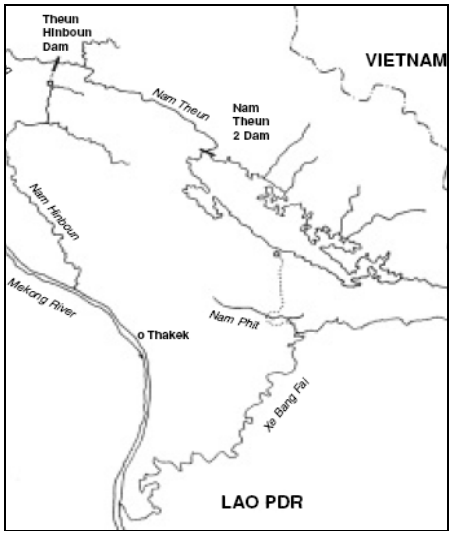

Figure 1: Map of the Nam Theun 2 Dam Site and its Adjoining Rivers (IRN, 2004).

Impact on people and ecosystem by the construction of the dam

Studies by various organizations and civil societies have revealed that the commissioning of the dam would lead to the displacement of 6200 indigenous people from their ancestral land (IRN, 2004), and severely impact a river system on which over 120,000 people now depend for their fishing and farming-based livelihoods. Farmers will be relocated to unproductive soils, and fisheries in both rivers will collapse. The reservoir will be subject to severe fluctuation that 80 percent of its bed will be exposed as water is drawn down to produce power and as a result one Laotian in 60 of the total 100,000 people will be directly and adversely affected (Project Finance, 2005). Studies also show that, 93% of the Nam Theun River's flow will be diverted into the adjacent Xe Bang Fai River basin and nearly 40% of the Nakai Plateau will vanish beneath a reservoir covering 450 square kilometers.

On the environmental front, Nam Theun 2 will have significant impacts on biodiversity. The project is located in and adjacent to one of the largest remaining tropical forests in mainland Southeast Asia. The 450 km^2 reservoir will inundate habitat for 60 species of birds and mammals and disrupt migration routes. The area is home to a large variety of rare and endangered plant and animal species, including the white-winged duck and one of the last remaining populations of wild elephants in Laos.

The project will have adverse impacts on fisheries on the Theun River and the Xe Bang Fai. The Theun River provides habitat to more than 80 species of fish, including at least 16 endemic species and will dramatically lower downstream flow on the Theun River and increase water levels along the Xe Bang Fai. This will destroy fish habitat, impede migration patterns and could lead to the extinction of native fish communities (IRN, 2004).

One other concern that has not been looked into is the sedimentation of the reservoir and how long they can remain viable. The decommissioning of such a huge dam can be expensive and bring losses to the ecosystem (Henry, 2005).

The rationale for the project is a compromise - much needed foreign currency for Laos to improve rural infrastructure offset against the environmental impact.

Institutional and Governmental Policy

The World Bank's executive board earlier voted in favour of providing a US$50m partial risk guarantee for Laos's US$1.3bn Nam Theun 2 hydroelectric power project, which has faced intense opposition from environmental and human rights groups. The risk guarantee is necessary for the project to secure commercial backing. The World Bank president, James Wolfensohn, who visited Laos in February as part of the consultation process relating to Nam Theun 2, said that the World Bank perceived the project's risks to be manageable. These risks relate to the relocation of around 6,000 people, threats to the area's biodiversity, and concern about the size of the project relative to Laos's economy.

Asian Development Bank is a co-sponsor for the project and it identifies the project as the one that aims to support two of the Lao PDR’s key national development objectives through the power sector: (i) promote economic and social advancement by providing reliable and affordable electricity supply, and (ii) earn foreign exchange from electricity exports. The Project is an integral part of the government’s development framework, which aims to achieve the country’s medium- and long-term economic growth and poverty reduction objectives. ADB supports the project through a $20 million public sector loan, a private sector loan of up to $50 million, and a political risk guarantee of up to an aggregate maximum liability of $50 million.

The other agencies supporting this project are the European Investment Bank (EIB), and Export Credit Agencies (ECAs), such as the French ECA, COFACE.

Community response

Various community organizations and dam-affected villagers have submitted letters and memorandums to the World Bank expressing their concern about the impacts of Nam Theun 2 on the Mekong River and noted the many unresolved problems of fisheries and other livelihood losses created by World Bank funded dams. Some of the memorandum statements questioned World Bank on whether the organization has looked into the concerns of the local people affected by the dam, or it has just been facilitated by the interests of the project investors.

Civil societies working on wildlife issues have also raised concern on the threat to the elephant population in Laos and also, to other endemic species in the region

Yali Falls dam

Background

The case of hydropower development in the Se San River Basin exemplifies the failure of transboundary environmental governance in the Mekong Region, and its great harmful effects for local communities.

The Se San River is one of the largest tributaries of the Mekong River, contributing approximately 10.4% of the total flow of the Mekong River and has been recognized as "one of the top 3 rivers in Vietnam in terms of hydropower potential (Center for Natural Resources and Environmental Studies CRES, 2001). Its headwaters lie in Gia Lai and Kon Tum provinces in the Central Highlands of Vietnam. The Se San then flows into Ratanakiri province, and then Stung Treng province in Cambodia where it enters the Mekong River (Figure 2).

Yali Falls dam was the first of the proposed dams in the Se San River basin to be constructed. Costing an estimated US$ 1 billion, construction of the 720 MW dam commenced in 1993, and was completed in December 2001 (CRES, 2001). The dam is located on a tributary of the Se San River - the Krong Poko - in the Central Highlands of Viet Nam, about 70 kilometers upstream of the Cambodian border.

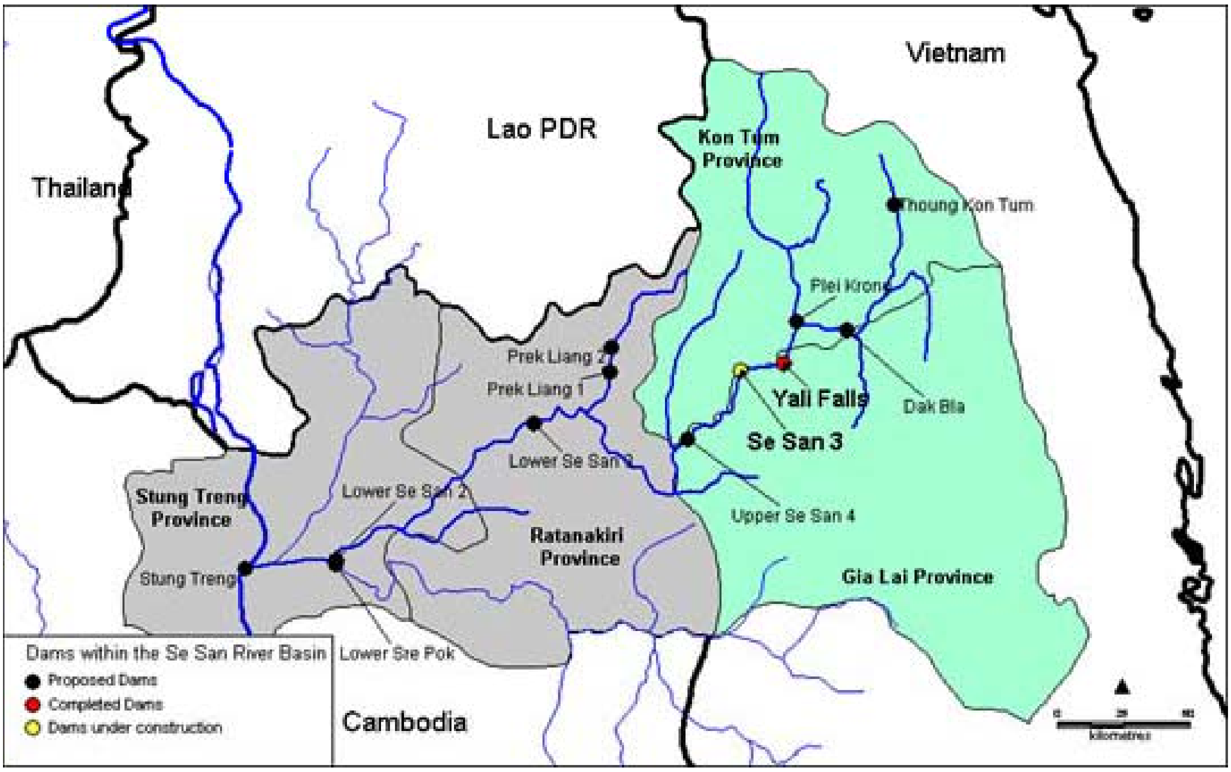

Figure 2: Dams Proposed, Completed, and Under Construction on the Se San River (Australian Mekong Resource Center, 2002).

Impacts

By 12 May 2000, when the first of four turbines were commissioned, Yali Falls dam had caused large-scale environmental, social and economic impacts to the communities living along the Se San River in Vietnam and Cambodia, upstream and downstream (AMRC, 2002). The construction of the dam created a reservoir covering 64.5 km^2, inundating areas of Kon Tum town and Sa Thay district in Kon Tum province. More than 1,100 local households in Vietnam had to be relocated to make place for the reservoir. (CRES, 2001). However, the greatest impacts have been experienced in the two downstream Cambodian provinces of Ratanakiri province (approximately 70 km downstream), and Stung Treng province (250-300 km downstream) (The Fisheries Office, Ratanakiri and Non-Timber Forest Products (NTFP) Project, DoF and NTFP, 2000). Estimation of up to 50,000 villagers living near the river are suffering because of the dam, according to two joint studies conducted by environmental groups and the Cambodia government. A study on the Vietnam side of the border found similar problems.

The closing of the dam and irregular releases of large amount of water have changed the hydrological regimes and the Se San downstream, which was first observed in later 1996. Since then, rainy season flooding and irregular dry season water level fluctuations believed to have been caused by water releases from the dam has damaged agricultural crops and flooded villages along the Se San River every year (DoF and NTFP, 2000).

The irregular fluctuations in the Se San River have seriously affected river rein vegetation, birds, reptiles and various aquatic life forms whose lifecycles are dependent on the natural rhythm of the Se San River. Native fish, fish habitat and rive rein fishery have been severely impact by changes in the hydrological regime and water quality. Fish catches have reportedly declined drastically, which has badly affected villagers, who are highly dependent on fishing for food and income (DoF and NTFP, 2000).

The overall downstream impacts of the Yali Falls dam have severely disrupted human livelihood system along the Se San River. Therefore, local people have had to increase wildlife trading, the collection of non-timber forest product, and general forest exploitation. The imbalance caused by dam impacts has negatively affected terrestrial resources, since local people have few alternatives (DoF and NTFP, 2000).

Poor transboundary water governance

Almost three years after the first turbine was commissioned and a little over nine years since construction began, the unmitigated and uncompensated large-scale environmental, social and economic impacts remain with these communities in Cambodia as well as Vietnam (AMRC, 2002).

Various studies reveal that information regarding dam water releases and explanation of the developments to the locals have not been inadequately and efficiently transmitted which was actually the responsibility of Vietnam and Cambodia government as well as those at the international organization dealing with transboundary river basin development issues (AMRC, 2002).

Please be noted that Yali Falls is not the only one, Vietnam would like to build six dams on the Se San and its tributaries; Cambodia has sought funding for two (AMRC, 2002). In June 2002, Vietnam's announcement of its commencement on the construction of Se San 3 took Cambodia by surprise, as Cambodian officials were amidst discussions with Vietnam regarding an environmental impact assessment for the new dam project.

The environmental study for Yali Falls Dam, conducted in the early 1990s, ignored downstream effects beyond a few kilometers of the dam. Vietnam was planned the second dam, Se San 3, on the same river, 20 kilometers closer to Cambodia. A 1999 feasibility study on the Se San 3 by a Swedish firm, Sweco, did not cross into Cambodia. Cambodia people do worry about this plan, although the Vietnamese experts suggested that using the second dam to lessen the impact of the Yali dam, as "There will be no changes in the water discharge ", (AMRC, 2002).

After the impact were reported, the Mekong River Commission (MRC) are trying hard to play important roll in helping the two countries to mediate the conflicting interests between them as well as and solve the problems by mainly focusing on the warming system. It brought some positive results; however, there was still lack of any institution to assist the authorities to avoid misunderstandings since the problems exist in coordinating environmental studies across international borders.

Policy implementation

The AMRC in the Case Study on Hydropower Development in the Se San Watershed proposed a list of countermeasures to solve the problems and prevent harmful effects to the environment and human in the future. Particularly, with more dams in the pipeline in the Se San River Basin, it is important to identify potential damages and influencing policy decisions. The policies cover the following aspects: (i) improving warning systems (methods and timing) from top officials to the locals, (ii) improve monitoring system and environmental impact assessment study , and (iii) support the affected communities in terms of providing knowledge of dam development, disaster management and advocacy training, understanding and helping the local community's needs.

Conclusions

International and government policies regarding water management in developing countries has always been sensitive and has been creating political debates at national and international levels. In this paper we have reviewed the role of international institutions like World Bank and developed nations and, their relevance in the region.

To World Bank watchers, environmentalists and multinational construction firms, the announcement of $270 million in grants and guarantees for the Nam Theun 2 dam was a landmark event. It represented the bank's return to big dam projects, a field in which it made its mark beginning in the 1950s with monuments in concrete like the Kariba Dam on the Zambezi in southern Africa. One reason for the construction of the dam was for bringing in Foreign exchange to one of the worlds poorest countries - Laos. But, then it questions the right of the indigenous people living in the proposed dam site.

In another study on the Mekong basin, the Yali Falls dam, which was supported by the Russian, Ukraine, Sweden and Government of Vietnam, the transboundary implications of the dam was hardly realized leading to dire consequence in the down stream Cambodia. Thus to improve the condition, there is a need to have an efficient warning system which can provide answers to the current problems. On a policy initiative, the Mekong river commission should look into this issue quite seriously for transboundary networks can help in solving national problems. It is also important to reinforce a strong river monitoring system for receiving timely accurate information. Environmental impact assessment study of Yali dam has already been done though it should be carried out to identify the ecological and human factors to identify the effect of the dam on the people downstream.

The paper also highlights the need for an integrated water transboundary management which requires the participation governments, local communities as well as international organization those have responsibility in transboundary water issue and regional development (Mekong River Commission, Greater Mekong Sub-region, the Association of Southeast Asian Nations).

It is thus important to look into institutional and government policies and to review whether the actual interests lies is for the people of the basin or for multinational industries.

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Community involvement in fish harvesting around Lake Victoria (Kenya)

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Abstract

Benefits accruing to fishing communities have not marched increases in fish yields. This has affected the disadvantaged groups especially women who rely on processing and marketing fish for their livelihood. The aim of this study was to asses the extent of community involvement in fish harvesting activities, the benefits accruing, perceptions towards fisheries regulations and their constrains in regard to threats and risks they face in Lake Victoria.

Sampling was conducted on 25 landing beaches between August and November 2000 and a total of 229 fishers interviewed. Data was obtained using a structured survey questionnaire on fish production and personal interviews. Seventy two percent felt that their occupation was not sustainable due to low prices of fish, 70% of fishers joined the fishery for period between 1 to 10 years, 81% operated on full-time basis, while 19% operated on part-time. During the Government of Kenya retrenchment exercise, there was a short-term influx into the fishery. In a good week, a fisher could earn an average of Kshs.7, 750. In a bad week one could earn approximately Kshs.1, 822. Fishers sampled were familiar with fisheries laws and regulations applied in the management of Lake Victoria fisheries 90%.

The results show most fishers have no alternative occupation apart from fishing with men dominating in the harvesting sector while women only owned fishing gears and equipments. Although majority of fishers worked on full-time basis, they have limited or no influence on the levels of benefits they receive from the activity and this can be supported by the unemployment caused by the fish processing factories that fish directly by providing efficient gears and boats to fishermen.

Key words: Fishery, Community, Fishing, threats and risks.

Introduction

The Lake Victoria fishing community comprises of fishermen, artisanal fish processors; small-scale fish traders and industrial processors. Thus fisheries activities play a vital role in the lives of the communities in terms of employment and nutrition. The fishery has evolved from a traditional and subsistence status to an industrial level characterized by high-level commercialization of production and distribution levels.

Butcher and Coloris (1973) estimated that during the early 1970s some 50,000 fishermen operated from some 12,000 fishing vessels the fishermen had a varying degree of involvement in the fisheries sector, some fished only part-time or seasonal basis, while others were full-time fishermen.

Eighty percent of fishermen derived their primary income from fishing and most of them were also engaged in complementary agricultural activities.

In Kenya the fisheries department estimated that a total of 798,000 people were directly or indirectly supported by the fishing industry as compared to 720,000 in 1995 whereby there were 34,000 fishermen, 238,000 dependants and 526,000 people engaged in the provision of support and ancillary services such as trade in fishing inputs, fish handling, processing and marketing

According to the recent statistics from the fisheries Dept. (2000), there are about 42,000 fishermen in Kenya and approximately 90% of them are in Lake Victoria basin but this number has increased by 28% since 1995.

Although fish has been the cheapest source of high quality animal protein and a major source of income, the native fish stocks have been heavily reduced due to over exploitation and have had socio-economic consequences for the fisher folk, other fish eating communities and the environment.

According to (Reynold *et al.,* 1992) Lake Victoria fisheries produced a total value of US$ 280 million between 1975 and 1989

Employment increased from 158,000 in fishing and ancillary activities in the entire Lake to 422,000 by 1992 when the Nile-perch fishery was at the pick (Wilson 1993).

The value of fish produced from Lake Victoria has grown since 1980 from kshs 0.2 billion to about 2.2 billion in 1995 (Ikiara, 1999).

Ikiara (1999) also estimated that the average monthly income for boat owners was to be kshs 6,000 while the crewmembers earned between kshs 1,000-2,000 per month in case of fish processing sector the earnings were slightly more than crewmembers.

Gibbon (1997) estimated that in 1996, 50% of all Nile-perch landed in Tanzania went to the filleting factories while in Kenya for the same period (Abila and Jansen, 19997) estimated that about 48% of all the Nile-perch was also taken by the filleting factories.

This study was necessary because opportunities in the harvesting and marketing have changed nutrition and health habits of people. Other social benefits have declined while government policies and regulations to manage the resource have not changed to march these changes. However community participation in the fishery is one of the concepts used to characterize the involvement of local communities in the management of natural resources (IUCN, 1991)

Specific objectives of the study

(1) To examine community involvement in fish harvesting, their benefits and problems.

(2) Examine the fisher's perception towards the fishery and fisheries regulations.

(3) Examine the movement of fishers into and out of the fishery

Methodology

This study was conducted on 25 landing beaches covering eight districts bordering Lake Victoria from August to November 2000. Data was collected using an open-ended survey questionnaire on fish production, Group discussion; personal interviews were also carried out.

A stratified random sampling method was used to select beaches for field survey. The beaches were categorized into small, medium, and large size based on the number of boats registered on that beach.

Small beaches had 1-25 boats; medium beaches 26-50 boats and large beaches had more than 51 boats.

Random sampling method was used to select respondents for the interview.

A total of 229 fishers were successfully interviewed

Data was analyzed using Excel package.

Results and discussions

Characteristics of fishers of Lake Victoria

In Lake Victoria, fish production is dominated by few ethnic groups of fishers of which the Luo people constitute a great majority 64%. The other groups involved in the fish harvesting were the Subas 27%, Luyhas 7% and other tribes (Somalis and Machitas from Tanzania) 2%.

IIRR (1998) defined the fishing community as an association of people living in a given area or sharing some general commonality in addition to geographic proximity.

A survey conducted by (SEDA WOG II, 1999) indicated that fishers were dominantly male and most of them were in the age range of 21-45 years. This study also confirms that out of 229 fishers interviewed, 98% were male and 2% females with an average age of 35 years and modal age of 25 years. The majority 69% was between age brackets 21-40 years, 20% were 41-60 years, and 6% were 61-80 years while those in the 1-20 years bracket formed 5% of the population.

However the females either owned a boat, gear or lamp and other items of wealth but were not involved in off-shore fishing activities except beach seining. Analysis made on the marital status of fishers indicates that majority of them had children ranging between 1-18 years with an average of 4 children per family and dependants ranging between 1-30 people with an average of 7 people per family who were either orphans, widows or single parents. This also confirms the study by (SEDAWOG II, 1999).

On education results show that 52.9% of fishers had attained primary level of education, 42.0% secondary level, 0.8% tertiary and 0.4% university education level. SEDAWOG II, 1999) indicated two-thirds having at most primary level of education.

Results on marital status involved in fish harvesting activity indicates that 90.3% of fishers were married, 8.3% were single, 1.0% were widowed while 0.4% were divorced.

Although most fishers depended on fish harvesting activities, they were involved in other income-earning activities like farming, retailing and food kiosk industry.

Entry of fishing community into the fishery

According to (Abila, 2000) the term fishermen usually refers to all the people involved in any aspect of fish harvesting. Fishermen are usually categorized into distinct groups depending on property ownership or the actual role they play in the fishing activity. The first category is the boat and gear owners who often do not participate in the actual fishing activity but leases out their boat and gears.

The second category is the fishing crew who are the hand man (jotich) in the fishing boat. Within the crew is a boat operator who directs the boat in water and its operations. In the fishing activity, there is also a boat manager who may or may not be part of a fishing operation, but who is always responsible for selling fish and paying crewmembers.

Results from this study show that 70% of fishers had been in the fishery for a period of 1-10 years showing that young entrants have joined the fishery, while older people who have been in the fishery for over 22 years decreased to 11%, 19% have been in fishery for 11-21 years.

The rapid increase in fishermen and equipment in the lake is mainly caused by the rapid growing population with few means of earning income. Many people who are not fishermen by heritage and tradition have turned to fishing as a last resort to earn a living. This is largely due to the recent retrenchment in the government and private sectors in 1999 after which many people had moved into fishery.

The other main reason why the number of fishers is growing from time to time is the easy entry to the fishing occupation. There is always an opportunity or guarantee to get a job by those desperately in need of money. The high rate of entry into the fishery has also persisted to date largely due to low prospects of employment in other sectors of the economy.

The result indicate that 56% of the fishers were introduced into fishing activities by either their family members or relatives, 18% perceived that most boys living in the lake region, regardless of their social background, have some knowledge about the work on the lake since they come from a fishing community, 18% were also influenced by their age mates, while 8% were introduced through other means e.g. crew in a boat

When asked why they joined fishing activities 93.1% joined fishing because they lacked employment elsewhere, 6.5% joined to look for school fees, while 0.4% joined because fishing was a family occupation.

In joining fishing activity, 59% of the fishers experienced many difficulties due to lack of starting capital to buy expensive gears and equipment for fishing, 25% indicated that the skills required in fishing was not easy to acquire, 8% felt there was insecurity in the lake due to strong currents and changing weather conditions. 5% indicated cultural hindrances restricting women from fishing in the lake, while 2% indicated strict laws and regulations imposed on fishers.

On entering the fishery fishermen had several ways of acquiring starting capital. 26% raised starting capital from their family members or relatives, while 40% acquired capital after working as laborer or crewmember on someone's boat (Figure 1).

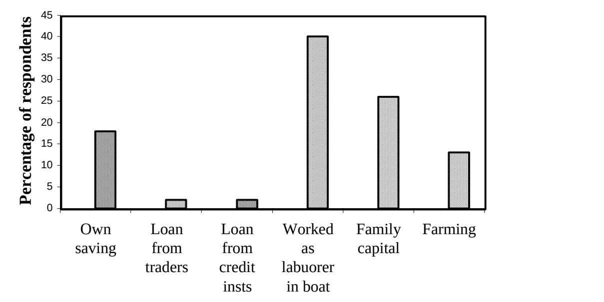

Fig 4. How fishers raised capital to start fishing activity.

Figure 1: How fishers raised capital to start fishing activity.

Job satisfaction and fishing operations

81% of fishermen were involved in fishing activities on full-time basis. This group is mostly married with constant demands from their families or dependants and can stay away from their homes for a long time. They usually own boats and gears. Those who work on part-time or on seasonal basis constitute a great portion of them and are only engaged on fishing during certain seasons of the year and are sometimes established agriculturalists working on the lake on a seasonal basis.

The length of time these groups are engaged in fishing activities varies from group to group due to depletion of inshore stocks where fish harvesting has now moved offshore.

Fishermen carry out their activities on different days of the month and for different periods during fishing the majority of them operated or fished for 21-30 days in a month and rested for 4 days in a month to attend church 82%. 16% of fishers operated between 11-20 days, while the minority 2% operated between 1-10 days a month.

These results show that for proper sustainability, fishers have to work for many days in a month while the other scenario indicates that to catch more fish fishers have to spend more time in fishing thus working for many days and spending more hours in fishing. On a fishing trip 55% fishermen took between 9-16 hours, 38% took between 1-8 hours and 7% took 17-24 hours.

According to (SEDAWOG II, 1999) and Wakwabi *et al.,* (2003), fishermen faced a number of critical limitations in their fishing occupation. Among these problems, were irregular and often low incomes from fish, lack of cold storage facilities for their fish and inability to organize themselves and improve their bargaining power, lack of information on saving options, poor business management skills and inadequate saving facilities. 72% of fishers felt they are not able to do their fishing activities effectively. The main reasons were due to decline in fish catches or fish scarcity in the lake 25%, 24% indicated the problem of gear limitations whereby fishers were not able to catch any fish using recommended gears apart from illegal ones (Figure 2).

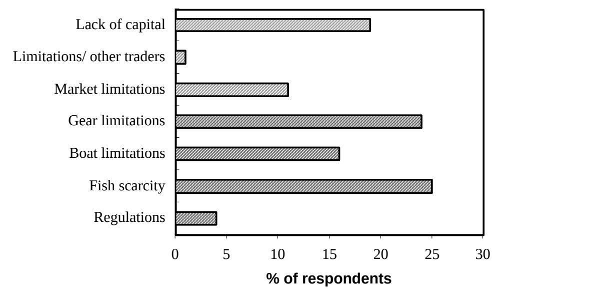

Figure 2: Most limiting factors affecting fishers.

Somehow the processors control prices at the beaches and the islands

Market of fish and source of credit facilities

Fishers sampled targeted all commercial fish species available in the lake with few indigenous fish species that are cherished by the local communities. Majority of fishers sold their fish to resident landing site traders and processors who sell fresh or process fish and sell to buyers from inland markets 36%, while 17% sold to factory agents with trucks and 18% sold to consumers on the beach.

Marketing channels of commercial fish species have expanded to export market and this has resulted to unemployment for artisanal fishermen now because fish processing factories send their people to go fishing in the Lake or they buy fish directly from the Lake.

The study indicates that over the period 1997-1999, 93% of fishers had not obtained any credit facilities for their fishing activities; remaining 7% got credit facilities from Agricultural finance cooperation (AFC), Merry-go-round commercial banks and relatives. Fishers normally do not qualify for credit facilities due to their migratory tendencies and lack of saving culture.

New technology used

Uses of spears, baited traps, baskets and barrier traps were earlier traditional fishing technologies used (Dobbs, 1927). Other gears in order of use are:

- Flax gillnets were introduced in lake Victoria in 1905 (Dobbs, 1927)
- Nylon gillnets stronger and easier to apply were introduced in mid 1950s (Geheb, 1997).
- Modern fishing hooks started at the end of second world war (Mbuga et al.,; 2000)
- Beach seines came into use in late 1940 (Geheb, 1997)
- Mosquito nets were introduced in the lake in 1950s.
- Attraction lamps were introduced in late 1960 (Okedi, 1981).
- 6,369 crafts still use paddles in Kenyan part of the Lake Victoria (Asila, 2000)
- 3,031 sail-propelled fishing crafts are used in Kenyan part of the Lake (Asila 2001).

However, 86% of the fishermen indicated that over the period 1997-1999, they had not adopted any new methods of harvesting fish and catch preservation. Those who used new methods used paddle propelled and sail propelled crafts with few motorized boats. On methods of improving fish quality and better preserving methods, 49% fishers felt that they needed out board engines to conduct fishing activities effectively in the open lake, 22% needed modern boats and more efficient gears, 21% wanted to use only ice in preserving their catch, 7% preferred to use refrigerated trucks, but 1% would not want to use any new methods that is preferred.

Wealth status of fishers of Lake Victoria:

This survey had also sought to understand what individual fisherman within the fishing communities has owned i.e. assets, other investments and status of their wealth. After money is got from fish sales certain money is provided for replacement of old gears, meeting food expenses, clothes, domestic expenses, and school fees, much of the remaining money was invested in buying animals.

Among the fishers interviewed, 60% owned about 1-5 boats, while the rest worked as crewmembers or boat managers.

Results indicate that out of 229 fishers sampled 56 fishers were landless, 29 had cattle, while 41 had no goats.

An analysis made on the wealth status of fishermen indicated that fishers around the lake owned several assets and items of wealth. Majority of them owned a house with an average cost of Ksh.15, 889, some owned a piece of land with an average price of Ksh.29, 085 an acre, a few owned a motor vehicle costing about Ksh.673, 000 and bicycles costing Ksh.4, 512 each, some owned cattle costing Ksh.8, 494 each, others owned goats costing Ksh.2, 080 each and radios worth 5,462 each.

From observation made apart from these investments the standard of living for the fisher communities is very low, most houses owned were either grass thatched, or semi-permanent and a significant proportion were landless as only 53 owned land.

Earnings from the fishery and remuneration systems

Earnings's accruing from the fishery differs substantially between beaches, for different fishermen, the number of boats and gears owned, on various days and for different fish species. Thus fishermen incomes may have wide ranges within the year.

Results show that in a good week fishermen earned approximately Ksh. 7,750. In a bad week they earned Ksh. 1,822 a week.

In 1999 (SEDAWOG II, 1999) estimated that the average boat owner earned in the range of US $ 65-305 per month in Lake Victoria (Kenya sector) with an average annual net income of US $ 2,240 (Ksh. 168,000).

In the course of carrying out their activities, fishers also employ labourers who earn monthly salaries or wages on daily or weekly basis. Those labourers with no nets earned approximately Kshs. 702 per week, while those who owned fishing nets earned Ksh. 1,740. Family helpers working on the boat earned an average wage of Ksh. 935 per week, while temporary workers who relieve these crewmembers on safari or during holidays earned Ksh. 417 per week.

On remuneration systems around Lake Victoria (Abila, 2002; Odongkara, 2003) indicated boat owners remunerate fishing crew using one of the main methods where the boat owner takes 50% of the income from fish sales, and the crewmember share out the remaining half amongst themselves. But this study also reveals that fishers have several ways of sharing catch or remuneration, which these methods vary from place to place with the kind of fishery.

The most common form of remuneration system used was percentage share of the proceeds after deducting expenses with 75% fishers using it.

Another method was boat owner to retain all the catch proceeds for six days while the crew took all the proceeds for the seventh day 12%, boat owner pays crews daily, weekly or monthly wage 7%, crew to take a percentage share of daily catch value and also receive a wage at the end of the month 4%, boat owner receives a higher percentage share of catch value on some days and crew take the higher percentage on the remaining days of the week 2%.

Fisher's perception on the future of fishery

The increased participation in the fishing industry does not necessarily mean that the fishermen are satisfied with the economic returns from their work, the enlarged number of people getting their income from the lake is rather a reflection of the fact that more and more are entering fishery; there are few or no alternative to fishing as a means of making a living. Some of the boat or gear owners can be people who are relatively well off, but the majority are poor. This is because of the remuneration system, which ensures that the crews earn the least from the fishery as compared to the boat owners or renters.

52% of the fishers sampled had a positive perception on the future of their fishing activity, while 42% had a negative perception (Figure 3).

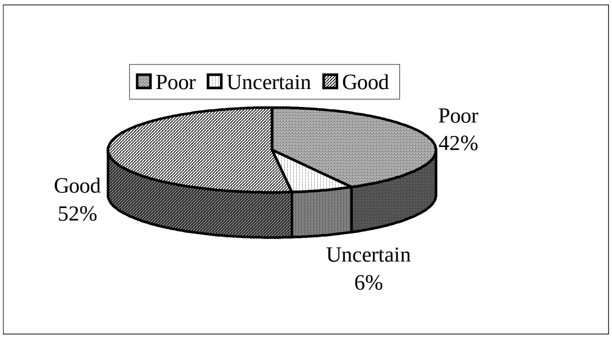

Figure 3: Fisher's perception on the fishery.

Those who indicated a positive perception based their perceptions on factors of receiving more or higher earnings in the future 61%, reliability of fishery 21%, 10% indicated job security in the fishery, 7% gave other factors and felt that there will be proper lake management and increase of fish stock in future while 1% based their perception on dignity whereby fishers will be recognized and respected.

Fishers also had negative attitude towards the future of the fishery. 32% felt that there was no job security in fish harvesting activity, 37% felt that fishing can not be relied on, 8% indicated that due to continuous depletion of fish resource, there will be low earning from the lake, 2% felt that fishing lowers ones dignity, while 22% felt that the future of fishery will be more corrupt than today.

Those who had uncertain perception of the fishery felt that the future of fishing activities depended on the will of God and seasons and nobody can tell the future.

Majority of fishers could not want to quit their fish activities, 83% found it impossible to quit fishing because they lacked alternative activities to sustain them, 8% mentioned that fishing was a family occupation and their only livelihood so they cant do without it, 8% also indicated that fishing was their only source of income, while 1% felt that their fishing equipment were not easy to dispose off.

Movement of people out of the fishery

Fishers listed several conditions that can make them quit fishing activity. The common condition that can make a fisher to desert fishing was sickness or death 43%, 27% could quit fishing if all the nets were stolen, 16% indicated that the time when all the fish is finished, while 14% could quit if they get a better job elsewhere.

Fishers also gave several reasons as to why they would want to quit fishing activities.31% could quit due to fish decline in the lake, 17% cited theft of gears and fishing equipments, 16% cited lack of capital or market for their fish, 11% indicated sickness while 2% cited the problems of trawlers destroying their nets.

Fishermen of Lake Victoria have no retirement age limit but majority of them revealed that they don't have to retire from fishing until one is dead 69%, while 31% indicated that their retirement age was after attaining the age of 60 years.

Figure 3 shows the strategies the fishers would take when the fishery declines. Majority indicated that if the fishery was declining, they could be forced to increase the fishing effort, while others would change to farming activities (Figure 4).

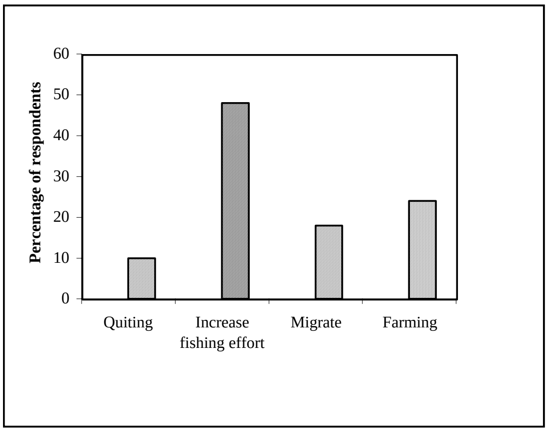

Figure 4: The strategies fishers would take when the fishery declines.

The study further indicates that fishers have no other complementary activities to supplement fishing, but if they would wish to move, they would most readily move into farming activities or trade in agricultural produce. The high level of dependence of lakeside communities on fishing activities reflects this.

Fisheries management initiatives (Laws and regulations)

The fish resource in Lake Victoria is declining due to use of illegal gears, retrogressive fishing methods and environmental degradation. For the purpose of co-management, this study was meant to investigate whether fishing communities are aware of fishing laws and regulations and their overall perception of fishery potential in the future.

The Fisheries Departments of the three riparian states collected statistics on the catch and adopted different types of regulations in order to control fishing effort. The government had however, very limited possibilities to enforce these regulations. Although there in principle this has been an open access to the fishery, local fishing communities have all through this century developed rules that regulate the fisheries (Ogutu, 1992, and 1994). These rules stipulate clearly who may fish, in what season, in what area, what type of fishing gear that is acceptable and type or size of fish can be caught.

Institutions had been developed in the local communities to enforce these regulations. The rules and nature of enforcement institutions varied from one area to another and they also changed over time. In some places these rules were detailed, explicitly expressed and well known in the community. In other areas the rules were be vaguer, covered less issues related to the fishing effort and were not generally recognized in the community. This system of local management has been threatened with the introduction of commercial fishing. The operations of the trawlers fishing in the lake had little knowledge of these rules or felt free to disregard them.

Results of this study indicate that 90% of the fishermen sampled had some knowledge of most of the fisheries laws and regulations.

The most common regulation cited by the fishers were restriction on harvesting juvenile fish and fish size restrictions whereby fish less than1 kg is restricted in case of Nile perch species 26%, gear type and size restrictions e.g. beach seines, gillnets, mosquito seines forming 26%, 24% were aware of fishing methods regulations restricting use of pesticide in catching fish, boat size requirement regulations 12%, 7% mentioned regulation on fishing time/closed seasons where fishing is only in certain months of the year, 13% indicated boat and fisher licensing regulations but other areas mentioned was not fishing on fish breeding grounds at shallow water and river mouths, children are not allowed to fish, drunkenness is prohibited at the beach or the lake.

Threats and risks associated with fishing activity

In the course of carrying out fish harvesting activities fishers experience a lot of risks, uncertainties and threats. The most common threat was theft of fishing gears and other equipments followed by drowning and attack by wild animals e.g crocodile's, hippos and snakes (Figure 5).

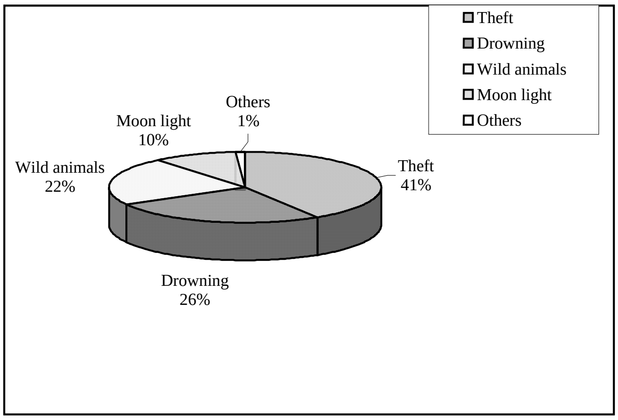

Figure 5: Common threats facing the fishing communities around the lake.

The occurrence of the moonlight lead to the reduction of catches of certain species e.g. Omena, which can be harvested in plenty during dark nights using pressure lamps to attract them. Due to these threats fishers suggested several methods to curb them. The majority suggested their beaches to have a patrol boat to safeguard theft of gears and equipments 46%, 30% indicated the use of life jackets every time they are fishing to prevent them from drowning, 16% suggested other safeguards in case of animals by either chasing animals from the fishing grounds or to confine them to national parks, 5% did not propose any safe guard, but 3% suggested day time fishing only.

Fishers also experience other risks and uncertainties where 35% of them indicated the unpredictable markets for fish, they were not sure who to buy their fish and on what prices, 44% indicated heavy rains during rainy seasons, 12% were stricken by lightening in the lake, 7% experienced a lot of floods and 2% mentioned other risks like strong currents in the lake and frequent raids at the boarder beaches.

To safeguard these risks and uncertainties, 48% suggested the wearing or covering themselves with black polythene paper during heavy rains, 40% suggested the provision of cold storage and transport facilities at the beach, fish prices control at the beaches, wearing of protective rubber shoes, provision of tents on the boats, broadcasting fish prices on the radio, insurance cover for fishermen incase they drown and die in the lake, incase of lightening they should provide a provision of lightening arresters at the landings ,but 12% did not suggest any safeguard.

Conclusions

Most fishers have no alternative occupation a part from fishing.

Lack of resources, financial and physical remains the main handicap to their fishing activities.

Men dominate the harvesting sector while women either own fishing gears and equipments.

Poverty amongst the fishing community is apparent from the small-scale nature of their fishing activities and trade.

Nile-perch fishery has changed the size of vessel and gear where those targeting the fish cannot afford expensive nets, bigger boats or outboard engine.

Although a number of fishers work on full-time basis, they have limited or no influence on the levels of benefits they receive from their activities.

Educational levels are low indicating high illiteracy and poor standards of living.

If the fishery declined fishers perceived to take other strategies by increasing the fishing efforts or changing to agricultural activities to earn a living.

Fisher folk have some knowledge on fisheries management laws and regulations used to manage the Lake.

Major threats facing fishers were theft of gears, drowning in the lake, attacked by wild animals and lightning

Recommendations:

- The concerns over the future of the fishery should be captured to make fishers realize the need to conserve the resource.
- Predictions of weather to avoid risky weather.
- Enforce safety of fishing vessels

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A social experiment by NPO on consensus building between citizens and the administration regarding public works

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Abstract

Consensus building between citizens and the administration is needed to ensure effective implementation of policies regarding public works. However, due to lack of understanding of policies it often takes time to reach consensus and sometimes conflicts occur between citizens and the administration occur. In this study, a social experiment concerning the involvement of citizens in the decision making process for conservation of the water environment of Lake Biwa was undertaken with a Nonprofit Organization (NPO) as a mediator. The study aimed at understanding the consensus building process between citizens and the administration. A questionnaire survey was carried out three times targeting the same respondents. Prior to the each survey background information about Lake Biwa was distributed to the respondents. Change in consciousness of citizens about Lake Biwa as a result of information dissemination was recognized. The order of priority for policy implementation for conservation of Lake Biwa was established by Analytic Hierarchy Process (AHP) method. It was recognized that information dissemination plays a key role in building consensus between citizens and the administration.

Key words: Citizen, consensus building process, Lake Biwa

Introduction

Lake Biwa is an important source of water for about 14 million people in the Kansai Metropolitan Region of Japan. Because of the great importance of the lake, Shiga Prefectural Government, which is responsible for managing the lake, has made efforts to address environmental problems within the lake and its basin. In recent years, it has become clear that involvement of citizens is indispensable for effective implementation of measures for conservation of the lake. As such, when implementing measures for conservation of the lake, consensus building between citizens and the administration is needed. However, it is not easy to achieve this because individual values and tools of communication have become diversified and concern of citizens for public works and the environment has increased.

In this study, a social experiment concerning the involvement of citizens in the decision making process on measures being implemented by Shiga Prefecture for conservation of the water environment of Lake Biwa was undertaken with a Nonprofit Organization (NPO) as a mediator. The objectives of the study were to understand the consciousness of citizens about Lake Biwa, to understand the change in consciousness of citizens by information dissemination, and to propose a consensus building process between citizens and the administration. A questionnaire survey was carried out three times targeting the same respondents. Prior to the each survey background information about Lake Biwa and sewerage systems around the lake was distributed to the respondents.

Materials and methods

Outline of study

The flow of this study is shown in Figure 1. Two types of questionnaire surveys targeting citizens and the administration were undertaken. Background information about Lake Biwa was disseminated to respondents through a newsletter that was distributed between the questionnaire surveys. Opinion exchange with citizens was held to take in needs of citizens for incorporation in the questionnaire survey.

Questionnaire survey

Two types of questionnaire surveys, one targeting the citizens and the other targeting Shiga Prefectural Government (SPG) officers, were implemented between January 2004 and February 2005. For citizens, three questionnaire surveys targeting the same respondents were undertaken while for SPG officials, one questionnaire survey was implemented. The questionnaire surveys for citizens were carried out in two areas, namely Moriyama City in the southeast of the lake and Takashima City in the northwest of the lake. The number of samples for questionnaire surveys for citizen ranged from 315 – 518 while that for SPG officials was 56.

Newsletter

Two newsletters were distributed to respondents, one between the first and second questionnaire surveys and the other between the second and third questionnaire surveys. The first newsletter contained basic information about Lake Biwa such as water quality, sewerage system, Lake Biwa Comprehensive Development Plan (Mother Lake 21 Plan), and regulatory measures (Table 1). The newsletter aimed at increasing the understanding of citizens about Lake Biwa. The second newsletter contained more technical information such types of sewerage systems and associated costs, pollution sources to Lake Biwa and policies against non-point source pollution (Table 2). The second newsletter aimed at deepening citizen's understanding of Lake Biwa.

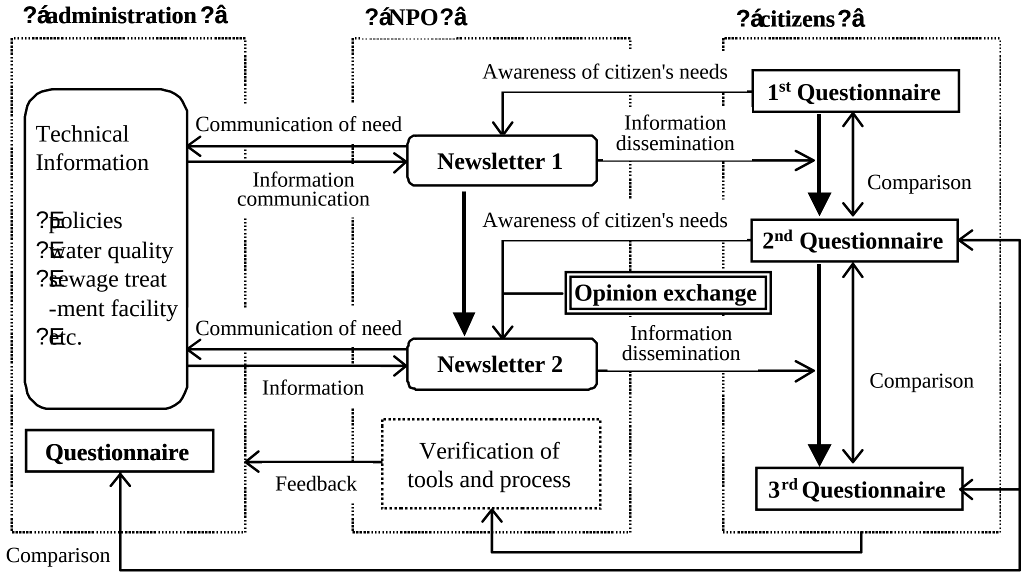


Figure 1: Flow of the study.

Table 1: Contents of 1st newsletter.

Content	Detailed Particulars
Water quality of Lake Biwa	T-N, T-P, COD
Condition of development	Coverage of sewage system (ranking)
Sewage system	Coverage of tertiary sewerage system (ranking)
	Connection rate of tertiary sewerage system (ranking)
Sewage system	Current sewerage system
	Upgrading sewerage system
Future sewage system	Target value
Improvement of water quality because of upgrading sewage system	T-N, T-P, COD, Trihalomethane
	Endocrine-disrupting chemicals, odour
Costs for sewage system	Initial cost, running cost
Costs for future sewage system	Payment for future sewage system
Pollution source of Lake Biwa	Domestic, industrial, agricultural, road surface
Measure other than sewage system	Measure to address agricultural drainage
	Measure to address the runoff

Table 2: Contents of 2nd newsletter

Content	Detailed Particulars
Water quality in Lake Biwa	T-N, T-P, COD, BOD
Planar distibution of water quality	T-N, T-P, COD, underwater visibility
Comparing with other lakes	T-N, T-P, COD
Eutropnication of Lake Biwa	Days with water bloom
Sewerage system	T-N, T-P, COD
	Coverage of sewage system
	Coverage of tertiary sewage system
Regulation targeting eutrophication	Regulation targeting eutrophication
Mother Lake 21 Plan	Outline of the plan
Emerging problems	Trihalomethane, endocrine-disrupting chemicals
Costs for water quality conservation	Water supply population
	Current effluent charge

Opinion exchange

Opinion exchange among citizens was held between the second and third questionnaire surveys. The opinion exchange was facilitated by the NPO. The aim of the opinion exchange was to get information needs of citizens and to get feedback on information earlier distributed to citizens. Draft questionnaires were discussed and opinions received reflected in the final questionnaires.

Classification of citizens according to level of knowledge

To comprehend citizen's level of knowledge regarding water quality of Lake Biwa, the first questionnaire contained questions about the most clean and most polluted area in the lake, the area where water blooms occur, and the cause of water blooms. The respondents were also asked to do self judgment of their level of knowledge about water quality of the lake. Based on the score of the questions and self judgment of level of knowledge, respondents were classified into three groups. The top 25% were classified as high-level knowledge group, the bottom 25% as low-level knowledge group and the remainder as middle-level knowledge group.

Contingent valuation method (CVM)

To estimate change in a consciousness of respondents for conservation of the water environment of Lake Biwa, questions employing CVM were included in all questionnaires. The benefit of conserving Lake Biwa was presented abstractly without concrete numeric data of water quality to make it easy for citizens to understand. Willingness to pay (WTP) indicated by SPG officers was understood as payment from the point of view of the administration.

Analytic hierarchy process (AHP)

AHP method was employed in the questionnaire survey to comprehend respondent's ranking of importance of policies for conservation of Lake Biwa. The hierarchy chart used was based on Mother Lake 21 Plan (Figure 2). The first level corresponds to the goal of Mother Lake 21 Plan, that is, conservation of water environment of Lake Biwa. The second level corresponds to three objectives of the plan, namely, protecting water quality, protecting recharge capacity of aquifers, and preserving the natural environment and scenic landscape. A fourth objective, economic efficiency, was introduced in this study. The third hierarchy level corresponds to policies of the objectives.

Normally, weight in the AHP method is calculated by paired comparison method. However, this method is complicated for ordinary citizens. Therefore, this study employed a simplified method for calculating weight. Respondents were asked to compare items on a line scale (Figure 3).

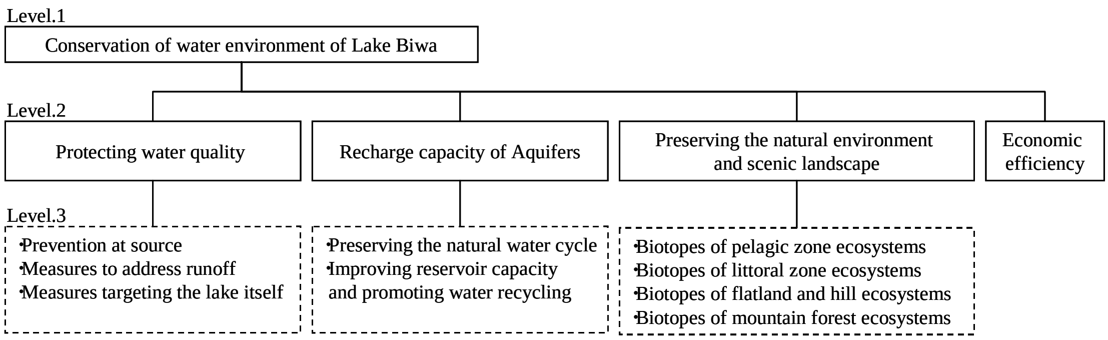


Figure 2: Hierarchy chart based on Mother Lake 21 Plan.

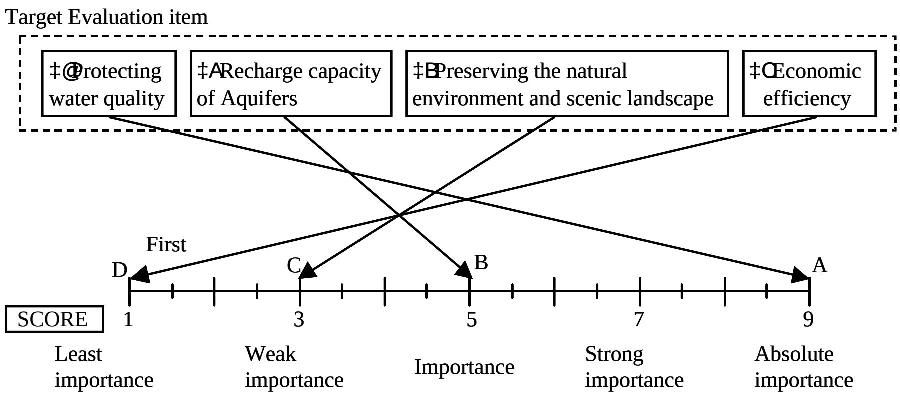


Figure 3: Example of answer for AHP questionnaire survey

First respondents pick the least important item and connect it to point 1 on the line scale. Next, other items are connected to the corresponding point of importance on the scale (relative to the least important item). Using the values from the scale, a paired comparison matrix was constructed with the formula in Table 3.

Table 3: Formula for calculating paired comparison matrix elements.

	Evaluation item			
	①(A)	②(B)	③(C)	④(D)
①(A)	1	A>B :(A-B)+1 ※1 A<=B :1/{(B-A)+1}	A>C :(A-C)+1 ※2 A<=C :1/{(C-A)+1}	A>D :(A-D)+1 ※3 A<=D :1/{(D-A)+1}
②(B)	※1	1	B> C :(B-C)+1※4 B<=C :1/{(C-B)+1}	B>D :(B-D)+1 ※5 B<=D :1/{(D-B)+1}
③(C)	※2	※4	1	C>D :(C-D)+1 ※6 C<=D :1/{(D-C)+1}
④(D)	※3	※5	※6	1

Results

Level of knowledge about water quality and water environment.

Citizens were classified according to their level of knowledge about water environment of Lake Biwa. Possible factors that influence the level of knowledge were classified into two, namely those of "direct relevance" to Lake Biwa and those of "indirect relevance" to Lake Biwa. Factors of direct relevance include frequency of fishing, swimming or walking in the lakeside park. On the other hand factors of indirect relevance include frequency of viewing the lake from far. Figure 4 shows the results of frequency of involvement in influencing factors classified according to the three levels of knowledge of respondents. Frequency of involvement tended to increase with respondent's level of knowledge both for factors of direct and indirect relevance to Lake Biwa. Therefore, for increasing interest of citizens in Lake Biwa, it is important to heighten their level of knowledge.

Change of consciousness of citizens

To clarify change of consciousness of citizens resulting from information dissemination, the same selected questions were included in all the three questionnaire surveys undertaken. Information about Lake Biwa was disseminated to respondents between the questionnaires through newsletters and opinion exchange meetings. Figure 5 shows the change of consciousness of respondents between the questionnaires.

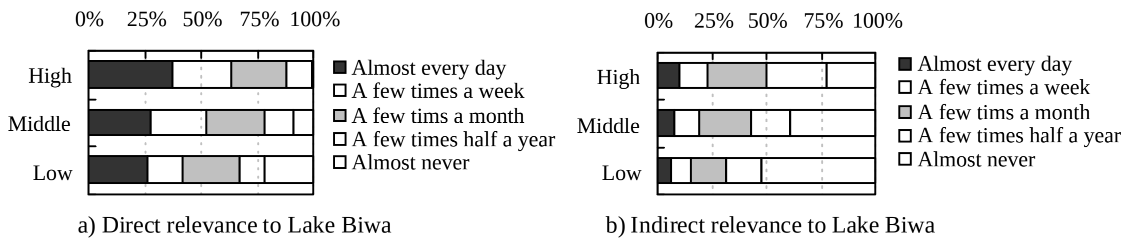


Figure 4: Level of knowledge and its relevance to Lake Biwa.

Regarding "Awareness of water quality of Lake Biwa" between the first and second questionnaire surveys the percentage of those who answered "dirty" decreased while those who answered "a little clear" increased. This was influenced by information comparing Lake Biwa and other lakes that was distributed in the first newsletter (Table 1). However, "a little dirty" accounted for more than half of respondents, implying that most citizens consider the water not to be of good quality. Regarding "Awareness of source of pollution in Lake Biwa", "domestic" decreased between the questionnaire surveys while drainage from other sources increased. Thus, through information dissemination, more citizens were made aware of the importance of sources of pollution other than domestic source.

As for the "Need to upgrade sewerage system", the number of citizens who considered it "necessary" increased between the first and second questionnaire survey. Similarly, regarding "Willingness to pay", the number of citizens who considered "payment is better" increased between the first and third questionnaire surveys. It may be said that because of information dissemination, sense of crisis of water environment of Lake Biwa was heightened and more citizens accepted the need to upgrade sewerage system and the need to pay more for conservation of water environmental of Lake Biwa.

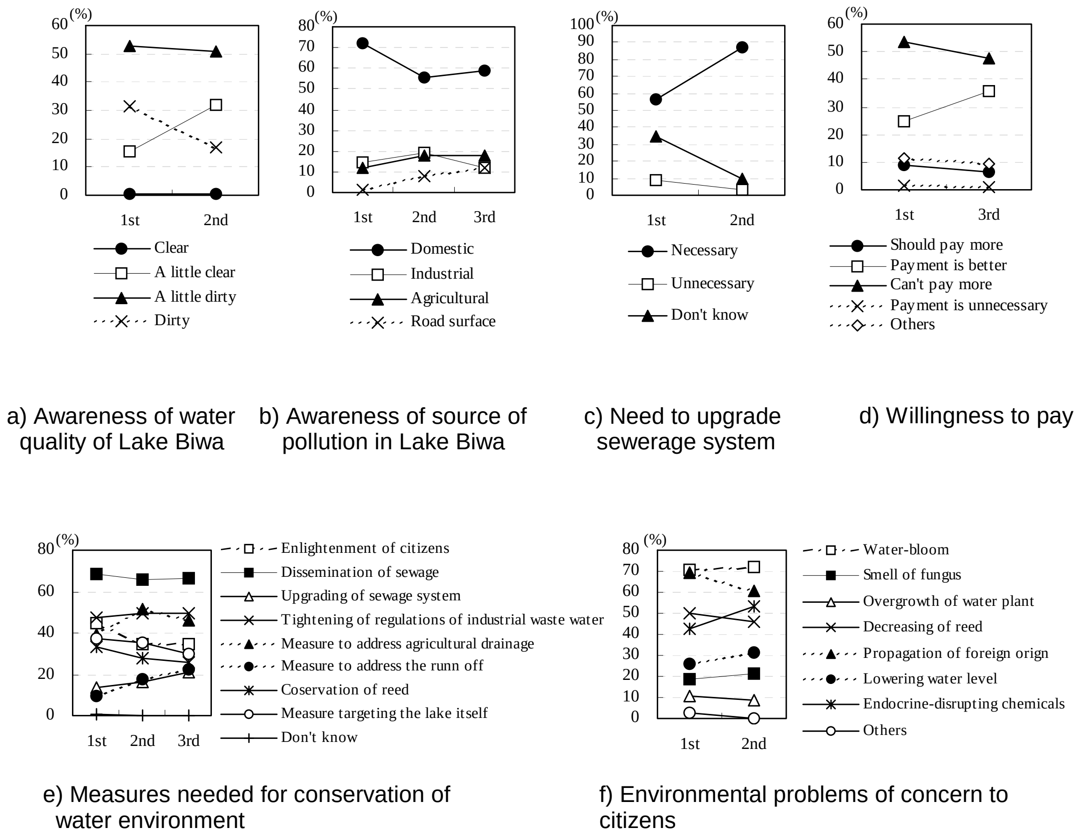


Figure 5: Change of consciousness of citizens.

Concerning "Measures needed for conservation of water environment", responses for "upgrading sewage system" and "measure to address runoff" increased between the questionnaire surveys. This could be attributed to the fact that sources of pollution other than domestic sources came to be recognized as significant and concern about emerging issues such as toxic chemicals was heightened. In the question "Environmental problems of concern to citizens", "water-bloom" had the highest response probably because it is one of the most visible phenomena and one whose effect is noticeable by citizens through odor of drinking water. The number of respondents who identified "endocrine-disrupting chemicals" as a problem of concern increased, indicating increase in concern about toxic chemicals.

Change in WTP

The WTP from the questionnaire surveys are shown in Figure 6 and Table 4. In Table 4 two scenarios, with and without consideration of data for 0 Yen, are presented. From the first to the second questionnaire the percentage of 0 Yen decreased but 1,000 Yen and 2,000 Yen increased. The average WTP increased from 572 Yen and 808 Yen to 653 Yen and 821 Yen, respectively for scenarios with and without consideration of data for 0 Yen. On the other hand, from the second to the third questionnaire survey, the percentages of 0 Yen and 200 Yen WTP increased while that with WTP of 500 Yen and above decreased. This could be attributed to the fact that information that 160 Yen/household/month was required to upgrade the sewerage system was disseminated in the second newsletter prior to the third questionnaire survey. Dissemination of this information in the third questionnaire survey made a significant impact on WTP.

Comparing WTP between citizens and the administration, the percentage of 0 Yen for citizens was less than that for the administration. The average WTP for citizens was less than that for the administration but without "0 Yen" answer the average WTP for citizens was more than that for the administration. This shows that the “0 Yen” answer made a significant effect on the difference between the average WTP for the citizens and the administration. Therefore, to build consensus between citizens and the administration it is necessary to reduce “0 Yen” answer from citizens.

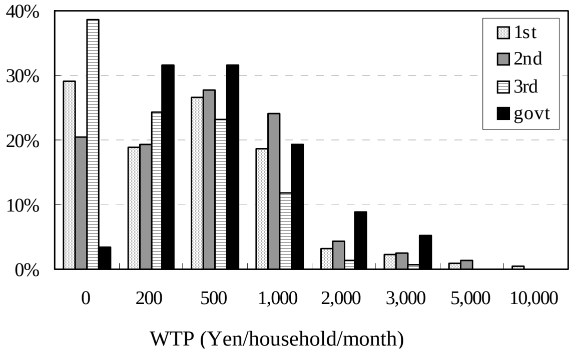


Figure 6: Distribution of WTP.

Table 4: Average WTP (Yen/household/month).

Questionnaire survey	Including "0 yen"	Without "0 yen"
1st	572	808
2nd	653	821
3rd	329	538
Govt	747	775

Relationship between WTP and level of knowledge

Changes in WTP were compared among three groups of citizens classified according to level of knowledge (Table 5 and Figure 7). The high-level of knowledge group showed the highest WTP in the first and second surveys. It was considered that the higher the level of knowledge the higher the WTP was. In the third survey the difference in WTP between high-level group and middle-level group was not significant. This may be attributed to increase in consciousness about conservation of water environment of the middle level group through information dissemination between the surveys. However the WTP of low-level group was lowest in all the three surveys. It is considered that increase in consciousness for water conservation of water environment was not achieved for this group.

Table 5: Average of WTP (yen).

		1st	2nd	3rd
High level	Avg	640	703	352
	n	180	172	62
Middle level	Avg	474	583	363
	n	450	449	138
Low level	Avg	403	519	268
	n	257	228	87

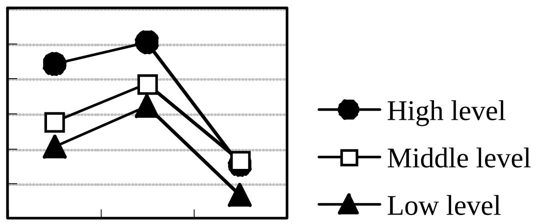
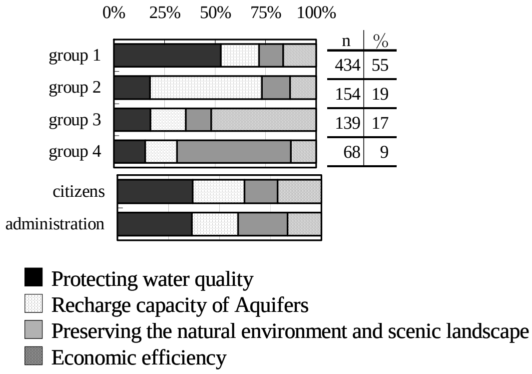


Figure 7: Average WTP.

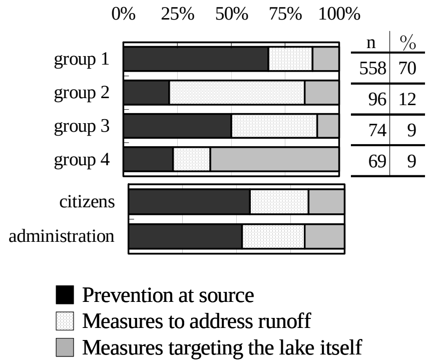
Prioritization of policy by citizens

Using a respondent’s weight from AHP, cluster analysis was done and citizens were classified into 4 groups based on objectives respondents hoped for. The results of the classification are shown in Figure 8. In the level 2 hierarchy “Protecting water quality” was most emphasized by citizens followed by “Recharge capacity of aquifers”. The proportion of citizens emphasizing “Economic efficiency” was relatively less, but it was higher than the corresponding value for the administration.

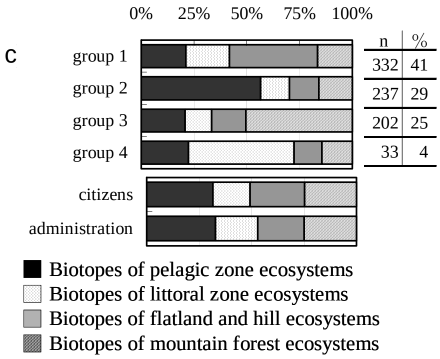
In “Protecting water quality” of the level 3 hierarchy, “Prevention at source” was most emphasized and accounted for 70 % of citizens. On the other hand, in “Protecting recharge capacity of aquifers” and “Preserving the natural environment and scenic landscape” no measure was emphasized more than the other. “Recharge capacity of aquifer” and “Preserving the natural environment and scenic landscape” were considered to be unfamiliar to citizens. Therefore it was difficult for citizens to answer the level 3 hierarchy questionnaire except for “Protecting water quality”. Comparing among citizens, significant differences were observed but there were no significant differences between citizens and the administration. Therefore, distributing more specific information about policies citizens were unfamiliar with and deepening citizen’s understanding were recognized as problems.



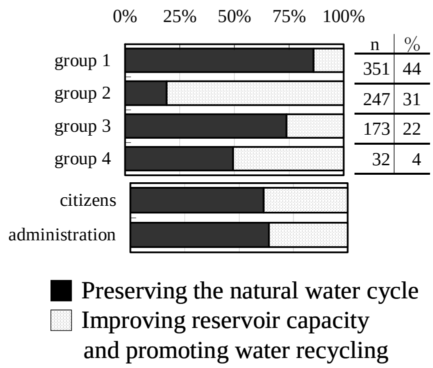
a) Level 2: Three objectives of Mother Lake 21 Plan and Economic efficiency.



b) Level 3: Protecting water quality.



c) Level 3: Preserving the natural environment and scenic landscape.



d) Level 3: Protecting recharge capacity of aquifers.

Figure 8: Classified AHP Results.

Conclusion

In this study, information about water environment of Lake Biwa was disseminated to deepen citizen's understanding about the lake. An attempt was made clarify the process of consensus building between citizens and administration. Comparing the responses to the same questions in consecutive questionnaire surveys, interest in non-point source pollution and toxic substances such as trihalomethanes was increased. Citizen's acceptance of implementation of advanced tertiary treatment system and measures to address the non-domestic sources of pollution were increased. WTP for conservation of Lake Biwa increased prior to disseminating specific information about the actual payment required per household per month to achieve the objective, but decreased after information about required payment was disseminated. It was therefore recognized that WTP was affected by dissemination of specific information about the actual cost of conservation. Using AHP method, the prioritization of policy for conservation of water environment of Lake Biwa was shown. Among the three objectives of Mother Lake 21 Plan, citizens consider protecting water quality as the most important. The need for this objective was not much different between citizens and administration. However, the need for the other two objectives ("Recharge capacity of aquifer" and "Preserving the natural environment and scenic landscape") was different between citizens and the administration, probably because these two objectives were unfamiliar to the citizens. It was clarified that reducing the number of citizens who consider "0 Yen" as WTP for conservation of Lake Biwa and increasing interest in conservation of water environment by citizens of the "low-level of knowledge" group were critical to building consensus between citizens and the administration.

Acknowledgement

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Application of ecological engineering principles in Lake Management

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Abstract

Ecological Engineering and Ecosystem Restoration (Mitsch and Jørgensen, 2003), presents 19 ecological principles to be used for all ecotechnological projects – it means all projects that use engineering and management of ecosystems should be based on these principles. The principles may be used as a checklist to take ecological considerations into account when ecotechnology and ecological management are applied. These 19 principles are here applied on lake management issues. It is shown that the principles are useful as a checklist also for lake management; but it is also possible to give 5 general and 12 specific recommendations to lake management based upon the 19 principles.

Introduction

Mitsch and Jørgensen proposed to base ecological engineering on 14 ecological principles in their book from 1989, *Ecotechnology, an Introduction to Ecological Engineering* (Mitsch and Jørgensen, 1989). In their book *Ecological Engineering and Ecosystem Restoration* (Mitsch and Jørgensen, 2003), the 14 principles were expanded to 19 principles. The idea behind these ecological engineering principles is that all ecotechnological projects – that is, all projects that use engineering and management of ecosystems, should be based on these principles. The principles are developed to be applied as a checklist on what to remember when ecological engineering projects are implemented in practice. The principles are very general in the sense that they should be applicable for all type of ecosystems and all ecological engineering projects. Jørgensen and Nielsen (1996) have previously applied the principles as checklist for organic and integrated farming and shown that industrial farming is violating several of the principles. Jørgensen (in print) has furthermore applied the principles in landscape management and shown that the principles are indeed applicable as a checklist to ensure that the ecosystem properties are considered in the landscape management

Lake Management is using ecological engineering of lakes and reservoir, whenever lake restoration methods are applied. In addition, Lake Management applies general ecosystem management principles. It would therefore be interesting to use the 19 principles on ecological management of lakes and see to what extent the principles can be used and to what extent the lake management can incorporate these 19 ecological principles and thereby be more sustainable. The 19 principles will be presented in the next section and it will be discussed how the principles can be applied in Lake Management. In the following section, it will be discussed what lake management is gaining by using these principles in practice. The last section attempts to make conclusions and recommendations on the application of ecological principles in practical lake and reservoir management.

Test of the applicability of 19 ecological engineering principles on Lake Management

The 19 principles are presented and their application in lake management discussed.

Principle 1. Ecosystem structure and functions are determined by the forcing functions of the system

Ecosystems are open systems; see also principle 3. If they were isolated they could not survive, because an energy source is needed to supply the energy needed for maintenance of the ecosystem far from thermodynamic equilibrium. A lake is an open system, which implies that the lake is influenced by its environment. Of particular importance for the health of a lake is the air pollutants brought by the wind and the pollutants in the rainwater and in the inflowing streams. Consequently, it is recommended to develop mass balances for the entire drainage area for the most significant pollutants to determine the pollution sources. The concentrations of these pollutants in the air, rain and inflowing waters should be reduced sufficiently to ensure a fully acceptable health for the lake. A relationship between ecosystem health and the concentrations of the focal pollutants is needed to be able to decide on what a sufficient reduction may be. It is often beneficial to use models to find these relationships, as it is difficult otherwise to overview all the interacting processes. Models require, however, good observations and a good knowledge to the characteristics of the ecosystem. These considerations lead to two recommendations:

R1: Set up mass balances for all possible pollutants for the entire drainage area and determine the inputs to the lake and their sources.

R2: Decisions on reductions of impacts require a good knowledge to the relationships between lake ecosystem health and concentrations of focal pollutants.

Principle 2. Energy inputs to the ecosystems and available storage of matter are limited

This is also the question about the impact on the lake. The impacts consist of energy and / or matter and the ecosystems can only absorb a certain amount of energy and various chemical compounds. When the chemical compounds are toxic, the amount of absorption is very limited, but also the absorption capacity for nutrients are limited, as it is known from the eutrophication problem of lakes. Lake Management requires a good knowledge to these absorption capacities, meaning which amounts of energy and various chemical compounds can be tolerated and would therefore be harmless. This principle supports recommendation number two.

Principle 3. Ecosystems are open and dissipative systems

This explains why ecosystems are dependent on the forcing functions see principle 1. It explains furthermore why it is preferable to apply management of the entire drainage area. As all ecosystems are open, the pollutants in one ecosystem will inevitably to a certain extent be transported to the other ecosystems in the drainage area. This principle leads to the following recommendation that is close to R1:

R3: A proper lake management requires a good management of the entire drainage area.

Principle 4. Attention to limiting factors is strategic and useful in preventing pollution or restoring ecosystems

In this context, it may also be formulated as homeostasis of ecosystems requires accordance between biological function and chemical composition. It means that the ratio of element flows through an ecosystem should follow approximately the ratio C:N:P = 41:7:1, which is the so-called Redfield ratio, that is valid for many organisms with a good approximation. Management of aquatic ecosystems often uses to play on a limiting factor (the element present in the ecosystem in the smallest amount relatively to the needs for the biological functions). Reduction of phosphorus is often used in Lake Management to reduce the eutrophication, because phosphorus is easy to reduce in wastewater, that is the main source of phosphorus. Waste water treated by a mechanical-biological-chemical wastewater treatment plant will typically have the ratio N:P = 30:1, that illustrates that phosphorus is limiting if well-treated waste water is the main source of phosphorus. These considerations lead to the following recommendation:

R4: It is beneficial to reduce the inputs to the lake of the element that most easily and most cost moderate can be made the limiting factor in the abatement of the eutrophication.

Principle 5. Ecosystems have homeostatic capability that results in smoothing out and depressing effects of strongly variable inputs

This capability gives ecosystems and reservoirs buffer capacities (Jørgensen, 2002), defined as the ratio between change of forcing functions and corresponding change of state variables; see Figure 1. In lake management it would be practical to assess the most important buffer capacities, as it is a quantification of the ability of the ecosystems to absorb the impacts determined by the forcing functions: which and how much impact can be accepted? When is the buffer capacity used up?

Wetlands and other natural ecosystems have several significant buffer capacities. Wetlands are smoothing out water flows and can thereby prevent flooding. Wetlands and forests are able to absorb nutrients and toxic compounds and can thereby depress the impacts of pollutants, included non-point pollution, that is opposite point pollution difficult to reduce. It is therefore of utmost importance to maintain the wetlands adjacent to lakes and wetlands and forest in the entire drainage area, as they contribute significantly to the over-all buffer capacities. There are numerous examples of flooding or pollution disasters due to drainage of wetlands. The latest example is the flooding of New Orleans. There are correspondingly numerous examples of erosion, as a result of deforestation. These examples have clearly illustrated the homeostatic capability of natural ecosystems, included wetlands and forests.

R5: It is beneficial to maintain wetlands adjacent to lakes and wetlands and forests as mosaic in the landscape to abate non-point pollution and maintain an over-all high buffer capacity to meet the impacts of possible pollutants.

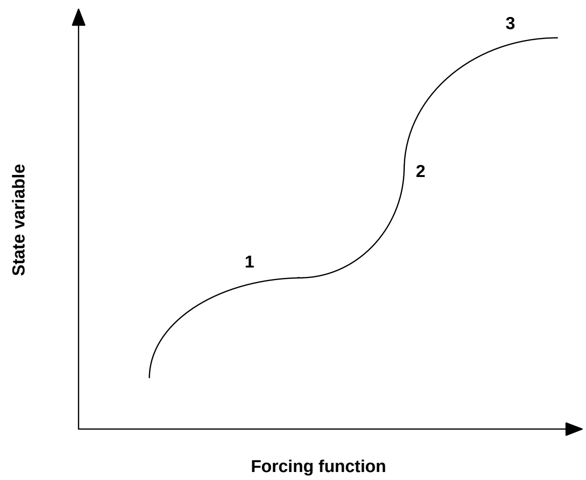

Figure 1: The ecological buffer capacity is defined as the ratio change in state variables / change in forcing functions (impacts). The buffer capacity at point 1 and 3 is high but low at point 2. In ecological management it is important to assess when the buffer capacities are low and high.

Principle 6. Match recycling pathways to the rates to ecosystems to reduce the effect of pollution

Ecosystems have ability to use and/ or decompose man-made pollutants. Microorganisms decompose organic matter – slowly for many toxic compounds – faster for non-toxic organic matter. Nutrients are taken up by plants and nitrate is used under anaerobic conditions for oxidations. Ecosystems have characteristic rates that will offer self-purification processes up to a limit. It is well-known for streams where oxygen is taken up by re-aeration with a certain rate that can compensate for the rate of oxygen consumption by aerobic microbiological decomposition processes. A lake manager needs to consider the “self-purification rates” in the lakes to avoid an over-loading. Ecological models developed on basis of a good knowledge to the ecosystems involved are therefore excellent management tools in this context, because they are able to consider the influence of the external factors (temperature, wind speed etc.) on the focal self purification rates. This may be formulated in the following recommendation:

R6: It is important in lake management to apply the self purification rates but it is very important that the rates are fully respected to avoid over-loadings. Models are good tool to assess the self purification rates as function of the external variables (the forcing functions).

Principle 7. Design for pulsing systems wherever it is possible.

Ecosystems with pulsing patterns often have greater productivity, biological activity and chemical cycling than do systems with relatively constant pattern. It is therefore important in integrated environmental management to understand and respect the role of pulses. This is of particular importance in lakes with short retention time and reservoirs, where the through-flow often is considerably higher in the early spring. These possibilities are touched on again by Principle 17.

Principle 8. Ecosystems are self-designing systems

Natural ecosystems have a very well-developed ability to find at least close to the best solution, offering survival of many adapted species, that will all contribute to a wide spectrum of buffer capacities. Therefore, let nature by use of its self-designing system find the right management solution, provided of course that we would not interfere with the natural processes for instance by discharge of pollutants.

Principle 9. Processes of ecosystems have characteristic time and space scales that should be accounted for in environmental management

A natural drainage area has a characteristic pattern that is crucial for the maintenance of species diversity. Violation of this principle by drainage of wetlands and deforestation has caused desertification. Wetlands and forests maintain high soil humidity. Application of too large fields prevents wild animals and plants from finding their ecological niches. It is therefore important to have a pattern of more-or-less untouched nature in the landscape. It is also important to maintain ditches and hedgerows as corridors in the landscape and ecotones between agricultural systems and natural ecosystems and between other man-controlled systems (urban areas) and nature. The recommendation corresponding to this principle is covered in R5.

Principle 10. Biodiversity should be championed to maintain an ecosystem’s self-design capacity

It has been shown that there is no simple relationship between biodiversity and ecosystem stability (May, 1977). Due to the wide spectrum of properties represented in various organisms, it is however important to maintain a high biodiversity, because it will ensure not necessary higher buffer capacities but a wider spectrum of buffer capacities. Eutrophic lakes have usually a high buffer capacity towards change in the eutrophication level; but have also a low biodiversity and buffer capacities towards other changes (Jørgensen, 2002). A high biodiversity will therefore give a higher probability of the lake to absorb new or unexpected impacts, or expressed differently high biodiversity makes the lakes and the entire drainage area less vulnerable.

R7: It is recommended to maintain a high biodiversity of lakes to meet unexpected impacts

Principle 11. Ecotones, transition zones, are important for ecosystems as membranes are for cells

Ecotones are buffer zones and protect the natural ecosystems. It is therefore important in environmental management to maintain the ecotones between agriculture and human settlements on the one side and natural ecosystems on the other side. The ecotones are able to a certain extent to absorb the impact from the man-controlled systems. A sound littoral zone or riparian zone with dense vegetation will be able to absorb contamination included non-point pollutants, before it reaches the lake ecosystem. This principle is covered in R5.

Principle 12. Coupling between ecosystems should be utilized wherever possible

Ecosystems are coupled in an interactive network. Therefore it is important to maintain some natural ecosystems in the drainage area, because it will ensure that a relatively high biodiversity is maintained in the landscape, for instance a high biodiversity of birds. This again will give the lake and the entire drainage area a wide spectrum of buffer capacities and increase the adsorption capacities for man-made impacts on the entire drainage area. This principle implies of course – like principle one – that pollution in man-controlled ecosystems for instance intensive use of pesticides in agriculture inevitably will contaminate the natural ecosystems. This principle is covered in the important recommendation R5.

Principle 13. The components of an ecosystem are interconnected, interrelated and form a network, implying that direct as well as indirect effects of ecosystem development need to be considered

Ecosystems are working in what we could call synergistic network, meaning that the components in the ecosystems due to their interactions in the ecological network to a certain extent are co-operating. Patten (1982 and 1985) has shown that the indirect effect (the effects that are not based on direct links but on the entire network) is often more important than the direct effect and shows more synergy. This implies that all species in the natural ecosystems have their positive functions in the ecosystems and should be preserved. Biomagnification is another result of the indirect effect in ecological networks. High concentrations of pesticides or heavy metals may due to biomagnification be observed for the later levels in the food-web. This should of course be considered in Lake Management.

R8: It is important in lake management to consider both direct and indirect effects that requires a good knowledge to ecosystem and ecological network functions and characteristics.

Principle 14. An ecosystem has a history of development

An old ecosystem has usually a high biodiversity and therefore also a wide spectrum of buffer capacities, while a young ecosystems is more vulnerable. It is therefore recommended in Lake Management to maintain and imitate the structure and diversity of old lakes.

Lakes show hysteresis in the sense that initial concentrations may determine the development. Figure 2 shows model results of increasing the phosphorus concentration that is limiting for the plant growth in a shallow lake with a low total phosphorus concentration (0.05 mg/l) and with dominance of submerged vegetation . At a phosphorus concentration of about 0.15 mg/l the concentration of submerged plant expressed as g P / m^2 decreases significantly and at 0.250 mg/l the submerged plants disappear completely, out-competed by phytoplankton. If the phosphorus concentration now is decreased the submerged plants will remain out-competed by phytoplankton until a phosphorus concentration of about 0.1 mg/l, at which concentration they will quickly recover. The competition between submerged plants and phytoplankton shows with other words hysteresis in shallow lakes. The initial concentration (the history) determines the result of changing conditions.

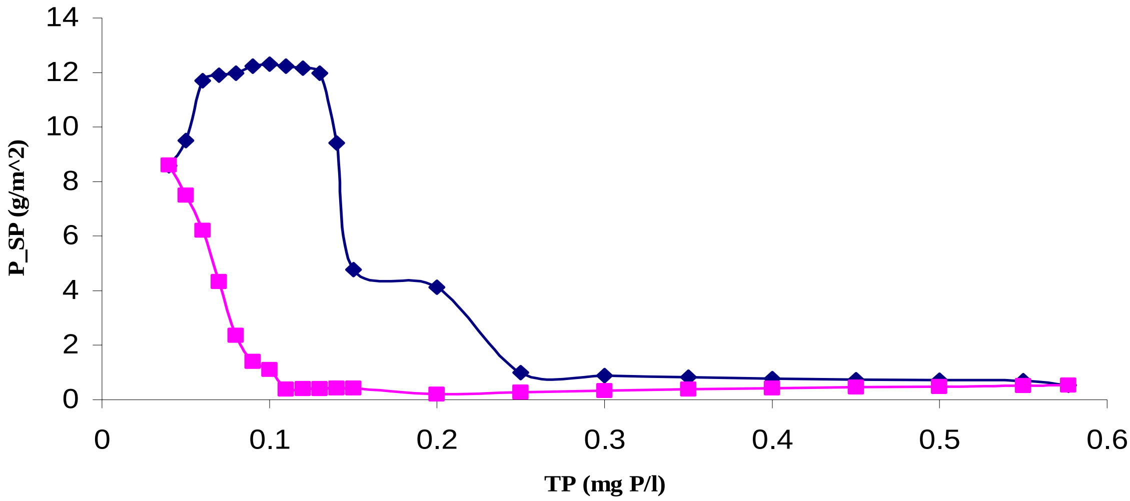

Figure 2: The initial phosphorus concentration, that is limiting for plant growth in a shallow lake, is about 0.05 mg/l. If this concentration is increased the submerged plants measured as P in submerged plants / m^2 is increased but at about 0.15 mg/l the concentration decreases significantly and at 0.250 mg/l the submerged plants disappear completely, out-competed by phytoplankton. If the phosphorus concentration now is decreased, the submerged plants will remain out-competed by phytoplankton until a phosphorus concentration of about 0.1 mg/l, at which concentration they will quickly recover. The competition between submerged plants and phytoplankton shows, in other words, hysteresis in shallow lakes. The initial concentration (the history) determines the result of changing conditions.

Shallow lakes in general show this submerged plant / phytoplankton hysteresis (Zhang et al., 2004). Lakes in general show a similar hysteresis between a zooplankton dominance and top-carnivorous fish dominance at low phosphorus concentrations and a phytoplankton and planktivorous fish at higher phosphorus concentrations. It is possible to use that two structures are possible at the same phosphorus concentration range by biomanipulation. It is more desirable to have submerged vegetation than phytoplankton and it is more desirable to have zooplankton dominance than phytoplankton dominance. In the range where the two structures are possible, it is feasible by biomanipulation to change from one structure to another from phytoplankton to submerged plants by planting submerged plants and from phytoplankton dominance to zooplankton dominance by a significant reduction of the planktivorous fish.

These considerations are formulated in recommendation number 9:

R9: The development of an ecosystem is dependent on the history (initial concentration), which can be applied to obtain improved water quality of lakes by biomanipulation in a certain phosphorus concentration range (phosphorus is assumed the limiting factor for plant growth).

Principle 15. Ecosystems and species are most vulnerable at their geographical edges

This principle should be considered when species are selected for ecosystem creation and restoration. A lake will have enhanced buffer capacity, if the applied species are in the middle range of their environmental tolerance. Generally, we should rely on the ability of ecosystem to self-design (see also Principle 8).

R10: Do not introduce exotic species to a lake. Rely on self-design as far as possible.

Principles 16. Ecosystems are hierarchical systems and are parts of a larger landscape

It is important to maintain landscape diversity, such as hedges, wetlands, shorelines, ecotones and ecological niches. They will all contribute to the health of the entire drainage area. Integrated agriculture can more easily follow this principle than can industrialized agriculture, because it has more components to use for construction of a hierarchical structure. This principle is covered by R5.

Principle 17. Physical and biological processes are interactive. It is important to know both physical and biological interactions and to interpret them

This principle is originated in ecohydrology (Zalewski *et al.,* 1997) in which hydrological processes are integrated with biota dynamics to achieve new operational strategies. For instance regulation of water levels in springs may influence the fish population and maintain a high concentration of filtering zooplankton. By knowledge to the interactions it is therefore possible to achieve water quality improvements by regulation of the hydrology. This is contained together with Principle 8 in R11:

R11: Due to the interaction between ecology and hydrology it is possible to obtain considerable water quality improvements by modification of the hydrology. It is often beneficial to use models to find the possible interactions between hydrology and ecology.

Principle 18. Ecotechnology requires a holistic approach that integrates all interacting parts and processes as far as possible

Lakes are very complex systems and there are difficult to overview. Ecological models (Jørgensen and Bendoricchio, 2001) are powerful tools to achieve a synthesis of our knowledge about an ecosystem or a drainage area. It is therefore recommended to develop at least a conceptual lake model to be able to apply an integrated strategy based on the presented ecological principles in integrated lake and drainage area management. Application of ecological indicators to assess the health of lake or reservoir is another recommendable holistic method that could work hand in hand with ecological modelling.

R12: Lakes are very complex systems and it is recommendable to apply holistic tools such as models and ecological indicators to overview the complex management problems.

Principle 19. Information in ecosystems is stored in structures

Increased information means higher and a wider spectrum of buffer capacities and higher biodiversity. It is therefore important to maintain structures as they store the ecosystem information. R7 encompasses also this principle.

Does Lake Management gain by application of the 19 Ecological Principles?

A careful and sustainable lake management would hardly be changed drastically by a comprehensive use of the 19 principles, because it should always be embedded in a sustainable ecological management. The open question is therefore more whether the lake management is facilitated by the 19 principles. The principles have been tested by a number of ecological engineering projects and have, therefore, a certain creditability. In addition, as demonstrated above, they are easy to understand and apply for an ecologist. They are furthermore consistent with ecological modeling and ecosystem health assessment. It seems therefore relevant to use the principles as a checklist in an integrated lake and drainage area management: have we remembered in our environmental management to consider all ecological factors? Have we been considering in our lake management strategy the properties of ecosystems? In addition 12 useful easy-to-use recommendations have result from the 19 principles.

Discussion of the applicability of Ecological Principles in Lake Management

The following five general recommendations are implicitly embedded in the 19 principles and can be used as a summary of this paper:

i. Know the lakes and all the ecosystems that make up a drainage area and their ecological properties and processes.

ii. Use this ecological knowledge in Lake Management.

iii. Develop models and use ecological indicators to enable a good survey of the many interacting components, the ecological networks and the most crucial ecological processes.

iv. Maintain high biodiversity and a high diversity pattern of ecosystems, zones, ecotones, corridors, ditches, ecological niches etc.

v. Everything is linked to everything in an ecosystem and the entire system is more than the sum of its parts. This should be underlying all ecological management decisions.

The application of the 19 principles has developed 12 specific recommendations on Lake Management that are summarized below:

R1: Set up mass balances for all possible pollutants for the entire drainage area and determine the inputs to the lake and their sources.

R2: Decisions on reductions of impacts require a knowledge to the relationships between lake ecosystem health and concentrations of focal pollutants.

R3: A proper lake management requires a good management of the entire drainage area.

R4: It is beneficial to reduce the inputs to the lake of the element that most easily and most cost moderate can be made the limiting factor in the abatement of the eutrophication.

R5: It is beneficial to maintain wetlands adjacent to lakes and wetlands and forests as mosaic in the landscape to abate non-point pollution and maintain an over-all high buffer capacity to meet the impacts of possible pollutants.

R6: It is important in lake management to apply the self purification rates but it is very important that the rates are respected to avoid over-loadings. Models are good tool to assess the self purification rates as function of the external variables.

(the forcing functions)

R7: It is recommended to maintain a high biodiversity of lakes to meet unexpected impacts.

R8: It is important in lake management to consider both direct and indirect effects that requires a good knowledge to ecosystem and ecological network functions and characteristics.

R9: The development of an ecosystem is dependent on the history (initial concentration), which can be applied to obtain improved water quality of lakes by biomanipulation in a certain phosphorus concentration range (phosphorus is assumed the limiting factor for plant growth).

R10: Do not introduce exotic species to a lake. Rely on self-design as far as possible.

R11: Due to the interaction between ecology and hydrology it is possible to obtain considerable water quality improvements by modification of the hydrology. It is often beneficial to use models to find the possible interactions between hydrology and ecology.

R12: Lakes are very complex systems and it is recommendable to apply holistic tools such as models and ecological indicators to overview the complex management problems.

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Gender participation in fisheries management of Lake Victoria, Kenya

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Abstract

Gender plays an important role in the artisanal fisheries, therefore it critical for both men and women to participate fisheries management. This paper analyzes gender responses to introduced or enhanced fisheries regulations and constraints to compliance so as to facilitate gender participation in the management of Lake Victoria. Both primary and secondary data have been used. Results indicated that in Lake Victoria, there is a clear-cut division of labor differentiated by gender, which is culturally defined. Men and women respond to management measures differently due to differentiated roles and space they operate in. Poverty emerged as a constraint to both men and women but affecting the women much more due to lack of economic and status empowerment. Fishers have organized themselves into groups that act collectively. These organizations are crucial in the establishment of co-management for Lake Victoria. The study observed that women's effective and meaningful participation in fishery management is greatly hampered by their subordinate positions at the household and community level. They have minimal access to and control over production resources and even much less, over benefits. Women should be empowered economically and socially to participate effectively in fisheries management. Further, they should be encouraged to organize themselves into support groups to; attain access to credit and fishery resources; to encourage appropriate fishery practices; and to diversify in non-fishing activities to ease pressure on the fishery.

Introduction

Lake Victoria, which is the second largest fresh water lake in the world, covering 68,800km^2, is a source of livelihood for about 3 million people of the lake Victoria basin in Kenya, Uganda, and Tanzania. Lake Victoria is also an important source of income to the fishing community and earns the nation a foreign income. Fish production for Kenya in 1995 amounted to 193,789 tones with Lake Victoria accounting for 94.6% of the total catch. Foreign currency earned from fisheries in 1995 amounted to 1.5 billion Kenyan shillings. (Ikiara, 1999). On the lakeshore, income is derived from selling fish and its products, boat building, net making and repairs, actual fishing, employment in fish factories and many others. Small beach markets have also been established on fish landing beaches.

Lake Victoria is faced with a number of problems, which affect the sustainable use of its resources. The problems of this fishery are 'common problems' which include overfishing, leading to reduced stocks, pollution from industrial effluent and sewage, infestation by water hyacinth, poverty of the fishing communities, poor infrastructure, use of illegal fishing methods among others. With reduced stocks, there is increased effort to maximize profits from the resource. Individuals continue investing hoping that the effect of reduced stock will fall on others. With everybody scrambling to increase his or her share of the declining resource, the fishery ends up being an object of a much greater effort. The net result is over-fishing, declining catches, destruction of fish stocks and over-capitalization. Indicators showing this decline in stock include the decreasing size of fish caught, further use of small mesh size than the required one, the increasing number of fishing gear per person and the rising costs of fishing (SEDAWOG, 2000).

The government mainly manages Lake Victoria through a Fisheries ACT that focuses on gear regulation, licensing, taxation, and prohibition of fishing in some areas and seasons. This kind of system was introduced during the colonial period and continued even after independence. This top-down approach of management has been implemented without the involvement of the fishing communities who utilize, and live with the resource, having good mastery over it. This command and control system has not been very effective because of the constraints the government has had, such as lack of capital, understaffing, poor infrastructure, and lack of appropriate technology. The regulations fail to capture the diversity within the communities and assume homogeneity in application and adaptation. An alternative suggestion of co-management has been suggested for involving more than one institution in the management of the lake's resource with the fishing communities playing an important role.

Gender *per se* has been left out from studies of Lake Victoria fishery. It has to be recognized that different people derive differing needs from the fishery, which determine how they utilize the resource. The traditional perception of gender *per se* has been misconceived to mean lessening the powers traditionally held by men. It should be appreciated that empowering women means working alongside men without discrimination or victimization. In other words, it means accepting gender issues as part of development. It is now evident that given equal access to opportunities and resources, women have proven to be equally efficient and dynamic as men and indispensable partners in development. Therefore, the output of the discussion will contribute to management policies that are sensitive to the needs of the whole community rather than to one gender.

Traditionally, both women and men were involved in fisheries but each performing different roles. As regards gender, the traditional division of labor in most parts of the third world dictates that men spend more time fishing than is the case for women. To some extent, women tend to fish occasionally, close to the beach or in rivers (though with less efficient technologies). This is because of the cultural division of labor that requires them to be near home to take care of the family. Today men play a dominant role in actual fishing as in the past, while women take a major role in post harvest activities. Despite the fact that men dominate the fishing sector, more women are also buying fishing gears and getting involved in this sector. Therefore, women alongside with men participate in the continuous processes of exploiting the fishery environment and challenging regulations governing fisheries.

Traditionally, the division of labor within lake communities dictates that men spend more time fishing, while women roles in the fishery were mainly concerned with post-harvest activities and marketing. In the past women have been marginalized in decision-making, yet they are important users of the same resources. Every member of the community should have a sense of belonging to have the incentive to develop and use the fisheries resources sustainably. Gender roles are now dynamic and fast changing. Women's role in harvesting, post-harvest handling of fish and marketing is a central position that can be used to influence critically every aspect of resource allocation in this fishery.

Understanding gender means understanding opportunities, constraints and the impacts of change as they affect both men and women" (World Bank). Partnerships and equality between men and women are the basis of strong families and viable societies in a rapidly changing world. Yet misogynistic views lie at the heart of continued discrimination against women. Women have been consistently excluded from decision-making across history and societies. Indeed, in all social groups women are being systematically discriminated against within systems of governance that allow for the dominance of a few social groups to the expense of others. It is such power structures that cause further imbalance, marginalization, suffering and conflict. Creating greater gender equity will contribute to building peaceful, democratic and prosperous societies.

Women play key roles in the fisheries processing and marketing sections, aquaculture sector, research and development and Networking activities. However there work and social space they occupy in the fisheries has remained invisible to researchers and policy makers because it is not directly connected to the capture fishery. This omission has been enhanced by the national policy agenda, which focuses on the production sector that is male dominated rather than the processing sector (female dominate). It is also difficult to extract information pertinent to the fisheries sector in general and to gender in particular at the national level as the data is not gender disaggregated. The lack of information on gender roles and spaces in the fishery sector has led to women being left out in maters of policy and development hence make worse the already unstable position of, and contribute to underused and undervalued the relationship between men and women.

Recently gazetted fisheries management instruments

Due to various regional projects on lake Victoria, the three countries Kenya Uganda and Tanzania have instituted new regulations and enhanced some which were not being enforced in an effort to manage the fisheries. Some of the new measures include (a) Introduction of slot size for Nile Perch; (b) Involve the stakeholders in managing the fisheries, thus co-management, and (c) Closed season for *Rastreneobola argentea* ("*dagaa"*). Regulations were also introduced to enhance the quality standards of fish landed after the European Union ban in 1998.

Kenya Gazette Supplement No. 55, (2000): Set of regulations and conditions to ensure hygienic handling and processing of fish and fishery products · The mandate to the Ministry responsible for fisheries to become the Competent Authority (CA) on the trade of fish and fishery products · Requirement for health certification by CA for fish and fishery products for all products destined for export market.

Kenya Gazette Supplement No.105, (2003), The Prohibitions on Fishing for, landing, processing, moving and trading in Nile Perch fish whose total length is not less than 50 cm and not more than 85 cm. It also prohibits Fishing, landing, processing, moving or trading in *Rastreneobola argentea* ('*dagaa'*) from the Kenya waters of Lake Victoria during the closed season (1st April to 31st July) every year.

These management measures have impacted differently on both men and women whose response in return is also differentiated by gender in their space of work. There are constraint that have hindered some fishers from implementing these measures as well some of these measures have been imposed without providing alternatives to fishers or enabling environment to change.

Overall objective

To assess the level of participation by gender in fisheries management of Lake Victoria and how various management tools affect them.

Objects

1. To assess gender response to introduced/enhanced fisheries regulations

2. To assess the impact of these management tools on gender.

3. To identify areas which require support to improve the skill and knowledge of women and men for effective management

Methodology

Both secondary and primary data was collected for this paper. To determine the impacts of the slot size measure, a survey was carried out which involved 156 artisanal fish processors and traders of Nile perch and tilapia selected from 13 fish markets in the 7 districts bordering Lake Victoria. Another study was also contacted which involved 300 fishermen from 14 beaches along Lake Victoria. Respondents were randomly selected.

Questionnaires were used during the interviews of respondents. Photographs were also taken. Data was analyzed in SPSS and Excel. Data was segregated by gender and sector e.g. traders and fishers. Secondary data was collected from various government publications.

Gender role in the fisheries

Both men and women play differential roles in the fisheries. Women play an important role in post harvest sector (75%) while males dominate the production sector (86%). However there are changing roles in the fisheries where men have seized opportunity to enter into fish trade, which was once a female domain. Thus we find men dominating the Nile Perch fishery, which is more profitable, and export oriented pushing women to the less profitable fish species of dagaa and other indigenous fish species.

Table 1: Gender Participation in the fisheries.

Occupation	**(%) of respondents by gender n=119**	
	Male	Female
Boat owners/ fishers	86	20
Trader / Processor	14	75
Other (petty traders)	0	5

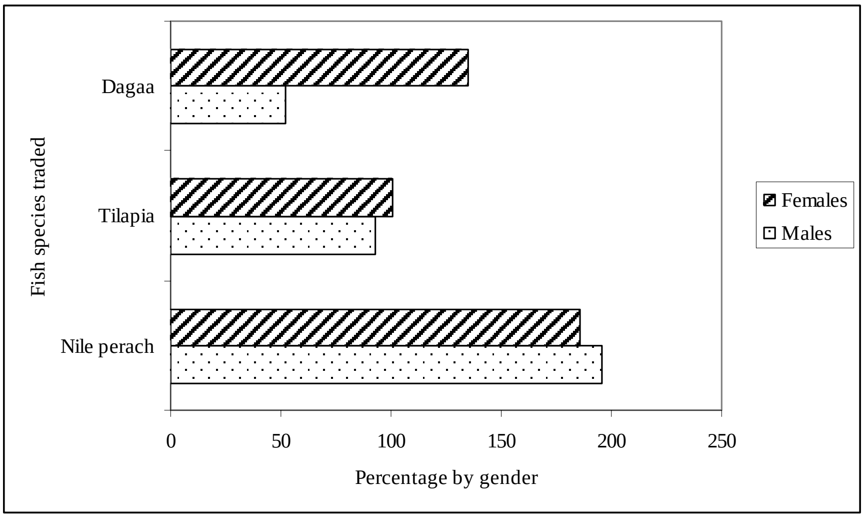

Figure 1: Principal fish species traded in by gender.

Figure 1 illustrates the principle fish species traded in by gender and women dominate the dagaa and the tilapia trade. Where women participation in Nile perch, it is mostly in fish that is less than 50 cm. In Lwenya and Abila (2001), women prefer to deal in dagaa fishery because it is affordable and easy to handle. Tilapine fishery has declined hence it has become expensive and fewer women deal in it.

1. Enhanced management

Sustainable management requires the full and equal participation of women at all levels.

It is inappropriate to try and address problems, to identify the appropriate strategies, or to implement the solutions if only half of the people concerned are involved in the process. Gender equity is an essential building block in sustainable management and development of the fishery. Indeed, none of the three "pillars" of sustainable development can be achieved without solving the prevailing problem of gender inequity:

Fisheries management requires a solid understanding of women's relationship to environmental resources, as well as their rights and roles in resource planning and management. It also requires acknowledgement and incorporation of women's knowledge of environmental matters, as well as an understanding of the gender specific impacts of environmental degradation and misuse

a) Slot size increase for Nile Perch

The slot size management measure for Lake Victoria fisheries has been in place since 2001. This regulation allows for the catching of fish (Nile perch) only of size range 50-85 cm total length, thus, protecting both young fish and brooding stock

This paper indicates that the level of awareness about the slot size measure is 95% of fishers. Despite the fact that fishers understood this measure to protect the fish stock, the level of implementation was about 75%. While implementing this measure, about 38.6% of the fishermen who are males, indicated that they had been forced to change gears they used so as to meet the factories' and the Fisheries Department demand of fish that is 1 kg and above

On the other hand there is a low level of adoption of the slot size amongst women fish traders. Only 30% of the women stated that they implement slot size fish measure compare to 70% who don't comply.

Despite the slot size regulation being put in place fishers still catch Nile perch of less than 50cm. Figure 2 indicates that artisanal traders/processors who are mainly women and factory agents still form a big market for Nile Perch less than 50cm. Factory agents claimed that they buy this undersize when they can not get enough fish that is above 50cm. Artisanal traders claimed that they do not have money to compete with the factory agents.

These fishers who cannot afford to change from illegal gears to the approved gears split off from the main beaches and form unregistered beaches nearby. These beaches normally attract a large number of women small-scale traders who have been displaced by factory agents purchasing the large sized fish for the fish factories. These women have no other option but to form a very ready market for the undersized fish landed using illegal gears. By forming illegal beaches both men and women involved undermine fisheries management. Second they cannot participate in decision-making and management of the fishery as they are not recognized.

The slot size measure has impacted on the male fishers who due to compliance, 81% have stated that their catch had declined, and about 63% of the fishers indicated that operation cost increased. This in return has lowered the income from fishing. With lower incomes fishers tend to increase effort to be able to survive.

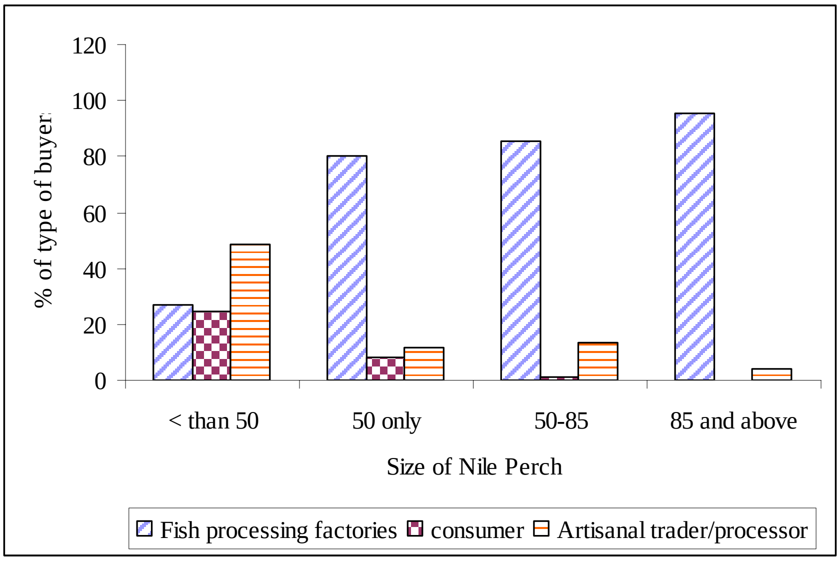

Figure 2: Nile Perch sizes and type of buyers.

Implementation of the slot size has been a disadvantage to women traders dealing in Nile perch because they cannot compete with the factory agents for the fish that is 50cm and above who have a high demand for it. The purchasing price is also prohibiting for the women who normally engage in the artisanal trade. This has reinforced women to deal in undersized Nile Perch. Dealing in undersized fish has resulted into increased workload for women more than it was before. Due to the small sized fish they trade in women spend more time in collecting and processing this fish.

Before industrialization of the Nile perch fishery women traded in whole fresh fish, which did not consume much of their time as, it does today. The women collected fish from the boats sold it at the beach market to hinterland traders or took it to the market later in the evening after completing her daily core at home. Now a woman has to spend about 68% of her time sitting by the beach waiting for undersized and rejected fish to get enough to process (Figure 3) She has to buy fish from various boats with the help of other women she employs. After spending all this time and energy to process fish the profit that women get is as low as Ksh. 70 (1 US Dollar) only.

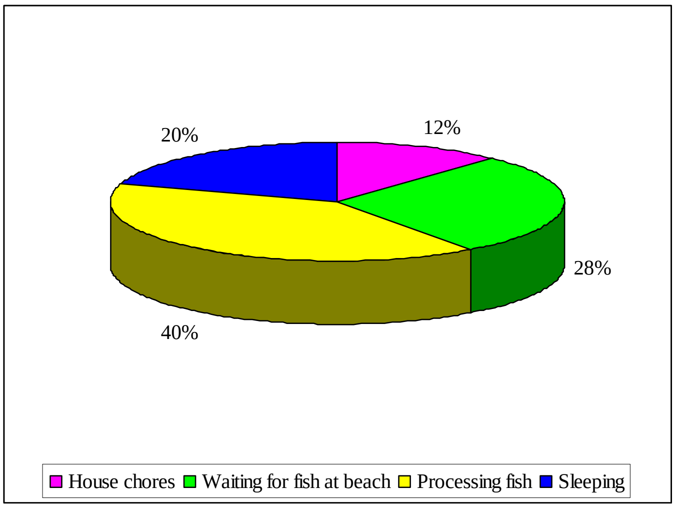

Figure 3: Time allocation for a woman fish trader and processor.

b) Co-management

Community participation is very essential for resource management. Many natural resources have been degraded due to exclusion of the resource users in decision-making and management. Fishery sector has not been an exception as lack of participation has lead to the degradation of the resource in terms of diversity and biomass**.** Within the 21-century we cannot talk about resource management without community participation. The bottom down approach to management has proved to be in effective and expensive hence lack of compliance by fisher.

The government through the Fisheries department has made some deliberate attempt to create new institution to cater for community participation in the fishery management. In the past the Fisheries Department worked with beach committees to communicate to fisher communities. Due to regional collaboration in harmonizing management of Lake Victoria, the beach committees changed to Beach management units adapted from Tanzania. This change of institution has come with defined roles and standard operating procedure unlike the beach committees.

Participation in BMU is supposed to be representative of all the resource users who include boat owners, crewmembers, fish traders and processors, factory agents and other people involved in the fishery activities. Roles that are expected to be performed by BMU include licensing and record keeping of fishing gears and boats.

There is unequal participation of gender in various meetings at the beach level. In general, female participation at community level is very low. There is a fair participation of women in the election of the BMU officials yet they have a very minimal representation on the executive committee. However there is a higher participation of women when visitors come to the beach. This assumes that women have to perform reproductive duties even at community level i.e. cooking and serving visitor.

c) Dagaa closure

Dagaa closure is a management tool that has been within the fisheries ACT but had never been implemented. In the year 2001 the Fisheries Department began to implement this regulation with intent to manage the dagaa fishery. The closed season for dagaa fishery begins from April till 30 July. At this period no one is allowed to fish or trade in dagaa fish within Kenya as other two countries do no have this measure.

The dagaa closure regulation impacts heavily on the women who are the dominant dealers in this fishery. Most women who own boats prefer to deal in Dagaa as well as many female fish traders deal in this fish (Figure 1). The closure of dagaa has impacted on the incomes of both males and female who deal in this fishery. However women are more disadvantaged as men shift to other fishery like hand lines or rent out their boats to other fishers. The closure of dagaa has impacted on other fishery by pushing more women there. More women have been absorbed in the trade of undersized Nile Perch hence challenging the management of Nile perch fishery.

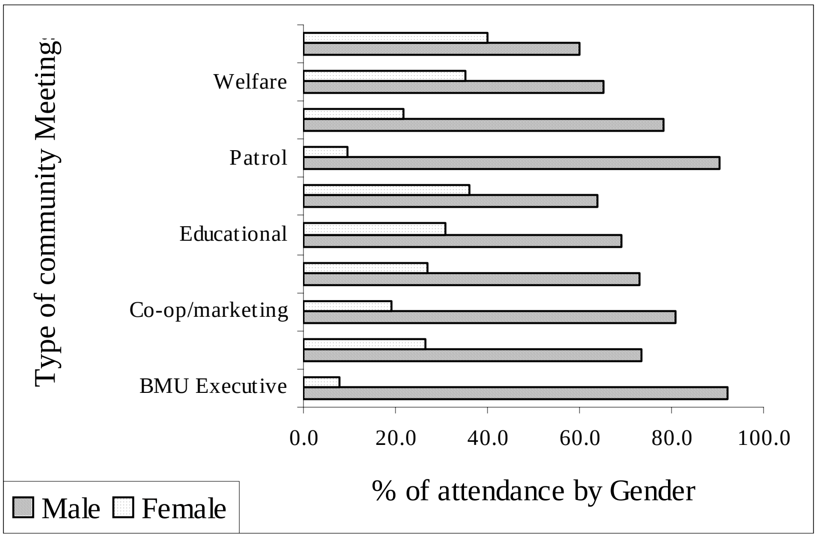

Figure 4: Participation by gender.

Constraints to implementing management measure

Poor working conditions

A good working environment is important for development, health and compliance to fisheries management. The Nile Perch fishery is more organized than the tilapia and dagaa fishery. Women traders have to wade through dirty water to buy fish from the boats. Women have also got to sit on the hot sunshine for many hours processing their fish. Poor working conditions are a disincentive to properly mange the resource. This poor working conditions also compromise the quality of fish hence lose to the value of fish and income.

Educational level of women

Education is important for any meaningful development in a population. The fishery sector has generally been characterized with low levels of education. There is a high number of school dropouts at the level of primary. Child labor in fishery sector is one of the causes of the high level of school drop out. This especially affects the boy child who once he has been introduced to the fishery economic gains does not see the need for completing school. The girl child has been a victim of early marriage and hence drops out of school. These factors together with poverty have contributed to the low levels of education. Illiteracy may hamper the participation of both men and women in co-management roles as they are will not be able to be effective in data collection and making decisions for management out of it. This also hinders the fisher communities to join alternative employment outside the fishery.

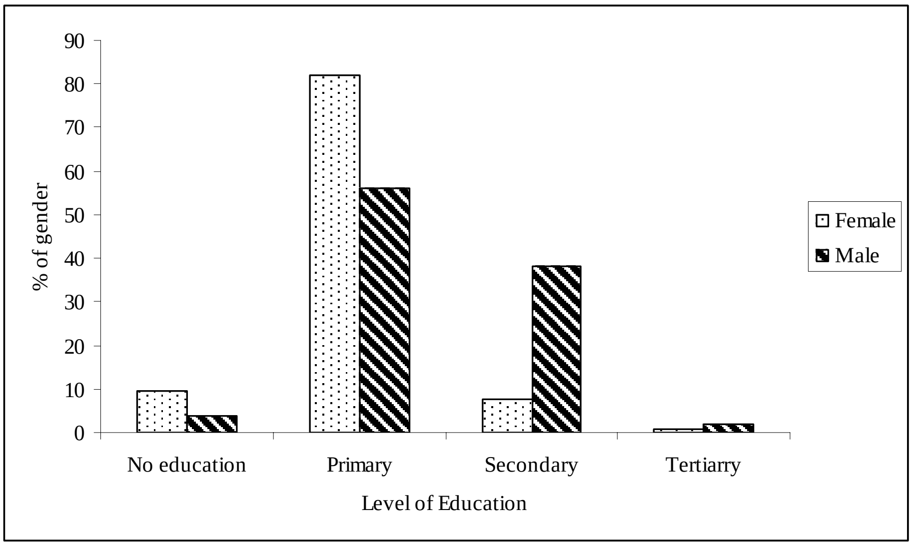

Figure 5: Levels of education by gender.

Other factors

Male fishers stated that implementation of the slot size had not been adapted by all due to poverty (42%), corruption (18%) and lack of enforcement (12.8%). Women fish trader sited Poverty (44%) and high prices of large size fishes (32%) as a hindrance to adapt to slot size measure.

Conclusions

- Managing the fisheries is important as it safe guards the ecosystem and the livelihood of Resource Users
- Management is challenged when a group of the resource users is marginalized
  - Their knowledge is not used
  - Their consent is not sought
  - Their commitment to conservation and management is not invited
  - Their compliance to rules is not assured
  - The resource that they fish- for food and livelihood are at risk
- Implementing a management tool without facilitating the change constrains the desired change.
- Equity in benefits and social status of women can enhance management
- Their knowledge is not used
- Their consent is not sought
- Their commitment to conservation and management is not invited
- Their compliance to rules is not assured
- The resource that they fish- for food and livelihood are at risk

Recommendations

1. There is a need for fishers to be sensitized to practice responsible fishing by changing their poor fishing practices and attitudes for sustainable utilization and proper management.

2. There is need to create awareness of the existing fisheries regulations to the fishers. Educating them on these may enhance their obedience and understanding of the consequences of a degraded fishery resource.

3. To mitigate the increasing entry into fishery, proper education needs to be provided to both girls and boys to increase their opportunities of employment outside the fisheries.

4. Research needs to be carried out to establish opportunities for alternative sources of income within the fisher communities to reduce pressure on fisheries.

5. Women's access to credit should be enhanced through removal of legal restrictions and modifying administrative formalities in credit institutions such that women can obtain credit in their own name; promoting women's saving groups and co-operatives to facilitate the financing of investment beyond the capability of individual women; and training and assisting women in financial management, savings and investment

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Mau forest: The way forward

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Abstract

This paper tries to highlight the essence of public participation in the water resource management. Various documents were studied to have a clear view of the impact of the forest degradation and the roles the youth and the public can play to reverse the wrongs done.

Many people have had the belief that the issue of catchment protection us not in their jurisdiction. The water catchments are of such importance that proper care should be taken of them. There is need for concerted efforts to ensure that everyone is involved in policy making and the decision making on maters regarding the environmental issues for sustainable water resource management with a bias towards catchment management. This will go a great deal with the theme of public and all the stakeholders' participation of the water resource management.

Conflicts, due to water resources, have been the major source of concern as it affects not only the local communities, but the international community as well. Even as these events take place before our eyes it is still difficult to understand why we can't take seriously the issue of preserving our main water catchments especially Mau forest escarpment. The water catchments are the major sources the head waters. They play a major role in water resource management through an integrated water management. Various case scenarios have been identified to know the importance of the Mau forest.

It is therefore worthwhile to include all the stakeholders in the process of decision making and to formulate programs encompassing the youth on the issues touching on various environmental issues. This calls for total and holistic participation of the public and holistic approach to the issues of the environment and water resource management.

Key words: Public participation, Water resource management.

Introduction

All over the world, conflicts always occur due to one thing; "Natural resources." These may range from oil wells, mountain ranges, water bodies, and many others. Conflicts due to water resources, however, have been the major source of concern as it affects not only the local communities, but the international community as well.

After all has been said and done, one issue still stands, and that is the crucial role that can be played by the youth and other stakeholders in the management of the natural resources and mainly the water resources. This calls for public participation.

What is public participation? It can be said to be the means by which the views of all parties interested in a given issue are integrated in the process of decision-making, B L Mimi, (1993,). In the subsequent text we are going to emphasize the youth's involvement in the processes.

Materials and methods

- The materials used were the documents such as the print media, book publications and journals.
- The method was documentary analysis.

Results

According to Payne (1986), all man's activities by all means do improve the environment. He, however, notes that with increasing intensities of agriculture, industries and urban development, many by-products can be detrimental to the water resources. This always leads to reduction in the water budget resulting to squabbles among the communities affected. A good example can be seen in the recent event here in Kenya where communities of the Agikuyu and the Masai fought for the water in the area (The Standard, June-8-2005). Internationally, most of the wars fought between the Palestinians and the Israelis evolved from water resources (Sharif, 1997).

Most of the catchments have been encroached such that the forest cover has shrunk drastically as people look for places to stay. The government has also not made the matter any easier by allocating the forestland to people. We are left with only one question… "Do we look for a land to stay and ruin our future water supply or do we do with the little spaces of land and maintain our water resource base." To answer this question one should have the basic knowledge of benefits of the water catchments to a nation and to the whole world as a community.

This calls for thorough sensitization of the communities within and without the Mau forest on the benefits of managing and maintaining the aesthetical and ecological value the forest. This can be done best by using all the means possible to achieve the goals. The youth thus have the mandate to take a closer look at the issue at hand and ensure that their future is not messed up with as they look on.

Discussion

Mau Forest catchment

The headwaters play a major role in the replenishment of the hydrological cycle among other benefits. Interference with the catchments therefore may pose a major risk of deforestation. They play a major role in water resource management through an integrated water management. This point is stressed further by (Gash *et al.,* 1999). To understand better the consequences of destruction of water catchments, let's look at different case scenarios.

a) The first and most important fact is that the backbone of Kenya's economy is agriculture (David, 2001) and for agriculture to flourish there has to be enough rainfall and ground water supply. This cannot occur if the forest cover is reduced by its excision.

b) Another consequence is the high risk of hydrologic extremes. Hydrologic extremes occur during high and low rainfall years. During high years we have discharge exceeding the bank-full capacity and this always results in flooding. Consequently when we have low years the naturally occurring runoff is abnormally absent and the intermittent rivers remain dry for prolonged periods of time. This is when drought is said to occur. The major factor here is the amount precipitation obtained at a particular time. The forests here play a great role in controlling the situation. They will either act as the buffer zone to control the amount of surface runoff and therefore control the amount of flooding or help in the contribution of the atmospheric water vapor content that is a fundamental factor in the hydrologic cycle. This will thus go a great way in either controlling floods or minimizing drought severity. All these extremes do come with their consequences. For instance according to a United Nations World Water Development Report, "…between 1991 to 2000, over 665,000 people died in 2,557 natural disasters of which 90% were from developing countries…." The droughts also contributed to a larger portion of the deaths.

c) Water catchments are the basic water source for various communities. Interference with the water sources will render the water unavailable for everyone's consumption. This is always a recipe for trouble as each and everyone in the area will try to gain access to the water. A good example, as mentioned earlier is the recent clashes between the Masai and the Agikuyu communities here in Kenya. They were all fighting for the same commodity so precious to them yet so rare. The Massais needed the water to quench their herd's thirst while the Agikuyus needed the water for the irrigation of their farms. But due to the interference of the Mau forest which acts as the major source of the rivers flowing in their regions, the water was not enough to supply all their needs. It has been found that millions of people in at least 16 countries have faced food shortages among other problems in recent years through crop failure which in turn breeds civil unrests or conflict (GEO, 2004/05).

d) Another problem is the systematic destruction of an important lake in Kenya, Lake Nakuru. The lake is one of the most important tourist attraction sites and a home to most important bird species, such as The "Lesser Flamingoes" among others. The lake has been continually shrinking due to destruction of its main inlets such as the River Ndarugu. The destruction comes mainly due to heavy siltation as most of the upper soils from cultivated areas are washed downstream. This tends to reduce the earnings of the eco-tourism sector in Kenya, which is estimated as bringing about 10% of the total GDP, W B David (2001.) The list may be endless. A case study conducted in Coweeta in the United States, Valdai in Russia and Jonkersoek in South Africa showed the enormous effects sediment yield that reflect the changes of the basin condition (United Nation Report, 2003)

What is the way forward

The best way forward is to try and incorporate all the stakeholders such as the youth and all those who are the closest to the water catchments. In their presentation to a proceedings at a workshop, (Gash *et al.,* 1999) stressed the participation of the public as among the best ways to help protect the catchments. They also proposed a shift from the top-down to bottom-up public participation. This would in the long run ensure that each and everyone is given an opportunity to give their views on the protection of the catchments.

It is imperative that we start looking at the case Mau forest habitation mare pragmatically. The best solution is to try and sensitize the communities within the affected areas on the benefits of sustaining the catchments for a better future.

a) This is where the university students' initiative comes in. The university as a community has such untapped energy that if utilized well, may be the source of the man power needed to bring back the glory of the Mau forest facelift. This can be done by using the many student organizations and club whose aims and objectives are geared towards a better environment for sustainable water resource. The clubs should be encouraged to have semester events of planting trees at the forest. This will in the long run improve the forest covers and consequently save us from the impending problems. Since one of the strategies of the World Lake Vision Committee in the sustainability of the lakes is the control of litter and garbage (World Lake Vision Committee, 2003), students can play a major role here as this one of the major activities within their clubs and organizations.

b) Encouraging the international organizations such as "The United Nations Environment Program" to formulate programs encompassing the youth on various environmental issues. This may go far in ensuring the participation of the youth at both the local environmental stage and the international stage. And that would be a better way to build up the confidence in the youth in tackling issues and involving the wider communities on the protection and management of the catchment.

c) Government should place stiffer laws and policies that governs the protection and management of all the catchments. There should be clear guidelines demarcating the forests. Since a mistake had already been conducted in allowing people to settle in the forest, it is in order that proper eviction laws are put in place so as to avoid unnecessary friction with the people and politicians. Those that bought land innocently should be well compensated or relocated to unforested areas. This will ensure that everybody is well served and the forests are well left alone thus securing the future of our younger generations.

Conclusion

Even as we struggle to draw attention to the public participation it is worth noting that the road to success would not be that easy. This may be mainly due to lack of awareness on fundamental issues such as integrated land management among many other things (Gash, *et al.,* 1999.)

I believe that given the opportunity the youth and the general public can help bring the changes needed in the management of our lake basins for sustainable water resources. All we have to do is to enlighten the general public and the youth on the benefits of the catchments and the lake basins to our lives.

Our driving slogan, therefore, should be, “Empower the youth and sustain the water resources”

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The eastern Africa flamingo Lakes: Building partnerships for sustainable resource management

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Abstract

The saline alkaline lakes of the Eastern Africa Rift Valley " Flamingo Lakes" support diverse biological resources that are of global, regional, national and local importance. These lakes form the center piece of some of the world renowned national parks and conservation areas and are major feeding, staging and displaying ground for the region's Lesser flamingo (*Phoeniconaias minor*), Greater flamingo (*Phoenicopterus ruber*) and for over 70 species of water birds. Unsustainable land use practices within the basins of these lakes during the last four decades have adversely affected the environment in many ways. Notable among the effects are the diminishing forested areas, rampant soil erosion, waste disposal problems and deterioration in catchment water quality. In view of these threats, the main challenges confronting conservation are; to reduce extreme poverty, maintain the vitality and integrity of the watersheds, restore ground cover to the extent possible under existing land use regimes, mitigate impacts of climatic variability, flooding, landslides and droughts, restore the water balance and water quality, reduce human-wildlife conflict, monitor trends in biodiversity and promote broad based environmental conservation.

Programmes designed to ensure the long-term protection of these lakes and their basins through adoption of conservation-based land use and development have been initiated and much progress has been recorded towards addressing these challenges. More terraces have been built, more trees planted, more water conserved, more people made aware of the environmental challenges and opportunities confronting us, more research and monitoring of water quality, water quantity and biodiversity has been undertaken, more time has been invested in integrating environmental considerations into the planning process and more partnerships that consist of governments, intergovernmental agencies, corporations, professional organizations, donors, individuals or any group of society have been built. Village Environmental Committees have been formed to act as fora for discussing issues related to the management of village lands and to take the lead in organising and co-ordinating community conservation work. The information presented in this paper was gathered from project records, seminars, workshops, training and convention reports, survey findings and records maintained by collaborators.

Key words: Flamingo lakes, Partnerships, Biodiversity

Introduction

Flamingo lakes are part of a chain of lakes found on the floor of the eastern arm of the Great Rift Valley of Africa. In Kenya the major flamingo lakes are Bogoria, Nakuru, Elementeita and Magadi. Other minor lakes are Solai, Sonachi, Oloidien, Amboseli, Shompole and Simbi. In Tanzania the main Flamingo lakes are Manyara, Natron and Eyasi. The minor flamingo lakes in Tanzania include the Momela lakes in Arusha National Parks, Lake Burungi, Lake Embakai, Ngorongoro crater, Lake Magadi in Ngorongoro Conservation Area, Lakes Lagarja, Basuto, Balangida and Lelu (Katondo and Mwasaga, 1997). In Ethiopia the main Flamingo lakes are Abijatta, Shalla, Metehara, Chitu, and Aranguade.

The chain of lakes and wetlands in the eastern Rift Valley supports globally important biodiversity at all levels: species, communities and ecosystems (Gichuki *et al.,* 1997). Birds constitute the most important and conspicuous component of biodiversity in the lakes and wetlands. According to Bennun and Njoroge (1999), all seven of Kenya's major lakes are designated as important bird areas (IBAS). These are sites of global significance for conservation of birds. Each of the seven major lakes supports 300-500 bird species of which about a third are waterbirds. The eastern Rift Valley is a major flyway of migratory birds that breed in Europe and northern Asia but winter in Africa. For instance, 50,000 European white storks stop over to feed or roost in the grasslands and large-scale grain farms in Kenya's central Rift Valley. The lakes provide special feeding sites for thousands of paleartic ducks, shorebirds and some fish-eating birds. The system of lakes and wetlands is also crucial to the survival of 47 species of Afro-tropical migrant birds. The most conspicuous of these birds are Lesser flamingos, Pink-backed pelicans and African spoonbills.

The lakes support endemic species of plants, animals and microbes that have become adapted to local environmental conditions. Large numbers of Greater flamingos and Lesser flamingos are some of the animal species that depend wholly on the Rift Valley lakes for their survival. At times, almost the entire population of Lesser flamingos is resident in the eastern Rift Valley lakes. Lesser flamingos have unpredictable spontaneous movements between the alkaline lakes, whose ecological triggers and forcing functions are not well known. Vareschi (1978) attributed them to a variety of factors ranging from changes in food quality and quantity, alkalinity changes, breeding migrations, fresh water requirements and predation pressure. High algal densities do not necessarily imply Lesser flamingo residence and movements from lakes with high phytoplankton standing crops can still occur (Brown, 1973; Tuite, 1979). Other attributes of the Eastern Rift Valley include the prehistoric and archaeological sites e.g. Kobi- fora site in Lake Turkana, freshwater resources, geological resources e.g. minerals (soda ash mining in Lake Abijata and Magadi) geothermal energy at Naivasha and extraction of gum arabica. Moderately saline lakes also produce some fisheries.

Major threats to biodiversity

Most of these lakes have witnessed dramatic changes in land use in their basins over the last four decades and resulted in the destruction of critical watersheds, themselves the last remaining bastions of biodiversity. The most important threats to Kenya's Rift Valley lakes and their biodiversity are human economic activities. Some of the environmental impacts arising from development and landscape modification in the respective lake basins include:

- alterations in the hydrological regime of the catchment resulting in increased seasonality of stream flow, declining yields from wells and bore holes, and frequent, prolonged dry-outs of the lakes as have recently occurred in 1993, 1994, 1995 and 1996.
- Climate change, drought and desertification especially in Ethiopia.
- Degradation of water catchments, over population, urbanization and industrialization within the lake ecosystem's increasing e.g. Awasa and Nakuru towns has caused loss of biological diversity and the capacity for disturbance regulation.
- Accelerated soil erosion, resulting in loss of farm productivity and income, which in turn leads to over exploitation of the natural resource base e.g. soil loss from farms in the Lake Nakuru catchment is estimated to range from 18 to 50 t/ha/annum (China, 1994).
- Contamination of the lakes and rivers with pesticide residues, heavy metals and possibly PCBs, dioxins and furans. Nutrient enrichment of the lakes, resulting in reduced productivity of the lake's natural primary producer (*A. fusiformis*), and the frequent occurrence of blooms of toxic blue-green algae (*Anabaena spp., Microcystis spp*.) has led to the desertion of the lakes by flagship species.
- Encroachment on wetlands and flamingo breeding areas, flamingo and fish mortality due to diseases, parasites, predation and toxic pollution. Disappearance of aquatic species such as the Clawless otter (*Aonyx capensis*) last reported in Lake Nakuru National Park in the 1970s.
- Introduction of alien invasive species e.g. in Lakes Naivasha in Kenya and L. Kitangili in Tanzania. Collapse of fisheries in Lakes Baringo and Naivasha. Over fishing and destructive fishing in Lake Awasa (Ethiopia), Lake Baringo and Naivasha (Kenya) and Lake Kitangili in Tanzania.
- Progressive alienation of neighbours to Protected Areas (PAs) from the interests and attractions of the PAs, gender disparities and cultural issues, wood fuel shortages, lack of good quality water and the loss of produce in farms bordering the PAs as a result of wildlife depredations.

These threats are inter-linked and many have similar causative factors throughout the region. The main challenges confronting conservation are to:

- maintain the vitality and integrity of the watersheds
- restore ground cover in the catchment basins to the extent possible under existing land use regimes
- restore the water balance and water quality of the catchment basins through better land use practices and sustainable water management
- entrench the conservation ethic among catchment residents and promote sustained conservation effort by building capacity and linking conservation with the achievement of development aspirations
- Monitor trends in biodiversity and environmental conservation to evaluate progress and identify new threats.

The resource management objectives are as follows:

- Raise environmental awareness among catchment residents through training and production of teaching manuals; slide packages, information leaflets and publicity materials. This is to help people become aware of and appreciate the value of natural resources and the ecological processes that support them
- Help people to understand the threats to their environment, how it should be managed and how they can contribute to its improved management.
- Provide training in essential conservation skills to residents of the catchment basins.
- Create an enabling environment for those in possession of these skills to apply them and transfer them to other members of the community
- Institute strategies to promote and guide sustainable landuse in the catchment basins.
- Establish programmes to monitor water quality, water quantity and biodiversity in both lotic and lentic environments of the catchment basins
- Develop plans for sustainable agricultural and industrial development in the basins that would not exhaust or degrade the natural resources of the catchments.
- Develop strategies that would perpetuate environmentally sound land use and natural resource management within the basins.

Materials and methods

There are seven national mechanisms of managing biodiversity in Kenya. These are national parks, national reserves, wildlife sanctuaries, forest reserves, Ramsar sites, World Heritage sites and Man and Biosphere Reserves. Six major lakes in Kenya's Rift Valley are protected by law under one or two of the seven management regimes.

Results

A number interventions relating to the management of natural resources and environmental conservation have been initiated at some of the Rift Valley Lakes by the government of Kenya in collaboration with local communities, NGOs, religious organizations and development partners.

Table 1: Past and current management interventions that have been funded by various donors and are relevant to the Rift Valley lakes in Kenya.

Bilateral donor	Nature of the intervention
Netherlands Government	Support Wetland conservation and community capacity building through Kenya Wildlife Service in Lakes Nakuru and Naivasha.
GEF/UNDP/FAO/Birdlife International	Institutional support for protection of EA Biodiversity through Forest Department in Mau and Kikuyu catchments.
GEF/UNEP/UNOPs	Community based management of land and water in lake Baringo basin
GEF/UNDP/GOK	Conservation and sustainable use of Biodiversity in Eastern Rift Valley lakes. Setting priorities for biodiversity conservation and Lake Management, through National Museums of Kenya
Ramsar	Conservation Fund Support for Waterbird Census &Monitoring by National Museums of Kenya and KWS in Nakuru, Bogoria, Elementeita and Naivasha.
Department of International Development (DFID, UK)	Support for protection of Lake Nakuru catchment through WWF and Ministry of Agriculture and Rural Development.
Swedish International Devpt Agency (SIDA)	Support for catchment rehabilitation and water conservation in Nakuru (Molo), Baringo and Magadi
JICA/JBIC	Support for Lake Nakuru Ecosystem Management

Table 2: Past and current management interventions by Government institutions, some NGOs and CBOs in Kenya.

Organisation	Nature of the intervention
Kenya Wildlife Services (KWS)	Management of PAs, research, community and stakeholder mobilization, resource mobilization and administrative issues
National Universities	Capacity building and applied research
Provincial administration	Policy enforcement and creating an enabling environment for sustainable lake environment management
Government Ministries of Agriculture, Water Development , Environment & Nature, KARI	legislation and polices, linked to programmes like the National Action Plan on Desertification, Poverty Reduction, resource management. Research on forestry, agriculture etc.
World Wide Fund for Nature (WWF)	Support for ecosystem monitoring, Wetland conservation and catchments rehabilitation in Lakes Nakuru and Bogoria
Municipal Councils/ County Councils	In-charge of urban development, setting trade effluent standards and monitoring, waste collection, management of PAs
Kenya Forest Working Group, FOMAWA, SUMAWA, Forest Action Network (FAN), WETCON	Working for the protection and rehabilitation of gazetted forests, particularly in the Mau Escarpment. campaigned against recent forest excisions, advocacy and Networking. Enjoys grass root support.
Darwin Initiative & Earth Watch	Support for ecosystem monitoring, Wetland conservation

Below is a general overview of impacts of current activities being carried out by various organisations:

- The teaching of Environmental Education (EE) in schools has been revitalized. More time is being devoted to EE and both teachers and pupils are better informed on local environmental issues. This is evident in the content of material presented by schools at competitions and celebrations. A heightened awareness among educators of the possibilities for incorporating EE into subjects taught in primary schools and at adult education centers.
- Records show that study tours by local schools to the Flamingo lakes have increased significantly since 1993. Interest in environmental education has grown in local schools. This is evidenced by the frequent requests made by schools for lectures and film shows and by the increase in number of wildlife and nature clubs.

- A growing number of high school and university students are undertaking research projects on local environmental themes. Requests from these students for information and advice are frequently received.
- Over 50% of the primary schools have initiated conservation activities within the school. These include starting a seed bank for trees, establishing tree nurseries, planting trees in the school compound, excavating earth dams to detain runoff, establishing kitchen gardens and participating in activities aimed at keeping the school compound and neighboring premises free of litter.
- Courses are offered to farmers, members of Village Environmental Committee's (VEC's), women groups, local leaders and members of the clergy. These individuals have gone on to play a key role in disseminating information to the wider public.
- Public meetings and gatherings at national celebrations are used to disseminate information on the environment and solicit public support for conservation. Articles published in the local and international press is an indication of a fuller appreciation of the natural attributes of the lakes and their importance as cultural, scientific and economic assets.
- Environmental markets jointly organized with communities to promote the sale of environmentally- friendly products such as tree seedlings, tree seeds, beehives, energy saving devices, compost etc. During these markets farmers assume the role of extension workers in raising environmental awareness.
- Workshops, seminars, exhibitions, field days and park tours are organized for local residents as well as regional conservation agencies. Greater awareness among urban residents of the hazards of waste accumulating in the environment leading to active involvement of the public in waste management programmes.
- Greater awareness among farmers of the economic and ecological consequences of deforestation and soil erosion leading to widespread interest in conservation solutions. Examples of successful conservation practice can be seen and exert a positive influence on the practices of the farming community. Soil loss from conserved farms has been dramatically curtailed. This, by the farmers' admission has resulted in a stabilization of crop yields and improvement in soil quality.
- Heightened awareness among administrators and planners of the impact of development on the natural environment of the catchment. This is manifested, among other actions, by the government's decision legislate relevant conservation Acts, and to set up pollution control committees and task forces e.g. in Nakuru and the declaration by the Municipal Council of Nakuru to develop Nakuru as the first "Eco-City" in Kenya.
- The involvement of trained farmers in training others has laid the foundations for village-based extension services. Extension workers share a common appreciation of the conservation issues and solutions and hence there is no contradiction in the extension messages conveyed to the public.
- Sediment loads in streams have begun to decrease and sewage is better treated. For example the planting of over 200,000 trees each year, ground cover in the Lake Nakuru basin, is steadily improving and is expected to alleviate the fuel wood crisis and have a positive effect on the water balance of the catchment.

Discussion

One of the key lessons learnt in biodiversity conservation during the past decade is the important and central role that local communities are playing in the conservation and sustainable use of natural resources. While national legislation, international treaties and their implementing mechanisms are indispensable frameworks for global biodiversity conservation, the level of awareness by local communities of natural resource issues and motivation and know-how of indigenous people to use resources sustainably have the biggest impact on the long-term future of these resources. As a result, it has become standard practice not only to involve, but to build substantially on the participation of national and regional non-governmental organizations (NGOs) and of local community-based organizations (CBOs). These organizations are essential collaborators today in the implementation of almost any conservation and development programmes. They are also important potential players in the "bottom-up" development and advocacy of natural resource- use policies. The training and capacity building of such indigenous NGOs and CBOs have become important programme objectives of many resource management organizations. By helping and strengthening such local organizations, governments and international NGOs are ultimately making their own work more effective (WWF, 2004).

Two broad approaches to training were adopted: training groups and individuals in the field through filed days, onsite training and home visits, and training small groups of farmers, youth, leaders, teachers, extension workers and women at a course in sustainable agriculture, held at Baraka Agricultural College (BAC) in Molo. The residential course lasts a week, is strongly oriented to practical training and covers the most fundamental skills and concepts related to conservation farming. Trainees have emerged as leaders in adoption and diffusion of skills as well as in the organization of communities for conservation work. As a result of the EE activities, environmental issues have been demystified. The cause-effect relationships between landuse and environmental degradation have been clearly articulated and the catchment approach widely understood. With better understanding of the underlying issues, residents in target areas are better positioned to find solutions, improvise techniques and appreciate the benefits that will accrue to them as a result of their conservation effort.

Our collective experience in extension has taught us that training people in conservation skills does not necessarily lead to application of skills. Intristic factors such as population densities, farm sizes, access to capital and tools, returns on investment and security and tenure rights together with intristic factors such as policy form a complex which influence a farmer’s options, choices and actions. It is beyond any project to address all these factors and therefore a strategy that entails building partnerships with farmers and other stakeholders was adopted. In the flamingo lakes region, partnerships consist of governments, intergovernmental agencies, individuals, corporations, professional organizations, donors or any group of society.

In practice the assistance rendered to the communities include: Convening meetings to discuss problems and work out viable solutions; preparation of resource management plans; providing opportunities to acquire practical skills where necessary; provision of inputs such as poly bags for tree nursery establishment; and initiating focused conservation activities such as soil and water conservation campaigns and tree planting drives. This participatory approach to problem diagnosis and resolution has been instrumental in achieving the conservation successes recorded by target communities. The formation of VECs is being actively encouraged. The VEC members are organised action oriented groups ideal for galvanising immediate conservation action. They are trained and equipped with appropriate conservation skills and insights needed to carry out broad-based conservation. VECs consist of between 15-20 members elected by community. Many members are BAC trained farmers and several have undergone leadership training.

In the formation of VECs, selection of target areas is based on the location of the village, relative to other villages, terrain and proximity to biodiversity hotspots such as wetlands, lakes, rivers and forested areas. Participants choose villages that are ideal conservation focal points and which can be catalysts and models for replicating sustainable natural resource management to other villages. Expert facilitation helps to guide villagers to democratically elect popular VEC leaders taking into consideration of age and gender. The process of developing Local Environmental Action Plans by VECs involves a series of 11 sessions culminating in the implementation of the plan.

Most farmers in high potential areas own small pieces of land of between 1-6 acres. The average family size is about 7 persons. In order to reach this large constituency where formal extension services are scant (about 1 extension worker to 2,000 farms); communities are invited to nominate a few members for intensive training in sustainable agriculture. These trained farmers are then expected to train other members of their community who would in turn disseminate the skills further. This training curriculum for the initial trainees is based on local needs and carried out at Baraka Agricultural College, located in Nakuru District, Kenya. Training components include soil erosion control, non-chemical methods for soil fertility enhancement, water harvesting, improvement of soil moisture content, tree seedling production and planting, skills related to the exploitation of draught power for tillage and transport and alternative income generating activities. Trainees also receive training in the art of information dissemination as well as in basic leadership skills.

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Policies and strategies on water management and the role of civil society organizations in Nepal

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Introduction

Perched on the southern slopes of Himalayas, Nepal is socially and ethnically diverse as its flat lands, broad valleys, and the highest mountain peaks in the world. “Top of the World” aptly describes to Nepal, home to eight out of world’s 10 highest mountains, including the 29,030-foot Mt. Everest. Nepal is a landlocked country located between India and China. In its 147,181 square kilometer geography, currently Nepal has 23.15 million population compared to 5.6 million in 1911 (CBS, 2001). Females account for more than 50 percent of total the population; out of them, more than 49 percent are in the reproductive age group (15 to 45 years) that is equal to 24.6 percent of the total population. It has been documented that 41 percent of population is under the age of 15. About 80 percent of people are dependent on agriculture. A large portion of the people (38 percent) lives below the absolute poverty line (less than 1$ per day). More than 33 percent of the people are underemployed and this leads to various social and economical difficulties in the country (The World Bank, 2002).

With an annual average precipitation of about 1700 millimeters, Nepal carries a vast water resource potential with a total average annual runoff of more than 220 billions cubic meters of water. The major rivers of Nepal originate in Tibet, traverse through Nepal and join the Ganga river in India before entering the sea. Water is one of the principal natural resources supporting the economy of Nepal, the others being the forestry and tourism sectors, based on the idyllic landscape of the country. At present, almost 30% of Nepal’s agricultural production is based on irrigation facilities. Similarly, 84% of Nepal’s electricity is currently produced by hydroelectric generation. A large increase in hydro power generation capacity would enable Nepal to meet its domestic energy demands as well as increase its revenues by exporting energy to India and neighboring countries. It has been reported that Nepal has more than 6000 rivers with potentiality of producing 43,000 MW electricity.

The present situation with regard to the country’s water resources development can be summarized as follows:

- 33% of the population does not have access to potable water supply.
- Only 42% of the net cultivated land has access to some form of irrigation.
- Only 41% of the irrigated land receives “year-round irrigation”.
- Less than 2% of the country’s estimated economically viable potential hydroelectric
- Capacity (43,000 MW) has been developed;
- Around 53% of the population has no toilet or sanitary facilities.

The Water Resources Strategy approved by His Majesty’s Government of Nepal has identified ten key strategic outputs for the coming next 5-year, 15-year and 25-year periods in order to maximize sustainable benefits of water use in the country. These relate to disaster management, environment, water supply and sanitation, irrigation, hydropower, other economic activities, water related information systems, policy and legal reforms, international cooperation and institutional mechanisms. The activities and indicators for each output have been identified by the comprehensive strategy document. The ongoing National Water Plan and its accompanying Environment Management Plan will translate the envisaged outputs into program’s and action plans. The Water Resources Strategy Formulation - Nepal (2001) has given the directional guidance and priority to address the problems of sustainable water resources development along with poverty reduction for the coming 25 years in order to sustainable enhancement in the living condition of the poor people.

To a large extent, donor and government recognition of the importance of beneficiary participation for development effectiveness and limitations on the capacity of government and public sector executing agencies to promote participation, has contributed to the increasing interest in NGOs. To an even greater extent, NGOs' and civil societies own capacity to influence new approaches to development has dramatically increased in the last decade. NGO leaders themselves have become articulate spokespersons for their grassroots clientele, taking on, in many cases, an advocacy role, where previously they were involved in service delivery. This has occurred as a result of many factors.

Involvement of civil societies in water resource management (WRM)

The president of the World Bank canceled the Bank's participation in the Arun III Hydroelectric Project in Nepal after the World Bank Inspection Panel declared that the Bank had violated its own policies concerning indigenous people and environmental assessment in approving the project. The Arun III project was the first case brought before the Panel, which began its operations in September 1994. It was Nepal's largest hydropower project, 201 MW with the investment of US $1.1 billion. There were 44 lending conditionalities making Nepal totally dependent on World Bank for future policy-making and hydropower investment. There were no adequate EIA and mitigation plans, and no money was allocated for the plan and the project was challenged before the Supreme Court on grounds of constitutional right to information which was denied by the project authority. The court gave a verdict in favour of petitioners/activists and its findings challenged the Bank's mishandling of the project. Finally the World Bank unilaterally decided to cancel the project in August 1995.

Siwakoti Gopal documented that the positive outcome of the two petitions was unexpected. According to him, both the lawsuit and the complaint before the Inspection Panel had at least three consequences for Nepal. First of all, they increased awareness among those affected by proposed development projects that individuals have the right to information regarding these projects. This will enable activists to safeguard the rights of indigenous persons and protect the environment more effectively in the future. Next, the Supreme Court's decision requiring that the terms of any loan agreement with the World Bank comply with the Nepalese constitution indirectly brings the Bank's activities within the scope of domestic jurisdiction, although the Bank itself remains immune from domestic lawsuits. Finally, the World Bank and the Nepalese government are now undertaking consultations with the local population regarding smaller, cheaper, and better alternatives to the Arun III Project.

This Debate has also led to the formation of local concerned, campaign, consumer and user groups all over the country. Several water and energy user groups, activists and academics have recently formed a Water and 'Energy Users' Federation (WAFED) and adopted the Kathmandu Declaration and Plan of Action for sustainable and environmentally friendly use of water and energy, including the conservation of rivers. Through these forums, they have been able to discuss the importance of their water resources and the potential benefits. They also have been able to influence the decision-making process and project compliance.

Partnership for sustainable development - Nepal

The Partnership for Sustainable Development (PSD) Nepal dedicated to the sustainable development and empowerment of the children and youth of Nepal. PSD aims to advocate for the protection of children and youth rights, explore and expand opportunities to grow to their fullest potential and meet their basic needs. Provide support and create opportunities to the poorest communities of Nepal; It has been running volunteer program to raise awareness about water resource and uses of rivers with local community groups. It has bee also working towards the formation of a more knowledgeable and responsible civic society and advocate for local governance as well as building the capacity to the rural water resource users groups.

Water and Energy Users' Federation - Nepal (WAFED) and its involvement in water resource management: A case study

About 100 groups and water/conservation activists from al over Nepal met in Kathmandu on February 12-16, 2001 and discussed all water-related problems, environmental issues and the question of sustainable development in Nepal in the 21st century. They also adopted a Kathmandu Declaration on Water and Energy Development, Human Rights and Environment, and a Plan of Action. The Declaration and Plan of Action include need of an inventory and conservation of all lakes in Nepal as one of its main priorities.

WAFED has adopted few lakes and rivers as its pilot project for the campaign and conservation through local participation. Other project includes the conservation of the Bagmati River system in the highly polluted Kathmandu Valley, and also the hundreds of rivers, and lakes that are the traditional water resources and are on the verge of collapse. Modern development has almost brought Kathmandu valley's seven UNESCO World Heritage Sites into the condition of non-revival unless something is done very urgently. Again the solution is being sought through empowering the local communities.

The Federation has been launching Save the Bagmati River system and the lakes in Kathmandu Valley Campaign from early 2001.The tragedy of Kathmandu Valley in recent years is that it has become over-populated, over-polluted and the traditional water-tabs, ponds, and nearby lakes are on the verge of collapse. The holy rivers (e.g. Bagmati, Bishnumati, Manohara, etc.) of Kathmandu Valley are converted to as permanent and natural sewerage and drainage system. The modern development has brought this valley of the great seven NESCO World Heritage Sites (Swayambhunath, Bauddanath, Pashupatinath, Kathmandu Durbar Squire, Patan Durbar Squire, Bhaktapur Durbar Squire and Changunarayan) almost into the condition of non-revival unless something is done very urgently.

Nepal Water Conservation Foundation

NWCF promotes sustainable development and management of water through knowledge building and disseminating to be used in informed decision making. It undertakes research and promulgates findings through education and advocacy with a specific focus on capacity building of the upcoming generation as well as disadvantaged groups. It has also publishes *Water Nepal*, an interdisciplinary journal on water management

Nepal Water for Health

NEWAH improved quality of life (socio-economic status) of all Nepalese by providing services in safe water, health sanitation and livelihood opportunities and it implements integrated drinking water, health hygiene improvement and sanitation within a gender and poverty framework. Its support has enabled about 7,50,000 people get access to services. It has also involved in the drinking water sector as catalysts and social auditing organization.

Conclusion

It has been accepted that role and importance of civil societies in the development of projects, especially water resource management project are unavoidable. The government and the donors such as the World Bank and Asian Development Bank also have been developing new set of policies and procedures in their financing of projects. In recent years, they have encouraged the local people to directly approach there institutions through their Inspection Panel or Function who claim as the victims of development projects funded by them. They also have developed series of policies and guidelines relating to information disclosure, public participation and Environmental Impact Assessment. At country level, the government has prepared this year new draft strategies on Water Resource Development and Hydroelectricity. Involvement of civil societies from grassroots to national level needs to be prioritized. Nepal has better and cheaper projects that are managed locally and without adverse lending conditionalities. No donors and governments can implement good projects without human rights and environmental conservation approach to development. There must be harmony of policies and procedures among the donors, investors and borrowing countries. The existing policies, procedures and other laws relating to access to information, public participation and Environmental Impact Assessment, compensation/resettlement and benefit-sharing must be implemented effectively and in a timely manner

Key Recommendations

Following are the key recommendations to upscale the water resource management in Nepal. It has been well understood that the role of NGOs cannot be under recognized.

- Nepal's existing water policies are not adequate to address water crisis and poverty issues
- There is a need to reform existing water policies and laws in line with community-based human rights and environmental approach to development
- Communities and affected people must be involved in EIA and implementation of mitigation plans from the beginning
- Proper institutional development and coordination is essential for better monitoring and evaluation at all levels
- For Nepal, small and medium-size hydropower and water projects are considered as the best options on the side of independent experts, civil society and general public
- No poverty can be addressed in water projects without the director involvement of the poor and marginalized communities
- Rainwater and local water harvesting are most reliable and cheaper options for poor and local communities for drinking water and irrigation
- Local resources must be managed with local knowledge and indigenous technology
- There should be a regional policy and framework convention for the management of all Himalayan water resources
- There must be an integrated approach to the management of all forms of natural resources with the involvement of all stakeholders
- In South Asia joint collaborative efforts between and among the co-riparian nations of the region is most essential in undertaking large and meaningful water resources management projects for the benefit of tens of millions of poor people of the region by bringing about a drastic transformation of the respective national economies through the judicious and equitable harnessing of the Himalayan waters.

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Informal environmental science education programs: An effective way to promote stewardship of the World's Lakes

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Abstract:

Informal Environmental Science Education Programs are an effective way to promote stewardship of the world's lakes. In such programs, non-governmental organizations, (NGOs), community-based organizations (CBOS), K-12 public education systems, and institutions of higher education often collaborate to design, promote and conduct environmental science education programs for youth and adults.

Some Informal Science Education programs engage organizations throughout a watershed in helping citizen scientists complete important watershed monitoring work. Informal Environmental Science Education Programs have become a vital connection between the people who live and work in a watershed and the professionals who are designated by government with the responsibility of managing the watershed.

In the Great Lakes Basin of the United States, the synergy of collaboration focused on inform environmental science education has enabled more people to become knowledgeable about freshwater ecology, best practices for watershed management, and the importance of developing lake management plans based on a stewardship ethic.

With a special focus on the Grand Traverse Bay Watershed in Michigan, the author will discuss how the Inland Seas Education Association (ISEA) Informal Environmental Science Education Program has raised awareness of freshwater issues, taught basic concepts of freshwater ecology, and fostered stewardship of freshwater resources to more than 65,000 learners of all ages. By utilizing a fleet of "school ships" and a shore-based education center, ISEA has developed an award-winning program.

Because of the effectiveness of this stewardship program, the Inland Seas Education Association Schoolship Program can serve as a model for watersheds around the world.

Key words: Collaboration, Informal Environmental Science Education, Stewardship

Introduction

Long abused by its human inhabitants, the Great Lakes Basin became the focus of an intensive rehabilitative effort by the governments in the United States and Canada during the 1970's and 1980's. In 1987, a landmark two-year study assessed the environmental conditions and trends of the Great Lakes Basin. The findings were published in a book entitled, *Great Lakes- Great Legacy*: Conservation Foundation and Institute for Research on Public Policy, (1987) Among the key findings of these distinguished researchers and their bi-national advisory panel was that every piece of good news was accompanied by bad news and that, "at least as much effort must be given to prevention as to cure (for the problems of the Great Lakes); to adopting policies and lifestyles that will avoid creating future legacies, as well as dealing with the legacy that has been inherited." In short, the future protection of the Great Lakes is dependent on education and pre-emptive action.

During this same period, a visionary group of mariners, teachers and scientists living along the shore of Lake Michigan established the Inland Seas Education Association (ISEA) as a non-governmental organization in 1989. The ISEA mission is to promote an enhanced public stewardship of the Great Lakes and the world's freshwater through educational programs for learners of all ages. Every year for the past seventeen years, ISEA has taken approximately 5,000 school children and adults aboard its Schoolship vessels. Several hundred more students have participated in programs at the Inland Seas Education Center located on the 45^{th} parallel along the eastern shore of Lake Michigan in Suttons Bay, Michigan USA.

Also in 1989, the American Academy for the Advancement of Science (AAAS) published the results of a five- year study, *Science for All Americans*: AAAS (1989). The study surveyed # scientists to determine which science concepts and skills every American needs to know. The study was followed by the publication of *Benchmarks for Science Literacy*: AAAS (1993). In turn, these documents led to the creation of the *National Science Education Standards*: National Research Council (1995), which has driven science education reform in the United States.

Because the U.S. does not have a nationally mandated curriculum, it has been the responsibility of each state's Department of Education to involve teaching professionals in establishing a curriculum framework for each content area. The Michigan Department of Education (MDE) produced *Michigan Science Standardsand Benchmarks*: Michigan Department of Education (1995) and a *Michigan Science Curriculum Framework*: Michigan Department of Education (2000).

The ISEA Informal Environmental Science Education Program was developed and has been revised periodically to be consistent with the national and State of Michigan Science Standards and Benchmarks (Goals and Objectives).

At the heart of the ISEA Informal Environmental Science Education Program is the Schoolship Program. The Schoolship is a unique sailing classroom equipped with state-of-the art navigational, safety and educational equipment. The Schoolship Program is designed as a half- day trip aboard a schooner. Activities are designed primarily for students in grades five through eight. A modified Schoolship Program is offered to older students and adults. Included in each Schoolship Program are topics such as: a safety orientation, sailing experience, and activities related to Great Lakes history, weather, geology, water chemistry, plankton, benthos, fish, seamanship and navigation/ geography.

Additional ship and onshore programs have been developed to respond to the needs of groups such as the Boy Scouts, Girl Scouts, Native Americans, and disadvantaged youth. Special opportunities have been developed for girls in grades 8-12, because studies have shown that interest in science and math begins to declines at this age level. A conscious effort has been made to recruit women as staff, volunteer instructors, and interns, so girls will have appropriate role models.

Materials

ISEA owns and operates the 26 meter Great Lakes schooner *Inland Seas*, the 14 meter Friendship Sloop *Liberty*, and charters other vessels (including the 36 meter schooner *Manitou*) for the Schoolship Program.

ISEA also owns and operates the Inland Seas Education Center, which includes a Science Laboratory, Science Classroom, Teacher Resource Center, a Great Lakes Library, Boat Building workshop, store, and exhibit hall. Exhibits are provided for the general public, which reinforce the learning stations of the Schoolship Program. Presently the displays include a number of aquaria and a specialized exhibit on Great Lakes Invasive Species, which was funded in part by the W.K. Kellogg Foundation.

ISEA staff stock plastic containers with the equipment needed for each learning station.

Table 1: Learning station equipment.

STATION	EQUIPMENT
Weather	Thermometers, wind gauges, cloud charts, visibility charts, secchi disks and line, buckets, barometers
Water Chemistry	300ml glass sample bottle, DO chemical packs, starch indicator, sodium thiosulfate, lemon juice, measuring tube and bottle, pH color cube, Phenol red, wash bottle, plastic cup, scissors, thermometers, baking soda, goggles, limestone samples, waste bottle, pH chart, large plastic tablecloth, VanDorn water sampler, graduated sampling line, messenger
Geography/ Navigation	Laminated navigation training chart, water soluble markers, watershed chart, lake chart, inflatable globe, hand-held compass, dividers, parallel ruler, hand-held GPS
Sediment/ Benthos	Large glass dishes, glass petri dishes, hand sieves, forceps, glass magnifying glasses, box magnifier, small eye droppers, large plastic droppers, white square plastic trays, white enamel tray, white round plastic tray, soap bottle, rubber matting, grain size chart, benthos key, food web diagram, aquatic plant key, Midge life cycle chart, 2-piece square sieve screens, ponar dredge, dissecting scope, garden sprayer, square plastic wash tubes, 5 gallon buckets, towels
Plankton	Clear plastic sample cup, small demonstration plankton net, small aquaria, plastic petri dishes, small eye droppers, penny, food web chart, microscope, camera and cords for camera/ video setup, tv/vcr. Large plankton chart, plankton net, graduated sampling line, inverter
Fish	Small aquaria, rubber/ preserved fish, measuring board, dip nets, model for trawl demonstration, rubber mat, food web poster, fish key, fish trawl, plastic tub, pail for plants
Seamanship	Digital camera and charger, blank floppy disks/ cds, green and red dots, pieces of steel, Dacron, canvas, aluminum, lead, pieces of line for know tying

Methods

Partnering with the Public Sector including government agencies, K-12 public education systems, colleges and universities has provided ISEA with in-kind services, equipment or funding. Collaborating with the Private Sector including businesses, foundations, non- governmental organizations (NGOs), and community-based organizations (CBOs) has established a broad base of funding support, as well as a network of technical expertise for these programs.

ISEA involved a variety of organizations and experts in the development of the program. First, ISEA staff worked with state and federal agencies to determine, which data would be appropriate for students to collect and how student data could support and enhance the data gathered by professional scientists in the field.

Then, the Inland Seas Education Association staff worked with area teachers to determine the learning stations and the specific goals and measurable objectives for each of these stations. It was essential that the learning stations support science units taught in the public school curriculum.

Finally the ISEA staff developed a comprehensive *ISEA Schoolship Teacher's Guide*: ISEA (2003) containing readings, activities and descriptive materials to help teacher prepare students for their Great Lakes learning experience prior to coming aboard the Schoolship. When they return to the classroom, teachers use many of the activities as extensions of their science curriculum units and in-depth study by students.

Learning stations

A brief description of the six learning stations is given below:

Weather station: Students use appropriate tools and make observations, measure, and record wind direction, wind speed, visibility, wave height, precipitation, air temperature, cloud cover (types and percent) and barometric pressure.

Water chemistry station: Students observe, measure and record surface and bottom water temperature, water transparency, and collect samples of bottom water, sediment and zooplankton for later analysis. They test the level of dissolved oxygen and level of acidity (pH). Through discussion, students learn how these factors affect living organisms in the lake.

Geography/ Navigation station: Students locate the Great Lakes and other major lakes on the globe of the Earth, identify various routes between the Great Lakes and the Atlantic Ocean, define, describe and locate the Great Lakes Basin. Students use a chart to locate visible landmarks on shore, as well as latitude and longitude lines. They use a hand compass/ GPS to determine a heading, take a bearing, and fix the schooner's position on the navigation chart.

Benthos/ Sediment station: Students describe sediment in terms of color, texture and contents, identify types of organisms found in the sediment, and record their findings. They describe the habitat conditions that might be found at a depth of 25 meters in terms of light, temperature, food supply, predators, and dissolved oxygen. They also discuss the importance of benthos as a recycler of organic materials and the difference between deep water habitat and the shallow water habitat where rooted aquatic plants are found.

Plankton station: Students define phytoplankton as floating plants and zooplankton as floating animals. They identify zooplankton in the sample collected earlier and record their findings. They discuss the role of plankton in the aquatic food web and the relationship among phytoplankton, zooplankton, fish, birds and humans.

Fish station: Students match the names of the parts of the fish's anatomy with their location on a diagram. Then they use a key to correctly identify and then count, the fish caught in the trawl, and record their findings. They discuss the existing threats to fish populations and their habitats in the lake, as well as the economic impact, environmental benefits and concerns of fish in relationship to the region. They also discuss the reasons for sampling and monitoring fish populations and for keeping scientific log sheets and records.

Seamanship station: Students assist the crew to hoist and lower the sails, steer the ship, and respond correctly to steering commands from the Captain. Through discussion, students understand how the sails propel the ship (Bernoulli's Law), how the wheel and rudder steer the ship, and how the ship's compass works. They also understand the purpose of the keel (ballast counters the heeling force of the sails limiting leeway), the concept of buoyancy (why heavy, steel boats float), and the concept of mechanical advantage (as demonstrated by the ship's main sheet tackle and ship's wheel). The history of shipping and ecological change are also discussed.

In order to extend the opportunities to other groups, ISEA has developed additional educational programs. Some are half-day programs in maritime history for the various ports and islands in the region were provided an in-depth look at Northport History, Suttons Bay Maritime History, and Gull Island History. Other maritime history classes to Power Island and the Manitou Passage involved extensive sailing and required one / two days onboard ship. Special program from two to four days in length have been developed for Young Women in Science, Boy Scout Island Adventures, and Great Lakes Research Methods. By reaching families through the Family Schoolship Program and Astronomy Cruises offered in the summer, freshwater education has become accessible to the general population.

Volunteer instructors

In order to implement this hands-on curriculum, each Schoolship program utilizes six instructors. Since the program is seasonal and offered only during the sailing season (spring, summer and fall), ISEA needed to recruit and train volunteer instructors. Each winter, ISEA educational staff and professional guest speakers present a training course consisting of a series of nine-two hour classes.

More than one hundred- twenty trained volunteer instructors, supervised by ISEA professional staff, teach aboard the schooner every year. In the year 2003, over $140,000 in working hours (calculated at $13.64 per hour) were contributed to ISEA by its volunteer instructors. These instructors also provide assistance with the onshore programs at the Inland Seas Education Center. Each year six to eight interns from various colleges and universities work aboard the ships and at the Center.

Table 2: Other ISEA educational programs.

Program	Adults	Youth	Length of program
Invasive Species Field Course	X		3.0 days
		X	2.0 days
Summer Overnight Program			
Young Women in Science		X	3.0 days
Great Lakes Research Methods		X	2.0 days
Comparative Limnology		X	2.0 days
Great Lakes Survivor		X	2.0 days
Island Adventure (Boy Scouts)		X	4.0 days
Maritime History Program			
Northport History	X		0.5 days
Manitou Passage History	X	X	2.0 days
Gull Island History	X		0.5 days
Power Island Exploration	X	X	1.0 days
Suttons Bay Maritime History	X		0.5 days
Boat Building Program			5.0 days
Family Boatbuilding	X	X	3.0 days
Volunteer Instructor Training Program	X		3.0 days
Schoolship			
Family Schoolship	X	X	0.5 days
Teacher Schoolship	X		1.0-3.0 days
Astronomy	X		0.5 days

Results

Program evaluation

Each student, along with the classroom teacher, evaluates their knowledge before and after participating in the Schoolship Program. Evaluations are processed regularly and feedback is relayed directly to the ISEA teaching staff, so instruction can be improved. Classroom teachers also provide follow-up communication on the extension activities after they return to school. Teachers compile a post-trip evaluation, which documents the retention of the information and concepts learned aboard the Schoolship.

Criteria for success include:

1. Appropriateness of the content level
2. The amount of new knowledge and experience gained at each of the science stations
3. Appropriateness of each topic and related activity
4. Usefulness of the program to the classroom teacher
5. Effectiveness of the pre-trip and post-trip activities, including the ISEA website

Results of ISEA's evaluation process are used by staff to upgrade and enhance future educational activities. The surveys and tests used in ISEA's evaluation process are designed to measure how well the mission and learning objectives are being achieved. Teaching methods, educational materials, and volunteer training programs are refined each year to enrich the learning process for participants in ISEA's educational programs. Modifications to the evaluation process itself are often made to increase the effectiveness of the process and the usefulness of the results.

Following the 2002 evaluation process, ISEA formed an Evaluation Committee to create new evaluation tools for the Great Lakes Schoolship Program that might better suit students of different age groups. In 2003, students were evaluated using three unique tests, based on student reading levels and subject matter complexity for elementary, middle and high school levels. Students levels were defined in this evaluation process as Level A (grades 4-6), Level B (grades 7-9) and Level C (grades 10-12).

This data is compiled in the *ISEA Annual Evaluation Studies*: ISEA (2003), which includes statistical information about participation in ISEA's educational programs, teacher and student evaluations of the Great lakes Schoolship Program, and summaries of participant surveys from a variety of ISEA's other educational programs. It also includes a summary of evaluations completed by ISEA's volunteer instructors on the Volunteer Instructor Training Program and the Great Lakes Schoolship Program. The final section of the report describes the next year's action plan, adopted to strengthen both the educational programs and the evaluation process.

Impact

- To date, ISEA has provided educational experiences to more than 65,000 people.
- Annually 5,000 people participate in ISEA programs:
- 100-140 public school classes
- 25- 50 community groups
- In 2003, 6218 people participated in the ISEA Informal Environmental Science Education Programs:
- Onboard ship- 4605 people
- Onshore- 2153 people
- Teachers report increased student interest in science after the Schoolship Program.
- Transferring the skills learned through the ISEA program has enabled participants to become citizen scientists in important watershed monitoring work.
- By teaching lake science to youth and adults, a constituency has been created to protect natural freshwater systems. As a result, more people are involved in protecting shorelines and important wetlands, as evidenced by the increasing member and activities of conservation and environmental organizations.

Discussion

Promoting freshwater stewardship can take many forms. The Inland Seas Education Association has found success by partnering with the public sector, collaborating with the private sector, and encouraging other non-governmental organizations to utilize the youth trained in its programs.

Partnering with the Public Sector

Government agencies often provide funds for ISEA's informal science education programs. For example, the U.S. Fish and Wildlife Service has contributed funds for restoration of wetlands along Lake Michigan adjacent to the Inland Seas Education Center. This project also will provide interpretive signage for the general public and classes on wetland ecology and the important role of wetlands in maintaining high water quality in lakes and streams.

Colleges and universities have partnered with ISEA in a variety of ways. The Northwestern Michigan College- Water Studies Institute provided credit for secondary public school teachers, who took an invasive species class offered by ISEA. Michigan State University- International Studies Program brought graduate students to ISEA for a day-long program on Global Freshwater.

Individual school districts have worked with ISEA staff to design week long programs for specific groups of students. One of these programs, called the Great Lakes Discovery Program, involved groups of disadvantaged youth in a week long study of a watershed. All of these classes reinforce the concept that everyone has a responsibility to use freshwater resources in a sustainable manner.

Collaborating with the Private Sector

Businesses also have provided funding for stewardship activities. The Harleysville Lakes States Insurance Company has provided a centrally located auditorium as a venue for the ISEA Great Lakes Seminar series. The speakers are scientists from various disciplines, who speak to the pubic about issues impacting the Great Lakes ecosystem. Topics vary from ballast water discharge to water withdrawals and bottled water. National City Bank provided funding for the schooner *Inland Seas* to travel to ten cities around Lake Michigan. The general public could tour the boat and participate in a family Schoolship program at each port.

Foundations located in the State of Michigan and beyond have contributed significant amounts of money for displays at the Inland Seas Education Center and for purchasing equipment needed for the Schoolship Program.

Other non-governmental organizations such as Rotary International and Zonta International have helped to fund programs to engage youth in protection of the Great Lakes. Young Women in Science and the Global freshwater Schoolship are examples of the collaboration.

Transferring skills

One of the greatest successes has come when youth, who participate in the Schoolship Program, use their newly acquired skills in community service and advanced academic study. One of the area lake associations has undertaken a lake predictive model project. When they needed assistance with water quality testing, local youth were hired to assist with the field work. They used skills gained during their experience with ISEA and transferred them to a real-world situation. Many students find their interest in science is fostered by ISEA programs, which motivates them to pursue advanced degrees and careers in fields related to freshwater.

The Inland Seas Education Association has successfully developed an award-winning informal environmental science education program. All of the hands-on activities are connected to what is going on in the school classroom *and* connected to real-world problems and appropriate solutions. These connections make learning more meaningful and long-lasting. Modeling the behavior of scientists encourages participants to work through the processes of science, such as observation, investigation and experimentation. People, who are active participants in meaningful scientific learning, develop a stewardship ethic toward the Earth and the world's limited freshwater resources.

Participants are not the only ones who develop a sense of stewardship, partners and collaborators do as well. Consequently, ISEA has become a vital connection between the people who live and work in a watershed and the professional who are designated by government with the responsibility of managing the watershed. Because of the effectiveness of this informal environmental science education program, ISEA is the leader in stewardship education in the Great Lakes Basin.

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Lake watershed management in developing countries through community participation: a model

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Abstract

In developing countries, water resources in the urban areas have been subjected to acute environmental degradation due to various unsustainable anthropogenic activities. To address these problems, lake management at watershed level must involve local communities and stakeholders to ensure its long-term sustainability. An action plan is needed to increase awareness among the communities regarding wise use practices and to motivate them to participate in the lake management. There have been several successful initiatives involving community participation for such action in India. Based on these experiences, a framework for the formation of a lake basin management authority with representation of local bodies, community groups and specialists functioning as information node and facilitator for developing capacity for community action in partnership through micro-watershed committees consisting of the local community which would implement the programme is suggested. To ensure sustainability, the programme will include watershed management, provide opportunities to the neglected and weaker section of the community to have better access to the resources and to be implemented with a labour intensive strategy for poverty alleviation. The most important element of the strategy would be to bring diverse groups together and encourage them to come forward with their aspiration and needs and to convert the community demand into community action. The community's involvement in decision-making processes would ensure conflict resolution and cooperative action with local perspectives/experience taken into account. A milli-watershed consisting of a group of micro-watersheds having common drainage would have a project implementation agency consisting of a multidisciplinary team of specialists, which would support the community groups. The local watershed committee would eventually maintain the assets created without government subsidy.

Key words: Community participation, watershed management, lake development authority

Introduction

The rainwater harvesting through construction of ponds and reservoirs is a tradition in India. The former rulers constructed numerous large impoundment for providing drinking water to the people in their capitals and elsewhere. They also patronized religious practices and constructed numerous relatively small water bodies along with temples through out the length and breadth of the country. Now with rapid urban development most of these water bodies have been subjected to degradation due to various anthropogenic activities. The scenario is not much different in parts of the world. Diversion of lake water for other uses causing decrease in water level, eutrophication, acidification, introduction of exotic species, salinization, siltation and contamination by toxic substances are the major impacts threatening lake ecosystems. The major causes of such impacts are, however, mainly due to catchment area activities, which in most cases are spread over in rural areas. Therefore, for management and sustainable use of lakes and reservoirs there is a need to have a complete watershed / catchment area or basin management plan.

The game plan for lake management in developing countries requires a great deal of motivation and training of village communities in order to make them aware of lake conservation and management issues involved. The initial participation has to involve the government and other agencies. There have been initiatives in India over the past several years to harness local community participation in other areas of water management; in particular, the Rajiv Gandhi Watershed Mission has had a number of successes in their programmes for water conservation through simple, labour-intensive techniques, which have been adopted readily by semi-literate villagers. Similarly, creation of assets under the public contribution scheme has caught the imagination of the rural masses. Under the scheme the community contributes equally to the cost in the form of cash, material or labour. A model for ensuring community participation in lake management is detailed out in this paper.

The strategy

For large lakes in developing countries, which do not cross international boundaries, it is necessary to establish a single lake development authority and empower it with full responsibility and authority for managing the entire basin and fringe area of the lake. The authority would consist of representatives of local bodies, community groups and specialists and function as an information node and a facilitator for developing the capacity for community action in a long term partnership mode through watershed committees consisting of the local community groups which would implement the actual programme. The watershed management will have to be viewed as a programme to be sustainable, not merely for lake soil erosion, nutrient and solid waste run off and toxic contamination control, but for providing opportunities to neglected and weaker sections of the rural community to have better access to the resources and will need to be implemented with a labour intensive strategy. This would lead to poverty alleviation of the community in the catchment area, which is essential for sustainability of any efforts of lake conservation. For a certain project period of say 4 years there will be govt funding with equivalent local level contribution and on completion of the project period maintenance will be entirely the responsibility of the watershed committee.

The most important element of the strategy would be to make rural people the hub of all development activities. It is essential to bring diverse groups together and encourage them to come forward with their aspirations and needs and to convert community demand into community action. For this the bottom to top participative strategy would have to be adopted. This would hinge on:

- Establishing multidisciplinary coordinating structures at various levels to act as the facilitators for community organisation, capacity building, planning and implementation and community action processes.
- Making rural people the key actors in the programme in planning, implementation, monitoring, management and maintenance for which necessary community structures at village level in participatory manner have been evolved.
- Harnessing all available techno-scientific resources to support the decision making process of the people.
- Location specific and need based action plans.
- Preference to low cost, indigenous and simple technologies, local materials and skills.
- Tying up area development as well as beneficiary oriented programmes and institutional lending so as to optimize utilisation of this resource base at the grass root level.
- Involving people's representatives and members of local govt. institutions in the programme.
- Organising training programmes for watershed based planning and implementation for implementation agencies.
- Equitable sharing of gains and benefits.

Objectives

The objectives of the establishment of a single lake development authority are as follows:

- Augmentation, conservation and optimum utilization of soil and water resources in the lake catchment area in a sustainable manner. Prevention of agricultural and solid waste runoff into the lakes. To restore ecological balance and improve the environmental resource base.
- To develop an easily available repository of scientific and technological inputs for detailed and area specific planning to the field level implementing agencies.
- To maximise people's participation in planning, implementation and maintenance of the activities in the watershed area to make the entire scheme more effective and transparent.
- To bring about an equitable distribution of resources and sharing of benefits so as to improve the lot of disadvantaged communities.

Implementation mechanism

The detailed phasewise implementation mechanism would be as below.

Phase I: Creating coordinating structures and selecting watersheds

In this phase various structures are set up at different levels to facilitate community participation in planning and implementation of the programme. These function as coordinating structures for the guidance and techno-scientific support to community organisations and monitor the implementation of the programme. Lake development authorities would be established which will work as an information node and a facilitator for other structures to enable them to shoulder the responsibilities being given to them and helps to develop the capacity for community action in long term.

For each milli-watershed consisting of a group of villages/ microwatersheds having a particular common drainage a Project Implementation Agency (PIA) is appointed. Each PIA be headed by a Project Officer who should be assisted by a multidisciplinary watershed development team (WDT) consisting of specialists from different fields (Irrigation, Forest, Agriculture, Horticulture, Animal Husbandry etc.), drawn from various technical departments of the Government. The PIA will be vested with the responsibility of facilitating the planning, implementation, monitoring and review of the lake conservation programme in the selected watersheds. They would conduct base line surveys and Participatory Rural Appraisal (PRA) to gauge the need and demand of community for preparing action plans and match it with the goals of lake conservation. They would undertake action research for adopting low-cost technologies and for helping the community to organise themselves in groups and also assist the community groups in implementation of activities, maintenance of records and accounts, maintenance of created assets and sharing of benefits.

***Phase II : Establishing trust, generating awareness, learning about* community and understanding its resources**

In this phase PIA members would establish rapport and communication channel with the community to build a relationship of partnership and trust. Another important task for the PIA would be to learn about the environment and the resource status of the selected area to understand the community perspectives, perceptions and priorities for watershed development and management.

Phase III : Problem identification and selection of watershed management activities

In this phase various studies, surveys and resource appraisal would be conducted to understand the issues related to soil erosion, nutrient and solid waste runoff and toxic contamination due to fertilisers and pesticides and its solutions. Simultaneously they would encourage the community to articulate their needs and aspirations. Based on the identified problems and the requirement of the community, location specific watershed management activities would be selected. Income generating activities would also be identified on the basis of local resources. While selecting the activities the ideas, experiences and indigenous technical knowledge available with the community would be used.

Phase IV: Community organisation

In this phase the community would be organised into groups to establish participative structures, with common problems and concerns, which would act as vehicle for resource support, for conflict resolution and for community action. These groups would be established in all the watersheds at the village level to enable the community to organise itself for managing the entire process of watershed management. The groups would carry out various activities from planning of watershed management activities and its execution to their maintenance. They would decide on the modalities for group functioning, the principles governing distribution of any incomes/resources and conflict resolution. A watershed committee would be established to act as the executive committee to manage the day-to-day affairs of the watershed at the village level and to facilitate the participation of the entire village community. It would have representations from all user groups, members of village local bodies, women, NGOs and representatives of the PIAs. The Watershed Committee would be the vehicle through which community meetings would be organised, watershed plans drawn up and executed, records and accounts maintained, funds distributed to community groups for executing the activities and implementation monitored. Maintenance of assets created under the project would be done after the project period by the same community.

Phase V: Conflict resolution

In this phase, the demands of different interest groups will be placed together and each group will get a feel of the demands of other groups. Different views of groups and member of groups will be reconciled to find impartial solutions. Efforts of conflict resolution will ensure that the benefits are shared equitably and assets maintained jointly by the community itself.

Phase VI : Community consolidation and capacity building

Capacity building and community consolidation would be simultaneous processes taking place along with the implementation of the programme. The PIA would organise capacity building and training programmes for community groups so that they can:

- act as a mechanism for motivating the community
- articulate their needs and demands for preparing action plan
- plan and implement watershed management or income generating activities
- ensure sharing of benefits
- take over and maintain the assets created during the programme

Phase VII: Community action

This is the phase in which the community energies will be used for developing action plans, implementing these plans and maintaining the created assets. Action plan of each micro watershed/village would be developed through sequential discussions held between the PIA and each group to decide the best option for meeting the requirement for solving the identified problems. This process would lead to the preparation of a technically sound action plan with people's participation, whereby cost effective local methods of watershed management already in vogue can be adopted after expert guidance of PIA for maximum returns and optimum utilisation. Each group would prepare its own plan for the proposed activity with designs and cost estimates. All such plans would be consolidated to prepare an action plan of the micro watershed. In the action plan the selected activities would be arranged in a timeframe say 4year programme schedule. Consolidated Action Plan would be submitted to the Lake Development Authority for sanction and release of funds. Once sanctioned, funds would be released directly to the Watershed Committee for implementation of the selected activities. The Watershed Committee would have its own bank accounts for financial transactions. It would have a Project Account and a Development Fund Account. In the Project Account, money released from the Lake Development Authority would be deposited for day-to-day transactions for implementation of selected activities during project period. The Development Fund Account would be a fixed deposit/interest based account in which the earnings from the assets would be deposited and will be maintained for post-project maintenance of assets. The Watershed Committee would implement the activities, as proposed in the action plan. For each of the implemented activities, 50% public contribution would be collected in terms of cash, material or labour from the beneficiaries. During the implementation of activities, continuous monitoring would be done by the PIA. Expenditure incurred on each activity is placed in the local body meeting and monthly physical and financial progress report would be submitted to the LDA through the PIA.

The activities, that could be taken up are:

- Land Development including *in situ* soil and moisture conservation measures. i.e. Contour Trenches, Gully Plugs, Contour Bunds, Contour Cultivation, Strip Cropping, Sequential Cultivation, Broad Base Furrows.
- Drainage line treatment with a combination of vegetative and engineering structures i.e. Check Dams, Gabian Structure, Underground Dykes, Soak Pits, Infiltration Trench
- Organic farming.
- Nursery raising for fodder, timber, fuel wood and horticultural species.
- Afforestation including block plantations, shelterbelts, bund stabilisation, etc.
- Agro-forestry and horticultural development.
- Pasture development either by itself or in conjunction with plantations.
- Repair, restoration and upgradation of existing common property assets and structures in the watershed to obtain optimum and sustained benefits from previous public investments.
- Solid waste management via biogas plants,vermicomposting.

Phase VIII: Programme evaluation

In this phase impact evaluation would be carried out with a certain frequency in a participatory manner to judge the progress of the programme towards the goal of sustainable development. It is a regular and integral activity rather than a sporadic and separate event. The evaluation will be carried out with reference to base line information of resources and socio-economic status. It will encourage participants to modify mechanisms, rethink priorities, reset development options and rechart their course of action and for preparing the recommendations for improving the strategies. The evaluation would cover:

- Operational success or failure of adopted strategies.
- Resource awareness among the community.
- Extent to which participation has been achieved in planning and implementation of programme.
- Growth of capability of the community to take up the task of planning and implementation.
- Technical feasibility and sustainability of implemented activities.
- Equitable sharing of benefits.
- Impact of income generating activities.
- Overall impact of the programme on restoring ecological balance and socio-economic condition of the community.
- Achievement of programme as compared to objectives, targets and success criteria laid down in project guidelines.
- Optimum utilisation of resources.
- Capacity of community to undertake follow up maintenance of assets created during the project.

The activities undertaken and the processes adopted would be identified and assessed by the stakeholders in the presence of the entire village and facilitators. This exercise would lead to increased ownership of the community for the activities carried out, identify gaps and made review of the action plan. This would lead to

- Validation of the claims made by the village level Watershed Committee.
- Satisfaction level of beneficiaries.
- Identification of members of the village community who have not benefited.
- Identification of areas, which need interventions. Preparation of action plan for future action and identifying the processes through which implementation is to be carried out.

Phase IX: Follow up maintenance

This phase is envisaged for participatory maintenance of the assets created. It will be done by the community through the Development fund they have collected during the project. In this phase the Watershed Committee will decide procedures of maintenance, role and responsibility of different group members.

Case study

The Upper Lake of Bhopal is a major source of potable water to the Bhopal city of 1.4 Million people. It has a catchment area of 361 sq. km, of which 40% area is urban and the rest 60% is rural dominated by agricultural practices. Due to rapid urbanization as well as intensive agricultural practices during the second half of the last century subjected this lake to various anthropogenic pressures leading to deterioration of its water quality. Therefore, the Government of Madhya Pradesh implemented the Lake Bhopal Conservation and Management Project for the conservation of this lake. Under this project various preventive and curative measures such as diversion of sewage, management of solid waste, fringe area management, catchment area treatment, removal of silt and weeds from the lake, etc were undertaken to increase the storage capacity and improvement of water quality of the lake.

The use of chemical fertilizers on the upstream crop fields being one of the major causes of nutrient enrichment of the lake, promotion of environmental friendly agricultural practices was started in 15 villages of the catchment as an added activity. Under this programme, awareness and training programme for the farmers were initiated to encourage them to adopt organic farming to reduce pollution of the lake. At the end of the project, a Lake Conservation Authority (LCA) has been created to facilitate sustenance of the conservation plan. The LCA is now promoting the environmental friendly agricultural practices in the entire catchment of the Upper Lake consisting of 66 villages in collaboration with the Agriculture department of the Government of M.P. and Winrock International India (WII), a not for profit organization to develop a mechanism for incentive based mechanism to encourage more and more farmers to adopt organic farming and compensate them for the loss they might incur due to use of organic manure in place of inorganic fertilizers for crop production.

Environmental education a key for better management of lake basins in developing countries like Tanzania

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Abstract

The environment has become a global concern as environmental problems become more apparent and grows wider in scope. Change and development in the twentieth century have brought many social and economic benefits to the developed countries, associated with these changes are a wide range of environmental problems. All around the globe, these problems are associated with poverty, hunger, infants, mortality, and accelerated environmental degradation

In Tanzania studies on the extent of public understanding of environment are not available and observations indicate that the level is very low, again the biggest challenge faced is how to transfer the little available knowledge to the local people who are the majority in the population. Limited public awareness as a result of insufficient knowledge, understanding on the part of citizens, local authorities, decision-makers and the media, on the human impacts on lakes contributes to the degradation of the values and uses of lakes. A major contributor to the lack of understanding and awareness by the public regarding lake degradation is the subtle nature of many types of lake problems. In order to avoid these problems environmental education is important as such problems can manifest themselves very slowly, often over generations. Experience shows that, where it is feasible, the involvement of the public can be beneficial in identifying lake problems and developing sustainable and public supportable solutions to them, thus a strong need for environmental education in all levels.

Key words: Environmental education, public participation, environmental degradation, developing countries

Introduction

The environment has been a global concern as environmental problems become more apparent and grows wider in scope. Change and development in 20th C have brought many social and economic benefits to the developed countries. However, these changes have been the cause for a wide range of environmental problems (World Commission on Environment and Development, 1987). Studies on the extent of public understanding of environment in developing countries are not available and observations indicate that the level is very low due to the marginalizations and cumulative effects of science and technology, (Tan M, 2002).

Again the biggest challenge facing these developing countries is how to transfer the available knowledge to the local people who are the majority in the population. Limited public awareness of the human impacts on lakes contributes to the degradation of the values and uses of lakes. Inadequate public awareness may result from insufficient knowledge, data and/or understanding on the part of citizens, local authorities, decision-makers, the media, industry and others of their roles, either individually or collectively, in causing lake problems or in helping to solve them, (Tan and Ferido, 2003). Further, in some cases, governmental agencies and/or decision-makers may believe that the only appropriate role for the public in such matters is to provide the required funds for the programs and activities to address lake problems, in contrast to the proactive approach of working with the public to identify and resolve current problems and/or avoid similar problems in the future. On the other hand, citizens may think they need to rely exclusively on governmental agencies and/or decision-makers for solutions to such problems.

Experience around the world, however, suggests that, where it is feasible, the involvement of the public can be beneficial in identifying lake problems and in developing sustainable and public supportable solutions to them (Jansky *et al.,* 2002). A major contributor to the lack of understanding and awareness by the public and decision-makers regarding lake degradation is the subtle nature of many types of lake problems. Such problems can manifest themselves very slowly, often over generations and become evident after the degradation has become very severe, and irreversible. This subtle nature of lake environmental degradation makes it harder to create awareness of lake problems among the public and decision-makers, and to initiate needed remediation or restoration activities in a timely manner

Overcoming these problems depends upon collaboration between researchers and governments in the region to find scientific, technological, legislative and economic solutions and provision of appropriate education on the environment through the concept of sustainable development. This education must be provided to field of studies with no exception, as anyone can become prominent leader in the future with an influence on the status of the environment building a sustainable future for the peoples of developing countries. Many of these solutions depend on environmental education; therefore there is a strong need for introduction and encouragement of environmental education in developing countries, like Tanzania.

Environmental education and its components

According to EPA 1978, Environmental education is a learning process that increases people's knowledge and awareness about the environment and associated challenges, develops the necessary skills and expertise to address these challenges, and fosters attitudes, motivations, and commitments to make informed decisions and take responsible action.

Unlike most formal education efforts, environmental education emphasize on effectiveness of having a distinct “action” component whose purpose is to encourage responsible, enduring decisions and actions that impact the environment. Encouraging “action” means teaching individuals how to examine a range of possible courses of action to address or resolve an environmental challenge after an investigation and evaluation has determined that action is needed. Environmental education component should not advocate a particular solution to an environmental challenge. Rather, they should provide individuals with the information, critical-thinking, and decision-making skills they need to make their own responsible decisions among a range of options. Environmental education should be included at all levels of formal education across disciplines in order to foster a sense of responsibility for the state of the environment and to teach people how to monitor, protect and improve it (Jansky *et al.,* 2002).

The GEF draft report 1, 2005 and the Tbilisi Declaration 1978, identified education as one of the most important component in management of lake basin others being; *awareness* and sensitivity to the environment and environmental challenges, *knowledge* and understanding of the environment and environmental challenges, *attitudes* of concern for the environment and a motivation to improve or maintain environmental quality, *skills* to identify and help resolve environmental challenges and Participation in activities that lead to the resolution of environmental challenges (UNESCO, 1978). While Aseto 2004 reported that the Value based lake management education can be applied for management of lakes. Environmental education is very important as it is relevant to our everyday lives because it can ensure the health and welfare of our nation by: Protecting Human Health, Advancing quality education, Expanding Employment Opportunities, Promoting Sustainable Development, Protecting world’s Natural Heritage.

Tanzania and environment

Tanzania is one of the leading countries in the world in terms of biodiversity. With a broad range of habitats including marine ecosystems, savannah, forests and lakes, it also contains some of the largest remaining herds of wildlife in the world.

In terms of lakes, Tanzania is extremely well endowed with lakes. The total water area in Tanzania covers nearly 61 500 km^2 or about 6.5% of the total land area, 88% of which is made up by three major lakes. The main lakes are shared with neighboring countries and are generally associated with the Great Rift Valley. These include Lake Tanganyika and Lake Nyasa, both elongated and rather deep, and Lake Victoria, which is a broad and relatively shallow lake. Almost half the areas of two of the Great Lakes (Victoria and Tanganyika) lie within Tanzania, and 800 km of shoreline on the third (Lake Malawi/Nyasa) is also in Tanzania. Other large lakes include Lake Rukwa and Kitangiri and a group of Rift Valley soda lakes (Lakes Natron, Eyasi and Manyara), which are very shallow and liable to dry up in low rainfall periods. Numerous smaller lakes are scattered throughout the country. There are comparatively few river systems within Tanzania as the main central plateau is arid. Four distinct river basins are apparent. Rivers flowing to the Indian Ocean drain the greater part of the eastern and southern regions. These include one of the largest rivers in Africa, the Rufiji, with an average dis-charge of 1 133 m^3/sec, and minor rivers such as Pangani, Ruwami, Ruvu and the Lake Nyasa rivers. The remaining basins are associated with Lake Victoria, Lake Tanganyika or the interior drainage including the Lake Rukwa Basin.

Various studies, including those conducted for the development of Tanzania’s National Environment Action Plan (NEAP), have identified six major environmental problems, which need to be urgently addressed. These are: (1) loss of wildlife habitats, and thus biodiversity; (2) deforestation; (3) land degradation; (4) deterioration of aquatic systems; (5) lack of accessible, clean water; and (6) pollution plus a combination of factors such as rapid population growth, economic liberalization, influx of refugees from surrounding countries, poaching, reliance on firewood, and competing demands on natural resources among agriculture, tourism, mining and other sectors which has resulted in increasing pressure on its natural resources and, consequently, on increasing environmental degradation.

Tanzania is doing fine in research field and a number of research institutions do exist these include the Universities, Tanzania Fisheries Research Institute, Tanzania wild life research institute and others. Tanzania also has a large amount of data on natural resources and environment. However, most of the data are scattered and exist in different formats. This makes it difficult to compare, extrapolate, or up-date information which is a serious drawback for proper environmental planning and/or monitoring. Moreover, there has been little or no coordination among the various agencies working in the same area and this has resulted in duplication of data collection and a waste of resources.

Education system in Tanzania

Tanzania with a population of 41 million people has a literacy level of 52%. The structure of the formal education and training system in Tanzania constitutes 2 years of pre-primary education, 7 years of primary education, 4 years of junior secondary (ordinary level), 2 years of senior secondary

(Advanced Level) and up to 3 or more years of tertiary education. The education system has three levels, namely: basic, secondary and tertiary levels.

Recognizing the importance of science and its potential impact on sustainable development, the government of Tanzania has put in place a Higher Education Policy to provide the direction and guidance to stakeholders and service providers. The policy has placed emphasis on the teaching of basic sciences and the development of corresponding skills. With regard to environmental sciences, the policy singles out the following subjects for inclusion in the national curriculum: the study and prediction of climatic and global change as a result of human activity on the environment; environmental pollution including water and air pollution with the disposal of toxic and radioactive wastes; disaster management; energy conservation; environmental conservation and enrichment; the effects of chemicals, drugs, pharmaceutical, fertilizers on the environment, biodiversity and genetic engineering. Although Tanzania is doing some effort to implement and teach people about environment; the biggest weakness in Tanzanian education system is that the Environmental education is not included in the formal education system again at higher level only few students have a chance to learn about environment.

Effort by the Government

Importance of Environment in the economy of Tanzania is of four folds: it provides the basic resources for virtually all socio-economic activity in the country, it holds natural habitats, plants and animals that are art of an irreplaceable global heritage, waste receptacle and a foundation for eventual alleviation of abject poverty. It follows therefore that; the major thrust of environmental management is protection of the natural living space of humankind and integration of environmental scarcity in making decision on all economic issues and activities. The government of Tanzania realised the danger faced by our Lake basins and its natural resources and takes appropriate measures ranging from policy, legal framework and institutional arrangement which are conforming to socio-political and economic system. Although these legal frameworks are not so effective. The government in collaboration with various stakeholders has put emphasis on promoting, strengthening and sensitising communities and individuals participation as a strategy to invigorate environmental conservation and management. Together with these there have been some awareness campaign, environmental education and skills development, which complemented on various issues of environmental conservation and management. Emphasise for the environmental conservation and management is to raise the capacity and ability of the communities and individuals in sustainable management for own benefits and for the future generation are being done.

It is vividly that the efforts has raised the public awareness, interests and actions as more than 159 Community Based Organisations (CBO) and non-Governmental Organisations (NGOS) has been formed as well as private sector and individuals joining the process. Furthermore, the government and other collaborating institutions and agencies such as CBOs/NGOs are implementing various programmes both in rural and urban areas. The media institutions (radio, TV, press, newspapers) has played a significant role in sensitising and undertaking various education programmes on environmental issues thereby cultivating public/ private interest, commitment and awareness on environmental management and conservation aspects. The government has recognized the need for Environmental Education and Communication (EE&C) to promote improved management of natural resources, which is a pre-requisite for sustainable development. It has also recognized that, any EE&C has to reach down to the community level, for it is there where changes in behavior towards the environment will result in meaningful improvement. NEAP, launched in 1994, called for a National Environmental Education and Public Awareness Program, which would utilize a combination of measures to improve public environmental awareness and would promote both formal and informal Environmental Education.

The National Conservation Strategy for Sustainable Development (1995) called for government to assist NGOs, groups, communities, and individuals to promote public participation and involvement in environmental issues. This call was echoed in the National Environment Policy (1997) in one of its objectives is "to raise public awareness and understanding of the essential linkages between environment and development, and to promote individual and community participation in environmental action." The Government's commitment to EE&C is evident by the fact that it is one of the priorities of the National Environment Management Council (NEMC). In Tanzania, the formation of conservation clubs is a relatively new endeavor. There are three different organizations, which are establishing school clubs and are focusing on environmental education for youth. The oldest of these organizations is Malihai Clubs of Tanzania, which was established in 1985 and has been working in secondary schools. Roots and Shoots and the Wildlife Conservation Society of Tanzania (WCST) were formed in the early 1990s and cater to primary and secondary school children.

Challenges in implementing environmental education in Tanzania

Although the Tanzania government in the field of environmental education is doing great effort, yet a number of challenges do arise, as summarized below. However, it is important to note that environmental education is a long-term process that requires on-going support and participation from all sectors of society. Thus the government should give emphasize on the following themes.

Environmental education must be a priority across the country

In Tanzania like other developing countries environmental education is not a clear priority at any level within our education system or society, and many programs face on-going resource, funding, staff limitations and widespread support. In addition, many view environmental education as an “add-on” and not part of mainstream education. For these reasons, there needs to be clear and consistent political and legislative support at all levels.

It is known that this lack of long-term consistent support and commitment at all levels has created a field that is often fragmented, inefficient, and duplicative. Much work still needs to be done at national, regional, and local levels to institutionalize environmental education and make it a nationwide priority.

Reaching important audience

In Tanzania much efforts is focused on primary schools. Important audiences in environmental education are being missed or inadequately reached, such as adults, people in villages, which are the majority and senior citizens.

Lack of materials, commitment and organizational support; uncertainties in knowing how to engage these audiences; and difficulties in adapting traditional teaching strategies to non-formal learning environments within communities and diverse cultures is one of the biggest challenge.

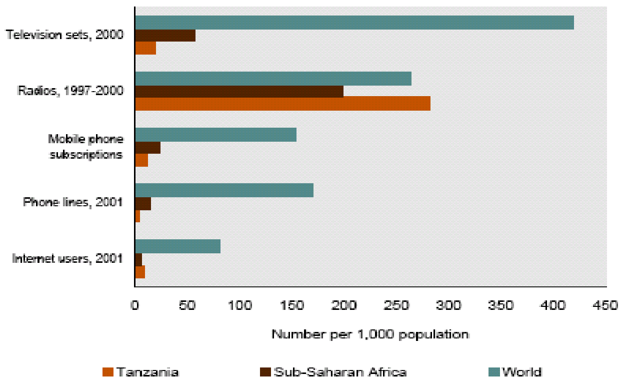

Figure 1: Tanzanians access to information and technology 1999-2002

Again environmental materials are rarely available in languages other than English. Media support is lacking and more often research-related news reports are not validated. Television, which is the most efficient way of communicating developments in science and technology do not give priority to science-related programs. Music, business and even pseudo-science get more publicity. Except perhaps for health-related news, other science breakthroughs do not attract much attention from the business sector-sponsors for such programs. The few science-related shows do not warrant primetime programming, either.

Need for greater resources and support

Although consistent leadership and commitment is critical to the success of environmental education in the Tanzania, most environmental education initiatives are best developed and implemented at the local, and tribal levels. The government’s primary role should be to support local initiatives that have evolved over the past years. Government support can help institutionalize such programs and promote a sustainable environmental education infrastructure that will function despite shifts in spending priorities.

Need for improvement for the limited resources

Solutions to environmental issues require increased collaboration among all sectors of society including business, industry, schools, community organizations, citizens, funding institutions, and government. In Tanzania the responsibility for environmental education rest mainly with nonprofit organizations, community educational institutions, and motivated educators scattered. The presence of partnerships and a better understanding that collaboration is the key to sustainability. Community and educational institutions need to work more closely with the formal education system and with parents and families. There also is a need to build on existing international partnerships. Environmental challenges are global and will increasingly need international cooperation to find effective solutions. It is critical that countries establish and enhance mechanisms to share success stories and lessons learned to improve national and international environmental education efforts

Need for improvement and integration of Environmental education into education reform

Environmental education has the potential to significantly improve the public education system. Many of the goals championed by education reform and improvement advocates such as the need to strengthen interdisciplinary teaching and critical thinking and problem-solving skills can be effectively accomplished using environmental education as a vehicle. Although there are some good efforts under way, environmental education has not consistently been well integrated into education reform and improvement efforts across the country and it has not generally been identified as a priority of the formal education establishment. This is partly a reflection of the environmental education establishment’s tendency in the past to focus more on reaching teachers and students rather than state education agencies, local school boards, principals and other school administrators. Consequently, key educational decision makers are not generally knowledgeable of the potential effectiveness of environmental education in achieving many of the basic goals of education reform.

Environmental education, by its nature, draws on and impacts many disciplines, such as science, math, history, and political science. It also is readily identifiable as a critical component of citizenship education, science literacy, career development, and a variety of other initiatives supported by the education reform movement. Education reform can be a mechanism for giving environmental education an established place in the curriculum, making it less subject to funding priority shifts and more likely to be a focus in teacher training.

What to be done in case of Tanzanian Environmental education: personal views

Awareness shapes a hierarchy of values, and at the same time has an influence on the sense of responsibility for inappropriate choice of values and indifference towards wrongdoing. To know and understand what is good and what is better, and at the same time commit a wrongdoing, is socially more injurious than committing a wrongdoing in ignorance. Therefore, building, in a society, a new system of values with the aim of creating environmental public awareness should include systematic training activities aimed at increasing the basic knowledge of ecology and environmental protection, and, at the same time, heightening the sensitivity of individuals to nature.

Altitude changing is crucial in developing countries. It is evident that people's relationships with their environments are influenced by their values and attitudes. Altitude examines the place and function of values education in environmental education and provides information in strategies for examining environmental values. Values clarification and role play gives the information on peoples life style example in developing countries people should visualize faeces as a normal this not as dirty thing as it is seen. Once you put it there then you are done. People need to see the direct relationship between human healthy and environmental deterioration and get the solution or an alternative ways in order to change their way of living, for example, eutrophication in Lake Victoria. Then, people should know what is eutrophication, how it affects the life and what should be done. In case of local people should be told that increase in nutrients results into eutrophication, eutrophication changes the whole lake foodweb and chain thus the aquatic ecosystem as a whole this can result into bloom of blue green algae, when blue green algae are in the water they produce toxins these toxins when taken by human or cows they get sick and sometimes death can occur. Again the water will not be good for swimming because the blue green algae will itch their bodies. Fish will die when the blue greens are decomposing thus we will have less fish. What you can do is to reduce the loading to the lake by separating the urine and faeces and use the faeces and urine as fertilizer. Again every family can have a small gappei jokasso to at least reduce the amount of waste which will be going into the lake.

Integration of local knowledge into scientific knowledge

Indigenous knowledge is the local knowledge that is unique to a culture or society. Indigenous people have a wide knowledge of the ecosystems in which they live and of ways of using natural resources sustainably. Indigenous knowledge in environmental education can be used to tell us on the status and identity, history and future, values, teaching methodology, collapsing barriers between the schools and home, a moral voice for conservation and institutional mediation in a certain area. Example to date scientist think that public ownership is a problem encourages environmental degradation because no one is responsible but the indigenous knowledge doesn’t show this, it shows that public ownership is not a problem the problem is the increase in population. Another example is siltation in lakes like Lake Tanganyika; local knowledge shows that this is a result of changing in traditional agricultural practices to the modern ones. Thus inclusion of local knowledge will lead to better management of lake basins as it first gives the picture how the situation was before the present time.

Awareness raising

Environmental public awareness comes from a result of general knowledge, specialist knowledge of a particular problem and also sensitivity to, and a sense of, responsibility for the environment. Environmental public awareness is shaped throughout the whole life of particular people living in a given local community, performing specific work and having definite personal characteristics, which have a deciding effect on their sense of responsibility and ability to emotionally perceive the environment as having value in itself. The knowledge acquired during school education and then systematically improved in adulthood, is an essential factor in heightening the environmental awareness of an individual and, at the same time, an indispensable condition for the development of a pro-ecological lifestyle. To undertake actions aimed at increasing environmental public awareness regarding the protection of lakes and water reservoirs, answers should be known to the specific question like Eutrophication and Siltation.

Involvement of other stakeholders: The role of women

The case of Tanzania regarding the involvement and role of women in Lake Basin management is typical of many other developing countries having similar cultural background. These communities dictate that women are subordinated to men thus making them socially very closer to the environment than men who are isolated from the problems. Women involvement is very important, as they are the daily managers of the living environment but also the educators to the children. Hence a particular need to ensure that women have education on environment.

It has been found that in many cases development efforts have not just by-passed women, but have actually made their position worse. It has also been noted that failing to consider the role women play in rural society, or excluding them from project planning, has resulted in the failure of projects (Edger, 1982). Women's views fully should be taken into account they are becoming the effective family decision makers in many parts of the world. A creative commitment to gender equality will strengthen areas of action to reduce poverty because women can bring new energy, new insights and a new basis for organization. And if poverty reduction strategies fail to empower women, they will fail to empower society and the environment in general.

Community participation

According to Aseto (2004), community is a group of people, who have cultural, socio-economic, political and spiritual commonalities are key variables in the operational definition of community. From both a developmental and anthropological perspectives, community is operationally defined as a group of individuals sharing common value system, living in the same socio-economic conditions in the same geographical location and affected by the same problems.

The concept of community-based lake management and conservation seeks to involve rural communities in taking joint responsibility for sustainable management of the lake and other natural resources, where they live and to share the direct and indirect benefits of its managements. It involves devolvement of power to the communities. "Involvement" means full participation and empowerment is a powerful and frightening concept for conservationists, governments and other stakeholders.

A vast amount of natural resources including the lake basin are held as common property - where a specific group of people own and manage resources in common. Yet, only in the last 20 years has research recognized the role of common property in production, risk diversification, poverty alleviation, natural resource management system and cultural heritage (Antinori, 1984). Research has sought to explain how people overcome obstacles to collective action, which sustain common property resource management systems, avoiding the predicted tragedy of the commons, in which overexploitation occur. Research has shown that effective participation requires transfer of proprietary rights to participants. Thus there is a need to see and develop a set of management and control options that could identify how people value common property and if alternative management systems can provide those benefits (Rebecca D'Cruz, 2004).

In developing countries like Tanzania, education systems have tackled water education through carrier subjects such as science, agriculture, social studies and other opportunities, little or no education on lake management has ever been taken to those many that are unfortunate not to go to school or drop out because of various reasons. In order to have an effective participation there is a need to have an informed stakeholder who is empowered further to take part in the decision making process. Thus, provision of adult education on lake management and sanitation is urgently needed. The education should be geared to meet local people demands and to empower the communities to understand the dynamics and complexities of the environmental issues facing them. Thus it is indeed true that; 'the answers to the perplexing issues associated with the environment lie not so much in an advanced technology as they do in a human population that at long last realizes that solutions exist in human beliefs and values, and in the ability of each and every person to confront the issues in logical and productive ways. At least part of the mechanism for resolution lies with educators who will shape the beliefs, values and skills of young people throughout the world (Menon, 1994 read in Aseto, 2004). Participation is guided by the observation that local stakeholders know better than anyone else what their problems are and what solutions might be the best ones and can work. When people commit to a course of action that is their idea, the results are more likely to succeed and continue than when ideas are imposed from outside, or delivered within a top-down approach structure (Oliver, 2004). People can be involved by the following methods; go to the people, Live among the people, Learn from the people, Plan with the people and work with the people, Start with what the people know; build on what the people have, teach by showing, learn by doing, not a showcase but a pattern.

Participation pays but is difficult. There is need to develop tools and identify best practice on the ground as there is a general agreement on the theme. Developing good participation is going to be extremely important but should be done around concrete examples. In order to change and shape the attitude and awareness of members of the community, Parents, teachers, colleagues, acquaintances, fellow-workers, leaders, media, moral authorities, scientists, and politicians can be involved and this can be conducted at home, family, schools, religious organizations, workplace and associations. Environmental public awareness messages can be transmitted through mass media, children, youth, daily, popular and specialist press, television and radio programme, films, including documentary films, own experience and observations, work for organizations, and, social status of the family and affluence.

Conclusion

Developing countries like Tanzania are rich in freshwater resources, which are of value to the communities. The resources are under threat and have continued to deteriorate despite much effort by national and regional institutions with national and international support. The experience so far show that there has been lack of effective action due to, limited accessibility and application of scientific information; poor dissemination of management information; inappropriate and is some cases un-harmonized laws and regulations; inadequate enforcement of existing laws and regulations; Weak institutions and institutional processes; and inadequate funds to implement programs. There is need to: Make appropriate information and data available to guide decision and formulation of policies, laws and regulations for sustainable management, Provide appropriate policies, laws, regulations, and standards to be used in management efforts; Establish and develop effective institutions, institutional mechanisms including community participation in provision of required data and information, promote sustainable use practices, Provide adequate financial resources and human capacity to implement environmental programs.

It is true that environmental public awareness comes from a result of general knowledge, specialist knowledge of a particular problem and sensitivity to, and a sense of, responsibility for the environment but in developing countries people need to see the direct relationship between human healthy and environmental deterioration and get the solution or an alternative way in order to change their way of living. Example incase of Eutrophication. The knowledge of factors affecting the environmental awareness is essential for the selection of optimum environmental programme and activities orientated at public participation in decision-making processes connected with resolving specific problems concerning water quality management in lakes and reservoirs.

Recommendations

Lastly, I would like to give the following recommendations: Environmental education should be a must in primary schools. Research Institutes should involve themselves in public awareness raising. Formation of environment-based community groups should be encouraged. Values based environmental education should be applied to youth, as it takes a long time to be incorporated. There is a strong need for having an interaction between science, politics and public which are the majority and the ones who are benefiting from the lake basins.

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Russian environmental education for lake managers

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Abstract

Practices and future strategies for environmental education for lake managers in Russia have been written. It is shown how the students may be informed about the importance of environmental education integrals and rules under studying Mathematics. The new environmental subjects are introduced into Russian education programs for lake managers. The special computer program has been created for studying transformation and transportation of pollutants in lakes for education in Russia. The models of Sevan Lake and Dead Sea have been created for environmental education in the capital of Russia. Russian students are study the changes of water level and other physical characteristics in the lakes with the aid of created special simple mathematical models. It is planned to use these models of lakes in primary and secondary schools for environmental education. The last achievements in theory of probabilities connected with generalization of Tchebysheff's (Chebyshev's) inequality and Kolmogorov's estimation are introduced in environmental education to managers of lakes basins. It is used for education, research and training.

Key words: lake, education, models

The promotion of environmental education for lake managers

There are many problems in environmental education for lake managers in Russia. Some of them are related to low level of communication among schools and non-governmental citizen groups for solving practical environmental lake problems. The Russian government supports environmental education and environmental studies on aquatic environments within primary and secondary schools through the Ministry of Education.

Many private schools are coming up Russia. With this, there is a problem with standardization of school education programs. The capital of Russia, Moscow, is a leader in environmental education in Russia. This relates to the special position of the capital city in Russia. 10^7 people live in Moscow. There are about 1500 schools with more than 1,000,000 pupils at the beginning of this century. There are new and improved teaching materials and methods in environmental education. These materials and methods are spread from Moscow's schools to schools in other parts of Russia.

The independence of the public sector has increased today, for example, the Moscow Society of Naturalists organizes the Environmental Olympiads for schools. The Moscow Society of Naturalists was founded in 1805 and is supported by the Russian Government. It has more than 3000 members, some of whom discussing problems of standardization of education programs in environmental protection. The first Moscow Environmental Olympiad was held in 1993 and two hundreds pupils took part in it, and more than 400 pupils took part in the Environmental Olympiad of Moscow 1999. These environmental Olympiads are a bridge between Moscow's schools, universities and scientific Institutions.

New and improved teaching materials in traditional subjects

There are two ways for developing environmental education for lake managers in Russia. The first relates to introducing some environmental problems in traditional subjects. Pupils may be asked to make some calculations related to environmental problems. For example, there is a problem of calculation of a flood (increasing the water level) near a destroyed dyke. The decision flow of this problem may be expressed as follows, as a ratio of two integrals

$$t = \int_{h_3}^{h_4} S(x)dx \Bigg/ \left[\sqrt{2g} \int_{h_1}^{h_2} A(x) x^{1/2} dx \right],$$

Where ***t*** is a time of critical rise of water level from the moment of destruction of a dyke; ***x*** is distance from the water level in front of a dyke to the depth (the time of the beginning of a flood); ***S (x)*** - is a square that has been limited by a line of equal heights; ***A (x)*** - is the width of a breach in a dyke as a function of ***x***; h_1 and h_2 are the distances from the water level before the dyke to the bottom and top of the breach in a dyke; h_4 is the distance from the critical water level after the dyke to the water level before the dyke; h_3 is the distance from the water level before the dyke to the bottom of place; ***g*** is the acceleration due to gravity.

Students study the theory of probabilities as general mathematical subject. Students can study the possibilities of estimation of rains and floods with the aid of the theory of probability for lake management.

There is a problem of estimation of the probability of floods and rains. It has been stated for any random value (aleatory variable) ζ, any function $\varphi(\zeta)$ and any exponent (***m***) ***m***: (***m***>0 *or* ***m***<0) that inequality (1) is the connection of generalized Tchebysheff's inequality and generalized Kolmogorov's estimation. This expression has been used for point estimation to probability of floods in Neva River in St. Petersburg and precipitation in Osaka under condition of unknown distribution function.

$$\frac{E[|\varphi(\zeta)|^m] - \left[\sup\limits_{\omega:|\zeta|<c}|\varphi(\zeta)|\right]^m}{\left[\sup\limits_{\omega\in\Omega}|\varphi(\zeta)|\right]^m - \left[\sup\limits_{\omega:|\zeta|<c}|\varphi(\zeta)|\right]^m} \le P\{|\zeta|\ge c\} \le \frac{E\left[|\varphi(\zeta)|^m\right] - \left[\inf\limits_{\omega\in\Omega}|\varphi(\zeta)|\right]^m}{\left[\inf\limits_{\omega:|\zeta|\ge c}|\varphi(\zeta)|\right]^m - \left[\inf\limits_{\omega\in\Omega}|\varphi(\zeta)|\right]^m} \quad (1)$$

The experimental data are shown by light grey shade (Figure 1). The results of point estimations are shown by circles, squares and triangles.

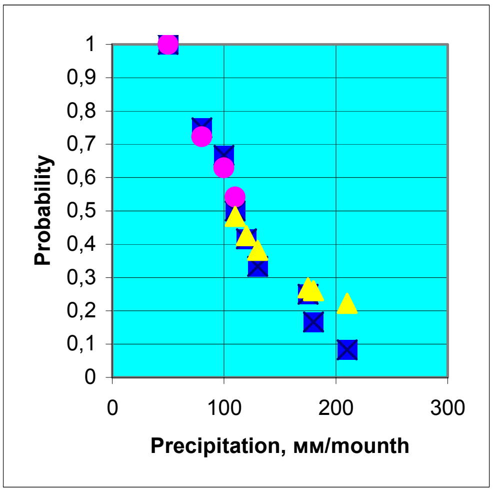

Figure 1: Point estimation of precipitation in Osaka.

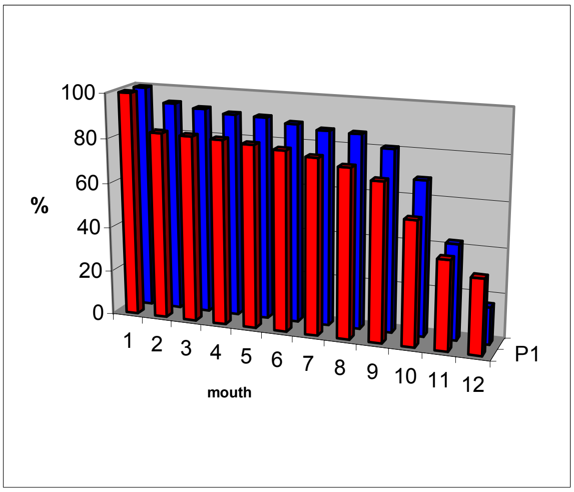

Figure 2: Point estimation of probability to Neva River flood in St. Petersburg.

Students see that all experimental data fully correspond to the stated inequality.

Pupils may study a problem of environmental calculations of a capacity index in settling centrifuges and centrifuge separators with the aid of the mathematical concepts of a square, a volume and integrals. They are taught how to use the settling centrifuges and centrifuge separators for environmental protection before beginning of these calculations. Then they study the rule for calculation of a capacity index of settling centrifuges and centrifuge separators. This rule i s stated as follows:

A capacity index of settling centrifuges and centrifuge separators is equal to the double product of the sum of volumes that have been limited by settling surfaces and the ratio of angular velocity squared to the acceleration due to gravity.

Pupils may understand the way to state this Rule with the aid of the following integral:

$$\Sigma = \frac{\omega^2}{g}\iint_s r\cos\gamma dS,$$

Were Σ is a capacity index of settling centrifuges and centrifuge separators, ω is an angular velocity of the centrifuge's rotor; g is an acceleration due to gravity, dS is an infinitesimal square of a settling surface, is a distance between the dS and axle of rotation, γ is an angle between the r and normal to dS, V is the sum volume that has been limited by the settling surface.

Then a teacher shows that the product $r\cos\gamma$ equals the $2dV$. Were dV is an infinitesimal prismoid with three-cornered foundations that has been constructed on the infinitesimal square dS. So, the pupils will understand that

$$\Sigma = \frac{\omega^2}{g}\iint_s r\cos\gamma dS = 2\frac{\omega^2}{g}\int_0^V dV = 2\frac{\omega^2}{g}V$$ and can state the rule for calculation of a capacity index of settling centrifuges and centrifuge separators.

We must take into account that this sum of the volumes that have been limited by settling surfaces may be much more than a volume for separation of disperse systems and even the volume of a settling centrifuge or centrifuge separators too! Thus, the pupils may be informed about this important aspect for environmental education integrals and rules in Mathematics.

Creating new environmental subjects

The second way of developing of environmental education relates to creating new subjects in school programs. A special computer program has been created for studying transformation and transportation of a mixture of pollutants in the environment. The students study a scientific law of transformation and transportation of the mixture of pollutants in the environment with the aid of the special computer program. Thus, students know how to address the problem of calculation of pollution under modern conditions with incomplete information.

The students are now studying the mathematical models of the some lakes and seas under anthropogenic stress conditions. They deal with modern dynamics of southern seas and lakes with the aid of the education models under anthropogenic stress conditions. There are currently four mathematical models for environmental education in Russian Orthodox University. The first is a model of transmission from two separated layers of waters to one layer in the Dead Sea under influence of the main intake water from Jordan River. The creation of this model was undertaken as described below. Jordan valley and Dead Sea were remotely sensed at an altitude of 570 kilometers in the false-color Landsat image. The deep saline water of the lake's large northern basin absorbs light rather than reflecting it, and so it is black. The swampy flats of the smaller, dried-up southern basin are dark green and light blue. The satellite image was acquired in December 1978, about when the Dead Sea's waters turning over. Evolution of the water column and the density, salinity and temperature profiles that influenced it were traced from 1960 to 1980. In 1960, as has occurred before, a large density difference (caused by a large change in salinity) separated the variable upper layers from the deep fossil waters. By 1976 the interface between the surface and fossil waters had descended. The upper layers' salinity and density had increased, but in summer warming decreased the surface density. These trends continued in 1977, but there was a new reverse salinity gradient in the summer. In 1978 the salinity was uniform throughout the water column; a small temperature difference maintained the stability of the fossil water body. In 1979, after the overturn, the fossil water body had been dissipated and the entire column was more saline and somewhat warmer. In 1980 after a rainy winter, there was a new but shallow salinity gradient. These phenomena are currently being studied by the students of the Russian Orthodox University with the aid of a mathematical model of the Dead Sea.

The second environmental education model is a model of changes of the Aral Sea under influence of main intake waters from rivers that discharge into this Sea. It is well known that the area of this Sea is now decreasing. Salt is moved from areas of former sea bottom to the surrounding villages and fields.

A third model of water level change was created for the mountain Lake Sevan for education. Use of the lake's waters for hydroelectric power stations has led to a decrease in evaporation and volume of runoff that goes into the lake. One of the lake's islands has become a peninsula due to decreased water level.

Thus, the changes of water level and other physical characteristics of the seas and lakes are studied by the students with the aid of mathematical models. It is planned to use these models of the Dead Sea, Aral Sea, and Sevan Lake in primary and secondary schools for environmental education.

The latest achievements in the theory of probabilities connected with the generalization of Tchebysheff's (Chebyshev's) inequality and Kolmogorov's estimation are introduced in environmental education for managers of lake basins, and for education, research and training.

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Reviving Wetlands - A Living Lakes Restoration and Management Project [Report]

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People need lakes and wetlands – they provide water, fish and reeds, prevent floods, reduce levels of pollutants. But they are also very vulnerable ecosystems providing habitat for endangered wildlife. The Living Lakes project “Sustainable Management of Shallow Lakes and Wetlands” was launched in 2001 in order to manage lakes and wetlands in ways which enhance their natural value while benefiting the social and economic needs of local communities. The project areas are the lagoons La Nava and Boada in Spain and the Nestos Lakes in North-eastern Greece. The two demonstration areas are typical for a great number of wetlands and shallow lakes. The majority of wetlands in Mediterranean countries such as Spain and Greece are extremely degraded in ecological terms. Almost all problems of water management are present: pollution, drainage, improper water treatment systems, nutrient enrichment, conflicts concerning the use of water, lack of management and lack of integration in local and regional land-use planning.

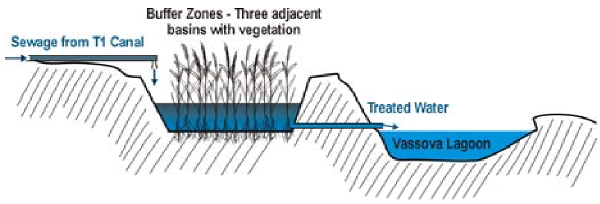
The broad aim of the project was to demonstrate that it is possible to manage wetlands in ways which enhance their nature conservation value while benefiting the social and economic needs of the local community. Management plans for the sustainable development of these wetlands have been created. These plans include agricultural extensification and the establishment of buffer zones and green filters around the lakes in order to reduce nutrients from sources such as agricultural run-off and sewage water entering the lakes.

The main problem of the Spanish wetland Boada de Campos is the poor quality of the water supply. The inflow is polluted with various substances from sewage with improper treatment. Water analyses carried out within the EU LIFE project showed, that the poor water quality is responsible for decreasing numbers of indigenous animal and plants species in the wetlands. The introduction of a Green Filter (Filter of Macrophytes in Flotation = FMF) for the wetland is considered the most effective way of purifying the water flowing into the wetland. The Fundación Global Nature Spain has already gained experience in the implementation of Green Filter systems in other areas. Once the FMF system is established, a great quantity of biomass is produced, and needs to be removed using periodic cuttings. This biomass reaches 2.2 kg/m² of dry material per year considering the aerial part in the case of bulrush (*Typha latifolia)*, and can be used for energy purposes. One square meter of channel produces the same calorific value as one litre of petrol. Moreover, this water-treatment system is easy to manage with minimum maintenance costs, an important factor to be considered in municipalities with low budget and less labour available. The capacity of the aquatic macrophytes is able to eliminate eutrophic matters, especially phosphorus and nitrogen at 40 % to 60%. It effects the decomposition of organic substances, by means of the micro-organisms attached to the plants’ root systems, and also helps decrease the amount of suspended solids attached to the root systems.

The advantage of this Green Filter in comparison to other systems is the high purification capacity, because the whole root-system of the green filter plants is submerged and all the effluent flows through this purifying mesh. The cutting of the biomass is relatively easy to manage. Moreover it is economical and easy to install. The FMF Green Filter system uses macrophytes which can be found naturally rooted in the ground, but which are here transformed artificially in floating. It’s a new method that combines the advantages of floating systems and emergent macrophyte systems, eliminating or reducing its disadvantages. The combined system can perform a tertiary treatment of the secondary effluents from the conventional water-treatment plants, removing the elements that cause eutrophication, especially phosphorus and nitrogen. Some emergent plant species have the capacity of absorbing enormous quantities of heavy metals or decomposing phenol, so the system can also be used for treating industrial wastewaters.

The system constitutes basically of a carpet of floating vegetation that occupies the whole surface of a lagoon or a group of channels where the water circulates. Native plant species should be used and have to be positioned in such a way that their roots, rhizomes and parts of the stem are submerged. The plantation should be established with a density of 2 plants per m². This high density assures a fast vegetation cover of the whole surface. From the plant species, which have been tested successfully, *Typha latifolia* in comparison to other species (i.e. *Scirpus* and *Sparganium*) has given the best results regarding growth and purification. When growing floating in the water, this species build a dense sponge of roots and rhizomes that occupy the whole volume of the vase (lagoon or channel) and keep the water circulating in this brush of vegetation. This also supports the micro-organisms that degrade the organic material. Similarly, leaves pump oxygen into the roots, which favours the process of degradation of the pollutants. At least two floodgates should be installed in each filtration channel, one at the beginning and one at the end. In this way the channels can be managed independently. Each channel can be emptied separately allowing cleaning, replanting etc.

The filter described here is more effective during the warmer months of the year, when the pumping of nutrients have a certain importance. The periodical harvest of the biomass is fundamental for eliminating the nutrients in the system, but the dynamic of nutrients in the treatment plant should previously be known. If an annual harvest of the vegetation once the leaves are dead is carried out, 40 % - 45 % of the nitrogen and phosphorus contained in the plants can be collected and re-used, the rest having already gone through to the rhizomes as reserves to initiate the next vegetative period. If this harvest is brought forward (to the end of September or the beginning of October), the nitrogen and the phosphorus absorbed by the plant can be extended up to 70 %, as they have not gone through the roots yet. In any case, and if the system is additionally protected with a greenhouse, the number of annual cuttings can be increased to two or three.



In the project area in Greece a comparable filter system with an area of about six hectares was created at a brackish water lagoon in order to remove nitrogen and phosphorus loads from more concentrated effluents of inflowing drainage canals. The installed buffer zone was planted with more than 50,000 water plants (*Typha angustifolia, Typha latifolia and Phragmites sp.*) in three adjacent basins. Between the last basin and the lagoon an overflow with an additional earth-gravel filter was constructed.

The project has a high potential for transferability. A multilingual handbook and a multilingual video documentary were published addressing the public, wetland managers and decision-makers. The measures are relatively easy to reproduce since they require low maintenance and investment costs.

The project was carried out in the framework of Living Lakes, a worldwide partnership for the protection of lakes and wetlands. Living Lakes is a partnership of public and voluntary organizations for the protection of lakes and wetlands, introduced in 1998 by Global Nature Fund. Aim of the partnership is to further and promote sustainable development objectives at international level. Currently the network comprises 39 lakes and wetlands spread across five continents. The overall intent of the international network is to prepare the ground for an on-going international dialogue and co-operation between private and public stakeholders involved in water issues. Objectives are to further the exchange of know-how, technologies and experiences between NGOs and other stakeholders like governments, scientists and businesses moving Agenda 21 objectives from paper to practice. The Living Lakes project fits perfectly with its economic partners‘ approaches to sustainable development. In both, the sharing of knowledge, encouraging best practice, recognising global responsibility and establishing local partnerships between NGOs, business and local communities, are all vital elements. Global partner of the Living Lakes project is Unilever. Supporters at international level are DaimlerChrysler and the Deutsche Lufthansa. Living Lakes is also supported by companies such as SIKA, Kärcher, Ziemann, a number of medium-size companies and media partners.

Meeting the MDGs on Global Sanitation- a paradigm shift of pathogen and nutrient control

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Abstract

Lack of basic sanitation and the necessary facilities for its provision is commonplace in most of the developing countries. United Nations MDGs clearly stated that the number of people without proper sanitation access should be reduced by one-half by 2015. Most rural and peri-urban areas in developing countries cannot afford sewage systems by 2015. Alternative methods are necessary to meet the MDGs of sanitation. While the necessity of sanitation is urgent in terms of pathogen control, the value of human excreta should not be disregarded, which contain nutrients for agriculture such as nitrogen, phosphorus and potassium. Japan has a sophisticated system to handle human excreta without pipe system. The system has been installed in peri-urban and rural areas in Japan since 1954, where provision of sewage system is not affordable. After re-evaluating the Japanese night-soil treatment system we propose the effectiveness of urine and feces separation according to the concept of Ecological Sanitation, and further possible improvement of the system by applying advanced sanitation technology for developing countries in terms of pathogen control, nutrient and energy recovery from treatment of human excreta.

Key words: sanitation, advanced sanitation, urine feces separation, night soil treatment plant, johkaso, vacuum truck,

Introduction

Lack of basic sanitation and the necessary facilities for its provision is commonplace in most of the developing countries. Since developing countries, urban areas in particular, are often confronted with difficulties of managing their own water resources in many aspects, their efforts to address such water issues should be fundamentally established upon dealing with sanitation problems (Matsui S., et.al., 2001). United Nations Millennium Development Goals (MDGs) clearly stated that the number of people without proper sanitation access should be reduced by one-half of them by 2015. How to meet this global sanitation goal is our big challenge.

Although sewage systems tried to develop in urban and peri-urban areas, only about 600 million people take a service of modern sewage systems with treatment plants (OECD, 2002). We draw Figure 1 that could indicate a map of world sanitation in terms of urbanization and technology development. Most rural and peri-urban areas in developing countries cannot afford sewage systems by 2015. Alternative methods to sewage systems are necessary to meet the sanitation of MDGs. Alternative methods must rely on non-pipe transport systems that imply vacuum trucks and other means of transport must be explored.

While the necessity of sanitation is urgent in terms of pathogen control with basically feces , the value of human excreta should not be disregarded, which contain nutrients for agriculture such as nitrogen, phosphorus and potassium. Especially phosphorus is a limiting resource. As a consequence of the needs for agriculture, chemical fertilizer accounts for 80% of total consumption of phosphate rock in the world. The depletion of current economically exploitable reserves of phosphorus can be estimated at somewhere from 60 to 130 years (Steen, 1998). We need to recover resources from human excreta as much as possible.

The purpose of this paper is to examine a new system for advanced sanitation, which can combine treatment of human excreta and recovery resources from them, and which developing countries can afford. Japan has a sophisticated system to handle human excreta without pipe system, different from sewage system, although little attention has been internationally given to the system. The system has been installed in peri-urban and rural areas in Japan, where provision of sewage system is too expensive and not affordable. We would like to reevaluate the Japanese night-soil treatment system.

The interest with ecological sanitation (Winblad ed., 1998) has been growing, which is the concept to achieve both treatment of human excreta and recovery of resources from them efficiently. It has been proposed in the concept of ecological sanitation that urine, the contents of which is much different from one of feces should be diverted from feces. We also examine the feces-urine separation in this study.

Based on the examination, we will propose a new system to treat human excreta in rural and peri-urban areas of water-limited developing countries.

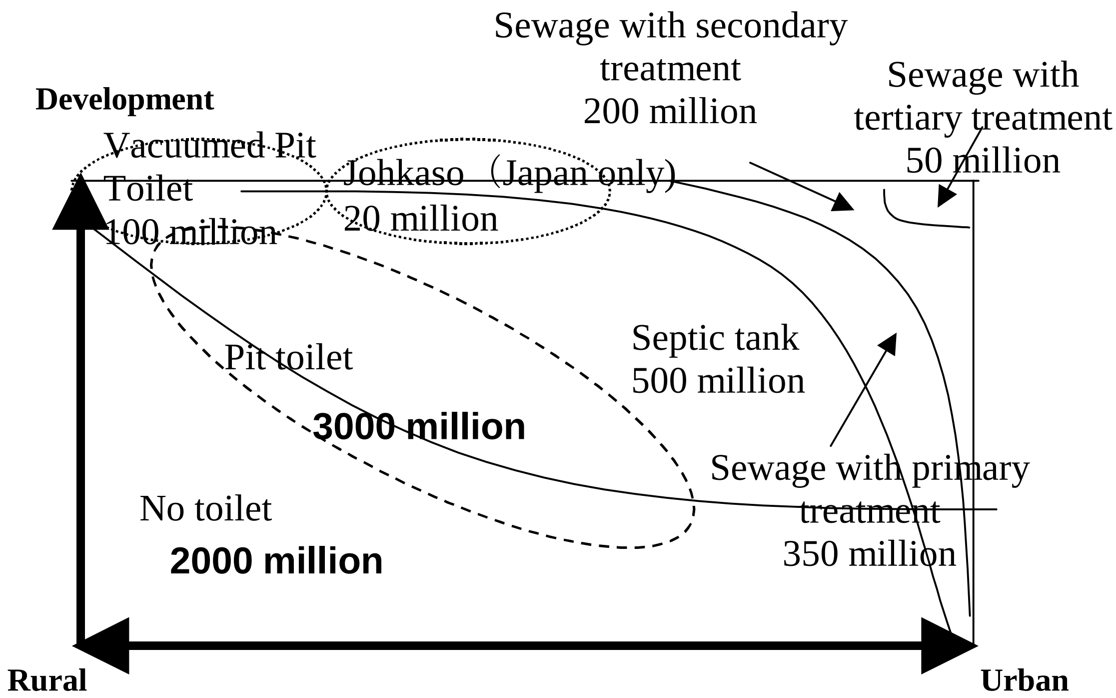

Figure 1: Sanitary Condition of World People.

Japanese Past and Present Sanitation Practices

One of the Japanese traditional sanitation practices dates back to its handling of human excrements from 13th Century to now. During such period, when Japanese had lived in a rice-based agricultural society, they had fully utilized and benefited from human excreta as a major fertilizer to their fields. Kept stored in individual household vault toilets, the night soil (i.e., human excrement) was collected by the farmers themselves in exchanged for agricultural products (Yasumoto, M., 2003). As an agricultural country, night soil was once one of the farmers' best friends to supply their plants with natural nutrients, thus increasing the yield of production. Night soil, therefore, had efficiently and effectively blended with the socio-environmental aspects of the Japanese society. This period in the Japanese civilization epitomizes the natural way of disposing of human excreta into the environment while maximizing their full potentials as valuable fertilizers, and breaking the chain of disease transmission that could be caused by improper disposal of such human waste. Only exceptions are not successful disease control due to round worm, tapeworm etc. Moreover, this way of excreta disposal and use shows that the Japanese previous toilet system was a non-water utilizing type that is commonly known today as "dry toilets." In the light of this system that led to the non-existence of transmittable diseases through the proper treatment of human excreta in particular, the Japanese society, hence, has a long history of traditional sanitation practices not only proven by time but also by traditional knowledge and processes.

At almost the same time as the development of sewerage systems in the West, Japan had laid down its early pipeline networks for the collection, conveyance, and disposal of sewage in Ginza, Tokyo at 1873 (Japanese Ministry of Environment - 1). In the early half of the 19th century (i.e., Meiji Period), some ordinances were established for handling wastewater. In 1934, the necessity for constructing a storm water and sewage separate sewerage system was also greatly recognized by the Japanese (Japanese Ministry of Environment - 1). This paved the way of treating storm water separately from the domestic sewage, which opened many opportunities for Japanese to explore more of how they could best manage their domestic wastewater.

The endeavor to address the growing need to manage domestic wastewater continued through the end of the 20th century that highlighted the development and adoption of all the many technologies such as activated sludge, trickling filter, anaerobic and aerobic processes, and the like. Moreover, such efforts were complemented with timely development and implementation of policies and laws particularly concerning pollution control and clean water (i.e., 1967 Basic Law for Environmental Pollution Control, and 1970 Clean Water Law). The rapid development of many parts of Japan into highly urbanized areas necessitated the construction of reliable and safe trunk infrastructure for basic services as also manifested by the abrupt concentration of population in such areas. These basic services – water supply and sanitation – have been long enjoyed by the Japanese people. At present, public sewerage systems all over Japan cover 66.7% of the total population with a portion of12% having their domestic wastewater treated by tertiary treatment processes(Japanese Ministry of Environment, 2004).

The dramatic change in Japan's industrial setting after the World War II, however, brought several changes described by challenges, replacements, developments, innovations and breakthroughs not only in terms of technological dimensions but also with respect to socio-cultural and environmental aspects. With the burgeoning population growth in the urban areas, which had incapacitated existing public service infrastructure particularly the public sewerage systems and other like

existing facilities during the period, the Japanese faced serious public health challenges caused by increasing cases of the spread of infectious diseases transmitted by fecal-oral route (Yasumoto M., 2003). The need to immediately address and solve these problems gave way to the birth of a number of laws that promote and ensure public health and dignified way of living for all. In addition, huge developments of facilities for public water supply systems and night soil treatment plants (i.e., a Japanese-developed technology that has recently been gaining acceptance and popularity for its potential use overseas specifically in the context of developing countries) have been carried out. Like any other country, however, Japan experienced great financial constraints that limited the progress and propagation of public sewerage systems. As a result, innovations and breakthroughs in the application of the night soil treatment technologies have offered practical and effective ways to collect, manage, and re-use human excreta. As of 2001, there are 1,124 operating facilities for night soil treatment scattered all over the country that utilize up-to-date technologies such as anaerobic and aerobic processes, high-loading and membrane separation treatment, accepted primary, secondary and tertiary treatments, as well as standard nitrification-denitrification processes. Recently, the Japanese Government and private companies have put in continuous efforts to promote the use of more advanced technological processes to complement the capacities of the night soil treatment facilities. As of year 2001, facilities that introduce standard nitrification-denitrification and high-loading treatment processes, for example, escalated to 307 and 195, compared to a number of 247 and 139, a decade ago, respectively (see Figure. 2, S55, H2 and H13 mean respectively fiscal year 1980, 1987 and 1998).

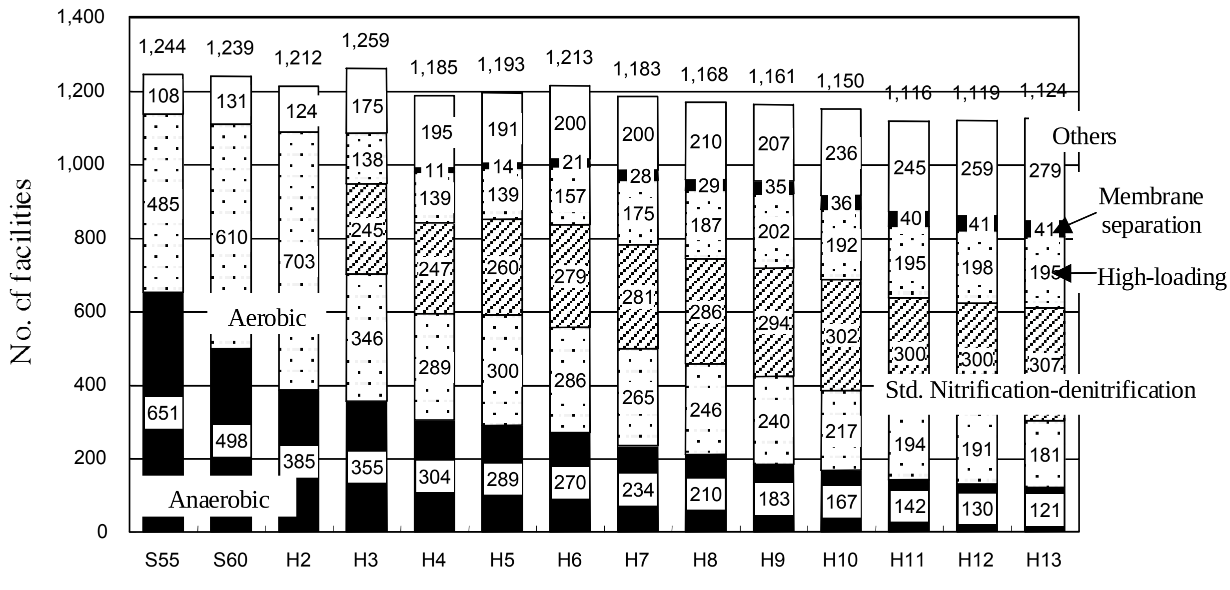

Figure 2: Number of night soil treatment facilities and applied treatment processes (Source: Year 2001 Japan Waste Treatment Report, MoE, March 2004).

The introduction and development of the aforementioned technologies have replaced and have shifted the management of human excreta from the traditional bucket style collection to vacuum trucks that collect and transport feces to the night soil treatment plant. With the achievements and developments of the combined application of public sewerage system and the night soil treatment plants, Japanese have again been able to prevent, if not eradicate, the occurrence of infectious diseases transmitted by the improper management of human excreta.

Alongside the height of modernization of Japanese standard of living and influences of Western culture, an abrupt adoption and introduction of flush-type toilets occurred. In this regard, with ingenuity of the Japanese people, and their demand-based response to issues, another Japanese-developed technology, now famously known as "johkaso" or simply purifying tanks was developed. Johkaso system is a Japanese-developed technology that is unique, sophisticated and cost-effective for managing domestic wastewater particularly in un-sewered areas.

First installed in 1911, it diffused rapidly all over the country particularly for household application. This continued to mass production of 'johkaso' small-scale units made of fiberglass reinforced plastic (FRP) and to the development of standards for johkaso system covering its design, installation, operation and maintenance (O&M), de-sludging process, inspection and examination. Moreover, unsatisfied of the quality of effluent and in quest of a more clean water resource environment, the johkaso system called "tandoku-shori johkaso" that was originally designed to only treat "black water" or the sewage coming from the flush-type toilets was re-developed to be capable of treating both "grey water" or other miscellaneous domestic wastewater, and black water. This has resulted to a now called "gappei-shori johkaso" and consequently terminated the application of "tandoku-shori johkaso", as supported by current existing Johkaso Law. Furthermore, considering an integrated approach and responding to the increasing volume of sludge produced by such combined treatment in johkaso systems, the existing night soil treatment technologies and its facilities are used to sanitarily treat the produced sludge. Currently there are more than 1 million johkaso systems in Japan serving more than 10 million of its population. One of the signs of public acceptance, such a system is installed at a rate of more than 200,000 per year. In addition, as of 2000, the ratio of johkaso systems (i.e., gappei and existing tandoku-type) to the total number of toilets in Japan (i.e., includes both flush-type and non-flush type toilets) is 27.2% while that of the gappei-shori johkaso only is 8.9% (see Figure.3).

Together and comprehensively, the Japanese Government has promoted the application of not only public sewerage system and night soil treatment plants, but also this on-site wastewater treatment system - 'johkaso' - to address the needs to manage its domestic wastewater.

Figure 3: Gappei -shori johkaso that accept urine and feces, and grey water to treat and discharge in a neighbor water channel. (Source: Year 2001 Japan Waste Treatment Report, MoE, March 2004).

Night-soil treatment plant and vacuum truck collection system in Japan

Priority of treating human excreta to grey water

We will begin our discussion by considering the human excreta in household wastewater. Table 1 (Japan sewage works association, 1999) shows statistic data of the pollution load of excreta and grey water in Japan. As Table 1 shows, human excreta are main source of nitrogen and phosphorus while the others contains much of BOD and COD. Nitrogen and phosphorus in wastewater should be treated properly since they induce eutrophication, and are targets of resource recovery, especially phosphorus that is crucial. High concentration of ammonia (much of the T-N) requires nitrification and denitrification of treatment of sewage. In addition, pathogens, which are contained in excreta should be sanitized completely. Therefore, excreta are more important than grey water.

Due to the low concentration of ammonia, grey water could be treated by simple treatment system such as artificial wetland and simple treatment equipment with open channel. The priority problem on the treatment of household wastewater in peri-urban and rural areas in developing country is how to treat human excreta.

Table 1: Pollution load of household wastewater (g/person/day).

	Average	**Standard Deviation**	**N**	**Excreta**		**Grey Water**	
BOD	58	18	125	18	31.0%	40	69%
COD	27	9	120	10	37.0%	17	63%
SS	45	17	125	20	44.4%	25	55.6%
T-N	11	2	19	9	81.8%	2	18.2%
T-P	1.3	0.3	15	0.9	69.2%	0.4	30.8%

Non-pipe system to treat human excreta

Sewage system is a main system to dispose and treat household wastewater, although most areas in developing countries cannot immediately afford the installation of it. As Table 2 (Japan sewage works association, 2000) shows, high cost of the system is derived from construction of the pipe system. High cost of the pipe system is born by the areas which tried to install sewage system. In addition, transport of excreta with the pipe system needs much water and it is, therefore, not suitable to water-limited area of developing countries.

Therefore, if a non-pipe system can perform properly, the non-pipe system can be alternatives to sewage system on the area. In fact, Japan has a sophisticated non-pipe system to treat human excreta with vacuum truck collection from pit toilets, which have dramatically contributed to improve sanitary conditions in Japan. Now we will examine the Japanese system to treat human excreta.

Table 2: Total construction cost of sewage treatment plant and pipe system in Japan

Year	Treatment Plant Cost		Pipe System Cost	
	Billion Yen	%	Billion Yen	%
1996	980	27.2	2,618	72.8
1997	898	26.2	2,532	73.8
1998	986	27.2	2,638	72.8
1999	999	26.3	2,804	73.7
2000	860	25.2	2,548	74.8
AVG.		26.4		73.6

History of night-soil treatment and vacuum truck collection system in Japan

Japan has a history to use human excreta as fertilizer (Kaneko et al., 1998). In the 17th century at the latest, people established a sophisticated system to recover human excreta. Human excreta were handled separately urine and mixed urine and feces as valuables. Human excreta were transported from urban to rural areas and used as fertilizer.

However, the amount of human excreta used as fertilizer reduced due to the urbanization and the prevalence of chemical fertilizer. Excess human excreta were not treated appropriately and deteriorate sanitary conditions of especially urban areas. As it was necessary to treat human excreta appropriately and sewerage system did not widely developed in Japan yet, Japanese government started to develop night-soil treatment plants in 1954 (Inoue, 2004). As people at the time were using pit toilets, vacuum trucks were used to transport contained human excreta to the plant, instead of pipe-system. From the 1950s to the 1970s, this system using vacuum trucks spreaded across Japan and dramatically contributed to reduce the number of water-born diseases derived from human excreta by 1970s together with development of water supply system and improvement of nutrient conditions (Magara, 2003).

Thus, Japanese unique system to treat human excreta was build up. However, water-flushed toilets were spread with the modernization after the 1970s by the development of not only sewerage system but also *johkaso*, which is on-site treatment system and treats human excreta and/or grey water by anaerobic and aerobic biological system. However, sludge accumulated in *johkaso* tanks need to be transported to night-soil treatment plants by vacuum trucks and treated in the plants. Public sewage system has developed in urban areas and the other systems covered peri-urban and rural areas. In 2000, the excreta-disposal systems consist of public sewage (56.2%), *Johkaso* (27.2%), and non-flashed pit toilet (16.6%) (Ministry of Environment, 2003). Therefore, 43.8% of total population take a service of night-soil treatment system.

Operarting night-soil treatment system in Japan

Vacuum truck collection

The scene of vacuum-truck collecting service is shown in Figure. 4. Vacuum truck is shown in Figure 4 (a). There are some kinds of trucks in the capacity tonnage from 2 -10 tons and all trucks have deodorizing equipments to meet to requirement of odor control. In general, two persons operate each truck.

Vacuum truck goes to each household once a few months to collect human excreta in each toilet pit. A truck stops in front of the each household and collects human excreta with waste paper for anal cleaning from the toilet pit, as shown in Figure 4(b). The opening to remove night soil shown in Figure 4 (b) is placed at just next to the each household. After a truck collects excreta from some households and is filled up, excreta are carried into a night-soil treatment plant. Sludge in *Johkaso* tank is also collected in the same way.

(a) (b)

Figure 4: Scenes of vacuum-truck collection: (a) vacuum truck in night-soil treatment plant, (b) vacuuming human-excreta from a toilet pit.

Night-soil treatment plant

At the night-soil treatment, collected human excreta and *johkaso* sludge are treated. A flow of major night-soil treatment plants is shown in Figure 5 as an example of the latest advanced treatment. Human excreta and *johkaso* sludge are treated without dilution. In a nitrification-denitrification tank, human excreta are intermittently charged into the tank, and aerobic (for nitrification) or anaerobic (for denitrification) conditions are created in the tank intermittently. The residual NO_x-N from nitrifying tank is denitrified in the secondary denitrification tank with the use of methanol as electron donor. The reaeration tank treats the residual BOD and residual methanol.

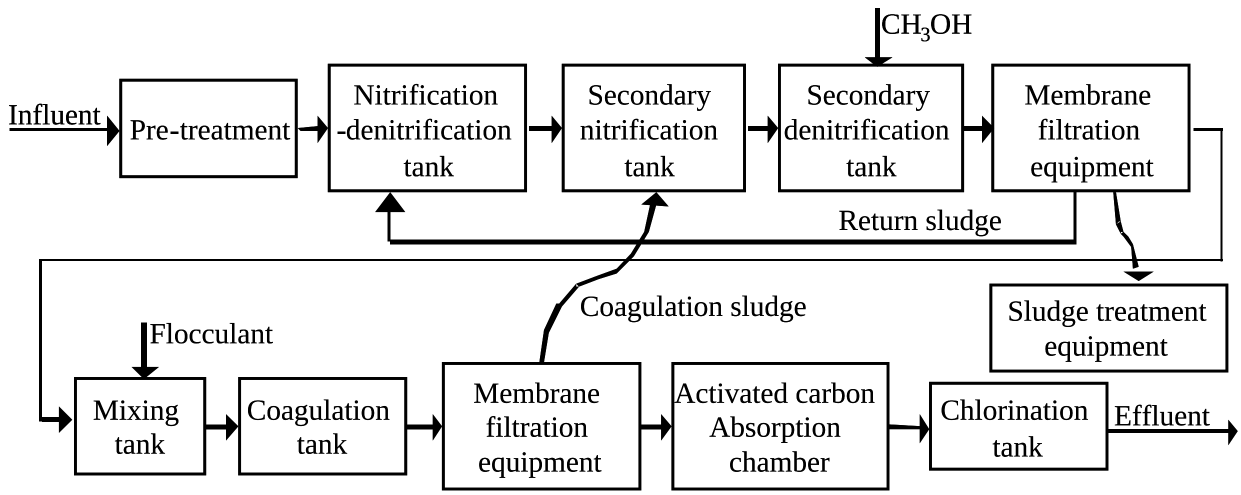

Figure 5: The process of a high-load night soil treatment by membrane filtration.

In order to keep high concentration of MLSS (12000 – 20000 mg/L) in the reaction tank and enable to treat wastewater in high concentration, the concentration of return sludge is increased by the use of ultra filtration or micro filtration in solid-liquid separation equipments (Japan waste management association, 2001). This process has two membrane filtration equipments: for the biological treatment process and for the coagulation process. The coagulation process removes phosphorus by addition of flocculants. This process also includes activated carbon absorption chamber for the removal of COD and as well as color.

The scenes of a plant are shown in Figure 6. This plant has two lines of biological treatment process and total capacity is 168 kL/day. As shown in Figure 6 (a), recent night-soil treatment plants are indoor plants to minimize the impact of the plants presence on the surrounding communities. The treated water quality of the plant is shown in Table 3. The quality is same or better than sewage treated water.

(a) **(b)**

(c) (d)

Figure 6: A night-soil treatment plant using high-loading denitrification process: (a) Outside of a night-soil treatment plant, (b) circulation pipe of nitrification-denitrification tank, (c) coagulation equipment, (d) activated carbon chamber.

Table 3: Quality of treated water of the plant.

	Measured Value	Standard Value
pH	7.3	6.0-8.5
BOD (mg/l)	1.2	20
COD (mg/l)	4.9	20
SS (mg/l)	3.9	70
T-N (mg/l)	6.3	10
T-P (mg/l)	0.4	1
Coliform group count (N/mg)	2	3000

Recently, the sludge treatment process has changed to resource recovery processes such as composting process, methane fermentation process and carbonization process. These processes can receive garbage. The wastewater generated in the garbage disposal process can be treated at night-soil treatment plants.

Effectiveness of urine-feces separation

Although pathogens found in human excreta bring about varieties of water-born diseases, their nutrient value should not be disregarded. Nitrogen, phosphorus and potassium are essential nutrients for agricultural activities and high concentration of them occurs in human excreta. Therefore, combination of treating and sanitizing human excreta, and recovering nutrients from them are crucial to treat human excreta properly.

Table 4 (Maksimovic and Tejada-Guibert ed., 2003) shows the ratio of the principle nutrients, or nitrogen, phosphorus and potassium, in between urine and feces. The important fact is that urine contains much of essential nutrients even though most people imagine that there should be more nutrients in human feces. In contrast, feces contain a large amount of pathogens, although urine dose not generally contain pathogens that can be transmitted though the environment (Hoglund, 2001).

When urine is collected without mixing with feces, it can be used as fertilizer easily with little risk regarding sanitation. Also, it has been noticed that urine-feces separation leads to efficient treatment and nutrient recovery from them (Matsui, 2001; Hellstrom, 1999). In addition, the amount of water used for flushing toilet is also reduced. Toilets in average use 6 - 8 litters of water for each flush, even for only urine, although the toilets based on separation system use only 0.2 - 0.5 litters for flushing urine. The systems can save water in water-limited environment. Thus, urine-feces separation has possibilities for alternative to existing sewage system to treat human excreta.

Table 4: The ratio of nutrient between urine and feces.

	Urine		Feces	
	g/person /day	%	g/person /day	%
Nitrogen	11.0	89	1.5	12
Phosphorus	1.0	87	0.5	33
Potassium	2.5	71	1.0	29

Combination of vacuum truck collection system and urine-feces separation

The system to handle human excreta with vacuum-truck collection can be an alternative to sewage system in peri-urban areas, where sewage system is not affordable, urine-feces separation can contribute to treat wastewater and recovery resources from human excreta more efficiently than the conventional way, in which urine and feces are mixed. We will now combine vacuum truck collection system and urine-feces separation, and propose a new system to treat human excreta properly and recover nutrient from them.

The image of the new system is shown in Figure 7. Grey water could be treated by the simple treatment system such as artificial wetland with existing channels. The new system is suitable to the area where infrastructure such as car transportation, tap water and local electricity is available but sewage system is unaffordable. Most of rural and peri-urban areas of developing countries meet to such conditions.

Collected feces could be treated in some ways. Japanese night-soil treatment can be one of the treatment ways to improve sanitation and prevent water pollution. Also, a more contributable treatment way to resource recovery could be thought as shown in Figure 8. In the flow in Figure 8, separated feces are treated by the fermentation of methane. By the separation of feces from urine, the fermentation progresses more easily due to the low concentration of ammonia that inhibits fermentation process. In addition, garbage could be treated together with separated feces. Recovered methane gas could be used for electricity to run this plant. Fermented sludge and liquid could be used for agriculture. The sludge may be further composted. All products and effluent do not contain much salt because they are separated from urine that contains much salt.

On the other hand, separated urine from feces could be used with dilution to farmland directly. Also, in one of other ways, as shown in Figure 9, nitrogen and phosphorus could be recovered from it as powder of magnesium ammonium phosphate (MAP, or struvite, which is a slow-release fertilizer) by adding $MgCl_2$ and controlling pH in alkaline conditions (Harada in press; Sato, 2004) and liquid fertilizer ($(NH_4)_2SO_4aq$) by aeration in H_2SO_4aq. Concentrating nutrients of urine as fertilizer is effective to transport and use it at other areas. The residue liquid contains salt in high concentrations and could be disposed of at site of salt accumulation after evaporation of liquid.

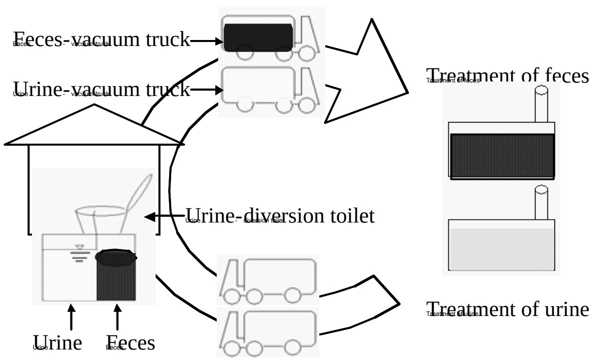

Figure 7: A vacuum truck collection system with urine-feces separation.

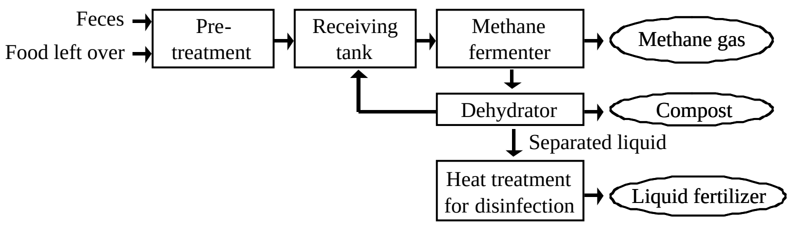

Figure 8: A treatment flow of separated feces and garbage to recover resources from them.

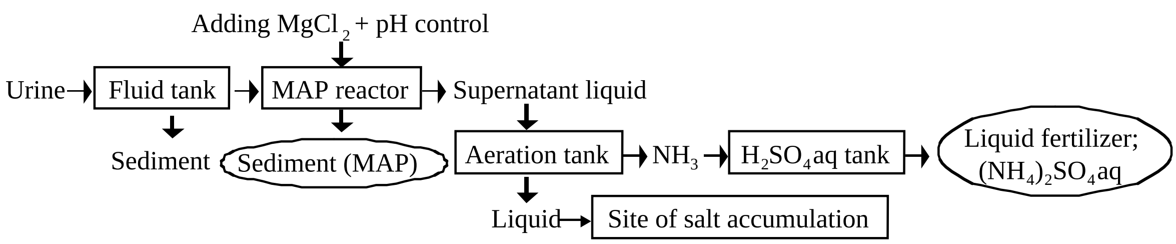

Figure 9: A treatment flow of separated urine to recover resources from it.

Conclusion

We proposed an alternative sanitation to conventional sewage works introducing the Japanese practice of sanitation. Because of non-pipe collection system of Japanese practice, it has a great advantage of cost saving of treatment of human excreta. Compared to construction cost of sewage treatment plants, construction cost of a night soil treatment plant may be much cheaper in spite of installation of advanced treatment of nitrogen and phosphate removals. However, the authors propose more advanced sanitation that means separation of urine and feces at toilet and collect separately to a new resources recovery plant where nitrogen and phosphate are recovered from urine, methane gas and organic fertilizer are recovered from feces with animal dung and other organic wastes. The proper treatment of human excreta with domesticated animal excreta may provide better sanitation practices controlling wide variety of pathogens among human and other domesticated animals. The urine and feces separation could provide water saving toilets for peri-urban areas in developing countries. Thus introduction of those new approaches could provide solutions for the MDGs on global sanitation.

The concept of ecological sanitation could explore many possible technologies of advanced sanitation in which we can control carbon materials with nitrogen, and phosphate and sulphate that are macro pollutants and basic elements on the earth. Global warming issues should be discussed with the sustainable cycles of carbon, nitrogen, phosphate and sulphur.

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The Aral Sea Basin Initiatives

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Abstract

The Aral Sea is one of the largest inland water bodies on the Earth. In terms of volume, it holds the fourth world position after the Caspian Sea, Lake Superior in Northern America, and Lake Victoria in Africa. The sea is located in southern part of the moderate zone, almost in the center of Eurasia, in a desert area. In 1960 the sea level was about 53.5 m, with a water area of 68,500 km^2, a volume of 1093 km^3, an average depth of 16 m, and a salinity of 10%. The Aral Sea is almost entirely sustained by inflow from the Amudarya river and Syrdarya river. Substantial decrease in inflow, as a result of irrigation development upstream and midstream, in last decades are the main causes of continuous draw-down in the sea level. In 1985-1986, with the water level down to 41 m, the Aral Sea was divided into the Northern Sea (south of Kazakhstan) and the Southern Sea (north of Uzbekistan), with a total water area of about 44 thousand km^2, a volume of 450 km^3, an average depth of 16 m, and a salinity of 30%.

The major consequence of the Aral Sea depletion, besides reduced volume and area as well as increased salinity, was formation of a vast salt desert covering around 4 million hectares of exposed seabed. The desert is a source of salt and dust polluting far into the surrounding areas. In the coastal zone (above 53m), the century-old ecosystems of deltas and coastal zones have been destroyed, surrounding lakes, wetlands and habitat have disappeared, solonchaks have replaced marshes, migration routes of birds have been destroyed, flora and fauna have diminished and local climate has changed.

Five independent Central Asian states located in the Aral Sea basin are seriously concerned with this problem of planet-wide importance and, with assistance of international institutions, exert every effort to establish new sustainable anthropogenic-natural system to restore productivity up to the maximum possible former level in the region.

Key words: Aral Sea, degradation, restoration

Degradation of the Aral Sea and South Prearalie

Though the Aral Sea desiccation is attributed to the Soviet State as the main initiator of this natural-anthropogenic disaster, the concept of sacrificing the Aral Sea for the sake of irrigation and agriculture development actually belonged to scientists of the pre-Soviet period. In Soviet times, irrigation development initiated by the Russian Government progressed greatly. However, till 1960 water diversion for irrigation was accompanied by development of drainage networks and, naturally, by increase of return water released into rivers that exerted little impact on river deltas and the sea.

Quasi-equilibrium of water and salt balances of the sea is typical for the period of 1911 to 1960. About 25.5 million metric tons of salts annually entered the sea; the basic part of this salt discharge underwent sedimentation with mixing of marine and river waters due to over-saturation of the Aral Sea water by calcium carbonate and was precipitated at shallow waters in bays, bights, and infiltration lakes situated along the northern, eastern, and southern coastlines. Due to freezing and melting of the sea, mean salinity in that period varied over the range of 9.6 to 10.3 percent. Relatively high annual river discharge (approximately 1/19 of the seawater volume) gave a peculiar salt composition to the Aral Sea water with a high concentration of carbonate and sulfuric salts, which differed from the salt composition of other inland seas.

The modern period of the Aral Sea, since 1961, may be described as the period of active anthropogenic impacts on its regime. Drastic increase in irretrievable river water withdrawal (which amounts to 70-75 km^3/year in recent years), exhaustion of compensating abilities of the rivers, and natural aridity in 1960 to 1980 (92 percent) resulted in disequilibria of the water and salt balances. The considerable exceedance of evaporation over the sum of all inflow constituents was typical for the period of 1961 to 2002. The river water inflow into the sea had decreased in 1965 by up to 30.0 km^3/year; in 1971-1980, it amounted to 16.7 km^3/year, on average, or 30 percent of mean annual runoff, and over the period 1980 till 1999 it made up 3.5 to 7.6 km^3/year or 6 to 13 percent of the mean annual runoff. During some dry years, runoff of the Amu Darya and Syr Darya rivers has not actually reached the sea (Table 1).

Table 1: The Basic Indicators of Water and Land Resources Development in the Aral Sea Basin.

Indicator	Unit	1960	1980	1990	2000	Forecast	
						Optimistic	Pessimistic
Population	Million	14.4	26.8	33.6	41.5	54.0	70.0
Irrigated area	thousand ha	4510	6920	7600	7890	9330	9300
Irrigated area per capita	ha/capita	0.32	0.26	0.23	0.19	0.17	0.12
Total water withdrawal	km^3/year	60.61	120.69	116.27	103.8	104.5	117.0
Incl. irrigation	km^3/year	56.15	106.79	106.4	93.6	86.8	96.7
Specific withdrawal per 1 ha	m^3/ha	12450	15430	14000	11850	9300	10400
Specific withdrawal per capita	m^3 /capita	4270	4500	3460	2530	1935	1670
GNP	bln.USD	16.1	48.1	74.0	54.0	109	77.0

River water quality has also changed owing to increase of highly saline waste and drainage water that resulted in a significant increase of salinity and deterioration of river sanitary conditions. During dry years, the mean annual salinity of the Amu Darya water entering into the sea reaches 0.8-1.6 g/l, and salinity in the Syr Darya amounts to 1.5-2.0 g/l. In some seasons, higher salinity levels are observed. As a result, in spite of a decrease of annual river runoff by 46 percent over the period of 1961 to 1980, the annual salts entry has decreased only by 4 million metric tons or by 18 percent for the same period. Other constituents of the salt balance have also substantially changed. Due to decrease of carbonates content in the river inflow, sedimentation of salts under mixing of river and marine waters was reduced by two times.

As a result, since 1961 the sea water level has steadily dropped. The total sea level drop, in comparison with the average annual value (prior to 1961) had reached 12.5 m by the beginning of 1985. The average annual rate of the sea level dropping was about 0.5 m, reaching 0.6-0.8 m/year in dry years. The annual sea level fluctuations also changed. At present, the annual sea level rise is practically not observed, at best, it does not change in winter, and in summer an abrupt drop takes place.

It was established that saturation of the Aral Sea water with calcium sulfate and precipitation of gypsum occurs at the salinity level exceeding 25 to 26 percent. However, the most intensive precipitation of gypsum takes place at salinity levels higher than 34 to 36 percent. Under these conditions, in the winter period in parallel with precipitation of gypsum, precipitation of mirabilite occurs, the latter being of the greatest risk for the Prearalie environment. Dehydrated ammonium sulfate is exposed to wind erosion and can be easily transferred far afield.

The sea level drop and water salinization have resulted in an increase in the amplitude of annual temperature over an all water column and in some shift in phases of the temperature regime. Modification of winter thermal conditions is the most important factor for the biological regime of the sea. Further lowering of the freezing point and modification of the autumn-winter convection mixing process under transition from brackish to high saline waters causes intensive cooling of all the sea water mass to very low temperatures (-1.5 to - 2.0^o). This is one of the main factors restricting implementation of acclimatization measures and hindering rehabilitation of fisheries in the sea in the near future. Lowering the sea level may result in rather noticeable modification of ice conditions, and even in moderately cold winters, ice cover of the entire seawater area with a maximum thickness of 0.8 to 0.9 m may be expected. Cooling and freezing of the sea will occur approximately during the same periods of time; however, reduction of its total heat storage will cause more rapid ice spreading. Increase in mass of ice per unit area will lead to a more prolonged period of ice melting.

Extremely low specific values of bioorganic substances inflow into the sea predetermine their low concentrations in seawater, a further constraint for development of photosynthetic processes in the sea, and its low biological productivity. Deterioration of the oxygen regime of the sea in summer owing to a decrease in photosynthetic production and intensive oxygen consumption for oxidation of organic substances causes formation of oxygen deficit zones.

Further salinity increase causes both reduction of species of phyto- and zooplankton, phyto- and zoo benthos, and appropriate reduction of their biomass resulting in further degradation of food resources for aquatic life. The existence of endemic fauna is impossible owing to increase in the Aral Sea water salinity.

Quantitative assessment of anthropogenic factors affecting the current water regime of the Aral Sea was carried out by means of calculation of reconstructed values of sea levels and salinity for the period of 1961 to 1980 using the values of reconstructed conditional-natural inflow into the sea. According to these calculations, more than 70 percent of current sea level lowering and of salinity increase are caused by the anthropogenic impact, the rest of these changes are related to climatic factors (natural aridity).

Major consequences of the Aral Sea shrinkage, apart from the decrease of its water volume and area, increase in water salinity and modification of salinity pattern, is the formation of a vast saline desert with the an area of almost 3.6 million ha on the exposed seabed. As a result, a huge bitter-saline lake and a vast saline desert located at the interfaces between three sand deserts have replaced the unique freshwater water body.

In 1985-1986, the Small Aral Sea completely separated from the Large Aral Sea at the sea water level of 41 m + BSL. This resulted in formation of a new desert area of 6,000 sq km with a salt storage in the top layer of up to 1 billion metric tons. Currently, precipitation of gypsum from the saturated marine water is under way. At a sea level of 30 m + BSL (total drop is 23 m) the western part of the deep-water Large Aral Sea will be separated from the eastern shallow part by islands.

After separation of the Small Aral Sea from the Large Aral Sea, their regimes started developing according to different scenarios. Since the Syr Darya River inflow has been higher than the Amu Darya river inflow, the Small Aral Sea level started rising and water salinity decreasing. A break in the Small Aral Sea temporary dam caused the water level to lower; however, previous filling has proved the correctness of the decision to create the separate Small Aral Sea at the elevations of 41 to 42.5 m + BSL. The developed project of an engineered dam, with a regulated spillway in the Berg's Strait, will provide the possibility of establishing a sustainable ecological profile for water body and its environment.

Thus, the Aral Sea has transformed from being an integral water body in the past into a series of separated water bodies each with its own water-salt balance and own future depending on what policy will be selected by the five countries that are economic entities of these river basins (Figure 1).

Prearalie habitat degradation consequences include:

- decrease of lakes' area in the Amu Darya delta from 400,000 ha in 1960 to 26,000 ha;
- groundwater table lowering up to 8 m depending on the distance from the sea coast,;
- erosion of river channels and their beds incision up to 10 m;
- development of salt and dust transfer within a 500 km wide belt with load capacity of 0.1-2.0 t/ha;
- top-soil changes: an hydromorphous soil area reduced from 630,000 to 80,000 ha;
- the area covered by solonchak increased from 85,000 to 273,000 ha;
- the reed growth area reduced from 600,000 to 30,000 ha;
- the tugai forest area reduced from 1,300,000 to 50,000 ha;
- climatic changes in the zone of 150 to 200 km from the sea;
- fish catch decreased from 40,000 to 2,000 metric tons per year.

All these effects have resulted in economic losses amounting to US$115 million and social losses estimated to be US$28.8 million annually. It should be noted that ecological changes related to the sea desiccation have been accompanied by water inflow reduction and, consequently, deterioration of potable water supply (increase in salinity and decrease in groundwater inflow - Figure 2).

In the early 1970s, when the Aral Sea started rapidly shrinking, the public of the former USSR arrived at an understanding of the need to undertake some reclamation measures. At that time several governmental commissions were established. They have concluded that it is necessary to undertake urgent measures if not on cessation of the sea level lowering, then at least, on mitigation of negative socio-economic and ecological impacts related to this disaster. Transfer of Siberian rivers' water amounting to 18-20 km^3 annually was proposed to improve water supply and concurrently environmental conditions in the Prearalie. The government of the USSR rejected this proposal in 1986 and submitted a range of alternative measures approved by the Resolution No 1110 of 1986. Eventually, two BWOs "Amu Darya" and "Syr Darya", a special organization "Aralvodstroy", and the coordinator of the program - the Consortium "Aral" were established. During the period 1987 to 1990, a certain scope of works related to water conservation improvement in the South Prearalie, the Right Bank Drain, and completion of the Tuyamuyun Reservoir Project was implemented.

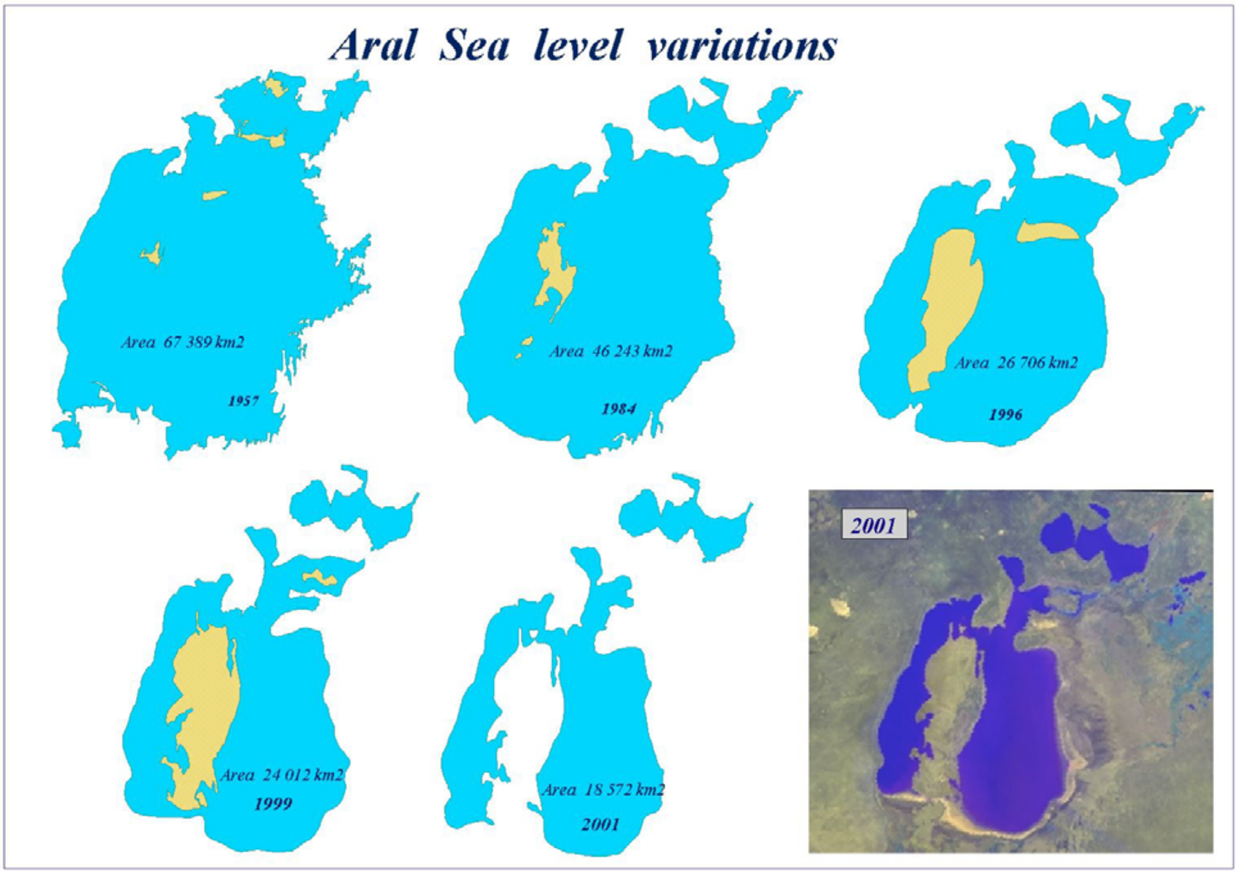

Figure 1: Dynamics of the Aral Sea desiccation.

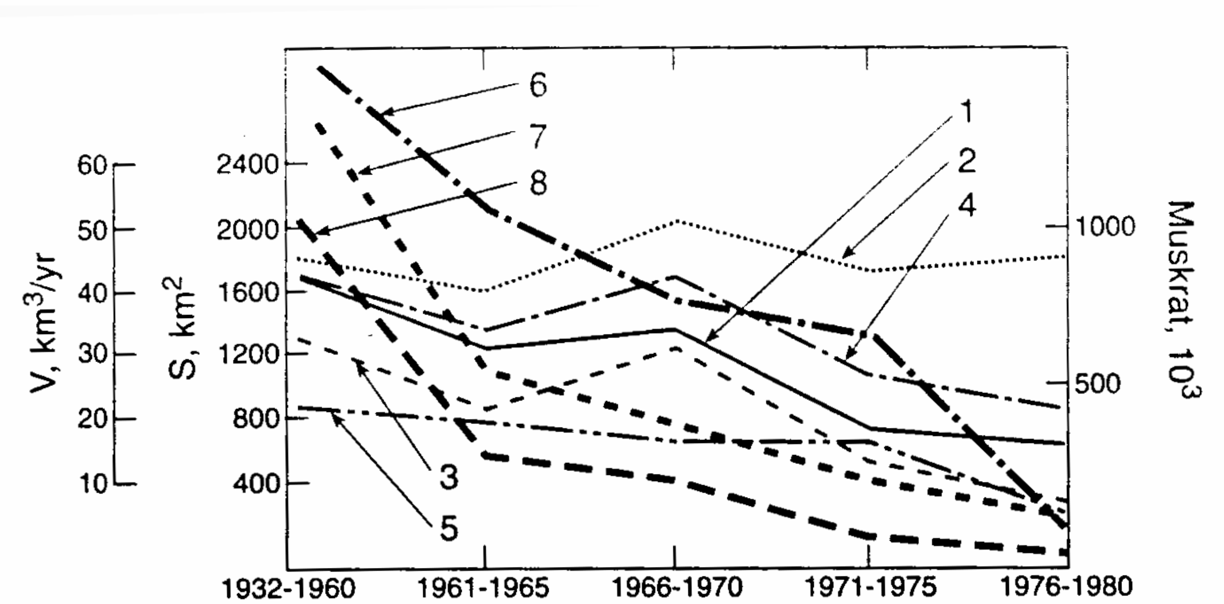

Figure 2: Environmental changes in the Amu Darya delta induced by a lower runoff.

1 - actual inflow into delta, cub. km per year; 2 - restored inflow into the delta region, cub. km per year; 3 - runoff to the Aral Sea, cub. km per year; 4 - runoff, used within delta, cub. km per year; 5 - lake area, sq. km; 6 - flooded area, sq. km; 7 - tugai forest area, sq. km; 8 - muskrat skins in units.

After the collapse of the USSR in late 1991 all these efforts were stopped until the Heads of five Central Asian States had established an International Fund for the Aral Sea in 1993 and on January 11, 1994 they approved the Aral Sea Programme, which includes measures on improving the situation in the South Prearalie. In particular, it was decided, "to develop the feasibility study for establishing artificially-inundated landscape ecosystems in the Amu Darya and Syr Darya deltas and areas adjacent to the dried-up Aral Sea bed as well as implementing proper reclamation measures to rehabilitate the natural conditions in this area". At the same time, the basic provisions of the Concept of Improving Socio-Economic and Ecological Situation in the Prearalie" were approved. These provisions distinctly stated that rehabilitation of the Aral Sea to its original state is impossible, and the main efforts should be placed on construction of necessary water infrastructure and measures related to creation of a new sustainable ecological profile of the South Prearalie by means of proper water supply, afforestation, and other reclamation activities.

The Decision adopted by the Heads of State of the five Central Asian Republics of January 11, 1994 concerning the Concept for improvement of socio-economic and ecological conditions in the South Prearalie stipulates that the Aral Sea disaster impacts must be mitigated by establishing the system of artificially regulated water bodies at the location of former coastal and intra-delta lakes and sea bays along with appropriate afforestation and land reclamation measures.

Preservation of these lakes and maintenance of their appropriate hydrological and hydro-chemical conditions entirely depends on inflow of river water i.e. on the availability of water in the Amu Darya River at the Takhiatash hydroscheme site. In wet and average years, favorable conditions for preservation of these lakes will be ensured under inflow of the Amu Darya water into these lakes at the rate of 3.0 to 4.5 billion m^3 per year. Problems may occur during dry years and in the future under reducing the availability of river and return water. Water supply at the rate of 5.2 billion m^3 per year (the net water supply) is needed to maintain the optimal water level of coastal and intra-delta lakes.

Initiatives to improve water management in the Aral Sea basin

Deep insight into the role played by water in the region and responsibility before the society for sustainable water sector operation generated political initiatives undertaken by Governments of all five countries, who in September 1991 - immediately after collapse of Soviet Union - declared the necessity of joint regional water resources management and use and in February 1992 established the Interstate Commission for Water Coordination (ICWC). This commission, to a certain extent, undertook some part of the functions carried out by the former USSR Ministry of Water Management, in organizing mutually beneficial cooperation related to water resources in the region and initiated a series of consequent activities, which have been well and in detail illustrated in the statements made by heads of water management organization of Central Asia.

Interstate Water Coordination Commission (ICWC) is a collective body managing transboundary rivers, responsible for water allocation among countries, monitoring, preparing preliminary assessment of proposals on institutional, ecological, technical and financial approaches, based on mutually agreed decisions by all sides. The two BWOs (Amu Darya and Syr Darya), the Scientific - Information Center and ICWC Secretariat are executive bodies of this Commission. The Commission was established in accordance with "Agreement on collaboration in the sphere of joint water resources management within interstate water sources" dated February 18, 1992, and then approved by the Head of States on March 23, 1993.

ICWC is represented by five Ministers (Deputy of Ministers or other leaders of water management authority, trusted by state to introduce interests of it in this Commission). All decisions could be made on the basis of full consensus, signed by all authorized members of Commission. Meetings of the Commission take place quarterly on rotational basis in alphabetic order.

The 1992 agreement provided that water allocations should be based on *"existing uses of water resources"* and that the two river basin agencies (BWOs) should continue to perform basin management functions subject to control by ICWC. Subsequently, the ICWC agreed that the 1992 agreement should remain in force until a *Regional Water Management Strategy* had been formulated which responded to new realities and which outlined more objective mechanisms and principles for water allocation and rational use.

In January 1994, the Presidents of the five Central Asian countries met in Nukus (Karakalpakstan) and approved a Program of Concrete Actions for the improvement of the environmental situation in the Aral Sea Basin and for its social and economic development. The Aral Sea Basin Program (ASBP) included eight thematic sub-programs, the first of which addressed the formulation of a general strategy of water distribution, rational use, and protection of water resources. The first stage of this work was finished in 1997 by presentation of the Fundamental provisions of the water resources management strategy. As a further step, in 1998, begun a new GEF Project consisting of five components. The component A-1 addresses the finalization of the water and salt management strategy for the Aral Sea basin. Now it is an ongoing activity.

Finally the existing structure of the interstate organizations responsible for water resources management was created during a long enough period (1991-1999), and distribution of their obligations was confirmed by the Head of States in Agreement dated April 9, 1999, which was signed in Ashgabad (Turkmenistan). These are the following:

International Fund for Aral Sea Saving (IFAS), of which the Board is represented by Deputy Prime Ministers of five states, is the highest political level of decision-making before approval by the Heads of State (if appropriate). *IFAS Executive Committee* – a permanent body, which includes two representatives from each state and implements the IFAS Board decisions through the IFAS National Branches. Besides, the EC IFAS on behalf of the Board could establish agencies for various regional projects and programs implementation.

Along with political initiatives some practical and scientific-research projects to improve the situation in the Aral Sea basin have been developed and implemented. Administrative pressure on the water distribution and water allocation, which creates practical problems for proper functioning of water management organizations, can be eliminated by implementation of integrated water management (IWRM). These approaches have been developed within the project IWRM in Fergana valley. Introduction of IWRM on national level will promote:

- water conservation; water supply stability increase;
- water distribution evenness improvement; water and land resources productivity increase;
- environmental situation improvement; social-economic situation improvement;
- inter-sector coordination of water resources management;
- public involvement in water resources management.

Another practical initiative is to restore wetlands in the Aral Sea basin to establish a new ecological profile in the area. Protection of the dried seabed from wind erosion and prevention of salt and dust transfer will be provided either by creation of so-called "lagoon" and water bodies behind it or by flooding of some former bays establishing one or two lines of water bodies (closed and flow-through water bodies) along with forestation and other measures.

The project of forestation is now being implemented under financial support of German government. In combination with development of small water bodies it will stimulate rehabilitation of livestock and fish breeding in the area. The programs of crop diversification, development and subsidizing of small agribusiness will improve the socio-economic situation in the region as well. The most important is establishing of water management monitoring and information exchange systems within the delta.

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A continental-scale survey by hydroplane of the ecological quality of the superficial waters in Brazil

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Abstract

A continental-scale survey by hydroplane for monitoring surface waters in inland continental ecosystems of Brazil was carried out. More than one thousand sampling sites were chosen. The main hydrographical basins, limnological features, as well as urbanization and land uses were considered. Laboratory analyses of nitrate, nitrite, and ammonium were performed with ion chromatography, and total phosphorus was determined by a spectrophotometric technique at the laboratories of the International Institute of Ecology in São Carlos, SP. In regions with higher population density related to untreated sewage loading in the water bodies, as well as in those characterized by extensive cattle breeding and agriculture, higher nitrogen and phosphorus levels were usually observed. The high nitrogen and phosphorus concentrations observed in the Solimões, Madeira, and Purus rivers were probably related to rock weathering in the Andes. This large-scale study provides information on the water quality of Brazilian inland water bodies and support for more detailed monitoring programs, and also contributes to a complete overview of the eutrophication status of surface waters in Brazil.

Key words: eutrophication, monitoring, water resources

Introduction

The Brazilian land mass is drained by an extensive network of rivers and covered by large basins. While some of these are lightly populated, having less than 1 inhabitant per km^2, others have more than 400 inhabitants per km^2. River interaction with the population and anthropogenic impacts in the watershed are highly relevant to future multiple use of these Brazilian water resources.

Because of the broad land mass, integrated monitoring of the water bodies in Brazil is a difficult task, especially in those regions of difficult access by land, such as the Amazon and the Pantanal wetlands. Consequently, little information currently exists on the ecological quality of the water bodies in most parts of Brazil, and that is generally on a regional scale and based on sporadic monitoring programs that preclude integrated results. In São Paulo State (southeastern Brazil) the Environmental Sanitation Technological Company (CETESB) has carried out annually integrated monitoring of water quality in the state's main water bodies, with resulting data available to the public (CETESB, 2005). In the BIOTA/FAPESP Research Program (www.biotasp.org.br), also carried out in São Paulo State, more than 230 water bodies have been studied, considering the physical, chemical, and biological features related to planktonic organism biodiversity. However, in Brazil programs like these are an exception. The scarcity or lack of information on water-resource quality undermines the basis for management decisions relative to reducing impacts in these systems (Braga *et al*., 1999).

In view of this situation, a research program was created to perform the first survey of superficial water quality on a continental scale in Brazil. Concerned about the progressive degradation of Brazilian water bodies, the pilot and engineer Gérard Moss, together with his wife Margi Moss, conceived of a way to collect water samples by using a hydroplane, transformed into a laboratory and adapted to allow surface water sampling by hedgehopping. Thus, sampling was carried out during 14 months at more than one thousand sites on water bodies throughout Brazil. The program, *Brasil das Águas* (Waters of Brazil) and coordinated by Gérard Moss and Margi Moss, was aimed at providing a complete overview of the ecological quality and eutrophication status of surface waters in Brazil.

The survey allowed identification of regions highly impacted by human activities, as well as those not only very well preserved but, in some cases, which had not even been studied before.

Besides the research itself, the program was aimed at civic and environmental educational programs, and bringing the attention of the population to the importance of properly safeguarding our dwindling water resources. All information gathered was frequently divulged by the program site (http://www.brasildasaguas.com.br), by the media, and personally by the Moss couple through lectures and interviews given throughout the country during the sampling campaigns.

Materials and methods

The sampling sites were chosen by both the non-governmental organization *Ecoforça* and the Brazilian Agricultural Research Corporation (EMBRAPA) - Satellite Monitoring Center, from the 12 main basins in Brazil (Figure 1) as defined by the Brazilian Council of the Water Resources (CNRH). The sampling period was between October 2003 and December 2004, during which 12 field campaigns were carried out. They were organized by river basins, with each campaign taking about one month, except for those in the Amazon Basin, which required three months. A total of 1,162 sites were sampled including a wide variety of water bodies, i.e. rivers, reservoirs, lakes, lagoons, and oxbow lakes. Samples were taken in preserved regions as well as urbanized areas or those impacted by anthropogenic activity including mining, cattle breeding, and agriculture.

Water samples from the surface were collected using a Lake Renegade hydroplane, model LA-250 (U.S.A.), with a 120- knot (220 km h^{-1}) cruise velocity, standard 1,500 km autonomy (7 flight hours), and 11.7 m wingspread, and adapted to get water samples by hedgehopping (Figure 2). This was done just above the water-body surfaces, with the sampled water being transferred from outside of the aircraft's bottom through a duct to a system of tanks installed inside the cockpit. After the system self-washed, a multi-parametric YSI probe model 6600 (Yellow Springs, U.S.A.) determined the pH, conductivity, temperature, redox potential, chlorophyll, and salinity data, which were transferred to a boarding computer. Part of the water sample was relocated to an automated system with bottles for chemical analysis. The collected water samples were stored in 20ml polypropylene bottles, frozen into an onboard tank filled with liquid nitrogen, and forwarded by express mail inside an isothermal box to the International Institute of Ecology (IIE) in São Carlos for carbon, phosphorus, and ion analysis.

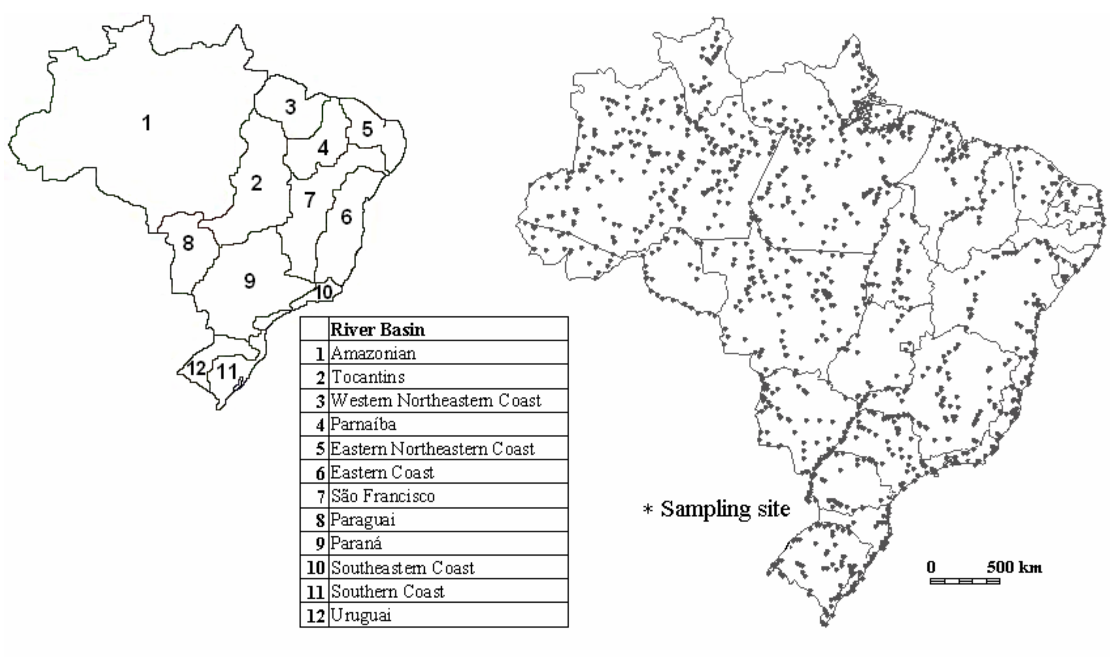

Figure 1: River Basins identified by the CBRH; sampling sites during the *Brasil das Águas* Project.

During the sampling, geographical coordinates were taken using a Garmin III GPS connected to the on-board computer. Video and photograph micro-cameras installed outside the aircraft registered at each sampling site images providing information on the vegetation in surrounding areas, riparian forests, land occupation and use, in addition to characteristics of the water bodies like water color and presence of algal blooms.

At the IIE laboratories, part of the water sampled was used for total phosphorus determination by a colorimetric method, according to Valderrama (1981), using a Varian Cary-50 spectrophotometer (Varian, Australia). Another part of the sampled water was filtered through a 13 mm Whatman GF/C filter for determining nitrate, nitrite, and ammonium, through the use of a Dionex model DX-80 ion chromatograph (Dionex, U.S.A.) according to APHA (1998).

Each sampled site was classified by trophic state based on phosphorus concentration, according to Carlson modified by Toledo Jr. (1990), which is the same criterion employed by CETESB (CETESB, 2005), as follows:

- total P lower than 20.0 µg-P L^{-1}: oligotrophic;
- total P between 20.1 and 53.0 µg-P L^{-1}: mesotrophic;
- total P between 53.1 and 211.9 µg-P L^{-1}: eutrophic;
- total P higher than 211.9 µg-P L^{-1}: hypereutrophic.

Figure 2: The hydroplane *Talha-mar* used for water sampling during the *Brasil das Águas* Project. Photo: Margi Moss.

Maps showing the sampled sites with ranges of nitrate, nitrite, ammonium, and total phosphorus concentrations, as well as respective trophic states represented in different colors, were elaborated using the geo-processing software Spring 4.1 for microcomputers. The geo-referenced map used was a 1:500.000 scale map from the Brazilian Institute of Geography and Statistics (IBGE).

Results

The maps showing the concentration ranges of total phosphorus, nitrate, nitrite, and ammonium are presented in Figure 3. Of the 1,162 sampled sites, 462 (40 %) were classified as oligotrophic, 405 as mesotrophic (35%), 280 as eutrophic (24 %), and 15 (1 %) as hypereutrophic (Table 1).

Generally, sites with higher concentrations of total phosphorus, nitrate, nitrite, and ammonium were observed in the northeastern, southeastern, and southern regions of Brazil, which are susceptible to higher anthropogenic impacts because of higher population density (Figure 4). In the arid northeastern region, eutrophication has probably been accelerated by local climatic conditions, which result in higher evaporation rates and greater solute concentrations in the water.

Higher concentrations of total phosphorus, nitrate, and nitrite were also observed in the Solimões, Purus and Madeira rivers, whose headwaters are located in the Andes. Higher ammonium values were also observed in the Paraná River, in southwestern Brazil, where hog operations are intensive.

Table 1: Trophic level proportions in each river basin in Brazil.

River Basin		Oligotrophic		Mesotrophic		Eutrophic		Hypereutrophic		Total of sites
		Sites	%	Sites	%	Sites	%	Sites	%	
1.	Amazonian	231	47	179	36	82	17	1	0.2	493
2.	Tocantins	57	66	21	24	8	9	0	0	86
3.	Western Northeastern Coast	16	40	15	38	9	23	0	0	40
4.	Parnaiba	19	73	7	27	0	0	0	0	26
5.	Eastern Northeastern Coast	4	8	13	25	32	63	2	4	51
6.	Eastern Coast	13	18	22	31	35	49	2	3	72
7.	São Francisco	16	27	29	49	13	22	1	2	59
8.	Paraguai	10	19	21	40	21	40	1	2	53
9.	Paraná	74	48	47	31	27	18	6	4	154
10.	Southeastern Coast	4	14	11	39	12	43	1	4	28
11.	Southern Coast	9	14	17	27	36	57	1	2	63
12.	Uruguai	9	24	23	62	5	14	0	0	37
Total		**462**	**40**	**405**	**35**	**280**	**24**	**15**	**1.3**	**1162**

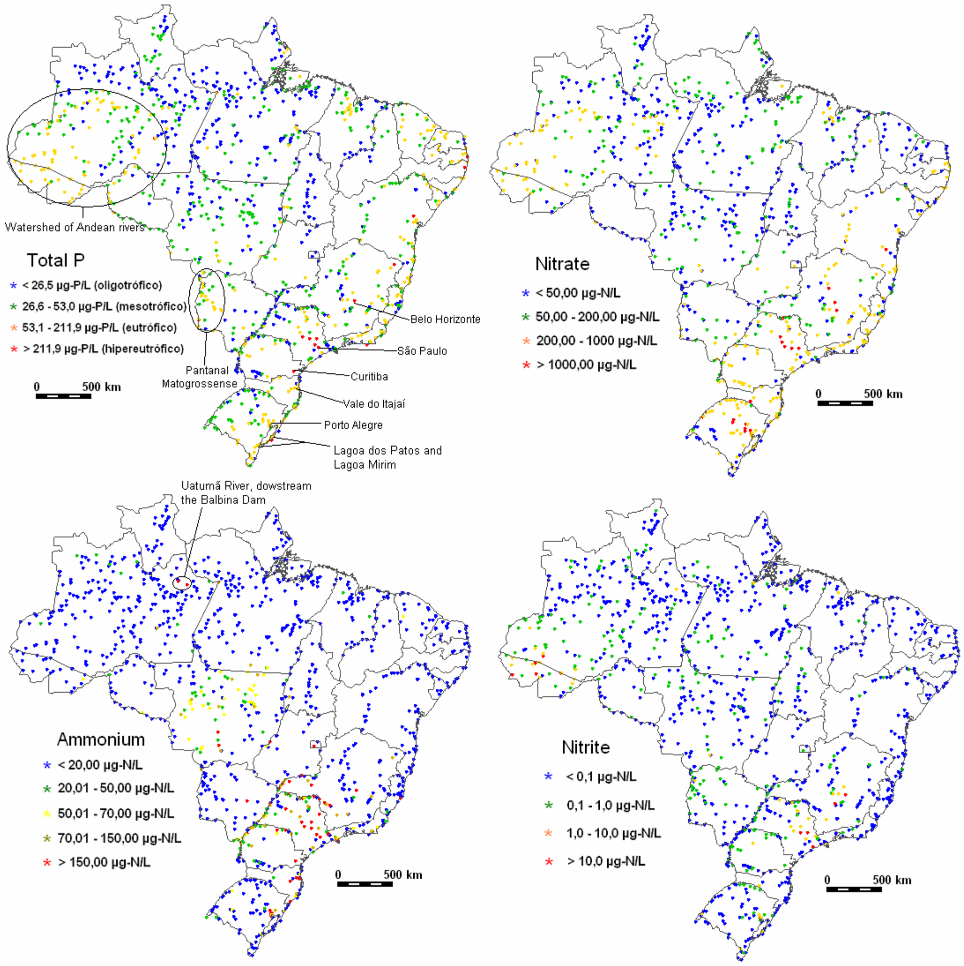

Figure 3: Maps showing total phosphorus, nitrate, nitrite, and ammonium distribution in Brazil.

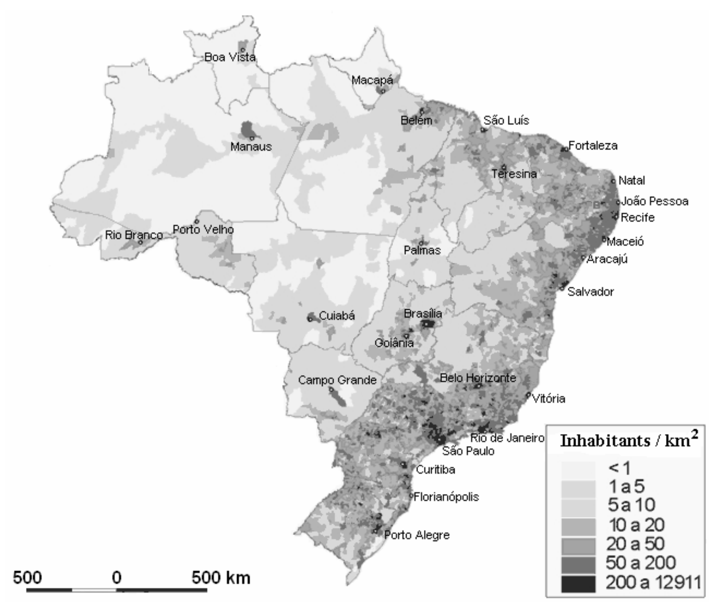

Figure 4: Population density in Brazil. Source: IBGE – Census 2000.

Of the Brazilian river basins, the Parnaíba and Tocantins showed the highest proportion of sites classified as oligotrophic (Table 1), corresponding to 73% and 66%, respectively, of the total sites sampled in each basin. On the other hand, the eastern northeastern coast, northeastern coast, and southern coast basins showed the highest proportion of sites classified as eutrophic, respectively corresponding to 63%, 57%, and 49% of the total. The eastern northeastern coast, Paraná, and the southeastern coast were the basins having the highest proportion of sites classified as hypereutrophic, corresponding to 4 % each.

Discussion

The results obtained in the present study clearly showed well-conserved water bodies, e.g., the Parnaíba and Tocantins basins, as well as those in the great part of the Amazon Basin. However, the data also showed impacted water bodies even in preserved regions like the Pantanal watershed, which is considered a natural human heritage and designated as a biosphere reserve by UNESCO. Many sites in that region were classified as eutrophic, specially in the rivers crossing large urban areas like Cuiabá, Aquidauana, Miranda, and Corumbá, into which untreated sewage is discharged. Furthermore, according to a census made by the IBGE in 2003, there is a population of 5 million cattle in the Pantanal region. Considering that each animal produce 5 times more excrement than a human being, the total excrement produced is equivalent to a human population of 25 million people, i.e., a very significant nitrogen and phosphorus load that certainly is contributing to eutrophication of regional water bodies.

But in other regions with low population density, in which higher nitrogen and phosphorus concentrations were observed, e.g., the Solimões, Purus, and Madeira rivers, the eutrophication process probably originated in Andean rock weathering in areas where these rivers' headwaters are found. Studies carried out by Devol *et al*. (1995) showed that the Andean rivers have significant influence in fine suspended-sediment concentration and in the alkalinity and calcium concentrations transported to the Amazon Basin. The authors also verified that phosphorus showed high correlation with fine suspended sediments, suggesting that the Andes are the main source of phosphorus transported to Amazonian rivers.

Hedgehopping for water sampling and the automatic system located inside the hydroplane cockpit allowed sampling, in a short period of time, a large number of sites in an extensive area. Furthermore, the high cruise velocity permitted quick sampling in long rivers like the Tietê (approximately 1,100 km). On this river in particular, the survey showed a high impact caused by the sewage loading in the metropolitan region of São Paulo (MRSP), with its more than 10 million inhabitants (Figure 4). In the site sampled on the river near the headwaters above the MRSP, the river was classified as oligotrophic. But downstream from the MRSP, the river was classified as hypereutrophic, with phosphorus concentrations as high as 1672 µg-P L^{-1} and ammonium concentrations of 6644 µg-N L^{-1}. However, clear phosphorus and nitrogen depuration was observed along the river. In the Tiete's middle section, the sites were classified as mesotrophic, while in the lower part the sampled sites were classified as oligotrophic and showed phosphorus concentrations similar to what was observed near the headwaters.

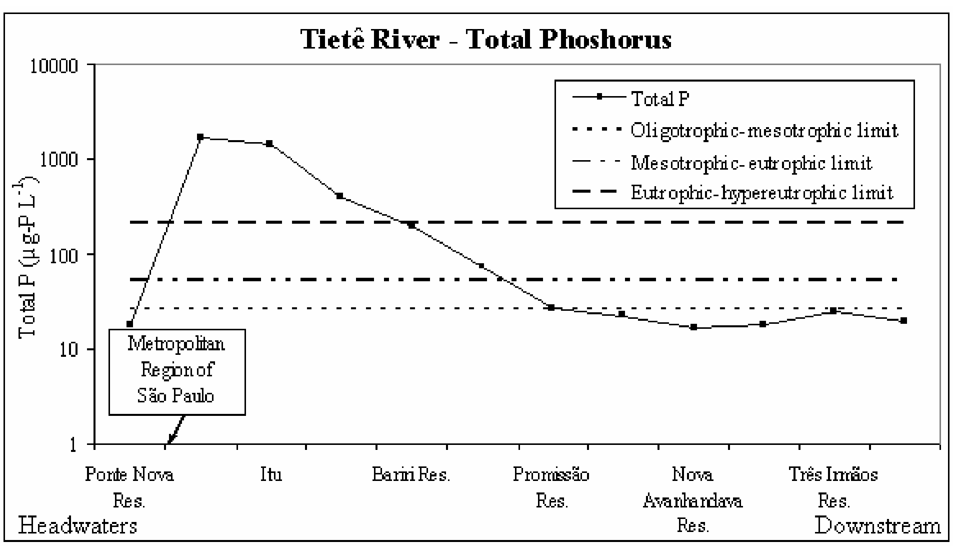

Figure 5: Variation of the total phosphorus concentration along the Tietê River.

The nitrifying process was also observed along the Tietê (Figure 5). After passing through the MRSP, ammonium concentration in the river was very high, decreasing gradually, followed by increasing nitrite concentration and, further on, by increasing nitrate concentration. After the middle section of the river, the three nitrogen ions showed low concentrations, characterizing a depuration process along the river.

The map showing the sites with higher ammonium concentrations provides information on other places with untreated sewage discharge near urban areas, and also on reductive environments rich in nitrogen. In the Amazon Basin, for instance, two sites with high ammonium concentrations were observed in the Uatumã River, just downstream from the dam of Balbina Reservoir, which generates hydropower. These data evidence reductive conditions in the reservoir's hypolimnion, resulting from decomposition of flooded vegetation.

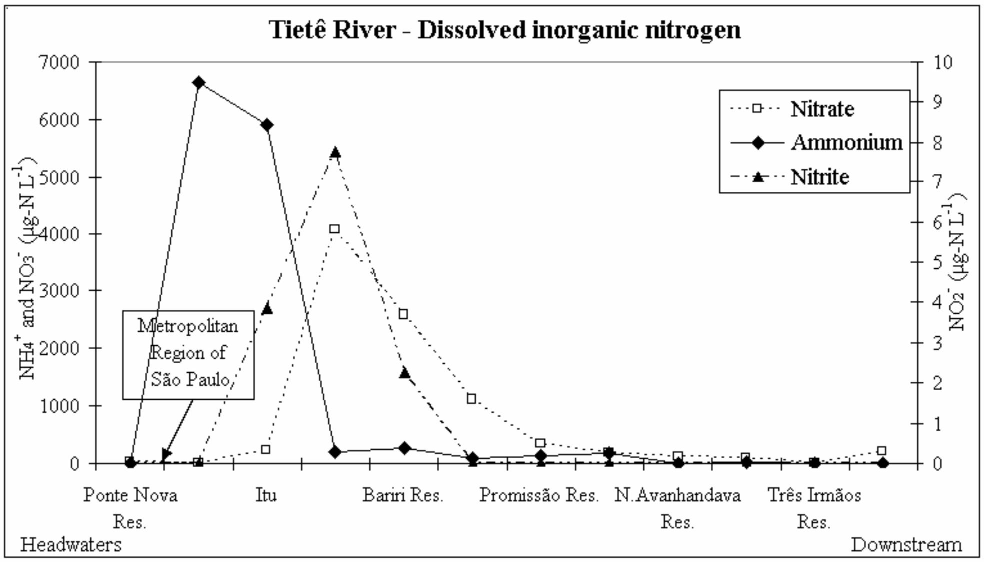

Figure 6: Nitrogen ion concentration along the Tietê River.

Although the results shown here clearly evidence both preserved areas and impacted areas in Brazil, sampling was carried out only once at each site, precluding the identification of variables susceptible to fluctuations associated with climatic factors. Armengol *et al*. (1994) showed that seasonality is one of the most important factors in the aquatic ecosystem variability in Spain. The authors verified that modifications in rain regime not only change the thermal lake/reservoir structures and the intensity of ongoing processes in the water column, but also alter the loading rates and, thus, concentrations of dissolved salts in the water bodies. In contrast, the effect of seasonality was minimized in this study as the sampling campaigns were not randomly organized, but according to river basins. Therefore, water body sampling in each river basin was carried out in the smallest possible period of time, which averaged 30 days.

Despite these limitations, the aim of the study was to provide an overview of the ecological quality of Brazilian water bodies, by identifying regions where anthropogenic impacts are evident, divulging the results through the media, and stimulating management efforts by the government to reduce impacts. The present study also obtained information from places never before studied, many of them in good conservation conditions, and will be useful as a reference for more detailed studies and monitoring programs designed to identify impacts in these areas.

The technology employed in this study may be used together with other tools such as remote sensing and acoustic Doppler current profilers (ADCP) for hydrodynamic studies of water bodies.

Acknowledgements

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Temporal Variations in the waterspread area of a tropical man made lake

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Abstract

Fluctuations in the waterspread area are natural process of lake ecosystems. In shallow waterbodies these fluctuations have a direct bearing on the water holding capacity of the system and can considerably affect the metabolism and biotic structure. An attempt has been made to observe the fluctuating waterspread area of a tropical lake ($23^0 10$` N and $77^0 25$`E) situated in the state of Madhya Pradesh, India, during a period of 20 years. The changes were recorded with the help of pre and post monsoon satellite data of the years 1984, 1988, 1993 and 2004.

During first 10 years period a considerable decrease (5.55 Sq. km in pre monsoon and 12.17 Sq. km in post monsoon) in waterspread area of the lake has been observed. The reduction is attributed to the accelerated siltation, lesser precipitation and extensive evaporation besides other losses viz., continuous withdrawal of potable water through treatment plants. The scenario entirely changed just after 10 years (2004). During this period the local government carried out various management and restoration activities. A significant increase (10.72 Sq. km in pre monsoon and 14.63 Sq. km) in the waterspread has been recorded from 1993-2004. The activities like desilting; deepening and widening of spill channel; catchment area treatment etc., have substantially helped in the increase of waterspread area.

Key Words : Waterspread , Storage Capacity , Siltation

Introduction

Inland waterbodies exhibit a wide range of fluctuations in their waterspread areas mainly due to the periodic imbalances between inputs and outputs. The extent of waterspread signifies the change that takes place in the waterbody in different seasons (Nandan, 1996). It has a direct bearing on the waterholding capacity of the system. These natural and seasonal changes in the waterspread area are most pronounced in aquatic ecosystems, depending upon its capacity and seasonal rainfall events. The fluctuating waterspread area can show a major impact on the storage capacity and tropic status of the lake. Especially in shallow waterbodies these fluctuations can affect the metabolism and structure of the entire lake ecosystem.

Bhoj wetland, Bhopal, Madhaya Pradesh, India is chosen for the present study to identify the fluctuating pattern of waterspread area during a period of 20 years. Among the dozens or so lakes in the Bhopal city the most famous are two lakes the Upper Lake (Bara Talao) and the Lower Lake (Chota Talao), the two together having been designated as the Bhoj wetland, which is a Ramsar site. The wetland is situated at an altitude of 494 m.s.l. with in the geographical co-ordinates of 23°10’-77°25’E. Bhoj wetland, which is a major source of water supply to the Bhopal city, is continuously receiving silt and other materials to such an extent that its future as a sustainable water source itself is threatened. The catchment area of Bhoj wetland, which is mainly covered with black cotton soil and the same, is subjected to severe erosion. As a result, large volume of silt and humus material is entering into the lake over the years. Effective capacity of the wetland has largely reduced due to siltation and this is estimated to be about 5 million m^3. Reduction in the depth of lake due to deposition of silt and organic matter also has a direct effect on increasing pollution in the lake. If the causes of siltation such as soil erosion, adverse human activities in catchment area and inflow of silts and waste etc into the lake are left unchecked, siltation of the lake is likely to take place in an accelerated phase.

Materials and methods

The change in waterspread area was recorded for the years 1984, 1988, 1994 and 2004 (pre and post monsoon seasons) using Landsat and Indian Remote Sensing Satellite (IRS) geocoded FCC data. The thematic maps were generated with the help of visual interpretation technique, on 1:50,000 scale and transferred to the base map. Survey of India toposheet numbers 55 E/3 and E/4 on 1:50,000 scale were used to prepare the base map. The changes in waterspread were measured with PLACOM digital planimeter (checked by conventional method) and computed.

Results

Temporal changes in the waterspread area of Bhoj wetland has been observed and recorded (Table 1) during 1984-2004. Pre-monsoon and post-monsoon seasons were selected for the observations. A continuous reduction (17.61 sq. km) in the waterspread area during both the seasons was observed during first 10 years period (1984-1994). It is observed that a total area of 5.5 sq.km. during pre-monsoon and 12.17 Sq.km during post-monsoon has been reduced during first 10 years (Figure 1). Changes in the waterspread of Bhoj Wetland has been directly related to the high siltation, lesser precipitation and extensive evaporation besides other losses viz., continuous withdrawal of drinking water through treatment plants and dense growth of aquatic macrophytes etc.

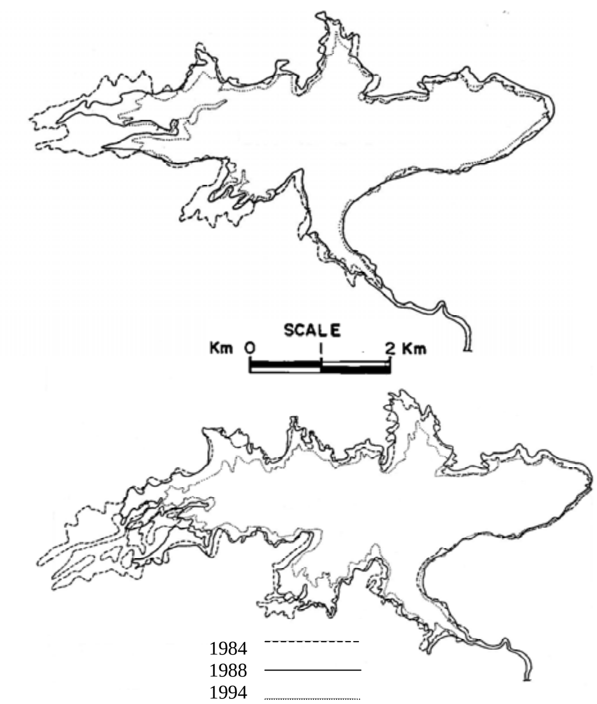

Figure 1: Waterspread changes during 1984-1994.

Table 1: Changes in Waterspread area (open water) of Bhoj wetland.

	Area Changes (Sq.km)				10 Yrs.	20 Yrs.
Season	**1984 (A)**	**1988 (B)**	**1993 (C)**	**2004 (D)**	**Total Decrease (C-A)**	**Total Increase (D-C)**
Pre-monsoon	21.525	19.275	15.975	30.60	-5.5	+ 14.625
Post-monsoon	33.495	30.175	21.325	32.05	-12.17	+ 10.725

The scenario is totally different during the next 10 years (1994-2004) period. A significant increase (10.72 Sq. km in pre-monsoon and 14.63 Sq. km in post-monsoon) in the waterspread area has been recorded from 1994-2004 (Figure 2). The state government has carried out various management and restoration activities on a large scale during this period. It involves several pollution control and environmental conservation measures and 14 sub projects. Dredging, desiltation, deweeding, diversion of sewage, catchment treatment, deepening of spillway channel etc., are prominent ones among all. The activities viz., disiltation in the fringe areas and deepening and widening of spill channel have played an important role in increasing the waterspread area considerably.

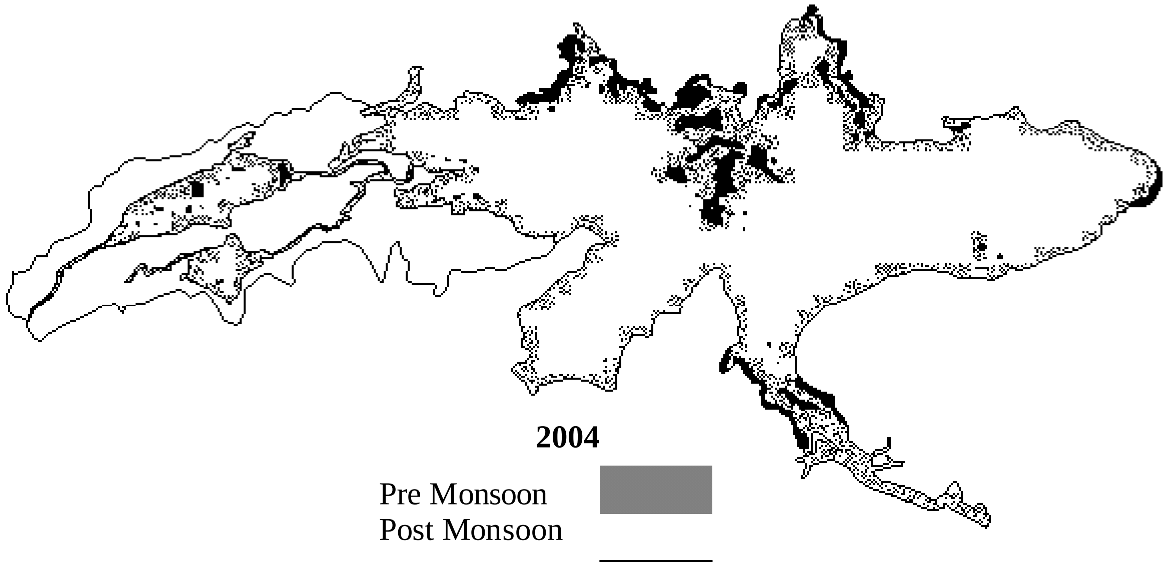

Figure 2: Waterspread changes in the year 2004.

Discussion

Since its origin (1000~1055 AD), Bhoj Wetland is receiving eroded soil from all the directions of its watershed area. The black cotton soil and the poor land use practices in the catchment area of this wetland are identified as major sources for the siltation. Opening up of the catchment area and large scale construction activities on the higher slopes, particularly in the urban areas such as Kohe-Fiza and Khanoogaon areas on the northern bank of the wetland started declining. The silting rate of the wetland is estimated to be about 1 cm to 2.58 cm per year on an average. Due to this the effective storage capacity of the lake has largely reduced and this is estimated to be about 5 million m^3 or 5% (SAPROF, 1994).

Bhoj Wetland, is a major source of water supply to Bhopal city. Under normal circumstances it has a supply capacity of 27 MGD drinking water. But this is not possible now, due to its reduced storage capacity. The low monsoon activity has also considerably reduced the water holding capacity of the wetland. The regular pumping of potable water is a major threat to the waterspread area of this wetland. On the other hand the water quality of the wetland is also affected by the following parameters:

- Introduction of organic matter and nutrients from re-flooded terrestrial areas (Nees, 1964; Cooper, 1966; McLachlan, 1970; Hestand *et al.,* 1973 and Osborne et *al.,* 1987).
- Increased concentration of dissolved materials due to water loss by evaporation (McLachlan, 1972).
- Increased turbidity due shoreline erosion and re-suspension of bottom sediment (Grimas, 1962; Swamson, 1967; Geen, 1974; Walker and Taylor, 1984; Mitchell and Rogers, 1985; Osborne *et al.,* 1987).
- Rapid re-flooding of shallow lakes (Hestand and Carter, 1974).

The macrophytes growing in the wetland result in excessive loss of water and offer a binding platform for the accumulation of soil. Many macrophytes are transmigrating from the totally submerged area to the half-submerged area as observed in the southern and western parts of the wetland. However, it has been observed that the rooted aquatic plants (mainly *Ipomea fistulosa*) arrest the incoming dead organic matter and silt from the western side of the wetland causing reduction in the depth of wetland. The fluctuating waterspread area also play a key role in the reduction of lake size which in turn effects the biotic structure of the shoreline population.

Therefore, in order to restore the normal and effective function of the Bhoj wetland as a major source of water supply to Bhopal city, it is first of all necessary to make the lake free from siltation to increase the storage capacity and to protect the shoreline. The state government initiated management and restoration activities viz., desilting in the fringe areas and widening and deepening of spill channel may have temporarily helped in enhancing the waterspread area but it is also important to develop sustainable solutions for the increase of waterspread area, as the wetland is the important drinking water supply source of Bhopal city.

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Management of a tropical water supply lake with emphasis on cyanobacteria control: case study of Vargem das Flores, Brazil

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Abstract

The paper describes the main limnological features of a tropical water supply man made lake (Vargem das Flores) in Brazil and the undertaken measures to tackle cyanobacterial blooms.Due to high water temperatures, tropic aquatic systems present quite specific characteristics, such as an enhanced dynamics in all metabolical activities and a stronger susceptibility of suffering from pollution processes, such as contamination and eutrophication. The main uses of Lake Vargem das Flores are water supply, recreation and irrigation for agricultural purposes. The paper covers a continuous sampling period of over three decades (1973 to 2005).Very few Brazilian lentic systems may show such a long term monitoring program. The lake is strongly stratified for most of the year with deep mixing occurring once during the middle of the cool, dry season (June to August).This feature leads to the formation of an anoxic hypolimnion and to the onset of internal fertilization processes. High nutrient concentrations, originated from sewage discharge, are responsible for frequent algae blooms, especially of cyanobacteria, which may excrete toxic metabolytes.A deep concern is dedicated here to this problem, since Brazil was the first country in the world to register human deaths caused by the ingestion of cyanoprocaryota toxins (city of Caruaru,1996).In order to prevent the occurrence of cyanobacterial blooms some preventive and corrective measures have been successfully carried out in recent years, such as construction of wastewater treatment plants, limitation of agricultural use in the watershed, control of recreational activities, use of natural wetlands for nutrient retention and use of air curtain and plastic barriers to keep algae scums away from the water intake.

Key words: cyanobacteria; tropical lake; water supply

Introduction

Eutrophication of lakes and reservoirs has become a serious pollution concern all over the world. The intensive agricultural use in catchment areas of lentic systems, together with anthropogenic influences derived from population pressure (e.g. discharge of domestic and industrial sewage) has led to severe impairments on the environmental quality of these aquatic systems. The deleterious effects of eutrophication are especially noted in tropical regions, where the aquatic metabolism is far more intense. Moreover the countries situated in the warm belt of our planet generally suffer from a chronic lack of financial resources for the implementation of preventive and corrective measures to tackle eutrophication.

The main characteristics of tropical lakes are summarized below (von Sperling, 1996):

(a) Intense solar radiation and high water temperatures accelerate nutrient uptake by the algae;

(b) Phytoplanktonic population peaks are less frequent in comparison with temperate aquatic environments;

(c) High nutrient assimilation capacity, associated with high recycling rates, lead to the prevalence of an intense degree of productivity;

(d) Nutrient concentrations are generally low; as a consequence many water bodies can be classified as oligotrophic in spite of their high productivity;

(e) There is a frequent occurrence of low phytoplankton densities, which are however associated with high growth rates;

(f) High mineralization rates lead to an accelerated oxygen depletion and to the formation of sediments that are poor in organic matter; consequently there is no direct connection between hypolimnetic oxygen deficit or content of organic matter in the sediment and the productivity of the water body.

Materials and methods

Lake Vargem das Flores is located close to the city of Belo Horizonte, Brazil. It has a surface area of 5.5 km^2, a volume of 0.044 km^3 and a maximum depth of 23 m. The main uses of the water body are human and industrial supply, as well as recreational activities. Since the filling of the reservoir, in the year 1973, a broad monitoring program (monthly frequency, eight sampling points, three depths) has been carried out, covering over thirty parameters.

Local climate presents two well defined periods: rainy season (October to March) and dry season (April to September), with an average yearly precipitation of 1500 mm. Air relative humidity ranges from 65 % (August and September) to 80 % (December), with an insolation average value of 2600 hours/year.

Results and discussion

The results of the long term monitoring programme in Lake Vargem das Flores can be summarized as follows:

Temperature: variations according to the climatic seasonality; as an example, Figure 1 presents the vertical profiles for the most recent period (October/04-June/05), with a circulation pattern for the colder months;

Secchi depth: in the range 0.8 to 2.3 m; higher values are obtained in the winter period (generally from July to September);

Dissolved oxygen: higher in the winter period due to enhanced gas dissolution; epilimnion: 6 to 7.5 mg/L; metalimnion: 3 to 7 mg/L; hypolimnion: 1 to 4 mg/L; as an example, the dissolved oxygen vertical profile for the most recent period (October/04-June/05) is presented in Figure 2; the water body circulation can be observed in the month of June;

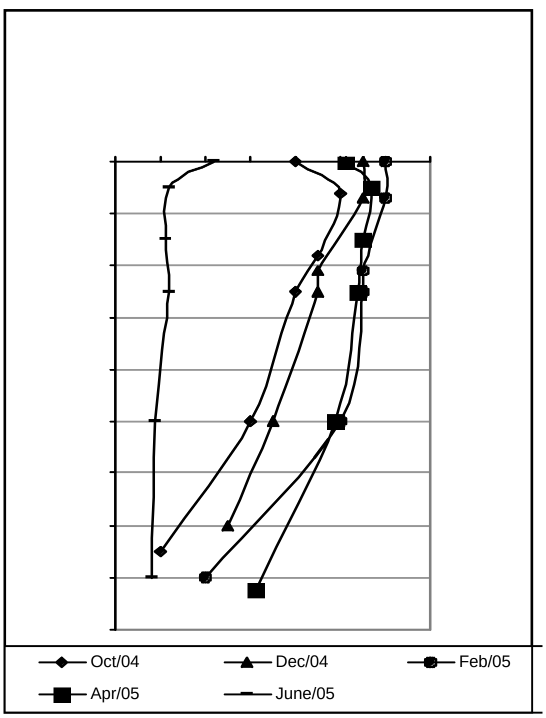

Figure 1: Temperature profile.

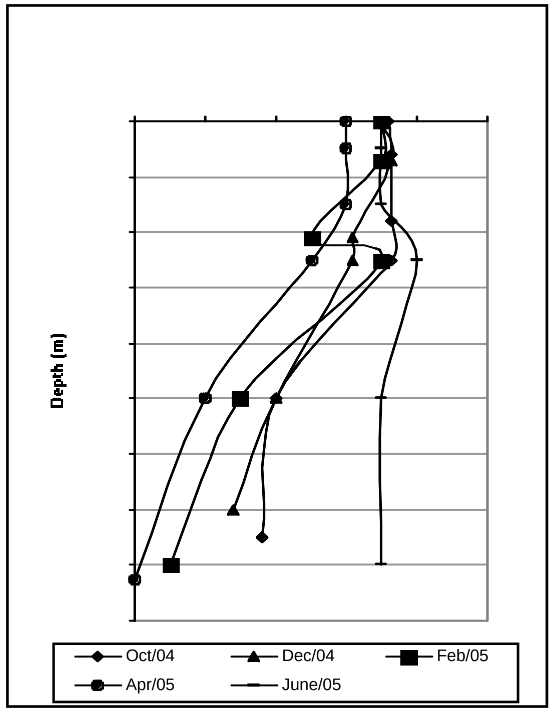

Figure 2: Dissolved oxygen profile.

pH: surface: 7 to 8; bottom: 6.5 to 7.5;

Turbidity: surface: 3 to 20 NTU; bottom: 3 to 100 NTU; seasonal variations, with lowest values in April, highest values in the rainy season (November-March); homogeneity during circulation;

COD: surface: 2 to 25 mg/L; bottom: 2 to 15 mg/L; parameter with low spatial variations;

Fe: surface: 0.1 to 3 mg/L; bottom: 0.1 to 9 mg/L (resuspension during circulation period);

Total phosphate (PO_4): surface: 0.01 to 0.2 mg/L; bottom: 0.01 to 0.35 mg/L; resuspension during circulation; higher values in cold periods, due to reduced phytoplankton assimilation;

Ammonium nitrogen (N-NH_4): surface: 0.1 to 1 mg/L; bottom: 0.1 to 2 mg/L;

Nitrate nitrogen (N-NO_3): surface: around 0.01 mg/L; bottom: 0.05 to 0.4 mg/L;

Phytoplankton density: 100 to 4000 org/mL;

Chlorophyll a: 2 to 11 µg/L.

Figure 3 shows the variation of TN/TP (total phosphorus/total nitrogen) along the year. Generally, in tropical climates eutrophic waters are N limited while oligotrophic waters are P limited (Ryding and

Rast, 1989). Reasons for N limitation in polluted tropical waters are sewage discharge (low N/P), denitrification (N lost from the bottom of the lake) and P release from sediment (internal fertilization, with consequent decrease of TN/TP).On the other hand further processes, such as nutrient excretion by zooplankton and algal/bacterial metabolism can significantly change TN/TP behaviour. In order to get a better understanding of the fluctuations of TN/TP values in Lake Vargem das Flores, the results have been grouped according to three well defined periods of the monitoring programme: period I stretches from the time of dam construction till the implementation of local regulations concerning soil use; period II refers to the time of installation of water distribution systems in the sub-basins of direct contribution to the lake and period III, the most recent one, reflects the effects of sewer construction in the watershed.

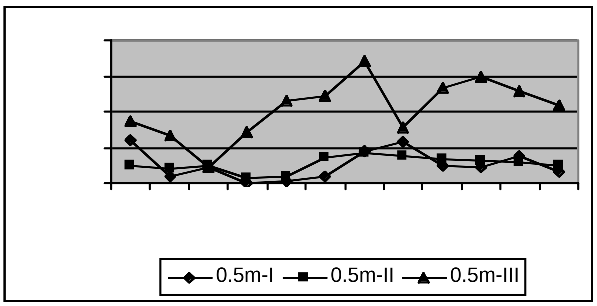

Figure 3: Relationship between N and P in 3 periods.

It can be seen that the highest TN/TP values are generally registered in July (middle of the dry season, when the lake is circulating), while the lowest ones are found in March/April, following the rainy period. This is probably due to a larger phosphorus assimilation rate by the algae in periods of higher water transparency, what happens in the winter time. There is also a marked increase in TN/TP values during phase III, indicating stronger phosphorus assimilation in recent times. Researches carried out in another tropical urban reservoir (Pampulha Lake, Brazil) have shown a clear increase in TN/TP ratios proportional to the distance from sewage discharge, i.e., in that case phosphorus was turning progressively limited (Pinto-Coelho et. al., 2003). The upward trend of TN/TP in Lake Vargem das Flores leads to the conclusion that, most recently, phosphorus has assumed the role of limiting nutrient, what should avoid the dominance of cyanobacteria, as extensively reported in the technical literature (Forsberg and Ryding, 1979; Smith, 1983; Shapiro, 1990 and 1997; Cooke *et. al.,* 1993; Chorus and Bartram, 1999). However an opposite trend has been registered in Lake Vargem das Flores, where blooms of *Microcystis aeruginosa* and *Cylindrospermopsis raciborskii* could not be coupled with low TN/TP ratios. Researches in Salto Grande Reservoir, Brazil (Deberdt, 2002) have also shown a reverse trend to the conventional assumption, i.e., cyanobacteria growth has been registered under conditions of high TN/TP. This means that other factors (grazing, sedimentation) may be involved in the complex relationship between TN/TP values and cyanobacterial blooms. Moreover it should be observed that high TN/TP values do not obligatorily means phosphorus deficiency. This could point out to high phosphorus recycling rates, which are a frequent issue in tropical aquatic systems.

The main purpose of this paper is to handle the problem of cyanobacterial blooms, which is currently an emerging issue in most countries in the world. A deep concern is dedicated to this topic in Brazil, since it was the first country in the world to register human deaths in a dialysis unit caused by the presence of cyanoprocaryota toxins (Azevedo *et. al*., 1996; Carmichael *et. al*., 2001). Most cyanobacteria have maximum growth rates above 25° C and are therefore favoured by higher temperatures. Blue-green algae or cyanobacteria are primitive microalgae with plant chlorophyll. These ancient and remarkable organisms may inhabit quite diverse environments. They have long been recognized as a water quality problem in lakes and reservoirs due to their potencial toxicity and to their capacity to impact off-flavours to drinking water (Hitzfeld *et. al.*, 2000). Consequently many water utilities are concerned about controlling cyanobacteria input to the treatment plant. Cyanobacteria present a range of characteristics that give them a clear competitive growth advantage over planktonic algae in certain environmental conditions. They are not favoured by high light intensity and require little energy to maintain cell structure and function (Mur *et. al.*, 1999). Moreover they present a buoyancy regulation capacity due to the possession of gas vacuoles within their cells. This is important in avoiding light damage in high-light environments, such as tropic lakes, or in gaining acess to light in turbid or low-clarity water (Haider *et. al.*, 2003). Cyanobacteria are also able to store phosphorus (luxury uptake), what is useful to allow continued growth under conditions of fluctuating nutrient concentrations. They are also not grazed by the zooplankton, since they are not a preferred food for this aquatic community (Chorus and Bartram, 1999).

Restoration measures

There are no simple and universal options for lake management to control cyanobacteria growth, since they will depend on local characteristics and also on the availability of financial resources. The adopted measures should have preferably a preventive character, in order to control the onset of blue-green algae blooms. The use of algicides should be avoided, considering the possible effect of lysing cyanobacterial cells and releasing intracellular toxins into solution.

For the restoration of Lake Vargem das Flores several preventive and corrective techniques are currently under implementation. Some of the adopted measures, under a preventive point of view, include limitation of agricultural use in the watershed, control of recreational activities, erosion control by hydroseeding and use of natural wetlands.

In order to minimise algae input in the water treatment plant (abstraction by multiple-depth offtakes), physical barriers or booms (similar to those used for oil spills) are being tested to keep scums away from intakes. Also an air curtain device, which has been successfully evaluated in a pilot model, will be installed around the water intake tower, preventing hence phytoplankton from reaching the abstraction point.

Conclusions

As consequence of anthropogenic pressure, represented by sewage discharge and agricultural activities, Lake Vargem das Flores has been subject to pollution problems, more specifically related to eutrophication. Cyanobacterial blooms occur frequently in the water body, leading to a serious concern about the production of toxic metabolites. Results of a three decades monitoring programme show that dominance of cyanobacteria is not coupled with low N/P values, as usually assumed in the technical literature. The implementation of preventive and corrective techniques has been undertaken, pointing out a general improvement of the water quality, but not avoiding the onset of cyanobacterial blooms. Currently two corrective measures are being implemented (installation of physical barriers and air curtain device), which should prevent algae input in the water treatment plant.

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The Asian Wetlands Symposium 2005 and the role of the Ramsar Center Japan

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Abstract

Water is the bloodstream of wetlands. In other word, without water a wetland can't be thought of. Just as water is essential for the sound health of wetlands, so too it is a crucial element for a healthy lake system. So the wise use of water is the crucial element in the management of a lake system. This paper attempts to explain how an NGO can bring together regional partners, especially government, the private sector and civil society in enhancing the wise use of wetlands and then extrapolates its lessons in the sustainable uses of lake resources.

The paper begins with the evolution of the idea of Asian wetland symposium (AWS), a multi-stakeholder initiative jointly undertaken at the regional level by governments and NGOs to promote the cause of sustainable use of wetland resources. The first Asian Wetland Symposium (AWS) was held in 1992 (Otsu and Kushiro, Japan) and then followed in 2001 (Penang, Malaysia). The third one was held in Bhubaneswar, India in February of 2005. The paper discusses how Ramsar Center Japan (RCJ), a NGO based in Japan, mobilized resources in organizing the 2nd and the 3rd AWS and brought together relevant stakeholders ranging from governments to NGOs and the media, from researchers to policy makers, managers and community leaders; from the private sector to universities, in sharing their improved understanding about wetlands and their resources in the same forum. Then the paper describes unique features of Asian Wetland Symposium 2005 including the discussion on the Tsunami and coastal wetlands and the adoption of the statement on innovative approaches to sustainable livelihoods. Besides the procedure of selecting papers, distinction between the Penang statement and the Chilika statement and the salient features of the resolutions on the Tsunami and coastal wetlands are also discussed.

Lesson reveals that the wise use of wetlands is a balance between hardware science (flora and fauna) and software science (culture, norms, laws and policy, etc.). And the fulcrum between these wares is hereby, called heartware (trust, confidence, participation, and good governance). The heartware dimension can be achieved only when (1) resources are used creatively, (2) stakeholders work collaboratively, (3) dialogue and negotiation occur consensually and (4) the concerns of different factors and actors, especially the environment, the economy and social equity are addressed compatibly.

Key words: Networking, stakeholder participation, wise use

Evolution of the Asian Wetlands Symposium idea

The idea of Asian Wetlands Symposium (AWS) is a multi-stakeholder initiative designed to bring the planner, policy maker, practitioner and promoter together in the management and conservation of wetlands and wetland resources in Asia. It is a loose non-formal forum established voluntarily by the joint efforts of the government, international non-government organizations, non-government organizations, the private sector, researchers, media and interested practitioners. Its proposed objectives are given below.

1. Discuss contemporary issues on wetland management and conservation
2. Exchange knowledge, information and best practices
3. Promote the idea of wise use and sustainable utilization of resources
4. Provide scientific inputs to the ninth Ramsar Conference of Parties, also known as Ramsar COP 9.

Role of Ramsar Center Japan and AWS

Ramsar Center Japan (RCJ) is a membership non-governmental organization established in 1990 in Tokyo, Japan. Volunteer staff is entrusted to manage its day-to-day affairs. Its total members has reached 130 and the membership covers a wide range of fields and hails from Australia, Bangladesh, China, India, Indonesia, Japan, Korea, Malaysia, Nepal, Philippines, Taiwan and Thailand, the largest number of members coming from Japan. The goal of the Center is to promote the sustainable uses of wetlands and foster the mission of the Ramsar Convention on Wetlands in Asia. The goal has been further broken down into two major objectives:

1. Provide leadership in the wise use of wetlands
2. Catalyze the process of wise use and its dissemination

The activities of the Center are diverse and varied. It has produced various educational materials including the proceedings of several workshops and three AWS's (1992, 2001, 2005), and translation of the AWS statements in over 20 languages, production of videos on the wise use of wetlands ant their conservation. The focus of its activities includes many but not limited to the following thematic areas.

1. Strengthening capacity and empowering grassroots people

2. Representing people's voices in international fora

3. Enhancing networking and collaboration

4. Promoting advocacy and dissemination

5. Undertaking participatory action research.

RCJ and wetland conservation

1. Since its inception RCJ has played a pivotal role in organizing AWS in several countries on different times, with the spirit of synergization of ideas, resources and efforts. The Center has been the driver and mover of the idea from the very beginning of early 1990's. It would not be out of place to mention that RCJ began its activities modestly to establish the networks in Asia with the help of wetland experts, practitioners and its international advisors hailing from eleven countries of the region. It successfully mobilized the networks and tapped resources from various sources including international organizations such as the Convention on Wetlands, donors, partners and the private sector. Because of this network, the Center has been successful in supporting regional activities in the region.

2. RCJ's role in strengthening the capacity of local partners, especially through organizing the issue oriented workshop at different times for different purposes, producing and disseminating educational materials, especially booklets on the wise use of wetlands, videos on wet wonderland and coral wonderland, publishing proceedings, organizing the Asian Wetlands Week (AWW) under the initiative of the Asian Wetlands Initiative, inter-country exchange of wetland practitioners, sensitization for the future leaders of wetland conservation, and so forth .

3. RCJ has always played a key role in establishing sisterly relation between wetlands of four different countries (among the stakeholders of Tale Noi, Thailand; Saroma lake, Japan; Chilika Lagoon, India, and Woopo wetlands, South Korea). Stakeholder-participants from these wetlands have successfully been sharing their experiences, issues and modalities of conservation and developed informal network for their mutual benefits.

4. Conducting participatory action research is one of its many activities, whereby the Center supports local practitioners, institutions and local governments in conducting demonstration projects and preparing action plans in several countries.

5. RCJ put emphasis upon the continuity of its creative initiatives on the wise use of wetland resources in the region, for which it has, on an experimental basis, conducted special programs for the children so that they can develop the essential quality of leadership for the future. In this case, RCJ has conducted pilot study of collaboration of the children from three countries of the Northeast Asian Region; China, Japan and South Korea.

Implementation of the AWS idea

The first AWS was organized in Japan in 1992 jointly by the Environment Agency of Japan, local governments of Shiga and Hokkaido prefectures, International Lake Environment Committee (ILEC), Ramsar Center Japan and the Regional Promotion Committee for the Ramsar Conference in Kushiro. The Symposium, which was the first of its kind was held in two phases, the fist phase being held at Otsu and the second one at Kushiro. About 1,000 people from 26 countries attended it. The Symposium established the tradition of making practical, action-oriented recommendations on the wise use and sustainable uses of wetlands and disseminated its proceedings, titled “Towards the Wise Use of Asian Wetlands” to the concerned partner organizations. The recommendations of Symposium was disseminated to the Conference of the Parties (COP) held in Kushiro in the same year. Its recommendations covered eight areas; awareness, institutional capacity and training, monitoring, policy and legislation, international cooperation, development assistance and conservation; and eco-tourism. The major achievements of the Symposium included;

1. Informal set up of a forum for various agencies engaged in wetlands

2. Sharing of information, experiences, good practices and trans-boundary issues

3. Establishment of an informal regional network

The second AWS was held ten years later in Penang, Malaysia in 2001 and was jointly organized by the Ministry of Science, Technology and Environment; University of Science Malaysia and Ramsar Center Japan. About 350 people from 34 countries attended it. It also adopted the Penang Statement for encouraging smart partnership and good governance for good practices in wetlands. The proceedings and its Penang Statement were disseminated in Ramsar COP 8 held at Valencia (Spain) in 2002. Concrete achievements included;

1. Continuity to the idea of AWS

2. Dissemination of concrete inputs to Ramsar COP 8

3. Technical inputs to complement the Ramsar regional activities in Asia

The third AWS was held in Orissa in 2005 with the joint cooperation of the Government of India, the Chilika Development Authority and Ramsar Center Japan. Some 400 participants from 32 countries attended the Symposium. The Symposium also adopted the Chilika Statement for promoting innovative approach to support local livelihood. The proceedings and the Chilika Statement are being planned to distribute in Ramsar COP9 to be held in Kampala, Uganda in November of this year.

The unique features of the Asian Wetlands Symposium 2005 can be summarized as follows:

1 Wetlands seen as a whole or in its entirety (not in fragmentations)

2 Focus on over-arching issues such as capacity building, wetland eco-system, partnership, etc.

3. Single forum for individuals from diverse fields; government, the private sector, civil society, media, academia and practitioners

4. Firsthand exposure to the participants on good practices prior to the symposium

5. Inclusion of a special session on Tsunami and coastal wetlands

The main concern of the Symposium was to ensure these features, for which the International Steering Committee issued the following directives to its Technical Committee.

6. Session coordinators are responsible for the selection and approval of the right papers for their respective sessions.

7. The approval of the paper should be made only after the receipt of the full paper

8. Emphasis should be placed on innovative ideas, cross-cutting issues and diversity in terms of types, approach and modalities of wise use.

As a result, a total of 75 papers were presented at the Symposium, of which 43 were presented at technical sessions, 14 on the Tsunami session, and 18 in side events. The papers covered the following areas.

- Capacity building, education and public awareness
- Biological diversity
- Cultural values of wetlands
- Assessment of, and options for, the Tsunami
- Networking and collaboration
- Restoration, management and wise use

On the basis of the gist of the papers and the outcome of the floor discussion, the authors have synthesized their conclusions. The wise use of wetlands is a balance between hardware science (flora, fauna, management, etc.) and software science (culture, norms, laws, policy, etc.). The balance can be maintained as and when the heartware aspect (trust, confidence, reciprocity, mutuality, etc.) is taken into account during the time of wetlands management and conservation. The heartware dimension can be achieved only when the formula that has been in a capsule form of the 4C's is used effectively, which stands as Creativity, Collaboration, Consensus and Compatibility

Creativity implies the creative use of resources, both material and non-material (such as Daskathia of Orisa and Sura and Mir Aab traditions of Afghanistan) to bring all stakeholders together on the ground

Collaboration should be the centerpiece of any wise use activity. All the relevant stakeholders should be involved actively, without which wise use will only be a dream.

Consensual process should be its approach. Any action that is initiated should be discussed thoroughly guided by the principle of broad-based consensus. Relevant stakeholders should be involved in the total decision making process.

Compatibility should be the key to the success of wise use of wetlands. It is ensured when the decision is made at the most appropriate level; the decision making process is transparent, decision makers are held accountable; efficiency and effectiveness are the ultimate goal of the wise use activity. The compatibility of the economy, the environment and equity should be the heart of the issue.

Suggestions for the future

Civil society and the private sector play an important role in the success of the management of wetlands and their resources. Their catalytic role is indispensable for raising the quality of human life. In order to promote the role of civil society and non-governmental organizations, the author call upon to propose their activities around the following themes.

1. Strengthen the existing networks and partnership through the organization of at least one workshop every year to catch up the recent issues in wetland management. The synthesis of many mini-workshops can be a substantial contribution to any Ramsar Conference of Parties (COP).

2. Continue the tradition of the AWS scheme triennially as stipulated in the Penang Statement and link its activities with the regional activities of the agency and organizations engaged on wetlands.

3. Push the idea of AWS to all Ramsar regions in general and Africa and South and Central America in particular.

4. Disseminate the idea and spirit of the Chilika Statement as far as possible. To this end, the Center has already translated it into some 30 local languages of the Asia region and distributed it through its network and regional advisors to the grassroots of Asian countries in general and the RCJ membership countries in particular.

Nonetheless, genuine efforts are underway but much more needs to be done. However, it is heartening to know that the foundation stone has already been laid down for the most difficult road to the management, conservation and sustainable development of wetlands and their resources. To accelerate this process, what is required is the voluntary, active, informed and responsible participation of the relevant stakeholders for the noble cause of wise use of wetlands and their rich resources, for which people's trust and confidence should be won, not demanded.

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Indonesian lake crisis, a reality?

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Abstract

Despite their small area, the Indonesian lakes store 500 km^3 of water, equal to 22-28% of the annual renewable surface water. The inland fisheries catch of 400,000 t/year equals to the South American grasp, standing fourth in the world after China, India and Bangladesh. How a country treats its water resources collectively reflects the successes and failures of the environmental management and policy performance. It cannot be in Indonesia's interest that incorrect signals of the ecological quality of its lakes are given. There is enough scientific evidence that the ecological quality of most of the larger lakes can be ranked as excellent, good, or satisfactory. The government's decisions are usually made in data-poor and knowledge-poor situations, seldom based on scientific facts and adequate ecological understanding. Too often they are also influenced by opinions of local pressure groups with insufficient knowledge and experience. Hardly ever foreign NGOs, which have moved away from the focus of water professionals towards a conceptual framework, have the capacity to specify their initiatives to and leave residual capacity in Indonesia. Such groups support formulation of the Indonesian Lake Vision, a far too superficial concept to guide the central and local governments. Compared to Finland's water resources management vision of only 67 words, nonetheless, the country is the world leader in the sustainable environment and water resources management. Visions do not stop degradation and pollution of aquatic ecosystems. Investment in healthy inland water ecosystems yields significant health, environmental and economic benefits. Improved understanding of lake ecology can be achieved only by examining the differences in physical, chemical and biotic properties among different aquatic ecosystems. The knowledge-based, predictive lake management builds on improved national capacity to understand the factual extent, causes, consequences, and control of disturbances, reducing uncertainties in lake management, risks in investments, and cost of failures in decision-making.

Key words: lake, resources, aquatic, ecology, quality, sustainability

Introduction

The Indonesian inland waters cover a total of 618,500 km^2 (32.6%) of the 1,900,000 km^2 Indonesian archipelago, of which 394,000 km^2 (20.7%) are peatlands, 119,500 km^2 (6.3%) rivers and floodplains, 16,000 km^2 (0.8%) man-made lakes, 5,000 km^2 (0.3%) natural lakes, and 84,000 km^2 (4.4%) irrigated areas, which can be considered as ecologically engineered shallow lakes. There are over 500-700 natural lakes, more than in any other Southeast Asian nation. Over 90% of the lakes are less than 1 square kilometer in area and shallow. These lakes are located at altitudes from near sea level to over 2,000 m and 14 of them are over 100 m and eight over 200 m deep. In the world there are only 20 lakes deeper than 400 m and three of them are in Indonesia. There are also nearly 200 multiple use reservoirs (Lehmusluoto, 2005).

The lakes store permanently roughly 500 km^3 of freshwater, the largest volume of lake water in Southeast Asia, equaling to 22-28% of Indonesia's annual renewable surface water resources, while reservoirs at full capacity hold 5% of the annual river flow (the full storage capacity is 10 km^3). According to the Agenda 21-Indonesia water was detected only in rivers, dams and marshlands. In some islands the water demand already exceeds the available water resources. Indonesian inland waters are also directly and indirectly significant in food production. With the annual inland fisheries catch of nearly 400,000 tons, which is equal to the catch of the entire South America, Indonesia stands fourth after China, India, and Bangladesh (FAO, 2005).

The environmental, socioeconomic and cultural value of the Indonesian inland waters is great. Though the Indonesian people have greatly benefited from their lakes, rivers, wetlands and coastal seas, their ecological integrity and sovereignty for the present and future generations have not been properly considered. Usually hydrological change and augmented point and non-point pollution by nutrients, agro-chemicals and toxic substances result from watershed modifications of large settlement programs and urbanization and from forestry, agriculture, aquaculture and industry. Commonly, five major aquatic ecological problems are identified: siltation, eutrophication, acidification, toxification and loss of biological diversity.

However, there are a number of others. Impaired hydrology and unsustainable water withdrawal, dam construction, canalization, water diversion and pollution expand all over the country, altering the natural flow regimes, affecting water levels, draining wetlands and disturbing ecosystems. In the densely populated areas activities are focused on the low-lying waterfront margins where soils are more fertile, disturbance of the riparian zones has increased soil erosion and fluxes of contamination. The total annual silt transport from the Indonesian watersheds is estimated at 3,000 million tons (over 1,000 tons/km^2/year), among the greatest in the world (Lehmusluoto, 2005).

Nonetheless, the truism of the Ministry of Environment that severe pollution from pulp, oil and fertilizer plants threatens most lakes with huge environmental impact and probability to environmental disasters (The Jakarta Post, 2005) is an overstatement. The most serious sources of pollution, community waste and sewage, were totally omitted. There is enough scientific evidence that the ecological quality of most of the lakes can be ranked as excellent, good or satisfactory (Ruttner, 1931, Lehmusluoto *et al*., 1997, 1999). Thus, the information of severe pollution, drop in ecological quality and causes of pollution provided by the ministry can be seen as unfortunate misguidance.

Materials and methods

The Indonesian lakes can be divided into two major clusters by their geographical features and the clusters into sub-groups (Table 1). Lakes with similar biological communities in pristine conditions should be identified for reference, enabling further comparison of respective clusters and sub-groups.

To manage lakes in the first cluster, which are generally starting points of rivers or “eyes of the seas”, the ecosystem approach shall govern the activities in the lake and the catchment area. However, these lakes have the advantage of being in the uppermost tributary and having relatively small catchment area/lake area ratios. Two exceptions shall be accepted, Dibawah-Singkarak and Matano-Mahalona-Towuti chains of lakes. Due to the long residence time of water, chances of recovery of lakes in this cluster are faint or will take hundreds or thousands of years.

Lakes in the second cluster are expanding and shrinking floodplains or in lowland areas appendices of rivers, where they may also form oxbow lakes or groups and chains of lakes. Such lakes are found in the lowland areas of Eastern Sumatra, Kalimantan and Papua. Reservoirs and rice fields are also included in this cluster. In the lakes of this cluster, increase or reduction of watershed effects is directly reflected in their status because water is rapidly renewed and the lakes could recover in years or tens of years.

Table 1. Clusters and sub-groups of lakes, stratification/mixing patterns of temperate lakes, water residence time and least approach required for the lake and basin management with examples of lakes (Lehmusluoto *et al.,* 2003). The European Commission (2002) applied a similar type of ranking in its Water Framework Directive.

Cluster / Sub-group	Mixing type	Residence time	Least approach	Examples
CLUSTER A				
A. Closed lakes				
- Shallow high-altitude’)	Monomictic	Long	Ecosystem	Batur, Bratan
- Shallow high-altitude meromictic	Atelomictic	Long	Ecosystem	Buyan, Tamblingan
B. Open lakes				
- Very shallow low-altitude	Polymictic	Short	Ecosystem	Limboto, Telaga Warna
- Shallow low-altitude	Oligomictic	Short	Ecosystem	Tondano, Sentani
- Shallow high-altitude	Monomictic	Short	Ecosystem	Diatas
- Deep low-altitude	Oligomictic	Long	Ecosystem	Lamongan, Poso, Towuti
- Deep high-altitude	Monomictic	Long	Ecosystem	Toba, Kerinci, Lindu
- Deep meromictic low-altitude	Atelomictic	Long	Ecosystem	Singkarak, Matano
- Deep meromictic high-altitude	Atelomictic	Long	Ecosystem	Dibawah, Ranau
CLUSTER B				
C. Floodplains, flooded forests				
- Very shallow	Polymictic	Short	Watershed	Sentarum, Tempe
D. Man-made lakes				
- Very shallow	Polymictic	Short	Watershed	Wlingi
- Shallow	Oligomictic	Short	Watershed	Saguling, Selorejo

*) Very shallow < 5-10 m, shallow < 50-100 m; deep > 50-100 m deep; low-altitude < 750 m, high-altitude > 750 m

In Indonesia, the lake area and usually unpredictable winds are important driving forces in the hydrodynamic events in contrast to the temperate lakes, in which the principal driving force is predictable seasonal variation in air temperature. The strong seasonal variation of precipitation may also have a considerable impact on water dilution and nutrient supply especially in smaller lakes. The seasonality of precipitation also essentially affects such biological events as algal blooms, zooplankton reproduction and fish spawning.

The traditional classification by stratification/mixing patterns is not adequate in Indonesia. In Table 2, the major features contrasting temperate and tropical lakes are emphasized. The tropical lake typology should base on the rate of metabolism or bioactivity: the rate of production and decomposition. However, in the absence of such data, a more relevant classification is the geographical features: origin, size, depth and altitude. In addition, factors like hydrology, water renewal time and irregular mixing make the management of tropical lakes more complex and unpredictable than of the temperate lakes (Lehmusluoto, 2003).

Table 2: Characteristics commonly contrasting in the temperate and tropical lakes, but due to the great variance in depth they may not always apply to reservoirs, shallow lakes, floodplains and wetlands (Lehmusluoto, 2003).

Characteristic	Temperate Lakes	Tropical Lakes
Watershed area / lake surface area ratio	High	Low
Water level fluctuation	Minor	Major
Water residence time	Short	Long
Annual regularity of events	Regular season driven	Irregular weather driven
Annual temperature variance	High	Low
Vertical temperature difference	10-30 Celsius degrees	2-3 Celsius degrees
Stratification pattern		
? Polymixis	Uncommon	Common (very shallow)
? Dimixis	Common	Uncommon
? Monomixis	Uncommon	Common (shallow and deep)
? Oligomixis (atelomixis)	Uncommon	Common (shallow and deep)
? Meromixis	Uncommon	Common (shallow and deep)
Reactive and metabolic rate	Low	High
Decomposition rate	Low	High
Amount of dissolved organic matter	High	Low
Amount of organic compounds	High	Low
Phytoplankton	Relatively rich	Relatively poor
Zooplankton diversity	Relatively rich	Relatively poor
Fish diversity	Relatively rich	Relatively poor

In the temperate regions, lake behavior is related to the rather predictable seasonal changes. In Indonesia, the irregular meteorological and weather events govern the limnological processes and the ecosystem approach is necessary in guiding the level of management efforts required in the basins. If the watershed degradation and pollution are efficiently controlled, rivers, river lakes and most reservoirs recover rapidly but recovery of the critically eutrophied or otherwise polluted lakes will take at least 5-6 times their water renewal time. Slow "flushing rate" lakes should be put highest in the management agenda. The average water renewal time of the world lakes is 17 years. Comparison of the key characteristics of the Champlain and Toba lakes clearly show that they are two entirely different lake types located in two latitudinal extremes (Table 3). The theoretical recovery time of Champlain is "only" 15 years but that of Toba nears 2000 years, though some changes may be irrecoverable. In general, there is space for both the watershed and ecosystem approaches.

Table 3: The key characteristics of Champlain and Toba lakes (Lehmusluoto 2003).

Lake	Maximum depth (m)	Volume (km^3)	Surface area (km^2)	Watershed area (km^2)	Watershed/ lake area	Residence time (years)	Approximate age (years)
Champlain	122	25.8	1,127	21,326	18.9	2.6	< 12,000
Toba	529	240	1,130	3,658	3.2	109-279	75,000

Results

Watershed, the physical entity integrating hydrology and ecology of lakes, is generally adopted as the unit for Integrated Water Resources Management (IWRM). The IWRM programs shall be locally adaptive and produce new ideas and innovative management tools, not to repeat the global commons. At present, there is a lack of such programs between researchers, lake managers and the public at large. Advanced research, continuous monitoring and impact evaluation integrating all expected and unexpected but known synergistic and/or antagonistic effects shall be a mandatory part of all spatial and development planning.

The generalized global frameworks and superficial visions and manifests of international organizations and NGOs such as the Lake Basin Management Initiative (LBMI) (ILEC and LakeNet, 2004) and Integrated Watershed Management (IWM) (UNESCO and UNEP 2004) are parts of the holistic IWRM, which aims at (1) integrating local knowledge of freshwater and coastal area issues, (2) shifting focus on self-reliant country and region level control of water resources depletion, degradation and pollution, (3) instigating science-based, knowledge-driven management and policy-making and (4) practicing more empirical and analytically rigorous decision-making in the environmental realm.

In addition to the decades old common IWRM culture, LBMI and IWM partly overlap with the IWRM. Therefore a critical and objective priority setting evaluating complementarities between IWRM, LBMI and IWM: (1) IWRM forms a holistic basin wide integrated watershed - wetland/riparian ecotone – water body (lake, river, wetland, coastal area, etc.) management framework with the objective of maintaining the quantity and good quality of water resources and ecological health of aquatic ecosystems, (2) LBMI is a generality and assumptions-based management initiative which needs to be adjusted by experts to region and country level and (3) IWM (ecohydrology and phytotechnology) is basically a river load issue with the objective to enhance the absorbing capacity of ecosystems by changing hydrology and artificially constructing wetlands or by other means manipulating ecosystems but first all human-induced pressures must be efficiently controlled.

Lakes, depressions of the earth's surface, contain water which is commonly received from rain and the interacting surrounding landscape or watershed areas. There are plentiful of lake types and their actual size, depth and the watershed area/lake area ratio vary significantly. However, the LBMI discusses also wetlands. In geography, a *wetland* is a flat environment at the interface between the truly terrestrial and truly aquatic ecosystems, making them different from each yet highly dependent on both. Their well being depends on the management of the parent water body.

The LBMI partners send ambivalent messages. The LBMI mantra is that in spite of the tremendous geographical, latitudinal and ecological diversity of lakes in the world, they share some common characteristics: (1) long water retention time, (2) complex dynamics and (3) transmissivity. Nevertheless, the ILEC emphasizes that the complex dynamics of lakes also argues for drawing on the best available scientific knowledge and, if necessary, mounting research programs to obtain knowledge that is critical to management. However, a proper conceptual model of these dynamics must be worked out well in advance of the programs (ILEC and LakeNet, 2004).

First, the long retention time is not a general rule, varying from days to thousands of years. The world average is 17 years. For the short retention time lakes the watershed (basin) approach might be used but especially for the lakes with longer retention times, a science-based ecological quality approach, in which the resilience capacity of individual lakes is evaluated. Second, the great diversity of types, complex dynamics and transmissivity are extremely site specific (origin, latitude, altitude, area, depth, etc.) and should receive more attention because global generality is a weak umbrella for sustainable lake management. As holistic studies are emerging, requiring especially new biological methods to evidence the quality of ecosystems, the government should concentrate on matters regarding quality of lake ecology and pollution control, i.e. sustainable development of lakes; (1) characteristics ("anatomy") and functions ("physiology") of the lake ecosystems, (2) interactions between lakes and their watersheds, (3) fish and fisheries and (4) runoff, wastewaters and effluents and their impacts.

Discussion

Professors Franz Ruttner and August Thienemann, the early developers of limnology, shaped the concept of tropical limnology in Indonesia in the late 1920s. What formerly seemed self-evident now becomes a problem because general concepts, as e.g. "the concept of production and tropic classification, appear in an entirely new light" (Thienemann, 1932). This saying also crystallizes the importance to understand the global differences and the critical role of science in practical lake management. There is a high risk to oversimplify the issues because the present knowledge of tropical limnology bases on momentary records and snapshots describing net effects of continuous processes. Professor Robert G. Wetzel, one of the world's most prominent limnologists, expressed apprehension over superficiality in understanding of ecological subjects and bibliographic negligence. In tropical limnology, universal move from basic structures, concentrations and biomasses to functional and metabolic aspects is a necessity (Wetzel, 2001).

Relative easiness is perhaps one of the main reasons to use the general conceptual frameworks and global visions in lake management. The dangers of wrong concepts and management failures are great and may lead to "creative disasters" in lakes because they may not capture the physical, chemical and biological processes that exist in different climatic and hydrological environments and cannot deal with uncertainty caused by poor knowledge of these processes and omission of important variables and site conditions. They also greatly overvalue the understanding of the management subjects and falsely generate confidence

The international organizations and NGOs promoting LBMI and IWM shall bear, together with their Indonesian counterparts, the responsibility if a clear consensus of a road map to the knowledge-based IWRM for lakes cannot be reached in the near future and lake deterioration advances. One cause to this is the country's weak capacity to evaluate the appropriateness and usefulness of the foreign-introduced initiatives when the foreign organizations try to promote and advance their own institutional interests or interests of some of their staff members. These organizations usually have inadequate knowledge of the Indonesian lakes and unconvincing scientific proof of the positive impacts of the initiatives.

Yet, the LakeNet has reasoned that the evolution of the conceptual framework for managing lakes is accelerating. While experts and sound science have a vital role in lake management, many are now moving away from a focus on "water professionals" toward an approach that involves stakeholders informed with scientific information throughout the process. The goal is that the LakeNet will bring to the world of lake stewardship a new set of collaborative tools that is greatly needed and that will improve water quality across the globe. Practical experience addressing lake management problems is perhaps one of the main reasons that the conceptual framework continues to evolve (LakeNet, 2005). It may, however, also be an expression of institutional inability to foster knowledge-based lake management.

In the LBMI, IWM, World Lake Vision and the many global conventions, the temperate zone bias is simply "avoided" by including information from a handful of tropical lakes. It is ever more important to analyze how the complex matrix of factors of differences in latitude, geography and lake type specialize basin management, especially when the objective of the LBMI was to improve the lake basin management practices.

The Indonesian Academy welcomed the IWM, or the ecohydrology concept, as one of the uniting and prospective tools to manage our water resources and simultaneously restore the environment (Lehmusluoto, 2005). However, before ecohydrological measures can be applied threats of point sources of pollution as well as non-point sources from both direct and indirect catchments must be eliminated (UNESCO and UNEP, 2004). Originally, ecohydrology focused on understanding the fundamental processes between riparian ecotones of rivers in South America and how these natural processes could be help in water management (McClain, 2002).

Instead of uncritically accepting all imported initiatives, in the interest of Indonesian people it is necessary to start debating and questioning them. In Indonesia, decisions involving the complex aquatic environments are usually made in data-poor and knowledge-poor situations, requiring substantial investment in scientific capacity, reliable data and sophisticated management culture. The knowledge-based approach builds on the national capacity. With access to the global domain of information it allows meaningful management objectives and self-reliant decision support systems to mature, diminishing reliance on foreign support. It also allows use of the ecosystem qualities to find and game with lake specific, results oriented but cost-effective management options.

Lakes have been reasonably well known but presently there is an ongoing shift towards conceptual frameworks and global visions in their management. However, how a country treats its freshwater resources is the single most important indicator of the environment policy and management performance because waters collectively reflect the cumulative effects of successes and failures, brought forward also to coral reefs and coastal seas. Especially, weak law enforcement allows these mainly unauthorized hydrological conversions and pollution to threaten most inland waters and coastal seas.

The Indonesian lake management program must be outlined by professionals to avoid the basic mistake, inadequate understanding of the management subjects. Knowledge-based predictive lake management radically reduces uncertainties in results, risks in investments and cost of failures in decision-making. Substantial investment in scientific capacity, reliable data and capable professional supervision and administration in lake management is the most cost-effective and impact-securing choice for Indonesia. A strong operational link has to be established between scientists, managers and citizens in order to improve and promote the ecosystem approach based integrative and predictive lake management at the watershed scale, because water is an overarching and cross-cutting denominator of the UN Millennium Development Goals (Millennium Ecosystem Assessment, 2005).

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Integrated lakewide management organizations: an approach to managing fisheries resources in shared lakes - the case for Lake George, Uganda [Report]

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Abstract

The Lake George Basin Integrated Management Organization is an exciting new initiative, bringing together the three local governments of Bushenyi, Kasese and Kamwenge and the eight community Beach Management Units on Lake George. It was launched in April 2003 after a comprehensive participatory institutional development process. The aim of LAGBIMO is “to provide a framework for coordination and coherence in planning and implementation of any form of interventions for socio-economic development of communities within the basin through sustainable management of Lake George basin natural resources”. The aim of such an integrated approach is poverty reduction through improved livelihoods resulting from sustainable management of the lake basin. The approach established a Lakewide management institution, brings together interests of all stakeholders, brings all three levels of local government and lower level structures together from different districts and it is inter-sectoral involving sectors such as fisheries, environment, water, wetlands and community development to provide a holistic approach to lake management, recognizing the interrelatedness of the system and livelihoods. In the past there were a number of development and management approaches on Lake George. However, the overarching need for setting up LAGBIMO was to facilitate an integrated approach to the management of Lake George basin, by bringing all stakeholders on board. This undertaking promotes a more integrated and coherent approach by drawing on key aspects for basin management. With this, there was need to bring together the many stakeholders’ interests to promote coherent and integrated management that involves a range of stakeholders from communities through district to national government agencies.

Formation of LAGBIMO is in conformity with World Lake Vision principles 2,4 and 5 since it draws on aspects of the basin. Also creation of Beach Management Units and giving them responsibility for resource management is relevant to principles 6 and 7.

Introduction

The first Lakewide Management Organization (LMO) in Uganda was initiated and developed with support from a DFID supported project, the Integrated Lake Management (ILM) that aimed at improving livelihoods of communities dependant on Lake George. The approach was later adopted by Lake Kyoga, the country’s 2nd largest water body. The ILM project had approaches that embraced best practices and cultivating lessons for people led but government supported for Lake management. Its strongest success track followed use of available institutions and arrangements. LMO approach looks at a whole lake ecosystem, and the immediate basin. It is integrating, poverty focusing and empowering local communities.

The Lake George Basin Integrated Management Organization (LAGBIMO) is a result of such approach. It is an exciting new initiative, bringing together the three local governments of Bushenyi, Kasese and Kamwenge, and the eight community–based Beach Management Units (BMUs) on Lake George. It was launched in April 2003, after a comprehensive, consultative and participatory institutional development process. It was the first organization of its kind to be formed in Uganda. It is an example of deepening decentralization and sharing responsibility of managing a lake with resource users.

Supporting policy framework

This lakewide management initiative is strongly rooted in Uganda Government policy framework to reduce poverty: the Poverty Eradication Action Plan (PEAP) and its Plan for Modernization of Agriculture (PMA). LAGBIMO partners cooperated under the Local Governments Act of 1997 which derives guidance from the decentralization strategy. The latter was a framework for decentralizing authority and empowering local authorities to engage in development of their own areas. The ILM Approach has been included in the draft Fisheries Bill 2005 where Lake Management Organizations will be formed and operationalized for each lake shared by districts. BMUs were established under the country’s present Fish Act by issue of a Statutory Instrument in July 2003.

Aims of LAGBIMO

The aim of LMOs in general and LAGBIMO in particular is to provide a framework for coordination and coherence in the planning and implementation of any form of interventions for the socio-economic development of communities within the basin through the sustainable management of lake basin natural resources.

The overall aim of such an integrated approach is poverty reduction through improved livelihoods resulting from sustainable management of lake basin natural resources. The approach is integrated in the following ways:

- Establishment of Lake wide management institutions, bringing together the interests of all those using and managing the lake.
- Inter-district, including bringing all three levels of local government and lower level structures (BMUs, Parish, Sub-county and District) together from different districts.
- Inter-sectoral, involving sectors such as fisheries, environment, water, wetlands and community development, to provide a holistic approach to lake management, recognizing the interrelatedness of the system and livelihoods.
- Inter-stakeholder, bringing together many types of stakeholders.

The vision of LAGBIMO is to have poverty eradicated in lake dependent communities reliant upon well-managed, economically productive natural resources and receiving effective service delivery in a clean and healthy environment. Its goal is sustainable management and use of Lake George natural resources for the improved livelihoods of poor communities within the Basin by 2013.

The need for change

In the past there were a number of development and management approaches on Lake George such as Lake George fishermen committees, rehabilitation committees, taskforces; to mention but a few. However, the overarching need for setting up LAGBIMO was to facilitate an integrated approach to the management of Lake George basin, by bringing all stakeholders on board. This undertaking promotes a more integrated and coherent approach, by drawing on key aspects for basin management.

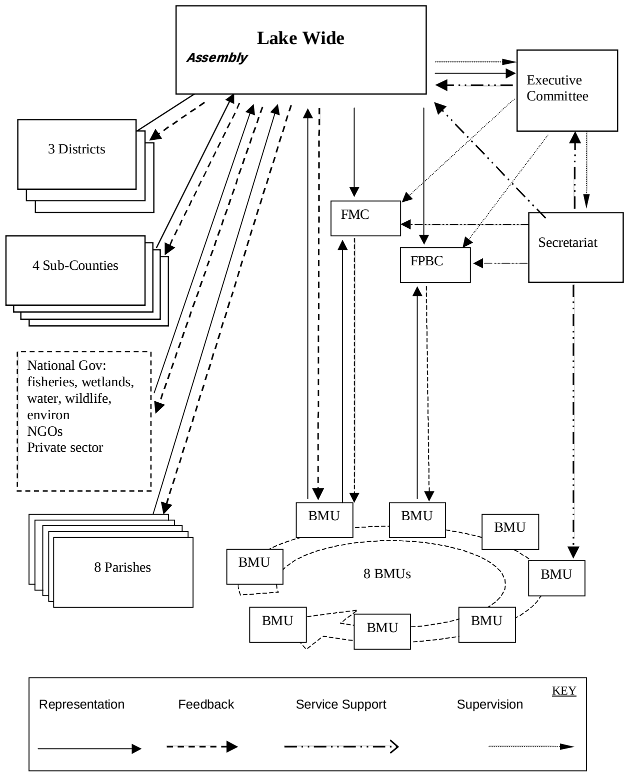
There was, then, a need to bring together the many stakeholders' interests and plans to promote coherent and integrated management that involves a range of stakeholders, from micro (communities) through meso (District) to macro (national government agencies).

Structure of LAGBIMO

LAGBIMO has the following structure:

- The Lake Wide Assembly (LWA), the overall decision making body of the organization
- Executive Committee (EC), the functional arm of and implements decisions of the LWA
- Fisheries Management Committee (FMC) with Fisheries Research and Monitoring Control and Surveillance (MCS) units attends to matters of fisheries. This is because fisheries development is a nucleus from which other livelihoods emanated.
- Finance, Planning and Budgeting Committee (FPBC) which is responsible for planning and sourcing as well as look at issues of the environment, alternative livelihoods including community tourism, aesthetic values e.t.c,.
- The Secretariat. This is like the "civil service section" for coordination of activities.
- The LAGBIMO structure is based on a solid legally empowered institutional foundation made up of community Beach Management Units.

Structure of Lagbimo



Activities of LAGBIMO and relevance to WLV

Formation of LAGBIMO is in conformity with WLV principle #2,4 and 5

Realization that most factors impacting on Lake George come from the catchment hence the basin approach. For the start the basin has been put to mean the three districts although future focus will be on the actual "hydrological basin". Water withdrawals through gravity flow schemes, irrigation schemes and hydroelectric power could affect the water budget of the lake but whether this is significant or nor is yet to be found out.

Improved governance - strengthening civil society

Fisheries management; the BMU–led MCS patrolling (WLV principle #6)

Empowerment and facilitation of communities to protect the resources from which they obtain livelihood. According to the Ugandan Constitution, natural resources including fisheries are held in trust by the Government for the benefit of all Ugandans. The BMU committees (BMUCs) have been empowered to protect fisheries in collaboration with government in an approach called co-management. Because the lakeside communities are present most of the time at the beaches, they are better placed to police the lake. Government officials provide technical and logistical support. On Lake George, they have been able to do this and they continually remove destructive fishing gear thus protecting the fish stocks and attendant biodiversity.

Decentralized decision-making and conflict resolution (principle #7)

During the course of fisheries management, conflicts usually arise between resource users themselves and between resource users and resource managers (BMUCs). Originally such small issues would wait for Government officials but now the communities resolve them even without waiting for the views of the bureaucrats. LAGBIMO provides a bigger forum for resolving conflicts at inter-Subcounty and inter-District level. LAGBIMO links these levels with national agencies and harmonize approaches. Community–based bottom up planning and community driven implementation of the plans is also one way of decentralizing decision making.

The BMUs vet / screen and do preliminarily selection of those people to be granted access rights for purposes of fishing on lake George using the selection criteria developed by the Department of fisheries resources in consultation with Local Governments. This is a form of decentralizing decision-making.

BMUs are also involved in:

- Identification of shallow lakeshore areas to be protected for purposes of fish breeding
- Development of byelaws to protect the lake and its shores
- Deciding on local fishing gear marks

Data collection

Community based catch assessment surveys

Fish catch data collection is an international requirement by the FAO but the mechanism to do it was lacking. Uganda in trying to implement this requirement included this as a responsibility for BMU committees which now record, use and disseminate fish catch data. LAGBIMO coordinates and gives technical support to the BMU-employed data collectors to ensure that national formats are used throughout the whole lake. This data is analyzed by the BMU committees on which local decisions particularly on monitoring, control and surveillance activities are based. It is entered into the computer at LAGBIMO Secretariat and disseminated to LG and DFR for planning and higher-level policy making. This is in line principle number 4 of the WLV

Fisheries research unit

The mandate to conduct fisheries research lies with the Uganda's National Agricultural Research Organization (NARO). However NARO's research involves a lot of logistics and demands high-level expertise. In an effort to demystify research LAGBIMO established a Fisheries Research Unit (FRU) under its Fisheries Management committee. Under the FRU research is used to generate facts and figures, which are used to validate information from the existing community–based fisheries information collection system and translate into sound plans and management decisions at all levels. For example, it was realized that a number of changes had taken place in fisheries legislation in the recent past, which aimed at effective management of the resources. Some of the changes address production constraints that are aimed at sustainable utilization of fisheries resources. The unit set out to look for information to convince policy makers the need for change in certain legislation that does not match with realities on ground (See Box 1).

> BOX 1: The gillnet mesh size for Lake Edward/George and the Kazinga Channel was changed from 5 to 4.5 inches by a statutory instrument in 2003 but there was no change in the legal size of Nile tilapia. Lake Victoria uses 5 inches gillnets and targets 11 inches TL Nile tilapia, the same as Lake George/Edward but for a smaller mesh size of 4.5 inches. A study was set to find out whether the shift from 5 to 4.5 inches had an effect on the total length of Nile tilapia caught.

Some of the policy decisions for lake management are based on "best available information at the time" which raises concerns on the optimal use levels and the sustainability of lake resources if actual researched information cannot be found immediately.

Environment management

During the transition ILM project to LAGBIMO, studies were done on the impact of hillside agriculture on Lake George and very interesting results come out most of which point at dangers of the lake silting should the current practices continue. Lake George being located at the foothills of the Rwenzori mountains experiences loads of silt from the hillsides which continue to be deposited in the lake margins now forming wetlands where there were not. If present rates of deposition of silt (no data on quantities) continue, the size of the lake might diminish and this goes with changes in aquatic biodiversity.

There is also a problem of industrial pollutants which are monitored by the national agencies for water and environment. Although some clean up technologies have been established to process the mine tailings, industrial pollutants from a former copper mine still find their way to Lake George.

Challenges and recommendations

Although the policies, organizations, structures and processes are in place and have begun to operate, they are in need of support. There has been a lot of capacity building for Integrated Lake Management approach. Despite the policy commitment, funds have not been forthcoming from Local and Central Government to make the various structures operational.

Before the approach can be rolled to other water bodies in Uganda, there is need for support to kick-start its pilot implementation on the pioneer lakes while Local Governments prepared to take over financing of the activities. Central Government and the international bodies and the donor community should make a contribution towards implementation of this innovative approach.

Applying the World Lake Vision to the Lerma-Chapala basin

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Abstract

During the last several decades, unchecked over-exploitation and contamination of water resources in Mexico's Lerma-Chapala watershed have put the existence of the country's largest lake under threat. To achieve a healthy and sustainable lake, it is necessary, for practical reasons, to make the lake an attractive economic asset. The first priority is to stabilize its storage volume at a reasonable level volume, taking into account cyclical oscillations. No appreciable investment in commercial fisheries, recreational sports, tourism and housing development will be made until this has been achieved. This vision implies effective watershed management, fostering environment-friendly productive activities that reduce water consumption, chemical and pesticide use and promote community organization, raising the quality of life for watershed inhabitants.

Our presentation will explore a recent study of the basin, examining the economic return on water usage for the key productive sectors and the relationship between water usage and job generation in each. It reveals that 68% of the basin's superficial water resources are utilized in agriculture which employs 2.7% of the work force and only produces a miniscule 0.6% of the economic product. By comparison, manufacturing utilizes 0.1% of the water, employs almost 25% of the work force, yet yields 47.9% of the economic product.

The report highlights the imperative of a major reorientation in the agricultural sector, focusing on modern irrigation methods and selecting crops that are more labor intensive, consume less water and produce greater economic return.

Our aim is to identify and analyze existing agricultural enterprises that incorporate any of these aspects in search of viable models that can be replicated throughout the watershed. Likewise, we will explore government institutions, programs and international resources that could facilitate a major shift in the economic, social and environmental well being in the farming sector.

Key words: Lerma-Chapala Basin, agriculture, economic return

Lerma-Chapala watershed

The Lerma Chapala basin is located in central Mexico, extended over approximately 54,000 km² comprising sections of five states: Querétaro, Mexico State Guanajuato, Michoacán and Jalisco. It is set in a sub-tropical semi-arid zone, with an average temperature of 21ºC. and an average rainfall of 735 mm per year. The watershed originates in the State of Mexico at the source of the Lerma River and empties into Lake Chapala in Jalisco.

The Lerma-Chapala basin is of strategic importance to Mexico from economic, political and social points of view. It supplies water to around 12 million basin inhabitants, plus another four million users residing in the Mexico City and Guadalajara metropolitan areas. Covering less than 3% of Mexico's territory, the region boasts per capita industrial and agricultural production surpassing national levels. It is the base for 20% of all national commerce and service activities, generates one third of the industrial GNP and plays a key role in the production of high-value agricultural exports. Around 10% of Mexico's irrigated land is located in the basin.

However, the basin is in crisis from a water perspective, with demand exceeding supply except during years of intense precipitation. About 80 per cent of available water resources is allocated to the farming sector, with the remainder destined for urban and industrial users. Efficiency in agricultural water use is low and nearly 70% of the basin's aquifers are over-exploited.

Lake Chapala

Lake Chapala is the largest natural lake in Mexico, the third in size in all of Latin America. Located in the highlands of west central México the statea of Jalisco and Michoacán, it stands at an altitude of 1,525 meters above sea level, with a maximum water storage capacity of almost 8 billion cubic meters over a total surface area of 114,000 hectares. As the final recepticle of the Lerma-Chapala watershed, one of the most over exploited basins in Mexico, the lake has been subject to extreme fluctuations in water level and stored volume, with the drastic declines registered periodically, notably in 1955, 1990-1992 and 2000-2002. Critically low levels appear to become more frequent and severe over the past 50 years as a result of population growth, construction of hydrological infrastructure and increased agricultural and industrial activity throughout the watershed.

11900 Lerma-Chapala Accords and Basin Council

Recognizing the growing fragility of this important hydrological system, Mexico's federal government and chief executives of the five basin states signed an historic cooperative agreement in April 1989, jointly adopted four main objectives: to improve water quality by treating municipal and industrial effluents; to control and regulate surface water, following a new water allocation policy to distribute water equitably among users; to achieve efficient water use; and to manage and conserve the basin and its tributaries.

The task force formed to enact the goals of the cooperative accord evolved to the January, 1993 creation of the Consejo de Cuenca Lerma-Chapala (Lerma Chapala Basin Council). Under the authority of the National Water Commission (CNA), this innovative body seats representatives of major economic stakeholders in the areas of farming, animal husbandry, fishing, industry and urban use, along with spokesmen for the five basin states and key federal agencies.

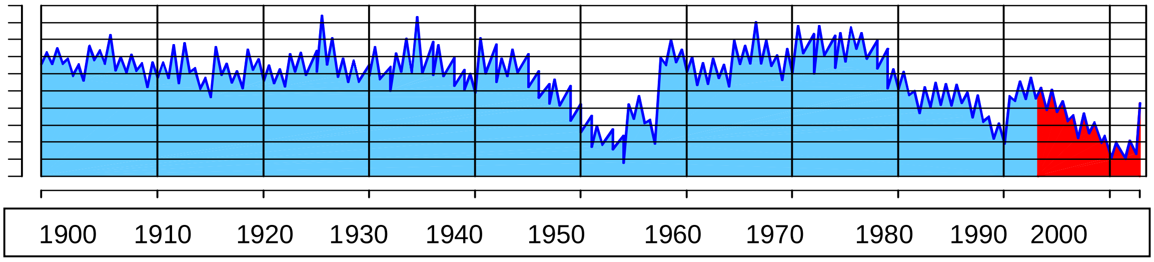

Figure 1: Fluctuating levels of Lake Chapala, 1900-2000.

This visionary effort to take corrective steps in the Lerma-Chapala is significant in that it represents a philosophical adherence to various principals laid out several years later in the World Lake Vision drafted by a team of international experts.

The Council model specifically embodies World Lake Vision Principal 2: "A lake drainage basin is the logical starting point for planning and management actions for sustainable lake use. In addition, the council's work to date has focused heavily on the concept of World Lake Vision Principal 5; "The management of lakes for their sustainable use requires the resolution of conflicts among competing users of lake resources, taking into account present and future generations and of nature."

Nonetheless there have been major stumbling blocks for restoring balance to Lerma-Chapala system. Lake Chapala continued suffering water shortages due to unfavorable climatic factors, added to economic and political obstacles in resolving conflicts related to reducing the high percentage of water resources allocated to the farming sector.

The rehabilitation and modernization of irrigation is considered as a key strategy to achieve water volume recovery, particularly in the upper and middle Lerma regions where the water deficit is most severe. But the magnitude and high costs of such measures have hampered their implementation in the short term.

It took three years of ardent negotiations for Council members to forge a major revision of the original formula for the allocation of surface water resources. The new distribution policy was eventually put into effect in December 2004, improving prospects for conserving Lake Chapala at healthier levels.

In the process of achieving a consensus on the new allocation policy, the key to winning over the farming sector appears to be comprehensive research on economic and social factors related to water usage by basin users.

While it is common knowledge that the agricultural sector is the largest consumer of the basin's water, the analysis--carried out by Julio Goicoechea, professor at the Universidad Autónoma Metropolitana School of Economy, under the auspices of the CNA-- shockingly quantifies just how inefficiently this resource is utilized. The study examines the impact based on the economic "value added" generated by each productive sector in pesos, (adjusted for inflation), with relation to the volume of water utilized. The social productivity is evaluated based on the impact of the use of water in generating employment.

At one end of the scale, we find that the manufacturing sector in the basin utilizes 0.1% of the water resources, employs 25% of the work force and yields 47.9% of the economic value added. At the other extreme, the agricultural sector uses 68% of the water, employs only 2.7% of the work force and produces a miniscule 0.6% of the value added.

Additional statistics reveal that this sector generates an average of only 1.4 pesos (US$0.15) for every cubic meter of water utilized. Stated another way, agriculture utilizes 708 cubic meters of water to generate $1000 pesos (US$96.15) of value added.

During the period 1997-2003, the surface area irrigated and harvested in the basin averaged 191,000 hectares, represented 8% of the national average and grew only 0.3% annually. The supply of water available during that period decreased at an average annual rate of 3.4%.

There is a large disparity in the efficiency in farming in the different areas of the basin. For instance, the State of Guanajuato has 56.5% of the irrigated farmland under cultivation, as compared to 25.6% for the state of Michoacán, yet Michoacán produces an economic yield per hectare of twice that of Guanajuato.

By comparison, livestock in the basin grew at an average annual rate of 7.5% during the same period and produced an economic benefit of value added of more than 5 times that of the agricultural sector. At the same time livestock produced $207 (U$S19.71) for every cubic meter of water used vs. $1.4 (U$S.15) for agriculture.

The clear conclusions of this study indicate the following:

- Irrigated agriculture in the basin is operating under precarious conditions with decreases in the availability of water, stagnation in the area harvested and in the value added per hectare as well as a decrease in workers employed.
- The data indicates the necessity to radically improve the technology utilized for irrigation, yet this would require considerable investment that would only generate little or no improvement in value added. Additionally, this would not have any significant impact in employment in the sector.
- Given the increasing need for water by growth in the population and in the industrial and service industries located in the basin, it is imperative to stimulate technological production in agriculture in order to maximize the economic and social value of the water resources.

The implications of the research point to the urgency of pushing for a major reorientation in agricultural production to a standard of crops that utilize less water, are more labor intensive and produce a higher value added. New models would significantly improve the economic and social well-being of farmers, while boosting conservation of the basin's natural resources.

Corazón de la Tierra

Corazón de la Tierra is a non-profit organization with ample experience in field work aimed at fostering a shift from traditional agricultural practices to a new pardigm that encourages water and soil conservation, preservation of endemic vegetation and wildlife, and schemes for establishing eco-tourism as an alternative livelihood for rural communities.

One of our current goals is to identify local farming ventures that demonstrate the viability of environment-friendly practices and document examples that can be duplicated in other zones of the Lerma-Chapala basin that still operate under inadequate systems. We will look for models that not only use water efficiently, but also takes advantage of Mexico´s low labor costs and the climatic advantages that allow basin farmers to produce crops year- round and compete effectively on the worldwide market.

With a continued tendency towards sound management based on the World Lake Vision principals, we are convinced that the Lerma-Chapala Basin Council and society at large can work hand-in-hand to assure the exploitation of the region´s natural potential to stand at the vanguard of sustainable development.

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Factors that inhibit the implementation of customary laws in Danau Sentarum National Park

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Abstract

Danau Sentarum National Park is a unique Ramsar site in Indonesia. This park consists of seasonal lakes, stunted swamp forest, peatland forest, and dry land forest. Biodiversity records show that the park is rich in fish fauna, birds, plants, mammals, primates, insects, reptiles and amphibians. Radiocarbon dates from peat in this park extend back to Late Pleistocene. This suggests the climatic conditions of the region have been predominantly ever-wet, which must be extremely important for the development of biodiversity.

High biodiversity of the park does not lead to the practice of sustainable management of park resources. At present, the park is not well managed due to poor management scheme, inadequate institutional capacity, the degradation of customary laws enforcement, and global wood market demands. The presently centralistic approach on the management of national park seems to prevent community participation. Consequently, this management scheme has degraded the adaptability of local communities to cope with pressures from external influences, such as globalization, rapid social change, and consumerism. A wider implication of this centralistic policy has driven outsiders in collaboration with few locals to over-exploit the common pool resources. In the present circumstances, the decline of park resources would change the relationship of local communities with nature, from harmony and long term vision into disharmony and short term vision.

Key words: Danau Sentarum, Indigenous People, Governance, Ramsar Sit

Introduction

This paper introduces Danau (Danau is Indonesia term, meaning lake) Sentarum National Park, an important freshwater habitat in West Kalimantan Province, Indonesia. In this paper, we argue that the decline of this park is strongly associated with the present governance that hampers the full participation of indigenous people to practice community resource based management scheme. The present government policy has slowly ruined local institutions that have some capacity to protect this important freshwater ecosystem.

This paper aims to analyze the underlying causes of Danau Sentarum National Park decline. Data were collected through focus group discussions with local communities, government officials, workshops, and policy analyses. This research has been based on our small scale project activities from 2001 – 2005 in Danau Sentarum National Park. The purposes of this project are to manage anthropogenic activities, and to increase public awareness on environmental roles, functions and values of the park.

In this paper, we briefly introduce important information and facts about Lake Sentarum. Next, we present research results, and descriptively analyze the findings. In the last part, we draw conclusions and offer some recommendations.

Danau Sentarum National Park

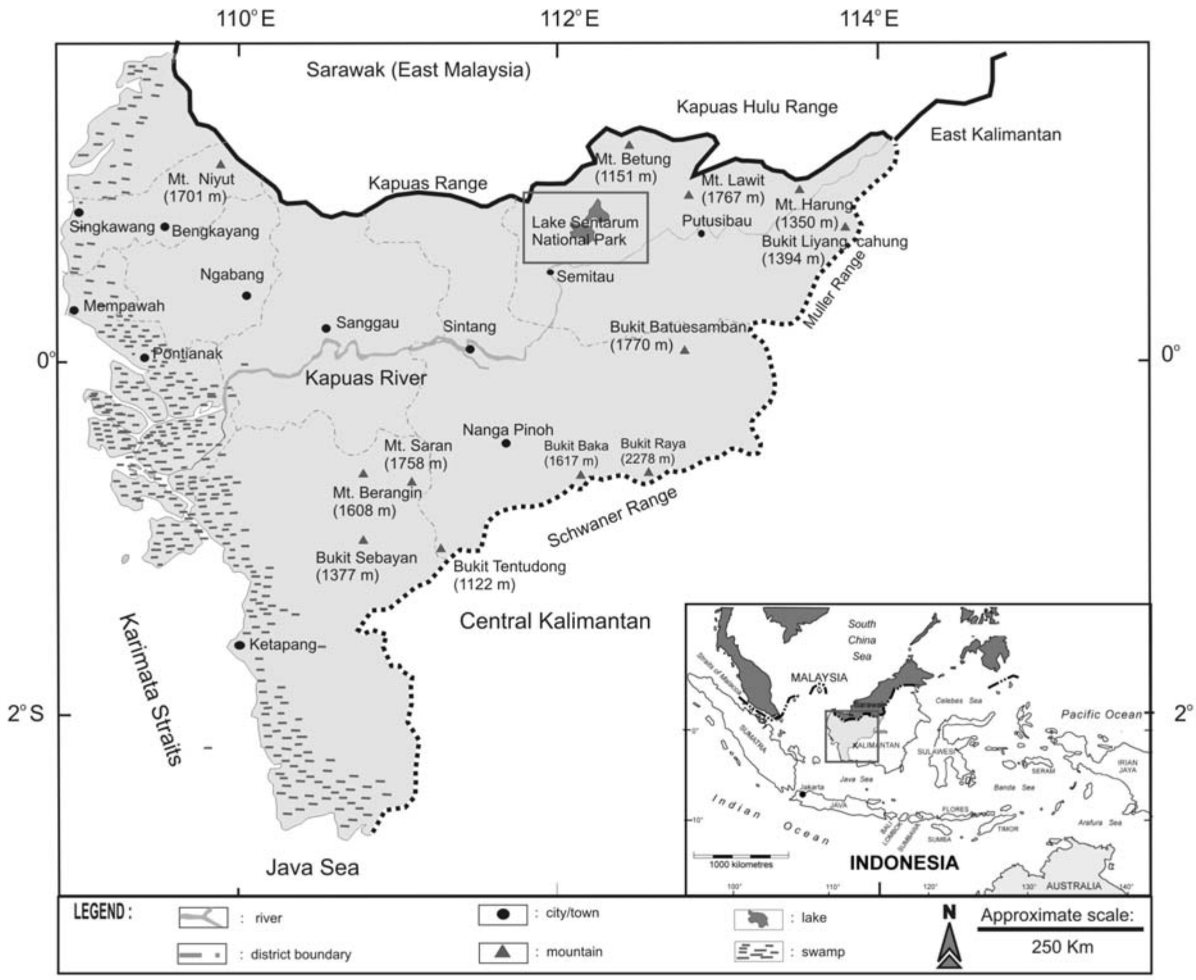
Properties and biodiversity

Danau Sentarum National Park, some 132,000 ha in extent, is situated close to the equator (0° 40’- 0° 55’N, 112° 00’-112° 25’ E) within the upper reaches of the Kapuas River, the longest river in Indonesia (± 1000 Km). The location of the park is about 700 km upstream, with an average altitude 35 m above sea level. The park is located in the district of Kapuas Hulu, West Kalimantan Province, Indonesia (See Figure 1). The area was firstly designated as nature reserve (80 000 Ha) in 1982, and then as national park in 1999. Danau Sentarum has been listed as Ramsar Site since 1994 (Frazier, 1999).

Danau Sentarum consists of single vast area of water (± 40 000 Ha), with 8-12 meters depth (Giesen, 1987). The water color is black due to organic acids, with pH 4-5. Frequently, this naturally seasonal lake system dries, changing into grass and bare lands. Only few rivers and scattered pools retain water in dry period. The size of swamp forests is about 60 000 Ha (Giesen and Aglionby, 2000).

The park is frequently dry, once every 3 years (Giesen, 1987). At present, this dry phase seems to be more frequent. In the last 10 years, the park was dry for 4 times (1994. 1997, 2003, and 2004). This seasonal nature of the lakes has occurred for thousands of years, and all living creatures (flora, fauna, and human) have adapted to this natural system.

The park is rich in biodiversity. The lakes function as a major habitat for the breeding of fish fauna such as expensive and endangered dragon fish (*Scleropages formosus*) (This fish is listed in Appendix I CITES) famous clown fish (*Botia macracanthus*), and many other fish species, such as *Notopterus borneensis, Oxyeleotris marmorata,* *Chitala lopis, Leptobarbus hoevenii, Channa melasoma, Channa micropeltes, Clupeichthys bleekeri, Pangasius nasutus,* and *Wallago leeri.* Most fish species are collected for consumption and trade. It was also thought that in the past, the park was a transit place for water birds (Jeanes, 1997).



Source: Modified from Bakosurtanal 2000

Figure 1: A map of Kapuas Hulu District, showing major sub-district towns and the location of Danau Sentarum National Park in the upper Kapuas River Basin.

The park has distinctive vegetation formation. On lake shores, it is commonly found stunted and dwarf forest, with *Barringtonia acutangula* as dominant species, which mostly live underwater (Giesen 2000). Also, peat swamp forest in Danau Sentarum region is different from coastal peatland. According to Anshari *et al.,* (2001, 2004), peat in this park was initiated in Late Pleistocene, and formed from kerapah (inundated heath forest). In contrast, coastal peat was mostly formed in mid Holocene, and from freshwater and mangrove forests (Anderson and Muller, 1975; Page *et al.*, 1995, 2004).

The park has many protected species. These, for example, include *Tomistoma schlegelii, Crocodylus porosus, C. siamensis* (reptile), *Neofelis nebulosa,* and *Pongo pygmaeus (*mammals*)* are also listed in Appendix I CITES. Other rare and threatened bird species include *Argusianus argus, Ciconia stormi, Anhinga melanogaster*, and *Aviceda jerdoni*. Threatened reptile and mammals include *Manouria emys*, and *Aonyx cinerea*, *Helarctos malayanus*, *Hylobates muelleri*, *Manis javanica*, and *Nasalis larvatus.* This biodiversity has rapidly declined due to intensive human activities such as over-fishing, forest fire, and illegal logging (Anshari, 2004).

Governance

According to the present regulation, BKSDA (a central government conservation agency) has an authority to manage the park. This agency has proven inadequate to carry out this mandate due to lacks of managerial skill, human resources, and budget. Since the management authority is under central government, the District Government of Kapuas Hulu is reluctant to interfere with park management. Both governments have difficulties in establishing collaborative management scheme, and intend to work on their own. Such government behavior has directed to mis-management of the park, and substantially caused the degradation of park resources and slowly destroyed local institutions that have great potentials in park management.

Two major ethnic groups live in the park. They are Malays and Dayak Iban (a sub-ethnic of Dayaks(Indigenous people of Borneo)). Originally, both Malays and Dayaks in interior of West Kalimantan have the same accentors or roots. Major differences between Malays and Dayak Iban appear to adhere with religions and occupation. The majority of Dayak Iban works as dryland farmers, and are mostly Catholic. In contrast, the Malays are Moslem and dependent on fish resources for their livelihood. These two indigenous communities have very limited roles in the present park management scheme (Colfer *et al.,* 2000, Wadley, 2002).

Result and discussion

Every village has customary institution, which is managed by selected community members. This institution has authority to equally distribute fishing rights and regulate the use of park resources. Members of fishing folk meet once a year in order to regulate the use of fishing tools, and to distribute fishing spots, using a lottery. The rules are only applied within village boundary. Since there are 40 villages in the park, with independent local institutions, customary fishing regulation is substantially varied, following the consideration and the need of members of each institution. For example, members of Genting village have agreed to ban the use of large trap, which has very small mesh plastic net. The gear is made from rattan. The size of the trap is 2 to 3 m long and 0.6 to1.0 m diameter (Dudley, 2000). This trap collects not only large fish but also juveniles to feed caged snake head fish (*Channa* spp), locally known as toman. It is unfortunate that the use of large traps is not prohibited in many other villages.

In the past, the enforcement of the laws was greatly influenced and controlled by King. No written documents are found to confirm the role of King in the development of customary laws in this region. Elderly people mentioned there was no division between laws. This means that both King and local communities recognized the same laws. This past condition contrasts with the present condition. The laws are divided between the government laws and customary laws. And, the government of Indonesia does not principally recognize the customary laws.

Outsiders commonly argue that local communities do not have rights to implement customary laws because national park is regulated by government regulation. At local level, members of fishing communities realize that the enforcement of customary laws is very weak. In many cases, sanctions are difficult to fall to violaters, who come from the same village. In contrast, violaters who are outsiders could be easily punished. Sanctions are usually in the form of fines and the confiscation of fishing gears. When the laws are not totally enforced in the whole park region, members of fishing communities feel unecessary to change or revise the current laws.

It is also a problem on how to communicate the laws, especially to outsiders, who may argue that they do not know about local customs, and they may not know that the customary laws exist in Danau Sentarum National Park. According to the present condition, the selected customary laws are only binding for members of villagers from the same communities. To have great influence, it is important for any people including outsides to respect, recognize, and follow the custormary laws when entering Danau Sentarum National Park. It is urgent for the government to recognize and conduct public awareness campaign on the implementation of customary laws in this region.

Large trap
(Illus. Zul MS)

Fish cages for raising toman (*Channa micropeltes*) i n Danau Sentarum. Photo: G Anshari

Figure 2: Large trap and fish cage are commonly found in Danau Sentarum National Park.

The customary laws do not only aim to regulate the use of water resources, but also to govern on how to use forest resources. Local communities absolutely see that forests in the Danau Sentarum is a part of one system. When someone disturbs forests, the impact would fall in the whole area.

Poor management scheme of Danau Sentarum National Park is rooted in the present government policy. As I have mentioned in the previous part, the central government (i.e. the Directorate General of Forest Protection and Nature Conservation of the Ministry of Forestry) has an authority to manage all protected areas. And, Danau Sentarum National Park is poorly managed by this central government agency, namely called BKSDA Kalimantan Barat. The present condition in the park is consequently open access since this central agency does not have enough capacity to control the whole park. At local level, the potential roles of indigenous institutions in park management are not officially respected and admitted by both central and district governments. The latter government feels no responsibility in park management since the designation of protected areas is solely decided by the central government. In theory, it is logical to hope that both central and district government would sit together, discuss, and share authority, responsibility, and budget. This dream is still from reality.

There are many problems to be overcome. In the last 4 years, we have conducted grass root activities, public awareness campaign, and policy advocacy. At local level, we have formulated participatory action plans that aim to protect park resources and secure livelihood of local communities. Since Danau Sentarum National Park is much more popular overseas than in country, we have actively written feature articles on newspapers, and published two books(Information on Danau Sentarum is mostly written by foreigners and in English, which is not accessible to most Indonesians. To take care of this, we have written information on Danau Sentarum in Indonesian language (bahasa Indonesia) on Danau Sentarum National Park. We also conducted several workshops on Danau Sentarum National Park that aims to make both central and district government to meet and discuss the problem. It is a great hope that the government would open their arms to cooperate, and give more rooms for local communities to participate in park management. We have also lobbied the district government to officially recognize the enforcement of customary laws in Danau Sentarum National Park. Our missions are to encourage the government to officially recognize the application of customary laws, and to form collaborative management scheme (Ingles *et al.,* 1999; Carlsson *et al.,* 2005).

Conclusions and recommendations

The underlying factor that inhibits the enforcement of customary laws in Danau Sentarum National Park is strongly sourced in the present management scheme. It is a reality that the designation of protected area usually has negative impact on indigenous people, who live in the park. The case in Danau Sentarum National Park shows that local institutions substantially degrade, and subsequently local communities lose their capacity to play a major role in sustainable park management. This occurs because there is no official recognition on customary laws, great differences in local institutions that apply the laws, and poor laws enforcement. Other intermediate factors that make difficulties in the implementation of customary laws are globalization, and social and environmental change. Local communities also intend to spend more on short term gains than on long term investments that would give sustainable benefits to environment and livelihood. When there are no rules, uncertainty and risk become high. Under open access condition, local communities avoid long term risks or failures by rapidly increasing the present consumption.

We strongly recommend that the present conservation management scheme should be revisited. Otherwise, it would more difficult to save national parks in Indonesia. The governments should give more rooms for local communities to participate in park management. It is a great hope that both central and district governments could establish a strong collaborative management scheme that places local communities as the main actor in park management.

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Lakes, culture and traditional belief: Examples from Nepal

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Abstract

Ponds in many parts of Nepal are personified as deities and are, therefore, considered sacred pilgrimage sites for Hindus and Buddhists, the result of which is the performance of various rites and rituals. The interface between men and lakes has entailed various forms of non-material culture; folklore, customs, traditional knowledge and wisdom. The paper provides an overview of non-material cultural practices of lakes and ponds, drawing on examples from different parts of Nepal. Then the paper focuses on the case study on a high altitude lake, Gosainkunda, located at the southern lap of the Himalayan range. The lake is revered as the sacred place and pilgrims from different parts of the country throng here for religious bathe on the occasions of the full-moon days of May and July and earn spiritual powers and merits for eternal bliss. The paper, talks about major issues facing the management of lakes and their resources in Nepal and makes some policy suggestion for their wise use through the active, well-informed and responsible participation of the relevant stakeholders on the ground so that the non-material culture could be used as an engine for sustainable livelihood of local communities.

Key words: Deity, pilgrimmage, sacred place

Why study lake culture?

People and the world have lived in close contact with wetlands. They are interdependent and interconnected to each other. Due to this, people have been using resources in a variety of ways. This interdependence has evolved many cultures, both material and non-material. These cultures have determined customs and beliefs that still influence the attitude of the contemporary local society. In due course of time, new traditions are emerging, which are tomorrow's cultural heritage in the making. That is the reason why wetlands are regarded as the treasure trove of cultural heritage and of antique and archaeological values, and the power of fertility and good fortune. For centuries, it was thought that bogs, a kind of wetlands were the home of vampires and creatures from beyond the grave (Vinals, 2002). If lost, then humans would loose the precious cultural heritage. Vinals (2002) further mentions, "*For reasons that cannot fully be explained and which are partly attributable to the mysterious nature of wetland landscape and features, wetlands are often associated with gnomes, witches, ghostly occurrence and all kind of legends that give them a special character as an endless source of fantasy. This is partly because lakes and lagoons are regarded as the "eye" of the land, thought which beings from the underworld can contemplate people, animals and plants*." She (p. 185) further reports; "*The legend that presents wetlands as places of spiritual decay has been interpreted by some authors as being a result of the absence of the two active elements (air and fire) and the fusion of the two positive elements (earth and water)*."

Wetlands have been transformed into cultural landscape (combined works of nature and men), in which natural and human made elements are uniquely combined. Wetlands are the actors and producers of our cultural heritage. They are rich and diverse heritage of materials products and non-material culture (folklore, oral traditions, legends, mythology, customs, traditional knowledge and wisdom).

Today's pace of economic development is a constant threat to this cultural heritage. The challenge the contemporary society is now facing in this era is to turn them into an engine for sustainable livelihood of people directly practicing them.

Culture is of two kinds; material and non-material. The paper is about non-material culture of wetlands in general and that of lakes and ponds in particular for lakes and ponds are classified as a type of wetlands. The paper provides a synopsis of non-material cultural significance of some lakes in Nepal. It also talks about the non-material culture of Gosaikund, a high altitude lake situated in the Himalayan region. Major issues and suggestions are presented at the end of the paper.

Non-material cultural values of lakes in Nepal

The IUCN Country Office, Nepal conducted a study on religio-cultural significance of wetlands, mainly of lakes and ponds (Sharma and Bhandari, 1998). A summary of non-material cultural significance of the study can be found in Box A.

Box A: Non-material cultural values of lakes and ponds

- Site for temple (shrine); human cremation and religious celebration
- Refuge for saints, hermits and panhandlers
- Holy place for sacred dips, rites and rituals and votive sacrifice of animals
- Place for recreation, water sports, research and cultural tourism
- Sources of legends, folktales, customs and values
- Special place for Shamanism and Hinduism to earn spiritual merits
- Regarded as having supernatural powers
- Venerated as god or some deity
- Source of drinking and irrigation waters

Examples of non-material culture of some selected lakes and ponds of Nepal are briefly described below. For details, please refer to Sharma and Bhandari (1998).

1. Sapsu Dhap (meaning marsh) of Khotang district is the most sacred site of pilgrimage for the Kiranti people. The Kiranti people make a pilgrimage to this lake every year on the occasion of Janai Purnima (a special festival for binding sacred threads around the wrist) and make their votive prayers and offerings to the lake and offer Panchabali (the sacrifice of five animals). They also offer colorful flags as the carriers of peace. Religious fair (or Mela) is held here to celebrate the occasion.
2. Jata Pokhari (pond) bordering Dolkha and Ramechhap districts, Rin Mokchhe Daha (pond) of Mugu district and Kuvinde Daha of Salyan district are regarded as the forms of Lord Shiva. Lord Shiva is regarded as having the power of fertility. Belief has that if the couples not having any child take a sacred bath in Jata Pokhari and Kuvinde Daha, the divine boon of potency is granted to them. However, it is said that a woman should not visit Jata Pokhari if she is already pregnant. Couples wishing to have son may get the divine boon, if they take a sacred dip in Rin Mokchhe Daha.
3. Local people believe that the water of Bhabishya Bakta Pokhari of Bhojpur presages a danger of big sinister trouble or misfortune if its color is changed into red.
4. Lakes and ponds in the mountainous region of Nepal are regarded as having many supernatural powers. For example in Mustang district people believe that Tilitso Lake has supernatural power for regulating heavy rain and drought, preventing avalanche, epidemics and misfortunes, enabling good agricultural harvest as well as family welfare. Likewise, people worship Bhutarchho Tal on the full moon days of June and September by sacrificing goats to fulfill their wishes. At the time of heavy rain and drought, people worship the Tal believing that the supernatural power of the Tal can stop these calamities and prevent further damages to the local surroundings.
5. Dhumba Tal (Mustang district) is regarded as a sacred place and pilgrims are not, therefore, allowed to carry liquors, meat and garlic, when they make pilgrimage to this place. If carried, there is a belief that frost damages crops of Thini village and flood occurs in the nearby stream.
6. In Siddha Baba Tal (Mustang district) people make pilgrimage to worship the Tal, especially during the time of birth, death and illness in a family. Also people believe that taking a neck-high dip into Tapta Dah – because its water contains high sulfur - would ameliorate the people suffering from various diseases, especially skin disease.
7. The Magars of Baglung district regard Jalpa Khagar Tal as their ancestral deity, Barah and offer sheep and goat. The Magars of Palpa district worship Ramba Pani as the form of Rambha Devi. It is believed that drought may occur if the goddess is not pleased. So, the people worship the deity on the occasions of Tij, Krishna Astami, and Kartik Purnima and sacrifice goats and sheep.
8. Satyawati Tal of Palpa district, Kalingchowk Mai Kunda of Kavrepalanchock and Surma Sarobar of Bajang disctrict are personified as deities. Pilgrims visit Satyawati Tal on the full moon day of Kartik to get their wish fulfilled and obtain divine boon. People remain awake for the whole night by singing, chanting and dancing for the whole night believing that the goddess come here on that day.

A case study of Gosainkunda

Gosaikunda, one of the mountainous lakes, situated at the elevation of 4,260m is in the district of Rasuwa, central northern Nepal, near the capital city of Kathmandu. It is a pilgrimage site for the Hindus. The pilgrimage takes place two times a year; the full moon day of July (Shrawan Purnima) and the full-moon day of June (Baisakh Purnima). The lake is in the cold arid zone and has no tree but only shrubs. The lake is dotted with a few temples of Lord Shiva and deities in the western corner. The image of the Lord is the examples of the 16th century art. Two other ponds are found on the southern lap of the Gosaikunda mountain.

Devotees of Hindu and Buddhism visit the lake to take religious bath and then worship the God, Mahadeva. The Hindus wear the sacred thread and tie it around their wrist. Some children of high caste come here to conduct the first initiation ritual. Usually, the first initiation process is a lengthy ceremony. But on this day here there is no need of conducting lengthy process. The Dhamphu dance, the Sherpa dance and the Bhajan songs are performed by the devotees of different ethnic groups.

Shamans come here to circumscribe the lake with their Mantra and invoke the God Mahadeva to bestow boons upon all human beings. Shamans are required to visit the place to hold over their spiritual powers.

The Newars of Kathamandu venerate the water of Gosainkunda as sacred as the Gangajal (the water of the Ganges is considered pure) and use it to sanctify houses and special sacrament. They also offer the water to the Pashupatinath. Thus, the people of all faiths come here for a complete rid of their sin and earn Punnya (merit).

According to the mythology, once upon a time Lord Shiva came to this place to suppress the burning effect of Kalkuth Bish (fatal poison), which came out of the churning of an ocean between gods and devils. As he was becoming convulsive with the effect of poison, he made three holes by his trident and produced the fountain springs to subdue the fatal effect of the poison. This is how three cascade of water came into being to provide water to the River Trisuli.

The long tradition of religious pilgrims to Gaosaikunda has been handed down from generation to generation through oral traditions, legends and fables. This tradition encouraged the younger generation to visit Gosainkunda to take holy dips on the occasion of Shrawan Purnima. In order to preserve this tradition and support the livelihood of local communities, it is essential to approach the issue in two ways. One is to involve the local stakeholders (the Tamangs, the Sherpas, the Brahamans and the Chhetries) together in the management of the lake in such a way that income goes automatically to local communities. The second is to raise the sentiments and feelings of the pilgrims to conserve non-material culture of this holy place. The third is to encourage the local government, especially the district development committees and the adjoining village development committees to make the long-term plan for the development of the place as the site for religio-eco-tourism because the spiritual sanctity of the lake is the key to the pilgrimage.

Major issues and suggestions

Many of the lakes of Nepal are threatened by the growing human encroachment, subsidence due to the accumulation of silts and sediments, pollution, presence of invasive weeds, particularly Water Hyacinth. Should those problems continue to grow rampant, many lakes would disappear from the relief map, which in turn, lose the rich cultural heritage related to lakes and ponds. In order to safeguard this unique cultural heritage relating to lakes and ponds, these threats should be used as precautions and the burning problems could be converted into resources for the benefits of human beings. In order to conserve the non-material culture of lakes and ponds, the following are suggested.

- Support local programs (activities related to raising awareness, appreciation, inspiration and sentiment of local communities particularly the relevant stakeholders, children, women, youth, etc.).
- Develop action plan in collaboration with the relevant stakeholders with a special emphasis on strengthening the capacity of local people to manage, conserve and sustain lakes and their resources for the benefit of local communities.
- Establish eco-museum for promoting non-material culture of lakes through environmental interpretation, especially intangible heritage in an attempt to pass on the life experience of other cultures. Interpretation tries to go beyond the mere transmission of knowledge; it attempts to generate emotions and attitude changes in visitors by making them more aware of the need to conserve and appreciate cultural heritage.

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Socio-economic dimensions of conservation of wetlands in African dry lands: A case study of River Ewaso Ngiro basin in southern Kenya

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Abstract

Wetlands that occur in arid and semi-arid areas have unique characteristics and support unique biodiversity. The permanent wetlands are relatively small and isolated by large areas of dry land. There are however, numerous temporary or seasonal wetlands that contain water for only short period in the year. These wetlands contain water, a critical resource for all people, livestock, wildlife and plant life. The availability of fresh water minerals, pasture and other useful products attract humans, thereby making the wetlands to become focal points of economic development and indeed urbanization. The changing lifestyles of resident communities, such as increased focus on subsistence and commercial agriculture and sedentarization as opposed to nomadic pastoralism have profound impacts on wetlands and the biodiversity that they support. This paper provides primary data deriving from the authors' own studies of wetlands and their utilization by the local community in the River Ewaso Ngiro basin, southern Kenya. The study results are supplemented with relevant secondary information from other river basin studies in eastern Africa. The paper exposes the immense natural and socio-economic potential of dry land wetlands in enhancing food security and livelihoods in the arid and semi-arid regions *of Africa.*

Key words: Wetlands, characteristics, values, millennium goals

Introduction

Inland wetlands cover about one percent of Africa's total surface area. The major wetlands are the Congo River swamps; the Sudd in the upper Nile, Lake Victoria basin swamps, Chad basin swamps and the flood plains and deltas associated with major rivers, such as Niger and Zambezi. In Eastern Africa, wetlands cover over about 4% of the total area. The major wetlands occur in Lake Victoria basin, in the rift valley and in the floodplains and deltas of major rivers, such as Rufiji in Tanzania and Tana in Kenya. Wetlands are important resource base, which yield a number of valuable goods and services Harper and Mavuti (1996). Wetlands support forests and enhance protection of diverse and rich fisheries, including fishes and mollusks. Wetland fishery contributes about 50% of the fishery landings in Africa Vanden and Bernacsek (1990). Artificial fishing activities are an important source of income and livelihood for many African communities, especially the poor. Wetlands are also important source of water for agriculture, livestock and domestic uses. Agriculture accounts for 88% of the total water use.

In spite of their importance in protecting biodiversity and supporting local livelihoods and economy, wetlands are among the most threatened ecosystems in the arid and semiarid areas of southern Kenya. The success of wetland conservation in Africa's arid and semi-arid areas is dependent on people's positive perception of their environment, sustainable use of natural resources, including land, water and biological resources and development of pro-poor policies and initiatives Maltby *et al.,* (1988). The purpose of this study was to determine the values and uses of wetlands by a local community and identify the socio-economic factors that should be considered when developing sustainable conservation programmes in dry lands. The Ewaso Ngiro basin in southern Kenya provided a good case study because the physical environment and patterns of socio-economic development are generally similar to those of other dry lands in Africa.

This study was carried out in the years 2002-2004 in River Ewaso Ngiro basin in Kajiado District, southern Kenya. The river basin lies within the rain shadow of Mount Kilimanjaro and borders Arusha region in northern Tanzania (Figure 1). The lower part of the basin lies in Eastern Rift Valley between latitudes 36° 05'E and 37° 55'E, and between longitudes 01° 10'S and 03° 01'S. The average annual rainfall is 765mm, but its distribution is bimodal with long rains occurring in March-May and short rains in October–December. However, Ewaso Ngiro basin has consistently high ambient temperature (26–33°C) and high potential evapo–transpiration, which ranges from 1700mm to 2500mm per year. Surface water resources are therefore scarce in the area.

The distribution of wetlands in the study area is strongly influenced by local topography and drainage. Major wetland systems were associated with the Rift Valley, Loita Hills and Nguruman escarpment. River Ewaso Ngiro (180 Km long) has a catchment area of 8536 km^2 and it constitutes the most important wetland system in southern Kenya. The river drains the southern flanks of the east Mau Hills and most of Loita Hills. The river flows into Ewaso Ngiro Swamp before debauching its water into Lake Natron, the most important breeding site of flamingos in East Africa.

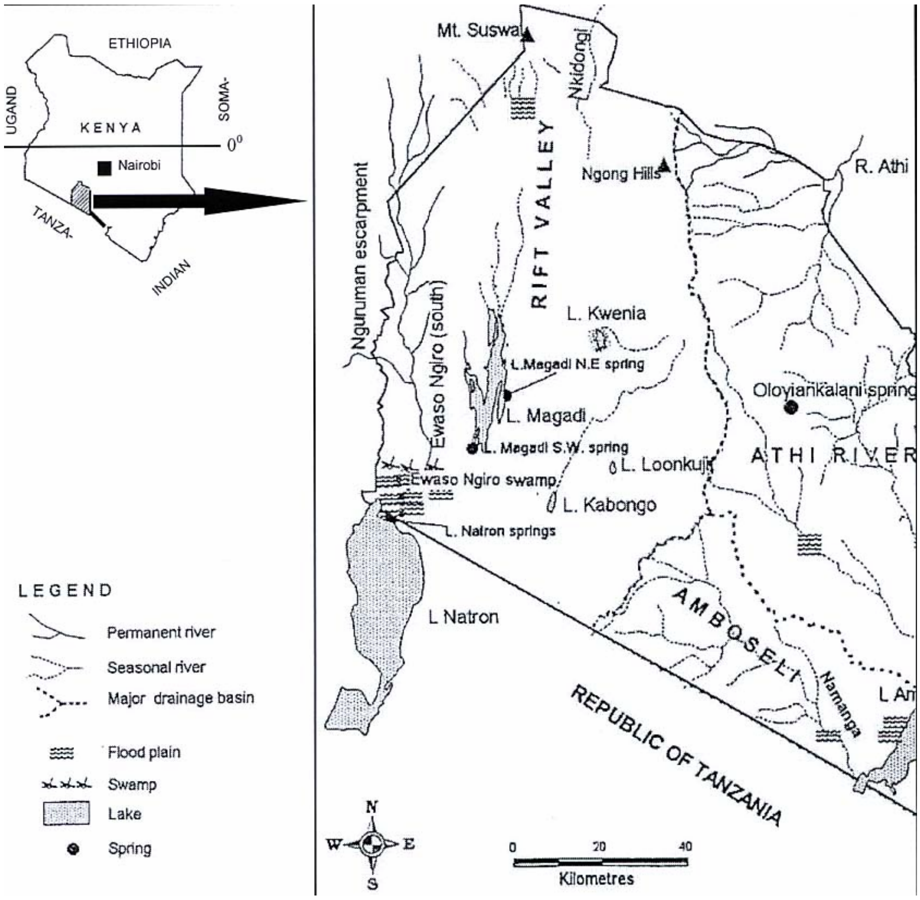

Figure 1: Study area.

About 30,000 people inhabited the basin with an average population density of 3.75 persons per km^2. The biological and physical resources in the basin, including fertile agricultural land, supported about 80,0000 heads of livestock from Kajiado, Narok and the neighbouring districts in northern Tanzania. The basin also supports large numbers of wild animals, including monkeys, gazelles, buffalos, elephants, elands, and Coke's Heartebeest. Most of the study was carried out in villages located in Nguruman, Olkirimatian and Shomploe locations in Magadi Division of Kajiado District.

Materials and methods

A physical inventory of wetlands and an assessment of their characteristics was conducted in Ewaso Ngiro basin. The wetlands were located and their size estimated using topographic maps of scale 1:50,000 and Geographic Information System (G.P.S). The local community was also involved in locating and documentation of wetland values and uses. The wetlands were classified into four broad hierarchical systems and subsystems as described by Cowardin *et al.,* (1979).

Eight villages in six sites were selected for study by systematic sampling procedure. These were settlements located approximately within 3km of the nearest wetland. It was assumed that people who depended on wetlands lived close to it. About 5% of the estimated total population of six thousand people in the eight villages was sampled. The villages were selected at regular intervals but the individual respondents were sampled at random. Information on wetland values, attributes, uses and threats was gathered through direct observation and interviews with local landowners with a view to increasing the range, relevance and reliability of data Theis *et al.,* (1991). In total 300 individuals responded to oral or written questions in a questionnaire administered by the project executants or field assistants. It was also found necessary to target certain respondents in order to get information on specific themes, such as cultural values and utilization of medicinal plants.

In the valuation of wetland resources and attributes, two approaches were used. The first approach was indirect opportunity cost whereby time spent in wetlands to acquire essential resources was valued against forgone opportunities of working elsewhere, earning the money and then using it to buy the items needed from other people or local shops. In the second approach, costs of using a substitute item that was available elsewhere other than in wetlands was use a measure of the value of the wetland product. The results were presented in the form of scores or indices of the relative importance, based on the number of respondents who considered wetlands to be essential (5 scores), very important (4 scores), important (3 scores), not important (2 scores) and no opinion (1 score). Thereafter, the mean scores for each wetland value were computed and compared.

Results

Ewaso Ngiro basin covers a total area of 8,536 km^2 of which wetlands cover 4.5%. The major wetlands were classified into four hierarchical systems each with several subsystems (Table 1). The riverine system comprised all wetlands contained within the channels of River Ewaso Ngiro and its tributaries: Oloibortoto, Entasopia, Sampu and Parkase. These streams drain the Nguruman escarpment and Loita Hills. A forest of fig trees (*Ficus natalensis*) and acacia trees (*Acacia xanthopholea*) occurred all along the river valley.

Table 1: Hierarchical classification of wetlands in Ewaso Ngiro basin.

Wetland system	Wetland subsystem	Typical wetlands
Riverine	Riverbed	River Ewaso Ngiro bed
	Riverine woodland	River Ewaso Ngiro Shrub/woodland
	Floodplain	Ewaso Ngiro Swamp
Lacustrine	Limnetic habitats	Lake Natron open water Marginal cold/hot springs
	Littoral habitats	Unconsolidated Rocky/gravel shore
Palustrine	Seasonal grasslands	Olkirimatian savanna grassland
	Unconsolidated bottom	Water pans/dams
	Shrub/woodland	Spring fed forest floodplain in Nguruman
Artificial	River-based impoundments	Fish ponds and irrigated farmlands
	Palustrine	Waste water lagoons, water storage dams

The Ewaso Ngiro swamp and the flood plain covered 8,000 hectares and the main vegetation types were *Echinochloa* sp. *Cyperus papyrus* and *Typha domingensis*. The river channels contained water throughout the year but the swamp received most of its water during the periods of heavy rain in the catchment area. Apart from surface water flow into the basin, there was additional and more permanent subterranean water supply to the Ewaso Ngiro Swamp from numerous springs that occur at the fringes of the swamp (Table 2).

The lacustrine system comprised all wetlands and deep-water habitats in natural depressions or dammed river channels that lacked trees, shrubs and herbaceous emergent plants. Permanently flooded basins, such as Lake Natron and water reservoirs were typical lacustrine systems with notable wave action at the shores.

The palustrine system comprised all non-tidal wetlands, such as marshes and wet grasslands. They also include fishponds and dams as well as small seasonal pools. Other typical palustrine wetlands were wastewater treatment lagoons for tourist lodges, dispensaries, boarding schools and private farms.

The distribution of all wetlands, however, was strongly influenced by the drainage pattern, local topography, and soils. The two main features of wetlands in this semi-arid region were their fluctuation in size and changes in water quality. Permanent wetlands changed in surface area by 15-30 % between the wet season and the dry season. The fluctuations in wetland size were attributed to the seasonality of rainfall, high ambient temperature and the associated high rates of evaporation. Seasonal wetlands were widespread during the long rains in April and May. For that reason, fresh water was widely available to livestock and wildlife, thereby reducing concentration of animals in the Ewaso Ngiro flood plain. However, most of the seasonal wetlands dried up before the short rains in November and December.

The lacustrine system comprised of alkaline or saline water bodies. These water bodies were permanent, but the water was not suitable either for domestic, livestock or irrigation of farmland. Even the seasonal wetlands contained moderately alkaline water, which was not suitable for human consumption. River Ewaso Ngiro is a crucial source of fresh water for people, livestock and wildlife.

About 80 % of the residents, especially the Maasai community, reared large numbers of livestock. Over many centuries these traditional pastoralists have established knowledge systems, which enable them to optimize utilization of specific products and services from wetlands. Permanent fresh water wetlands were rated as essential for agriculture, water supply and livestock grazing by both farmers and livestock keepers (Table 3). However, farmers considered wetlands to be very important for fisheries while the pastoralists did not consider wetland fisheries to be an important livelihood or income generating resource. Collection of wild food plants and medicinal plants were considered to be important use values by pastoralists but not by farmers. The livestock keepers valued salt licks for livestock and the salt pans, where women collected salt for domestic use or for batter trade.

Table 2: The relative water stability and quality in the wetlands.

Wetland type	Water stability	Relative water quality
Riverine system		
Major rivers	Permanent	Fresh
Secondary streams	Permanent	Fresh
Fresh water springs	"	Fresh
Floodplains swamp	Seasonal	Fresh
Lacustrine system		
Major lakes	Permanent	Alkaline
Hot springs	"	Alkaline
Palustrine		
Seasonal grasslands	Seasonal	Moderately alkaline
Water storage dams	"	Fresh water
Water pans	Seasonal	Moderately alkaline
Rock ponds	"	Fresh water
Irrigated fields	"	Fresh water*

Note: water flowing from irrigated fields is contaminated with pesticides, which are harmful to wildlife and livestock.

Table 3: Socio-economic valuation of wetlands by adult men and women from the pastoralist and farming communities in Ewaso Ngiro basin.

Wetland value/attribute	Pastoralists		Farmers	
	Men (81)	Women (53)	Men (96)	Women (70)
Agriculture	4.1	3.2	4.8	4.9
Fisheries and aquaculture	2.6	2.1	4.1	4.4
Food and medicine	3.2	4.3	1.2	1.2
Livestock grazing	4.9	4.5	4.3	4.2
Biomass harvesting	3.3	2.4	3.2	3.6
Water supply	4.9	4.7	4.3	4.8
Waste water treatment	1.3	1.1	1.4	3.2
Wildlife conservation	1.2	3.5	3.1	2.2
Mineral mining	3.4	4.7	2.1	2.4

While the farmers considered wetlands to be valuable for biomass harvesting, the pastoralists valued them for grazing and watering their animals. Both farmers and pastoralists did not consider wildlife conservation and waste water treatment to be important use of wetlands. The importance of wetlands for wastewater treatment was, however, recognized by operators of tourist lodges, slaughterhouse managers and service institutions, such as dispensaries and boarding schools in Nguruman area. The community, however, recognized the importance of wildlife in the development of tourism.

Gender differences in wetland valuation

Adult men and women from the farming and pastoralist communities valued wetlands differently. Use values allocated to wetlands were not independent of sex of the respondent ($X2 = 8.99$, d.f $= 3$, $p<0.05$). in four indirect use values (Table 4). Gender differences were apparent in the way men and women valued wetlands for livestock grazing, agriculture, water supply and all other values put together.

Table 4: Gender differences in wetland valuation.

Gender	Livestock	Agriculture	Water supply	Other values
Male	32	43	16	9
Female	55	65	64	16
Total	87	108	80	25

Data in the table are numbers of adult men and women respondents who ranked wetlands either as essential or very important for a given user value or attribute.

Women activities, such as fetching water, preparing food for the family, looking after the young and sick animals and selling salt or exchanging it with food crops, showed stronger links with wetlands than those of men in the same community. Hence, gender considerations are important when planning for management of wetlands in the Ewaso Ngiro basin and other semi-arid areas of southern Kenya.

Discussion

The wetlands in the Ewaso Ngiro basin vary in size considerably, expanding during the wet season and shrinking in size during the dry season Gichuki and Oyieke (1997). The wetland ecosystems support valuable biodiversity, including diverse populations of mammals, reptiles, fishes, birds and rich plant communities Gichuki et al (1998). Seasonal and temporary wetlands constitute an important component of the dry lands and their primary function is to increase access to water and maintain the life cycles of opportunistic plant and animal species. Wetlands in dry lands also perform important ecosystem services and functions Shumway (1999). The Ewaso Ngiro wetlands play an important role in disturbance regulation, water supply and flood control. They also support unique species of wild plants and animals. The riparian woodland on the riverbanks and flood plain regulate river floods by slowing down the speed of water and encouraging silt deposition. The silt deposits permit regeneration of pasture and subsistence agriculture.

African wetlands sustain rural livelihoods and provide basic resources that are harnessed for socio-economic development Thieme *et al.,* (2005). In Ewaso Ngiro basin, wetlands support subsistence agriculture, livestock, wildlife conservation, tourism, fisheries, mining of soda ash and other socio-economic activities. In fact wetlands contribute 40% of the total income deriving from local natural resources Gichuki et al., (1998). Wetlands recharge shallow wells with water thereby making it available to people. Overall, water supply is an essential function of wetlands in all Kenya's arid and semi-arid areas.

Availability of freshwater influences the distribution and activities of people, livestock and wild animals Mungai (1992). The occurrence of wildlife and livestock in the wetlands, enhances competition for pasture and soil compaction. In the study area, the foraging activities of large animals and those of people, such as burning of wetlands vegetation, appeared to initiate an ecological succession with the nutritious herbaceous vegetation being replaced by woody vegetation. This has been observed in semi-arid lands of northern Nigeria and in Mali in West Africa Child *et al.,* (1984).

In Ewaso Ngiro basin, livestock keeping is the most important economic activity. Both farmers and pastoralists considered wetlands to be essential for livestock grazing, water supply and agriculture. Other values of wetlands, such as salt licks, food and medicinal plants were of secondary importance, more so to the farmers rather than to the pastoralists. The low user values accorded to natural wetlands as sources of salt, food, medicine and fish can be attributed to the fact that those products were available in shopping centers or in other areas away from the wetlands. In Uganda, Lwanga (1996) found that lower user values were accorded to wetland products, whose suitable alternatives were available in the local markets.

In the study area, women attached higher values to wetland products than men. These gender differences can be attributed to the different roles of men and women in the community. For instance, women were responsible for fetching drinking water and were therefore interested in the quantity and quality of water available within their home range. They were also responsible for collecting fuel wood, nurturing children and caring for young or sick animals at home. The activities of the women brought them closer to wetlands. Despite those gender differences, the community had a strong cultural attachment to wetlands and had established mechanisms that ensured wetland conservation.

Millenium Development Goals (MDGs) address issues of poverty eradication and sustainable development through a set of targets and dates World Bank (2002). In order to ensure achievement of those goals the New Partnership for Africa's Development (NEPAD) adopted a strategic action plan for conservation and management of wetlands in Africa NEPAD (2003). The recognition of the role wetlands in water and biodiversity conservation as well as sustainable development in Africa is relevant to Kenya's current development policies and strategies.

Wetlands can play a significant role in the implementation of millennium development goals. Extreme poverty, hunger and malnutrition are closely related to people's livelihood and vulnerability of households. The communities resident in Ewaso Ngiro basin derive a large part of their food and income from livestock, cultivated crops and wild plants. Availability of water and pasture in wetlands is therefore of direct relevance to poverty reduction (MDG One).

Well-preserved wetlands can continue to provide domestic drinking water as well as water for livestock and farm use. The wetlands would also continue to yield plant biomass and fisheries as well as food and medicinal plants (MDG 7). Hence, maintenance of ecological integrity of wetlands in dry lands of Africa is necessary for ensuring food and nutritional securities as well as a socio-economic development in general Dugan *et al.,* (2002).

Wetland resources can also help to promote gender equality and empowerment of women (MDG3). The dual role of women as micromanagers of family property and providers of food and health care to the family makes them vulnerable to factors that generate poverty and restrict access to education by the girl child Henninger and Hammond (2000). In the Ewaso Ngiro basin, women and children are responsible for collecting drinking water, food and fuel wood. They are therefore vulnerable to the negative effects of poverty and ignorance. The wetlands in the area provide clean or filtered water, fish for protein, fibre and food plants on continuous basis. Availability of those resources allows women to engage in other productive activities and children to go school.

In conclusion, water security is a major issue affecting many aspects of socio-economic development in the African dry lands. In order to ensure water availability wetlands should be conserved by all means possible. The livelihoods of many rural communities in Africa, particularly fishing are tied to wetlands. The whole issue of poverty alleviation and socio-economic development in semi-arid lands is closely linked to wetlands conservation. Indeed, wetlands have immense potential for helping African countries to conserve biological diversity and address the millennium development goals.

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Culture and practice of securing safe water at home; Indigenous knowledge practiced in Chembe lakeshore village at Lake Malawi

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Abstract

The problem of getting safe drinking water is worldwide, but for African people it is most severe. People around Lake Malawi are no exception. Located in southeast Africa, Lake Malawi occupies most of the country's eastern border. Malawi was formerly called "Nyasaland", meaning 'Lakeland' of Africa. Out of 206 nations of the world, it was ranked 199th in GNP per capita in 1999. More than 60 percent of the population is living below the poverty line.

A number of Japanese residents and students have paid regular visits to villages along Lake Malawi since 1995, conducting basic study of social, cultural and ecological problems with local people as resident researchers. Out of the villages that the Japanese group visited, Chembe Village, located in the south of Lake Malawi National Park inhabited by Bantu tribe speaking Chewa dialect, is especially noteworthy. The Village population in the beginning of 20th Century was merely 500, but it has now grown into a big village of about 10,000 residents. This rapid growth has resulted in many social and environmental issues like water pollution and food shortage. Getting safe drinking water is one of the most concerns for the village people.

Thus we have studied the attitudes and practices of getting safe water among village women in 2000, 2004 and 2005. The village people in Chembe had to draw drinking water directly from the Lake until 1998 when 8 boreholes were built in the villages.

Observing these changes we have studied the following topics and this paper focuses on these:

- What was the process that led to the borehole introduction and how the boreholes function for getting the safe water?
- What are the differences of everyday water usage practices before and after the borehole introduction?
- How do women perceive the "safeness" of drinking water and what are the practices of the everyday life?
- How are the people in the village taking care of the borehole or lakeshore environment as the community?
- What is the future vision for securing safe water and enough foods for the village people?

We have found out that women in the village have strong credibility to the borehole water as the drinking water, namely the underground water, but still women have kept strong attachment and commitment toward the lake water for their water utilization by activating their indigenous knowledge and feelings about the lake. In addition the trial check of the borehole water quality implies us the new issue of the water pollution that is the much nitrogen contents of the borehole water, seemingly because of the increased heavy agricultural chemical input resulted from the introduction of the so-called "green revolution" which include hybrid seeds of maize and chemical fertilizer for their food production. Here we have seen a set of dilemma among the new technology and indigenous practice among the people.

Introduction of borehole and the changes of water usage

Chembe Village, located in the south of Lake Malawi National Park is inhabited by Bantu tribe speaking Chewa dialect, is noteworthy because of its rapid population growth. This rapid growth has resulted in many social and environmental issues like water pollution. According to Kyoto-Seika University research in 2002, about 60% of the households do not have toilet and thus many people are using lakes, rivers, bushes and farms as toilets. Feaces and urine are scattered everywhere in the village and eventually these are flushed into the lake in rainy season. Village people had used lake water for all the water related activity from drinking to washing clothes.

In 1997, the Villagers experienced severe Cholera attack although we do not have accurate number of persons affected because of lack of statistics and records. Thus people in the village started to realize the needs for safe water and asked the government to build boreholes in the village. Fortunately enough, one international organization, Save the Children Fund of UK, built 8 boreholes in the village in 1998. After this introduction, people have changed their water utilization customs and started to rely much on boreholes for drinking purpose.

Figure 1 through Figure 6 shows the everyday scenery of water usage as well as firewood collection and scattered feces in Chembe Village at lakeshore and around a borehole. This picture shows that women and children are the major users of water, although small boys under 10 years old take important roles in fetching water in daily life.

In 2004, we conducted interviews with 20 women in Chembe Village in order to find the changing attitude toward the lake water. The respondents were chosen through friendship network and their age range was 20-64 years old. Since this village does not have any resident records, we were not able to make random sampling process which could be carried out in developed countries. The representative ness, however, could fairly be secured because the lifestyle in the village community have much common features and much visible in daily lives.

Figure 1: View of Chembe Village (Aug.2000).

Figure 2: Everyday lakeshore (Aug. 2003).

Figure 3: Washing dishes (Aug. 2002).

Figure 4: Feces behind reeds (Aug. 2003).

Figure 5: Transporting firewood (Aug. 2003).

Figure 6: Introduced borehole (Aug. 2004).

(All pictures taken by Kada, Yukiko except Figure 6 which was taken by Arai,R.)

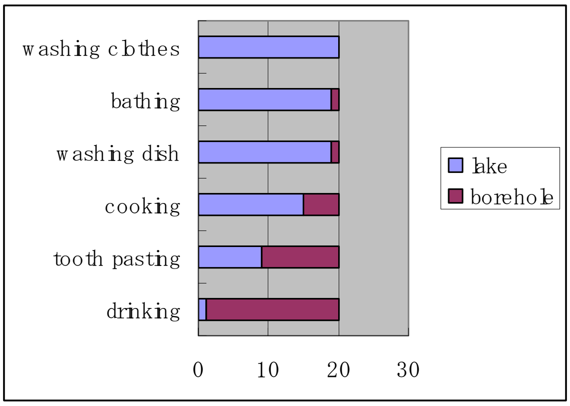

Figure 7: Differentiation of the source of water for daily use after borehole introduction (Aug. 2004).

Figure 7 shows the differentiation in the source of water for daily use between the lake water and borehole water based on the result of interview with 20 women. Before the introduction of borehole, every water related activity used lake water. After the borehole the women started to differentiate water use according to the water quality, quantity and the places of water use. Thus Figure 4 reflects the women's perception of water evaluation in terms of water quality and quantity. We will explain the details in the next section.

Women's perception of "safeness" of the drinking water and the practices in the everyday life

As far as the drinking water is concerned we found that 19 out of 20 women are drawing drinking water from borehole and only one woman aged 64 used lake water for drinking. All the women answered that borehole water is much safer than lake water including the 64 year old lady but she is using lake water for drinking purpose because the lake is close and the taste is better than borehole. In addition she does not have any family member who can bring the distant borehole water for her.

Next water related activity using borehole water is tooth pasting, and as for the cooking only one third of women uses borehole, the rest use the lake water. As for washing dishes, body and clothes, most of the washing activity are made along the lakeshore and use the lake water. In these washing activity not only the quality but also the quantity of the water is thought to be important. In addition most women are fond of washing clothes at the wide and water abundant lakeshore rather than at the boreholes.

Some people talk that “even if we had electric washing machine we may want to rinse the clothes in the lake, otherwise we may not feel the clothes are clean”. Needless to say this village people cannot use washing machine or electricity now although the electricity line was introduced to the village area in 2004.

Based on this interview we found that water related activity which take the water directly into the body are carefully managed to be safe to the body and health in everyday life. But at the same time washing activity at the lakeshore is important for their everyday well beings.

Before the borehole water was introduced the drinking water was fetched from the lake and most women interviewed answered that they had to boil the water for the drinking purpose. The woods for boiling water also had to be fetched from the surrounding forests from early morning and our another interview in 2003 revealed that every women had to fetch the woods twice or three times per week by carrying a heavy loads by head. Thus firewood for boiling drinking water was saved by the introduction of borehole and eventually less labor burden for the women as wall as less ecological burden for the forest which is under the National Park Control.

The way of keeping drinking water reflects detailed perception of women. All the women interviewed were very much careful about the way to keep the drinking water at home. The container for drinking water is “mtsuko” (clay pot) and women are very much conscious that mtsuko keeps water cool even in hot summer. Some of the women have explained why the water kept cool. This is because of evaporation of the clay pot and evaporation does not work in the case of bucket. In addition they are very conscious of where and how they put the pot. Two thirds of the women keep the water pot inside the house at the corner of rooms and the rest of the women keep the pot outside of the house where the wind bring cool air. Under the pot, sand from the lake or an old container is used for helping in the cooling. Some women put the raise cover to decorate the pot. All the women put the lid to prevent insects and dust to enter. Figure 8 through 10 shows how women keep and care their drinking water mtsuko in the house.

Figure 8: Mtsuko outside.

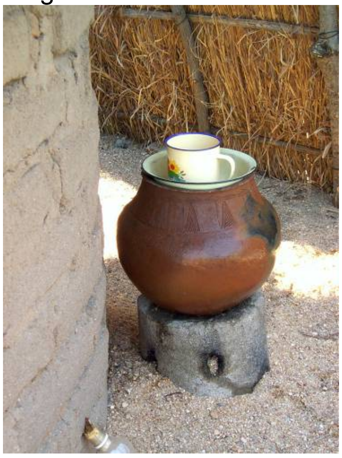

Figure 9: Mtsuko with raised cover.

Figure 10: Mtsuko inside.

Maintenance of borehole and lakeshore environment as the community

Among boreholes introduced into Chembe Village in 1998, one is broken and is not used at the time of September 2005 but all the other 7 boreholes are in operation. We have interviewed the borehole management committee members of all 8 boreholes in order to find out the community efforts for the maintenance of the borehole.

All the boreholes haves management committee, which has a member of 8 to 10 people. Among the 8 chairpersons, 4 are women and 4 are men. All the committees were formed just after the borehole completion in 1998 and at that time the formation of the committee was compulsory ordered by the “Save the Children Fund”. At the same time those committee members were trained to repair the boreholes in case of malfunction.

Among the 8 boreholes only one has never experienced malfunction but all the other have experienced malfunction from 3 times to 10 times. Every time the borehole has been broken, the committee members collect the money needed for the maintenance from the users. Most of the labor were supplied by the committee members themselves and we found that the internalization of the techniques at village level proved to be very important for the maintenance.

The one which do not function now is because of the lack of maintenance money. The committee member emphasized that they need about 5000 kwacha for the purchase of the repair parts but they were able to collect only 1000 kwacha and the village people of this area are forced to walk more to fetch the next borehole water.

New emerging concern in water quality

The farming process of this village has experienced a big change after 1990s, namely the introduction of hybrid maize for the increase of the staple foods. Hybrids maize need the big input of chemical fertilizer and the village people started to apply a lot of chemical fertilizer after the 1990s. Based on the research made by Kyoto Seika University in 2004, about 200kg chemical fertilizer was applied to 1 hectares of maize farm on average.

Since the soil condition of this village is sandy and thus the underground water pollution could be new suspicion. Although the local people have strong faith in the safety of the borehole water, we have tried to make water quality test in Sep. 2005 at lakeshore and borehole and found the result shown at List.1. The test was made by using the simple test kit and thus we need more accurate water quality test for the future, we found out that nutrient level (especially COD and NH4) of borehole water is not good compared with lake water. Among the borehole water, the Fat Monkey Borehole is worst, where maize farm drainage is seemed to be collected at this area because of the terrain of the area.

Table 1: Results of the water quality test at the lakeshore and boreholes.

(1) Lakeshore (20050905)

	Point name	time	COD	NH4	NO2	NO3	PO4
1	Mpani river	14:40	6	0.2	0.02	1	0.1
2	Mchenga under the big tree	15:04	6	0.2	0.02	1	0.5
3	Fat Monkey	15:29	4	0.2	0.02	1	0.2
4	Gecko’s guesthouse	15:54	8	0.2	0.02	1	0.2
5	Steven's house	16:15	2	0.2	0.02	1	0.1
6	Fisheries	16:40	2	0.2	0.02	1	0.05
7	Edge of golden sand	17:08	4	0.2	0.02	1	0.1

(2) Borehole (20050906)

	Point name	time	COD	NH4	NO2	NO3	PO4
1	Dwale	14:52	6	0.2	0.02	1	0.5
2	Pansika	15:08	2	0.3	0.02	1	1
3	Near school well	15:24	8	0.3	0.02	1	1
4	Fat Monkey	15:39	6	0.7	0	0	0.15
5	Madothi	15:56	4	0.1	0	1	1.5

From this result we have to think that the village people in this area is not only suffering from the classic type of water pollution, namely the water pollution from human waste (feces and urine), but also new types of pollution of chemical fertilizer although the effect is not acute for this stage.

Governing the commons: A case of Mbenji Island fishery [Report]

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Abstract

Lakes and their resources have been a source of livelihood for people living close to the coast of these lakes. Across the world, aquatic resources forms an important source of food supply but evidence and reports suggest that aquatic resources are on the decline. In Malawi fish catches have been high but have been on the decline since the on set of two decades. Several reasons have been postulated to explain this and one of them is the role of traditional knowledge in the management and conservation of fish. A research was carried out at Mbenji Island on Lake Malawi. Conscious of the fact that the fish resource cannot be reaped in perpetuity without putting in place some mechanisms. A set of rules and regulations were set that govern the fishery. The rules and regulations included those on fishing times, fishing gears among others. The island fishery has remained relatively productive over the years and the benefits have spread to the communities. There are also some problems that are being encountered including the ever rising pressure from the population, depletion of natural resources, lack ok of resources. However the communities have responded well and are working very hard to ensure the survival of the problems in spite of the problems. Traditional management is a viable option for managing natural resources like fish.

Key words: Traditional management,, Lakes, Aquatic resources.

Introduction

Ever since humans walked on earth, they have sought more knowledge to feed their families, stay health, argue with their neighbours and getting better understanding of their environment. For hundreds of millennia, local needs and constraints and day to day challenges drove the quest for knowledge. Scientific approaches to knowledge generation, as we know them today are, historically speaking, a very recent phenomenon. Though modern approaches have brought about tremendous results, we still have crises. Science and technology alone cannot provide all the answers or solutions to these unsolved problems or how we can overcome them.

As scientists struggle to respond to global challenges, they have increasingly distanced themselves from local pathways of solving problems. Local solutions were even discriminated against as hindering progress, out dated, “old wives tales” or simply just unfashionable. As we modernized our societies, a degree in traditional or indigenous knowledge was not planned for. Hence we overlooked its potential as a resource and even further neglected the knowledge that women and men, families and communities had developed themselves for centuries.

Malawi is a country rich in natural resources: fertile soil forests, wildlife, rivers, lakes and, of course, fish. Conservation and management of these natural resources is therefore a priority in the interest of national development. In keeping with the themes of the conference, this paper intends to share with the gathering the experience of a community based fisheries management program of Mbenji Island on Lake Malawi. However, distant and remote the Mbenji story might be to the majority of the participants, I trust that the story will stimulate debate in the areas of conservation and management of lakes and the resources in them.

Indigenous knowledge and practices are on the decline but continue to exist in some parts of Africa and Asia albeit on a small scale. Lakes and their resources have been a source of livelihood for people living close to the coast of these lakes and even beyond. Across the world, aquatic resources form an important source of food supply but evidence and reports suggest that aquatic resources are on the decline. In Malawi, fishing is one of the most important activities providing employment to many persons and a acting as a major source of protein for the majority of the population. Earlier studies indicate that fish contributes up to 70% of the protein intake. As such there was an interest in conserving and managing the fish resource so as to reap its benefits in perpetuity. Among others, the Government established the Fisheries Department to manage and conserve the fish resource sustainably. The Fisheries Department has emphasized in gear selectivity and restriction of mesh sizes and the enforcing of other rules and regulations like the closing and opening season of the fish. This notwithstanding, fish catches in Malawi have been high in Malawi in 1970s and 1980s but have been on the decline since then. Several reasons have been advanced to explain for this. Fish catches have been on the decline due to among others stagnation of technology used in catching fishes, the growing demand from a prolific population growth and the total disregard of traditional practices in the management and conservation of the fish resource. The declining fish catches are posing serious challenges to the survival and subsistence strategies of the people living along the coast of the lake.

However, on Lake Malawi there remains a thriving yet productive fishing industry that has attracted a lot of interests from social scientists and fisheries researchers. Mbenji Island is situated within the jurisdiction of Traditional Authority Msosa in Salima district in Central Malawi. The Island is about 15 km off the mainland.

Methodology

A combination of different approaches was used in order to understand the Mbenji Island fishery. The first approach that was used was interviewing. Although interviewing has been has the weakness of including fewer numbers of people, it was appropriate in this study because there were a few people to participate in the study. While it is difficult to maintain consistency in all the interviews so that responses are more comparable, the study was not necessarily after comparisons and hence the interview method was appropriate. Interviews can be used with almost all segments of the population and a respondent is allowed freedom to express all his/her responses fully. Interviews have great flexibility. There is always a possibility of repeating or rephrasing questions to make sure that they are understood or of asking further questions in order to clarify the meaning of a response. The interview revealed information about complex, emotionally laden and offered an opportunity for probing the sentiments that may underlie an expressed opportunity. Observational methods are primarily directed toward describing and understanding behaviour as it occurs. The observational methods were structured so that only those aspects that relate to the fishing industry could be observed. All these helped in gathering information for the study.

Background

Mbenji Island is situated on Lake Malawi about 15 Km off the mainland in Salima district in the central region of Malawi. This is in the area of Traditional Authority Msosa.

The Mbenji Island fishery is a classic example of traditional fisheries management system in Malawi where a major aspect of the regulation fisheries involves an annual closed season, which begin on an agreed date in December to April the following year. The existing fishery management program has organically evolved, at least dating back to the colonial time. The initiative to have closed and open season came in place in the 1950s and was started by sub-Chief Msosa (then known as Chief Makanjira) and his elders. The period for the “closed season” was not just imposed “from above” but was a result of careful observation by the Mbenji people of changing and fluctuating abundance of fish catches. Experience taught them that fish catch rates were usually higher after the rainy season between December and April, and therefore concluded that this period could be the breeding season for fish. It was thus necessary to “close” fishing during this period to allow fish rest, breed and mature. Essentially, it was a discovery “from below” not borne of scientific investigations but is today helpful to scientific research in many respects. The people of the area who are predominantly of Yao ethnic descent have a long history of fishing dating back to their native village across the border in Mozambique from where they migrate at the of the twentieth century. They simply extended their age-old fishing practices and skills to their present location.

The management program

Most of indigenous knowledge and practices that have governed and continues to govern natural resources are influenced by the belief in ancestral spirits. Central to the management strategy is the belief that ancestral spirits are custodians of the lake and the fish in it, much as they are guardians of all creation on Mbenji Island Both the closing and opening of the fishery are marked by special traditional ceremonies attended by the fisher folk, traditional leaders, invited government official and, off course, the general public. To mark the opening ceremony, the Chief and a select group of elders go to the island to offer sacrifice *(nsembe)* to the ancestors and pray for blessings and good luck for the coming fishing season. The offering of the sacrifice is meant to venerate the ancestral spirits on the Island, which are believed to be the key to successful fishing on the Island.

Several rules and regulations guide the management program, which include the following: During the closing season, nobody is allowed to stay on the Island or fish in the surrounding water, This allows fish stock to breed and recover. Where as the following are prohibited from the Island during the opening season; Alcoholic beverages; Intoxicating drugs; Gambling; Women; Theft; Setting of bush fire; Killing of snakes; Lamp fishing at night (kauni) and Small mesh size nets (there is specification of gear types allowed on the Island)

Opening and closing ceremony

At the annual opening ceremony all fishermen and invited guests are reminded of the rules and regulations governing the fishery and the relevant penalties imposed on violators. The fishermen are particularly instructed to abide by the rules, lest they jeopardize include all those outlined above, but of particular emphasis is the specification of fishing gears that can be brought for use at Mbenji. The mesh size regulation is strictly enforced, as it is feared catching of juvenile and immature fishes may lead to depletion and extinction of some fish species, thereby depriving future generations a share in this most cherished natural resource, not only in the Mbenji Island area but in the country as a whole.

The closing ceremony provides an opportunity for the Mbenji community to asses and review activities of the year’s fishing season and strategize on the way forward. Selected fishermen present some kind of an “annual report,” giving an account of the status of the Mbenji fisheries in the foregoing year outlining both problems and successes.

Management committees

For the smooth running of the Island fishery management and administration, two committees that work hand in hand are always in place. The first, known as the Main Committee of Mbenji Island Fishery, comprises the Chief's appointees, including some of his own counselors who assist in the day to day administration of justice in his area. Some of the members of the current committee include: Mr Jonn Bvumbwe (Chairperson), G.V.H Mpilingidzo (Vice Chairperson), V.H. Chitepete, Richard Mnumbe, V.H. Mnyanja, Ben kalemba, G.V.H Nyanguru, V.H. Manguwala and a woman. This committee is based on the mainland but oversees affairs related to fishing both on the mainland and on the island.

The second is an elected body based on the Island, and is largely composed of the fishermen themselves and other small time business men. Together these committees look into matters of community policing and enforcement of fishery regulations. They have the powers to independently decide and impose appropriate penalties and fines on violators without involving the Chief. The Chief is only providing with information of the offences as well as name of offenders, and one of the rituals the Chief performs at the closing ceremony is to publicly rebuke and denounce such offenders for their uncalled for behaviour at Mbenji Island. The system has been operation essentially without government intervention. It is only towards late 1990s that the government of Malawi through the Fisheries Department recognized the Mbenji Island fishery. However the Fisheries Depart does not interfere with management and conservation aspects of the fishery, they just offer moral and material support especially during the closing and opening ceremonies opf the island to fishing. Although the committees play the leading role in enforcing regulations, every community member act as a watch dog of the other effect that the entire community is involved in policing, hence in the management program itself. This active community involvement in itself acts as a major restraining mechanism to would- be violators.

The island fishery also benefits from the Beach Village Committees that have been set up by the Fisheries Department in all the fishing committees along the lakes in Malawi. The BVC as they are popularly known play a bigger role in inspecting fishing gears that should be allowed to enter the island fishery. The inspection of fishing gears is a vital aspect that has seen the island fishery surviving to this day. Destructive fishing gears have been mentioned by experts as contributing significantly to the collapse of fishing.

Violators, punishments and conflict resolution

A traditionally based justice system operates in the area and is key to the success of the management program. Violators of any of the regulations are brought to the main committee for "trial" and appropriate fines or penalties are imposed on them. Rather than being exclusively judgmental in handling violator's cases, the committee also uses the "trial" sessions as forums through which conservation knowledge is imparted to those involved. Violators are, for example, briefed on the rationale behind the fishing rules and regulations so that they can begin to think about the rules and penalties imposed positively. The most common form of punishment is the imposition of a fine on the offender, which is usually calculated and paid in kind, precisely in goats. A violator is asked to pay a given number of goats to the committee, and the maximum penalty imposed is six goats. Failure to comply with the decision of the committee on the fines attract even more severe penalties such as confiscation of fishing nets or suspension form further participation in the island fishing activities for a period of no less than two years. Since most of the fishermen make a lot of money from their fishing activities, it has been realized that some of them deliberately violate the rules and regulations because they know that the money they will make would be more than what would be asked to be paid as a fine. However this has been dealt with by first confiscating the fishing gear and kept at the Chief's place for at least 14 days. It is believed that this is a deterrence to wanton disregard of rules and regulations because to stay without fishing for 14 days is a big loss and by that the time of the "trial" the offender may not have any money to pay the associated fine.

It should be noted that resolution of this nature are widely accepted and respected by the communities, and are without questions considered legitimate. It is interesting to note that there is no single case in the history of Mbenji when a decision on a violator was challenged either openly in the public domain or in a government court of law. This has been the case largely due to the transparent nature of the management system that rises above all possibilities of challenging its credibility and legitimacy.

Benefits

The closing and opening of the Island to fishing enables the people in the area to conveniently and effectively combine fishing on the Island with farming on the mainland. Farming, thus, reigh as the dominant homestead preoccupation during the closed season while fishing is a preserve for the open season. Because of the community – based fisheries management system, Mbenji Isalnd produces several thousands of tons of fish in a given year. This translates into better nutrition and higher income levels of the majority of stake holders in the rural economy of the area who are involved in the fishing industry either directly. At the end of each fishing season, families raise enough income to enable them sponsor their children to schools and universities, and many are able to build decent homes for themselves. The effort for managing the resources is thus justified by the fact that it yield tangible benefits or returns to the community, which as it were, bears the cost of management. Indeed, the fishermen of Mbenji continue to achieve optimum fish harvests during every annual open season, which is irrefutable testimony that the Mbenji fishery culture has all the essential elements for successful and sustainable resource management program.

Problems

The Mbenji Island fishery being one of the few productive fisheries has attracted interest of many and sundry fishermen from all parts of the country. This has brought up the question of carrying capacity of the island. Up to now there has not been any study to determine the number of fishing gears at the island. There are fears that the ever increasing number of fishing gears can pose serious challenges to the fishery. There is need to conduct a study that would determine the number of fishing gears that can exploit the fish resource without causing depletion.

The second problem is the deforestation taking place at the island. There are virtually no trees and other plants at the Island. Those that there well there have been used by the fishermen residing at the island. We fear that this might lead to ecological imbalances at the island. We have tried a forestation programme but the drought that was experienced in the country made that the seedlings could not survive. However, we are appealing for more seedlings and other technical assistance in order to replant the island with trees.

The Mbenji Island does not have sanitary facilities and we have problems during the rainy season. Diseases like cholera have led to the death of some fishermen. We are appealing for technical expertise to build sanitary facilities that will be compatible with our situation.

The other problem is lack of resources. As there are more people now than in the past, there is need to intensify the policing activities. Since some of the violators go to far away places, we need a bought and out board motor engine and life jackets. These cost a lot of money. The Fisheries Department has given us some of these materials but they are not enough and we are appealing for more.

Besides these problems, the committee is trying its best to make the island fishery productive.

Traditional use of small *"lakes"* and the subsistence of local populations in African tropical forest: A case of *Bakuele* of southeast Cameroon

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Abstract

Congo Basin is covered with tropical rainforest. In addition to permanent waters, there appears small "*lakes*" or water pools inside forest caused by seasonal flooding. To understand the possible roles of local waters on people's subsistence, a study was carried out among *Bakuele*, a Bantu speaking people of *Dja* basin, Cameroon. People use the waters variously and perception on waters seems to reflect its variety. Fishing is an activity practiced throughout a year. Spatiotemporal change of water level provides various occasions of fishing. Sexual division is observed in fishing methods. Men fish in mainstreams and women and children fish in small *"lakes"* and small water courses by simple method of bailing. Catch by Women seems smaller than men *per effort*, but they never fail to get fish. It is suggested that women's fishing in temporal waters can contribute to household level food security.

Key words: Seasonal flooding, Women's fishing, Central african tropical rainforest.

Introduction

Central african tropical rainforest of Congo River basin has developed both terrestrial and aquatic ecosystems, rich in biodiversity. Seasonal change of rainfall makes the boundary between terra and water unclear. Bantu speaking peoples in the forested area of this region have been described as *multi-subsistence people* [e.g. kimura(1992)], who use forest environment in multiple ways. It is explained that their subsistence is based on shifting cultivation and people lacks animal protein in tropical forest environment. So people need to engage in other activities like hunting or fishing for survival. Some researches reveal that people even consume more time in hunting or fishing than in cultivation. Many anthropological studies treats hunting on terrestrial mammals in tropical Africa. But study on fishing in inland forested area in central Africa is few, despite of rich aquatic fauna (787 spp.: estimated total ichthyofauna of Congo R. [Daget et al.(1984-1991)]), contrary to Amazonia where considerable amount of study exists[e.g. Gragson(1992)]. The aim of this report is to provide some information on people's perception and use on the local waters, with reference to fishing activities.

Material and methods

Research area and *Bakuele* people

The research area is N village of Boumba-Ngoko district, the East Province of Cameroon as located on the shore of middle *Dja* River, on the border of Cameroon and Congo(Brazza)[Figure 1.]. Total population of the village is 405 (December, 2003). The two major ethnic groups inhabit: *Bakuele,* a Bantu speaking people [classified as Bantu A-85b by Guthrie (1971)] and *Baka,* one of central african hunter-gatherers. Majority is *Baka*(282) and *Bakuele* is about one third of *Baka*'s population(123). Two groups have coexisted for more than a century. *Bakuele* is distributing in 5 sub-groups, across western equatorial africa from Gabon to Cameroon. *Bakuele* prefer to inhabit close to water, contrary to *Baka* who prefer inside forest as principal habitat. Every *Bakuele* family keeps dugout canoes for fishing and daily transportation.

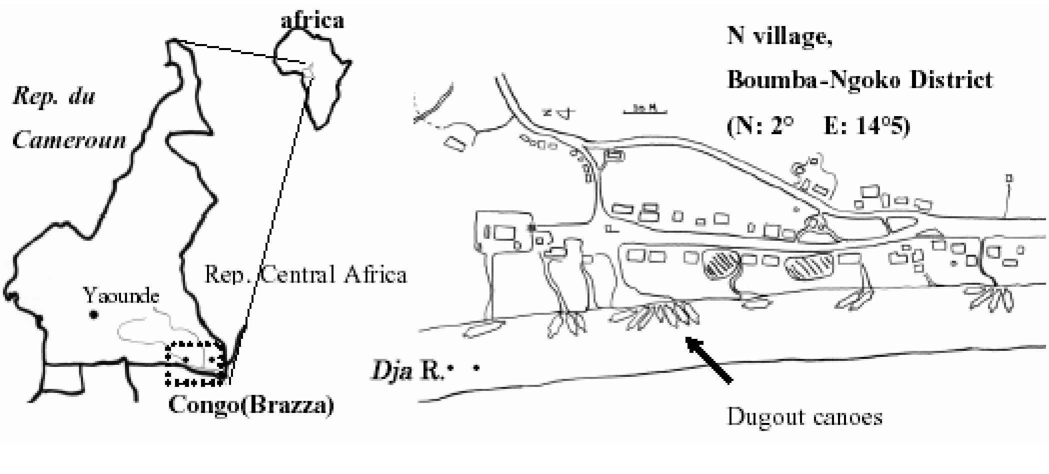


Figure 1: Location of the site and overview of village.

Mean annual precipitation is about 1519㎜ and mean annual temperature is about 25.2℃(Moloundou city, quoted from Tsuchiya et al. (1994)). There are two times of rainy seasons and two times of dry seasons each year. Rainy and dry season visits by turn. Seasonal flooding occurs in the middle of the major rainy season (annually from October to Novembre) (Table 1 & 2).

Table 1: Precipitation and temperature.

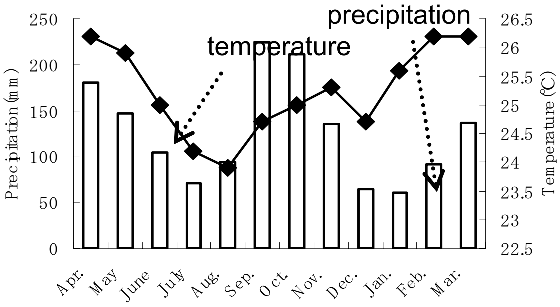
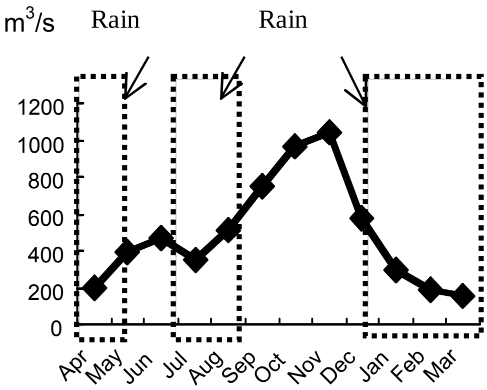


Table 2: Monthly Water flow at *Dja* River.



Climate, hydrology and vegetatation

Change of water level can be a trigger to immigration or reproduction of aquatic animals as fishes [Chapman, 2001] and season of most active fishing coincides low water level periods [Table 2].

Mosaic of various vegetations covered the region such as tropical evergreen forest, tropical deciduous forest, riparian forest, swamps and wetlands, and secondary forests at various succession levels caused by shifting cultivation, etc.

Annual life cycle and activities

Bakuele subsistence economy is based on shifting cultivation. Two types of agriculture exist, traditional shifting cultivation (for food crops like plantain, cassava, and maize etc.) and Cacao cultivation as cash crop. Each household gains most of their cash income by selling Cacao. Schedule of farming, especially of cacao production, determines annual life cycle of *Bakuele* people. People slash secondary vegetations during dry seasons and burn them just before the next rainy season. In rainy season people rest in village, harvesting and processing Cacao beans, and hunting and fishing, and gathering are practiced near around the settlement. In major dry season, many people disperse into the forest, often far from village, for fishing and hunting sometimes more than 2 months. Interestingly, *Baka* also stay long in deep inside the forest for hunting and gathering in major dry season [Yasuoka, in press].

Field Survey and Methodology

Fieldwork was conducted in February 2002, and from December 2003 to April 2004 (total 6 months). French and *Bakuele* language was used. Three key informants are chosen from *Bakuele* residents born and raised up in the village. But information is also collected from any people in the region occasionally. To investigate perception on the local water system, a map was made on rivers, streams and marshes and ponds along mainstream of *Dja* R.. On survey trips I plotted and identified all those waters *with specific local names*, one by one. Local terms related to aquatic environment were also collected. Fishing and the other activities related to water are observed and if possible, participated. Names of fishes, tools and methods are recorded with people's explanation. Data on number of participants, their sex and age, time spent, fishing spots used, and the yields were recorded as possible. Fishes were identified according to field guides.

Results

Perception of waters *Bakuele* people classifies waters into 3 generic categories as *dii*(river), *zaab*(marsh), and *bOOz*(waterpool and small lake). *dii* means watercourses. *mO-dii*(child river) corresponds to streams which pour into *dii* or *bO-dii*(big river) at their mouth. *mO-dii* often disappears in dry season and *bOOz* appears after flooding of major rainy season.[Figure 2.] People is familiar with seasonal extension and decrease of water and has developped several *folk ecological terms* according to their observation [Figure 3]. People's cognition on *habitat of fishes* might be reflected on these knowledges.

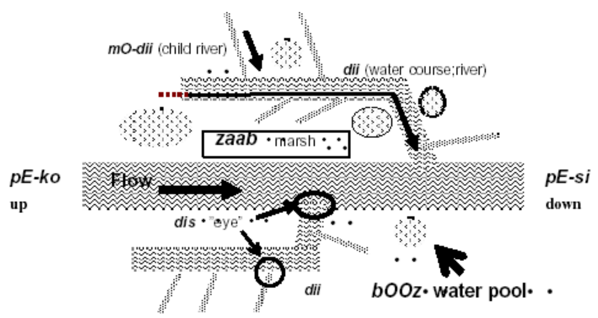


Figure 2: Sheme of *Bakuele* perception on basic water systems.

Use of aquatic environment Drink water is taken from well at village, but also from streams (*mO-dii*) or lakes (*bOOz*). Other essential needs for water (bathing, washing) were satisfied in flowing water (*dii*). River plays a significant role in transportation, especially useful for long distance transport of Cacao. At swamps like *zaab* or *mbal*, where Palmae is dominant, people gather *Raphia* stems and leaves for building material, and men extract Palm Wine. Oil palm(*Elaeis*) is known as multiple used, semi-domesticated plant from west to central africa. Hunting targets mammals attracted to water in dry seasons. Only three hunting methods are recorded: Snares, dog chase, and guns, but gun is rare because it costs. Ritual uses are related to boy's circonscision ceremony and indigenous believes on spiritual existences.

Cognition map of *Dja*

Result of place name mapping is shown in Figure 7, with the distribution of fishing camps (February 2004). More than 110 folk names were collected. This shows that people's geographical cognition extends over 50km from village. I want to make a precised analysis on this map on another paper.

Table 3: General use of aquatic environments.

	Time	Space				
Use	Season	*dii*	*zaab*	*bOOz*	*mbal**	*saka*
Drinking (and cooking)	*Throughout**	++	+	+	-	-
Bathing (body)	*throughout*	++	-	+	-	-
Washing (clothes/dishes)	*throughout*	++	+	+	-	-
Transport with dugout canoe	*throughout*	++	-	-	-	-
Camping	Dry season	+*	-	-	+	++
Palm Wine Extraction	*throughout*	-	++	-	++	-
Roofing/Building material (*Raphia*)	March-June	-	++	-	++	-
Gathering *Inrvingia* nuts	Jul.-Aug./Jan.	-	-	-	-	++
Hunting	Dry season	+	+	-	++	++
Fishing	*throughout*	++	++	++	-	+
Ritual and Ritual material	Dry season	+	+	+	+	-

++: essential or intense use; +: used; - : not used. *mbal* is savanna near watercourses[Figure 3.]. People often make camps on *sangha*, island in water; *throughout* means "throughout a year".

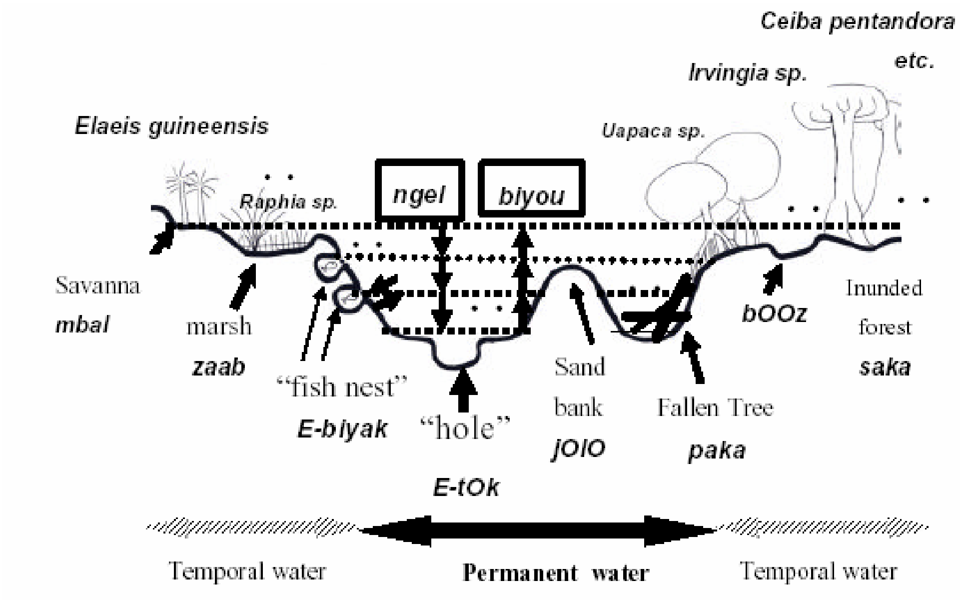


Figure 3: Across cut sheme of river-forest system: topographical sequence in relation to *biyou*(inundation) and *ngel* (water decrease).

Variety of fishing activities

Total number of activities which falls into *u-wa-dii*, *Bakuele* folk fishing category is 23. Table 4 shows the relation between fishing methods and habitat and seasons. Mainstream can be used only in Dry seasons. Contrary, extended lakes in forest is used in flood season. Barrier makes use of seasonal move of fish, in the end of rainy season. *Bailing and digging*, *hook*, and *net* are applicable for situations.

Table 4: Relationship between fishing methods and habitat/ seasons.

Habitat	River (14)			Stream (8)		Lake (4)	Forest (1)
Fishing Methods	• main•	• side•	• bank•	• mouth•	• stream•	• pool•	• *saka*•
poisoning (3)	X	•	•	•	X	X	•
bailing (2)	•	•	•	•	X	X	X
digging out (1)	•	•	X	•	X	•	•
net (4)	X(2)	X	•	X	•	•	•
barrier (2)	•	•	•	X	X	•	•
hook and line (5)	X	X(3)	•	•	X	X	•
spear (2)	•	X	•	•	•	X	X
trap (1)	X	•	•	•	•	•	•
long-lining (3)	X	X(2)	•	•	X	•	•
N methods (23)	6	7	1	2	6	4	1

: DRY season
: throughout
: RAINY season
: Transition from RAINY to DRY season

Sexual division in fishing methods

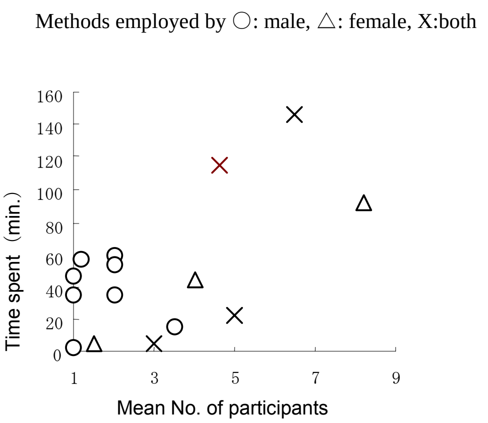


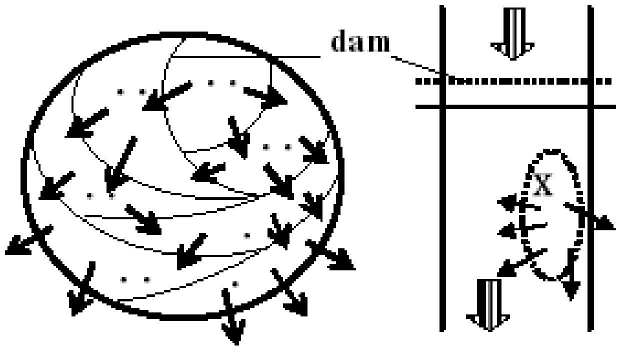
Figure 5: Mean no. of participants and mean time spent for 16 methods. o – digging; ∆ - bailing streams, x – bailing lakes.

Three methods of *bailing(2)* and *digging(1)* is said to be women's fishing and actually these are practiced by only women as long as I observed. Oppositely, *spear, longloning, net* are methods practiced by men. *Poisoning, barrier, hook* are practiced by both sexes.16 methods are observed more than 3 times and Figure 5 shows relationships between mean time spent for each fishing method and number of participants. It's evident that men's methods are practiced not for long time per event and in small number.

And women's bailing fishing, especially in "lakes" are practiced for longtime by many participants. Bailing fishing often requires cooperation among many participants.

Bailing fishing Fig 6.1-2 shows a scheme of bailing procedure at *lake* and stream. Instant dam is made and water inside pool would be bailed out in order as shown (lake). At stream, water run away after constructing dam at upstream of target "hole", **X (*e-tok*)** and then participants bail out the water to catch fish by hands. From downsteram to upstream, bailing dishing can be continued repeatedly.

Fish catch efficiency of Women's fishing per effort, bailing seems to be low, because of it takes long time to construct dams and to bail out water, and furthermore, many participants. But catch by bailing tends to continue constantly and steadily. This is because women can surely get fish by bailing "*as long as there would be fish*"[Table 5].



Black arrows indicates direction of water bailing.

Number in circle indicates the order of bailing.

Figure 6: Bailing at lake (left) and at stream (right).

Table 5: Fish catch by 1 family (2M,4F.1C) during 4 days, at fishing camp (Feb. 2004).

fishing methods	Long-lining	gill net	hook and line	bailing
day 1 (16.5kg)	8.5 (51.5)	0	0	8 (48.5)
day 2 (6.3kg)	0	0	1.5 (23.8)	4.8 (76.2)
day 3 (13.4kg)	4.5 (33.6)	6.7 (50)	0	2.2 (16.4)
day 4 (11.8kg)	0	8 (67.8)	0	3.8 (32.2)
total (48 kg)	13 (27)	14.7 (30.6)	1.5 (3.1)	**18.8 (39.2)**

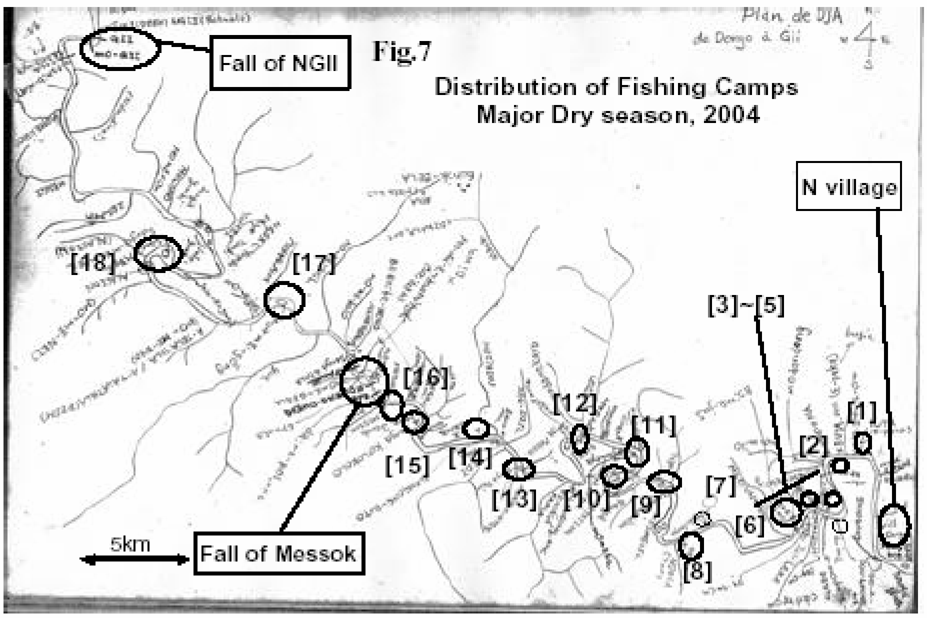


Figure 7.

Distribution of Fishing Camps

In major dry season people use large area of Dja basin by dugout canoe. In 2004, there has been observed 18 fishing camp sites along *Dja* mainstream, distributed approximate 3-40 km (distance in a straight line) from N village (Figure 7).

Discussion

Seasonal Flooding is strongly reflected on People's Knowledge and Behaviour

Multiple use of aquatic environment is enabled by complex water dynamics of terrestrial- aquatic ecotone caused by seasonal flooding. And *Bakuele* has developed fluent traditional knowledge on the seasonal change of the waters.

Fishing can play a role in self-sufficient subsistence economy in tropical Africa

Bakuele is familiar with fishing as "multi-subsistencist". Contrary to Hunting, Fishing can be practiced by everyone of community by many various ways. Especially women's fishing, *elwOk* (bailing) is a remarkable technology in 1) that it doesn't requires special gears or investment and 2) that it is highly applicable to various forms of waters *in tropical forest environment* where women and children can approach, and 3) that it may secure minimum catch of fish as precious animal protein (*titt)*.

Aquatic culture in central Africa: call for information on the other areas

It is suggested that there are some common features in aquatic culture (e.g. fishing methods, fish names, ways of fish preparation), between East and West of Congo basin, in reference to Ankei(1982). To understand the cultural diversity and variation in the use of wetlands in central africa, considerable comparison is needed.

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Traditional water management practices and their implications for improved water governance in Mzingwane catchment, Zimbabwe

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Abstract

'Modern' water resources management concepts, among other things, promote decentralising water management to water users as an essential step towards of integrated water resources management (IWRM). The current wave of water reforms especially in southern and eastern Africa, modeled along the same lines, tend to concentrate on the use of statutory laws, and give little consideration to the potential of already existing traditional practices. However in rural Africa, traditional practices, often based on different ethnic groups, play an important part in natural resource management including water resource management. This paper presents the findings of a case that examined traditional water management practices in the Mzingwane catchment, which forms part of the Limpopo Basin in Zimbabwe. The case revolved around the Sibasa dam, a small multipurpose dam fed by base flow which has survived major droughts, and more significantly has not silted up in its more than 30 years of existence. Key informants and structured questionnaires were used to examine traditional water management practices, in terms of existence and effectiveness for sustaining the rural livelihoods. Implications for operationalising IWRM were also assessed. The study revealed that water resources were governed by customary laws, and were quite effective for achieving sustaining livelihoods. Traditional leaders presided over all water-related issues. It was significant that water was managed on administrative rather than hydrological boundaries, which runs contrary to IWRM conventions. Water resources were also managed as a whole system - during the rain season people used water from other sources, while reserving the dam for the dry season. The paper concludes that it is important to seriously take into account traditional water management practices, as these are vital ingredients for improved water governance and that For IWRM to be effective it is important to first assess the traditional practices that may exist in different communities.

Key words: Traditional Water Management Practices (TWMP), rural livelihoods, water governance

Introduction

Since the early 1990s water reforms have been and continue to be undertaken in many African countries, including Zimbabwe. The reforms are mainly based on the new paradigms for water management, like integrated water resource management (IWRM) and river basin management (RBM), among other things. IWRM is defined as a process that promotes the coordinated development and management of water, land and related resources, in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems (GWP-TAC, 2000). The water reforms are aimed at decentralising water management from the central government to new institutions made up of water users, and in Zimbabwe, this has been done in the form of catchment councils (CCs) and sub-catchment councils (SCCs). The implied and sometimes explicit meaning behind promoting decentralising water management is improved water governance.

The challenge for these reforms relates to what extent these reforms have practical relevance for the majority of the people. Poor water management has been identified as threatening many livelihoods particularly agriculture-dependent rural livelihoods (van der Hoeck, 2001). The question is how can the water reforms improve water governance? Indeed the water crisis in the world has been said to be one of poor water governance (Toepfer, 2004). It is important to observe that the current wave of water reforms especially in southern and eastern Africa tend to concentrate on the use of statutory laws, giving little consideration to the potential of already existing traditional practices. However, in rural Africa, traditional practices, often based on different ethnic groups, play an important part in natural resource management including water resource management.

In this paper a 'tradition', 'custom' or 'indigenous' practice is used to distinguish between what people today consider to be their own established practices and rules governing access to natural resources like water and land, as opposed to outside interventions which propose new rules and regulations to which people are unaccustomed (Dore, 1996). This definition encompasses those 'living traditions', those traditions that were and are still existing, with minimal external influence. In this paper 'traditional', 'indigenous' and 'customary' are taken to mean the same and will be used interchangeably.

Study area

The general study was Zimbabwe, a country located in the Southern African region. It is a land locked country located between latitudes 15^0 30' N to 22^0 30' S, and longitudes 25^0 W and 33^0 E. This study focused on wards 3 and 11 of Insiza district, one of the over fifty districts in the country. A ward is made up of 6 villages with each village estimated to have 100 homes. Insiza is located in Upper Mzingwane, one of the four sub-catchments of the Mzingwane catchment. (The Mzingwane catchment is one of the seven catchments of Zimbabwe, and is part of the

Limpopo Basin, which falls in the Zimbabwean side). The study focused on Sibasa reservoir, which is a water source for three wards.

Sibasa dam is a small multi-purpose a reservoir, which was constructed in 1954. It is perennial and is the only source of water during the dry season. It is said to have survived the 1992 drought, the worst in living memory of Zimbabwe. The dam is presumably supplied by base flow, though this is yet to be confirmed through studies. Its overall management is under Chief Sibasa, who lives less than 2 kilometers away from the dam. The water is mainly used for domestic use and livestock watering in the winter season. During the rain season the water is used minimally for only domestic use by the people with in less than 4 kilometers around it. No livestock is allowed to drink from this dam. During the rainy season, the livestock are watered from other dams like the Tekwani, Imvu, Sidleni, Kaba, Emganwini, Duze, Simezi and Mawela dams. These are approximately 6-10 kilometers away. In the dry season the water in the dam is used only for domestic use and for livestock watering, while there is a nearby well used for domestic water. During the dry season, people bring their livestock from as far as 15 kilometers away to water their livestock.

This research used the case method, as this helpful in drawing out data through an in-depth study. Unstructured and structured questionnaires were used. Data collection was through unstructured questionnaires completed by informal interviews, structured questionnaires administered to individual households, and the respondent's impressions. The data collected was analysed using the statistical package for social sciences (SPSS).

Research findings

Authorities responsible for setting up rules concerning the water resources

The individual households were asked about the authorities responsible for setting up the rules and regulations pertaining their water resources.

It was observed that across the three villages, the rules pertaining to the water resources were basically set-up by both the traditional leaders and the community including dams, boreholes and the unprotected wells. The councilor was not involved at all. Key informants characterised the rules pertaining the water resources as customary. In other words the rules existed since time immemorial, and had been set-up by the ancestral traditional leaders, together with the community. The rules are not written, but everyone was aware of them. However, the rules pertaining water for irrigation were set-up by 'other' authorities, which included ZINWA, the irrigation department from the ministry of agriculture, and AREX officials.

Management of Infrastructure

Table 1 shows that the day-to-day management of the boreholes and reservoirs was mainly done by members of the community, who worked together with the neighbourhood police and the traditional leaders. It is significant to note that the neighbourhood police were chosen by the people and are voluntary. While the day-to-day operation of the reservoirs and infrastructure was the responsibility of the community, the neighbourhood police ensured that all culprits caught breaking the rules were taken to the village head, who presided over such issues. The community was also responsible for keeping to the good side of the law. This included ensuring that they did not wash directly in the dams, or to fish with a net in the dams, ensuring that their livestock do not drink at the dam during summer, and abstaining form using scotch carts(Scotch carts are donkey driven carts.), trucks and/or drums to fetch water from the dam.

Table 1: Responsibility of management of the reservoirs and boreholes.

Responsible Authority	Day-to-day operation (%)	Maintenance of infrastructure (%)	Ensuring good water quality (%)	Managing conflicts (%)
Traditional leaders	20.0	17.7	23.1	60.8
Councilor	0.0	3.8	0.0	2.5
Neighbourhood police	27.8	0.0	20.0	0.0
Community	49.4	67.1	10.1	31.6
Other	3.8	11.4	46.8	5.1

Interviews with key informants revealed that while it was the role of the Village Health Worker (VHW) to ensure that the water quality of the dam was good. It was the responsibility of the neighbourhood police, the community and the traditional leaders to watch out for anyone polluting the water. The neighbourhood police also dissuaded people from washing their clothes with in 50 meters of the water source and any livestock getting within 20 meters of the water sources (dams). The maintenance of the infrastructure was the responsibility of the community. This includes, among others, scooping silt from the silt traps, removal of vegetation around the dam wall. However, in other cases like when the dam wall needs to be repaired, it was the responsibility of the traditional leaders to report this to the relevant authorities, including government agencies such as DDF. Management of conflicts was the responsibility of the traditional leaders in collaboration with the community.

Management of unprotected wells was exclusively done by the owners. It was only when disputes or conflicts arose that the village head and maybe the chief or headman got to be involved. The councilors only got involved in the management of dams and boreholes when there was any need for external funding.

Management of conflicts

The respondents were asked about the relevant authorities for managing conflicts concerning their water resources according to the various water uses. The results are presented in the Table 2.

Table 2: Authority responsible for settling conflicts concerning water resources.

Authority for settling water conflicts	Domestic (%)	Livestock watering (%)	Small garden watering (%)	Irrigation (%)	Brick making (%)
Traditional leaders	59.5	32.9	31.0	16.1	56.6
Councilors	0.0	0.0	0.0	6.5	0.0
Community	17.7	22.9	20.7	0.0	34.4
Other	1.3	12.9	0.0	77.4	0.0
Both Traditional leaders and the community	21.5	31.4	48.3	0.0	9.4

Table 2 confirms the observation that the traditional leaders and the community were the major authorities involved in the management of conflicts concerning domestic water, water for livestock watering, water for small garden watering and water for brick making, while the councilors were not involved at all. The case of water for irrigation was different in that the management of conflicts was mainly by the irrigation committee, and to a certain extent by the traditional leaders. Conflicts over the water resources were not common, but once there was a conflict, the village head would try to solve it. If he failed he then took it to the chief or headman. The chief then tried to solve it between him and the village head, with the concerned parties. However, in cases where the conflicts were complex, and involving a big part of the community, then the rest of the community was called to witness and assist in solving the conflict. Some of the respondents mentioned that the commonest conflicts were usually over the unprotected wells, where people try to fetch water from their neighbours' wells without permission.

When the chief decided to involve the community in solving a conflict, they gathered in the village court, a building near the chief's residence. The chief together with the village head chaired the village court. One of the common conflicts mentioned was when invasion of people's livestock from other wards during the droughts.

Main institutional actors

Traditional leaders and spirit medium

The traditional hierarchy concerning water management comprised the chief being at the top of the top with the headman and village head being below, in that order. There used to be the kraal head below the village head, but at the time this study was carried out, this had been scrapped due to unknown reasons. The spirit medium is another traditional leader who was solely responsible for communicating with the ancestors, especially for rain-making purposes. The Chief is the head of all the traditional leaders, but in cases where the chief is too far from some villages, a headman is put in position to be the immediate substitute for the chief. However, if the headman fails to handle some issues, he can then pass them on to the chief. The village head handles matters at village level, which entails individual households, while the kraal head used to be responsible for 5-7 households, but this position was scraped since about four years ago.

Other relevant officials

Other relevant authorities mentioned with regards to water resources during the interviews were the ward councilors, village health workers (VHW) and the AREX officials. Ward councilors are not involved in the day-to-day management of the water resources. They could get involved when there was a new project like a pipeline or a new borehole or new dam being offered by the government. Their role as regards water resources management also included, to a certain extent, to report issues like any need for development of the water resources to the government. This could be the need of a new dam or borehole or the site for a new borehole. The councilors may also intervene in solving some extreme conflicts, but this was only at the invitation of the chief. The role of the AREX officials was focused in the irrigation scheme where their basic role was to help the irrigators in agricultural issues, among which include good soil water conservation practices.

In an effort to establish the extent of launching of IWRM in this area, the respondents were asked about their knowledge of the newly introduced IWRM-driven methods of water management.

They were asked whether they had heard of ZINWA or met someone from there, whether they had heard of the new institutions of water resources management, the catchment councils (CCs) and the sub catchment councils (SCCs). The respondents were also asked about their knowledge of the new

Water Act of 1998. Their responses across all three villages are presented in the Figure 1.

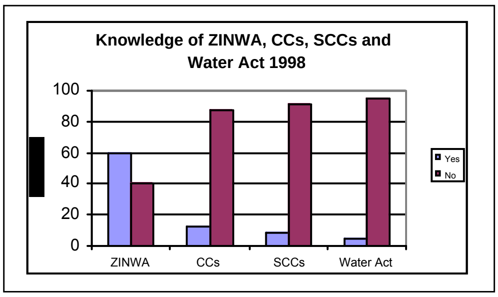

Figure 1: Knowledge of IWRM- driven structures.

Discussion

As the findings have revealed, the management of the water resources across the three villages was informed by customary practices, under the leadership of the traditional leaders. The TWM in this area spanned the entire spectrum of issues: overall water use and access including the rules and regulations; conflict management and handling of offenders; handling of water development issues, and issues pertaining water resources conservation. Jurisdiction over natural resources, customary rules governing the distribution of water and the procedures for initiating development programmes, were managed “traditionally” (see Katerere and van der Zaag, 2004; Maganga *et al*., 2003).

It was clear from the findings that IWRM-driven structures are still quite alien to the people, who are, in spite of everything, still dependent upon customary law for the management of their water resources. This is in spite of the country’s statutory law for water management, that is, the water Act 1998, which instituted the water sector reform, six years ago. Other related such cases have been revealed, especially around Africa (Boesen *et al*., 1999).

From the findings, it is observed that the majority of the rural water users was not consulted during the water sector reform, and was thus ignorant of this reform and the structures that the reform introduced; the CCs and SCCs, and the new water act of 1998. Those who had heard of ZINWA are not even ware of its role as the national water authority for regulating and operating the water resources. The process of the water reform was supposed to be participatory, involving the lowest possible level. However, the findings expose that this was not the case as regards the rural stakeholders. Researchers reveal that the consultations leading to the water reform focused more on the major water users; the large-scale commercial farmers and the urban water users, neglecting the rural water users (see Kujinga, 2002; Dube and Swatuk, 2002; Latham, 2002).

An examination of how these people have relied on these customary water management practices to survive in such an arid area, suggests that these practices have been efficient in sustaining livelihoods. In the case of this study, the chief reserves the Sibasa dam for the dry season. Therefore it would be more empowering if introduction of new modern methods of water resources management built on such practices, for effective governance of resources.

TWM systems have long been in existence and are vital to the rural people in terms of water governance, food production and sustaining livelihoods. Hence it is important to sustain or preserve such practices. In addition, most modern practices are alien to the people, for example the IWRM-driven like hydrological boundaries, CCs and SCCs, and catchment outline plans. Since traditional practices, traditional knowledge and customary law are passed down from generation to generation, they will die out completely if they are not practiced continuously, or protected (ISW, 2001). The role of customary law and practice in the governance of water resources, which has existed since time immemorial, might be eroded by movements that are taking place in society due to globalisation processes and trends of modernity.

Recommendations

When introducing the modern practices, there is need to address gaps between the newly introduced IWRM and the water management at the local user scale. The following practical and academic suggestions are proposed:

- Formally recognise the validity and legitimacy of local community-based water systems – as longs as they progressively comply with constitutional imperatives and principles of human rights.
- Recognise small-scale rural water uses for livelihoods as lawful without burdensome administrative obligations, for example by categorising this water use in the ‘domestic’ category so the these rural people do not have to pay high prices for the water.
- Train both scholars and practitioners in studying local community-based water arrangements.
- Avoid imposing alien and unrealistic organisational and registration and requirements that hamper the functioning of effective and inclusive community-based arrangements.
- Learn from the experiences elsewhere, about synergetic co-existence of plural legal frameworks from countries that have achieved this, like Tanzania.

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Citizen Participation in Lake Management in the Main Lake Areas in Japan

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Abstract

Following on from the period of rapid economic growth at the end of the 1960s, serious water environmental problems have occurred in waterside regions of Japan. These problems have in turn given rise to a number of secondary problems, which include industrial problems, employment problems and economic compensation problems.

Such problems are particularly acute in lake areas. Among these lake areas are some regions where, starting from the final years of World War II, lakes were extensively reclaimed and drained in order both to secure farmland zones and raise agricultural production. A wide range of other serious water environmental problems have arisen, including changes in the lake landscape caused by urbanization in lakefront regions; aggravation of the lake environment, which presents itself in the phenomenon of water pollution; eutrophication with consequent blue-green algal bloom and freshwater red tide; persistent organic pollutants; low oxygenation of lake bottoms; and the destruction of the intrinsic ecosystem by the invasion of introduced species.

Various countermeasures have been implemented to cope with the complex changes in the environment surrounding the lakes, in accordance with the particular regional characteristics of each lake area. In recent years, increasing attention has been paid to the importance of partnerships between various regional participants, who include local residents, NPO/NGOs, local government, entrepreneurs and scientists; and we are now seeing the gradual emergence of lake management that draws on citizen participation.

The purpose of this study is to (1) review the present condition of the main lakes in Japan and their surrounding environment, and get an idea of the activities and networks that are being built up for lake environmental conservation; (2) after comparing and considering local residential participation in lake management in typical lake areas in Japan, investigate how lake management ought best to be carried out with citizens' initiatives.

Key words : Citizen Participation, Lake Management, Partnerships

1. Introduction

Following on from the period of rapid economic growth at the end of the 1960s, serious water environmental problems and water contamination problems have occurred in river and costal areas and other waterside regions of Japan. Typical examples of such problems include the extinction of purple laver in Tokyo Bay caused by water pollution and oil spills (1968), sludge pollution in Tagonoura (1970) and an outbreak of red tide in the Seto Inland Sea (1972) (Hirai, 1995)'*. These problems have in turn given rise to a number of other, secondary social problems, which include industrial problems, regional employment problems and economic compensation problems.

Lake areas also have faced water environmental problems similar to those occurred in river and costal areas. In addition, starting from the final years of World War II through the post-war period, some lakes were reclaimed and drained in order both to secure farmland zones and raise agricultural production. Examples include reclamation of the attached lakes of Lake Biwa and the Hachiro Lagoon reclamation project. However, thanks to the recent rend to review large-scale public works projects, reclamation and desalination works on Nakaumi (a national project of Nakaumi land improvement) was suspended in 2004.

In addition to problems brought about by reclamation, a wide range of other serious water environmental problems have arisen, including changes in lake scenery caused by urbanization in lakefront regions; eutrophication with consequent water pollution, water bloom and freshwater red tide; aggravation of the lake environment, which presents itself in the phenomenon of rising chemical oxygen demand (COD) and low oxygenation of lake bottoms; and changes in the ecosystem by the invasion of introduced species.

This study examines the present conditions of main lakes in Japan and their surrounding environment from the viewpoint stated above for the purpose of grasping the characteristics of citizen participation-based lake management in each region.

2. Framework of Study and Research Method

In this study, Section 3 summarizes the characteristics of main lakes in Japan based on literature research. In Section 4, the research regions of this study are selected on the basis of the findings in Section 3 and the outlines of characteristics of these regions are given. In Section 5, in addition to literature research and interviews, field surveys are conducted (2000-2005) with the aim of grasping the characteristics of lake management involving citizens in each region by making a comparison among regions. Section 6 presents the conclusions of this study and gives an idea about future research.

3. Characteristics of Main Lakes in Japan

Table 1 gives 15 largest lakes in Japan in decreasing order of size. As the table shows. Lake Biwa, Lake Kasumigaura, Lake Saroma and Lake Inawashiro, which exceed 100 km^2 in area, are deemed to be very large lakes in Japan. Compared with their counterparts in other countries, however, they are rather small. Furthermore, larger disparity can be seen in the volume of water between Japanese and foreign lakes than the lake area difference.

Table 1 : Outline of main lakes in Japan.

Lake Name	Prefecture	Area(km^2)	V'olume(km^3)
Lake Biwa	Shiga	670.5	27.5
Lake Kasumigaura	Ibaraki	167.6	8.5
Lake Sarorna	Hokkaido	150.4	1.3
Lake Inawashiro	Fukushima	103.3	3.9
Lake Nakaumi	Shimane-Tottori	86.3	-
Lake Shinji	Shirnane	80.3	0.4
Lake Toya	Hokkaido	70.7	8.2
Lake Harnana	Shizuoka	69.0	0.3
Lake Towada	Aomori-Akita	61.0	4.2
Lake Kitaura	Ibaraki	35.2	-
Lake Tazawa	Akita	25.8	-
Lake Mashu	Hokkaido	19.2	2.7
Lake Suwa	Nagano	12.9	6.3
Lake Chuzenji	Tochigi	11.8	1.2
Lake Ikeda	Kagoshima	10.9	1.5

Note: This table was compiled on the basis of data issued by Lake Biwa Research Institute (1993).

4. Selection of Research Areas

4-1. Research Areas

This study examines five lake areas - the Lake Inawashiro area (Fukushima Prefecture), the Lake Kasumigaura area (Ibaraki Prefecture), the Lake Suwa area (Nagano Prefecture), the Lake Biwa area (Shiga Prefecture) and the Lake Shinji and Lake Nakaumi area (Tottori and Shimane Prefectures) - as examples of regions where citizens are involved in lake management that reflects regional characteristics. Figure 1 indicates the locations of these areas on a map of Japan.

4-2. Outline of Research Areas

The outline of lakes covered by this study is shown in Table 1. All of these lakes

are freshwater lakes with the exception of Lake Shinji and Lake Nakaumi, which are brackish lakes. In terms of lake size, Lake Biwa, the largest lake in Japan, has an area of 670.5 km , followed by the second-largest Lake Kasumigaura of 167.6 km", the fourth Lake Inawashiro of 103.3 km^2, the fifth Nakaumi of 86.8 km^2, the sixth Lake Shinji of 80.3 km^2 and the 13th Lake Suwa of 12.9 km^2.

In this study, Lake Kasumigaura represents the area covering three lakes - Kasumigaura, Kitaura and Nishiura. Lake Kasumigaura has the longest length of lakeshore in Japan, of 252 km, longer than Lake Biwa's 235 km. This is because Lake Kasumigaura has indented lakeshore and also because rivers that links the three lakes are included in the calculation of the length of lakeshore.

5. Characteristics of Citizen Participation-Based Lake Management in Research Areas

5-1.Lake Inawashiro Area

In the area covering Lake Inawashiro and the group of lakes in Urabandai, the development of water sources and recreational facilities have arisen concern over the quality of lake water and the lakefront environment. In order to preserve a good water environment through mutual cooperation among citizens ofFukushima Prefecture, local residents, lake users, businesses, Fukushima Prefecture and related municipalities, the Regulations Concerning Conservation of the Water Environment of Lake Inawashiro and the Group of Lakes in Urabandai in Fukushima Prefecture was established in February, 2002. A key feature of these regulations is involvement of not only local residents but also tourists and other lake users. Various entities concerned with these lakes got together and established a fund named *"Kirameku Mizuno Furusato Bandai, Miziimirai Kikin"* in a bid to dispatch information on their water environmental conservation activities and develop such activities.

Furthermore, based on the provisions of the regulations mentioned above, the Water Environmental Conservation Promotion Plan in Lake Inawashiro and the Group of Lakes in Urabandai in Fukushima Prefecture (2002-2010) was established in March, 2002. This plan is a set of regional programs and it has been established on the basis of the Basic Plan of Water Environmental Conservation in Fukushima Prefecture (1996-2010), which covers the entire prefecture. In this plan, specific targets have been set for conservation of water quality of Lake Inawashiro and five lakes out of the group of lakes in Urabandai—Lake Hibara, Lake Onogawa, Lake Akimoto, Lake Sohara and Bishamon Swamp. At the same time, concrete measures that are necessary to accomplish these targets have been provided in the plan. A fundamental goal of this plan is, as represented by its subtitle, to "Pass Azure Lake Inawashiro and Clear and Blue Lakes in Urabandai on to the Next Generation." In addition, three targets have been set—the conservation of quality of water, the waterfront environment and the formation of water cycle in the basin.

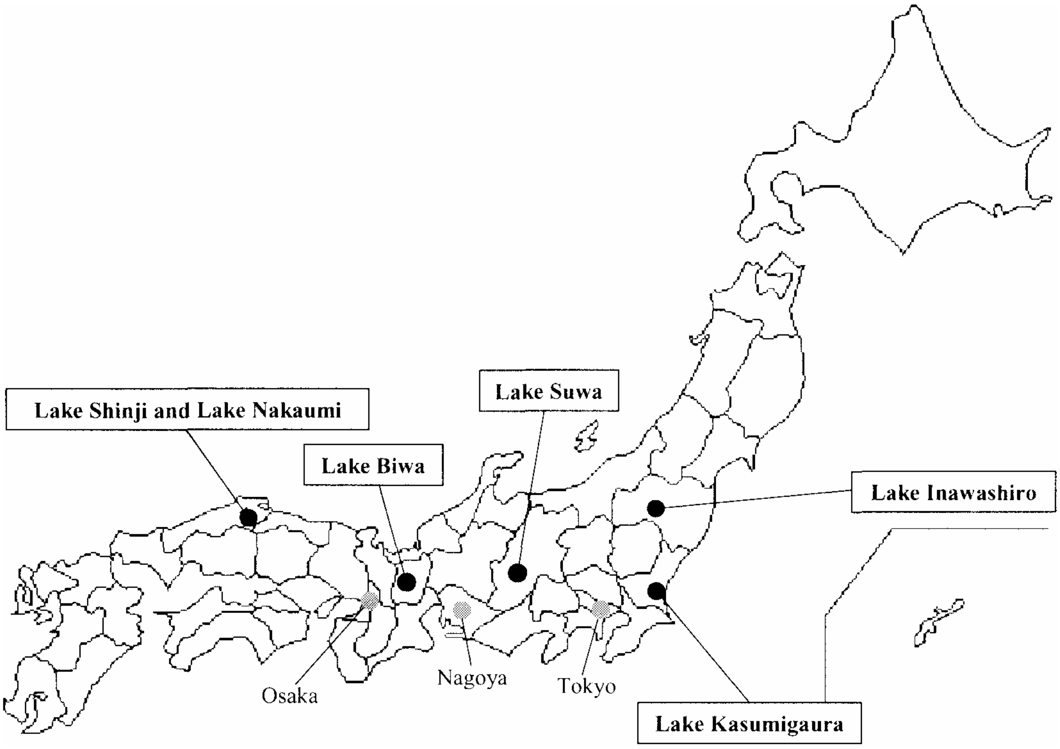

Figure 1: Location of study areas.

5-2. Lake Kasumigaura Area

Since the designation of Lake Kasumigaura as a lake needing special measures based on the Law Concerning Special Measures for Conservation of Lake Water Quality (the Clean Lake Law) in 1986, Ibaraki Prefecture has set its Lake Water Quality Conservation Plan every five years. Under the fourth plan (for 2001-2005), the prefecture aims to recover the level of water quality in the second half of the 1960s (COD of 5 mg/1) in a medium term, with its ultimate goal set at COD of 3 mg/1 or lower. Thus, the prefecture envisages Lake Kasumigaura that is friendly and approachable to every citizen of the prefecture. Meanwhile, A Vision for Environmental Creation for Lake Kasumigaura, which proposes an ideal situation of Lake Kasumigaura in the 21 st century, was presented in 1997. To embody this vision, the Kasumigaura Environmental Creation Project Promotion Plan—Basic Plans and Action Plans were established in 1998, and they are now in progress.

For the five years starting from 1997, the Science and Technology Promotion Foundation of Ibaraki, as a core organization, had been promoting the Project for Water Environment Renovation of Lake Kasumigaura, a joint research project mobilizing regional resources in Ibaraki. Furthermore, the Foundation launched in 2004 a new research project, the Biomass Recycle Development Project in Lake Kasumigaura, which aims at purification and reuse of organic waste, as a project promoting cooperation between government, industry and academia in urban areas, on the is, as represented by its subtitle, to "Pass Azure Lake Inawashiro and Clear and Blue Lakes in Urabandai on to the Next Generation." In addition, three targets have been set—the conservation of quality of water, the waterfront environment and the formation of water cycle in the basin.

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5-4. Lake Biwa Area

Following the completion of the Lake Biwa Comprehensive Development Plans for over 30 years, Shiga Prefecture initiated in March 2000 the Mother Lake 21 Plan (Lake Biwa Comprehensive Conservation Plan). The plan specifies regional units on the basis of river basins. In addition, seven river basin units are provided, with each administrative office's jurisdiction taken into consideration to ensure uniformity at the level of implementation of measures. In each river basin unit, various programs that reflect regional characteristics are carried out in collaboration among such parties as local residents, companies and the administration.

According to the results of examination by Yamamoto et al, (2003) [)], these comprehensive environmental conservation programs by river basin units in the Lake Biwa area can be characterized by united activities of upstream, midstream and downstream parties concerned. To be more specific, the parties concerned in each regional unit share information on their circumstances and relevant problems to gain mutual understanding. Then, upstream, midstream and downstream units in each river basin get together and act as one to deal with issues through such familiar organizations as neighborhood associations. Ultimately, such activities will develop into a partnership aimed at environmental conservation of Lake Biwa, for which citizens, companies and the administration will take the initiative. As a base for such programs, a council will be formed by each of the seven river basin units in the Lake Biwa area to draw up an agenda for each unit.

5-5. Lake Shinji and Lake Nakaumi Area

The area covering Lake Shinji and Lake Nakaumi, which are brackish lakes, extends across the border between Shimane Prefecture and Tottori Prefecture. Since the major part of the region is included in Shimane Prefecture, administrative measures related to these lakes have been mainly taken by the prefecture. In response to the designation of these lakes as lakes needing special measures based on the Clean Lake Law in 1989, the prefecture has formulated the Lake Water Quality Conservation Plan every five years. Its third plan was established in 2000.

With the lake showing no improvement in quality of water, the prefecture failed to attain its water quality target set under the second 5-year plan. Therefore, under the third plan, the prefecture plans to investigate in a more efficient manner the causes of measures' inability to improve water quality. At the same time, further efforts will be made to purify water and achieve the target in cooperation with local residents, companies, organizations and municipalities concerned. Meanwhile, the Environmental Basic Plan of Shimane Prefecture, established in 1999, specifies that the formulation and promotion of the lake water quality conservation plan is one of its priority tasks. Accordingly, the prefecture is striving to build a basic model for water environmental conservation.

6. Conclusions and Future Research

This study aimed to examine the present conditions of main lakes in Japan and their surrounding environment with the aim of grasping the characteristics of citizen participation-based lake management in each region. It has been verified from the results of this study that a variety of activities that reflect characteristics of each region have been carried out through a partnership among entities in each region. In addition to local residents, tourists and other lake users are supposed to participate in water environmental conservation activities in some regions, such as the Lake Inawashiro area.

Future research might include further investigation of various examples and the comparative study of citizen participation-based lake management both in Japan and abroad.

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Forms of participation of public, local municipality and NGO in decision-making in the management of waters resources: Example of Lake Sevan

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Abstract

This research theme focuses on understanding how governments, communities and entire societies change their habitual behavior in managing water resources when faced with water scarcity. To gain this insight requires a detailed study of laws and rule - making, policies and institutional arrangements in developing countries – ranging from the community to the regional and national levels.

The goal of this research is to produce knowledge-based guidelines and best practices in institutions and policies that allow countries to deal with specific types of water management problems

This research theme deals with institutional and policy implications of:

- Strategies for enhancing the productivity of water (at national, basin and local levels).
- Building Poverty and Gender concerns into national and subnational water management regimes.
- Managing water scarcity and its consequences.

Objectives: To understand the institutional arrangements and policy frameworks that have the highest potential to improve the productivity of water in ways that promote livelihoods for poor men and women, and environmental sustainability. This will be done through a program of thorough systematic comparative research.

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Objective is to understand the institutional arrangements and policy frameworks that have the highest potential to improve the productivity of water in ways that promote livelihoods for poor men and women, and environmental sustainability. This will be done through a program of thorough systematic comparative research.

1. To identify, test and evaluate research-based guidelines for water policy reform that lead to more effective management of water in like basins. The avenues explored will include organizational options and roles and support systems for the local management.
2. To test and validate the application of internationally established best practices so that they are effective in the regional and subregional contexts, particularly for the lake Sevan.

Lake Sevan is a prospective source of drinking water supply for Armenia and neighboring countries, and is a reservoir for trout fish breeding. Lake Sevan is located at the north - eastern part of Armenia. It is a large tectonic depression surrounded by mountains. The Lake and its basin were finally formed 25 to 30 thousand years ago. The lake has two parts – Minor Sevan and Major Sevan differing by age and origin.

Physical dimensions of Lake Sevan and its basin are as follows:

- Altitude 1895.4 m
- Surface area 1242 m^2
- Maximum depth 78.4 m
- Mean depth 26.8 m
- Length of shoreline 400 km
- Area of drainage basin 3649 m^2

Before the artificial lowering of its water level (1916.2m above the Baltic Sea level) Lake Sevan was a large reservoir with an average length of 70 km and width of 20 km. Due to its level lowering (1895.4m) the morphometric, hydrological, hydrochemical and hydrobiological parameters of the lake have greatly changed.

The Armenian government must do the following in this area:

1. Produce case studies of innovative and large-scale water-sector institutional and policy reform programs and carry out an ongoing synthesis of the lessons learned.
2. Finance water service delivery mechanisms.
3. Analyze the negative gender and poverty impacts of: water scarcity, competition for

water in basins, and explore strategies for mitigating these.

4. Analyze institutional arrangements for similar basin management to identify best practices that can be transferred to help others.
5. Analyze water conflicts and alternative approaches to managing them.
6. Water policy modeling and scenario generation, as with the policy dialogue model.
7. Policy analysis, using a comprehensive, multidisciplinary, issue-based approach.
8. Policy roundtables, consultations and other mechanisms for research-based advocacy, supported by the targeted dissemination of research results to achieve maximum impacts.
9. Develop and support the implementation of policies and institutional strengthening programs that will lead to improved management of water used in agriculture.
10. Identify the pro-poor potential of interventions in the water resources sector by evaluating the impact of past investments this resources development and management.
11. Developing practical policy guidelines for designing and strengthening support systems for local irrigation management.
12. Assess the impacts of infrastructural development on poverty alleviation in Armenia, develop performance indicators to measure the impact of infrastructure projects.
13. Evaluate water user associations in the three cities sharing the Sevan basin (Sevan, Gavar, Vardenis), analyze legal and institutional constraints to effective water management, and monitor variables affecting water productivity and agricultural performance.
14. Many Armenian water management institutions are failing to live up to their original promise. By allowing these institutions to stagnate, we risk the loss of a vitally important tool for research and policy making. Recent research has identified traits that set high-performance institutions apart from those failing to deliver. By applying these concepts to lower performance institutions, Armenia can make good its initial investments and create world-class institutions for research, policy formation and development.

Societies need forward-thinking knowledge institutions in the water sector to help them deal with the opportunities and crises that will arise in the future. Armenia has some leading, high-performance knowledge institutions. But it also has many more that no longer deliver high-value thinking, insights or perspectives. Can these under-achieving institutions be transformed? How can the government, NGOs and international organizations design, build and maintain successful, high-potential institutions?

Practical answers have been found in a recent review of the diverse Armenian institutions. The review part of an effort to improve institution building in the water sector found many traits that set the "winning" institutions apart from the poor performers. First, it is the quality of an institution's design and launch that determines its ability to lead and to be recognized as a leader in the future. Second, good operative practices with regard to human resources, fund-raising policy, management style and core products and services ensure an environment where innovative thinkers can excel.

The research argues that:

- Both these aspects are vital if an institute with high potential is to flourish and
- Capital investment is necessary, but not sufficient to achieve success. Finally, the study recommends a complete relaunch of under-achieving institutions, with new NGO staff and a fresh mandate.

Research and academic institutions have a special place in our society. They are a force for positive change because they have the time, resources and mandates to examine tomorrow's questions and issues today. They help shape and update the thinking of society's leaders and policy makers, and so set the country's future directions. This is the theory.

In practice, many institutions have become outdated. Or, due to a lack of focus and the wrong combination of professional skills, they no longer deliver useful perspectives or insights.

Unfortunately, very few of today's organizations are "high-performance" knowledge institutions with reputations for creative research, innovation or advancing the frontiers of knowledge. Fewer still think "ahead of the curve," and make plans to exploit future opportunities or cope with future problems—this issue is critical in the water sector. Research from many developing countries confirms that the root cause of their water problems is a scarcity of institutional innovative capacity—in equal measure with a scarcity of water. The result, fortunately, is investment in specialized research and capacity-building institutions of quality and excellence. But, as Armenia's experience shows, more than just financial capital is needed. Training and research institutions in the government sector are generally the first to suffer budget cuts. When resources decline, barely covering salaries and overheads, core infrastructure, such as the library, computers and labs, is sacrificed. Dejected professionals leave.

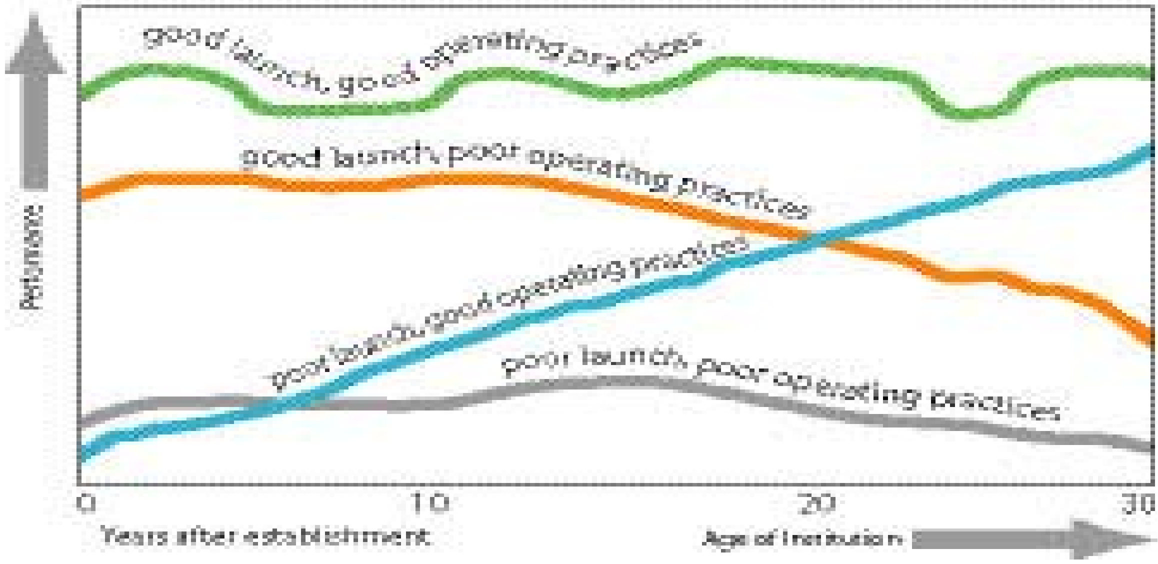

Figure 1.

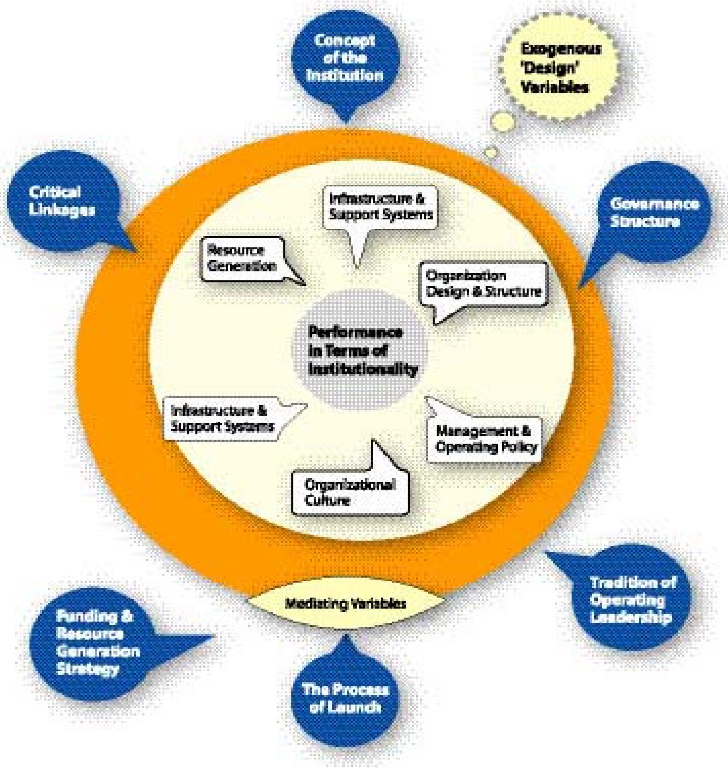

Figure 2.

New ones cannot be attracted. The institution is left with clerks and ministerial staff. This is a common pathology of decline. The result? A low-performance knowledge institution. So, if it is not simply to become part of a government department, a new institution needs to be designed to stand on its own feet from the start. A good design/launch and good operative practices constitute the winning combination when building high-performance knowledge institutions (Figure 1).

Design/launch and operative practices affect institutional performance a poor launch and poor operative practices contribute to the underachievement of many of the Armenian institutions assessed. And although a good launch can ensure success in the short and medium term, poor operative practices commonly cause a decline in performance later on. Institutional performance was rated "high" if an institution

i. Had survived for a long period without compromising its missions and goals,

ii. Was perceived as having intrinsic value/usefulness by professionals in the field and by interested members of the public, and

iii. Sets the standards for, and leads in, its particular field. Research has identified six parts of the design/launch process critical to building high-performance knowledge institutions (figure 2, outer circle), and the best operative practices found in these high fliers (figure 2, inner circle) Design and Launch of High-Performance Knowledge Institutions Governments, NGOs and international organizations should consider six critical areas when designing or relaunching knowledge institutions.

1. Managing the Design and Launch Design and launch are critical because they shape public perceptions of the institution and its relevance. These determine what researchers and funding an institution attracts. Put simply, the way an institution is perceived in 15 years' time depends on how it projects itself at its launch. Traditions are then created which, years later, are sources of vitality in high-performance knowledge institutions, and of decay in mediocre ones. So, first-class management is essential from the very beginning.

2. Concept—the Founding Vision Institutions of excellence begin with bold concepts and great purposes. These inspire the staff long after founders move on. The XXX Institute, for example, was created as "a center for research that would radiate to the rest of the country standards as high as any to be encountered anywhere." So, the mandate of institutions should not be limited to dealing only with problems relevant at the time of their launch. Their concepts should be "ageless," adapting to the new challenges to society, as they arise.

3. Governance—the Role of the Board The Boards of high-performance knowledge institutions have key traits in common. They are autonomous and their members are interested, well respected and regularly renewed. Members are selected from a cross-section of stakeholder groups, and often include persons eminent in their field. Such Boards are active. Meeting regularly, they shepherd and oversee the activities of the institution and step in swiftly when there is any threat to the institute. Boards that consist entirely of staff seconded from government departments, who often have little interest in their role, are unlikely to shape a high-performance knowledge institution. Constructive relationships with the government are vital. High-flying, autonomous institutions benefit from having one or two key government members on the Board. Other successful institutes are government-sponsored, but have a dynamic, fully autonomous Board and some financial independence.

Also, links with internationally recognized organizations benefit some high-performance knowledge institutions in terms of staff training. The Armenian Institute of Hydroecology, for example, is linked to the Ruaain Nantional Academy of Sciences.

The Board selects good directors. Long-term tenure and operational freedom are crucial here. In the formative years, these leaders establish norms of self-regulation, standards of individual and institutional performance, and collective leadership cultures. These prepare an institution for leadership changes. Model directors generally view their leadership role as a lifetime's work. They reflect on successes and failures, have great "entrepreneurial energy," and nurture many productive linkages. If a directorship is held as an additional duty or if there is a high turnover of directors' leadership becomes ineffective.

High-performance institutions maintain traditions of faculty governance, freedom, group work, peer-review and rigor by

- Nonthreatening individual and group assessments
- Acting on feedback
- Rigorous reviews of publications
- Strategic planning by committees
- External reviews and evaluations
- Monthly meetings of the entire group where all staff (technical and nontechnical) share innovative ideas and present their work-in-progress
- Participatory decision making, to allocate work and projects to staff members.

The Water Policy translates the findings of research in water resources management into useful information for policy makers. The program presents new perspectives and practical solutions derived from the wealth of research done in Armenia on water resources management. Its objective is to help policy makers at the central, State and local levels address their water challenges—in areas such as sustainable water management, water scarcity, and rural poverty—by translating research findings into practical policy recommendations.

Through specific the Government has highlighted the importance of water management planning. A provincial planning framework and the subsequent development of water management plans are seen by the research as the basis for important decisions relating to Sevan's water, such as issuing of licences and approvals, and identifying and implementing strategies for aquatic and riparian ecosystem protection. The paper believes an integrated planning approach, with public involvement as an integral component, will play a strong role in achieving the identified outcomes.

We recommend an overall provincial framework for water management planning be established by the Government within a two to four year time frame from the date of proclamation of the new water legislation. This provincial framework should be developed with broad input from Sevans, including local input, and include:

- Identification of provincial water management principles,
- Clearly defined water basins based on geographic limits or boundaries,
- Criteria for establishing the order in which basin plans are needed,
- The ability to allow for regional/local flexibility, and
- An outline of the process to be used in developing, implementing, reviewing and revising water management plans; this process should:
- Ensure that available knowledge is used,
- Provide opportunities for government-stakeholder partnerships and stewardship,
- Use a systems approach to establish goals and implement an action plan, and
- Recognize the importance of continually improving plans through monitoring, reporting, assessment and evaluation.

These plans should be carried out in the order identified in the provincial framework. Water management plans should generally address a number of issues within a basin, such as groundwater management, aquatic and riparian ecosystem protection requirements, human activity requirements, transfers of allocations of water under licenses, "micro" interbasin transfers, non-point sources of contamination, need for moratoria, water allocation limits, water use during times of general shortage and water conservation. Plans could also identify implementation tools to achieve desired outcomes specified in plans.

We recommend there be a mandatory requirement in the new water legislation for the Government to follow an approved water management plan in making decisions under the new water legislation.

Generally, participants in the public consultation process recognized planning as the key to the efficient use of water. They fully supported the Government's commitment to managing water on a like basin basis and indicated the importance of an ecosystem approach to planning.

Some people were concerned that under the Discussion Draft, the need to develop a water management plan is a discretionary decision of a Director or the Minister. Sevans commented that such plans should be a mandatory requirement under the new water legislation. Many suggestions were also offered regarding the process for developing water management plans, and what these plans should include.

- Public involvement was identified as a very important component of the water management planning process. Some felt that public input should be sought at all stages in the development of water management plans.
- There should be a requirement under new water legislation for water management plans to be prepared for each of Sevan's like basins.
- Some people were concerned that once the requirement for a basin plan is legislated, the time and process to develop and approve such a plan "may unduly delay developments that are beneficial to the people of Sevan". Therefore, licensing cannot be put on hold until these plans are developed. In their opinion, the legislation should obligate the Government to produce the required basin plans within a specific time frame.
- Some suggested that in the absence of approved water management plans, the new water legislation should allow issuing of approvals and licenses during the time that basin plans are being formulated and implemented.
- Sevans identified their expectations of water management plans saying these plans should:
- Be based on an ecosystem approach,
- Ensure the sustainability of water access,
- Accommodate the needs of all users,
- Be in place before decisions are made and/or legislation is implemented,
- Clarify the scope of planning, i.e., determine the level of details to be addressed,
- Clarify minimum public participation in the planning process,
- Ensure a cost-effective planning approach and "secure the highest total economic and social benefits possible to all Sevans",
- Address emergency situations,

- Protect existing commitments and allow for effective representation from local stakeholders,
- Be flexible enough to accommodate the considerable variation in water supplies and demands in different regions of the province, and
- Be managed cooperatively with the available water shared.

The Discussion Draft provides the ability for the Director to impose a moratorium. This power could be used in situations where the Director is of the opinion that either a water body has reached full allocation or is about to reach full allocation. By imposing a moratorium, the Director is not required to accept any license applications for water, which is subject to the moratorium.

Few Sevans commented on this subject. Those that did generally supported moratoria as one of the means for preserving water for instream needs. However, they suggested there should be a full disclosure of facts on which the decision to impose a moratorium is made.

- Some Sevans suggested that when the Director declares a moratorium the reason for such a decision should be published. They also recommended that when the Minister makes an order to impose a moratorium, such an order should be published with supporting reasons, and should be challengeable.
- Some felt that there should be a moratorium on all further allocations of water in like which are heavily allocated and in which instream needs have not been determined.
- Others suggested that an appropriate management process should be used when the Director is to decide that no more licenses should be issued for a river basin. All applications and water- related activities should be tested against the goals and objectives of the water management plan.

The dynamic nature of water and the important role which it plays in everyone's life requires that Sevans be informed about water and have the opportunity to share information and provide advice on water management decisions. During the public consultation process, a large number of Sevans indicated that they want to understand and be informed about all aspects of Sevan's water. Sevans also commented that they should have opportunities to provide input on decisions made under the new water legislation. The importance of establishing clear criteria for determining the parameters of public involvement is reflected, as is the importance of ensuring a balance between consultation and effective decision-making.

When the new water policy and legislation is completed, the Government undertake an efficient and extensive public education program. This program should be aimed at informing Sevans about the importance of water, the importance of aquatic and riparian ecosystems, how Sevan's water will be managed, the importance of water to the economic health of Sevan and the transition from the existing Water Resources Act to the new water legislation.

The public involvement processes be established under the new water policy and legislation and such public involvement processes be guided by the following principles:

- Good information guides water decision-making,
- Opportunities are provided for bringing forward innovative ideas,
- Opportunities exist for constructive public involvement,
- Issues being discussed are relevant to the decision being made,
- "Directly affected" persons are encouraged to participate, and
- Mechanisms are in place to ensure closure to public involvement.
- The new water policy and legislation not restrict public involvement relating to the development of a provincial framework for water management planning.
- Many Sevans felt that the ability of the public to participate in water decisions is inadequate, and too much is left to the discretion of Government officials under the Discussion Draft. They want the Government's strong commitment to public involvement in decisions on water management and use, particularly at the local level. As well, Sevans strongly support education and information sharing as a way to encourage meaningful public involvement.
- A firm commitment to public participation must be demonstrated in the legislation with consistent and fair rules for all. The legislation should specify which type and size of projects require full public participation before approval, and which would be allowed without public notice.
- The public process must be streamlined, flexible and designed to enable stakeholders to fully understand their role in the process. It also must be clearly recognized that while consensus among stakeholders is desirable, it is not always achievable.
- Public involvement in water related decision-making should not be restricted to those "directly affected". Any concerned or interested member of the public should be able to engage in public consultation.
- A well-informed public is essential to the implementation of a fair and acceptable water policy, and to the reduction of public controversy, therefore, adequate information about water management activities in the province should be provided to the public.
- There should be a stronger emphasis on research and education in the legislation, as a method for achieving conservation goals. A comment received was that "An educated user

is less likely to abuse the system if the implications are understood".

- Public involvement is an essential component of water management planning, and stakeholders should be able to provide their input at all stages in the development of water management processes and plans, including determination of instream needs and water conservation and management objectives and guidelines. Participants suggested specific requirements for an effective and meaningful public involvement process.
- General support was expressed for the "notice" provisions of the Discussion Draft, however, many people were concerned about the "waiver of notice" provisions. It was suggested that notice requirements should be universal and that waivers should only be issued in emergency situations. Some suggested that the circumstances under which notification can be waived should be clearly identified in regulations.
- The exemption of "minor matters" from notice requirements concerned some people. They felt that "minor matters" should be defined in the new water legislation.

Many comments encouraged the Government to establish an effective formal appeal process and consultative mechanisms that would protect the needs of those who are actually affected by the decisions, and would not allow third parties to use it to further their agendas. Many Sevans expressed concern about the lack of consistency in the way water issues are dealt with in Sevan under various pieces of provincial legislation, and the apparent lack of coordination among various government departments and regulatory agencies in making water-related decisions. Of particular concern was the length of time and the costs associated with obtaining various licenses or approvals related to water. People felt strongly that the Discussion Draft's decision-making processes should be streamlined and better integrated with that of other government departments and regulatory bodies. They also suggested stronger coordination with other provincial legislation to eliminate and/or minimize overlap between various provincial legislation, and to "streamline paperwork". They pointed to various instances where there is a need for clarification and coordination between new water legislation and other legislation.