

Our Freshwater Under Threat – Vulnerability of Water Resources to Environmental Change in Africa.

Prof. Eric O. Odada
AfricanNESS Secretariat
University of Nairobi
Nairobi, Kenya

1.0 Introduction

This article summarises the results of a rapid assessment of vulnerability of water resources to environmental change in major river and lake basins in Africa. The detailed assessment results will however be published in “Our Freshwater Under Threat – Vulnerability of Water Resources to Environmental Change“ volume by UNEP-DEWA and START-Africa. This summary provides the status of water resources across all of Africa, touching on multiple dimensions of the complex issues (southern, eastern, central, western, and northern Africa) and the Western Indian Ocean Island States) and of major river, lake and groundwater basins (Fig. 1). The assessments were carried out by sub-regional groups of African researchers under the leadership of Prof. Eric O. Odada of START-Africa, using natural (physiographic), anthropogenic (socio-economic) and management criteria.

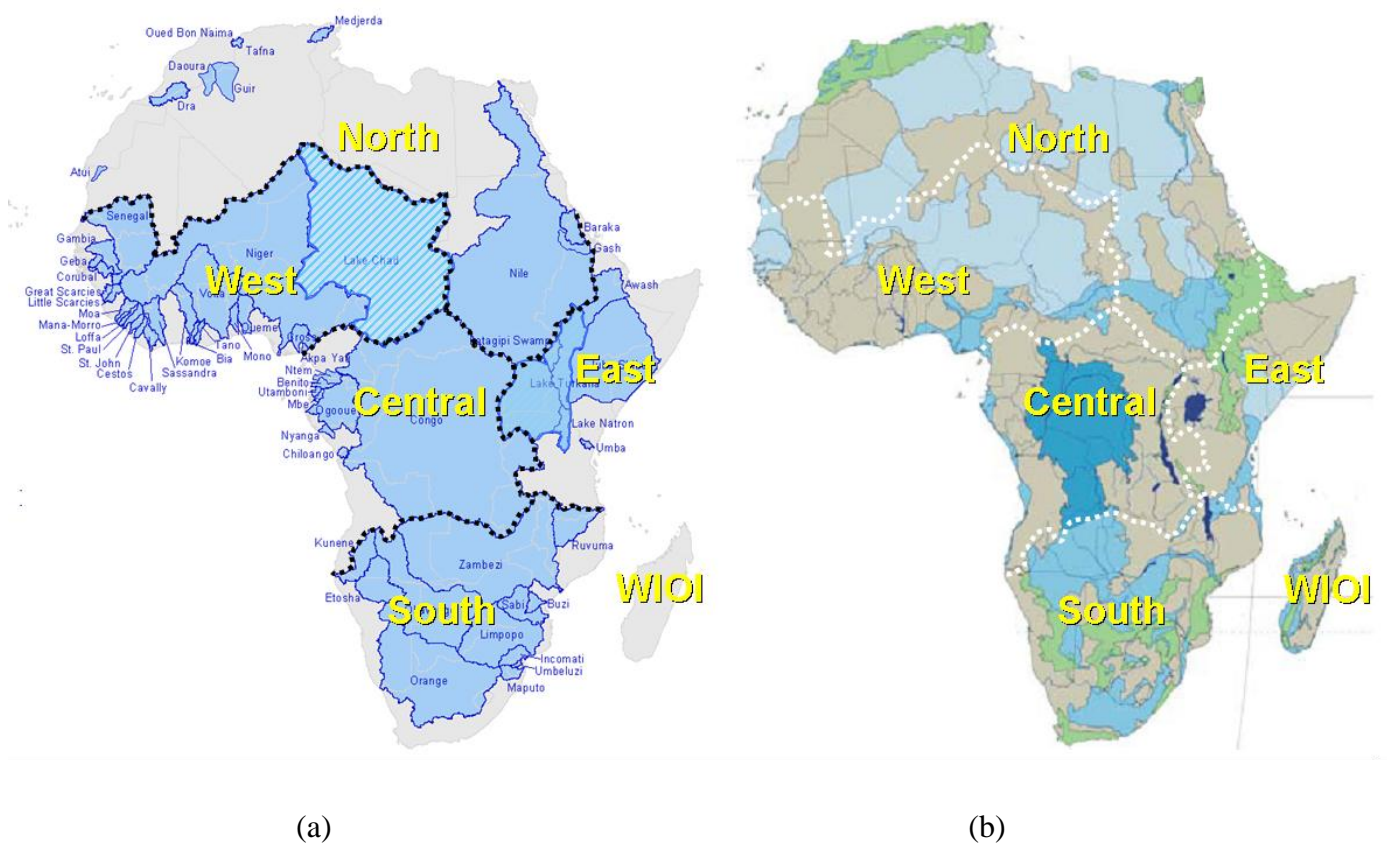


Figure 1: (a) Major river and lake basins (Transboundary Freshwater Dispute Database, 2000); (b) Major groundwater basins (WHYMAP, 2005 BGR/UNESCO)

This rapid assessment was however adopted to provide a summarised overview of sub-regions and basins which culminated in key issues of vulnerability of water resources to environmental change and ways of addressing these issues through appropriate adaptation and mitigation options. Issues, adaptation and mitigation options were also grouped under the three broad areas of: *physiography* (e.g. increased frequency of droughts and floods which are affecting water supplies and livelihoods, wetland/land degradation, desertification, water pollution, over-exploitation of aquifers, etc.), *socio-economy* (e.g. high population growth and urbanisation, HIV/AIDS and water related diseases, poverty, increased water demand, etc.) and *management* (e.g. lack of or weak River Basin Institutions, weak legislation, lack or limited data and/or monitoring, human resources training, etc.).

2.0 Key Messages

This article clearly shows common concerns and regional differences in the areas of water resources availability, development pressure, ecosystems health, management challenges and knowledge gaps. It is intended for managers, planners and other key decision-makers in water resources management in Africa.

2.1 Water Availability

Africa's extreme variability of rainfall in time and space is reflected by an uneven distribution of surface and groundwater resources - from areas of severe aridity with limited freshwater resources like the northern and southern parts to the tropical belt of mid-Africa with abundant resources. The high temporal and spatial rainfall variability has repeatedly led to extreme climatic events (drought and floods) that pose a continuous risk to Africa's people and their livelihoods and its national economies. Global change scenarios predict an increasing frequency of drought and flooding, thus increasing the vulnerability of Africa's water resources.

Southern Africa: has experienced floods in the northern and southern parts and episodes of severe and prolonged droughts in other places. It is among the few regions in the world for which most global climate models agree upon increase in aridity in the future and hence a further lowering of the water availability for livelihoods. Countries have to prepare better for the increased magnitude, duration and impacts of floods and droughts.

Western Indian Ocean Islands: global warming, in the worst case scenario, is expected to cause a 1m sea-level rise by 2100 which would have dire consequences: loss of coastal land, agricultural opportunities, groundwater resources (due to salinisation), and loss of biodiversity critical to community support and livelihoods. The social impact of a sea-level rise will cause displacement of people, water-related diseases and water-supply problems.

Eastern Africa: general moisture circulation models predict an increase in rainfall of up to 20%, a change in seasonal distribution of rainfall and an increase in air temperature of up to 5 °C for this century and there are also indications of increasing frequency and intensity of droughts.

Central Africa: is characterised by an abundance of freshwater resources, except for the northern parts where in the past three decades there was a decline in rainfall (shrinkage of Lake Chad). The demand for water is rising, but it is unlikely that the region's freshwater

availability will be affected much in the coming years. Pollution of the water resources is a major issue that needs special attention.

Western Africa: climate change is expected to bring about reduced rainfall and increased evaporation in the areas to the north, thus advancing the rate of desertification in the Sahel.

Northern Africa: is the most water-stressed sub-region of Africa and freshwater availability will become an even more important issue in the coming decades. Climate change scenarios for western Maghreb predict a rise in temperature of up to 4 °C this century accompanied by a reduction in rainfall of up to 20%. This would result in decreased soil moisture and reduced surface and groundwater resources. Salinisation of soils, which threatens food production, is already a concern in irrigated areas, especially along the river Nile, and may worsen. Another concern is seawater intrusion resulting from over-exploitation of groundwater resources in coastal areas, where the main urban centres are located.

2.2 Development Pressures

Population growth, urbanisation and economic growth in general, all exert pressure on water resources through increased demand and pollution. Water is essential for life and its supply for safe drinking water, food, health and the environment needs to be secured.

Safe drinking water and sanitation

Only 51% of the rural areas in Africa were covered by water-supply in 2002 whereas the coverage for urban areas was 86% (Figure 2). Analysis of water-supply data of the region reveals that despite the progress in the coverage for drinking water between 1990 and 2002 (see Figure 2 below) the improvement still falls short of the progress needed to achieve the MDG target of 75% coverage by 2015. Regarding the MDG sanitation target the situation is critical and progress should be accelerated. Northern Africa is almost on track in meeting both targets although it is the most water stressed sub-region.

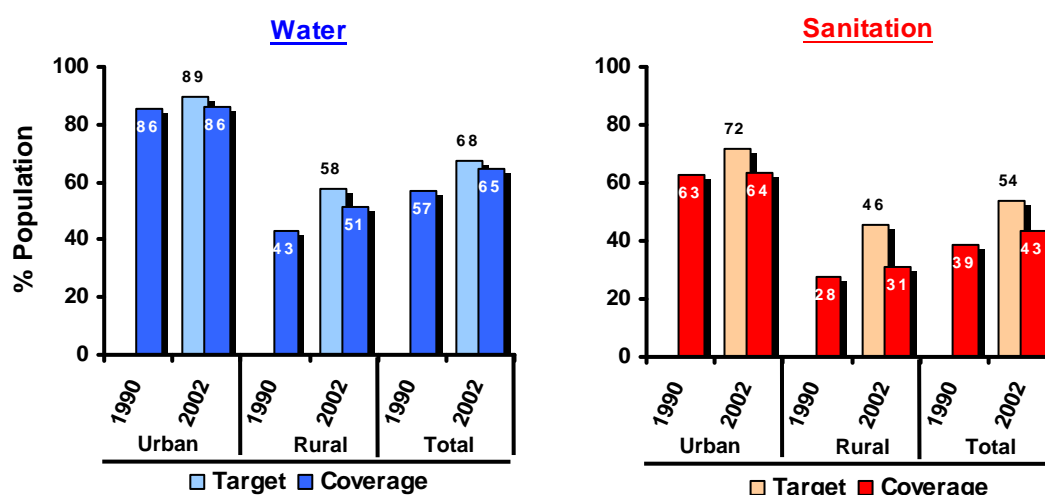


Figure 2: Water-supply coverage in rural and urban settings between 1990 and 2002 for Africa. Source: WHO/UNICEF 2004.

Obstacles to accelerating the rate of progress towards the MDG targets in all sub-regions with the exception of northern Africa include political instability, high rates of population growth, poor governance, dwindling or diminishing budgetary allocations and subsequent increased

demand from the agricultural and domestic sectors and low priority given to water and sanitation in terms of investment in infrastructure and maintenance.

Food security

Currently, huge crop failures, arising from droughts and flooding, are being experienced more frequently now than ever before in Africa, causing famines and economic hardships to families and communities. Insufficient national government investment and operational funds for irrigation infrastructure in many African countries is a major threat to the availability of water resources for irrigation. In all the sub-regions, there is a pressing need for food security, and thus meeting water needs for food security is of paramount importance.

Public health

Africa has relatively high morbidity and mortality rates as a result of waterborne and water-related diseases such as malaria, cholera and diarrhoea. It also has the highest incidence of HIV/Aids in the world. The implications of the above diseases are enormous particularly on the African economies as the young and productive age is most affected. Water availability to the infected and affected families is important to ensure that adequate hygienic conditions are maintained so as to curb spreading of diseases. Any decline in drinking water quality and inadequate sanitation facilities will lead to increased (public) health risks, particularly for those people with compromised immune systems.

Environmental degradation

For countries relying on hydropower generation for their electricity supply, environmental degradation is a serious concern. Hydropower generation requires the reliable water for most of the time (wet and dry seasons). Degradation of the catchment area's environment results in the decline of springs, streams and rivers with catastrophic consequences for human welfare and environmental integrity. Pollution of water resources is also a great concern as it is a threat to both the environment as well as availability of freshwater.

Poor land use practices have resulted in sedimentation of river channels, lakes and reservoirs and changes in hydrological processes. Deterioration of the quality of water resources resulting from further increases in nutrient loads from irrigation (irrigated agriculture) and the domestic, industrial and mining sectors has also significantly depleted available fresh water resources and increased water scarcity. Increased human activities lead to the exposure of the water environment to a range of chemical, microbial and biological pollutants, as well as micro-pollutants. The mining and industrial sectors in particular produce high concentrations of waste and effluents that act as non-point sources of water quality degradation, including acid mine drainage which pollutes groundwater resources.

Africa's water resources are thus already facing serious risks from development pressures. Large dams (over 60 metres high) have been built on many basins such as the Nile, Volta and Zambezi rivers for water supply and power generation, and new dams are currently under construction in the Niger, Orange and Oued Draa river basins. The construction of dams has caused significant changes in the flow regimes of rivers resulting in negative impacts on the environment and loss of ecosystems functioning. Hence there is need for a balance between water resources development and ecosystems degradation due to water resources development.

2.3 Ecosystems Health

The major threats to Africa's water resources in lakes, rivers and wetlands come in several forms, among them eutrophication, salinisation and pollution from industrial effluents and chemical spills, and extend to broader ecosystem concerns, including exotic weed infestation, loss of fish population, habitat destruction, and loss of biodiversity. Most, if not all of these effects, can be traced to a generalised single cause: human activity. The introduction of alien fish species, de-vegetation of catchment areas, use of pesticides, and disposal of wastes, to name a few examples, driven by a variety of competing human needs, have severely impacted these finely balanced ecosystems; current usage patterns are simply unsustainable. A comprehensive assessment can help us understand the chemistry, biology and physics of the relevant interactions, at least as challenging are the contextual socio-economic factors, such as population pressure, poverty and globalisation, which lie at the heart of the matter.

2.4 Management challenges

The fundamental issue facing water resources in Africa does not appear to be one of water availability only, but also of human factors. These human factors are related to the governance of the available water resources, legislative and institutional frameworks, over-exploitation and pollution of the resources, conflict and political instability, inadequate technical know-how and institutional capacity, and low priority given to water in terms of human resources and budgetary allocations. For example, certain water-scarce regions in northern Africa have succeeded in providing water resources to large segments of their population, while other parts of Africa with abundant water occurrence, such as Central Africa, have limited water supply coverages (<50% of the population).

The water supply problem in Africa is mostly a problem of management. It is typical for a number of different agencies to be responsible for the numerous freshwater ecosystem resources in a given country. Fisheries issues, agricultural issues, industrial waste issues and drinking water issues, for example, have been addressed separately, and without coordination. Government policies have generally emphasised exploitation for development at the expense of conservation and sustainability. Complicating matters further, the major freshwater ecosystems in Africa are shared by multiple nations, making management of the water resources a daunting task.

Water sector reform

The lack of, or weak regulatory and management instruments, directives and institutional and human capacity pose a threat to the realisation of populations'/communities' expectations and needs when it comes to water provision. Although water sector reforms in Africa intend to address the above, they have been constrained by various factors, which include internal resistance from executives of institutions, the lack of political will, frequent changes in governments, and dependence on development partners to fund the reforms. Other, common obstacles for effective water resource management are the fragmentation of water management administration among various institutions, absence of mechanisms for coordination, inadequate institutional capacity and resources and the lack of an integrated approach towards water management.

2.5 Knowledge Gaps

One of the biggest challenges that must be addressed immediately to reach the African Water Vision and the MDGs is that authorities lack adequate human (technical and managerial), financial and material resources to plan and implement water and sanitation policies and programmes, among other things. There is generally a shortage of know-how and institutional “strength”, particularly in the area of IWRM, and this has limited the success of water resource management initiatives. Africa is also faced with the problem of capacity retention of trained and highly skilled personnel.

Information generation and management

A key limitation at national, sub-regional and continental level that is linked to inadequate financial and human capacity is the lack of adequate and good quality data on water resources which are prerequisites for effective and sustainable development and management. Water-related data and information are often lacking, too general or poor due to inconsistencies and prolonged periods of instrumentation breakdowns resulting in limited records. Conflicts which occur in some countries may result in data not being collected, or hinder instrumentation maintenance. Another obstacle is the shortage of facilities and of skilled people at various levels to collect and analyse the information and data for longer-term water management.

Water quantity and water quality

There is generally an information bias towards water quantity against quality. Information on groundwater resources is also less detailed and accurate in comparison to surface water resources. More information is needed in the areas of climate variability and change, water pollution and environmental flow. More and longer-term time-series of data and analyses are also needed, and what still needs to be resolved is the often restricted access to databases and the limited sharing of transboundary information.

Disaster management

Another area in which there is a lack of knowledge is disaster management. This is of particular importance for small islands, such as the Western Indian Ocean Islands, and low-lying coastal areas which are among the areas most vulnerable to extreme climatic events and environmental disasters as was highlighted by the Indian Ocean tsunami of 26 December 2004.

3.0 Opportunities for Actions

Opportunities to address the key issues identified for Africa’s sub-regions and major river, lake and groundwater basins are grouped according to the thematic areas of resource availability, development pressures, ecosystems health, management challenges and knowledge gaps.

3.1 Water availability

Although it is critical that continuing efforts are made to mitigate climate change by reduction of emissions of greenhouse gases (see box on mitigation of global warming on next page), the focus of the water sector should rather be on adaptation to the effects of climate variability and change. Adaptation options can be grouped according to policy instruments at international, regional and national levels, technological and structural instruments, risk sharing and spreading, land use measures and knowledge, skills and participation (DCW,

2003; Changing the water policy climate – A summary for policy makers of the report “Climate changes the water rules”)

3.2 Development pressures

In 2002, water was internationally recognised as a human right through the United Nations Economic and Social Committee. Clean and safe drinking water for domestic use ranks as the most crucial and urgent water need. Among the approaches shown to be effective in accelerating progress towards achieving the water MDG are decentralising responsibility and providing a choice of service levels to communities based on their ability and willingness to pay.

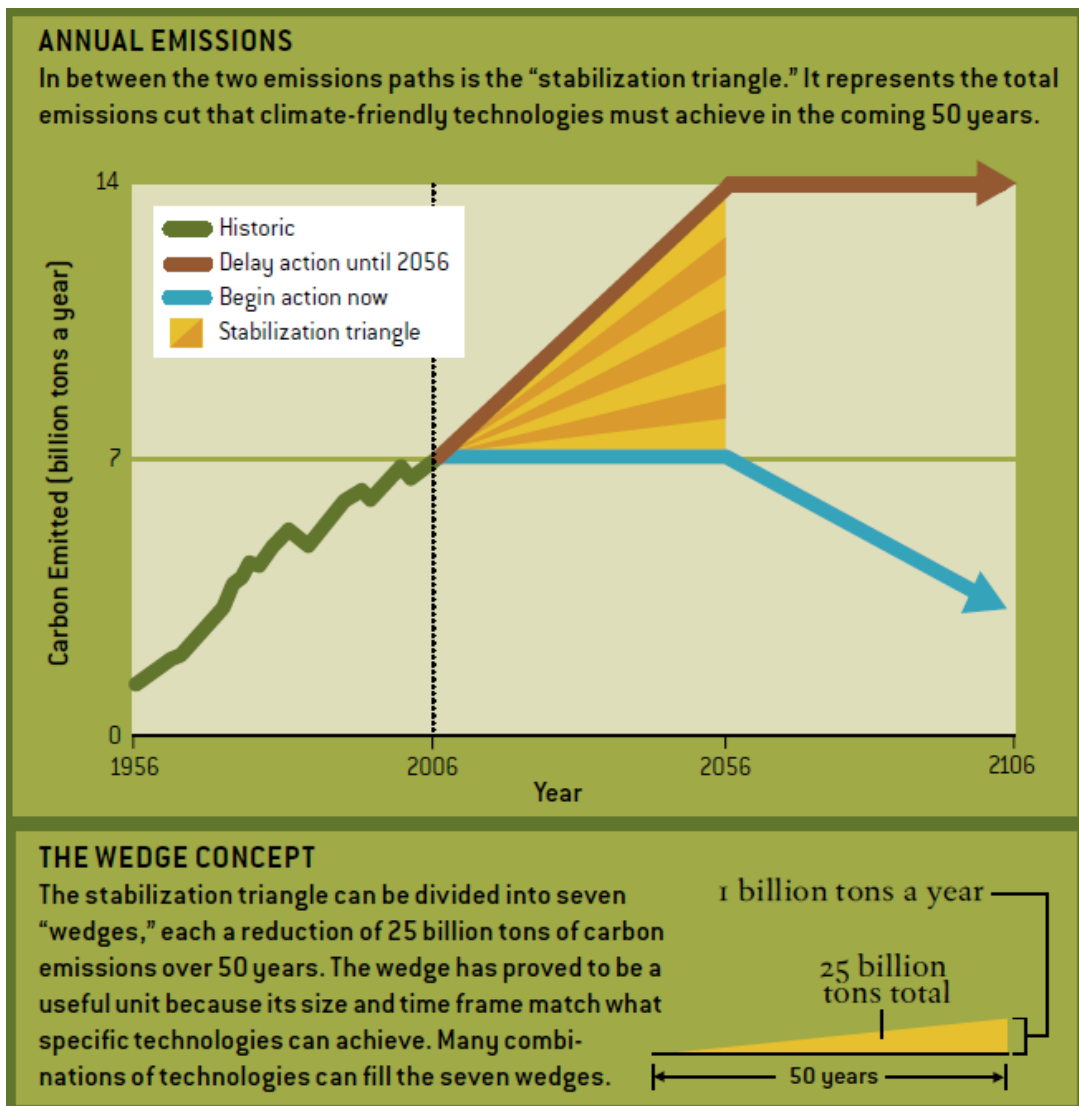
Meeting irrigation water needs for food security and economic development is another important area. Several basins are utilised for irrigated agriculture such as the Limpopo Basin with 82% of the potential irrigation area of ~0.3 million ha, over 50% of the 10 million ha of the Nile river basin with Egypt utilising 70% of 4.4 million ha of basin land area and Sudan utilising 70% of its 2.8 million ha. Utilisation of potential irrigation areas of other basins is less (eg Congo: 0.4%; Zambezi: 5% and Niger: 33%). With its 30.3 million km² of irrigation potential Africa provides considerable opportunities for further expansion of irrigated agriculture.

Another opportunity for meeting urgent water needs is hydropower generation. Only 7.6% of Africa’s economically feasible hydropower potential of 1 million GWh/yr is being utilised. This provides great opportunities for expansion amid competing demands on our environmental resources. In Tanzania for example, of the total electricity generated in the year 2000 (i.e. 2484 GWh) 86% was hydro-generated. It should be noted that for sustained economic development, freshwater supply needs to be guaranteed and this can only be achieved through effective forest and watershed management.

In meeting the urgent water needs, there is scope for alternative technologies such as rainwater harvesting, wastewater recycling, desalination and leakage detection. Wastewater recycling is practised in particular in the SADC region. Botswana plans to recycle about 60% of its urban flow by 2020, while Windhoek, the capital city of Namibia, re-uses all its wastewater for irrigation purposes. Artificial groundwater recharge may be applied to enhance the sustainability and yield of aquifers.

Mitigation of global warming

With the current trend of increasing atmospheric CO₂ by two parts per million per year, which contributes to global warming, we're only three and a half decades away from a threshold of 450 parts per million beyond which scientists believe future centuries will likely face the melting of the Greenland and West Antarctic ice sheets and a subsequent rise in sea level of giant proportion. Robert Socolow and Stephen Pacala (in *Science*, 2004, *Scientific American*, 2006 and *National Geographic*, 2007) made an assessment of the possibilities for rapid and dramatic cuts in emissions. They designed so-called stabilization wedges – changes big enough really to matter, and for which the technology was already available or clearly on the horizon. Some of them are more fuel-efficient cars, better-built homes, wind turbines, and biofuels such as ethanol. Others are newer and less sure: plans for building coal-fired power plants that can separate carbon from the exhaust so it can be "sequestered" underground.



Dramatic cuts in emissions mostly concern those countries and regions that contribute most to global warming. In 2002, the three main contributors were North America (28%), Europe (16%) and East Asia (15%). Although Africa only contributed 4% to the CO₂ emissions in 2002, they will also need to cut their emissions relative to what they would have been.

Source: Robert, H. Socolow and Stephen, W. Pacala, 2006. A plan to keep Carbon in check. *Scientific American*, 1-7.

Opportunities for actions to accommodate for development pressures are identified as follows:

- Ensure sustainable access to safe and adequate water and sanitation services for all
- Secure food production:
 - Potential for irrigation expansion
 - Consider focusing on small-scale irrigation projects in the short term
- Utilise economically feasible hydropower potential
 - Ensure sustainable forest and watershed management (include multidisciplinary and multi-stakeholder approaches linking forest, water, environment and people)
- Conserve water:
 - Invest in development and maintenance of infrastructure for urban and rural water supplies
 - Improve agricultural techniques (e.g. modify cropping patterns and select crops consuming less water)
 - Introduce water demand management measures (e.g. apply intermediate technologies, new technologies based on traditional systems and involve the community; introduce water pricing)
 - Reduce water leakages to within 10-15%
 - Enhance public awareness
- Control pollution:
 - Invest in domestic and industrial effluent treatment and disposal facilities
 - Introduce economic incentives and disincentives (polluter-pays and user-pays principles)
- Explore and expand alternative technologies (e.g. water harvesting including artificial recharge and wastewater recycling).

3.3 Ecosystems Health

Climate change and variability, population growth and increasing water demand, overexploitation and environmental degradation have significantly contributed to the worsening of the state of freshwater resources, leading to an increasing number of African countries where water demand outstrips available resources.

Not only is the quantity of freshwater a fundamental instrument in the development of all sub-regions, but also the quality of the resource. Deterioration of water resources results from increases in salinity and nutrient loads from irrigation (irrigated agriculture) and the domestic, industrial and mining sectors. It significantly depletes available resources and increases water scarcity. For the more arid countries, which are highly dependent on underground aquifers for their drinking water supplies, groundwater pollution is a particular concern. Disposal of sewage effluent into rivers and reservoirs has resulted in the flourishing of water hyacinths (alien weed species) and algae which choke the rivers and reservoirs. Aquatic life is invariably seriously affected by the pollution of the water resources. The economic dependence of African communities on the fishing industry is being affected.

Increased pressure on the finite arable land due to increasing human population is causing unprecedented land degradation as communities seek for agricultural land from slopes and wetlands resulting in desertification, soil erosion and siltation of river systems and reservoirs and disappearance of the wetlands. This seriously affects both the ecological and hydrologic balances.

Water resources pollution and land degradation are major factors determining ecosystems health.

Opportunities for actions to accommodate for water resources pollution and land degradation pressures are identified as follows:

- Establish effective institutions that monitor water resources pollution and land degradation
- Set up monitoring standards and enforcing systems
- Governments should establish tertiary industries that would add value to agricultural produce so as to lessen dependence on agriculture as the prime industry for employment
- Effect land tenure systems that promote effective land management
- Invest in the establishment and maintenance of waste disposal infrastructure
- Involve communities in ecosystems management; projects which directly benefit the communities should form an integral part of the management
- Introduce economic incentives and disincentives (polluter-pays and user-pays principles)
- Enhance public awareness

3.4 Management Challenges

Governance is the central issue for water resources in Africa, especially in the light of water scarcity and environmental change. An increasing number of countries are developing new policies, strategies and laws for water resource development and management based on the principles of Integrated Water Resources Management (IWRM) that aim at decentralisation, integration and cost-recovery. Countries which are undergoing water sector reform have often restructured their institutional and legal frameworks, which include the set-up of river and lake catchment/basin organisations.

The multiplicity of transboundary water basins in Africa has led to international cooperation and action plans, such as the establishment of the Africa Ministerial Council on Water (AMCOW) and the Africa Water Task Force to steer the processes. Through NEPAD, a Short Term Action Plan (STAP) was prepared with the aim of strengthening the enabling environment for effective cooperative management and development of transboundary water resources and of initiating the implementation of prioritised programmes. The Southern African Development Community (SADC) Protocol on Shared Watercourses and the Nile River Basin Initiative (NBI) are examples of transboundary cooperation that unlock development potentials and seek win-win benefits.

Significant scope exists to incorporate groundwater considerations in water treaties and protocols. Africa has a number of transboundary groundwater basins that need to be managed in a cooperative manner and for which management systems will need to be developed. Though it is necessary to manage water resources at national and sub-regional levels, the management of water resources is best done at local level. Community-based natural resource management, especially water management, plays a critical part within holistic and integrated approaches for solving water scarcity problems. Key components of successful local water management are decentralising decision-making, accountability, and fostering ownership.

Opportunities for actions in governance of water resources are identified as follows:

- Establish improved legislative and institutional frameworks with enhanced transparency and accountability that address:
 - Basic principles such as equity and efficiency in water allocation and distribution

- Regulatory regimes (e.g. surface and groundwater use, pollution control, etc.)
- The roles of government, civil society and private sector and their responsibilities regarding management and administration of water resources;
- Implement an integrated water resource management (IWRM) approach at local, national and transboundary levels:
 - Use the catchment and basin as basic units
 - Increase international cooperation in the management of shared water courses and basins
 - Balance the different water uses (e.g. for socio-economic development versus maintenance of ecosystem integrity)
 - Decentralise responsibilities to lowest appropriate levels
 - Ensure broad stakeholder participation and involvement in water resources programmes and projects
- Establish risk management frameworks to accommodate climate variability and change and water-related disasters.

3.5 Knowledge Gaps

The opportunity should be grasped of linking capacity-building strategically to water resource management through its systematic inclusion in IWRM plans. The capacity should be developed at all levels. Tailor-made capacity-building programmes for Africa can be developed and sustained that include institutional, human (technical and managerial), material and technological as well as financial aspects. Creative approaches can be applied - in particular: networking of education and training institutions, nationally and internationally (e.g. CapNet, GWP); establishing and sustaining national and international centres of excellence for critical issues; enhancing distance education (e.g. the UN Water Virtual Learning Centre); and strengthening partnerships with international training institutions (e.g. the UNESCO IHE institute for Water Education).

Opportunities should be grasped by establishing partnerships with civil society and the private sector to enhance implementation of community projects, particularly targeting the poor.

To date, it has been a constraint that authorities lack adequate human (technical and managerial), financial and material resources to plan and implement, among other things, water and sanitation policies and programmes. Another constraint Africa is faced with is the problem of capacity retention of trained and highly skilled personnel. Linked to inadequate human and financial capacity is the lack of adequate data on water resources for planning, developing and implementing projects. Monitoring and assessment programmes need to be improved and, often, re-established.

Because of the past neglect, political will and a strategic approach to address this issue of capacity strengthening and retention are therefore essential. Progress has been made in the PanAfrican Conference on Implementation and Partnership on Water (PANAFCON 2004) where delegates concurred that the biggest challenge that must be addressed immediately to reach the African Water Vision and the MDGs is human and institutional capacity-building.

For establishing adequate monitoring and assessment programmes that can answer today's questions and prepare for tomorrow, new and emerging monitoring technologies (e.g. the ESA/UNESCO TIGER/SHIP Earth Observing Programme) exist that can be exploited

(PANAFCON 2003 recommendations) and certain institutions are established (e.g. International Institutions for Geo-Information Science and Earth Observations) that can underpin such advances and provide on-the-ground monitoring, assessment and associated capacity development.

Mainstreaming gender

Central to integrated water management at basin level are the interests of the people who carry buckets of water to their homes or fields to ensure a minimum level of welfare. Women are usually the ones who are most directly concerned with the family's water supply. Women also play a pivotal role in agriculture by providing labour to family fields or their own fields. Although the pivotal role of African women in the provision and safeguarding of water for domestic and agricultural use is widely recognised, they have a much less influential role in the management and decision-making processes related to water resources than men.

Sustainable WRM requires that the role of women is reflected in institutional arrangements for the development and management of water resources and that men and women alike are given influential roles at all levels in water resources programmes, including decision-making and implementation. Mainstreaming gender concerns along these lines can speed up the achievement of sustainable water management by improving the access of women and men to water and water-related services to meet their essential needs.

In realising the active and effective participation of women in IWRM, consideration has to be given to the way in which societies assign certain social, economic and cultural roles to men and women. These social and cultural differences require tailor-made approaches, mechanisms and activities for women to participate in IWRM.

Opportunities for actions to address the knowledge gaps are identified as follows:

- Enhance capacity/develop tailor-made capacity-building programmes:
 - Strengthen networking of education and training institutions, nationally and internationally and strengthen partnerships
 - Develop human and institutional capacity for IWRM at appropriate levels
 - Mainstream gender issues in IWRM capacity-building and at all levels in water resource policies and programmes, including decision-making and implementation
 - Secure and retain skilled and motivated water professionals
 - Enhance research and development
- Develop effective systems for monitoring, collection, assessment and dissemination of data and information on water resources:
 - Improve or re-establish water resource monitoring and assessment
 - Improve access to and sharing of water-related information and data
- Specific opportunities for actions:
 - Strengthen/establish basin institutions and adequately capacitate them
 - Establish better and longer-term time series of water-related data and information especially on water quality (pollution) and groundwater resources
 - Establish impact of climate variability and change on water resources
 - Strengthen disaster management of extreme environmental events (e.g. early warning systems)
 - Explore different mechanisms that fit into the social and cultural context of communities for increasing women's access to decision-making processes and participation in IWRM

4.0 Concluding remarks and recommendations on the way forward

The results of these rapid assessments outlined in this article clearly show that Africa's water resources are already facing serious risks and the situation is expected to worsen in the future. The results of this study should thus be regarded as a vital starting point for comprehensive vulnerability assessments of Africa's river/lake/aquifer basins to inform the management of vulnerability risks at various levels. Still, more data remains to be collected, both in order to understand the changes that have already occurred in these ecosystems and to establish baseline data by which future changes can be assessed. If policy and management decisions are to have any hope of ensuring sustainable use of water resources, they will have to be informed by sound scientific assessments and this calls for a more comprehensive assessment that will focus on specific issues at the sub-regional level from which specific actions applicable at the local and sub-regional levels can be developed.

5.0 REFERENCES

- Beekman, H.E. and Pietersen, K. 2007. Water Resource Management in Africa: Issues and Opportunities, Proceedings Biennial Groundwater Conference 2007, Bloemfontein - South Africa, 8-10 Oct., pp. 16.
- Briscoe, J. 2000. The World Bank's role in Water Resources Management in Nigeria and its implications for the Bank's Water Resources Sector Strategy: Results of a consultation. The World Bank/IFC/MIGA. Office Memorandum.
- DWC 2003. Dialogue on Water and Climate; www.waterandclimate.org
<http://news.nationalgeographic.com/news/2008/01/photogalleries/Mozambique-pictures>
- National Geographic 2007. Carbon's new math, Oct. 2007, 32-37, by Bill McKibben
- NEPAD 2002. NEPAD's Short Term Action Plan (STAP) for transboundary water resources – framework for implementation; www.nepad.org
- Nyirabu, C.M. 2002. Freshwater Basin Management: Experiences and lessons learnt from implementation of Lake Victoria Environmental Management Project (LVEMP). Paper presented at "The Second Global Environment Facility (GEF) Biennial International Waters Conference, 25-29 September, 2002, Dalian - China.
- Pacala, S. and Socolow, R. 2004. Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies, *Science*, Vol. 305, 968-972.
- PANAFCON 2003. Outcomes and Recommendations of the Pan-African Implementation and Partnership Conference on Water (PANAFCON), Addis Ababa, December 8-13, 2003; www.uneca.org/awich/PANAFCON/outcomes%20and%20recommendations.pdf
- Socolow, R.H. and Pacala, S.W. 2006. A plan to keep Carbon in check. *Scientific American*, 1-7.
- SOWAS-GTZ 2004. Sharing the experience on regulation in the water sector, SOWAS – working group on regulation and PSP in Sub Saharan Africa, pp. 36
- Transboundary Freshwater Dispute Database 2000. Oregon State university; www.transboundarywaters.orst.edu
- UNEP 2002. Vital Water Graphics. An Overview of the State of the World's Fresh and Marine Waters.
- UNEP 2005: After the tsunami – Rapid environmental assessment, pp. 140.
- UNEP-WRC 2008. Our Freshwater under Threat - Vulnerability Assessment of Freshwater Resources to Environmental Change –Africa Report.
- WHYMAP 2005. BGR/UNESCO – Groundwater Resources Map of the World of the World-wide Hydrogeological Mapping and Assessment Programme (WHYMAP).

WHO/UNICEF 2004. Joint Monitoring Programme for Water-supply and Sanitation; Meeting the MDG drinking water and sanitation target: a mid-term assessment of progress.

www.arabenvironment.net/archive/2006/9/95463.html

www.eia.doe.gov/emeu/cabs/inga.html

www.gsfc.nasa.gov/topstory/20010227lakechad.html

www.lvemp.org

www.nilebasin.org/SVP_Overview.html

www.treehugger.com/files/2006/12/the_hippo_water.php