THE SOCIAL AND ENVIRONMENTAL IMPACTS OF NDAKAINI DAM ON THE CATCHMENT COMMUNITY, KENYA

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C50/69115/2013

Research project submitted in partial fulfilment of the requirements for the degree of Master of Arts in environmental planning and management of the University of Nairobi.

September, 2015

Declaration

This research project is my original work and has not been submitted for examination in any other university.

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Approval

This research project has been submitted for examination with our approval as University supervisors.

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Dedication

This work is dedicated to my parents who supported me in making this dream a reality and to a special friend, Emily N. Mutea who motivated me.

Acknowledgement

I would like to thank the almighty God for the gift of life and the capacity to carry on this study. Along the way towards this end, I never stood, nor walked alone, I have been guided and supported by many people. Others are those who mentored me and others with whom we shared many ideas and experiences that shaped my thinking towards this accomplishment.

First of all I would like to thank the Almighty God for giving me the strength and intellect to conduct this Research and my gratitude goes to **Arcelor Mittal Liberia,** under whose sponsorship I have conducted this research.

Secondly, my supervisors, **Dr. John K. Musingi** and **Mr. L.K. Karingi** whose keen and superb supervision and guidance this study would never have been a success. I extend my deepest appreciation for their invaluable support.

I also sincerely express my gratitude to the Ndakaini dam communities, for their great cooperation and hospitality during the study period. Special thanks are due to the authority of Ndakaini dam that supported me throughout the study. I also enormously recognize and thank in a very special way the dedicated enumerators, who worked tirelessly and prudently to collect the necessary data for the study.

While undertaking the study, I came across information from other researchers and writers that reinforce my understanding of the subject. I am deeply indebted for all their work and support.

Abstract

Dams have been used for thousands of years to regulate river flows and ensure adequate supply of water during dry periods. In the future, as population increase and water consumption rises, many people believe there will be a need for more dams. However, in recent years proposals for new dams have, in many places, aroused intense opposition. There are many social and economic arguments against dams, but underpinning many of these arguments is the fact that dams produce major ecological changes in river ecosystems. This project investigated the environmental as well as the social impacts that had arisen from the creation of a Ndakaini dam in Thika. The sampling procedure selected three sub-locations (Ndakaini, Kimandi, and Makomboki) in the Gatanga Districts and the respondents were randomly selected from the three sub-locations.

The study adopted a survey research design with a targeted population of 14,218 persons in Muranga County, Gatanga districts. A sample size of 73 respondents was used for this study. Primary data were gathered directly from the affected community using structured questionnaires, interview schedule, photography and observation data collection. Analysis of the data was done by use of SPSS. Chi square and Pearson's correlation were used to analyse statistical relationships of variables. The results were presented in bar charts, percentages and mean. From the findings, the study found out that the environmental impacts was not significant to the livelihood of the catchment area among residents.

It also found out that the social impacts have significantly affected the Ndakaini Dam and its catchment areas amongst residents. I finally found out that the mitigation measures are not significant to dam conservation. The study concluded that the rate of deforestation and erosion in the study area is linked to the methods of farming practices as well as the removal of the catchment vegetation as part of land preparation. It also concluded that the issue of land degradation if not appropriately dealt with in the future, it could lead to the decrease in the water table capacity of the dams due to filling up with silt materials and the ultimate shortening of the life span of the dams. The study recommended that afforestation with multiple-use species will have the benefits of renewing the watershed's ability to regulate ground waters, reducing soil erosion and producing useful commercial crops. These activities will result in the production of significant environmental as well as socioeconomic benefits to the communities. Furthermore,

health education is one of the vital instruments to reducing health problems and the dam authority should take more responsibility in the delivery and monitoring of health education to the surrounding communities, especially Ndakaini, Makomboki and Kimandi

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Acronyms and abbreviations

AU - African Union

EA - Environmental Audits

EIA - Environmental Impact Assessment

EMCA - Environmental Management and Coordination Acts

GOK - Government of Kenya

ILO - International Labour Organization

IODIR- International Organization on Dam Impact Regulation

IRN - International River's Network

ISO - International Standard Organization

NEMA - National Environmental Management Authority

UK - United Kingdom

UNCED - United Nation Commission on Environment & Development

WB - World Bank

WCD - World Commission on Dam

WCED - World Commission on Environment and Development

WCIP - World Council of Indigenous People

WHO - World Health Organization

WMR - West Management Regulation

CHAPTER ONE: INTRODUCTION

1.1 Background of the study

According to the World Commission on Dams (WCD, 2000) the global debate about dams is overwhelmingly complex and at the same time fundamentally simple. It is complex because the issues on dams are not limited to, design, construction and operation of dams themselves, but give support to a range of social, economic, environmental and political choices on which the human aspiration to development and improved well-being depend on. In the future, as population increases and water consumption rise, many people believe there will be a need for more dams. Dams fundamentally alter rivers and the use of a natural resource, frequently entailing a reallocation of benefits from local users to new groups of beneficiaries at a regional or national level.

Dams transform landscapes and create risks of irreversible impacts. Clashes between dam proponents and critics have brought the dams issue into focus as one of the most intensely debated issues in sustainable development.

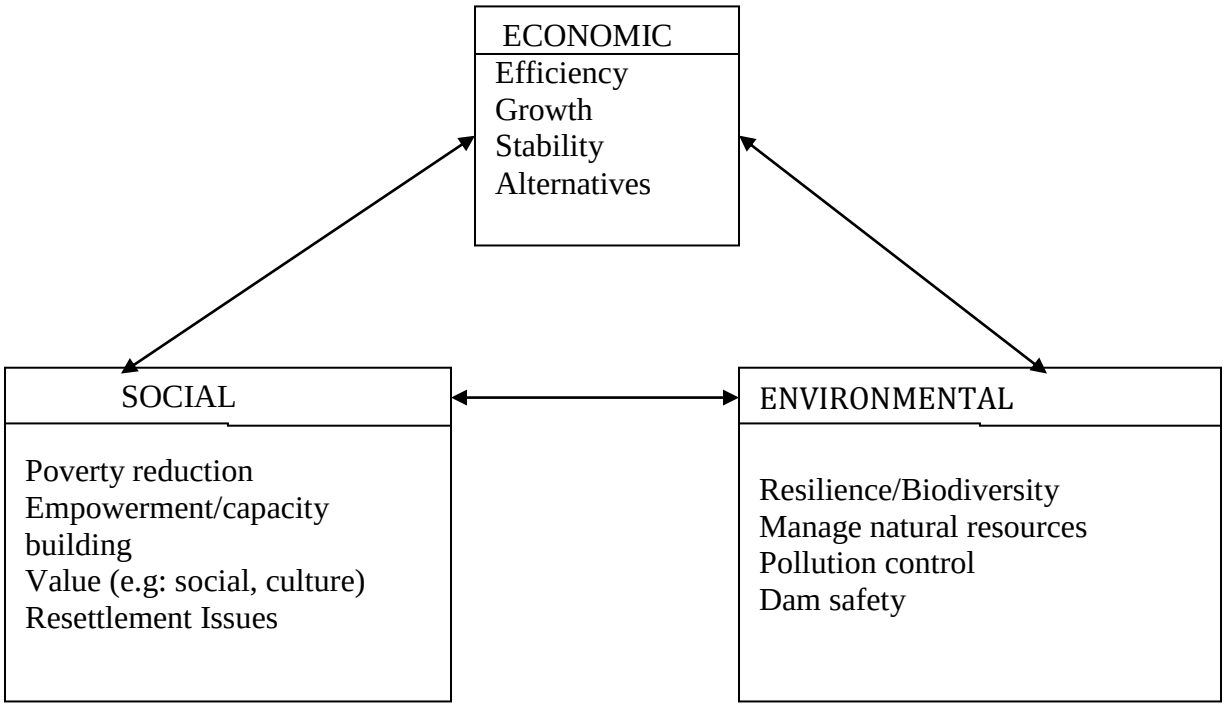


Figure 1.:Intra-general Equity (Source: WCD, 2000)

The earliest concept of sustainable development emphasized the need for economic development to be in harmony with the constraints set by the natural environment, one that satisfies the needs of the present generations without putting in jeopardy the satisfaction of the needs of the future. More recently, it has also been stressed that economic development should be compatible with political and social institutions. Therefore, a holistic concept of sustainable development has emerged in which economic, ecological, social, and political factors need to be simultaneously considered. Participation by individuals, particularly at the community level, is seen as an important means for achieving sustainable development and formulating development goals. As applied to dam projects, the core idea of sustainability and development is that all resource management decisions must give adequate weight to accommodating both consumption and conservation as well as to the legitimate role of equity. Dam promoters face the challenge of devising sustainable strategies that both accommodate societal demands and maintain the essential geomorphic and ecological functions of hydrologic systems, while simultaneously pursuing the attainment of economic prosperity, environmental quality and social equity (Figure 1.1). Large dams have been the subject of growing international debate and controversy. They have played a key role in economic development, serving a variety of purposes, including electricity generation, flood control, and irrigation. Dams provide about 20% of the world's electric power. They also provide flood control services and water supplies for agriculture. There are about forty-five thousand large dams in the world. About half of the world's dams are in China and India. Yet concern about their adverse environmental, social, and even economic impacts is growing.

Disagreements and confusion over what happened in the past have splintered the debate and have grown increasingly, with high polarization between people grouped in stark terms as proponents and opponents of dams. Mistrust among the various interest groups with different agendas made it difficult to achieve a collaborative consensus-building process. Dam projects have been a classic target of the strong environmental lobby and the critiques of top-down technocratic development due to the immense nature of the impacts created by these vast undertakings.

Controversies surrounding dam projects, including environmental and social destruction and high price tags, have grown, especially in the last twenty years in developing countries. Dams like the Sardar Sarovar Dam on the Narmada River, India.

1.2 Problem Statement

Over the past few decades, construction of dams for water supply around the world has attracted much attention concerning the social and environmental impacts that have arisen from such developments. Construction and operation of dams have always been associated with changes in the physical and biological environment as well as effects on the social and economic aspects of the surrounding community including exploration of the land.

The social and environmental changes coming out of the dams are in various amounts and in different importance degrees (Boycen, 2012). Boycen further reports that estimation of these effects should be made separately for each dam. This study aims at investigating the social and environmental effects of Ndakaini dams to the community because data on its effects is very little and scattered. Furthermore, the exclusion of water services from the local communities by the Ndakaini dam owners (The Nairobi City County) is a source of conflict (Yatich, 2009).

At the time of Ndakaini dam construction the amount of water flowing in the face of the dam and its surrounding land seem that the project did not undergo a strenuous environmental impact assessment (EIA) process. In view of this, there are several issues of environmental impacts, which were not considered under mitigation measures as should have been done also in the strategic environmental assessment (SEA) process in which monitoring of the project affect was not evaluated and disclosed to the community.

The study aim is to examine the social and environmental impacts of Ndakaini dam construction and how mistakes from the past can be rectified for better implementation of the projects. While acknowledging the vast benefits that can be derived from reservoirs, the discussion details the negative impacts, too, in order that these adversities are lessened and dam construction can be utilized as a positive development objective without hampering the well-being of the society, environment, and their interrelations.

1.3 Research Questions

The following research questions will be addressed.

1. What are the environmental impacts of the Ndakaini Dam?
2. What are the social impacts of the Dam on the catchment community?
3. What are the mitigation measures that have been put in place to conserve the dam?

1.4 Research Objectives

1.4.1 General objective

The general objective of this study was to examine the socioeconomic, environmental impacts of the Ndakaini Dam on the catchment community.

1.4.2 Specific objectives

I. To assess the environmental impacts of the dam.

II. To assess the social impacts of the dam on the catchment community.

III. To evaluate the mitigation measures that have been put in place to minimize the social and environmental risks of the dam.

1.5 Research Hypotheses

$H_0$1: There is no significant relationship between the environmental changes of Ndakaini dam and the catchment community.

$H_0$2: Dam construction has not significantly improved the living standards of the catchment community.

$H_0$3: There is no significance difference in the rating of environmental management by the catchment community.

1.6 Justification of the Study

The construction of dams in the country is given too much of structural or engineering consideration with little or no environmental impact assessment (EIA) of the operations after the design and construction. The environmental impacts as a result of operation are usually devastating, thus there is a need for impact assessment. The dam is only interested in the supply of water in Nairobi without due consideration of social impacts to the community. This study is significant as it identifies these impacts & examines implementation of mitigation measures.

1.7 Scope

The study was carried out in Murang'a County and it focused on the effects of the dam that are important to the issues of community livelihoods and culture. Other effects of the dam where tourism, which was not considered because it did not fall within the subject matter of my study.

1.8 Study Limitations

The survey was conducted only in the region affected by the Dam; the impact was not the same as for other dams. Most respondents had low levels of education, a demographic factor that influenced respondents' choices and language barrier. 1.9 Definition of Terms

Catchment Area: A catchment is an area where water is collected from the natural landscape. In a catchment, all rain and runoff water eventually flow to a river, and dam.

Chlorophyll: Any of a group of green pigments that absorb light energy used in photosynthesis and that is found in the chloroplasts of plants and other photosynthetic organisms such as cyanobacteria, especially.

Clonorchiasis: infestation with or disease caused by the Chinese liver fluke (*Clonorchis sinensis*) that invades bile ducts of the liver after ingestion in uncooked fish and when present in numbers causes severe systemic reactions including edema, liver enlargement, and diarrhoea.

Community: A group of people living in the same place or having a particular characteristic in common.

Cultural Alienation: the act of alienating. Alienation in Culture Expand or a feeling of separation or isolation.

Deforestation: The permanent removal of trees from an area of forest or woodland.

Diseases: An abnormal condition of a part, organ, or system of an organism resulting from various causes, such as infection, inflammation, environmental factors, or genetic defect, and characterized by an identifiable group of signs, symptoms, or both.

Ecologist: an expert who studies the relation between organisms and their environment.

Ecosystem: ecosystem an ecological community made up of plants, animals, and microorganisms together with their environment. A pond or a rain forest is each example of complex ecosystems.

Ecotourism: Tourism involving travel to areas of natural or ecological interest, typically under the guidance of a naturalist, for the purpose of observing wildlife and learning about the environment.

Erosion: The wearing away of land surface by wind or water, intensified by land clearing.

Flood: an overflowing of a large amount of water beyond its normal confines, especially over what is normally dry land.

Household: definitions of the household usually include some intersection of keywords relating to residency requirements, common food consumption, and intermingling of income or production decisions.

Hypolimnion: The layer of water in a thermally stratified lake that lies below the thermocline, is no circulating, and remains perpetually cold.

Indigenous Peoples: are those groups, specially protected by international or national legislation as having a set of specific rights based on their historical ties to a particular territory, and their cultural or historical distinctiveness from other populations

Inundating: To cover with water, especially floodwaters or to overwhelm as if with a flood; swamp.

Irrigation: is the artificial application of water to the land or soil. It is used to assist in the growing of agricultural crops, maintenance of landscapes.

Landscape: An expanse of scenery that can be seen in a single view, or a picture depicting an expanse of scenery.

Marginalisation: Social exclusion (or marginalisation) is social disadvantage and relegated to the fringe of society

Mesotrophic: is a body of water, lake and pool: having a moderate amount of dissolved nutrients.

Morphology: The branch of biology that deals with the form and structure of organisms without consideration of function

Mutatis Mutandis: is a Latin phrase meaning "the things being changed which need to be changed" or more simply "the necessary changes having been made. Food security: defined as a situation “when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life.

Oxygenated: To treat, combine, or infuse with oxygen.

Paragonimiasis: chronic infection by the lung fluke Paragonimus Waterman, occurring most commonly in Asia. It is characterized by hemoptysis, bronchitis, and occasionally abdominal masses; pain and diarrhoea; ocular pathologic conditions; cerebral involvement with paralysis; or seizures. The disease is acquired by ingesting cysts in infected freshwater crabs or crayfish, the intermediate hosts. Practices related to farming, residential development, sand wining or logging.

Schistosomiasis: also known as bilharzias are or snail fever, is a primarily tropical parasitic disease caused by the larvae of one or more of five types of flatworms or blood flukes known as schistosomes.

Thermocyclops: is a genus of crustacean in family Cyclopidae. It was first described and later extensively researched by Friedrich Kiefer, who discovered some 20 species.

Tributaries: a stream that flows into a larger stream or other body of water.

Water Born Diseases: Waterborne bacterial diseases cause a wide range of syndromes, including: acute dehydrating diarrhoea (cholera), prolonged febrile illness with abdominal symptoms (typhoid fever), acute bloody diarrhoea (dysentery), and chronic diarrhoea (Brainerd diarrhoea). Common agents causing waterborne diseases include the following bacteria.

Zooplankton: Plankton that consists of animals, including copepods, rotifers, jellyfish, and the larvae of sessile animals such as coral and sea anemones.

CHAPTER TWO: STUDY AREA

2.1 Introduction

In the year 1988 the Kenya Government compulsorily acquired approximately 1,200 acres of land to create space for the construction of the Thika Dam (Ndakaini) to supply potable water to Nairobi and its environs. When full about 600 acres of land acquired are under water. The rest of the land was used for the provision of the construction site for extraction of Quarry stones at Kiruga; construction site for the Installation of Thika River gauging station (Thika) for river compensation monitoring; and construction sites for Raw Water intakes in the Kiama River portal, Kimakia River shaft and Chania River outfall respectively.

2.2 Demographics

Table 2.1: Population distribution by the three sub-location in Muranga

Sub-locations	Census Year	Total population	Area
Ndakaini	2009	2,444	8.5sqkm
Makomboki	2009	8,295	42.5sqkm
Kimandi	2009	3,479	9.17sqkm

(Source: Republic of Kenya population and housing Census, 2010)

2.3 Climate

Climatically it lies in the upper middle altitude an altitude range of 1920 MAs and longitude of 360 53'E and latitude of 00. 47'S with the soil type marginally varying as well drained, deep, dark, red to yellowish red friable to firm, sandy clay with humic acid soil i.e. Humic Acrisols on tertiary as basic igneous rocks.

2.4 Geology

The sediment beneath the Dam consists of Middle and Upper called pumicite in its powdered or dust form, is a volcanic rock that consists of highly vesicular rough textured volcanic glass, which may or may not contain crystals. It is typically light coloured. Scoria is another vesicular

volcanic rock that differs from pumice in having larger vesicles and thicker vesicle walls and being dark coloured and denser.

2.5 Topography and Physiographic Features

Ndakaini is located in Central Kenya, covering an area of 2,558km2. Murang'a town, formerly referred to as Fort Hall, is the county headquarters. Situated approximately 85 kilometres northeast of the capital city, Nairobi. Muranga town lies on Latitude -0.7167 (0o43'0) and Longitude 37.1500 (37o8'60E), at an altitude of 4,120ft (1,255m) above sea level. The county borders. Nyandarua to the West, Embu Along the way towards this end, I never stood nor walked alone. To the East, Nyeri to the North, Kiambu to the South while Machakos and Kirinyaga counties lie to the Southeast and the Northeast respectively. It has a total human population of about 942,581 which translates into a human density of 524 people/ km2. The area is accessible mainly by road, as well as the old railway line serving key town centres. It takes approximately one hour by road from Nairobi, one and half hours from Nyeri, 40 minutes from Thika town and two hours from Embu town. The county is home to notable geographical features. To the North of the county is the expansive Aberdare Forest, which is a major tourist attraction and one of Kenya's water towers and home to varied fauna and flora. The Aberdare is one of the most important water catchment areas supplying 55% of the water in Nairobi. There is also Mukurwe WA Nyagathanga which is believed to the origin of the Kikuyu community. Within the southern Aberdares is the Kinangop peak (3,906 m), which is the second highest peak and the most impressive peak of the mountain ranges besides being a popular hiking area. The Elephant Hill within the Aberdares gives excellent views, especially of the Kinangop plateau. In addition, the hill is a major attraction to hikers. The county is also known for the breathtaking hills, forests, rivers, waterfalls and valleys. The major river in the county is Mathioya which flows into Tana River.

2.6 Soils

The dam catchment area has a fragile ecosystem owing to deforestation of the Aberdares and a weak soil structure that is prone to landslides. It has inherent high fertility, being of basaltic origin. They are well drained, normally very deep, dark reddish brown, friable clays with a humid top soil layer. Soils on the western boundary are also of medium to high inherent fertility, but are more variable and interspersed with poorer draining soils and lower fertility. The soils of

the moorlands are umbric andosols. They are derived from volcanic glass. They have a high content of organic matter and are very porous. The clay fraction is composed of allophones. The structure, drainage and water retention capacity are good for plant production. The soils of the dam are rich in clay content and consist almost exclusively of kaolinite. Red kaolinite soils are found on slopes and dark grey, swelling montmorillonitic (black cotton) soils are found in areas of impeded drainage. The soils of the southern area are characterised by dark surface horizons and are rich in organic matter. Their bulk density is low and include Leptosols which are characterised by continuous coherent hard rock at very shallow depth, strong brown loams, eutrophic brown soils on volcanic ash and Gleysols which show hydromorphic properties within 50 cm of the surface and are found in valley bottoms.

2.7 Population

The population of the district, according to the 2010 population census estimated to be around 14,218 people. The population of the district 2009 was 942,581. The population growth rates of the district as indicated in the table below for 2010 (Table 2.1).

2.8 Functions of the dam

Ndakaini dam is a cold-water reservoir that exhibits thermal, gas and chemical stratification, with longitudinal and vertical patterns of distribution of physicochemical and biological properties. The water is well oxygenated (surface value of 8.71 ± 0.29 mg/I.) with even higher values during the wet cold periods. The hypolimnion is cold and anoxic. The influence nutrient levels are low, but the transitional zones have magnified level of both nitrogen and phosphorus, which are attenuated with depth and towards the dam wall. Chlorophyll is a high level near the dam. Wall (10.24 ± 2.02) and were positively correlated with nutrients. Thermocyclops species. Dominated zooplankton group with its distribution skewed towards the infant son. Individuals were most abundant individuals collected during the fishing exercise and their growth condition factor were greater than one. It was shown that Thika reservoir is a mesotrophic reservoir and integrated management interventions are required to maintain its capacity to supply water to Nairobi. (Wambua, Msafiri Philip 2002).

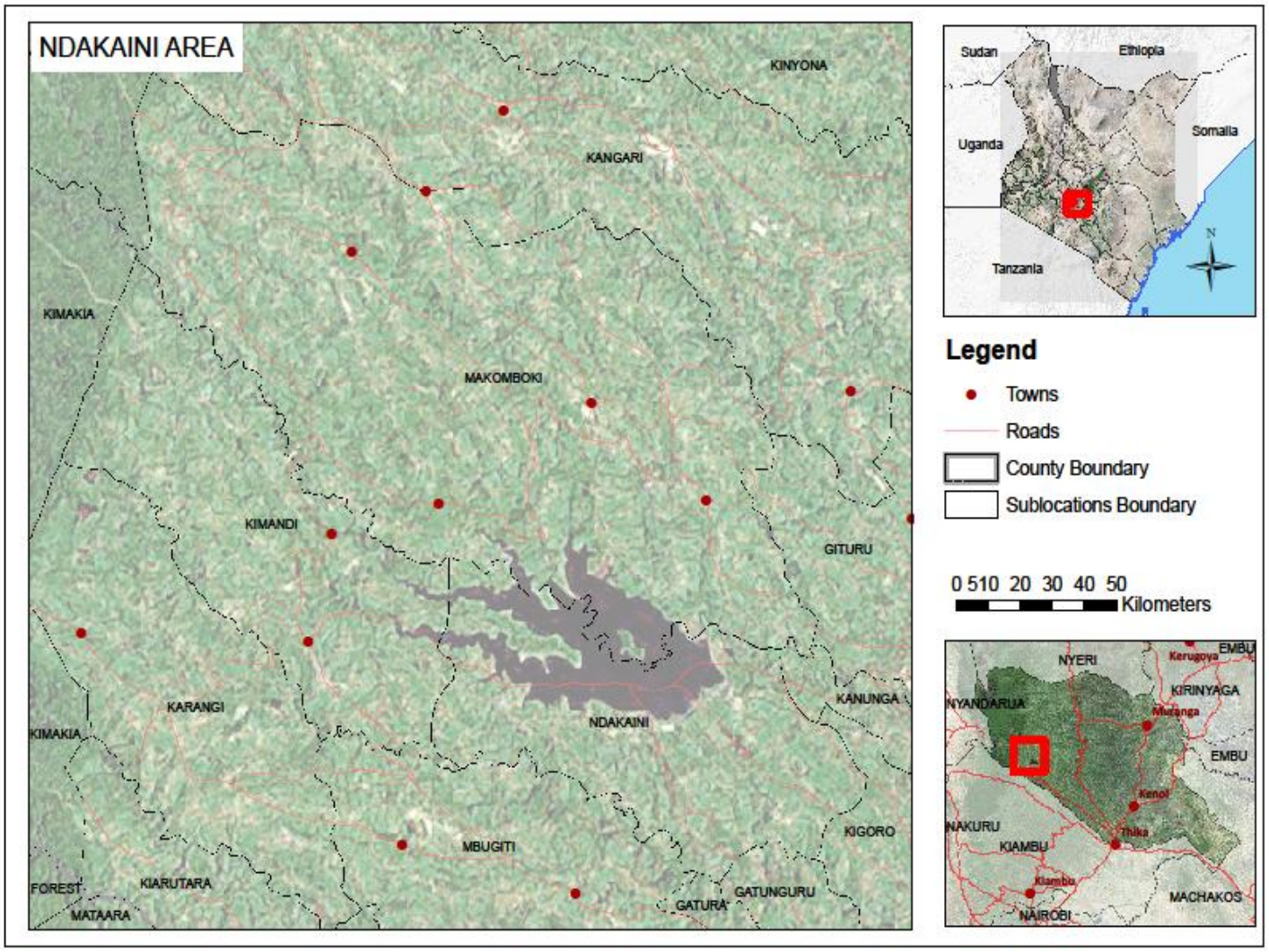


Figure 2.1: The study area-Ndakaini dam area in Muranga County, Kenya

(Source: Centre for training and integrated research in ASALs Development (CETRAD), 2014)

CHAPTER THREE: LITERATURE REVIEW

3.1 Introduction

The literature review provided an overview of previous research on the impacts of Dams across the world, how it has led to the disruption of many traditional production systems; including flood recession agriculture (through changing the availability of water on the surface and in shallow aquifers, and by changes in the distribution of fertile sediments delivered with the flood waters. It introduced the framework for the case study that comprised the main focus of the research described in this project.

3.2 Background Information

Reservoir dam has been constructed around the world as far back as 5000 years ago (Tortajada, 2001). Most of these dams were primarily constructed to accommodate water for farming and drinking purposes. However, over the past 60 years, dams and other water related projects were built to supply the industrial development with a cheap, in terms of operational cost and clean hydropower. In the present times, there are more than 40,000 large dams around the world and more than 400,000 square kilometres of area have been inundated by reservoirs worldwide. One of the world's largest man-made lakes in terms of surface area is the Volta Reservoir created behind the Akosombo dam of Ghana with an area of 8,500 Sq Km and flooded around 4% of the country's land area (Moxon, 1984). World Health Organization (WHO, 2005), recommends that health be added to the list of issues that must be addressed to ensure that dams are supportive of, and not detrimental to health, and for all communities. Thus, this study on Ndakaini dam provides results that can be used to mitigate the impacts of the dam on social and environmental impacts, because the issue has been given less attention in the existing policy and Legislation as seen in the subsequent sections.

3.2 Policy and Legislation

3.2.1 Legislation

Policy can be implemented through a range of instruments. These may include international conventions, national legislation and regulations and standards. Not all the instruments are, however, legal in nature; they may also include changes in departmental practices, and agreements with local and regional communities. Existing regulatory mechanisms could be used,

such as those associated with environmental laws. There are also a series of international standards that could be used to support health. These include ISO9000, on quality assurance, andISO14000, on environmental protection. In Kenya, the Environmental Management and Coordination Act (EMCA, 1999) provides in section 58 of the Act and legal Notice No.8, a project proponent whose project falls under the second schedule 9 (i) of the Act is required to submit impact assessment and audit report to the National Environment Management Authority (NEMA). Part V of the Environmental Impact Assessment (EIA) and Environmental Audit (EA) regulations provide for Environmental Audit and monitoring. The Act provides that an Environmental Impact Assessment shall be undertaken on all upcoming development activities, which are likely to have adverse environmental impacts. These development activities include ongoing projects that commenced prior to the coming into force of the foresaid regulations. Under the Waste Management Regulations, 2006 Part I (20) stipulates that the provisions of the Act relating to water quality regulations shall apply *mutatis mutandis* to effluents discharged into the aquatic environment. However, it is the Environmental Management and Coordination Act (Water Quality) Regulations, 2006 which provide comprehensive guidelines on water quality requirements for domestic use (Part II) and the quality limits of irrigation water (Part IV). Cultivation for example is prohibited within 50 metres. The Penal Code Cap 63 is also relevant in protecting water bodies because it prohibits the fouling of water, air and the emission of offensive noise and smell as follows: Section 191 states that "Any person who voluntarily corrupts or fouls the water of any public spring or reservoir so as to render it less fit for the purpose which it is ordinarily used, is guilty of a misdemeanour" answer the following questions:

- Does the project have a multi-stakeholder forum empowered to participate fully and actively in the decision-making process and be party to all negotiated agreements throughout the project cycle, from options assessment to final implementation, operation and monitoring?
- Does the multi-stakeholder forum includes all those rights holders whose rights are at risk from the project?
- Does the project enjoy the demonstrable public acceptance or, where indigenous peoples are affected, their free prior informed consent?
- Has an Options Assessment being undertaken at a sector level and has a river basin approach being taken in the assessment of environmental and social impacts?

3.2.2 Policy Framework

Researching and analysing the history of water resources management, the emergence of large dams, their impacts and performance, and the resultant dam's debate led the Commission to view the controversy surrounding dams within a broader normative framework. This framework, within which the dam's debate clearly resides, builds upon international recognition of human rights, the right to development and the right to a healthy environment. Within this framework the Commission has developed seven strategic priorities and related policy principles. It has translated these priorities and principles into a set of corresponding criteria and guidelines for key decision points in the planning and project cycles. Together, they provide guidance on translating this framework into practice. They help us move from a traditional, top-down, technology-focused approach to advocate significant innovations in assessing options, managing existing dams, including processes for assessing reparations and environmental restoration, gaining public acceptance and negotiating and sharing benefits. The seven strategic priorities each supported by a set of policy principles, provide a principled and practical way forward for decision-making. Presented here as expressions of an achievable outcome, they summa- rise key principles and actions that the Commission proposes all actors should adopt and implement.

1. Gaining Public Acceptance Public acceptance of key decisions is essential for equitable and sustainable water and energy resources development. Acceptance emerges from recognizing rights, addressing risks, and safeguarding the entitlements of all groups of affected people, particularly indigenous and tribal peoples, women and other vulnerable groups. Decision making processes and mechanisms are used that enable informed participation by all groups of people, and result in the demonstrable acceptance of key decisions. Where projects affect indigenous and tribal peoples, such processes are guided by their free, prior and informed consent.
2. Comprehensive Options Assessment Alternatives to dams do often exist. To explore these alternatives, needs for water, food and energy are assessed and objectives clearly defined. The appropriate development response is identified from a range of possible options. The selection is based on a comprehensive and participatory assessment of the full range of policy, institutional and technical options. In the assessment process social and

environmental aspects have the same significance as economic and financial factors. The options assessment process continues through all stages of planning, project development and operations.

3. Addressing Existing Dams Opportunities exist to optimize benefits from many existing dams, address outstanding social issues and strengthen environmental mitigation and restoration measures. Dams and the context in which they operate are not seen as static over time. Benefits and impacts may be transformed by changes in water use priorities, physical and land use changes in the river basin, technological developments, and changes in public policy expressed in environment, safety, economic and technical regulations. Management and operation practices must adapt continuously to changing circumstances over the project's life and must address outstanding social issues.

4. Sustaining rivers, livelihoods, watersheds and aquatic ecosystems are the biological engines of the planet. They are the basis for life and the livelihoods of local communities. Dams transform landscapes and create risks of irreversible impacts. Understanding, protecting and restoring ecosystems at river basin level is essential to foster equitable human development and the welfare of all species. Options assessment and decision-making around river development priorities the avoidance of impacts, followed by the minimization and mitigation of harm to the health and integrity of the river system. Avoiding impacts through good site selection and project design is a priority. Releasing tailor- made environmental flows can help maintain downstream ecosystems and the com- munities that depend on them.

5. Entitlements and sharing benefits joint negotiations with adversely affected people result in mutually agreed and legally enforceable mitigation and development provisions. These recognize entitlements that improve livelihoods and quality of life, and affected people are beneficiaries of the project. Successful mitigation, resettlement and development are fundamental commitments and responsibilities of the State and the developer. They bear the onus to satisfy all affected people that moving from their current context and resources will improve their livelihoods. Accountability of responsible parties to agreed mitigation, resettlement and development provisions is ensured through legal means, such as contracts, and through accessible legal recourse at the national and international level.

6. Ensuring compliance, ensuring public trust and confidence requires that the governments, developers, regulators and operators meet all commitments made in the planning, implementation and operation of dams. Compliance with applicable regulations, criteria and guidelines, and project-specific negotiated agreements is secured at all critical stages in project planning and implementation. A set of mutually reinforcing incentives and mechanisms is required for social, environmental and technical measures. These should involve an appropriate mix of regulatory and non-regulatory measures, incorporating incentives and sanctions. Regulatory and compliance frameworks use incentives and sanctions to ensure effectiveness where flexibility is needed to accommodate changing circumstances.

7. Sharing Rivers for Peace, Development and Security Storage and diversion of water on trans-boundary rivers has been a source of considerable tension between countries and within countries. As specific interventions for diverting water, dams require constructive co-operation. Consequently, the use and management of resources increasingly become the subject of agreement between States to promote mutual self-interest for regional co-operation and peaceful collaboration. This leads to a shift in focus from the narrow approach of allocating a finite resource to the sharing of rivers and their associated benefits in which States are innovative in defining the scope of issues for discussion. External financing agencies support the principles of good faith negotiations between riparian States.

3.2.3 Policy Practice

The Commission's recommendations can best be implemented by focusing on the key stages in decision-making on projects that influence the final outcome and where compliance with regulatory requirements can be verified. Among the multitude of decisions to be taken, the Commission has identified five key decision points. The first two relate to water and energy planning, leading to decisions on a preferred development plan:

Needs assessment: validating the needs for water and energy services;

- Selecting alternatives: identifying the preferred development plan from among the full range of options.

- Where a dam emerges from this process as a preferred development alternative, the further critical decision points occur:
- Project preparation: verifying that agreements are in place before tender of the construction contract;
- Project implementation: confirming compliance before commissioning
- Project operation: adapting to changing contexts.
- Social, environmental, governance and compliance aspects have been undervalued in decision-making in the past. It is here that the Commission has developed criteria and guidelines to innovate and improve on the body of knowledge of good practices and add value to guidelines already in common use. Seen in conjunction with existing decision-support instruments, the Commission's criteria and guidelines provide a new direction for appropriate and sustainable development. Bringing about this change will require:
- Planners to identify stakeholders through a process that recognizes the rights and assesses risks
- States to invest more at an earlier stage to screen out inappropriate projects and facilitate integration across sectors within the context of the river basin
- Consultants and agencies to ensure outcomes from feasibility studies are socially and environmentally acceptable
- The promotion of open and meaningful participation at all stages of planning and implementation, leading to negotiated outcomes
- Developers to accept accountability through contractual commitments for effectively mitigating social and environ- mental impacts
- Improving compliance through independent review; and
- Dam owners to apply lessons learned from past experiences through regular monitoring and adapting to changing needs and contexts.

According to McCully (1996) environmental impacts of dams can generally be classified into two groups, due to the existence of the dam and reservoir and due to the pattern of dam

operation. He summarized these two categories as follows: Negative and positive Impacts due to existence of the dam and reservoir as are follows:

3.3 Positive impacts of Reservoir dams

Reservoirs can provide access to irrigation for agriculture by storing water in times of surplus and dispensing it in times of scarcity. Reservoirs can be effectively used to regulate river levels and flooding downstream of the dam by temporarily storing the flood volume and releasing it later. Reservoirs can save labour for the elderly and women's families in irrigating the crops. Reservoirs can promote aquaculture and fisheries development in a river basin. Reservoirs can promote the development of non-agricultural activities, such as ecotourism, recreation, and inland navigation.

3.4 Negative impacts of Reservoir dams

Imposition of a reservoir in place of a river valley (loss of habitat). Changes in downstream water quality: effects on river temperature, nutrient load, turbidity, dissolved gases, concentration of heavy of heavy metals and minerals. Reduction of biodiversity due to blocking of movements of organisms (e.g. Salmon). Changes in downstream hydrology Change in extreme high and low flows. Changes in downstream water quality caused by altering flow pattern. According to Paul Schuler (2007) during the past 20 years, a growing international movement against dams has emerged, rallying behind the charge that governments notoriously ignored human and ecological costs when beginning hydropower projects. The dangers that dams pose to the natural environment have been widely documented. The International Rivers Network (IRN) reports that 60 percent of the world's major rivers are dammed and just less than one percent of the world's land surface has been inundated by reservoirs worldwide. The detriment to rivers, wetlands and forests have been extensive, and "led to irreversible loss of species and ecosystems.

This paper, however, centres its analysis on the social effects of hydropower dam projects. The WCD found that between 40 and 80 million people have been physically displaced by dams worldwide. A WB review of projects between (1986 -1993) estimated that 4 million people were displaced annually by the 300 dams (on average) that were constructed each year. This scale of mass-displacement makes it imperative that the potential impacts on livelihood, health, and traditional cultures be carefully monitored and managed. Equity concerns are also relevant.

Displaced communities are frequently indigenous people and other ethnic minorities whose voices have too often been silenced by existing power structures. The most commonly cited negative social impacts of dams are described below: (Paul Schuler 2007).

3.5 Discrimination

In (1994), the World Bank acknowledged in its "Bank-wide Review of Projects Involving Involuntary Resettlement" that those resettled as a result of dam projects are generally from the poorest and most vulnerable sections of society. The WCD Thematic Review on Social Issues also concluded that due to structural inequities and institutionalized racism, indigenous populations and other minorities have "suffered disproportionately from the negative impacts of dams, while often being among those who have been excluded from sharing the benefits. As an example, the Indian government estimates that over 40 percent of displaced people are from the adivasis (tribal) communities that represent only 6 percent of India's total population. Moreover, dams may impose a disproportionate cost to women who are often more. (Paul Schuler 2007).

The United Nations World Commission on Environment and Development (WCED) defines sustainable development as development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs (WCED, 1987). Thus, any developmental project (including reservoirs) should be mitigated to reduce major impacts of human and natural ecosystem. Further, Principle one of Agenda 21 (UNCED, 1992) places people at the centre of development, and therefore justifies the inclusion of health concerns in all development policies and recommends environmental and health impact assessments (UN, 1993). In Europe, the Maastricht Treaty, 1992, and the Amsterdam Treaty, 1999, require that the European Union shall ensure that development proposals do not have an adverse impact on health, or create conditions that undermine health promotion. The European Policy for Health advocates multi-sectoral accountability through health impact assessment of both internal and foreign policies (WHO, 1998). The European Charter on Transport, Environment and Health recognizes the need for health impact assessment (WHO1999). The UK government has published a White Paper on Public Health and a report on health inequalities that establish policies for the assessment of health impacts of all government policies (Acheson *et al*. 1998).

3.6 Construction

Reservoir construction projects demand large amounts of skilled and unskilled labour, which can benefit the surrounding communities. Although many of the dam construction projects promises to provide employment opportunities for local people, they often tend to be a minority of the labour force. For example, in Saguling Dam in Indonesia, not more than twenty-five resettles were employed, and in James Bay Project in Quebec, less than 5% of the labour force were Cree Indians. Most of the local people seldom have the skills required by the contractors. Crash training programs seldom bring skills up to the required standards (e.g., Lesotho Highland Water Project).

3.7 Compensation

Compensation for the value of their homes and land. In many cases this deal has been fulfilled without a problem. In what is likely the overwhelming majority of cases, however, relocated citizens have either been given far too little in compensation or their dues have been slimmed through corruption and embezzlement. Compensation in some instances has been as meagre as the equivalent of $7 a month, and many claim they have received only half the land compensation they were promised (Hvinstendahl 2008). This has meant problems for many as the cities and towns they have had to move to are more expensive, driving many people deeper into poverty (Yardley 2007).

3.8 Involuntary Resettlement

According to the World Bank, forced population displacement caused by dam construction is the single most serious counter developmental social consequence of water resources development. The displacement toll of the 300 dams that, on average, enter into construction every year is estimated to be above four million people, with at least 40 million so relocated over the past two decades. The social cost of involuntary resettlement varies greatly between projects; however, a disproportionate number of ousters are tribal or landless people who in many instances were resettled with force and violence. The trauma of resettlement can be devastating as a result of weakened or dismantled social networks and life support mechanisms, thereby leading to the loss of their capacity to self-manage. With an extensive comparative analysis of resettlement issues related to dam construction, Cernea (1990) has identified eight risks that lead to social impoverishment: landlessness, joblessness, homelessness, marginalisation, increased morbidity,

food insecurity, the loss of access to common property, and social disarticulation. Scudder (1997) has added a ninth risk, which is the loss of resiliency. However, resettlement can have positive impacts if well planned, but this takes time. Usually the second generation of the displaced community can realize the benefits of a successful resettlement with better utilization of the resources available to them. Provided that such communities are relocated with adequate compensation, new economic opportunities, and social benefits, they can exploit the new circumstances as a chance to strengthen their income-earning capacity and thus their living standards. The new settlement may provide upgrades infrastructure facilities and reduced exposure to natural hazards.

3.9 Post-construction

Reservoir can support numerous economic activities that generate employment for both local people and immigrants. However, the changes in the downstream flow patterns can severely disrupt economic activities and social organization downstream. Farming patterns on flood plains are severely affected and require irrigation water. Fish populations fall and the effects are felt even in the estuarine areas where the productivity can drop to extremely unacceptable levels. Economic activities and social organization in the downstream regions can therefore be disrupted with increased rates of out-migration, reduced agricultural productivity and hence land prices, and many other negative impacts. Loss of historic or cultural sites is another cause for concern that arises as a direct impact of reservoir inundation.

3.10 Cultural Alienation

The fertile soils of river valleys have always been densely populated, giving rise to some of the world's most ancient civilizations. Displacing these community risks the loss of valuable traditional knowledge systems and destroys part of the world's cultural heritage. The (WB) has recognized that forced displacement threatens traditional kinship associations. Moreover, the abandonment of symbolic markers such as grave sites and ancestral lands can sever linkages with the past and undermine a community's cultural identity. The physical landscape of indigenous communities is often intimately linked to their social, cultural and political way of life. For example, Survival International notes that "the Akawaio have invested the landscape with special significance. It is an environment transformed by their ancestors in conjunction with the mystic forces of the universe, thus the landscape is dynamic, every part is living, functional, has

meaning and moral value" (referring to the Akawaio Indians of Guyana threatened by the Upper Mazaruni Dam in the (1970s Health.

The World Health Organization (WHO) has reported that the reservoirs created behind dams are often breeding grounds for waterborne illnesses (such as schistosomiasis, malaria, and cholera) and other potentially toxic bacteria. 31 Numerous studies have corroborated these health risks. For example, a study undertaken in the Cote D'Ivoire documented significant increases in schistosomiasis after the construction of two large hydroelectric dams (from 14 to 53 percent around Lake Kossou and from 0 to 73 percent around Lake Taabo). A study in Sri Lanka revealed that increased outbreaks of malaria "seem intimately related to hydrological changes brought about by major irrigation and hydroelectric schemes on the Mahaweli River, "exacerbated by the increased migration caused by resettlement. The report concludes that "this story is a classic of health impacts overlooked in favour of agricultural and industrial development.

Elevated mercury levels in fish downstream of dam projects have also been documented, posing long-term health risks linked to fish consumption. One study in Brazil found fish mercury increases in Lago Manso, a hydroelectric reservoir. The authors expected mercury levels to return to normal "Within some decades," but warned that the reduced fish populations downstream from the dam would most likely be permanent because of the decreased water flow. According to the study, "the risk of elevated mercury (Hg) concentrations in fish has become one of the most important issues in assessing the environmental impact of hydroelectric reservoirs. Finally, the stress of relocation and disruption of social networks is also known to adversely affect health and wellbeing. Women may be particularly vulnerable to the resettlement process, as noted by the WCD report: "Compulsory resettlement is stressful because of the way in which people are uprooted from homes and occupation and brought to question their own values. Gender is an important factor in resettlement. Women as marginalized entities within marginalized communities are often forced to shoulder the ordeal of displacement far more intensely. (Paul Schuler 2007)".

3.11 Environmental Impact

Reservoir dam has potential environmental nightmares (Hvistendahl 2008). That said, one of the most immediate environmental effects of the dam has been an increase in landslide activity. This

results primarily from erosion caused by the drastic increases and decreases in reservoir water levels, which, when at their peak, create a body of water almost as long as Britain (Watts 2010). Another major issue with the dam is the ways in which it is affecting biodiversity in the area. Animal and plant life has been greatly threatened due to flooding in some habitats and water diversion in others. Furthermore, fragmentation of habitat may lead to heavy losses of biological diversity (Jianguo et al. 2003). As one author compellingly shows, fragmentation leads to species insularization by creating virtual islands, which confound processes of ecosystem stability and biological enrichment (Quammen 1996). Fragmentation of habitat, moreover, is disturbing the reproduction patterns of many species, suggesting that if they haven't disappeared yet, they soon may. Whether one agrees that this means a loss of spiritual and cultural wealth, it undoubtedly means a loss in resources that might otherwise have been tapped. Examples might include medical plants, among others. Decreases in freshwater flow have meant that more saltwater is creeping up the Yangtze, endangering fish populations already threatened by overfishing (Hvinstendahl 2008). This again signifies a loss of valuable resources. There has also been a 50% loss in sediment and nutrients downstream, a common issue with most dams, which will cause erosion to river systems, wetlands, and seacoast ecosystems, leading to adversely impact fisheries and wetland watersheds (Handwerk 2006).

Lastly Dam may have been tied to major earthquakes, including the one in May of 2008 which killed 87,000 people (Associated Press 2011). By placing tremendous pressure and fluctuation (by rapidly raising and dropping water volume) on the underlying geological plates, TGD arguably increases seismic activity. Proving that this leads to increased earthquakes, however, is more difficult (Naik et al. 2009).

3.11.1 Human health and dams

Environmental change and social disruption resulting from large dams and associated infrastructure developments such as irrigation schemes can have significant adverse health outcomes for local populations and downstream communities. The issue of equity - in terms of pre-existing nutritional and health conditions of the population and the capacity to resist new health problems is at the root of the adverse health impacts of dams (WHO, 1999). Among the resettled communities, access to drinking water, health services and ability to cope with new social and physical environment determines health conditions. Numerous vector borne diseases

are associated with reservoir dam development in tropical areas. Schistosomiasis (Bilharzia) spread through snails breeding in still or slow moving waters was a significant public health problem that emerged from many early projects, such as Akosombo (Hira, 1969) (Mungomba, 1993), Jobin (1999). The sporadic outbreak of the Rift Valley Fever has also been associated with the Aswan and Kariba dams and irrigations systems undertaken along the Blue Nile in Sudan (WHO 1999). Most reservoir and irrigation projects undertaken in endemic areas increase

Transmission and diseases (WHO, 1999). In new dams tropical, subtropical, and arid and semi arid regions is rapid eutrophication resulting in problems of excessive aquatic weed growth or blooms of toxic cynobacteria. This is reinforced by enhanced nutrient pollution through the growth of towns, agriculture and mining operations in the catchment.

3.11.2 The magnitude of health problem

Water-related diseases are a human tragedy, killing millions of people each year, preventing millions more from leading healthy lives, and undermining development efforts (Nash, 1993, Olshansky *et al* 1997). About 2.3 billion people in the world suffer from diseases that are linked to water (Kristof 1997, UNCSD, 1997) Some 60% of all infant mortality is linked to infectious and parasitic diseases, most of them water-related (Rowley, 1990). In some countries water related diseases make up a high proportion of all illnesses among both adults and children. In Bangladesh, for example, an estimated three quarters of all diseases are related to unsafe water and inadequate sanitation facilities. In Pakistan one quarter of all people attending hospitals are ill from water related diseases (Ali, 1992) Effects of diseases associated with water bodies can be classified into three categories: waterborne diseases, including those caused by both faecal oral organisms, and those caused by toxic substances; water based diseases; and water related vector diseases (Bradley 1994, Kjellen and McGranahan 1997). Waterborne diseases waterborne diseases are “dirty-water” diseases- those caused by water that has been contaminated by human, animal, or chemical wastes. Worldwide, the lack of sanitary waste disposal and clean water for drinking, cooking, and washing is to blame for over 12 million deaths a year (USAID 1990, Warner 1998,). Waterborne diseases include diarrhea, cholera, typhoid, Shigella, polio, meningitis, and hepatitis A and E. Human beings can act as hosts to the bacterial, viral, or protozoal organisms that cause these diseases. Millions of people have little access to sanitary waste disposal or to clean water for personal hygiene. An estimated 3 billion people lack a

sanitary toilet, for example. Over 1.2 billion people are at risk because they lack access to safe, fresh water (Khan 1982, WHO 1997). Diarrhoea, the major waterborne disease, is prevalent in many countries where sewage treatment is inadequate. Instead, human wastes are disposed of in open latrines, ditches, canals, and water courses or they are spread on cropland. An estimated 4 billion cases of diarrhea disease occur every year, causing 3 million to 4 million deaths, mostly among children (Olshansky *et al* 1997, USAID 1990, Warner 1998, World Bank 1993). Toxic substances that find their way into fresh water are another cause of waterborne diseases. Increasingly, agricultural chemicals, fertilizers, pesticides, and industrial wastes are being found in freshwater supplies. Such chemicals, even in low concentrations can build up over time and, eventually, can cause chronic diseases such cancers among people who use the water (Silfverberg 1994). Health problems from nitrates in water sources are becoming a serious health problem almost everywhere. In over 150 countries nitrates from fertilizers have seeped into water wells, fouling the drinking water (Maywald *et al,* 1988). Excessive concentration of nitrates causes blood disorders (Bowman 1994). Also, high levels of nitrates and phosphates in the water encourage the growth of blue-green algae, leading to deoxygenation (eutrophication). In tropical, sub-tropical and arid regions of the world, it is almost inevitable that new dams will become atrophied (nutrient enriched) rather quickly, often within the first few years of filling and operation. Eutrophication brings with it problems of excessive aquatic weed). Arid zones of the world are particularly at risk, where the artificial impoundment of water in the growth or 'blooms' of toxic cyanobacteria (cyanobacteria are a type of microscopic algae hot climate creates the perfect ecological environment for the growth of toxic cyanobacteria. Added to this natural climatic effect is the enhanced rate of nutrient pollution that accompanies the growth of towns and agriculture in the catchment around a dam, often with inadequate effluent collection and treatment facilities. Blooms of freshwater algae and cyanobacteria have always occurred in eutrophied waterways, but the toxicity of these organisms has only been elucidated in recent years (WHO 1999). The most severe and well documented case of human poisoning due to cyanobacterial toxins occurred in the Brazilian city of Curaru in 1996. Inadequately treated water from a local reservoir was used for patients in a local kidney dialysis clinic. As a consequence, more than 50 people died due to direct exposure of the cyanobacterial toxin to their blood stream during dialysis. Elsewhere in SouthTh America, in 1988, more than 80 deaths and 2,000 illnesses due to severe gastroenteritis have also been linked with toxic cyanobacteria in a newly

constructed dam (WHO, 1999). In China, a high incidence of primary liver cancer has been linked to the presence of cyanobacterial toxins in drinking water (Chorus and Bartram, 1999). The lessons learnt from these cases are that drinking raw water from a dam is dangerous to health and can lead to disease outbreaks. This study will document the disease situation that can be linked use of untreated water.

3.11.3 Water borne diseases

Waterborne diseases are caused by aquatic organisms that spend part of their life cycle in the water and another part as parasites of animals. These organisms can thrive in either polluted or unpolluted water. As parasites, they usually take the form of worms, using intermediate animal vectors such as snails to thrive, and then directly infecting humans either by boring through the skin or by being swallowed (Bradely, 1994). Water based diseases include guinea worm (*dracunculiasis*), paragonimiasis, clonorchiasis, and schistosomiasis (bilharzias). These diseases are caused by a variety of flukes, tapeworms, roundworms and tissue nematodes, often collectively referred to as helminthes that infect humans (Muller and Morera 1994). Although these diseases usually are not fatal, they can be extremely painful, preventing people from working and sometimes even making movement impossible. The prevalence of water-based diseases often increase when dams are constructed, because of the stagnant water behind dams is ideal for snails, the intermediary host for many types of worms. For example, the Akosombo Dam, on a Volta lake in Ghana, and the Aswan High Dam, on the Nile in Egypt, have resulted in huge increases of schistosomiasis in these areas (Basch 1990). Also, in Mali a survey conducted in 225 villages in different ecological settings found that the prevalence of urinary schistosomiasis was five times greater in villages with small dams (67%) than in the drier savanna villages (13%) (Hunter *et al*, 1993).

3.11.4 Water vector diseases

Millions of people suffer from infections that are transmitted by vectors- insects or other animals capable of transmitting an infection, such as mosquitoes and tsetse flies- that breed and live in or near both polluted and unpolluted water. Such vectors infect humans with malaria, yellow fever, dengue fever, sleeping sickness, and filariasis. Malaria, the most widespread is endemic in about 100 developing countries, putting some 2 billion people at risk (Chatterjee 1995, World Bank 1993). In sub-Saharan Africa, malaria costs an estimated US$1. 7 billion annually in treatment

and lost productivity (Olshansky *et al* 1997). Lack of appropriate water management, along with failures to take preventive measures, contributes to the rising incidences of malaria, filariasis, and onchocerciasis. Dam construction projects often increase the mosquito population due to stagnant water (Hunter *et al* 1993). For example, in West Africa an epidemic of Rift valley fever in 1987 has been linked to the Senegal River Project. The project, which flooded the lower Senegal River area, enabled the type of mosquito that carries the virus to expand so much that the virus was transmitted to humans rather than remaining in the usual animal hosts (Olshansky *et al* 1997).

3.11.5 Prevention and solutions

Studies by Alam (1989), Esrey and Habicht (1991), Haines and Avery (1982, Henry (1981), Khan (1982), and Young and Briscoe (1987) and WHO (1999) show that waterborne diseases can be prevented by improving public sanitation and providing a clean water supply. These are the two steps needed to prevent waterborne diseases and deaths. Water-based diseases can be prevented by improved sanitation, refraining from entering infected water bodies and providing hygienic disposal of human waste (Yacoob *et al* 1989). Some water development schemes have started disease control programmes along with construction of facilities. In the Philippines, for example, where the development of water resources is a high priority, the National Irrigation System Improvement Project in Layte, began in 1979 and has included specific provisions and funding to control schistosomiasis. As a result the prevalence of water-based diseases fell from 24% in 1979 to 9% in 1985 (Hunter *et al* 1993). And since few people fell ill, the average increase in productivity was an estimated 19 days of work per person per year, worth an additional US $1 million in wages. Water-related vector diseases are problematic to prevent as many methods of removing the vectors has resulted to negative environmental impacts (Olshansky *et al* 1997). The most feasible methods are those that use biological control (WWF 1998). This includes breeding fish species that eat mosquito larvae and releasing them into the reservoir. Other management options suggested by research include flushing of streams and irrigation canals at critical times to reduce mosquito densities and malaria transmission. Further testing of different options for flushing regimes can provide an optimal combination with both health and agricultural benefits (van der Hoek *et al*. 1998; Matsuno *et al.* 1999).

3.12 Social Impacts and mitigation measure

Dams have enormous consequences for people's lives and livelihoods, which include controversial issues such as displacement and resettlement. The opponents of dam construction argue that the social and economic consequences (and also environmental) of dams are more far-reaching than those associated with other infrastructure projects because of the huge impact across time and space in both the ecosystem and in social, economic, and cultural structures. The impacts, both positive and negative, can be better illustrated in connection with the dam project cycle.

3.13 Ndakaini Dam Marathon

A summary of experiences and lessons learnt on the Ndakaini Dam has been presented by Kamau (2000). He concludes that there is a need for water availability for specific uses to be clearly identified, including the range of many inputs which compliment water availability to realize the identified specific socioeconomic and environmental benefits.

Ndakaini Half Marathon is an initiative that started in the year 2004 to raise funds towards conservation of Ndakaini dam catchment area. It has been ongoing since its inception with the aim of supporting sustainable supply of safe water to the Ndakaini dam through conservation of the catchment area and empowerment of the local community to develop viable social economic enterprises associated with the dam. The marathon was coordinated by the Ndakaini Dam Environmental conservation Association (NDEKA) and was supported by corporate organizations that are keen on environmental conservation.

Particularly on a project that is geared towards promoting water efficiency amongst the farming communities in the two sub watersheds of upper Tina. The project is in Maragua and Sagana constituencies under the support of The Nature Conservancy (TNC) and UNDP. It focuses on mobilizing community members to adopt water efficient farming techniques and harvesting technologies which include; adoption of drip kit, irrigation technology aimed at protecting and conserving the watershed areas, and the on-farm rainwater harvesting for supplementary farming by the use of water pans. Some of its activities are:

- To strengthen Farming Institutional and Organizational capacities.
- To enable Farming at different levels to influence policies on priority subjects.

- To improve Farming entrepreneurial capacities and participation in value chains.
- To strengthen the capacity of the Pan-African Farmers' Organizations to participate and influence policy processes in agriculture and rural development at continental and international levels

3.13.1 Project Results

- Improved performance of small-scale farmers with respect to increased incomes, increased production, increased productivity or access to new markets
- Selected farmer organizations have the capacity to effectively provide economic services for their members
- Policy-related challenges affecting performance of farmer organizations have been addressed
- The successes, best practices, challenges and failures of significant economic initiatives are capitalized and shared among members and partners

3.14 Gaps identified from the literature review

That most dams planning designs do not factor in the component of community human health in their budget in spite of its significance.

- That although community socioeconomic is always one of the justifications for the purpose of reservoir dams, but many of the projects do not necessarily achieve it sustainable.
- Community participation is vital in reservoir management though it is only recently that this has been acknowledged.
- That although Ndakaini Dam should have significantly improved the livelihoods of the local communities.
- Encouraging small scale irrigation farming methods is very important for reducing deforestation and erosion as well as the removal of the catchment vegetation as part of land preparation.

3.15 Operational framework

The environmental and social consequences of the dam have several dimensions that are worth considering in the conceptual framework designed for this study. Reservoirs projects are considered to be major assets in terms of the quality and quantity of water they generate for industrial, domestic, irrigation, and the tourist attraction. Notwithstanding these benefits, there are many deleterious social and environmental impacts which have been considered to be adverse on humans and the natural environment. Whenever dams are constructed, multiplicities of actions, both natural and artificial are set in the process. These include; loss of land and vegetation, which translates to the net loss of habitat for plants, animals and human beings. Another impact is the increasing rate of river/lake sedimentation. Usually human activities within dam catchment areas have accelerated the sedimentation process through farming, human attachment, etc. Due to inundation of the habited areas, by the lake water there is the urgent necessity to resettle the local inhabitants. It is important to note that resettlement and compensation generally constitute the greatest socioeconomic cost of water Dam project development. Furthermore, several aspects of the socio-cultural as well as environmental health related problems have to be considered for redress. The components of the conceptual framework of the study below reflect the key issues under investigation in this project.

3.15.1 Dependent and Independent variables

Independent variable

Environmental changes

Social impacts

Dépendent variables

Livelihoods and Culture

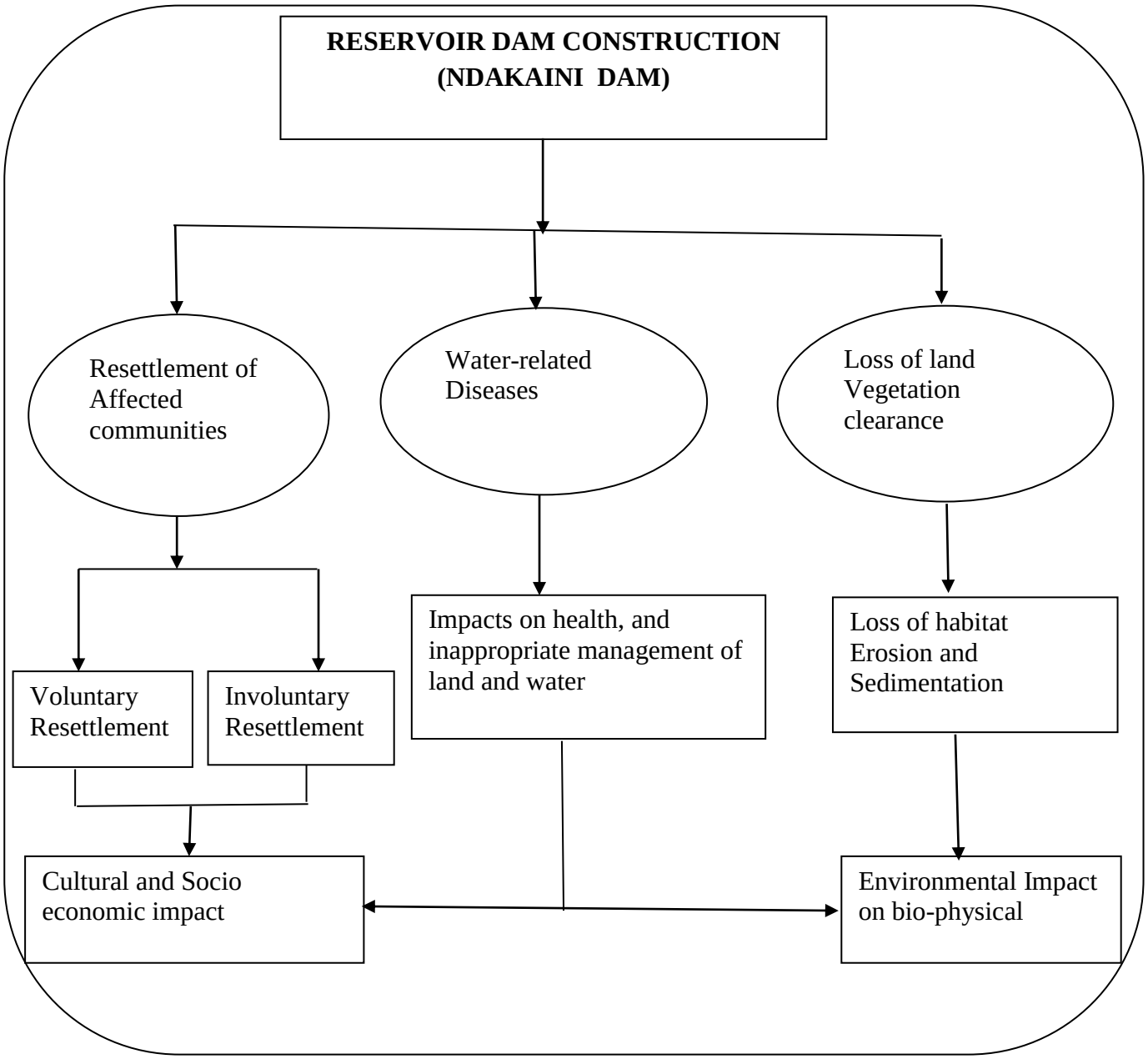


Figure 3.1: Operational framework

Source: Modified from Yonatan Girmay (2006)

CHAPTER FOUR: RESEARCH METHODOLOGY

4.1 Introduction

This chapter examined the research methodology, the approach adopted for sourcing data or information in order to achieve the study objectives and answer the research questions. The chapter contains the study design, definition of the target population, sample size, and analyses techniques/tools.

4.2 Target Population and sampling frame

The population of the study consisted of catchment community who are residents of the three sub-locations. The catchment community formed the target population of 14,218 (KNBS, 2009). The sampling frame was the list of the sub-locations in Gatanga sub-county.

4.3 Sample size and techniques

Sampling is the process by which inference is made to the whole population by examining a part of it (GMU, 2004). May (1993) mentions the advantages of sampling to include: first, the data collection being cheaper; secondly, it requires fewer people to collect and analyse data; thirdly, it saves time; fourthly, It permits a higher level of accuracy as the sample size allows a check on the accuracy of the design and administration of the questionnaires; and finally fewer cases make it possible to collect and deal with more elaborate information.

The sample size (**n**) was calculated using the Fishers formula as recommended by Mugenda and Mugenda (2003):

$$n = \frac{Z^2 \quad p \quad q}{d^2}$$

Equation 4.1: Fishers formula

Where:

- Z refers to the confidence limits of the study results, i.e**. 95%** where **Z = 1.96**
- P refers to the proportion of the population who have experienced the social and environmental effects of the dam. Estimation (**0.05**)
- q = (**1-p**) refers to the proportion of the population who have not experienced the social and environmental effects of the dam. Estimation (**0.95**).

- d refers to the desired precision of the estimates (within a range of plus or minus 5%)

So, using Fisher et al. (1983) equation above, one gets:

$$n = \frac{1.96^2 \quad 0.05 \quad 0.95}{0.05^2}$$

=73

Equation 4.2: Sample size

A sample of 73 catchment community was selected. Fisher's formula for selecting a sample of a population above 10,000 was used to get the sample size (Mugenda and Mugenda, 2003).

Purposive sampling was used to select the sub-locations which host the dam. The respondents were then selected by use of random sampling technique to constitute the sample size because the sample size was homogenous. This gave each resident an equal chance of being selected. Table 4.1 gives the sample from each location.

Table 4.1 Population size for each location and sample sizes for each location

Location	Population size	Sample size
Makomboki	**8, 295**	**42**
Ndakaini	**2, 444**	**13**
Kimandi	**3, 479**	**73**
TOTAL	**14, 218**	**73**

(Source: Republic of Kenya population and housing Census, 2010))

4.4 Primary Data collection

4.4.1 Research tools

The study collected data from the catchment community within the three sub-locations. Both questionnaire and interview schedule were used to collect data on information pertinent to social and environmental effects of Ndakaini dam.

Semi-structured Questionnaire

The questionnaires were semi-structured and administered by means of personal interviews which encouraged the respondents participate and to allow probes, clarification by the interviewer as observed by Peil et al (1982). The open ended questions will be used to allow the respondents to give their own opinions. Closed questions will be presented with a series of choices to allow the respondents to choose one answer. The questionnaire will be used to gather information on the location and background of the respondents, Environmental Health Issue, social economic and cultural issues. The questionnaire will be administered by oral interviewing during the month of October and November 2014 to randomly selected respondents.

Plate 4.1: Questionnaire administration in Makomboki (Photo by Researcher, 2014)

Plate 4.2: members group discussions

(Photo by Researcher, 2014)

Focus group discussions were conducted in a selected sub - location each representing one location. The focus groups comprised 10 – 15 participants who selected with consideration of all social group representations; men, women, youth, aged people, influential people in the village and village leaders. From focus group discussions, qualitative information such as general opinion, awareness and attitude towards Ndakaini dam will be collected. The checklist was the basic tool for conducting focus group discussions. Participants' responses were recorded in a notebook during the discussions or immediately thereafter.

Pre-test of survey Instruments

The semi-structured questionnaire was pretested before by piloting in order to gauge its reliability in gathering the required data. A sample of 20 respondents was being selected randomly outside the area of the study and involved in filling the questionnaire. The number 20 was chosen for pre-test because according to Kothari (1993) it is the smallest number that can yield meaningful results on data analysis in a survey research. The required corrections were made to the questionnaire/interview schedule before being administered to the households involved in the study.

Field Observation

Field observation was used to verify some, such as encroachment, flooding, fishing activities, crop destruction by wildlife and recreational activities in the study area.

Photography

Photography was used in data gathering. Areas affected as a result of dam flooding, dam situation as well as the human activities that take place around the dam.

4.5 Secondary data collection

Secondary data were sought from annual reports of relevant ministries and journals, Nairobi Municipal council reports, hospital/clinic reports and books relevant to the area of research.

4.6 Study Design

A case study design was adopted for the study. The Case study design is a research methodology and also an investigative tool that is commonly used in studying social phenomena (Babbie and Mouton, 2004). The study saw a case study as a research strategy that will facilitate investigation of a phenomenon within its real-life context. Thus, the Case Study Design permitted an in-depth investigation of individuals, focus groups, or events which may be descriptive or explanatory.

The design was the most relevant approach of collecting and analysing data and reporting the results in the attitude and knowledge towards the impact of Dam within the study area. The study further saw this design as appropriate for providing clear understanding of the issues being studied.

4.7 Study location

The study was carried out in three sub-Locations namely, Makomboki, Ndakaini and Kimandi of Gatanga sub-county in Muranga County. These locations were chosen for the study because they host the Ndakaini dams.

4.8 Data analysis

4.7.1 Descriptive statistics

Descriptive statistics were used to analyse the characteristics of the population studied. According to Trochim (2006) descriptive statistics are used to describe the basic features of the data in a study providing simple summaries about the sample and the measures. Measures of central tendency (mean) and percentages were used to summarize the data occurrences. Data presentation included the use of graphs, percentages, pie charts and moving averages. These were used to describe demographic data such as age, education, employment status etc.

4.7.2 Inferential statistics

According to Rwegoshora (2000) inferential statistics are used to make inferential statements about a population. Pearson's, Chi-square was used to test hypotheses and Pearson's correlations were used to test the hypothesis and to test the presence of relationships between parameters.

CHAPTER FIVE: RESULTS AND DISCUSSIONS

5.1 Introduction

This chapter presents the results, profiles of the respondents and discussions of the findings and also the impacts of the mitigation measures that have been put in place to minimize the social and environmental risks of the dam objectives, as the collection of data during the survey. The chapter also gives evidence relevant to the research questions and objectives.

5.2 Response Rate

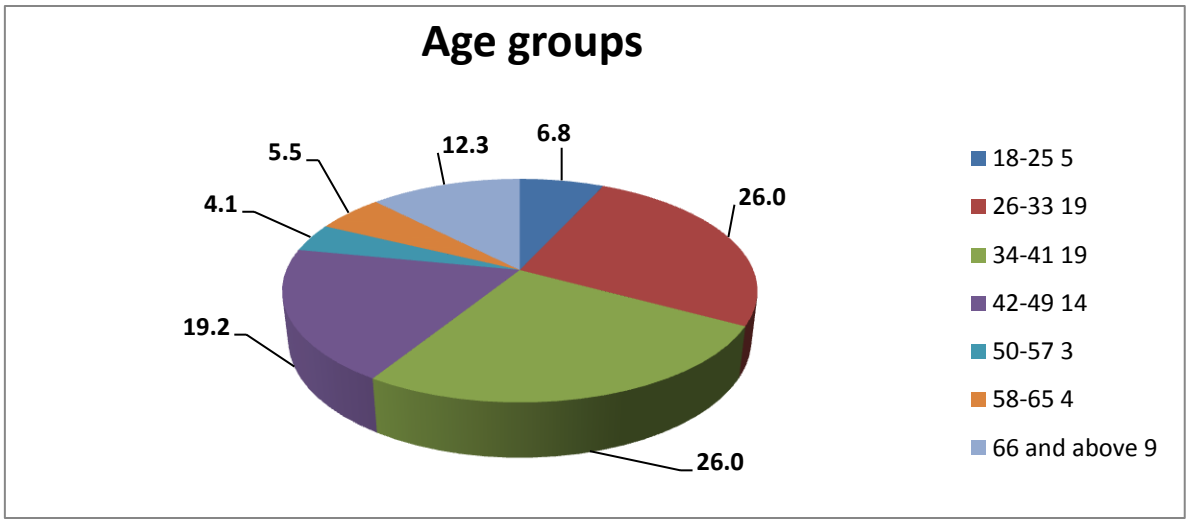
The research was conducted on a sample of 73 respondents who was the residents of the catchment area, of the three sub-locations to which questionnaires was administered. However 73 questionnaires were returned duly fill in making a response rate, which was sufficient for statistical reporting 5 unstructured questionnaires were also administered by the Ndakaini Dam authority as key informants. Based on the rate, the research commenced the process of data analysis. The following sections present findings as arranged on the research instruments.

5.3 Demographic characteristics of the respondents

5.3.1 Age of the respondents

The age of the respondent is important for the study because it shows that there is a strong relationship between the age of the respondents and the long term dam knowledge of the social and environmental effect. Using this approach, a high proportion of older are recruited (Braunstein, 1993; Liebman and Thomas, 1992; Robles et al, 1993; Watters, 1993; Watters and Biernecki, 1989). Figure 5.1 shows the group's distribution. It is reported that all the respondents were adults, with the majority of the respondents being over 34 years. Secondly the age of the respondent was important in this study because it determines the reliability of the answers provided during questionnaire administration. Their opinion on some issues about their environment should, therefore be reliable.

Figure 5.1 Age of the respondents

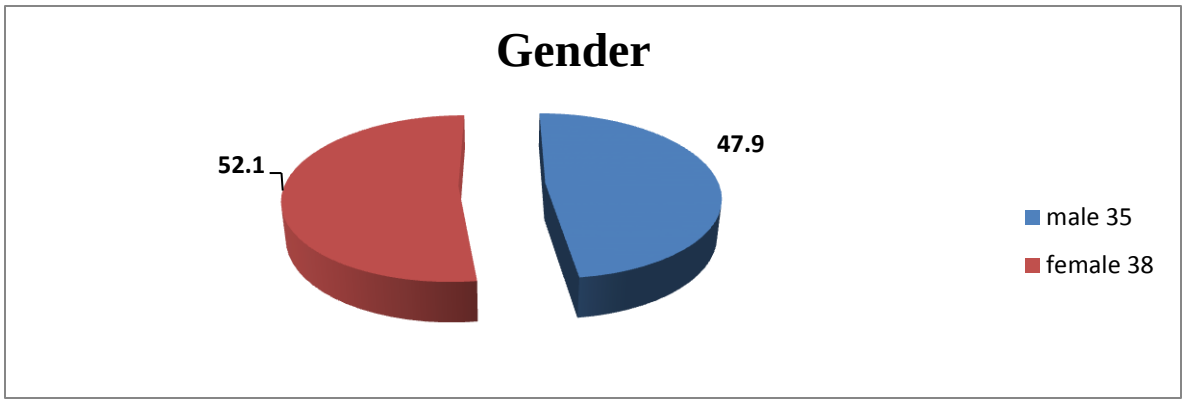


(Source: Field Data, 2014)

5.3.2 Gender of the respondents

More research, including social issues and theories, suggest that survey responses are influenced by interviewer gender, however, some studies have reported significant gender differences, with more women than men reporting being subjected (Salin, 2001; Vartia & Hyyti, 2002). In this research, the sample was collected randomly and the characteristics of the population were normal that the population was made up of mostly people of same community living in a safe environment. The sample analysis showed that the gender composition of the respondents was 47.9% men while the households headed by women were 52.1% (Figure 5.2).

Figure 5.2 Gender of the respondents

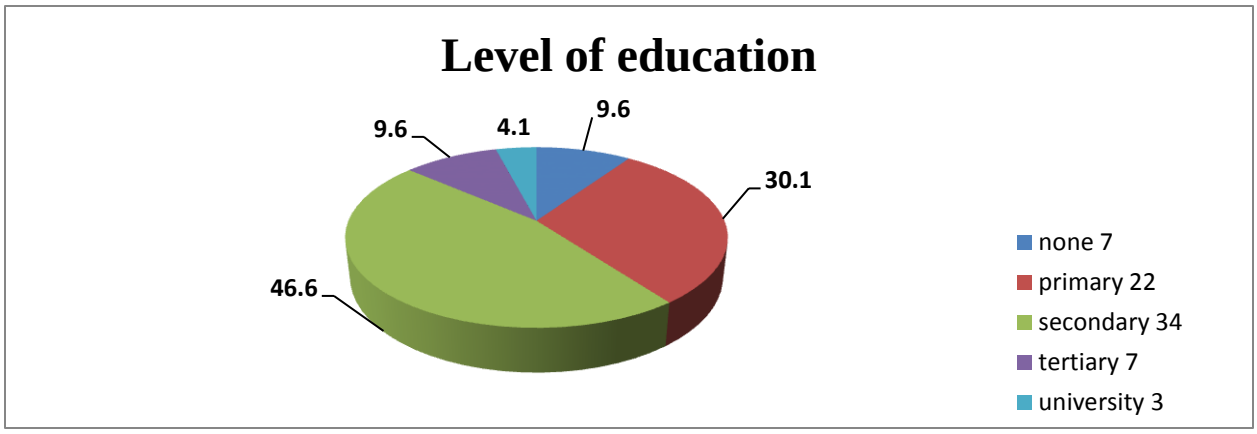


(Source: Field Data 2014)

5.3.3 Education level of the respondents

In this study education level basically enable the respondent to comprehend the issues of the local environment and the questions being asked by the research assistant in the mother tongue to the respondent. Overall, 77% of the respondent had either primary or secondary school level of education. Based on the below result, it can be said that quite a large proportion of the population in the selected communities and catchment area have little level of education. This is exhibited in the Figure 5.3 below.

Figure 5.3 level of respondents



(Source: Field Data 2014)

5.3.4 Source of income

The study shows various occupations of the community near the dam. A diversity of people from various occupations is also an indicator of the representativeness of the sample. Table 5.1 indicates that 47% of the respondents were local farmers engaged in subsistence farming. This is an indicator that the sample is representative of common local livelihood around the dam; farmers will appreciate the issues affecting their environment in relationship to health and livelihood. The report shows 5.5% of the people interviewed were farmers, while 5.5% were local business people with 24.7% being people engaged in causal worker.

Table 5.1 Source of income

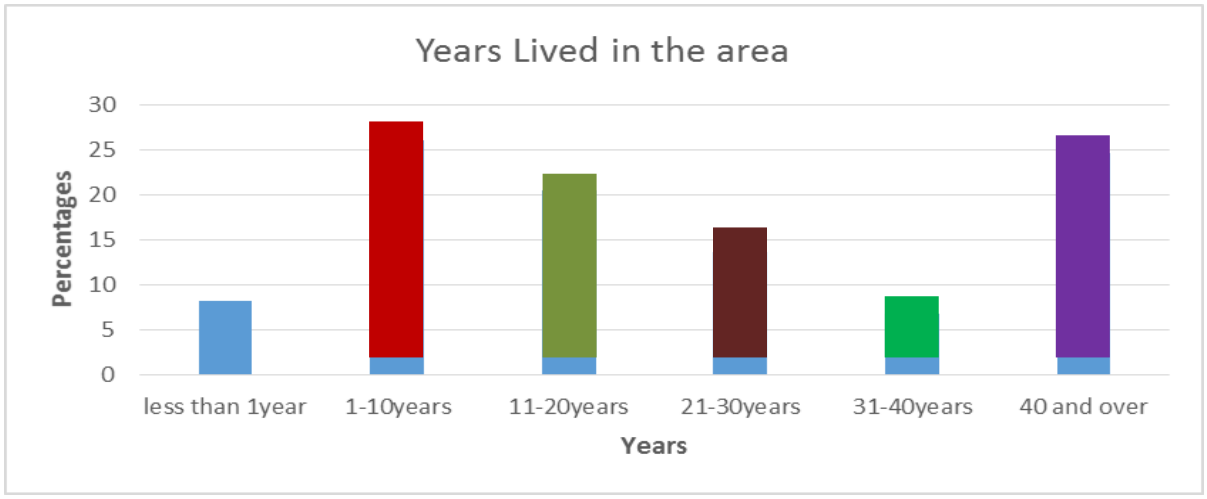
		Source of income			
		Salary %	Farming %	Business %	Casual work %
Location	Ndakaini	0	38	24	38
	Kimandi	11	78	0	11
	Makomboki	5	67	2	26
Total		5	65		25

(Source: Field data, 2014)

5.3.5 Years lived with the respondent in the study area

In the study area the respondents were sampled based on, among other things, years lived in the study area. The results show that the majority of the respondents has lived in the study area for a long period, with 87% having lived in the study area for over 21 years (Figure5.4). This indicates that they have lived in the area long enough to notice the changes that may have occurred due to the dam and may have formed social networks to adjust or exploit or resist the effects emanating from the dam in areas of health, agriculture and other aspects of their livelihoods.

Figure 5. 4 Years lived in the study area



(Source: Field data 2014)

5.3.6 Source of drinking water

Sixty six present (66%) of the respondents reported that their source of drinking water is by means of piped water of course it is very much expensive but the water is safe for drinking and 38% of the lower majority of the respondents continue to use untreated water because they cannot afford water treatment methods due to poverty, while 26% were ignorance of any water and 17%,also respondents reported that their source of drinking water is by means of harvesting the water from local stream and watershed management. Some respondents reported that their source of water is by river, wells borehole etc.

5.3.7 Access to potable water

Over 89% of the respondents reported that they have good drinking water that is provided by other streams that is far from the community, and also 11% reported that they do not have access to good drinking water and the means of getting drinking water is very much capital intensive, so they depend on wells and neighbours who can afford to pay the large amount of money to be connected to piped water.

5.4 Environmental impacts of the Dam on the livelihood of the catchy community.

5.4.1 Flooding cases

The majority of the respondents (92%) reported to experience no flooding, while only 8% experience flooding. The respondents who experience flooding live closer to the dam stream and flooding mainly occurred during the heavy rain seasons which raise the Dam water volume. In a nutshell, flooding is not common in the dam community and thus their livelihoods are never affected.

5.4.2 Deforestation

About 86% of the respondents reported that dam construction has led to deforestation, 15% reported that dam construction has not led to deforestation. It was reported that the dam area had enough trees which were cut down to give room for the construction of the dam and there has been a little form of afforestation after the construction. However, during the key informants' interview it was noted that the dam authority had started raising awareness of tree planting in the past 10 years.

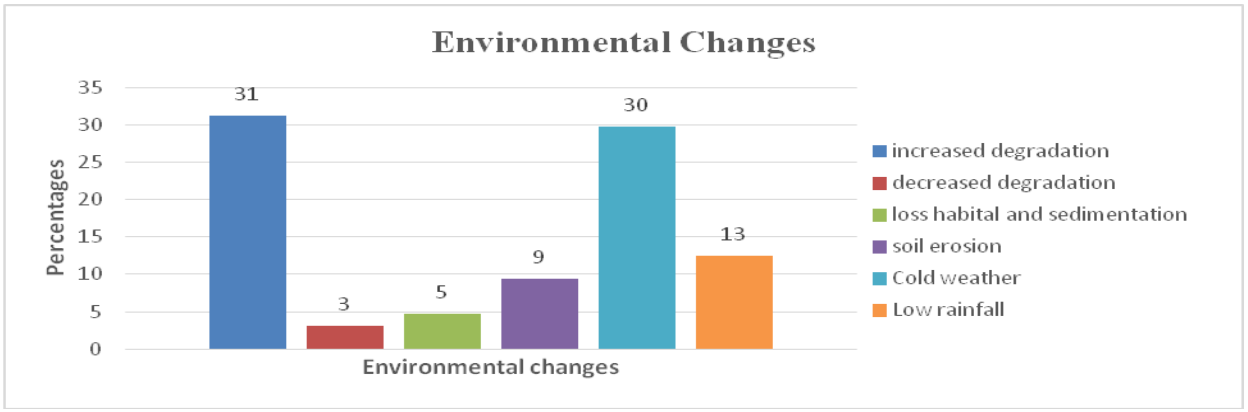
5.4.3 Awareness of environmental changes

Results indicate that 86% of the respondents are aware of the environmental changes that have taken place since the dam was constructed compared to only 14% who reported to be unaware of the any environmental changes. This was because the change has led to serious impacts to the community around the dam for the changes to be ignored.

5.4.4 Environmental changes

Finding in Figure 5.6 indicates that some of the changes that have occurred. 31% of the respondents reported that there is increased degradation, 30% reported that the weather became colder after the dam construction which lowered their productivity and led to changing of crops planted and 13% of the respondents complained of low rainfall which affected farming activities.

Figure 5.5 Environmental changes



(Source: Field Data 2014)

Plate 5.1: Soil erosion and loss of vegetation around the dam

(Photo by Researcher, 2014)

5.4.5 Toilet facilites

About 85% of the respondents have good toilet facilities with only 15% having no good toilet facilities. During the study it was noted that 15% of the respondents with no good toilet facilities live adjacent to the dam and this caused stream water contamination which in return contaminates the dam water. Plate 5.2 below shows a toilet in Kimandi sub-location which is poorly built and could have led to water contamination**.**

Plate 5.2: A toilet in Kimandi sub-location (Photo by Researcher, 2014)

5.4.6 Hypothesis Testing

Hypothesis one

H_0: There is no significance difference between environmental changes in the catchment community. The variables for the hypothesis are environmental changes and the three sub-locations (Table 5.2).

Table 5.2 Cross tabulation between Location and Environmental Changes during last years

		Environmental changes during last years		Total
		Yes	No	
Sub-Location	Ndakaini	12	1	13
	Kimandi	16	2	18
	Makomboki	35	7	42
Total		63	10	73

(Source: Field Data 2014)

The calculated value (0.812) is less than critical value (5.99) at 0.05 significance level. Hence, the null hypothesis is adopted since there is no enough evidence to reject it (Table 5.3). Thus, there is no significance difference between environmental changes in the catchment community.

Table 5.3 Chi square test

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	.812[a]	2	.666
Likelihood Ratio	.864	2	.649
Linear-by-Linear Association	.789	1	.374
N of Valid Cases	73		

(Source: Field data, 2014)

Further analysis from Pearson correlation value 0.105 shows a statistically significant positive correlation between environmental changes in the catchment community at 95% confidence interval (Table 5.4).

Table 5.4 Pearson's correlation

		Value	Asymp. Std. Error	Approx. T[b]	Approx. Sig.
Interval by Interval	Pearson's R	.105	.103	.887	.378[c]
N of Valid Cases		73			

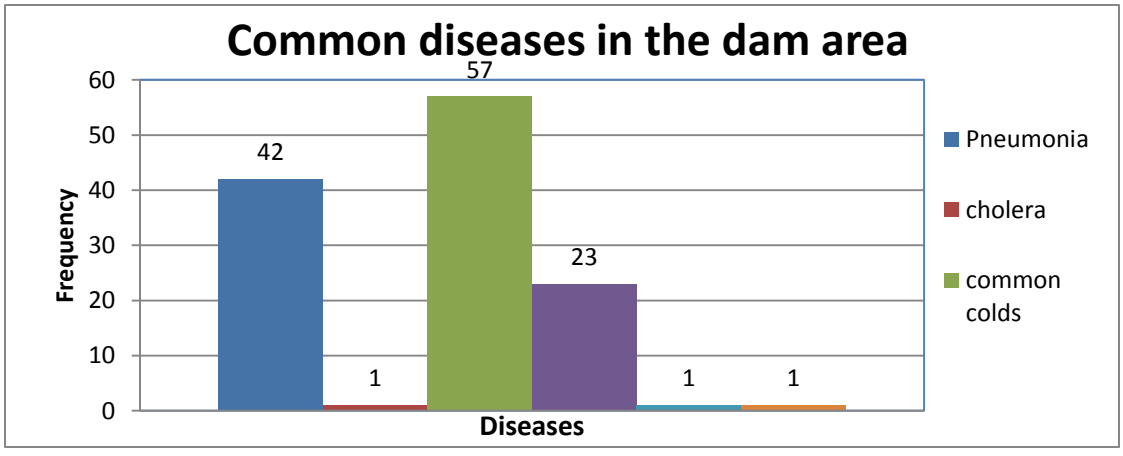
(Source: Field data, 2014)

5.5 Social impact of the Dam on the catchment community

5.5.1 Common diseases in the area

Finding in Figure 5.7, indicate that 57% of the respondents experience common cold and 42% of the respondents reported of experiencing Pneumonia after the construction of the dam.23% of the respondents who experienced malaria are settlers from Kisii County who work with the dam authority. There are no malaria cases from the community from Ndakaini. Respiratory diseases are common in the study area with 57% of the respondents reporting to have such illness. This is attributed to the cold weather which begun since the construction of the dam.

Figure 5.6 Common diseases



(Source: Field Data 2014)

5.5.2 Improvement of Living standards

Over 77% of the respondents reported that the dam construction has not improved their standards of living. During the study it was noted that one of the dam's corporate social responsibility was to build a school. The school was built in Makomboki, but it was later closed down due to lack of financial support by the new administration. Also in the area of agriculture and health there has been no improvement by the dam's authority. Notwithstanding these facilities (agriculture and health) has been supported by some local NGOs. The 23% of the respondents who reported that their standards of living have improved due to the dam construction were the people who have been employed by the dam authority.

5.5.3 Loss of property during and After Dam Construction

Fifty six percent of the respondents reported that they lost property during dam construction and 44% reported to have not lost any property. The respondents who lost property had been displaced during the dam construction and their land was directly used by dam authority.

5.15: Loss of property after dam construction

After the dam construction, 99% of the respondent reported to have not lost any property. Loss of property was very minimal among most of the respondents after dam construction because the area of land that was needed by the dam authority had already been taken.

5.5.4 Recreational facilities and loss of culture

Majority of the respondents (82%) reported that dam construction did not lead to loss of any recreational facility. Respondents felt that the natural river flow which acted as a water fall for residents for viewing was damaged. Others reported that the natural clean water site where residents could go swimming and drinking water was damaged.

Loss of culture

Over 88% of the respondents agreed that there was no loss of culture while 12% reported the dam construction led to loss of culture. The culture that was reported to have been lost was their traditional marriage system which was replaced by intermarriages

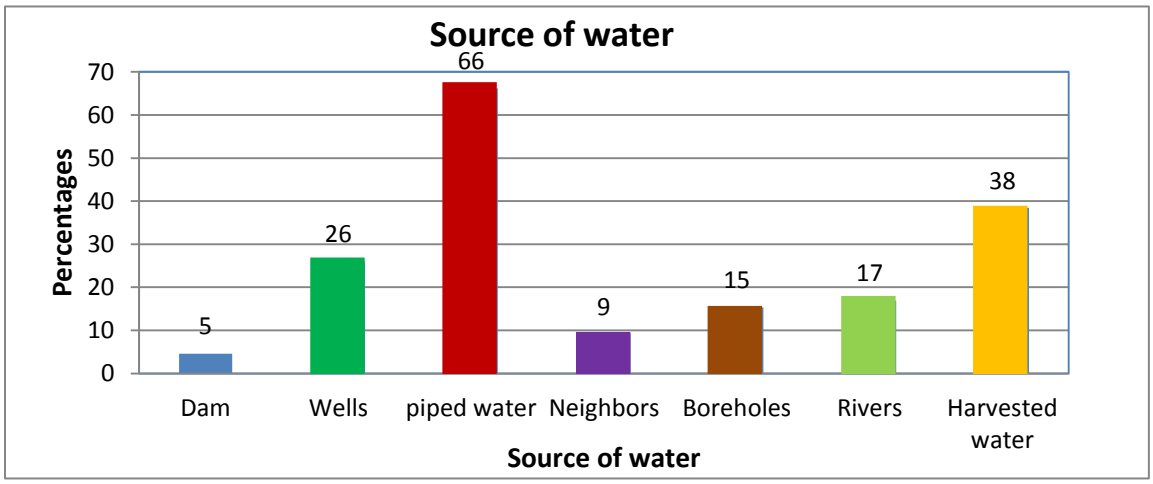
5.5.5 People with Access to Water and Safe Drinking Water in Their Homes

About 89% of the respondents explained that their current sources of drinking water, is by means of piped water which is very safe for drinking but expensive and 11% of the respondents reported that their source of drinking water is by harvesting their water from local stream, river, wells borehole and treat their water before use for drinking. The means of treating their water was by boiling, while others use chemicals, filtering and solar disinfection and watershed management process. Nearly half of the entire respondents are aware that unsafe water increase exposure to water borne diseases and other related health risk.

5.5.5.1 Sources of water

Findings in Figure 5.9 shows that two quarters and the half of the respondents (66%) perceive that their current water sources, report that their source of water is by means of piped water of course it is very much expensive but the water is safe for drinking, and 38% of the respondents reported that their source of water is not safe and in such they harvest their water from local stream, river, wells borehole neighbour and landlord and roof catchment etc.

Figure 5.7 People with Access to drinking water



(Source: Field Data 2014)

5.5.7 Food security

About 66% of the respondents in the area reported that food insecurity in the area is not a problem because they are engaged in such as tea farming and others are those who work in the tea factory and the Dam. Commercial tea farmers sell tea to the tea factory so as to earn their living, 34% of the respondents reported that food shortage is common in the area due to the

weather conditions and un-employment. They reported that if nothing is done by the dam authority to mitigate the bad weather and encourage irrigation, farmers will not hesitate to replace the common crops tea to tobacco which will increase the severity of food shortage.

5.5.8 Hypothesis Two

H_0: Dam construction has not significantly improved the living standards of the catchment community. The variables for the hypothesis are living standards and the three sub-locations (Table 5.5).

Table 5.5 Cross tabulation between the sub-locations and improved living standards

		Dam improved living standard		Total
		Yes	No	
Sub-Location	Ndakaini	7	6	13
	Kimandi	6	12	18
	Makomboki	4	38	42
Total		17	56	73

(Source: Field Data 2014)

The calculated value (12.266) is greater than critical value (5.99) at 0.05 significance level. Hence, the null hypothesis is rejected and alternative hypothesis adopted (Table 5.6). Thus, Dam construction has significantly improved the living standards of the catchment community

Table 5.6 Chi square test

	Value	df	Asymp.Sig. (2-sided)
Pearson Chi-Square	12.266[a]	2	.002
Likelihood Ratio	11.962	2	.003
Linear-by-Linear Association	12.079	1	.001
N of Valid Cases	73		

(Source: Field data, 2014)

Further analysis from Pearson correlation value 0.410 shows a statistically significant strong positive correlation between dam constructions and improved the living standards of the catchment community at 95% confidence interval.

Table 5.7 Pearson's Correlation

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Interval by Interval	Pearson's R	.410	.113	3.783	.000[c]
Ordinal by Ordinal	Spearman Correlation	.407	.110	3.754	.000[c]
N of Valid Cases		73			

(Source: Field data, 2014)

5.6 Mitigations measure to minimize the social and environmental risks of the dam.

5.6.1 Compensations and resettlement Issues

From the key informant discussions, it was revealed that the construction of the dam affected around 250 households from the three communities. The resettlement was not encouraging in terms of the execution of the whole program. According to the key informant discussions, the resettlement program of the Dam project was designed on the basis of two core policy approaches. These included:

- Compensation in cash,
- Settlement in large communities;

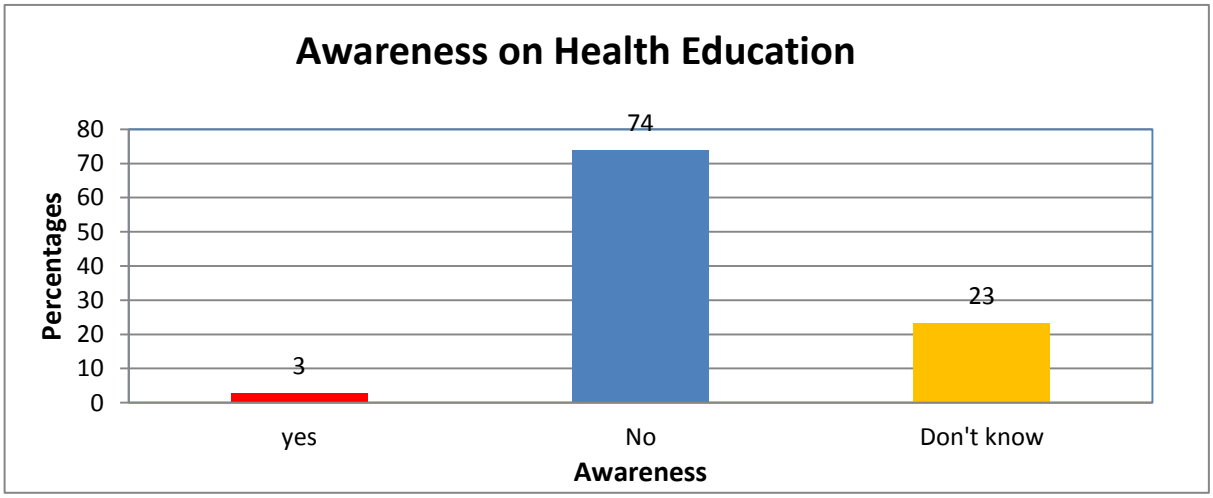
Additionally, respondents stated that the people to be relocated had been given two options; to have compensation and relocate themselves or to be relocated by the government. There was an indication that over 81% of the people agreed to be relocated by the government program. In order to facilitate the compensation process it was necessary to evaluate land, farming, housing and other properties. One of the responsible governmental organizations for implementation of this process was the Land commissioner. Unfortunately, the release of the evaluation of the land and other properties were delayed and thus became the major focal point of for complaints. The

second approach was to resettle the people in large communities. The outcome of this experience was a disaster for the whole resettlement program. The problem with this approach was that it did not take into account what the people were occupying before the resettlement exercise. The rest of the household were left to be developed by the resettled communities. At an aggregate level, results in Figure 5.23 of the questionnaire survey over the issue of 'compensation 'show that 72% of the respondents confirmed that they were not happy from the compensation they received for their lost property. However, 3% of the surveyed population indicated that they were very happy from the compensation they had received and 19% were least happy from the compensation. These results clearly demonstrate that the issue of compensation is still unresolved and controversial to the local people.

5.6.2 Awareness on health education

Findings in Figure 5.10 indicate that 74% of the respondents do not appreciate the level of health education and awareness of the environmental management by the dam authority, respondents believe that the knowledge and awareness of one's environment is critical for the livelihood and involvement of the community, they also know that it is impossible to conserve the environment if one does not known the negative and positive effect of the environment. As shown in Figure 5.10, 23% of the respondents don't know anything about the health and education of the dam impacts. 3% who responses were yes, are those who are working directly with the dam authority and the conservation groups.

Figure 5.8 Awareness on Health Education



(Source: field data (2014)

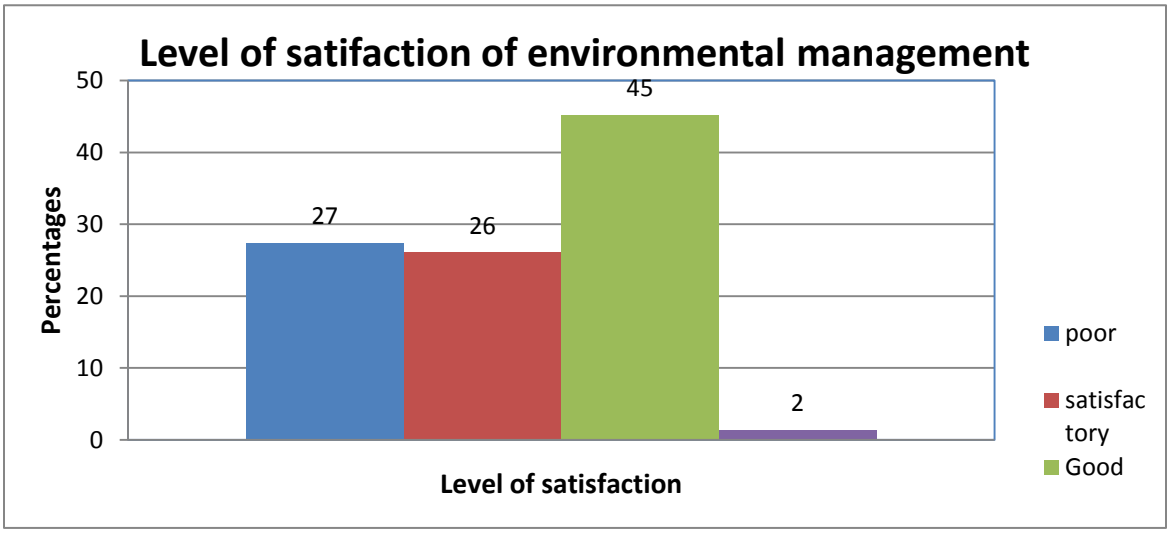
5.6.3 Community involvement in Dam management

Sixty four percent (64%) of the respondents reported that there are different types of environmental management that the Dam authority involves various members of the community. For instance, the community is involved in, planting of trees around the dam and other area in order to reduce the degradation in the area. Furthermore, the community appreciates the dam authority for financially supporting the environmental conservation team to be established in the area to help dam authority management and conserved the dam. 36% of the respondents reported that the dam authority do not involved any member of the community in the management of the dam which is causing more harm for people around the dam, because dam authority do not understand what is affecting the people.

5.6.4 Level of satisfaction of environmental management

Figure 5.11 shows that various levels of satisfaction by the respondents from the environmental management. 27% of the total respondents said the environmental management t is poor, 26% of the respondents said they are satisfied with the environmental management by the dam authority and 45% of the respondents said the environmental management is good. 2% of the total respondents did not give any feedback on the environmental management.

Figure 5.9 Level of satisfaction of environmental management

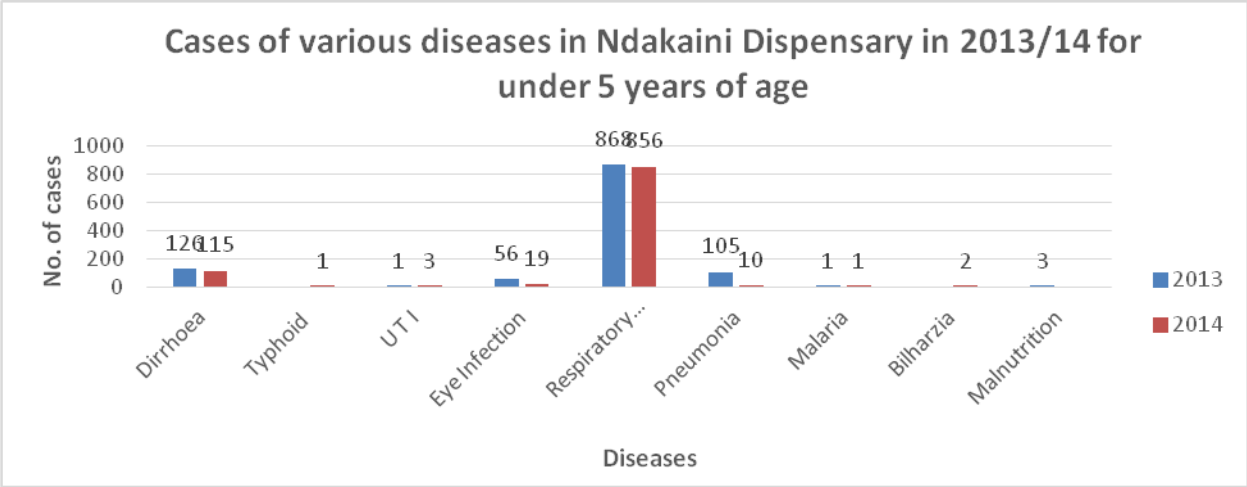


(Source: field data (2014)

5.6.5 Cases of diseases

Findings in Figure 5.12 indicate that the cases of various diseases have decreased since 2013. For instance, there were 868 respiratory disease cases in 2013 compared to 856 cases in 2014 for persons less than 5 years of age.

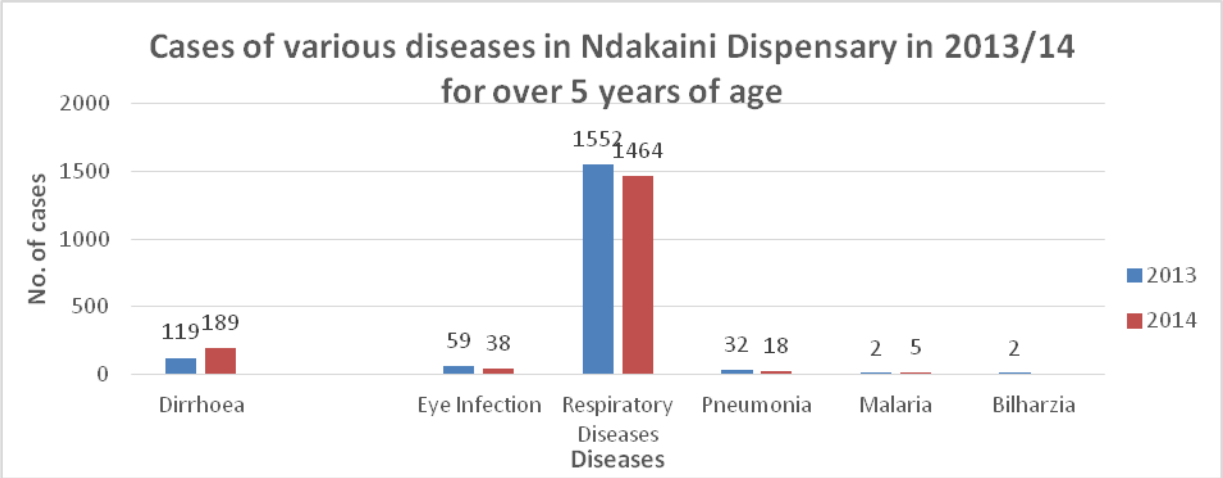
Figure 5.10 Disease cases from under 5 years of age persons in Ndakaini Dispensary



(Source: Field data, 2014)

Results in Figure 5.13 also shows a decrease in disease cases for persons over 5 years of age with their cases being 1552 and 1464 in 2013 and 2014 respectively. This was attributed to the taking over of the health systems by County Government from Dam authority. The County government has improved the medical facilities and health care systems which have led to increased awareness among community members on how to prevent the diseases. During the Key informant discussions it was noted that 10 years ago the construction of the dam caused a lot of respiratory disease and pneumonia for community's dwellers. The data for past years was not available due to the poor management of the dispensary. A number of disease cases in each month of 2013 and 2014 for both persons under 5 and over 5 years of age are shown in appendix I-VI.

Figure 5.11 Disease cases for persons over 5 years of age in Ndakaini Dispensary



(Source: Field data, 2014)

5.6.6 Hypothesis Three

H_0: There is no significance difference in the rating of environmental management by the catchment community. The variables for the hypothesis are rating of environmental management and the three sub-locations (Table 5.8).

Table 5.8 Cross tabulation between sub-location and the rating of Environmental Management

		Rate the environmental management				Total
		Poor	Satisfactory	Good	Very Good	
Sub-Location	Ndakaini	2	3	8	0	13
	Kimandi	7	4	7	0	18
	Makomboki	10	12	17	1	40
Total		19	19	32	1	71

(Source: Field data, 2014)

The calculated value (3.794) is less than the critical value (12.59) at 0.05 significance level. Hence, the null hypothesis are adopted since there is no enough evidence to reject it (Table 5.9).

Thus, there is no significance difference in the rating of environmental management by the catchment community.

Table 5.9 Chi Square test

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.794[a]	6	.705
Likelihood Ratio	4.094	6	.664
Linear-by-Linear Association	.231	1	.631
N of Valid Cases	71		

(Source: Field data, 2014)

Further analysis of Pearson correlation value 0.057 shows a statistically significant weak correlation between dam constructions and improved the living standards of the catchment community at 95% confidence interval (Table 5.10).

Table 5.10 Pearson's Correlation

		Value	Asymp. Std. Errors	Approx. T[b]	Approx. Sig.
Interval by Interval	Pearson's R	-.057	.113	-.478	.634[c]
N of Valid Cases		71			

(Source: Field data, 2014)

CHAPTER SIX: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary

In general, the construction of the Ndakaini dams respectively has led to the alteration of the surrounding environment; both the physical and the socio-cultural environments. The study has revealed the most common environmental impacts that translate into health effects in the surveyed area which are the occurrence of water-related diseases. Deforestation accompanied by the bad farming practices has intensified the rate of accelerated soil erosion that ultimately lead to the situation of the reservoirs which will subsequently contribute to the shortening of the lifespan as well as decrease the performance capacity of the dams to provide water. One of the dramatic social impacts associated with the construction of the dam is the issue of involuntary resettlement (see discussion under resettlement). The impoundment of the dams on the Thika River all together affected the relocation of over 250 families. As mentioned earlier the execution of the resettlement program for Ndakaini dam in the 1994 had been a bad experience for some of the resettles. According to the Focus group discussion held by the people of Makomboki and Kimandi during the field study indicated that most of the people were unhappy about the treatment which they received from the Government at the time of the construction of the Ndakaini Dam and Authority.

One of the positive impacts of the construction of the Ndakaini project was to produce safe drinking water for the people of Nairobi country, in this context the set objective of the project has been materialized to an appreciable extent for some dwellers. However, this is not true for the local people of the catchment area. In fact, this objective has been materialized at the expense of the environment as well as the social impacts to the surrounding communities. In an interview with some respondents who are pioneers to the area, before the creation of the dams, some of the major economic activities in the area were farming and fishing. The farming practices before Dam construction was accompanied by natural flooding, this was a part of the river ecosystem where flooding help to maintain the fertility of soils by depositing layers of silt which promoted farming and fisheries. However, this has changed due to the creation of the dam. Other major impacts to the people of the dam are that the dam destroyed the recreational area. This affected the women population of the area, who were predominantly engaged in the activities of swamping.

Furthermore, some respondents confirmed that the major social impacts of the creation of the Ndakaini Dam are migratory, contamination, unemployment and waterborne diseases. Based on the field appraisal the main social and environmental health problem linked to the impoundment is the issue of water-related diseases. As shown earlier in the surveyed, people suffer from diseases like Pneumonia, cholera, river blindness (Onchocerciasis), malaria and the common cold. Since the establishment of the dams the incidence of the above mentioned diseases has been increased. The reason for that could be attributed to the modification of the surrounding environment. Particularly, the prevalence of respiratory diseases has been increased dramatically since the impoundment in 1994. In an interview with key informer, who revealed that some NGOs authority have tried to put in place some mitigation methods to control the spread of Malaria and respiratory diseases. One of such mitigation measures was the periodic clearing around the dam and planting of trees. In addition, the key informs further pointed out that the government has provided a free medication to improve health service in an outreach program to the surrounding villages. Secondly, deforestation accompanied with the acceleration of soil erosion has been recognized as one of the acute environmental problems facing the Ndakaini Dam. Owing to slash and burning farming practices as well as uncontrolled human settlement along and around the dam area causing severe deforestation. However, the authority has in recent times recognized the problem and had put the measure to avert the issue. Reforestation (afforestation) program has been put in place to mitigate deforestation around the dam, particularly along the slopes of the dam. The Planting of economic trees around the dam has already started according to Gilbert Omweri the Human Resource Management and that program is sponsored by Dam authority and other non-Governmental Organization.

6.2 Conclusions

The study concludes that since the construction of Ndakaini dam, it has contributed to major social and environmental impacts of the catchment community, (i.e. Resettlement, loss of land, deforestation and common diseases), in particular of the above mentioned problems the Dam project has more or less materialized its set objective of providing safe drinking water to Nairobi and its environs.

The study found that the rate of deforestation and erosion in the study area is linked to the methods of farming practices as well as the removal of the catchment vegetation as part of land preparation. If this issue of land degradation has not appropriately dealt with, in the future, it could lead to decreased water infiltration.

The project supports the Marathon that started in 2004 to raise funds towards conservation of the catchment area and empowerment of the local community to develop viable social economic enterprises associated with the dam. The marathon was coordinated by the Environmental conservation Association (NDEKA).

Finally, it is a hoped that the findings from the study communities will provide useful insight into the current state of the environment, and the recommendations proposed in this paper would equally be helpful to mitigate the risk, control and to improve the management of the dams.

6.3 Recommendation

Dam Management

- Authority should encourage and support the use of agro-forestry in the Communities, which is the practice of growing trees with agricultural crops or livestock on the same parcel of land, and at the same time, reducing the need to exploit the natural forest of the catchment area.
- Authority should put in place a computer-based technology system to assist in combating the problems by providing reliable, up-to- date and comprehensive data on land use change and other environmental variables.
- Authority should also put in place a health awareness team and introduce health education in the catchment areas which is a vital measure to control common diseases.

Policy makers

- The research recommends the progressive restoration and protection of ecological systems and biodiversity in the strategic water catchment area.
- The research recommends that, policy, guideline should be put in place to regulate water use for irrigation and provide efficient and coordinated methods of irrigation. Irrigation can be expanded by putting up programmes to empower local people, especially women, to make more use of the dam water through irrigation.
- It is recommended that a project should be initiated as a matter of priority to ensure that clean water is provided for use by the local community. This can be done by establishing treatment plant away from the dam shore and making provision so that people can fetch potable water for domestic use.
- Government should insure inter-basin water transfer in Kenya as a strategic intervention for optimized used of water resources.
- There is a need to increase research funding for sustainable development and management of water resources in the field of water supply in order to generate useful information for planning, design and decision making.

- Water governance should be improved in Kenya to avoid the current lack of government presence in meeting water demand and targeting training for the water technology need to be encouraged by government intervention.

Further Researches

- Further Research is necessary as the findings were based on a relatively small sample that may have influenced the nature of the results that were obtained. There is need to expand on the sample size and carry out similar research in other location.
- The analysis that was used is always not sufficient to draw conclusions on a phenomenon, and to provide adequate information that can be used for policy development. Further research focus accessing the perception of catchment community in strategy implementation is recommended.
- The research recommends the establishment of continuous water quality monitoring and mapping at strategic areas along the reservoir to alert policy makers on possible reservoir contamination.

REFERENCES

Anon L. (1997): Central Pollution Control Board's (CPCB) 1997 Report, India.

Atakpu, L. (1999): Large dams and sustainable development in Africa; an overview; Serial No. Env. 13.

Baltazer, J. **(1988).** Can the case control method be used to assess the impact of water supply and sanitation on diarrhea? A study in the Philipines. Bulletin of the World Health Organization 66:627- 635.

Berdare Forest Reserve Management Plan [Online] Available at

Birley, H., Peralta L (1995). The health impact assessment of development projects. Environmental and Social Impact Accessed on 14.06.2014

Birley, M. H. and G. L. Peralta (1995). The health impact assessment of development projects. Environmental and Social Impact Assessment.F.Vanclay and D.A. Bronstein. New York, Wiley.233,235 Legislation in Kenya. Ist Edition, 2007

Birley, M. H., A. Boland (1998). Health and environmental impact assessment: an integrated approach. London, Earthscan / British Medical Association. Accessed on 14.06.2014

Birley, M. H., R. Bos (1996). "A multi-sectoral task-based course: Health opportunities in water resources development." Education for Health: Change in Training and Practice 91: 71-83. Accessed on 14.06.2014

Birley, M. H., Scott-Samuel A. (1999). Report of the first UK training course in health impact assessment. Liverpool, University of Liverpool. Accessed on 14.06.2014

Bowman, J. (1994) 'Water is best': Would pindar still think so? In: Carltledge, B.ed. Health and the environment: The Linacre lectures 1992-3. Oxford, Oxford University press,. p. 85-125 Accessed on 14.06.2014

Bradley, D. (1994). Health, environment and tropical development. In carltledge, B., ed. Health and environment: The Linacre lectures 1992-3. Oxford, Oxford University press,.p. 126-149. Accessed on 14.06.2014

Brown, L., Gardner, G., and Halwel, B. (1997): Beyond Malthus: Nineteen dimensions of the population challenge. New York, W.W. Norton & Company, 167p. Accessed on 14.06.2014

Brown, L.R and MITCHELL, J. D. The agricultural link: How environmental deterioration could disrupt economic progress. Washington, D. C., Worldwatch Institute, (worldwatch paper No. 136) 73 p. 224

Bunyasi M.M (2012) Vulnerability of Hyrdo-Electric Resources in Kenya due to climate Change effects: The sase of the seven Forks Project [Online] Available from http://aripd.org/journals/jaes/Vol_1_No_1_December_2012/4.pdf Accessed on 15.06.2014

Centers for Disease Control and Prevention (CDC, 2005). United States Centre for Diseases Control and Prevention,1600 Clifton Rd., NE, Atlanta, GA 30333. (800) 311-3435, (404) 639-3311 Chartered Institution of Water and Environmental Management (CIWEM)http://www.ciwem.org/knowledge-networks/panels/water-resources/reservoirs-global-issues-.aspx

D. M. H. S. K. Ranasinghe http://journals.sjp.ac.lk/index.php/fesympo/article/view/683

Diplomat East Africa Magazine: ndakaini dam –the lifeline of nairobi [Online] Available from http://www.diplomateastafrica.com/s and / Accessed on 12.06.2014

Doos, B. **(1994)**: Environmental degradation, global food production and risk for large-scale migration. Ambio 23(3): 124-130.

Dr. Eleanor E. Faye, Dr. Bruce P. Rosentha, Dr. Zimmerman (1992) leaders in low vision. Lighthouse International. [Online] Available from.www.lighthouse.org/services-and-assistance/low.../meet-our-team .Accessed on 14.06.2014

Environmental and Social Issues of the Three Gorges Dam in Chinahttp: //www1.american.edu/ted/ICE/china-dam-impact.html

Food and **Agriculture Organization (FAO) (1996)**: Food for all. Rome, FAO,.

GMU (2004). Basic Concepts of Sampling, George Mason University. [Online] Available from http://ene.gmu.edu. Site visited on 5/6/ 2014.

Government of Kenya (GoK, 1992): Ministry of Water Development: *The Study on the National Water Master Plan*, Prepared with the assistance of Japan International Cooperation Agency (JICA).

Government of Kenya (GoK, 2012) mapping of tourist attractions and assessment of the proposed anima orphanage [Online] Available from http://muranga.go.ke/index.php?option=com_ Accessed 04.06.2014

Guatemala. In: Chen, L. C and Scrimshaw, N. S., eds. Diarrhea and Malnutrition: Interactions, mechanisms and interventions. New York plenum Press.. p. 235-266

Hira (1969), Mungomba (1993), Jobin (1999): In; World Health Organization (WHO) (1999): Working Paper on Human health and Dams, Kariba Dam Akosombo and Aswan dams
http://www.eolss.net/sample-chapters/c12/E1-06-02-06.pdf
http://www.kenyaforestservice.org/documents/Aberdare.pdf Accessed on 2.12.2014

Hughes D.J (1997): In Harrison R.M (edit): Understanding our Environment; an Introduction to Environmental Chemistry: Chap. 9: Regulation and the Economics of Pollution: Second Edition; The Royal Society of Chemistry,1992 pg 305.

International Commission on Large Dams (ICOLD), **(1998)**: *World Register of Dams*.

International Hydropower Association (IHA, 2004): The IHA Sustainability Guidelines Framework for good practice in Hydro-power Generation: In OECD Arrangement and New Subsidies for Dams;

International Institute for Land Reclamation and Improvement –ILRI publication 45, Wageningen, the Netherlands

Jaetzold, R., and Schmidt, H. (1983): *Farm management handbook of Kenya.*Atlas of the agro-ecological zones of Kenya. Ministry of Agriculture in cooperation with German Agency of Technical Cooperation. Nairobi, Kenya.

Jellali, M. (2004): Large dams and sustainable development in Africa; an overview; Serial No. Env. 13

Kakonge,(1999):Cited in **World Commission on Dams (1999)**: Regionalconsultation of the world commission on dams: Summary Report:Africa and Middle East.

Ki-zerbo, J. (2004): Large dams and sustainable development in Africa; an overview; Serial No. Env. 13

Mahabaleshwara1 H., Nagabhushan H.M. (2014) Study on Soil Erosion and Its Impacts on Floods and Sedimentation. *Deforestation, Geographical Information system, Soil Erosion, Reservoir Sedimentation, Mining and cultivation.*

Manatunge J, Nakayama M., Priyadarshana T. (2006).Oceans and Aquatic Ecosystems - Vol. I - Environmental and Social Impacts of Reservoirs: Issues and Mitigation a Guide to Social Science Research.

Mann E. and Witschonke A., (2006): The Hoover Dam : The story of hard times, tough people and taming of a wild river.

Maphalala B, (1999): Recommendations to the WCD from Dams Affected People in Southern Africa. In WCD 1999230

May, T. (1993). Social Research: Issues, Methods and Process. Buckingham Open University Press.

Maywald, A. ., Zeschmar-Lahl, B., and **Lahl, U**. **(1988):** Water fit to drink? In: Goldsmith .E and Hilyard, N., eds. The earth report: Monitoring the battle for our environment. London, Mitchell Beazley,.p. 79- 88.

Mungomba (1993): In; World Health Organization (WHO) (1999): Working Paper on Human health and Dams, Kariba Dam Akosombo and Aswan dams

Mutisya J. (2003): Gender perspective in soil conservation: Masinga dam catchment; PhD Thesis (un published); Kenyatta University 231

Mzalendo (2012) National Assembly Official Report on Ndakaini Dam construction [Online] Available from http://info.mzalendo.com/hansard/sitting/national_assembly/2012-02-23-14-30-00 Accessed on 14.06.2014

National Framework and Guidelines for Environmental Health Impact 232

Ndakaini Half Marathon Connecting, Transforming and Sustaining Livelihoods http://kenaff.org/articles/ndakaini-half-marathon

Pimentel, D., Houser, J., Preiss, E., White, O., Fang, H., Mesnick, L., Barsky.

Rahman, M. (1985): Impact of environmental sanitation and crowding on infant mortality in rural Bangladesh. Lancet 8445(2) 28-31.

Repetto, R.. (1996): The 'second India' revisited: Population growth, poverty and the environment over two decades. Proceedings of the conference on Population, Environment and Development, Washington, D. C., Mar 13-14,. Tata Energy Research Institute (TERI) and World

Republic of Kenya: Kenya Population Census 1999: Kenya Bureau of Statistics, Nairobi. Resources Institute (WRI) 1-34 p.

Ross and Wu 1995: In **Kim J. and Durden E.** (2007): Socioeconomic status and age trajectories of health: In *Social Science & Medicine, Volume 65, Issue 12, December 2007, Pages 2489-2502*

Schuler P. (2007): The Journal of International Policy Solutions [Online] Available from http://irps.ucsd.edu/assets/012/6359.pdf accessed on October 06.2014

Secretary of State for Health (1999). Saving lives: our healthier nation. London, The Stationary Office London, UK.

Silfverberg, P. (1994)Environmental health hazards. In: Lankinen K. S. Bergstrom, S., Makella, P. H., and Peltomaa, M., eds. Health and disease in developing countries. London, Macmillan Press,. p. 67-78.

Sithole, M.: in UNEP (2006): Africa's Lakes: Atlas of our changing Environment. Division of Early Warning and Assessment (DEWA). UNEP, P.O.Box 30552, Nairobi 00100 Kenya. Pg 12.

Sudman S. (1976): An Investigation of Interview Method, Threat and Response Distortion, JASA, June, 1976

Tana River, Kenya (2003): Integrating downstream values into hydropower planning [Online] Available from http://cmsdata.iucn.org/downloads/casestudy06tana.pdf accessed on 14.06.2014.

United Nations (UN); Commissions on Sustainable Development. Comprehensive assessment of the freshwater resources of the world. Report of the Secretary General. New York, UN, 1997.39. pg.

United Nations Environment Programme (UNEP) (1996): Water quality monitoring for lakes and Rivers – UNEP, Nairobi – Kenya.

United Nations Environment Programme (UNEP) (1997): Natural Resources Conservation Authority: Guidelines for Conducting Environmental Impact Assessment, July, 1999

United Nations Environment Programme (UNEP) (2006): Africa's Lakes: Atlas of our changing Environment. Division of Early Warning and Assessment (DEWA). UNEP, P.O.Box 30552, Nairobi 00100 Kenya. Pg 12.

Wambua, Philip M. (2002). The limnology and management of Thika dam Ndakaini, Kenya [Online] Available from: http://erepository.uonbi.ac.ke/handle/11295/24145 last accessed on October 12.06.2014.

Warner, D. **(1998)**: Drinking water supply and environmental sanitation for health. Presented at the International Conference of Water and Sustainable development, Paris, Mar. 19-21,. p. 1-10.

Westing, H, A (1990) edit:Environmental hazards of war: Releasing Dangerous Forces in a Industrialised World: International Peace Research Institute, Oslo Norway. 236

World Commission on Dams (2000): Dams and Development: A New Framework for decision making, The Report of The World Commission on Dams. Earthscan Publications Ltd, London and Sterling, VA

World Commission on Dams (2000): Large dams and sustainable development in Africa; an overview; Serial No. Env. 13

World Commission on Environment and Development (1987): Report of the United Nations Commission on Environment and Development: *Our Common future* (Brundtland Commission, 1987). United Nations; New York

World Health Organization (WHO) (1999). Draft charter on transport, environment and health. Copenhagen, World Health Organization**:**

World Health Organization (WHO) (2005): The Health and Environment Linkages: Regional Consultation on Health and Environment Initiative (HELI), and Children's Environment Indicators (CEHI): WHO Amman, Jordan.

World Health Organization (WHO) (2006): Report of the first meeting of the core expert team on public health functions and services. Valencia, Spain July, 2006.

World Health Organization (WHO) (2007): Division of Control of Tropical Diseases, Geneva, Switzerland.

Yatich T, Patwa Shah W, Mutua J, Tanui J, Kuria D, Githiru M, Kinuthia W, Waithaka J, Njoroge I. (2009). Challenging conventional mindsets and disconnects in conservation: The emerging role of Ecoagriculture in Kenya's Landscape Mosaics. ICRAF Working Paper no. 83. Nairobi, Kenya: World Agroforestry Centre accessed on 14.06.2014

Young, B. and **Briscoe, J.A (1987)**: Case-control study of the effect of environmental sanitation on diarrhea morbidity in Malawi. Journal of Epidemiology and Community Health 42:83-88.

APPENDICES

Appendix I: Questionnaire for the General Public

This research is aimed at assessing how the dams have impacted both negative and positively to the local communities around the dams. Your response will help in identifying some of the constraints faced by the community.

This can be used for future policy improvements in the area. The research is a nonprofit assignment. All the answers provided are confidential and will not be used to disclose any person's identity without their knowledge.)

SECITON A: LOCATION AND BACKGROUND OF RESPONDENTS

Q. No:	Date:
Location:	Sub-location:
Name of the respondent:	
Gender of the respondent:	Male (2) Female
Contacts Number:	
Start time:	End time:

Please fill the following questions as frankly as possible (Tick √) where appropriate.

Age bracket

18-25 ( )

26-33 ( )

34-41 ( )

42-49 ( )

50-57 ( )

58-65 ( )

66 and above ( )

2. Level of education

None ( )

Primary ( )

Secondary ( )

Tertiary ( )

University ( )

Others (Specify).....

3. Indicate the source of your income

Salary ( ) Casual work ( )

Farming ( ) Others (specify).....

Business ( )

4. Indicate average household income per month?

Less than Kshs.1,000 ( ) Kshs. 3,501- 6,000 ( )

Kshs. 1000- 2,000 ( ) Kshs. 6,001- 10,000 ( )

Kshs. 2, 001-3,500 ( ) Over Kshs. 10,000 ( )

5. For how long have you been living here?

Less than 1 year 21-30 years ( )

1-10 years ( ) 31-40 years ( )

11-20 years ( ) 40 years and over

SECTION B: ENVIRONMENT, HEALTH ISSUES

6. Do you think the construction of the dam has led to deforestation?

Yes ( )

No ( )

Don't know()

7. What do you consider to be the most important environmental issues facing the Ndakaini dam?

……

……

……....

8. Do you see any environmental changes in your area during the last years?

Yes ( )

NO ( )

If YES, what has changed?

Increased degradation ( ) Soil erosion ( )

Decrease of degradation ( ) Loss of vegetation ( )

Loss of habitat and sedimentation ( ) flood ( )

9. What are the common diseases/ illnesses in the area in this area?

Billharzia ( ) Malaria ( )

Cholera ( ) River Blindness ( )

Schistosomiasis ( )

10. Do you have any health education about Bilharzia and river blindness?

Yes ( )

No ( )

Don't know ( ).

If yes, which health education is offer on river blindness and Bilharzias'?

Awareness rising ( )

Bylaws through chief ( )

Health training ( )

11. Do you have health post (hospital) in the area?

Yes ( )

No ( )

If yes, how far is the hospital/clinic?

……Kms

12. Do the Dam authorities involve members of the community in the management of the dam?

Yes ( )

No ( )

If yes, what are the activities?

Trees planting ( )

Awareness rising ( )

Bylaws through chief ( )

Others (Specify) ( )

13. How would you rate the environmental management of the dam?

Poor ( )

Satisfactory ( )

Good ( )

Very Good ( )

14. Do you experience flooding in this area?

Yes ( )

No ( )

15. Do you think that there is a greater awareness these days about how the environment around the Dam is changing?

Yes ( )

No ( )

If yes, do you discuss what you can do to improve it?

Tree planting ( )

Good water management system ( )

General soil and water conservation ( )

Others (specify).....

SECTION C: SOCIO-ECONOMIC and CULTURE ISSUES (COMPE&RESSTL)

16. What are the main forms of livelihood in this area?

Farming ( )

Fishing ( )

Others (Specify)

17. Since the construction of the dam, have your living standard improved?

Yes ( )

No ( )

No change ( )

18. Did you lose property during or after dam construction?

Loss of property	Yes	No
During		
After		

19. Have you got compensation for lost of property?

Compensation	Yes	No	Have been promised
For lose during construction			
For lose after construction			

If yes, are you happy about what you have got?

Very happy ( )

Happy ( )

Somewhat happy ( )

Least happy ( )

Not happy ( )

If promised, when will you be compensated? What is the promise?

……

……

20. Do you have a good source of drinking water?

1. Yes ( )

2. No ( )

21. If yes, what are the sources?

dam ( )

wells ( )

(8) piped water ( )

Neighbour ( )

Other specific ( )

22. Do you have electricity?

Yes ( )

No ( )

if Yes, did you get the electricity as a result of dam construction?

Do you have any good toilet facilities?

Yes ( )

No ( )

23. Are you happy with the house you are living in?

Yes ( )

No ( )

24. Do you have any toilet facilities? Yes ( ) or No ( )

25. Who provided these facilities in this area?

Dam authority ( )

Self ( )

Other (Specify) ……..

26. Have the construction of dam caused any damage to your culture?

Yes ( )

No ( )

If yes, explain,

……

……

27. Have the construction of dam caused any damage to any recreational features?

Yes ( )

No ( )

If yes, which recreational features?

……

……

28. In your opinion is fishing by locals

Regular practice

Rare

29. Do people have to obtain license to fish in the dams?

Yes ( )

No ( )

If Yes: What criteria is used to obtain fishing license

Explain…….

……

30. What is the cost of license for fishing in the dam? kshs……

31. In your opinion is the licensing fee permit affordable by local fishermen?

Yes

No

Explain your answer……

…….

SECTION D: AGRICULTURE: IMPACTS OF NDAKAINI DAM ON COMMUNITY FOOD SECURITY

32. Does irrigation take place by locals using Dam water? I) Yes ii) No

Explain your Answer……

……..

33. Would you classify the area (if any) under irrigation?

Significant

Not significant

34. Name the crops frown through irrigation (if any) from the dam in this area? **.....**

.....

35. Have the crops diversity grown in this area increased due to irrigation water from the dam?

Yes

No

Explain your answer……

……

36. If people are not using dam water for irrigation, what are the reasons (you can tick more than one)?

Not allowed by authorities

Lack of money to buy water pump

Soil not good for irrigation

Lack of irrigation know how

Any other Specify? .....

……

37. Is this area affected by wildlife from the dams (choose the level of impact?)

(1) Highly serious (2) Serious (3) Not serious

Wildlife	**Level of impacts**
Crocodiles	
Hippo	
Others (Specify)	

If Yes: What has been the response from authorities in terms of compensation? **.....**

……

38. In your opinion. What should be done to reduce the wildlife menace to people and agriculture in this area……

……

39. Does the area experience food security? Yes ( ) or No ( )

40. What are your recommendations to increase food security in this area?

Availability of potable water from the dams

State how many households have been supplied with potable water from the dams?

Rural …….

Rural trading centers……

Any other: state…….

41. Water reasons accounts for low water supply to households?

Bureaucracy in application for connection

Low application

Cost of application (low income of families)

Institutional capacity to cope with demand

Any other (Specify) …….

42. What is the main source of water for those not using piped water?

Raw water from the dams

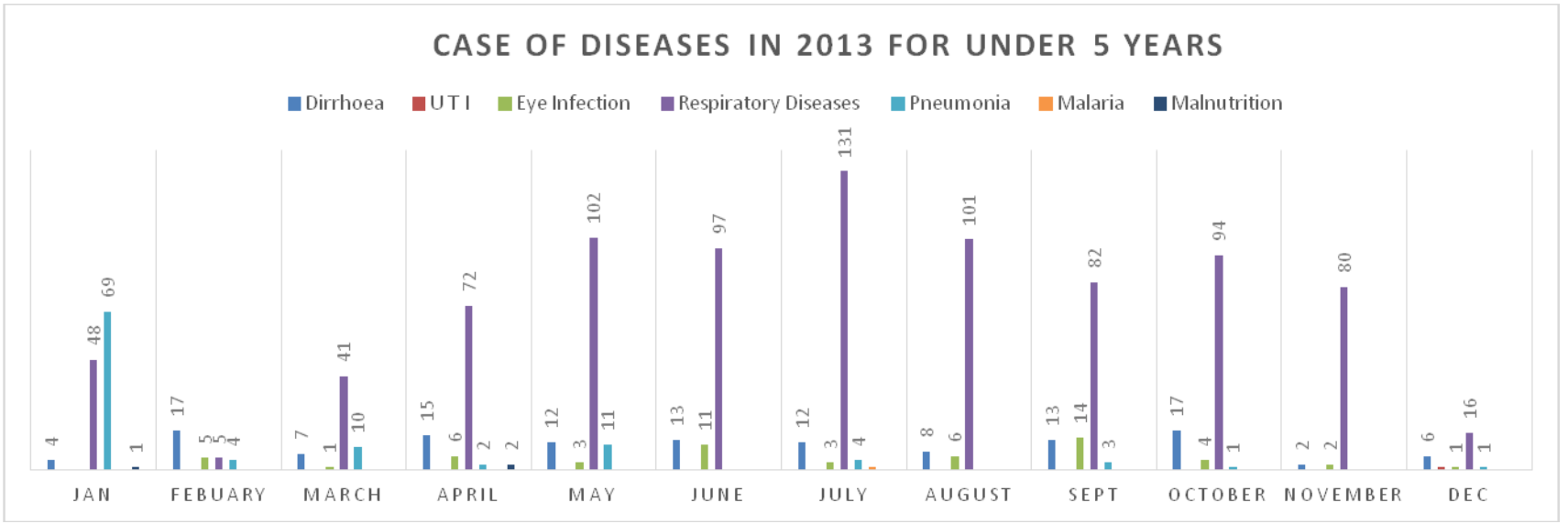
Borehole water

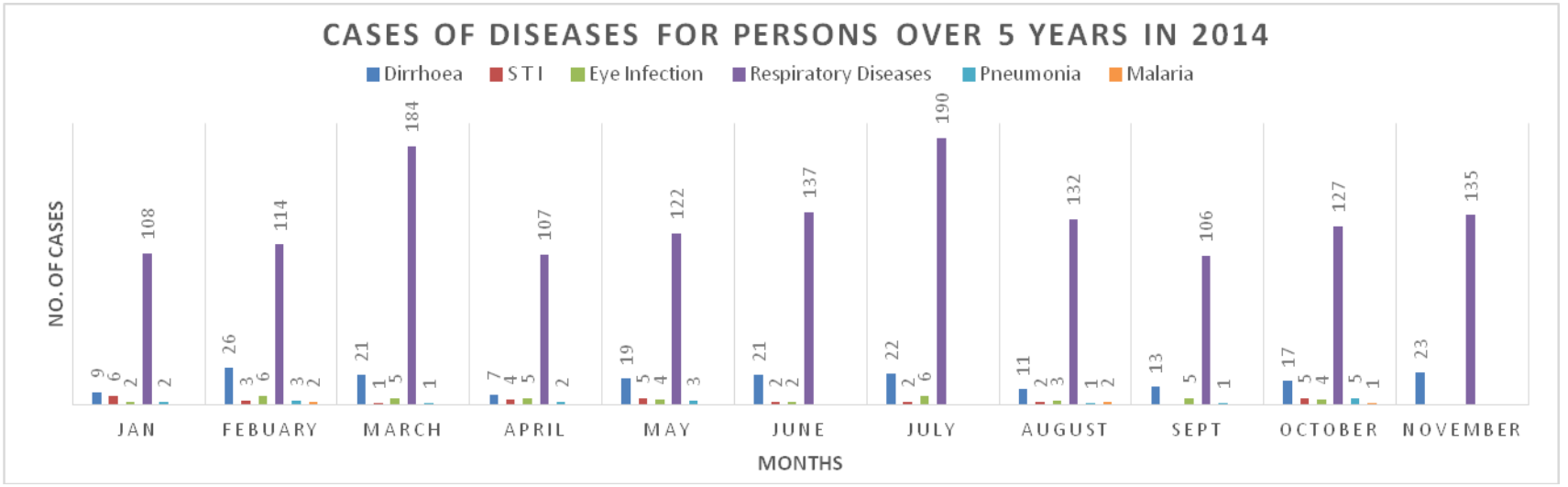
Raw water from the rivers]

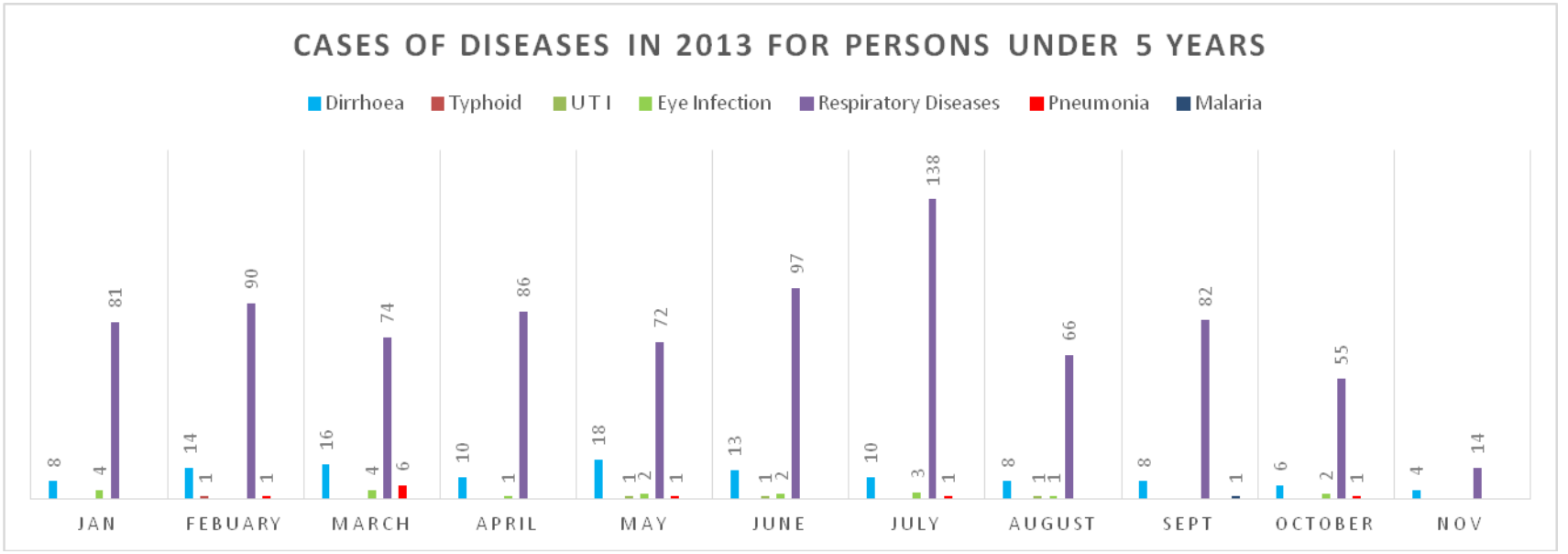
Any other (Specify)……

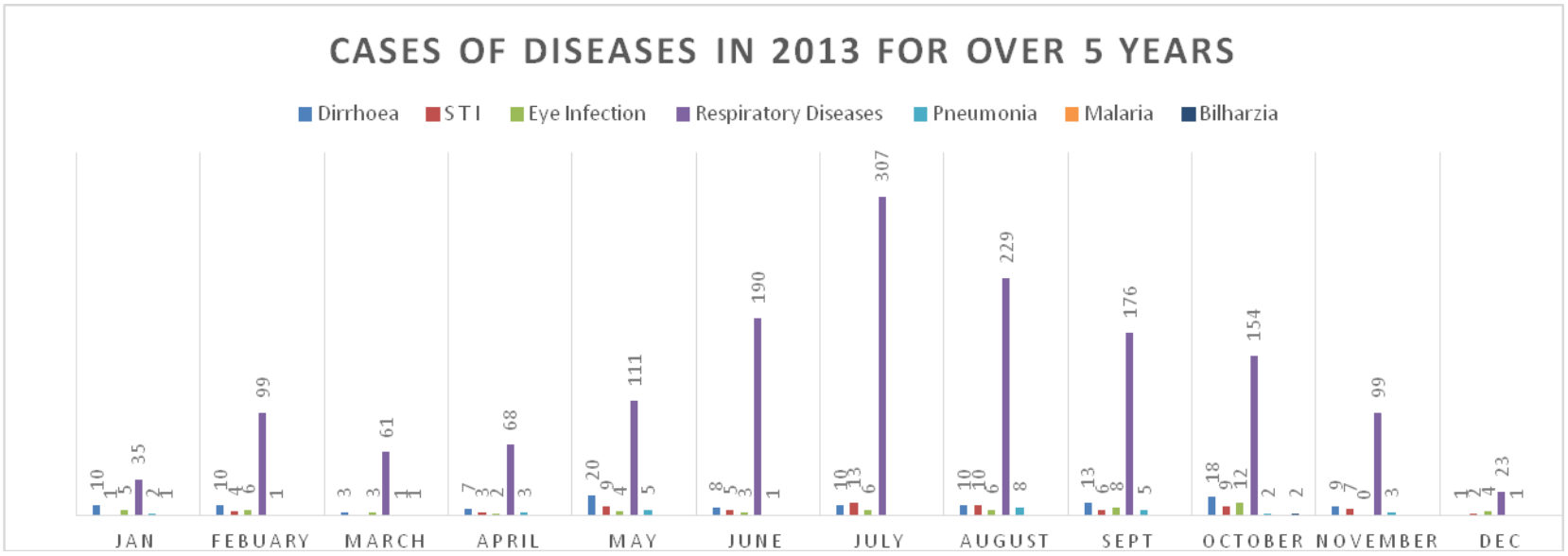
43. that is the end of the questionnaire; do you have any remarks to make?

Appendix II: Report of diseases from Ndakaini Dispensary






CASES OF DISEASES IN 2013 FOR PERSONS UNDER 5 YEARS
Dirrhoea
Typhoid
UTI
Eye Infection
Respiratory Diseases
Pneumonia
Malaria
JAN
FEBUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPT
OCTOBER
NOV


CASES OF DISEASES IN 2013 FOR OVER 5 YEARS
Dirrhoea
STI
Eye Infection
Respiratory Diseases
Pneumonia
Malaria
Bilharzia
JAN
FEBUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPT
OCTOBER
NOVEMBER
DEC