INFLUENCE OF WATER RESOURCE USE PATTERNS ON THE LORIAN SWAMP ECOSYSTEM

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DECLARATION

I declare that this research thesis is my original work and has not been presented for examination in any other university.

Sign: ..... **Date:** 17-07-2019

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This research thesis has been submitted for examination with our approval as university supervisors.

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DEDICATION

This work is dedicated to my loving Mother, who gave me the chance to go to school while she took the mantle to look after the livestock, and to Prof. Wangari Maathai whose footprint I am following through the Wangari Maathai Institute for Peace and Environmental Studies in building a peaceful and safer world.

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LIST OF ABBREVIATIONS

ASAL	-	Arid and Semi-Arid Land
CAS	-	CAS Consulting Limited
CETRAD	-	Centre for Training and Integrated Research in ASAL Development
CIDP	-	County Integrated Development Programme
EIA	-	Environmental Impact Assessment
GOK	-	Government of Kenya
ICOLD	-	International Commission of Large Dams
KNBS	-	Kenya National Bureau of Statistics
LAPSET	-	Lamu Port, South Sudan, and Ethiopia Transport Corridor
MCM	-	Million Cubic Meters
NWCPC	-	National Water Conservation and Pipeline Corporation
SPSS	-	Statistical Packages for the Social Sciences
WCD	-	World Commission on Dams

ABSTRACT

River ecosystems are under intense pressure from water user's resultant from human or economic activities. Population pressure are over-stretching most of Kenya's water towers including the Ewaso Nyiro water catchment areas which was the study area. Developing countries including Kenya have identified water as a vital ingredient in meeting the socio-economic developments as envisioned in Vision 2030. Among the proposed projects was the construction of Isiolo mega dam to support the development of Resort City against the backdrop of depleted water resources in the Ewaso Nyiro River due to water abstractions, large scale irrigation farms and used ranches in the upstream. The study investigated the influence of water resource use patterns on the Lorian swamp ecosystem, which narrowed down on the trend of water levels and pasture in time and space and the overall effects of the proposed Isiolo dam on the ecosystem services namely water and pasture. The data was collected from four sub-location namely, Merti, Mulandanur, Matarba and Saleti in Isiolo County. The respondents were randomly selected using a sampling formula from the targeted sub locations. 100 respondents were administered with questionnaires to obtain the data needed. Additionally, focus group discussion was conducted to gather in-depth information as a triangulation measure. Observations added valuable information to the overall data collection. The field data was uploaded on statistical package for social sciences (SPSS) and the data was analyzed using descriptive statistics. River flow data from CETRAD were calculated and tabulated to triangulate primary data for comparison and validation. The results were presented in bar charts, percentages and mean. The data analysis indicated significant water reduction in Ewaso Nyiro over the years affecting the Lorian Swamp ecosystem. The research finding indicates that from 1960-1969, the cummulative water discharge was 964 million cubic meters and from 2001-2010 it was 572

million cubic meters showing a major decline in water discharge with a difference of 392 million cubic meters translating to 40% reduction over four decades. Further analysis showed that pasture and water are currently adequate but under threat due to loss of traditional governance system, invasive species *(Prosopis Juliflora),* climate change, water abstraction upstream for farming and other uses, deforestation, encroachment of the catchment arears and ever-increasing population. It was therefore concluded that the further development of proposed dam will have serious effects on water discharge of the Ewaso Nyiro River. The Dam will be anticipated to take 214millions cubic meter against the backdrop of the available annual average water of 583 million cubic meters translating to annual reduction of water in the river by 37%. The future impacts will shrink the Lorian swamp ecosystem from the current 2918-kilometer square to 1809-kilometer square affecting forage production, water reduction including the underground water, Loss of indigenous trees and increased conflict over limited resources. The research further concluded that to balance human developments and sustainability of the Lorian swamp ecosystem the water uptake in the dam be spread over three years at a rate of 71.4 million cubic meter, about 12.3% of annual water discharge. It means that the dam will be filled in three years. The research study further recommends that the National government should explore sustainable timeline to fill the dam in meeting the water demand without compromising the critical Lorian Swamp Ecosystem. Additionally, the County government should constitute an Independent Institution to conduct potential Environmental and Social Impact for the proposed dam. Also, the traditional governance system of the resource management should be formalized and strengthened so as to manage the Lorian Swamp Ecosystem. Finally, the need to curb the serious threat from the invasive species (*Prosopis Juliflora)* and the concerned Authority should consider innovative ways of taming it.

CHAPTER ONE

INTRODUCTION

1.0 Background Information

River ecosystem formed the cradle of human civilization and which help in triggering both early and modern developments. River basins have supported livelihoods, connected businesses and supported habitats and ecology. History has it that alterations to rivers be it man made or natural have impacted riverine communities in one way or another (WCD, 2000). African countries are faced with severe challenges in securing safe and clean water to meet the growing demands of an expanding population and the 21st century developments goals as enshrined in their respective national priorities while preserving the essential waters ecosystems to protect water sources (Global Water Partnership, 2015).

Poor governance in African Countries have degraded many water catchments which has affected thousands of critical ecosystems (Global Water Partnership, 2015. Water resources planners have largely ignored the intrinsic relationship of different uses of water such as in agriculture, domestic industrial use, domestic and to sustain the ecosystems (Global Water Partnership, 2015). The demand for water will increase rapidly in the future, especially in the context of ambitious Vision 2030 projects (Republic of Kenya, 2010).

Water is an essential ingredient to Kenya's economic planning be it agriculture, industry, energy, or wildlife tourism. The Ewaso Nyiro river catchment area which is a target for the research, have been experiencing land use practices and increased human pressure beyond unsustainable level, and declining wildlife, increased human-wildlife conflicts and conflicts between ranchers and herders. (Ojwang *et al*, 2009).

Land-use changes in the Ewaso Nyiro basin have arose as a result of pastoralists changing to settlement lifestyles as a result of globalization that demand for education for children, better health care and permanent homes among others. The sedentary lifestyles have resulted in increased livestock populations, habitat fragmentations and depletions of pasture, water, browse, all of which will have negative impacts on wildlife and livestock (Ojwang *et al* 2009).

In the upper catchment areas, the intensive use of water for irrigation has an impacts on the livestock in the lower areas due to reduced water levels in the Lorian swamp. The available data of the river flow within the Ewaso Nyoro Basin have indicated declining water discharge especially during dry seasons (Mati, *et al.*, 2005). This has been due to the high levels of farming activities on the upstream, which can reach sixty percent of the water discharge during the dry seasons (Gachupin, *et al*., 1998). In Kenya, the vision 2030 proposed major infrastructure development including development of mega dams. One such project is the construction of Isiolo mega-dam to support the proposed Resort City, a flagship project of Vision 2030. The National Water Conservation and Pipeline Corporation (NWCPC) has identified the construction of the proposed Isiolo Dam in the Ewaso Nyiro River to provide water to the proposed Resort City, Isiolo town and its environs (CAS, 2016).

The Ewaso Nyiro has twenty tributaries with the main economic activities being pastoralism which the river supports at the downstream. The river feeds the Lorian swamp stretching to Habaswein in Wajir providing palatable pasture and water to the livestock, the main economic activty for the region. The Lorian swamp also re-charges the Merti aquifers, the source of the shallow wells and borehole water (Leeuw, *et al.*, 2012).

1.1 Problem Statement

Despite the water resources being plentiful, the problems of water shortages are increasing. Africa's situation and for Kenya, it is worse than the other continents given that most of the continent falls within the Sahel and the desert regions as opposed to equatorial wet regions. In Kenya, the arid and semi- arid lands (ASALs) make up 80% of the country's land surface. This situation is coupled with the fact that Kenya's population doubles every ten years and one of the countries with the highest population growth rates (GOK, 1996).

Kenya vision 2030 is set to accelerate economic growth in order to realize hopes and dream of all communities living in Kenya. This is long-term development policies that seek to transform the Country into middle level income, by improving people's life through adaption of green economy, clean, secure and sustainable environment.

Vision 2030 underpinned marginalization and Northern Kenya is the recipient of the Lamu Port, South Sudan, and Ethiopia Transport Corridor (LAPSET) projects. Once these growths are facilitated, the government will establish three Resort Cities in Lamu, Isiolo, and Turkana through private financing valued at (US$ 970m, 200m and 42 respectively) To trigger the infrastructure needed for this growth, the government proposed the construction of Isiolo Dam which envisaged providing water to the proposed Resort City, Isiolo town and its environs, supporting hydropower production and the tourism sector. The National Water Conservation and Pipeline Corporation (NWCPC) has carried out a Feasibility study and Social impact of the Proposed dam (CAS Consulting Ltd, 2016).

The assessments are skewed toward population living around the Dam without taking into consideration the primary downstream beneficiaries of the Ewaso Nyiro River basin and the critical ecosystem of the Lorian Swamp. With the projected economic development on the Lorian Swamp, the fragile ecosystem is under threat from the proposed construction of mega Isiolo dam. The Lorian Swamp has served the environment with water resources that are about to be curtailed by the construction of dam, laying siege to water resources availability for pasture and farming. The water from the Lorian swamp serves the pastoralist's community in watering the livestock and a reduction to the water level results to inter-tribal clashes and conflict over the water resources. The study focused on the undocumented benefits of the Lorian Swamp Ecosystem, its trends over the years and the proposed dam future effect on the ecosystem.

1.2 Objectives

1.2.1 General Objective

To examine the influence of water resource use patterns and the management of the Lorian Swamp Ecosystem

1.2.2 Specific Objectives

i) To evaluate the trends of water levels of Ewaso Nyiro River

ii) To examine water and pasture availability in the Lorian Swamp Ecosystem

iii) To assess the potential effects of the proposed Isiolo dam on the water levels and pasture in the Lorian Swamp Ecosystem

1.3 Justification

The constitution of Kenya 2010, outlines the sustainable use of natural resources with high responsibilities on the state and the individuals in protecting and conserving the environment and natural resources (Kariuki, 2016.). This calls for collaborative efforts in protecting and conserving critical ecosystems that support the growth of Kenya's economy and the wellbeing of its citizen in a more robust and sustainable manner.

The Ewaso Nyiro catchment is a vast area which comprised of different ownership including private, ranches, trust lands, and community wildlife conservancies mostly under communal management and commercially oriented enterprises and agricultural farms managed by smallholder agribusinesses and farmers (Georgiadis, *et al*. 2007). Ewaso Nyiro catchment faces unprecedented challenges related to increased human pressure, unsustainable land use practices, declining wildlife and human-wildlife conflict (Ojwang *et al* 2009). The upstream abstraction of river water for irrigation farming and other economic activities has an impact on the livestock in the lower stream reducing water levels in the swamp. (Mati, *et al*., 2005).

Kenya's Vision 2030, envisioned flagship projects in Northern Kenya including the development of a Mega Dam on the Ewaso Nyiro River in Isiolo. The Mega dam project was proposed against the backdrop of a shrinking ecosystem of the Ewaso Nyiro River (Thias, *et al.,* 2017).

River discharge flowing from higher upstream areas, provides surface runoff water to downstream users and rejuvenate pasture production in lowland drylands. The downstream benefits of rivers are becoming insecure due to increased human demand for water at upstream level of Ewas Nyiro basin (leeuw, *et al*., 2012).

Uncontrolled use of water upstream will reduce water discharge in the Ewaso Nyiro River and will deprives downstream communities from the benefits derived from their cultural sources of

water. The consequences will also shrink the critical ecosystem of the Lorian Swamp affecting its ecosystems service functions. The Ewaso Nyiro River Basin, is an excellent example of the consequences that uncontrolled river basin development has on life and livelihoods of downstream users. This study underpinned the current trends of water use pattern and the effect on the Lorian Swamp Ecosytem against the backdrop of the proposed Isiolo mega dam on the upper catchment. The findings of this study will influence policy planning and decision-making at County and National level.

1.4 Scope and Limitation

The study was delimited to investigating the influence of water resources use patterns on the Lorian swamp, water and pasture trends in time and space and underpinning the effect of the mega dam on the water discharge levels in the river.

CHAPTER TWO

LITERATURE REVIEW

This chapter presents an overview of issues and perspectives of Lorian Swamp ecosystem.

2.1 Introduction

The literature review highlights an overview of the trends of water resource use patterns at the global, Africa and the Kenyan situation with specific reference to the Ewaso Nyiro river basin and its effects on water discharge and pasture in the Lorian swamp ecosystem. It further interrogates the likely effects of the proposed Isiolo Mega dam on the Lorian Swamp Ecosystem in the light of Vision 2030 and what it means for the livelihoods of the pastoralists depending on the rich ecosystems.

2.2 Background Information of River Basin Ecosystems

River ecosystem formed the cradle of human civilization and most early and modern developments were triggered by the availability of river ecosystems. River basins have supported livelihoods, connected businesses and supported habitats and ecology. History has taught us that alteration to rivers whether man made or natural have affected riverine communities in many ways (WCD, 2000). There are over 55,000 large dams worldwide according to the International Commission of Large Dams (ICOLD) 2010 report.

The period of industrial revolution triggered the demand for energy and the growth of dams escalated after World War 11 and it was a record high in the 1970s. After 1980 there was a decline in dams' construction to the realization of the negative impact to the environments and ecosystems including community heritages (WCD, 2000).

The populations affected or threatened by dams have staged strong resistance around the world. Globally, construction of large dams have caused displacement of over 40 to 80million people

(WCD, 2000). In Africa, Egypt is in conflict with Ethiopia over the construction of the Renaissance dam. They fear drastic water reduction and economic sabotage.

In Isiolo County, construction of a proposed mega dam on Ewaso Nyiro River has brought heated debate and oppositions from the pastoralists and civil rights activists. The dam would likely affect the water levels and pasture availability in the Lorian Swamp Ecosystem with long-term consequences on human livelihood and aquatic habitats.

2.3 Global Water Resource Use Situation

Over the past few decades, demand for water has increased all over the world, however, water quality has deteriorated, the water environment has degraded and the cost of developing new water resources have risen dramatically. This combined with population growth and fragmented water management, has created unsustainable situation in some parts of the world (World Bank, 1993).

Water is a critical life sustaining resource found on mother earth and it constitutes of oceans, rivers, lakes, sea and underground water. Water is crucial for human survival, health and social-economic development (UN Water 2011). Both Millennium Development Goals (MDG) and later Sustainable Development Goals (SDGs) have captured water as an ingredient that will transform the world and supporting it goals on sustainable developments. Water has been universally recognized as a fundamental human right and equally vital that it be manage efficiently to support humanity. (UN Water 2011).

2.3.1 Water Availability and Distribution

It's estimated that 75% of the surface of the earth is covered by water but due to the water dynamics it difficult to take the stock (Kibona, *et al*. 2009). The earth's hydrosphere is estimated to contain approximately 1,386 million km3 of water (Cassardo and Jones 2011). However, not

all of the water resources are available to humans. Freshwater is highly required for domestic use, industries, agricultural sector and recreational use (Lui, *et al*., 2011). The estimates for fresh water are three percent (3%) %) and its physical state changes from being solid, to liquid or gasses. Sixty-nine percent (69%) of the fresh water is made up of ice, glaciers and snow and are mostly found in the polar region. Groundwater hold thirty percent (30%) of the clean water on Earth, while rivers system, reservoirs and lakes constitute 0.3% of freshwater (Lui, *et al.*, 2011). Ninety-nine (99%) of water are not available for human consumption due to multiple factors. The remaining one percent (1%) is groundwater, which is costly in exploitation. Only 0.0067% of water on Earth is treated as fresh surface water that can be used for consumption by human. That leaves a total of 2120 km3 of freshwater that is available for human use (Cassardo and Jones 2011).

Water has two fundamental functions in shaping human life on earth, first water supports human life and secondly as a commodity supporting the economic pillar. Human and economic demands often compete for the same commodity and are on constant conflict with each other over water usage. These conflicts have resulted in exploitation often degrading the water catchment areas risking many aquatic ecosystem (Pimentel, *et al.*, 2010).

World Business Council for Sustainable Development (WBCSD) estimated that the minimum basic water level requirement for human is 50 liters per capita per day and the minimum amount of water required per capita for food is approximately 400,000 liters per year.

2.3.2 Water for Agriculture Use

Its estimated that 69% of world water is used for agriculture, mainly through irrigation; 22% support industrial use, eight percent (8%) is used for domestic consumption, and one percent (1%) is used for recreational (Kibona et al. 2009; Rosegrant et al. 2009; Cassardo and Jones

2011). Agricultural activities are the biggest sectors on Earth due to human demands to sustain themselves on earth. Agricultural usage of water resources includes irrigation, livestock, fisheries and aquaculture. The size of agricultural areas has doubled between 1970 and 1995 (Lui, *et al*., 2011; UN 2012).

The projected global population growth are approximately 2-3 billion people over the next 50 years. The demand for food will shoot up by 70% by 2040. The water supply remains the same, because no one can invent water on the other hand the food demand will increase due to increased population, that means food must be produced using less water through innovative technology (Rosegrant, *et al*., 2009). The world has the potential to increase the acreage of farmland to feed the ever-increasing population, however, approximately five to six million hectares (0.6%) of the farm acreage is lost annually as a result of increased human activities. This has resulted to the amount of cultivated land per person to decline from 0.4 ha in 1961 to only 0.2 ha in 2005 (Kibona, *et al*., 2009).

2.3.3 Mining and Industries

Mining and Industrial is the second biggest consumer of water after agriculture. The consumers in this level imcludes economic sectors such as oil refineries,mines, manufacturing plants, as well as power plants energy use (Kibona, *et al*., 2009). The industrial sector of a country is generally determined by the average income of the Country's population. (Lui, *et al*., 2011).

Industrial water usage constitutes five percent (5%) in devoping countries as opposed to the 40% in some developed Countries. A number of Asians Countries economically refered as Asian Tigers are investing more in industrial development which will ultimately trigger increase in water uptake over the coming years. Energy uses more water but which are intricately depended

on each other. Sources of energy needs water in the production processes, while energy is also required to make water available to people through pumping and conveyance (Lui, *et al*., 2011).

2.3.4 Water use for Domestic, Recreation and Environment

Domestic activities use approximately eight percent (8%) of the water consumption and number three in water usage. The water needed for human essentials includes drinking, bathing, washing, and gardening activities among others. The estimated basic water needed for household are estimated at 50 liters per person per day (Gleick, 2006). Approximately 2 liters of the 50 are used for drinking, 20 liters for sanitation, 15 liters for bathing, and 10 liters for cooking. (Kibona, *et al*., 2009).

Recreational water takes one percent (1%) of the global water consumption (Kibona, *et al*., 2009). Recreational activities include water skiing, boating angling and swimming among others. Recreational water use is minimal but it competes with other water users that include agricultural and energy sector. Like any other sector recreational activities compete for water in the future as a result of the acceleration in the world's population and the demand for more recreational facilities (Lui, *et al*., 2011). Environment uses the least amount of water of the mentioned categories and its benefits ecosystems. The percentage of water use for environmental is small but progressively increasing in demand as a result of investment in creation of artificial lakes and wetland due to increased demand for conservation and environment (UN, 2012).

2.4 Africa's Demand for Water Resources

Most African countries face challenges in securing water to meet the increasing demands of an ever-growing population and developments goals, while preserving the essential water towers that support water sources (Global Water Partnership, 2015). Poor governance in African Countries have led to the over exploitation of water resources and destroyed water catchments

areas and in some cases terminated the life of species in ecosystem. Water resources development plans often ignored the intrinsic relationship of the many different uses of water – for agriculture, domestic and industrial use, and for sustaining the ecosystems and hydrological services. (Global Water Partnership, 2015)

In sub-Saharan Africa, agriculture water use is 87 percent, in comparison to 70 percent worldwide (FAO, 2008). Rain supported agriculture takes 96 percent of all cultivated land (FAO, according to the FAO, "Many intensively overused river basins in food producing zones are already operating beyond the limit of their resource base." This pose a serious threat as more than two thirds of the population depends on agriculture and other livelihoods (FAO, 2008). In Kenya, water demand exceeded the available renewable water resources in three out of six water managements zones, in 2010 (WRMA, 2011). Climate change is expected to fuel the risk of crop failure and livestock death in arid and semi-arid regions. FAO predicts that by the 2080s, land unsuitable for rain supported agriculture in the region will shoot up by 30 to 60 million due to climate change and land degradation (FAO, 2008).

Grey and Saddoff (2007) describe regions isuch areas as having water deficiency where extreme weather and unpredictable rainfall patterns add significantly to the unsustainable management of water resources. Sustainable management is crucial to improving food and nutritional security, and increasing economic growth. Ethiopia, Djibouti, Somalia, Eritrea, and parts of Kenya are mostly considered vulnerable to drought and related factors. Irrigation plays an important part in promoting the agricultural growth of cash crops in Kenya, Ethiopia and South Sudan. (Ministry of Water Resources, 1998).

Further investments and expansions of towns and cities are cropping up in all East African countries. Unless a more sustainable approaches is taken to manage water resources, these

developments may have huge impacts on downstream communities and potentially disrupt the watersheds ecosystems (UN-Water, 2015). Sub-Saharan Africa's population is growing fast and has reached 973 million in 2014 and thus the demand for fresh water for both domestic and industrial use is rapidly increasing in a region in which water resources are limited andunevenly distributed compared to other parts of the world (UN-Water, 2015). This is true for Ewaso Nyiro River basin where increased population in upstream creates unbalanced use of water resources with negative consequences for downstream users.

2.4.1 A Case Study of the Renaissance Dam Project Nile River

The Nile Basin is one of the most complex and fascinating river basins due to its size and varying topography, hydrology, climate, demography and population (Sileet, *et al*., 2013). This water user patterns pose many challenges to the transboundary Nile water resources of the basin. The population pressure, famine, poverty levels, shrinking water flow, climate change and related power shortages, dams construction and agricultural development plans affect the health of the basin (Batisha, 2013). These challenges have raised tensions among the communities and nations threatening socio-political and economies of the region (Batisha, 2013). The shared water resources traversing boundaries offer a great opportunity for all. They can be used for agriculture, domestic, energy generation, navigation and other social needs. The full potential of the Nile water basin has not been exploited due to the lacking of sound investments and agreed benefit sharing mechanisms. Shared water resources present opportunities for social, political and economic growth through cooperation and collaboration in the management and sustainable use of it without disrupting critical ecosystems (Nile Basin Initiative, 2012). The Nile river have two critical water supply sources which are the Eastern Nile Basin (Blue Nile) which contribute 85% of the Nile water and its origin is in Ethiopia and the Eastern Equatorial Nile (White Nile)

which contribute 15% of the water flow. The Blue Nile constitute 60% of the total water flow at Aswan and is important water tower for Egypt, Ethiopia and the Sudan, which constitute the Eastern Nile Countries (Mulat and Moges 2014). Egypt entirely depend on the Nile water for hydropower and irrigation and Sudan to a lesser extent use it for irrigation (Waterbury 2002). In contrast, Ethiopia use of the Nile water is minimal, with less than 5% for irrigation and less than 3% for energy generation (Block, *et al.*, 2007). Ethiopia has multiple sources of water resources and huge hydropower potential that is estimated to about 30 000 MW with a total potential of 159 TWh/year (World Energy Council 2007). 94% of Ethiopia's population unfortunately still depends on fuel wood for cooking and heating and 83% has no access to electricity (Thomson 2006).

The Ethiopian government has triggered ambitious plans and programs to develop its hydropower in an efforts to utilize the potentials of water resources, enhance water security and energy in order to reduce poverty, develop an environment for social transformation and thus bring economic growth to the country (Whittington, *et al*., 2005). Ethiopia is putting up the biggest dam in Africa called the Grand Ethiopian Renaissance Dam (GERD) which is under construction on the Blue Nile River which produce 805 of the Nile water. It's being built in the upstream of the Ethiopian-Sudan border in Ethiopia. The GERD will create a water reservoir with a capacity of 74 billion m3 and is expected to generate 6000 MW of power energy. The developments will have significant impacts on the Nile flow for countries situated downstream of the GERD (Mulat and Moges 2014). large project like GERD will have serious impacts on the social and natural environment . Large-scale development demands consensus planning for all affected stakeholders before initial implementation of individual country project(s). Nile river

basin is an international river shared by eleven riparian countries, such planning ought to have promoted further international cooperation (Mulat and Moges 2014).

The international panel of experts handed its final report in May 31, 2013 on the impacts of GERD to Egypt and Sudan and the main gaps on GERD project studies. The report notes that the main dangerous impacts is the reduction of water levels in Lake Naser which ultimately reduced power generation in Aswan dam. During impounding cultivated agriculture will be serious affected both in Sudan and Egypts resulting into loss of food productions which is the main economy especially for Egypt. The GERD project is rising tension and might lead into conflicts among the affected countries (IPoE 2013).

The environmental impacts of the implementation of the Grand Ethiopian Renaissance Dam include indirect and direct impacts on the physical, biological and chemical features of the river and the affected environment (International Rivers, n.d.-b, 2011). The GERD project will transforma riverine ecosystem upstream of the dam into an artificial manmade lake, the river's natural course that support animal species and plants are undermined. Riverine plants and animals are exposed to unfamiliar environment which will make them hard to adapt not adapted especially to a lake environment, a cultural shock for that matter (Federal Democratic Republic of Ethiopia Ministry of Water Resources, 2002a; International Rivers, n.d.-b; Than, 2011). The changes in water temperature, chemical composition, dissolved oxygen, physical properties and salinity of the impoundment generally happen too fast for the species to adapt themselves thus loss of critical biodiversity (International Rivers, n.d.-b; Than, 2011). Similarly, the emergence of invasive and non-native species will threaten survival of existing natural animals and plants creating conflicts. A second undermining factor could be the separation of animals‟ spawning habitats and rearing habitats due to the dam construction (Federal Democratic Republic of

Ethiopia Ministry of Water Resources, 2002a; International Rivers, n.d.-b). Likewise, the distribution vegetation of wild life in the river catchment are seriously affected and the inundation of the riverbanks and the forest will ultimately force plants and animals to migrate uphill (Ahram online, 2013; International Rivers, 2012b). Extinction for plant and animals could occur which definitely affect the catchment's biodiversity (International Rivers, 2012b). These documented potential environmental impacts are applicable to the current construction of the proposed Isiolo mega dam and increased use of water resources for commercial use in upstream thereby require more studies done to ensure that the habitat and biodiversity is not lost.

2.5 The Situation of Water Resources user Patterns in Kenya

Kenya hosts major water sources of East Africa but 90 percent of the country is either semarid or arid (Republic of Kenya, 2008). Rainfall patterns are very variable, seasonally and annually, a challenge likely to be further aggravated by climate change. Water is the biggest stress to the Country's economy growth, not only in the arid areas but cut across the country, including areas where water-intensive economic activity has grown rapidly, such as the Mau, Mt Kenya region and part of Rift valley. The demand for water will increase rapidly in the future, especially in the context of ambitious Vision 2030 projects (Republic of Kenya, 2010).

Water is an essential ingredient to Kenya's main economic activities be it agriculture, industry, energy, or wildlife tourism. Sustainable water resource use is necessary for social-economic development and well-being of Kenya's 44 million people (Ministry of Water and Irrigation, 2007). The management and the development of sustainable water resources are critically important for the economy, the environment and society (Ministry of Water and Irrigation, 2009).

Kenya's Vision 2030 development plan aims to transform the country to middle-income, improving quality of life for its people by the year 2030 (Republic of Kenya, 2010). The Government recognizes that water in adequate quantity is a critical factor to the realization of its development targets in achieving Vision 2030 (Ministry of Water and Irrigation, 2010).

Notably, access to water is a basic rights to human life and survival, and Kenya has undergone historical trajectory in enhancing water governance and enabling the use of water technologies. Before the colonial time, management of water was subjected to the customary laws and behavioral norms of the tribal society. More importantly, water sources, especial water springs were highly valued as cultural heritage and sacred (Huggins, 2000). These customs have been eroded, modified and others are still in operations. Community governance on water resources is critical in influencing the use of shared water resources among communities and it will foster peaceful co-existence (Huggins, 2000). Water tenure is so important that any development on the water resources has tendencies to raise tensions (Ramazzotti, 1996).

it is possible to say that ownership of water sources usually rest with the local community rather than an individual household thus the community control all the water sources with laid down rules :this is the case for the Boranain Northern Kenya, for instance (Huggins, 2000). Water was treated as a commodity to be shared by all, supporting the sanctity of life, even in Boran community, they don't entirely owned the water sources and other community have reciprocal rights too upon following the laid rules governing the water. This is a good traditional governance system, as explicated by the Boran community on the Ewaso Nyiro river basin, who have a system of sustainable use of water resources to support livelihoods(Orendo, 2003).

Sometime a distinction was made between different water uses which enhanced the water user patterns (Msuya, 1999). However, as regards water for livestock, permission had to be granted

and it was possible to permit or not to permit, to charge or not charge charge people for use of a private watering-hole (Ramazzotti, 1996). Mutual understanding over water use are particularly central amongst pastoralists communities who are highly nomadic, in order to strategize migration-routes. Pastoral societies have long tradition of a negotiated democracy and kinship networks that allow access to water and grazing rights among the territories of their tribe and amongst other neighbouring tribes (Huggins, 2000). This is another example of traditional governance structures being shaped by the necessities, challenges and opportunities posed by the need to gain access to water which explains how the water user's patterns affect the water resources like the Ewaso Nyiro river basin.

2.6 Ewaso Nyiro River Basin

The Ewaso Nyiro catchment is a vast area which transverse through huge chunk of rangeland namely private, trust lands, cattle ranches and conservancies mostly under communal management and commercial oriented enterprises, as well as irrigated farms managed by smallholder farmers and agribusinesses (Georgiadis, *et al*. 2007). Ewaso Nyiro catchment faces unprecedented challenges due to increased human pressure, unsustainable land use, declining wildlife and human-wildlife conflict (Ojwang' and Wargute 2009). Land-use changes in the Ewaso Nyiro basin have occurred due to nomadic pastoralists shifting to settlement lifestyles to test the fruit of modernization. Multiple factors have resulted in overstocking, habitat fragmentation, and depletion of water, pasture, browse, all of which have serious implications for livestock and other users (Ojwang' and Wargute 2009). The upstream abstraction of river water for irrigation farming and other economic activities has an impact on the livestock in the lower stream reducing water levels in the swamp. (Mati, *et al*., 2005).

2.7 Current Trends of Water Levels and Pasture in the Lorian Swamp Ecosystem

In his book, '*Through Juba land to the Lorian Swamp',* I. N Dracopoli described the Lorian swamp as wide flood plain, with its wild animals roam undisturbed over wide and silent plains or lie unmolested over shadow of its bush but this state of the affairs cannot last (Dracopoli, 1914). He said that "The spread of civilization, which ultimately, no doubt, brings peace and prosperity, the interesting customs and habits of the tribes must change. Giving place to new, and so brief is this period of transition that within a short space almost all traces of the old are obliterated, wild animals are driven and finally exterminated" (Dracopoli, 1914)

The above statement describes the true state of the Ewaso Nyiro basin and its current status. The population pressure and other anthropogenic factors have over the years affected the flow of the River. Notably, the river drains from the glaciers of the Mount Kenya through the expansive farms and populated region of Laikipia in Central Kenya and ends in the Lorian Swamp in the arid North East part of Kenya (Leeuw, *et al.,* 2012).

The 2918 square kilometer Lorian Swamp is lifeline for people and their livestock during the dry period (Africa-cover, 2000). The Pastoralists depend on the river's flooding of the Lorian plain for grazing and cultural values. The river used to flow all year round, but in current years, it has faltered emanating from various aspects one being the land use change (Fred, 2015). The river has since become seasonal and can hardly reach the Lorian Swamp except during the short and long rains. This has threatened the ecosystem services for the downstream users and other abiotic and biotic factors in the short and long term (Leeuw, *et al.*, 2012).

The river has several threats: abstraction for agriculture farming, including large scale horticulture in Laikipia, increased pressure from conservancies and tourist lodges and deforestation along its course, which reduces the basin's ability to store water (Fred, 2015). The

changing climate and occasional intense floods over the years has created uncertain and unpredictable life on the downstream users. A further potential threat is the planned construction of a new proposed Mega Dam on the river at Crocodile Jaws near Oldonyiro, in Isiolo County (CAS Consulting Ltd, 2016). Both the dam and and Lorian swamp depend on the seasonal floods, According to CAS. 2016, the Dam with a capacity of 214MCM will harvest the flood un off which at the same is critical to breed life into the Lorian Swamp. The narrative that Dam will retain water and ensure continuous flow of river doesn't hold water for the wetland which depend on the flood for its to support the ecosystem services. Although the wetland like Lorian Swamp would be sensitive to retention and use of water upstream, none of the research considered the impacts of upstream water use on the Lorian Swamp and its ecosystem services and livelihoods depending on it (Leeuw et al, 2012). Mutiga et al 20122 reported that the level of abstractions of water upstream for irrigation and other uses was such that in February, no water reached the middle of the rivers at the Archerst Post.

2.8 Availability of Water and Pasture in the Lorian Swamp Ecosystem

River basins discharges provide surface water to downstream users and sustain critical ecosystems in many dry lands in Africa (WCD, 2000). Over exploitation of water resources in upstream have subjected downstream communities in an insecure environment. Mungai, *et al.*, 2014, argued that if not controlled, increasing retention and overuse of water upstream will deprive downstream communities their lifeline benefits derived from their traditional sources of water.

The Ewaso Nyiro River, which originates from Aberdares Forest and Mount Kenya, terminates into large chunk of wetland called the Lorian Swamp. The swamp supports both fauna and flora and huge livestock economy of the downstream users. Over the pasts decades due to climate

change and over exploitation in the upstream, there has been dwindling water flows. The Swamp full recharge occurs only during high rainy season. Big flower farms cropped up in the upper stream has over the years affected the flow of the Ewaso Nyiro River affecting the Lorian swamp ecosystem downstream (Leeuw, *et al.*, 2012).

According to Jan, *et al.*, 2012, Ewaso Nyiro River contributes heavily to the greening and regeneration of fauna and flora of the Lorian Swamp. The swamp, which measures 196 km long and a width of 25 km (231,000 hectares), provides water and pasture for livestock in the dry season, and it helps pastoralists to regulate grazing patterns (Hughes, 1992). The pastoralists' divide their land into phases namely, dry period, drought period and wet period. The pastoralists movements across the grazing patterns are dictated by the seasons and each rangeland are utilized during specific period. The wetlands of the Lorian are accessed during the dry periods (Leeuw, *et al.*, 2012).

The Lorian swamp performs ecosystem functions, including helping to reduce and regulate the impacts from flooding and sandstorm, maintaining and preserving quality of water in rivers, recharging Merti aquifer (groundwater used for domestic and livestock), storing carbon, helping to stabilize and regulate climatic conditions, controlling pests that causes livestock and crop diseases, acting as home for biodiversity. They support primary products such as farming, fisheries, forestry and pasture for livestock. Wetlands have cultural significance and historical significance for the pastoralists who found and lived with it for centuries (Leeuw, *et al.*, 2012).

2.9 The Impacts of the Proposed Isiolo Dam on the Water levels and Pasture in the Lorian Swamp Ecosystem

The impacts of proposed Isiolo Dam are anticipated to affect a wide range of environmental ecosystems ranging from Upper stream, middle stream, wild animals and other hosts depending

on the river (Jan, *et al.*, 2012). The research concentrated on the Lorian Swamp, the heartbeat of the downstream ecosystem which provides ecosystem services such as water for domestic and animals, discharge of Merti aquifer (the groundwater used for domestic and animals), replenishment of pasture plains through floods, supports fish and habitats biodiversity (Jan, *et al.*, 2012). Dams have negatively affected people's lives, socially, culturally and economically around the world (WCD, 2000). The vulnerable communities and future generations are likely to meet the burden share of the environmental and social impacts of large dam projects without gaining much benefits that is derived from the dam (WCD, 2000). Many landmark projects to transform natural resources usually target high-end business magnets with thin benefits to the locals (WCD, 2000). In the case of Isiolo County, the priority of the dam is to first supply water to Resort City as planned in Vision 2030 where the Average Day Demand for 2026 of 10,000m3/day for Isiolo town and Isiolo Resort will be 55,000 m3/day (CAS Consulting Ltd, 2016).

A total of 147 households are anticipated to be directly affected by the construction of the Dam and Reservoir inundation area, and a number targeted for compensation (CAS, 2016). The consultant failed to discover the real affected pastoralists living downstream of the River whose livelihoods depend on the river (Thias, *et al.*, 2017).

There exists a big gap because pastoralists have been misunderstood for too long and their economic systems have never been exploited fully. The River alteration changes are estimated to cost local herders USD 13 million per year, due to livestock mortality and price changes (Thais, *et al.*, 2017). The total number of people affected by the Isiolo dam-related drought and around the Lorian Swamp is close to 20,000 (Thais, *et al.*, 2017).

The communities living downstream will be severely affected; their livelihood will be disrupted

including farming, firewood, grazing lands and other forest products. The impact will also result in the displacement of the downstream population and in the case of Isiolo County, according to Thais, *et al., 2017*, it will trigger migration upstream and ignite long-standing conflicts.

Over 80% of the County population depends on livestock, which is the main economic giant of the pastoralists (CIDP, 2015). The major challenges have been livestock diseases and poor marketing system. The major threat is the frequent droughts causing major movements in search of pasture and water (CAS, 2017). The livestock depends on seasonal Ewaso Nyiro River, which flows from April to December with a dry period from June to August (Leeuw, *et al.*, 2012). The upstream large-scale flower farms and effect of climate change has affected the flow over recent decades (Leeuw, *et al.,* 2012). The flow of the River will severely be affected by the mega Isiolo dam. It will have a severe long-term impact on water reaching downstream and in particular, the Lorian swamp. The pastoralists livelihood will be affected, which trigger migration upward and create water conflict (Thais, *et al.*, 2017). The Merti aquifer will also be affected severely by dwindling underground water in the long run. The current study and assessment on Isiolo dam have underestimated the severity of the impacts both on human and ecosystems (Thais, *et al.*, 2017).

The influence of water resources user patterns remains a literature gap that needs to be documented on how it can impact river basin ecosystems since documentation of the same is scanty. The study seeks to add knowledge of the influence of water resources use patterns on the Lorian swamp from the Ewaso Nyiro river basin activities and the role of governance in enhancing the sustainable use of the river basin ecosystems.

2.10 Theoretical Framework

The research is based on sustainability theory by Donella Meadows 1972, Donella emphasized that the only way to alter the structure of system to get human needs and that needs must be sustainable and get less something which is not desirable (unsustainable). Donella was a known environmental scientist and writer and as the best author of the famous book "The Limits to Growth, 1972". She emphasizes that the politicians and Policy Makers tend to focus on the least effective leverage point like the economic problem rather that the environmental pillar which is driving force of other sustainability pillars. Environment plays critical roles in supporting other pillars that provide social justice and economic prosperity.

Cultural pillar is a new aspect of sustainability and in Kenya, the same is reflected in our constitution and policies. Vision 2030 strategies for Northern Kenya recognized the unique difference of the North from the rest in terms of its ecology, livelihood, culture, and aspiration, which must be valued and respected (GoK, 2012). The proponents of Isiolo dam focused on the economic pillar, which targets the high-end business of the Resort City in disregard to the critical ecosystem of the Lorian swamp and its social-economic impacts to the pastoralists. Based on this theory, the construction of the proposed Isiolo mega dam satisfies the unsustainable wants which has significant impacts on the ecosystems and the environment in totality.

The sustainable use of basin resources and the proposed dam on the Lorian swamp ecosystems requires the inclusion of the traditional systems of governance so as to enhance the structures in place to safeguard the ecosystem.

The sustainability theory supports the local community resistance to the construction of the proposed dam in that the political systems focused mainly on the economic development with little to the core of the theory which is the environment. Significantly, the environment, more

specifically the ecosystem provides the appropriate environment for forage for pasture and therefore a destruction of this will disrupt livelihoods of the pastoralists and increase more conflict over limited resources.

The theory explicates the delicate nexus between human activities and wildlife which when disrupted results in human-wildlife conflicts adding to the inter- communal conflicts due to insufficient pastures and water availability.

2.11 Conceptual Framework

The conceptual framework outlines how water resources use patterns affect the livelihoods of the community without proper governance and community participation, sustainable use of the water resource breeds conflict and misuse. When the water use patterns are structured as supported by the sustainability theory then sustainable use of the ecosystems is attainable as illustrated in Figure 2.1. The unbalanced use of water in the upper catchments will reduce water levels flowing downstream of the Ewaso Nyiro River and affecting the Lorian ecosystem services such as water and pasture use for livestock which is the lifeline for the pastoralists in the North of the country. Understanding the nexus of the interdependence of the sustainable water use will balanced the ecosystem for the benefits of all reducing over exploitation by one party over the other. Community involvements is critical for mutual understanding and sustainable use of the ecosystem for the benefits of all.

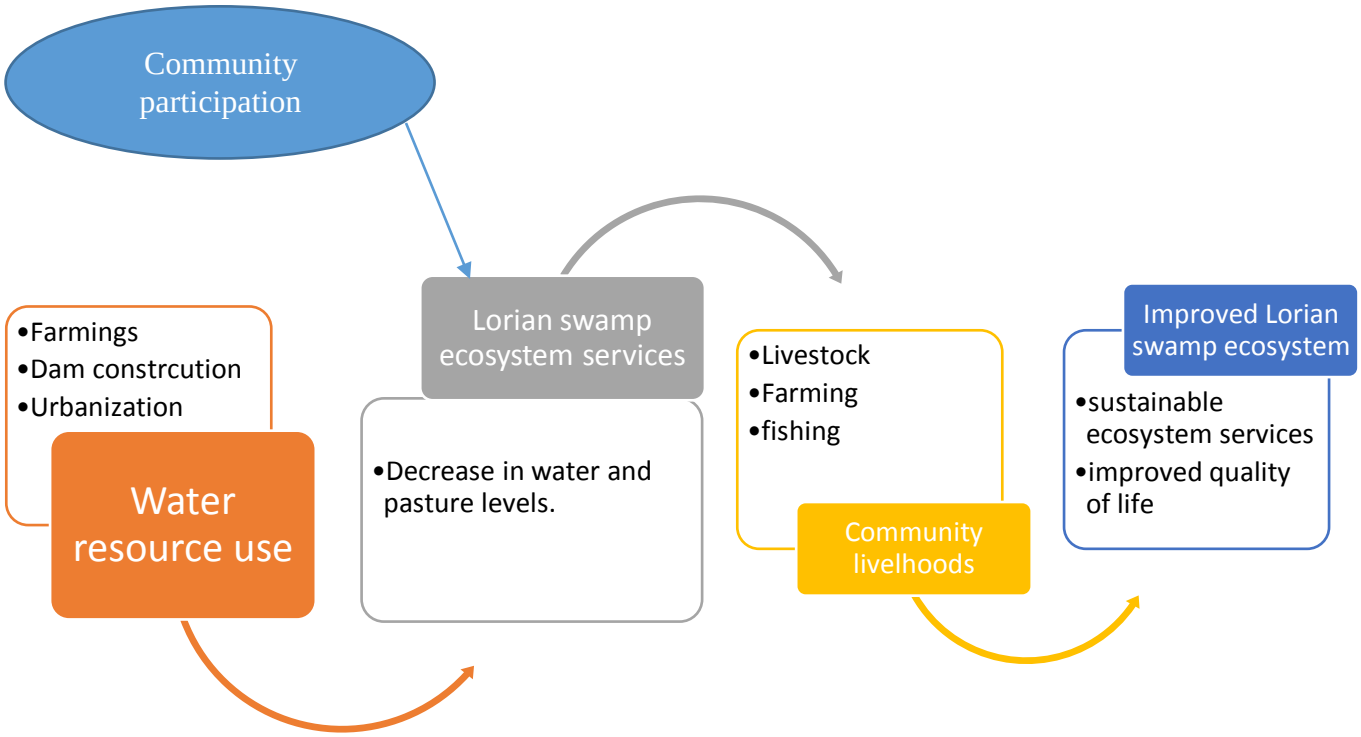

Figure 2.1: Conceptual Framework

Source; Authors modification based on the theoretical theory

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Study Area

The study area is situated at the downstream of the Ewaso Nyiro River (Figure 3.1), and is locally known as the Wasso Boran. The area is characterized by low lying rangeland, bushes and shrubs and in some areas characterized by plains with pasture. The area is 300 m above the sea level and 200m at the end of the Lorian swamp in Habaswein (CAS, Consulting ltd, 20116). The area is hot and dry in most part of the year with annual rainfall of 150-250mm. The landmark feature is the Ewaso Nyiro River, which terminate into Lorian swamp. The Lorian swamp regenerates pasture for the livestock (CIDP 2015). The land is 80% communally owned and mostly rangeland used to support the livestock economy with a population of cattle (53,244), Goats (586,119), Sheep (531,355) and Camels (45,000) (CIDP, 2015). The projected population in 2017 was 84,000 (Census, 2009), and 95% practiced pure pastoralism.

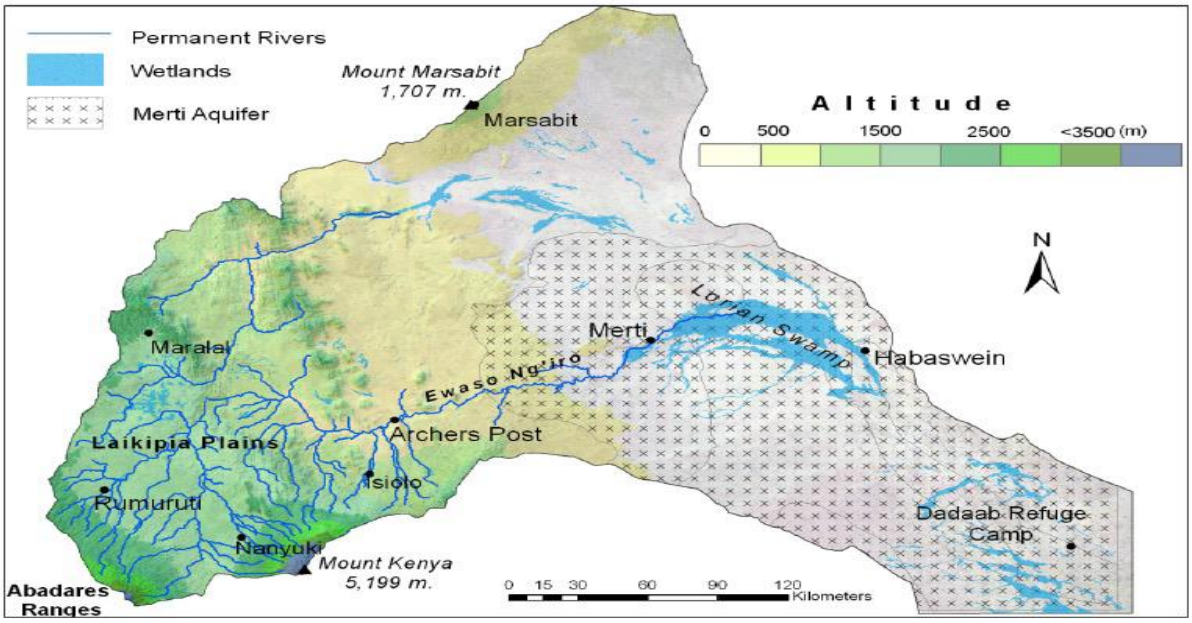

Figure 3.1: Ewaso Nyiro basin (Source: Lee., 2012)

3.2 Physical and Topographic Features

Most of the land in the Isiolo County is low and flat rangeland. The land rise from an altitude of 1100 meters at Isiolo town above sea level to 300 meters at Merti and subsequently goes low at 200 meters at Habeswein. (CIDP, 2015). There are six perennial rivers that breed life in Isiolo; Ewaso Nyiro North, Bisan-gurach and Bisanadi in Kina, Likiundu and Liliaba in Shaba area. Ewaso Nyiro North River originate from the slope of Mount Kenya and in the Aberdare ranges. It cut as a boundary between Isiolo South and Isiolo North constituencies. Isiolo River is an important river that originates from Mount Kenya, supporting many small-scale irrigations before it drains into the Ewaso Nyiro River at the Archers point (Leeuw, *et al*, 2012). Bisan-gurach and Bisanadi Rivers are found in Kina, supporting livelihoods mainly farming and livestock and it end into the Tana river. Likiundu and Liliaba stretch from Nyambene hills and drains into Ewaso Nyiro River. The county has a metamorphic rocks and other multiple and precious rock deposits. Tertiary rocks are found in the parts of the county. The areas are covered with tertiary sediments and with high potential for ground water including the Merti Aquifer (CIDP, 2015).

3.3 Ecological Conditions

The county is divided into two ecological zones namely arid and semi-arid. The semi-arid zone has medium potential to support pastoral and agro-pastoral livelihoods with mostly sedentary lifestyle. These areas include Kina and Isiolo town (Leeuw, *et al.*, 2012). The county receives rainfall that ranges between 400 – 800 mm annually. The Arid zone covers, the largest part of the county and it includes Cherab ward, Chari ward, Sericho ward, Garbatulla ward, OLdonyiro ward and part of Burat ward (Leeuw, *et al.*, 2012).

3.4 Climatic Conditions

The county is hot and dry in most parts of the in the year with two rainy seasons. The short rain season start from October to December with the high peak in November while the long rain starts from February to April. The topographic nature of the landscape determines the amount of rainfall received in particular area or zones (Leeuw, *et al.*, 2012). The higher altitude areas near Mount Kenya and Nyambene Hills receive between 500-800mm of rainfall per year (Isiolo town and Kina area). The drier eastern and northern part of the county receive less than 300mm. Different altitudes influences the temperature in a particular zone creating different variations. The mean annual temperature in the county is 30 degrees centigrade (Leeuw, *et al.*, 2012). The county receives more sunshine almost 9-10 hours per day and it has huge potential for harvesting solar energy. Monsoon winds blow from the Indian ocean and sweep across the county except for the month of January and February. The strong winds are an asset for potential wind energy (CIDP, 2015)

3.5 Population Size

According to the 2009 Population and Housing Census, Isiolo County registered a population of 143.29 thousand. The average growth rate between 1999 and 2009 catapulted to 3.7% although with the demographic dynamics such as increasing adoption of fertility rates, in-migration, family planning measures, mortality and morbidity rates, life expectancy etc, the growth rate is expected to be different (CIDP, 2015). The total population is expected to increase the current KNBS projections of 165 thousand by far in 2022. This is as due to the focus given to Isiolo as the hub and strategic point for LAPSSET, the Resort City and the regional international airport. The total population of Isiolo County is therefore expected to be about 280 thousand (CIDP, 2015).

The population of Isiolo are mostly the Oromo-speakers (Borana and Sakuye) and the Turkana, Meru, Somali Samburu, and other immigrant communities from other parts of the country. The LAPSSET projects such as the airport, resort city and oil refineries are expected to increase the population in the new future (Leeuw, *et al.*, 2012).

3.6 Environment and Climate Change

The county is dry in most part of the year hence the vegetation cover is minimal and scattered across the vast rangeland(CIDP, 2015). Environmental degradation such as charcoal burning and sand harvesting are common practices around Isiolo town due to urban poor population. There are overgrazing in other part of the rangeland due to influx from the neighbouring counties. Soil erosion is common in Oldonyiro with deep gullies reducing the rangeland size. Runoff water are the main causes of soil erosion, degrading the rangeland (CIDP, 2015). Environmental degradation has led to increased environmentally induced diseases such as respiratory diseases, eye problems and kalaazar. During the dry season, there are strong wind that sweep across the counties with increased human diseases like cold, air and water related diseases (CIDP, 2015). Agricultural and livestock productivity have been greatly affected due to unpredictable rainfall and has made investment in these field difficult (Leeuw, *et al.*, 2012).

Isiolo is among the vulnerable counties affected by the vagaries of the climate change. Some of the key vulnerabilities includes frequent conflict over water and pasture, huge influx from the neighbouring counties, drought and reduced rainfall. Decrease in water discharge level in Ewasonyiro river, Bisaan Adhi, Isiolo and Lewa river. There are serious scarcity of portable water in Isiolo and other satellite towns (CIDP, 2015). Loss of watershed and catchment areas will reduce related ecosystem services endangering the life that depend on. If not mitigated

climate change will affect production trigger climate migration, loss of livelihoods especially for pastoralists and increased communal conflicts over shrinking resources (CIDP, 2015).

3.7 Target Population and Sampling Size

The population of the study consisted of catchment community who are residents of Merti Sub County. The catchment community formed the target population of 500 households (KNBS, 2009).

Table 3.1: Target Population and Sampling Size

Location	No of households (projected 2009 census)
Merti	4500
Mulandanur	1000
Mata arba	2500
Saleti	2000
TOTAL	10000

The projected current population under study are 10,000 based on the last census 2009. Since this population size is huge, the researcher employed Mugenda and Mugenda's (2008) recommendation of selecting a sample size of 1-10% from a target population of 10000 and more. Therefore, the sample size for this study was 1% of the target population which came to 100.

i.e. 1/100 * 10,000 = 100

therefore n = 100

The research targeted four location, namely Merti, Mulandnur, Matarba and Saleti. The households are sparsely populated and divided by major road in the four locations. The researcher used transcend walk to administer the questionnaires to the responded through systematic random sampling. The use of the methods demonstrated unbiased representation. Each household regardless of the gender and age has an equal chance of selection. The researcher targeted households head and incase where the household head was not available, the researcher chooses the next household but after skipping two house the third household is automatically selected.

In focus group discussion and key informants, the researcher used purposive sampling method, in selecting the key elders to provide insights into the research due to their expertise and knowledge of the natural resources around their region.

3.8 Research Design

The research adopted a descriptive research design which takes in to account populations and correlates the study using both in qualitative and quantitative data. Both qualitative and quantitative forms of data was put into consideration so that the data collected would support the objectives of the study (Creswell and Plano-Clark, 2007). Primary data collection methods entail the use of questionnaires, interview schedules and observation. Secondary data was collected from both electronic and non-electronic repositories. The design was the most relevant approach of collecting and analyzing data and reporting the results in the attitude and knowledge towards the effect of water user pattern on the Lorian swamp ecosystem. The design method is also flexible in allowing new discoveries and exploration as research develops. The study further saw this design as appropriate for providing clear understanding of the issues being studied.

3.9 Research Data Collection

The researcher adopted multi modal approach in collecting the data.

3.9.1 Research Tools

Data collection included oral interviews to the respondents, where direct questions were asked to the respondents. Open ended questionnaires were also used; a set of questions were written and submitted to the sampled population for response. Focus group discussion was employed to get more indebt knowledge of the subject matter under study

3.9.2 Questionnaires

Questionnaires with open and closed-ended questions was used to elicit responses from the targeted households, herders and pastoralists. The questionnaires were designed to capture information on the demographic information (ages, gender and time lived within the studied area), ecosystems services received from the Lorian swamps, observed environmental changes to the Lorian swamp over the years and pasture and water availability.

The questionnaires were administered to the respondents through random sampling method in the four targeted locations of Merti, Mulandnur, Malkagala and Saleti. The researcher soughted assistance of 10 enumerators to interview the respondents across the four sub-locations. The first day, the enumerators were inducted through the questionnaires, and pretested to allow clarity of questions to the respondents. Each enumerator was given 30 minutes to interview three households. Later validation were done to remove any challenges encountered and corrections made to ensure reliability of the tool

Plate 3.1: Researcher guiding the Data Collectors and on right side respondent interviewed

3.9.3 Key Informant Interviews

The purpose of key informant interviews was to collect information from a wide range of people who have significant firsthand knowledge and understanding on the natural resources and can provide insight on the nature of problems and give recommendations for solutions. The key informants targeted the heads of institution in water sectors, civil societies dealing with water and advocacy, community elders conversant with the Lorian swamp and the Ewaso Nyiro River, Deedha Council of elders managing the rangeland, Isiolo Water Service Board, Ewaso Nyiro North Development Authority and local administrators.

3.9.4 Focused Group Discussions

Focused group discussions were used to generate relevant information on collective views and was very useful towards generating understanding of the participants' knowledge, experience and beliefs. The targeted members are six elders, two of them community leaders. The body of knowledge on environment are culturally vested on the Elders in Boran tradition. The Boran have defined social roles for each gender.

The choice of Elders was deliberate and purposive in order to gather the data needed for the research. The tools used include a recorder, checklist and a notebook to document the discussions. Qualitative data on water resource use, water and pasture availability was recorded, changes in the Lorian Swamp ecosystem over the years and the likely impacts on their livelihoods captured from the Boran elders. The data captured by the recorder was encoded then analyzed to give results as per the guidance script for the information encoded using the software for analysis.

Plate 3.2: Focus group discussion

3.9.5 Secondary Data

Secondary data on recorded river data flow were gathered from Centre for Training and Integrated in ASAL Development (CETRAD). The data records dated back to 1945 when the then Colonial Government established semi-automatic water level data loggers at the mid of Ewaso Nyiro River at Archest post to record water discharge by cubic meter per second. The data provided was raw showing daily records for each day from 1960 to 2011. Other relevant journals were also used to gather the data to enrich the research.

3.10 Data Analysis

3.10.1 Descriptive Statistics

Descriptive statistics were used to analyze the characteristics of the population studied by the researcher. 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. Data was presented using graphs, tables, percentages, pie charts and averages.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter presents the results, demographics information of the studied population and discussions of the findings. The discussion explored the influence of water resource use patterns on the Lorian swamp and zoomed into specific ecosystem services (water and pasture) availability to the pastoralists living along the swamp areas. The chapter also gives evidence-based result to validate the research questions and objectives.

4.2 Response Rate

The research was conducted on a sample of 100 respondents, all respondents are residents of the four sub-locations situated along Lorian swamps. The researcher employed the assistance of 10 enumerators with each 10 questioners and all 100 questionnaires were returned dully filled, coupled with researchers focus group discussion with six elders. The data collected are sufficient for statistical reporting. Based on the rate, the research commenced the process of data analysis. The following sections present findings as arranged on the research instruments.

4.3 Demographics

4.3.1 Gender of the Respondents

The researcher used systematic random sampling to collect the data from the sample population. The sample analysis showed that the gender composition of the respondents was 66% for men and 44% for women which is slightly skewed to male domination. This means that women views were not left behind and the data collected was unbiased representing the structural way the community exists.

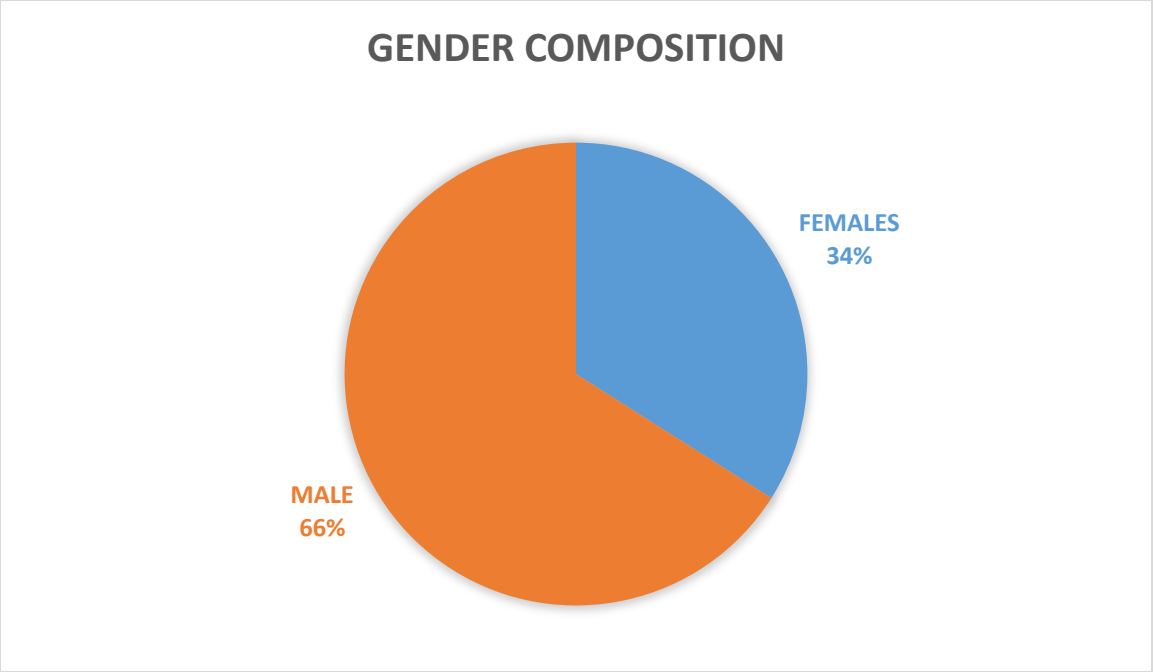

Figure 4.1: Gender of the Respondents

4.3.2 Years lived by the Respondents in the Study Area

The data indicates that 71% of respondents have lived for over 21 years in the Ewaso Nyiro Ecosystem. This indicates that they have lived in the area long enough to observe the changes that have occurred in the ecosystem in time and space and can appropriately underscore the influence of water resource use patterns on the Lorian swamp. The respondents have the knowledge and experiences on the Lorian Swamp and their adaptations to the changes over the years added valuable inputs into the data collected.

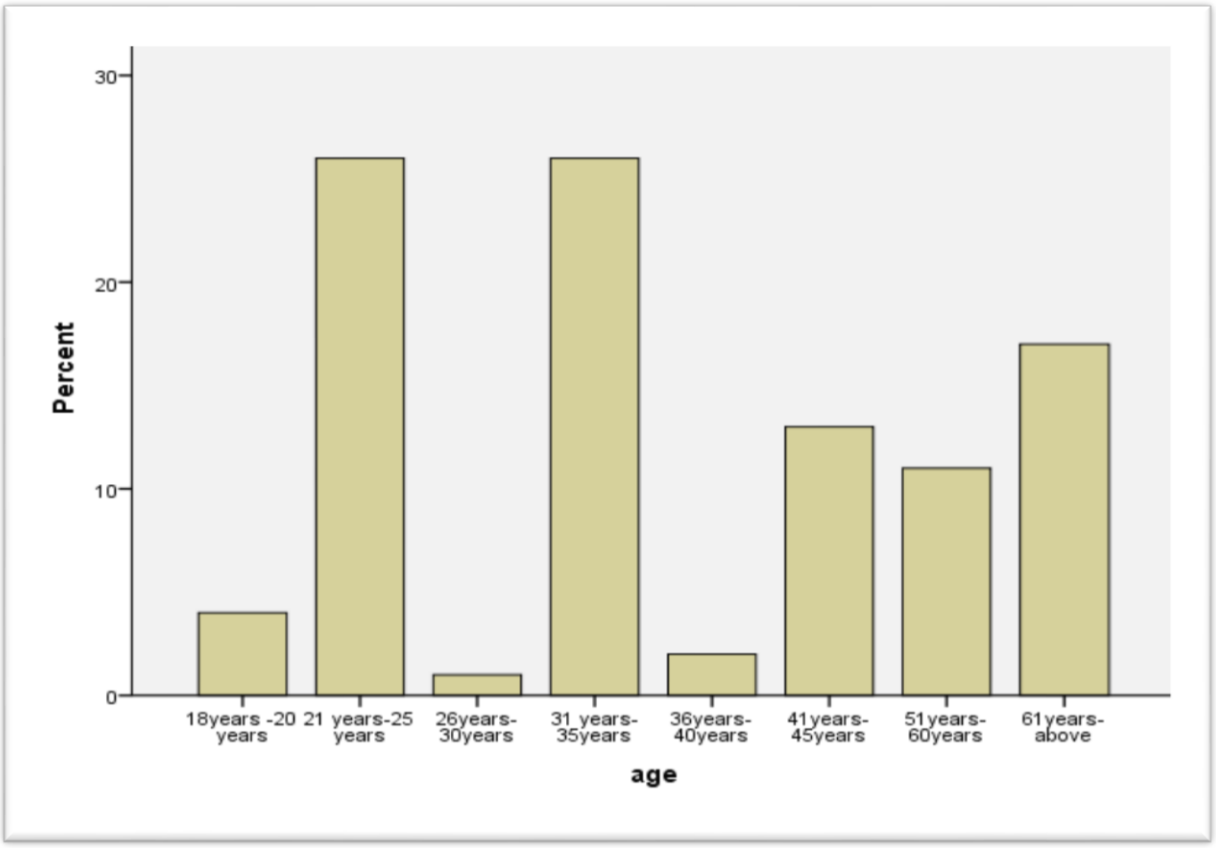

Figure 4.2: Years Lived in the Study Area

4.4 Assessment of the Trends of Water levels in Ewaso Nyiro River

The trend of water use pattern affecting water levels in Ewaso Nyiro River are clearly demonstrated by the secondary quantitative data collected at Archest post by Centre for Training and Integrated Research (CETRAD) from 1960 to 2011 using semi-automatic water level data loggers. The data indicates that from 1960-1969, the cumulative water discharge per cubic meter was 964 million cubic meters and from 2001-2010 it was 572 million cubic meters showing a major decline in water discharge with a difference of 392 million cubic meters translating to 40% reduction over four decades as shown by table 4.1, figure 4.3 and figure 4.4. This data supports the first of objective of the study in assessing the impact of the water use patterns on the water levels on the Ewaso Nyiro River.

Table 4.1: Average Annual Water Flow in Ewaso Nyiro River

Period 1960-1969	**Annual water discharge measured in million cubic meters**	**Period 2001-2010**	**Annual water discharge measured in million cubic meters**
1960	326.50	2001	54.01
1961	2,532.98	2002	619.52
1962	720.48	2003	802.79
1963	934.40	2004	731.93
1963	1,015.82	2005	263.83
1965	387.51	2006	887.05
1966	652.80	2007	693.72
1967	989.58	2008	363.85
1968	1,618.53	2009	146.51
1969	465.90	2010	1162.16
Cumulative total	9,644.50		5,725.37
Annual average	**964**		**572**
Water loss in 40 years in million cubic meters			**392**

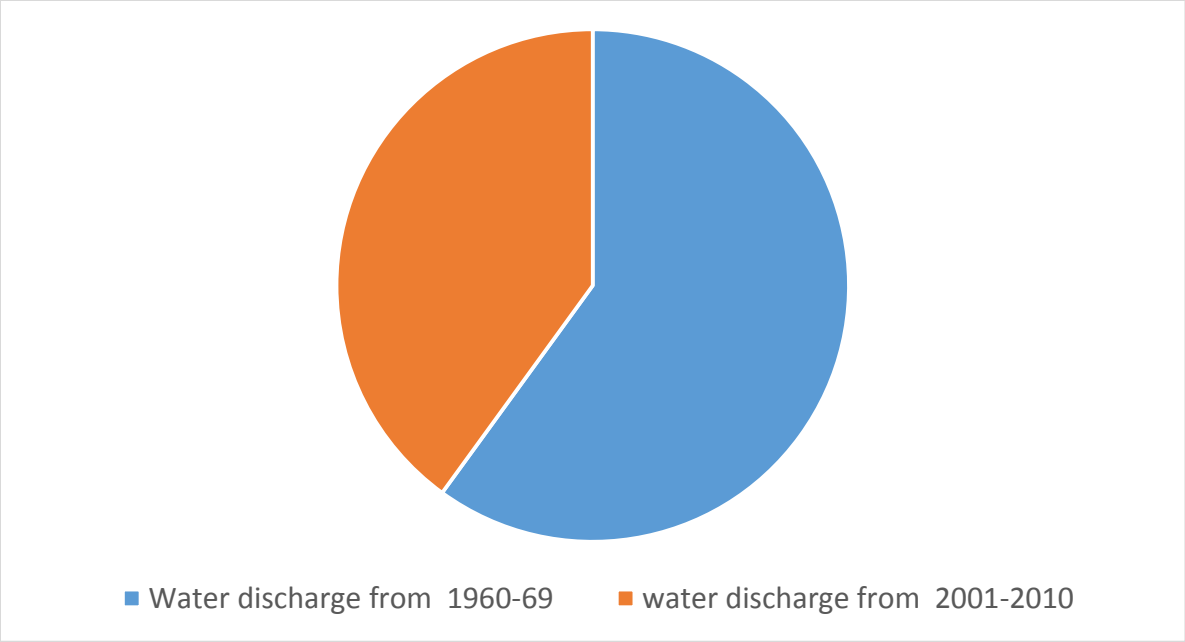

Figure 4.3: Percentage Comparison of Decline in Water Discharge over the Years

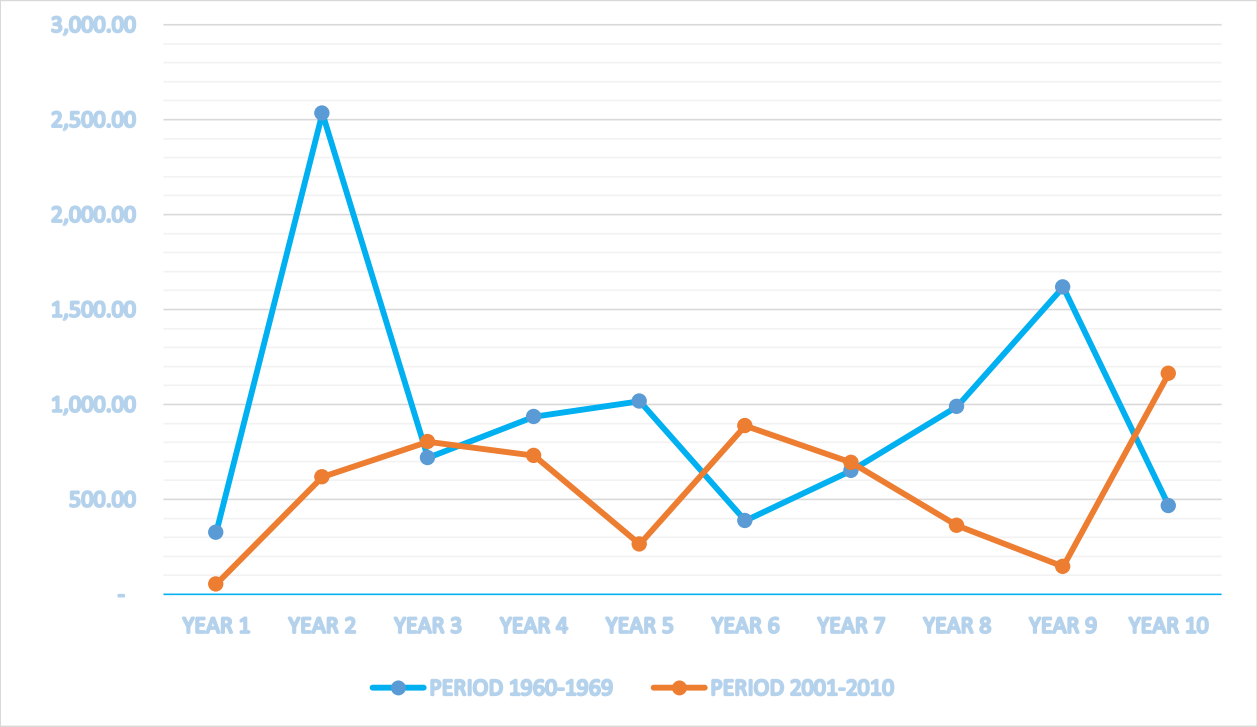

Figure 4.4: Water Trends Comparison from 1960-1969 versus 2001-2010

The trend analysis in the above time series plot show major decline in water level discharge in comparison with the last forty years. This is an indicator of multi-dimensional factors such as increased in water use pattern in upstream of the Ewaso Nyiro River, population pressure, climate change and urbanization that increased demand for more water usage. The water declined by 40% as shown by table 4.1 and figure 4.4 which further supports the third objective of the study in underpinning the need for more comprehensive sustainable plan of use of the Ewaso Nyiro river.

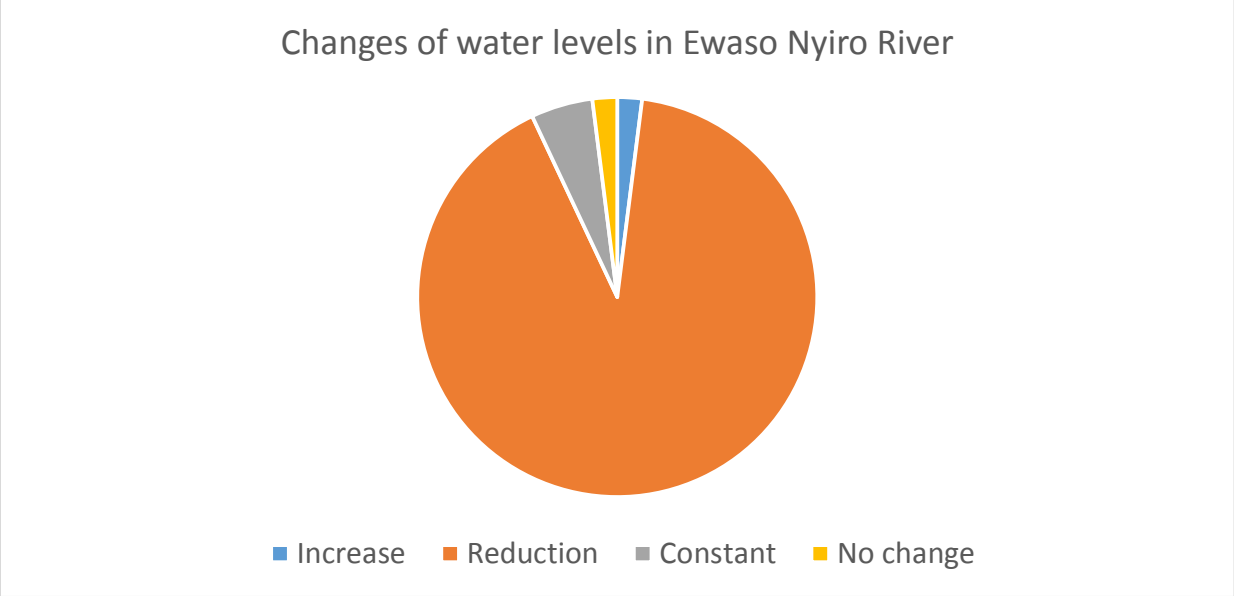

Figure 4.5: Changes of Water levels in Ewaso Nyiro River over the Years.

The researcher triangulated the secondary with the data collected from the respondents. 91% of the respondents stated that there has been reduction in the water levels in the Ewaso Nyiro River with a minority 2% citing increased and no change respectively with the remaining 5% suggesting constant water levels (figure 4.5). This data further agrees with previous authors who have highlighted the need for a comprehensive review on the construction of the proposed dam on Ewaso Nyiro river and the economic ventures targeted.

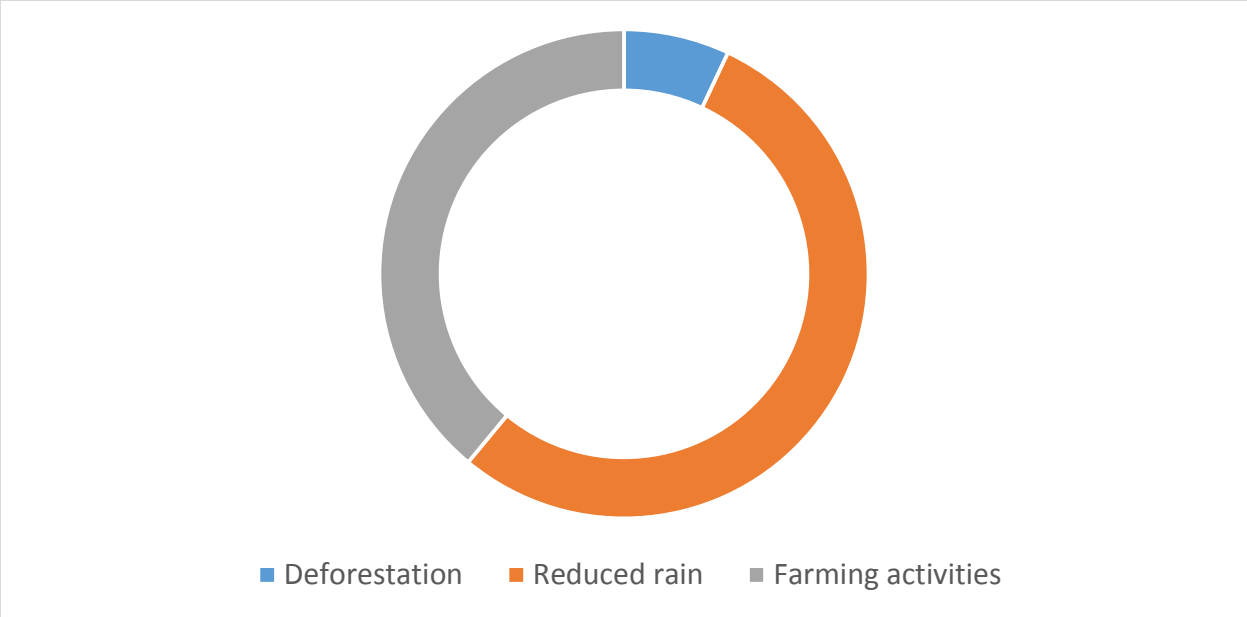

Figure 4.6: Cross Tabulation of Changes and Causes of Water levels in Ewaso Nyiro River over years

In focus group discussion, the elders opined that the water levels have reduced in volumes over the years. Sometimes the water levels are determined by the amount of rain per season which has been affected by the effects of climate changes. They confirmed that during the past period, water increased mostly in July (*Sodom bules),* they said, that from 1977, the water levels reduced significantly due to upstream water use for farming. 50 years ago, the river used to dry only for three months (*Bon agaya*) with steady flow during the remaining months as evidenced by time series plot figure 4.4, which shows that in 1960-1963, it recorded the highest water discharge in the river. The situations have changed over the years due to upstream use, reductions in rainfall and climate change. The elders concluded that the volume of water have reduced over the years, except during heavy rains.

4.5 Pasture and Water Availability in the Lorian Swamp Ecosystem

The Researcher interviewed six elders who are well conversant with the pastoral livelihood and tabulated the annual water and pasture availability on the Lorian swamp. During normal season water and pasture are available throughout the year as shown on Figure 4.8. During the dry period which last for five months, the pasture is significantly reduced and water can be accessed through shallow wells. The failure of two rainy seasons results into drought period which has a huge impact on the community livelihoods.

The elders stated that during old days, the pasture and water in the swamp were regulated through elaborate grazing pattern. Elders had control over grazing zone and at what particular periods based on the yearly timeline as in Figure 4.7. The traditional grazing rules are adhered to entirely and mechanism for sanction are implemented without fear or favor which dispels the conflicts that may arise from inadequate pasture and water availability. Livestock are separated according to the strength, lactation and weaknesses. The strong livestock are taken to far pasture zones while the lactating and weaker livestock are left near settlement for maximum utilization of the rangeland resources. As a result of this circle of well managed grazing pattern, pasture and water were available throughout the year. If these rules are adhered to, no livestock would die due to inadequate water and pasture availability.

A significant point is that water and pasture availability depend on the amount of rain which increases or reduced the volume of water in the river as well as affects the underground water too.

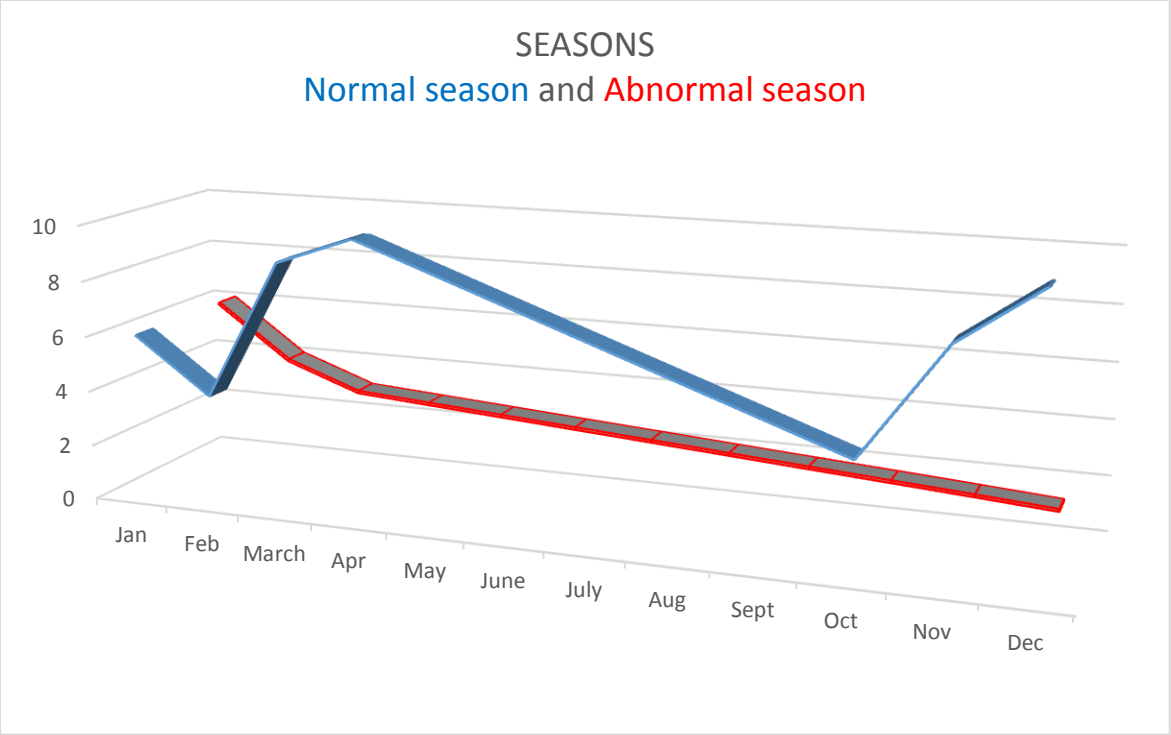

Figure 4.7: Pasture and Water Availability in the Lorian Swamp During Normal and Abnormal Season

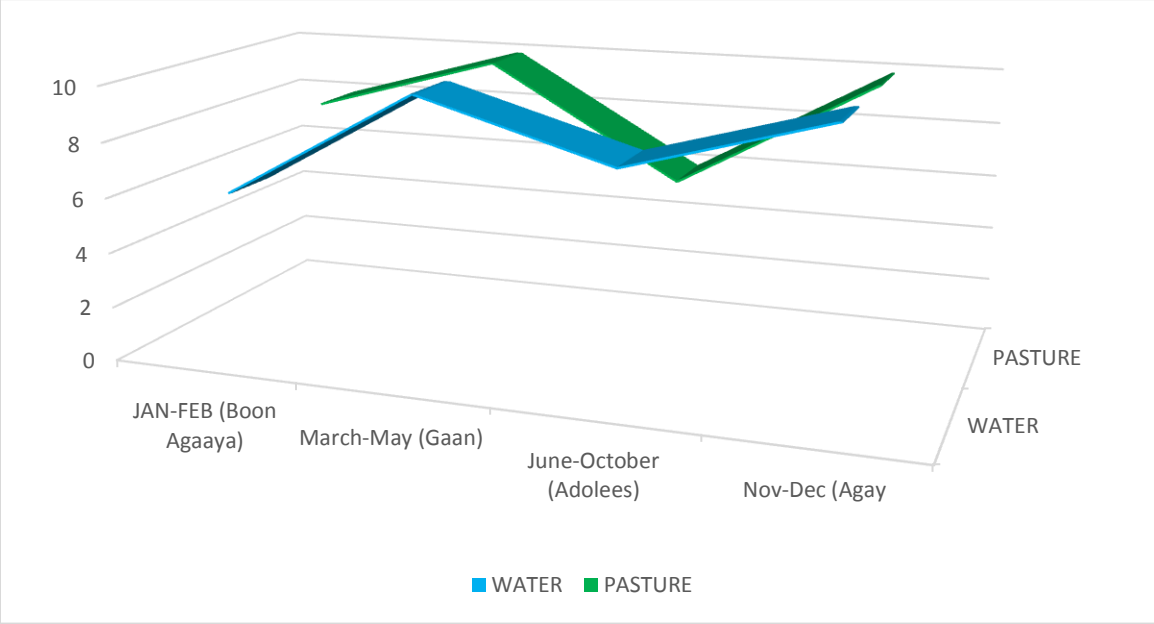

Figure 4.8: Water and Pasture Availability during Normal Period

The Boran community divides the year into four seasons, (***Bon Agaaya)*** January and February which is the hottest period of the season. The River dries up during this period but usually the pasture and lagoons water are available if the preceding rainy season was normal. Mutiga et al 20122 reported that the level of abstractions for irrigation and other uses in the upper reaches of the catchment was such that in February, no water reached the confluence of the rivers. The month of March and May are long rainy season ***(Gaan)***, this rainy season is critical as it connect to the long dry spell of June and October ***(Adolees)***. The community refers the period as when the calf of an Impala matures its horn and that define the longest dry spell. At this period, both the pasture and water get depleted but pasture are more threatened as water can be found underground. The period from November and December (Aggay) is the short rainy period but according to the discourse narrative from the elders, the amount of rain depends with season where the short rainy season become long and vice versa.

The data in figure 4.9; illustrates that a majority of the respondents at 63% support that there is adequate water and pasture when there is no interference with the Ewaso Nyiro river as opposed to 37% of them who disagreed.

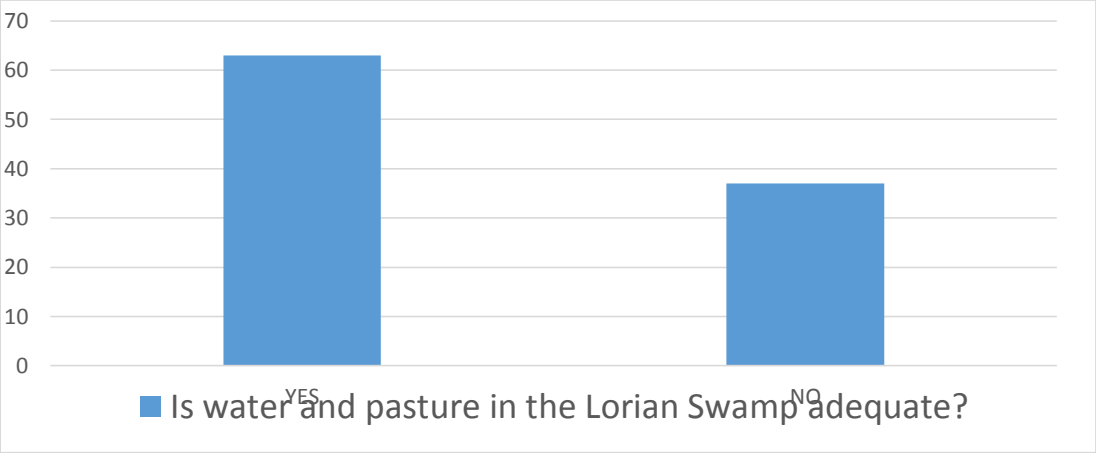

Figure 4.9: Water and Pasture Adequacy in the Lorian Swamp

The question as to whether the water and pasture are available indicates more respondents confirming adequacy of the same, considering all other external factors remained constant. The data from the FGD and the respondents supports specific objective two that examine the availability of water and pasture in the Lorian Swamp Ecosystem.

4.5.1 Observed Changes on the Lorian Swamp over the last 20 Years and More?

The focus group discussion highlighted a number of changes that have taken place in the Lorian swamp which they highlighted the invasion of the invasive species called *Mathenge (**Prosopis Juliflora***). It was introduced by the development partner (ActionAid) to eradicate desertification but now has taken over the swamp, replacing all indigenous trees and pasture, reducing water levels significantly and blocking water flow leading to flooding to the settlements. *Mella*, the very palatable pasture for the livestock are mostly threatened by the aggressive invasive species. The bushy terrain attracts wild animals increasing wildlife and human conflicts as they search for pasture as well.

Plate 4.1: The Photo showing Palatable Pasture and Invasion of *Prosopis Juliflora*

4.6 The Possible Effects of the Proposed Isiolo Dam on the Water levels of the Ewaso Nyiro River

The data in Figure 4.9, shows that majority of the respondents at 79% have heard of the proposed dam construction unlike the 21% who were not aware of the proposed dam construction. The FGD data also confirmed that a majority of the respondents were aware of the proposed Isiolo dam construction.

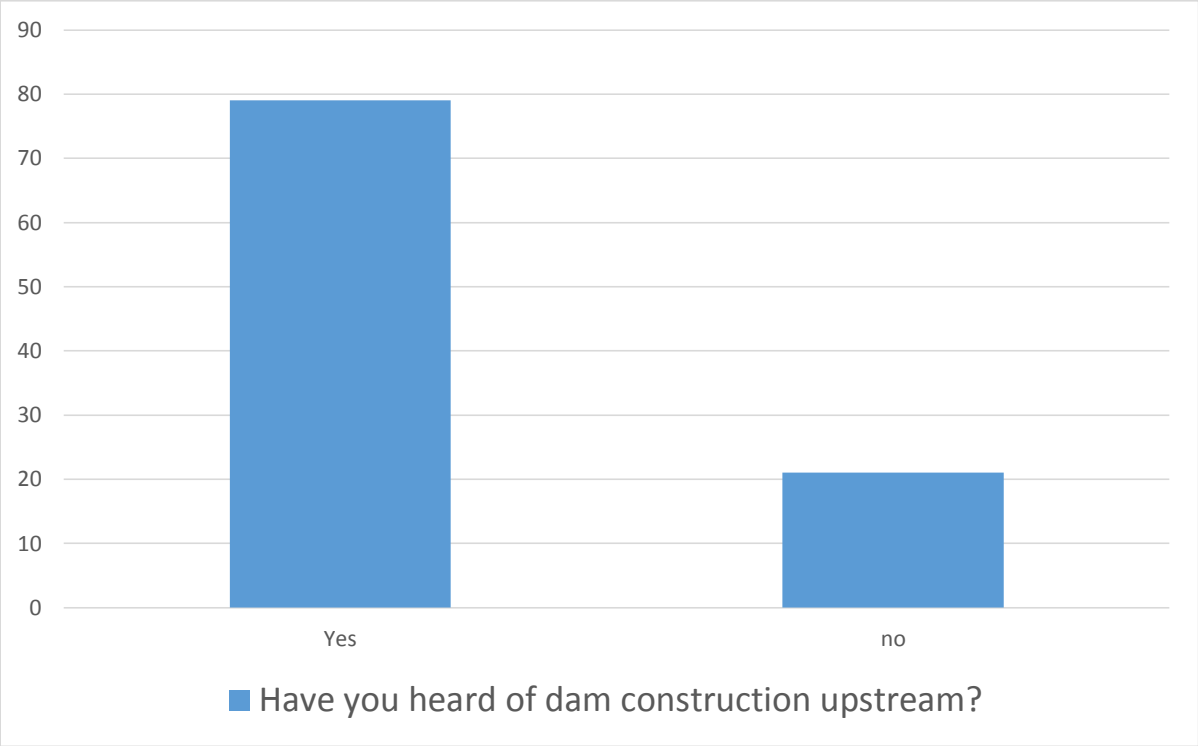

Figure 4.10: Level of Awareness on the Proposed Dam Construction

Majority of the respondents agreed that the construction of the proposed dam will have impact on the Lorian Swamp Ecosystem with a majority pointing out that it will decrease water levels that will ultimately affect pasture and water availability. They also indicated that any obstruction will lead to protracted conflict over water resources and pastures for their livestock.

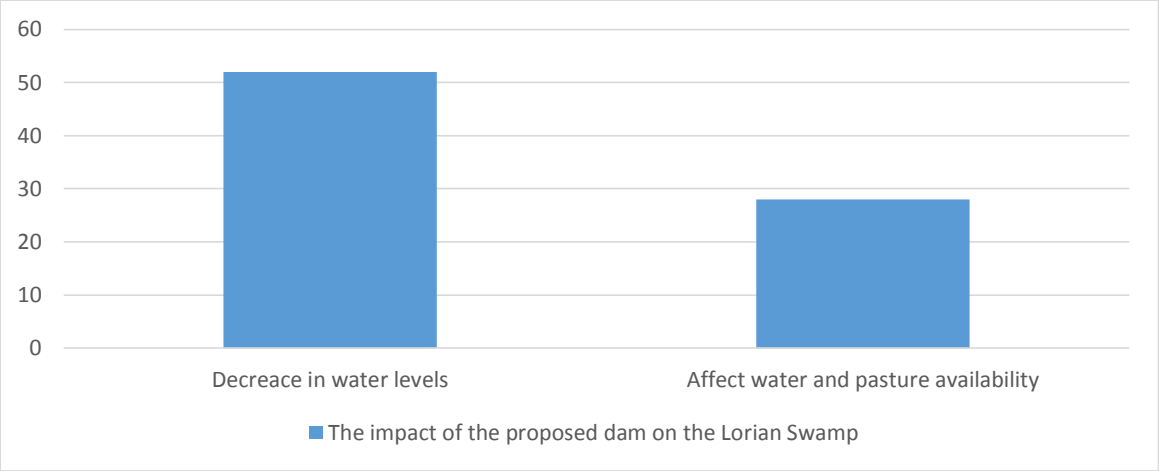

Figure 4.11: The Impact of the Proposed Dam on the Lorian Swamp

According to the EIA report by the CAS Consultants limited, the storage volume of the proposed dam is 214 million cubic meters. The available data triangulated from CETRAD to establish the impacts of the dam on the water discharge of Ewaso Nyiro River does not support the construction of the proposed Isiolo mega dam.

Plate 4.2: Ewaso Nyiro river at the entry point of the Lorian swamp in the morning of April 2018

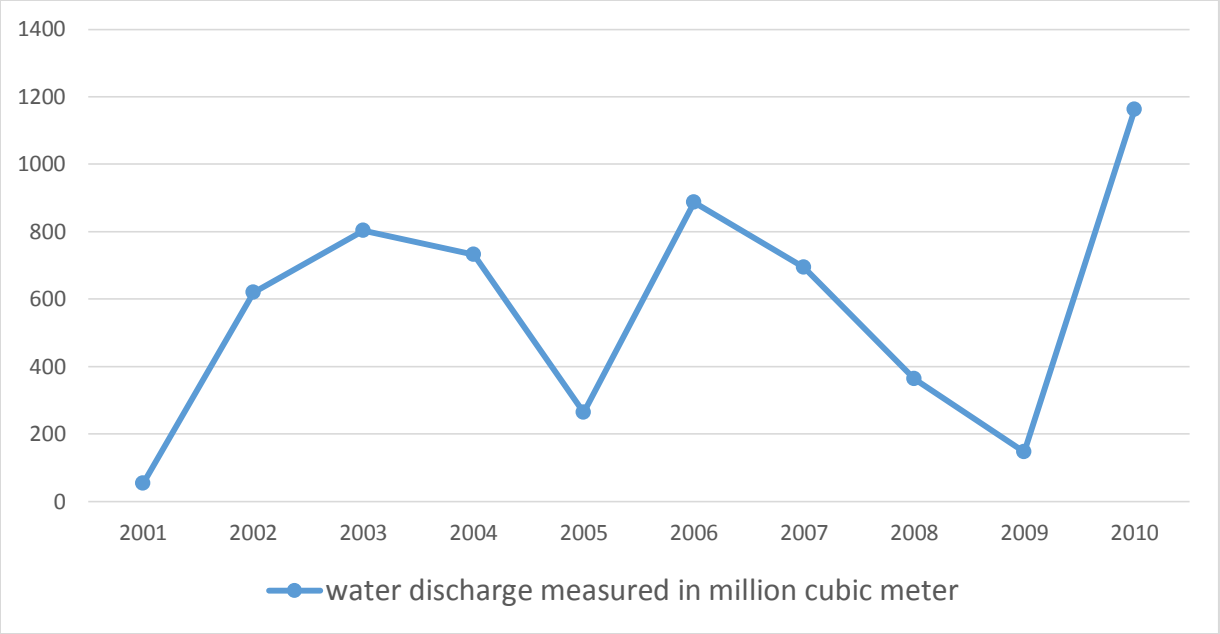

Figure 4.12: Water Discharge Measured in Million Cubic Meters

The proposed mega dam will have a storage volume of 214 million cubic meters against an annual average water discharge flow of 572 million cubic meters. That translate into 37% of the available unregulated river flow river flow.

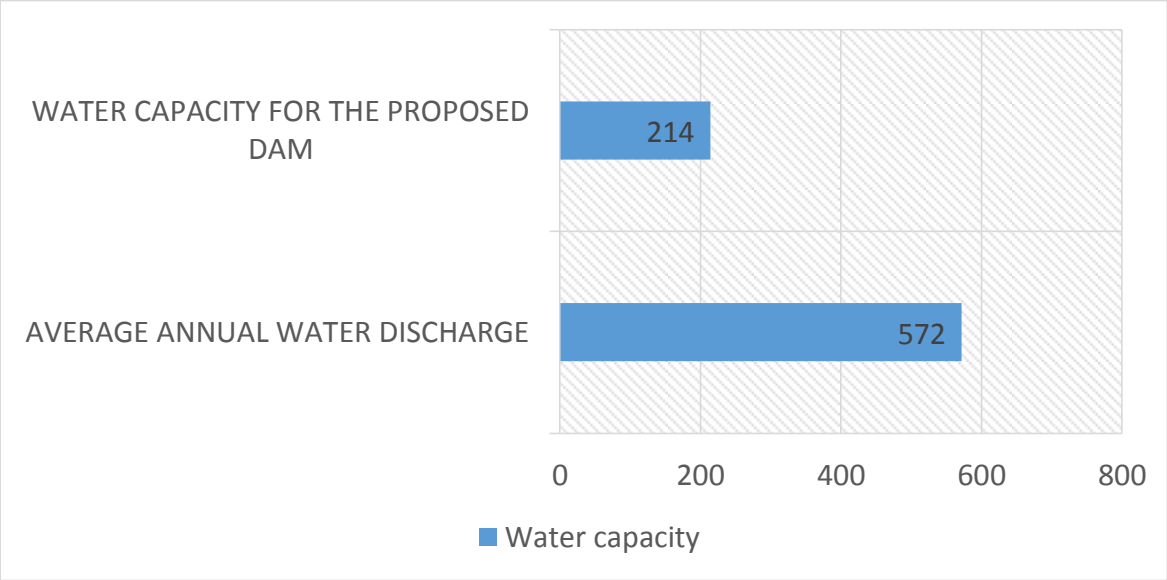

Figure 4.13: Water Capacity in the River and Proposed Isiolo Dam

4.6.1 Effects of the Reduced Water Discharge to the Lorian Swamp

The more recent Afri-cover 2000 map represents the swamp as a slightly larger area of 2918 kilometer square. At reduced water discharge by 40% on the current flow, the Lorian Swamp will shrink to 1838-kilometer square. It means that pastoralists will be at loss due to shrinking of forage production, water, including the underground water, loss of indigenous trees and increased conflict over limited resources. According CAS 2016, the dam will be anticipated to harvest the flood water during the rainy season and that will ensure the flow of water throughout the year to be used for domestic, livestock and wild animals. The research finding is that the volume of water to be stored by the dam is huge and will automatically affect the length and breadth of the Lorian swamp. The swamp survival is through flood water and the proposed dam will also compete for the same flood. The assured and continuous flow has no capability to flood the longest swamp in the Country.

Plate 4.3: Part of the Lorian Swamp Ecosystem

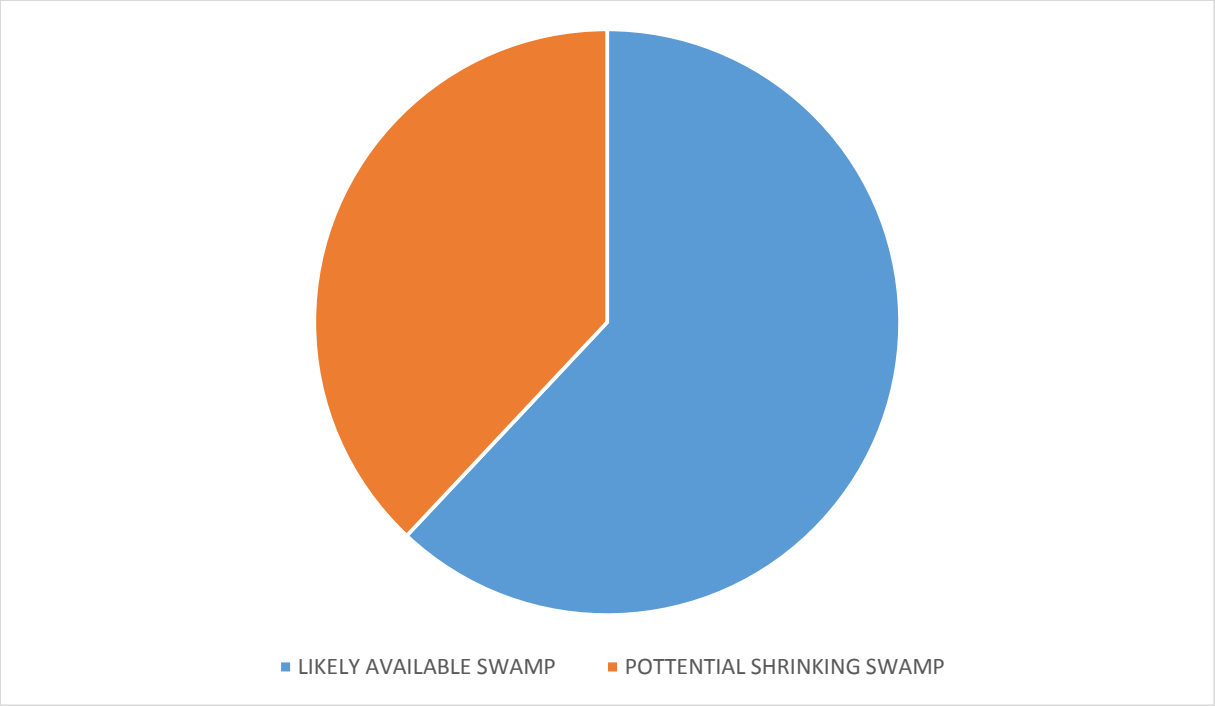

Figure 4.14: Estimated effects of Proposed Dam on the Lorian Swamp

4.6.2 How to Mitigate the Impacts of the Proposed dam Construction

The research pointed out that the demand for water is ever increasing and human being have the rights to use the environment to satisfy these basic rights. Kenya's vision 2030 sets major development to foster social and economic growth and the construction of the mega dam in Isiolo is among the priority areas. The findings have shown that that Dam construction will take up about 214 million cubic meter (mcm) translating to water 37% of the annual water discharge in the river which will take four months to fill up the dam. To balance the sustainability and conserve the Lorian swamp basin, the research recommends impoundment of the dam be spread over a period of three years as shown by researchers' calculation in figure 6.3 translating to 71.4 million cubic meters, about 12.3% of annual water discharge.

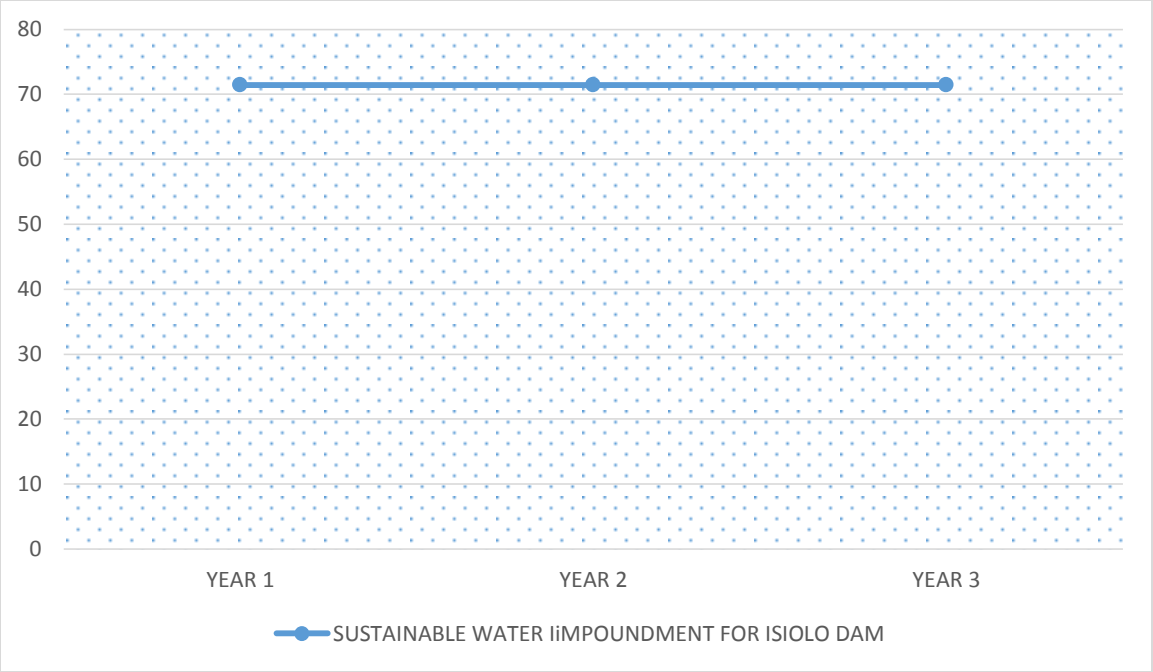

Figure 4.15: Sustainable Water intake for Isiolo Dam

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The study provided the assessment on influence of the water resource use patterns on the Lorian swamp, and the subsequent effect of the proposed dam on the water discharge and pasture in the Lorian swamp. The analyses were based on the data collected from the respondents, river flow data provided by CETRAD, literature review and online data.

The research concludes that there was significant water reduction in Ewaso Nyiro over the years affecting the Lorian Swamp ecosystem. 91% of the respondents confirmed the same and the triangulated data shows significant loss of water. The research finding indicates that from 1960-1969, the cumulative water discharge per cubic meter was 964 million cubic meters and from 2001-2010 it was 572 million cubic meters showing a major decline in water discharge with a difference of 392 million cubic meters translating to 40% reduction over four decades.

The research concludes that pasture and water are currently adequate but under threat due to loss of traditional governance system, invasive species, climate change, water abstraction upstream for farm and other uses, deforestation, encroachment of the catchment areas and ever-increasing population growth.

The Research also concluded that the proposed dam is likely to have serious impact on water discharge of the Ewaso Nyiro River. The Dam is anticipated to take 214, million cubic meter of the annual average available water of 572 million cubic meter translating to 37%. The impacts will shrink the Lorian swamp ecosystem from the current 2918-kilometer square to 1838-kilometer square. This means that pastoralists will be at loss due to shrinking of forage production, water reduction including the underground water, Loss of indigenous trees and

increased conflict over limited resources. The research further concluded that to balance human developments and sustainability of the Lorian swamp ecosystem the water uptake in the dam be spread over three years at a rate of 71,420,516 million cubic meter, about 12.3% of annual water discharge. It means that the dam be filled in three years.

5.2 Recommendations

- The National government to explore sustainable timeline to fill the dam in meeting the water demand without compromising the critical Lorian Swamp Ecosystem.
- County government should constitute an Independent institution to conduct potential Environmental and Social Impact for the proposed dam
- The traditional governance system of the resource management should be formalized and strengthen to manage the Lorian Swamp Ecosystem.
- The future of the Lorian Swamp is under serious threat from the invasive species (*Prosopis Juliflora)* and the Authority should consider innovative ways of taming it.

5.2.1 Further Research

- In-dept research on the ecology of the Lorian Swamp Ecosystems, current health status and future threats.
- Further research on the impacts of the Invasive species (*Prosopis Fujiflora)* on the Lorian Swamp Ecosystems.

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APPENDICES

Appendix 1: Questionnaire for the General Public

Introduction:

Good morning/ afternoon, my name is Salat Jiilo Tutana, a student undertaking a Masters degree in Environmental Governance at The University of Nairobi; Wangari Maathai Institute. My research seeks to evaluate the influence of land use change on the Lorian Swamp ecosystem.

The information you give in response to this questionnaire will be held in confidence and not used for any other purpose apart from the academic purpose.

Section A: Personal information

1. Name :(Optional)……
2. Age:

   ☐18years- 20 years ☐21years- 25years ☐26yers- 30years

   ☐31 years –35years ☐ 36years- 40yeas ☐41years- 45years

   ☐46years- 50years ☐51years-60years ☐61years and above
3. Gender: ☐Male ☐Female
4. Marital status: ☐Single ☐Married ☐Widowed ☐Divorced
5. County…… Sub county……
6. How long have you lived here? 1- 5 years ☐6- 10 years ☐ 11-15 years

   ☐16- 20years ☐over 21 years

Section B: The trend of water levels in Ewaso Nyiro River

7. Do you use access water from Ewaso Nyiro River?

Yes ( ) No ( )

a. If yes, for what purpose?

Domestic () Livestock () Farming ( ) Other (specify)……

8. Is water from the Ewaso Nyiro river enough for your need as stated above?

Yes ( ) No ( )

a. If no, state why?

.....

.....

.....

9. Were there changes of water levels in the Ewaso Nyiro river over the years?

Increase ( ) reduction ( ) constant ( ) no change ( )

a. If yes, how often? Seasonal ( ), bi-annual ( ) annual ( )

10. What are the likely causes of change of water level as stated above?

……

……

……

……

Section C. Pasture and water availability in the Lorian Swamp Ecosystem

11. Do you think the Lorian Swamp Ecosystem is important?

Very important ( ) Important ( ) Not important ( )

a. Give reasons, based on the above question? .....

.....

12. Do you experience flooding? Yes ( ) No ( )

a. How often?

Once a year ( ) 2 years ( ) 3 years ( ) Others (specify)……

13. Is water and pasture in the Lorian swamp adequate? Yes ( ) No ( )

a. How adequate is it in the year?

Pasture…… Water……

14. What land uses affect the water and pasture availability in the Lorian Swamp?

Give your answer: ……

……

15. What can be done to sustain the pasture and water availability in the Lorian Swamp Ecosystem? Give your answer……

……

16. Have you heard of dam construction in the Upper stream? Yes ( ) No ( ).

a. If yes, in what ways will it affect the Lorian swamp? ……

……

b. How can we mitigate the impact as stated in (a) above? ……

……

Thank you for your time

Appendix II: Questionnaire for the Focus Group Discussion

Introduction:

Good morning/ afternoon, my name is Salat Jiilo Tutana, a student undertaking a Masters degree in Environmental Governance at The University of Nairobi; Wangari Maathai Institute. My research seeks to evaluate the influence of land use change on the Lorian Swamp ecosystem.

The information you give in response to this questionnaire will be held in confidence and not used for any other purpose apart from the academic purpose.

SECITON A: LOCATION AND BACKGROUND OF RESPONDENTS

QN No		Date		
Location:		Sub-location		
Name of the Respondent				
S/no	Name	Gender	Mobile no	Proffession
Time		Start	End	

Section 2; The trend of water levels in Ewaso Nyiro River

This part of the question is subjected to respondent over 45ys to compare the recorded data of the River discharge over the years with oral data.

1. Do you use access water from Ewaso Nyiro River?

   Yes ( ) No ( )

1.1.If yes, for what purpose?

   Domestic ( ) Livestock ( ) Farming ( ) other(specify)…….

1.2.Is water from the river enough for your need as stated above?

   Yes ( ) No ( )

1.3.If no, state why?.....

1.4.Were there changes of water levels in the river over the years?

Increase ( ) reduction ( ) constant ( ) no change ( )

1.5.If yes, how often? Seasonal ( ), bi-annual ( ) annual ( )

1.6.What are the likely causes of change of water level as stated above?

……

……

……

Section 3. Pasture and water availability in the Lorian Swamp Ecosystem

2. Is Lorian Swamp important to you?

   Very important ( ) Important ( ) Not important ( )

2.1.Give reasons, based on the above question? .....

   .....

   .....

2.2 Do you experience flooding? Yes ( ) No ( )

And how often?

Once a year ( )

In two years ( )

In three years ( )

Others (specify)……

2.3 Is water and pasture available in the Lorian swamp? Yes ( ) No ( )

And how available in a year? Tick in the box for availability and leave it blank for non-availability.

Period	**Pasture**	**Water**	**Which month do you access the swamp**
January			
February			
March			
April			
May			
June			
July			
August			
September			
October			
November			
December			

2.2.Which type of pasture/grass are available in the swamp

Name in Kiborana	Scientific name	Name in Kiborana	Scientific name

2.3.Did you observe any changes on the Lorian swamp over the last 20 years?

……

3. What land uses affect the water and pasture availability in the Lorian Swamp?

Give your answer: ……

……

3.1 What can be done to sustain the pasture and water availability in the Lorian Swamp Ecosystem? Give your answer……

……

Have you heard of dam construction in the Upper stream? Yes ( ) No ( ).

3.2 If yes, in what ways will it affect the Lorian swamp? ……

……

3.3 How can we mitigate the impact as stated in (a) above?

……

Thank you for your time