COMMUNITY ENVIRONMENTAL PERCEPTIONS AND AWARENESS AND THE FUTURE OF LAKE OL'BOLOSSAT WETLAND IN NYANDARUA COUNTY, KENYA

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A Thesis Submitted to the Graduate School in Partial Fulfilment for the Requirements of the Master of Science Degree in Environmental Science of Egerton University

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DECLARATION

This Thesis is my original work and to the best of my knowledge has not been presented for a degree or diploma before at Egerton University or in any other university.

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ACKNOWLEDGEMENT

I would like to take this opportunity to express my utmost gratitude to a number of individuals and institutions for their contribution either materially or otherwise that has led to the successful completion of this study.

Many thanks go to my employer the Ministry of Livestock Development for granting me a study leave, which enabled me to pursue this course without undue stress. I also extend many thanks to Egerton University for offering me the opportunity to undertake my studies in this prestigious institution. The special guidance proffered by the graduate school throughout the course of my studies is also highly appreciated.

My very special thanks go to my academic supervisors Professor F.K. Lelo and Professor W. Shivoga who worked with me relentlessly from the beginning of this study right through to its completion. I also highly appreciate the assistance, advice and constructive criticism by Dr. J. J. Kitetu and other members of the Faculty.

I am also grateful to my mother, my brothers and sister Dan, Susan, Ben, Simon, Solomon and Sammy for their encouragement and support financially and otherwise throughout this course. My special thanks go to my wife Milly, and sons Patrick, Samuel and Daniel who had to bear with many inconveniences including my frequent and sometimes prolonged absences from home during the course of my study.

I am also highly indebted to the farmers and all other persons whom I interviewed during the course of this study for their invaluable patience and willingness to answer my questions most of them without any prior appointments.

ABSTRACT

According to the Ministry of Environment and Mineral Resources wetlands in Kenya cover 2 to 3% of the country's surface area. Most of these wetlands are threatened ecosystems with the threats arising from human activities. However, the way socio-economic activities are carried out and their impact on the environment is determined to a great extent by the level of environmental awareness, knowledge and attitude of the local people who use wetland resources. The main objective of this study was to examine how environmental perception and environmental awareness of the local communities influences their socio-economic activities around Lake Ol'Bolossat wetland. The study was carried out in Nyandarua North and Nyandarua West Districts of Nyandarua County, in settlement schemes adjacent to the lake. Two hundred and twenty three households were interviewed to collect information in order to establish relationships between variables under investigation. Other key informants were also interviewed. The information collected was analyzed using Statistical Package for Social Sciences (SPSS). Both descriptive and analytical procedures were used to analyze the data and test relationships between variables. As a complementary methodology, satellite images covering the study area were analysed using ENVI computer package for image analysis to assess changes in forest cover. The study found out that, environmental awareness more than environmental perception was influential in determining how farmers carried out their socio-economic activities. The socio- economic status of the respondents was found to have an inverse relationship with the degradation of the wetland thus individuals of better socio-economic status were causing more degradation to the wetland than those of lesser socio-economic status. Grazing practice was found to be the most significant determinant of the wetland degradation. Analysis of satellite images revealed that there had been 32% decline in forest cover in the study area between 1986 and 2006. The study recommends that efforts to raise environmental awareness especially the conservation of the wetland, be given the first priority to save the lake from further degradation. Any effort to conserve the lake should first resolve the problem of its ownership and should involve the local communities as the major stakeholders.

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LIST OF ACRONYMS

ANOVA	Analysis of Variance
CHP	Crop Husbandry Practice
EA	Environmental Awareness
EC	European Commission
EP	Environmental Perception
FRU	Forest Resource Use
GOK	Government of Kenya
IBA	Important Bird Areas
IP	Irrigation Practice
KWS	Kenya Wildlife Service
NEAP	National Environmental Action Plan
NWP	Netherlands Wetland Project
OECD	Organisation for Economic and Cultural Development
RCB	Ramsar Convention Bureau
SES	Socio-Economic Status
SFT	Settlement Fund Trustee
TLU	Tropical Livestock Unit
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
WCED	World Commission on Environment and Development

CHAPTER ONE

INTRODUCTION

Worldwide, wetlands were in the past considered to be wastelands and therefore worthless (William, 1994). They were regarded as wastelands if not bogs of treachery, mires of despair, home of pests and disease and refuges for outlaw and rebel. Their transformation through drainage to give way for agriculture, industrial development, and harbours or for waste disposal seemed a good fate for them (Williams, 1990).

Since 1900, over half of the world's wetlands may have disappeared (Barbier, 1994). In the United States alone an estimated 54 percent of its original wetlands have been lost. Similar pattern of wetland conversion is also common in developing countries (Ibid). In Kenya, the Ministry of Environment estimates Kenya's wetlands to cover 2 to 3% of the country's surface area. Most of these wetlands are threatened ecosystems with the main threats arising from human activities (Government of Kenya, 1994)

Wetlands have assumed a new attraction and value in the recent decades as their hydrological, physical, chemical, biological and socio-economic benefits are acknowledged and as they become eliminated at an alarming rate (Williams, 1990). Wetlands are rich ecosystems, which provide essential livelihood products and services such as fish, water and moderation of climate. However their attributes that are not directly related to human use (for example removal of pollutants, control of floods) are often not appreciated until a wetland is destroyed or modified and when the restoration of wetland to revive those functions proves very expensive or inconvenient.

The responsibility for wetland degradation has been blamed on governments and or their agencies, which often, under pressure of local demands carry out major agricultural projects in these areas (Pyrovetsi *et al,* 1999). The problem is further aggravated by lack of legal instruments or their enforcement to provide adequate protection for wetlands. The other party held responsible for the deterioration of wetlands are the users of these areas, such as fishermen, farmers and livestock keepers. These people living in settlements close to the wetlands and earning their livelihood from wetland resources have remained largely ignorant of the conservation policies and the implications of their socio-economic practices and uninformed of the new messages or the benefits they could achieve from implementing these new environmental conservation messages (Pyrovetsi *et al*, 1999).

Agricultural activities have been cited as being among factors that negatively affect functions and values of wetlands (Gerakis *et al*, 1998: Barbier, 1994). Intensified agricultural production has been made possible through increased use of fertilizers, pesticides, irrigation and mechanisation. However, this has also been coupled with severe environmental impacts. High nutrient levels in surface water in many parts of the world have been attributed to agricultural activities (Stone *et al.*, 1995: Mitchell *et al., 2000:* Jarvie *et al, 2010)*. These high nutrient levels are a major contributor to algal blooms and eutrophication in surface water bodies. Kammerbauer *et al,* (1998) and Castilho *et al.*, (2000) reported high level of pesticide residues in water systems served by agricultural watershed.

The process of agricultural modernisation has been greatly intensified in the last few decades in Kenya. This is already impacting negatively on some of the important water bodies in the country. For example, Scheren *et al*, (2000) reported that agricultural land runoff may contribute up to 22% of the nitrogen and up to 55% of the phosphates while in total, anthropogenic activities contribute as much as 94% of the nitrogen and up to 90% of the phosphates that enters Lake Victoria. This has contributed to the rampant growth of the water hyacinth that has become a noxious weed in the lake. High levels of agrochemicals have also been reported in Lake Ol'Bolossat (KWS and NWP, 2000)

Supporters of an environmentally compatible form of agriculture emphasize the need to preserve the ecological balance of soil and water, secure food safety and maintain the health and quality of life of the rural people and their communities. Wetlands, as highly vulnerable and valuable areas supporting a diversity of species and habitats, require an environmentally compatible agriculture. Recognition of the serious wetland decline globally and appreciation of their ecological and economic functions and values have recently generated a response for international and regional communities (Pyrovetsi *et al*, 1999).

In developing countries, like Kenya, ensuring food security through increased food production and improved production systems is a national goal. Conserving the ecological structure and functions of wetlands while maintaining the agricultural resource base by practicing environmentally compatible agriculture should therefore go hand in hand. The role of the local people in management and control of environmental degradation should be enhanced.

1.1 Problem Statement

Lake Ol'Bolossat wetland has been exposed to several anthropogenic disturbances. These include deforestation of the catchment, siltation, overgrazing, pollution from agrochemicals, and obstruction of streams entering the lake for irrigation, allocation of riparian reserve for settlement and drainage of the swamp. Most of these disturbances are closely linked to socio-economic activities in the lake basin. However, the impact of socio-economic activities on the environment is determined to a great extent by the level of environmental awareness, knowledge and attitude of the users of the natural resources. There is need to assess these and improve them in order to ensure sustainable management of the wetland resources. This study aimed at assessing the environmental perception and awareness of the communities living adjacent to Lake Ol'Bolossat wetland.

1.2 Justification

The Ministry of Environment and Mineral Resources lists Lake Ol'Bolossat as an important wetland (Government of Kenya, 1994). It is rich in biodiversity and is considered to be one of the Important Bird Areas (IBA) (KWS and NWP, 2000). Over 185 bird species have been recorded around the lake (Gichuki, 2004). Among these were thirty Palaearctic and 15 Afro tropical migrant species (KWS and NWP, 2000).

Lake Ol'Bolossat is the origin of River Ewaso Narok, which is the main tributary of River Ewaso Nyiro. River Ewaso Nyiro is the third largest river in the country after Rivers Tana and Athi. The river flows southwards and then eastwards to end up in the Lorian swamp in Garissa County.

Along its course the river serves an important role in supporting the lifestyles of communities living in parts of the arid and semi-arid areas of North Eastern, Eastern and Rift Valley regions. The thriving tourist industry in Samburu, Shaba, and Buffalo Springs National Reserves is made possible by the flow of River Ewaso Nyiro. It is the main river draining the North eastern part of the country.

The wetland also supplies water for Nyahururu municipality and is the only natural lake in Central region of Kenya. The continued degradation of the wetland from anthropogenic activities around the lake therefore has ecological, social, aesthetic and economic ramifications.

There is limited knowledge regarding the relationship between farming practices and wetland conservation in Kenya. This knowledge is central to the development of sustainable farming and the formulation and implementation of effective management measures to conserve wetland resources. No study had been carried out to assess the level of environmental awareness of the communities living adjacent to Lake Ol'Bolossat. In addition, the possibility of using findings from this study to address other wetlands in the country facing similar threats made Lake Ol'Bolossat a suitable study site.

1.3 Objectives

1.3.1 Broad Objective

The broad objective of this study was to examine the effect of households' environmental perception and awareness on the degradation of Lake Ol'Bolossat wetland as influenced by household's socio-economic activities.

1.3.2 Specific Objectives

1. To assess how a households' environmental perception influences their arable crop husbandry practices around Lake Ol'Bolossat wetland
2. To examine the relationship between households' environmental perception and their grazing practices around the wetland ecosystem
3. To investigate how households' environmental perception influences their forest resources use within the wetland's catchment.
4. To assess how households' environmental perception influences their irrigation practices around Lake Ol'Bolossat the wetland
5. To examine how a households' socio-economic status affects the quality of Lake Ol'Bolossat wetland
6. To make appropriate recommendations based on the findings

1.4 Hypotheses

1. The households' environmental perception significantly influences their arable crop husbandry practices and their effects on the quality of Lake Ol'Bolossat wetland.

2. The households' environmental perception significantly influences their grazing practices and their effects on the quality of Lake Ol'Bolossat wetland.
3. A households' environmental perception significantly influences their forest resource uses and their effects on the quality of Lake Ol'Bolossat wetland.
4. Households' environmental perception significantly influences the households' irrigation practices and their effects on the quality of Lake Ol'Bolossat wetland.
5. Households' Socio-economic status significantly affects the quality of the wetland ecosystem.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter looks at the available literature relevant to this study from which a conceptual model was developed.

2.2 Wetlands

The Ramsar Convention on Wetlands of International Importance defines wetlands as areas of marsh, fen, peatlands or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres (Ramsar Convention Bureau (RBC), 2000). It thus includes floodplains, rivers, lakes, and coastal areas such as salt marshes, mangroves, and sea-grass beds, but also coral reefs and other marine areas no deeper than six metres at low tide, as well as human-made wetlands such as wastewater treatment ponds and reservoirs. Williams (1990) defines them simply as lands with soils that are periodically flooded. Wetland include any part of the landscape which regularly has a water table at or above the soil or sediment surface at some time of the year and in which the major primary producers are aquatic plants or non-planktonic algae. Wetlands are transitional ecosystems between upland and open water. As such they exhibit characteristics of both aquatic and terrestrial ecosystem (Doust *et al*, 1995). Because of their location, wetlands serve unique functions that are not matched by either of the other environmental component (William, 1994).

Wetlands were the first ecosystem to receive international attention through the "Convention on Wetlands of International Importance especially as Habitats for Waterfowls," opened for signature at Ramsar, Iran, in February 1971. Kenya ratified this convention on 5th June 1990 through designation of Lakes Nakuru as Wetlands of international importance (Ramsar Sites). Lake Naivasha was designated as a Ramsar site in 1996 (Bennun *et al*, 1999).

According to the Kenya National Environment Action Plan (NEAP), prepared in 1994, a substantial proportion of Kenya's water resources are found in wetlands, which cover 2 to 3% of the country's surface area (GOK, 1994). These wetlands are diverse in type and

distribution. Some of the larger wetlands of Kenya include the shallow Lakes Nakuru, Naivasha, Magadi, Kanyaboli, Jipe, Chala, Elmentaita, Baringo, Ol'Bolossat, Amboseli and Kamnarok; the edges of Lake Victoria and Lorian, Saiwa, Yala, and Shompole swamps; Lotikipi (Lotagipi) and Kano plains; Kisii valley bottoms and Tana Delta; and coastal wetlands including the mangroves swamps, sandy beaches, sea grass beds and coral reefs.

2.3 Functions and Values of Wetlands

Wetlands include some of the most important biological and ecological ecosystems on the face of the Earth. They have values and functions that are important. Wetland functions are the physical, chemical and biological processes performed by wetlands. Wetland values are the wetland processes and features (or a combination of them), which are valuable or beneficial to society (Gerakis *et al*, 1998).

According to Doust *et al* (1995), wetlands have been described as nature's lungs and nature's kidneys. Along the same analogy he describes them as nature's womb (nursery areas for aquatic organisms) and liver (detoxification centre for pollutants and excess nutrients). Its estimated that as many as 45% of endangered animals and 26% of endangered plants either live in wetlands or depend on them for their continued existence (Botkin and Keller, 1995; Ramsar Convention Bureau, 2000). Broadly their uses, functions and values can be grouped into three categories, intrinsic, subsistence and commercial values.

The intrinsic values accrue by the very existence of the wetland. These include provision of habitat to wildlife for both material benefits and exploitation of their gene pool. Other intrinsic values include their role in the hydrological cycle. Wetlands store floodwaters and hence buffer downstream effects of storms. They allow recharge of ground water aquifers and encourage sideways flooding of grasslands to the fringes of permanent swamps. Wetlands are also important in removal of non-point sources of pollution. They may remove up to 90% of sediments and nitrate and up to 50% of phosphates entering them (Gilliam, 1994).

Lake Ol'Bolossat is not short in intrinsic values. It provides habitat for both resident and migrant bird species. Among birds recorded at the lake, the Great Crested Grebe is rated as rare-fewer than 50 recorded in Kenya-by the Ornithological Sub-committee of Nature, Kenya (KWS *and* NWP, 2000). Others like the Black Heron, Little Bittern, White Backed Duck,

Maccao Duck, African Marsh Harrier, Allen's Gallinule, Black tailed Godwit and bar tailed Godwit are water birds recorded at the lake and rated as rarities.

The lake is also a breeding site for a number of bird species among them the Red-knobbed Coot (*Felica cristata),* the African Jacana (*Actophilornis africanus),* the Blacksmith plover (*Vanellus armatus),* the African Snipe (*Gallinago nigripennis)* among others. The lake also provides habitat to hippopotamus (*Hippopotamus amphibious)* (KWS *et al*, 2000). Wetlands provide source of food, building materials and other raw materials. These are the main subsistence values. They also act as a source of fresh water supply (Williams 1990).

In the case of Lake Ol'Bolossat, the riparian land functions as an important grazing area for the local people. The lake and its riparian land has also over the years acted as the dry season grazing area for livestock from different areas of the County and sometimes for pastoralists from as far as Kajiado County.

The commercial values have no boundary with the subsistence values except the level and purpose of exploitation. Wetland resources can be used for cash economy or barter (for example: fish, reed mats, and rice growing). Wetlands can also be used for recreation as nature reserves or national parks. Most commercial exploitation of wetlands results in their ecological degradation (Williams, 1990).

Most of the Kenyan wetlands are under threats arising from human activities. Already some of the wetlands have been targeted for reclamation. This is the case of Yala swamp that was partly drained in the 1970s for agricultural production. Yala swamp is the country's largest papyrus swamp and contains numerous threatened fauna. The swamp acts as a filter of agro-pollutants and silt which otherwise would be deposited in Lake Victoria. The swamp also supports a variety of rare fish, birds and mammals (BP Conservation Project, 2003). According to Mfudisi (2003), the drainage of the swamp affected the ecosystem productivity and the various functions and values of wetland for biodiversity. Its drainage also affected the ecology of Lake Kanyaboli, (Osienala 2002).

2.4 Agriculture and Environmental Degradation

Environmental degradation entails deterioration or decline of any of the environmental resources, water, air, soil, and biological resources. Agriculture is the biggest land use in terms of area globally and also the most significant in terms of impacts, (Mather, 1986). Any

use of land has some impacts on it, with effects varying in terms of intensity of use and the type of use. However, Chamwada, (2001), notes that low intensities of land use do not necessarily imply that there were no effects, or that they are negligible.

While environmental degradation may occur naturally, human activities accelerate these processes. This may be through introduction of foreign materials (chemicals, plants, animals) that may not occur naturally at the same levels in that environment or through creating an environment that allow natural processes to be accelerated. For example cultivation may open up land to the natural elements hence accelerating soil erosion.

Agriculture has both primary and secondary environmental effects. Primary effect also called onsite effect is an effect on the area where agriculture takes place. A secondary effect or off-site effect is an effect on an environment away from the agricultural site. Effects of agriculture can be divided into three categories based on the extent of the effects. These can be local, regional or global Local effects occur at or near the site of farming. These include, loss of soil, increase in sedimentation in local rivers. Regional effects on the other hand result from combined effects of farming practises in the same large region. Global effects include the climatic change as well as potentially extensive changes in chemical cycles (Botkin *et al*, 1995).

The WCED identified three crude types of contemporary agriculture across the globe: 'industrial' (largely confined to industrialized world but also in specialized enclaves in the developing world), 'green revolution' agriculture (in areas of developing world that have reliable rainfall or irrigation technologies) and 'resource-poor' agriculture (found widely in the developing world). It's estimated that a quarter of the world's population are dependent on this 'resource-poor' agriculture. These farmers, because of their economic positions, lack the financial resources to invest in the capital equipment or inputs necessary o raise production or to implement the land use management techniques appropriate to the physical ecology of their areas (Elliot, 1994)

Tolba (1988) notes that, shortage of food in many developing countries creates insecurity and environmental threats. The quest to meet rapidly growing food needs combined with insufficient attention to the environmental impacts of agriculture policies and practices, has been causing great environmental damage.

According to OECD, (1986) the concern about environmental degradation by agriculture

has gained currency, as its associated cost to society has become better known. These include degradation and depletion in the form of soil loss and forests loss, desertification, overgrazing, deterioration of quality surface and ground water, reduction in genetic diversity of fish stocks, water-logging, salination, accumulation of toxic metals and organic compounds, siltation and eutrophication caused by improper use of pesticides and fertilisers (Botkin and Keller, 1995).

The use of agro-chemicals has deleterious effects on the environment. Studies worldwide indicate that the use of fertilisers in a watershed affects the concentrations of nutrients in the water systems within the catchments. Fertilisers increase the concentration of nutrient in the surface soil and consequently in the runoff (McDowell *et al*, 2001). The amount of fertiliser applied in a given watershed has been found to relate to the amount of nutrients in the river served by the watershed (Stone, 1995: Sharpley *et al,* 1999: Jarvie, *et al 2010*).

Livestock keeping also impacts negatively on the environment. Tabuchi *et al* (2000) found the levels of nitrate-nitrogen concentration in a river to correlate highly to the stocking density in a given catchment. Jarvie *et al (2010)* found the concentration of dissolved organic Nitrogen, and dissolve hydrolysable phosphate to be significantly higher in streams serving areas with intensive livestock farming. Even the amount of coliforms present in water have been found to relate to livestock activities in a given watershed (Fisher *et al*, 2000). According to KWS and NWP, (2000) livestock grazing in the wetland destroys nests for ground nesting birds. Livestock also accelerate the process of soil erosion through trampling and removal of vegetation cover especially where the land's carrying capacity has been exceeded leading to overgrazing.

In Kenya agricultural policies have focused on agro-chemical use as an important focal point in the effort to increase production. Efforts in promoting fertiliser use in Kenya have included fertiliser trials, demonstrations and extension programs and provision of subsidies on fertilisers. It was anticipated that, these efforts would spread and enhance the use of fertilisers among farmers (Muriithi *et al*, 1993). The use of fertilisers is already impacting on water resources. Studies in Lake Victoria show that agricultural land runoff may contribute up to 22% of the nitrogen and up to 55% of the phosphates (Scheren *et al*, 2000)

2.5 Environmental Awareness

Most people today are aware of the existence of environmental problems. Many are

concerned about the quality of life that they can enjoy in their own locality. These thoughts may be triggered by various events affecting the air t hey breathe, the water they drink or the open space they are accustomed to for leisure, (Irimu, 1995). In reality, problems arise from human use of land, air and water, since pressures on land and resources are growing fast.

Across the world the impact of socio-economic activities on the environment is determined to a greater extent by the level of environmental awareness, perceptions knowledge and attitude of the users of the natural resources (Pyrovetsi *et al,* 1999, Gadhi *et al*, 1997, Stein *et al*, 2010). Nevertheless critical decisions for the future of wetlands are sometimes taken without assessing the local people's knowledge on the potential harmful effects of their practices and ways in which they can act positively towards the environment. Furthermore the local peoples' involvement in the formulation of environmental policies or in the implementation of management plans for natural resources is ignored (Lelo *et al, 1999).* There has been a common assumption by governments that rural people simply do not understand the issues relating to resource conservation and can therefore not be entrusted with this responsibility. Giving people a direct role in formulation of policies influences their attitude towards the environmental resources (Curry, 1997).

Decisions on natural resource management are not made by government and international organisations but by millions of individual decision makers –farmers who decide what crop to grow, what inputs to use, whether to increase or decrease their cultivated area by clearing forest, fishermen who decide what fishing gears to use among others (World Bank, 2002).

Participation of people in environmental protection and improvement depends upon their being aware of the environmental problems, possibilities of how the changing state of the environment will affect their well-being and how their lifestyles affect the environment (Tolba, 1988). Studies by Aboud, (1992) and Anyango (2000), found that farmers' perception and awareness of environmental problems influenced their choice of coping strategy or conservation measures they employed.Sustainable development can better be achieved with the support and cooperation of an informed public. Often, wrong decisions have been taken as a result of lack of awareness. Indeed studies show that, a number of resource conservation problems in wetlands are caused by fishermen or farmers' limited environmental awareness (Pyrovetsi *et al*, 1999). Information to the public can either be through formal or informal education. As such, the society can internalise values that support sustainable environmental management.

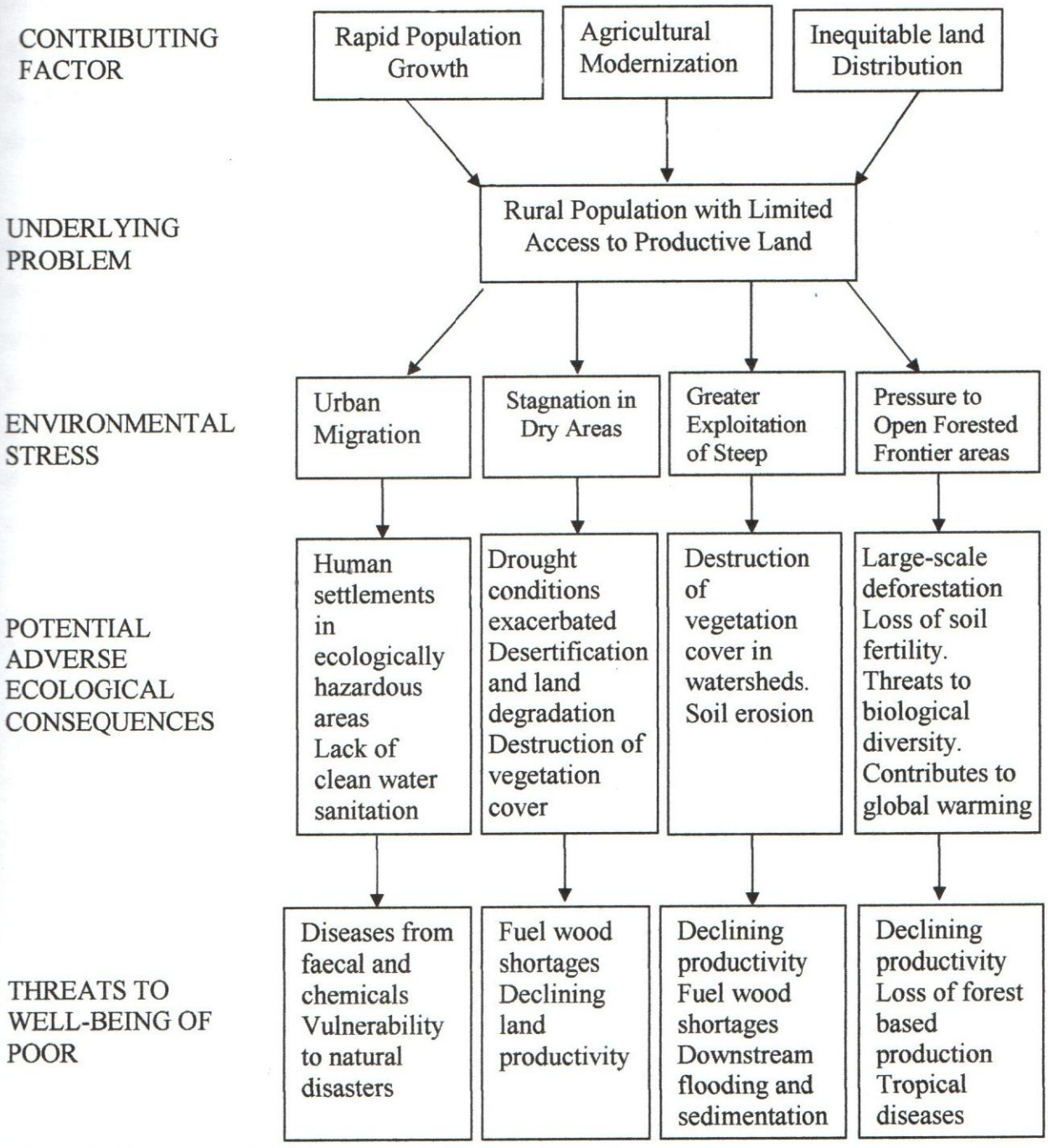


Figure 1: Poverty and Environmental Connection

Adopted from Elliot, (1994)

2.6 Socio-Economic Status and Environment

Environmental problems such as deforestation have been blamed on underdevelopment resulting in over dependence on biomass energy sources. Indeed poverty has been widely

blamed for the degradation of the environment by resource poor communities (Figure 1). According to WCED threats to sustainable use of resources comes as much from inequalities in peoples access to the resources and from the ways in which they use them as from the sheer numbers of people.

All forms of economic and social activities make demands on the resource base, whether agricultural production, industrial production or human settlement. To be sustainable such activities must ensure that the resources are used with the greatest efficiency, that the undesirable effects of these activities are reduced to a minimum and that irreparable damage to the environment is not done. Inequality in access to resource threatens the prospect of sustainable development in many ways. Primarily, it confines large number of people to poverty which often leaves them with no choice but to degrade and destroy the resource base on which their future livelihoods depend (Elliot, 1994).

2.7 Legal and Policy Issues on Wetlands

Wetlands were the first ecosystem to receive international attention through the "Convention on Wetlands of International Importance especially as Habitats for Waterfowls." The convention provided guidelines for governments to develop and implement national wetland policies (Ramsar Convention Bureau, (RCB) 2000). Kenya ratified this convention in 1990.

The Ramsar convention advocated for establishment and strengthening of local communities and indigenous people's participation in the management of wetlands. It also advocated for promotion of the conservation and wise use of wetlands through communication, education and public awareness (RCB, 2000).

In Kenya there exists a number of Acts and policies that relate to the management of wetlands. These include Sessional Paper No. 1 of 1999 on National Policy on Water Resources Management and Development, which recognises wetlands as important sources of water. Others include, the Water Act, the Wildlife Management and Conservation Act, the Fisheries Act among others. However notwithstanding the existence of these Acts and policies wetland degradation has been on the increase countrywide.

In recognition of the important functions and values of wetland the government provides for the protection and conservation of all wetlands in the country in the Environment

Management and Coordination Act (EMCA) (Government of Kenya, 1999). Section 42 and 43 of the Act provides guidelines for management and utilisation of rivers, lakes and wetlands. While these legislations have been in existence for several years now, there has been little in form of creating public awareness to promote adherence to these provisions.

2.8 Lake Ol'Bolossat Wetland

2.8.1 Location of study area

Lake Ol'Bolossat is located in the northern part of Nyandarua County (Figure 2). The lake is located at the northern foots of the Aberdare ranges, and to the West of Satima escarpment (Aberdare Escarpment). Administratively, the wetland is located within three districts: Nyandarua North, Nyandarua West and Nyandarua Central districts of Nyandarua County. Nyandarua County is one of the six counties in Central province of Kenya. It neighbours Laikipia County to the North, Nyeri and Murang'a Counties to the East, Kiambu County to the south and Nakuru County to the West. Nyandarua County is the largest county in Central province with a total land area of 3,528 square kilometres (Government of Kenya, 1997). Administratively the county is divided into seven districts namely Nyandarua North, Nyandarua South, Nyandarua West, Nyandarua Central, Kipipiri, Kinangop and Mirangine

The open waters of the lake are located about 30 Km south of Nyahururu town and 15 Km Northeast of Ol Kalou towns at about 2340 M above sea level. The Open waters of the lake cover an area of 4 square kilometres. The lake is shallow ranging in depth from 0.73m to 1.73m.The total wetland and the riparian land have an area of 90 km^2 (KWS and NWP, 2000).

Lake Ol'Bolossat is a small fresh water lake situated on a flat plain known locally in the Maasai language as Ongata Pusi (the valley of marshes). The plain has developed on the floor of a small valley in the form of a trough. The lake basin is generally flat bound to the eastern side by a 36 km long escarpment known as Satima that rises to 2550 m above sea level. Satima escarpment runs south from Thomson's fall where it takes the place of the Laikipia and Chui-Lolderodo escarpment as the easternmost scarp of the Rift Valley.

The watershed of the lake covers approximately 540 km^2 and includes Satima escarpment, parts of Aberdare mountain range and Dondori hills. This internal drainage basin receives water from rainfall, underground seepage and surface runoff from the surrounding highlands (Gichuki, 2002)

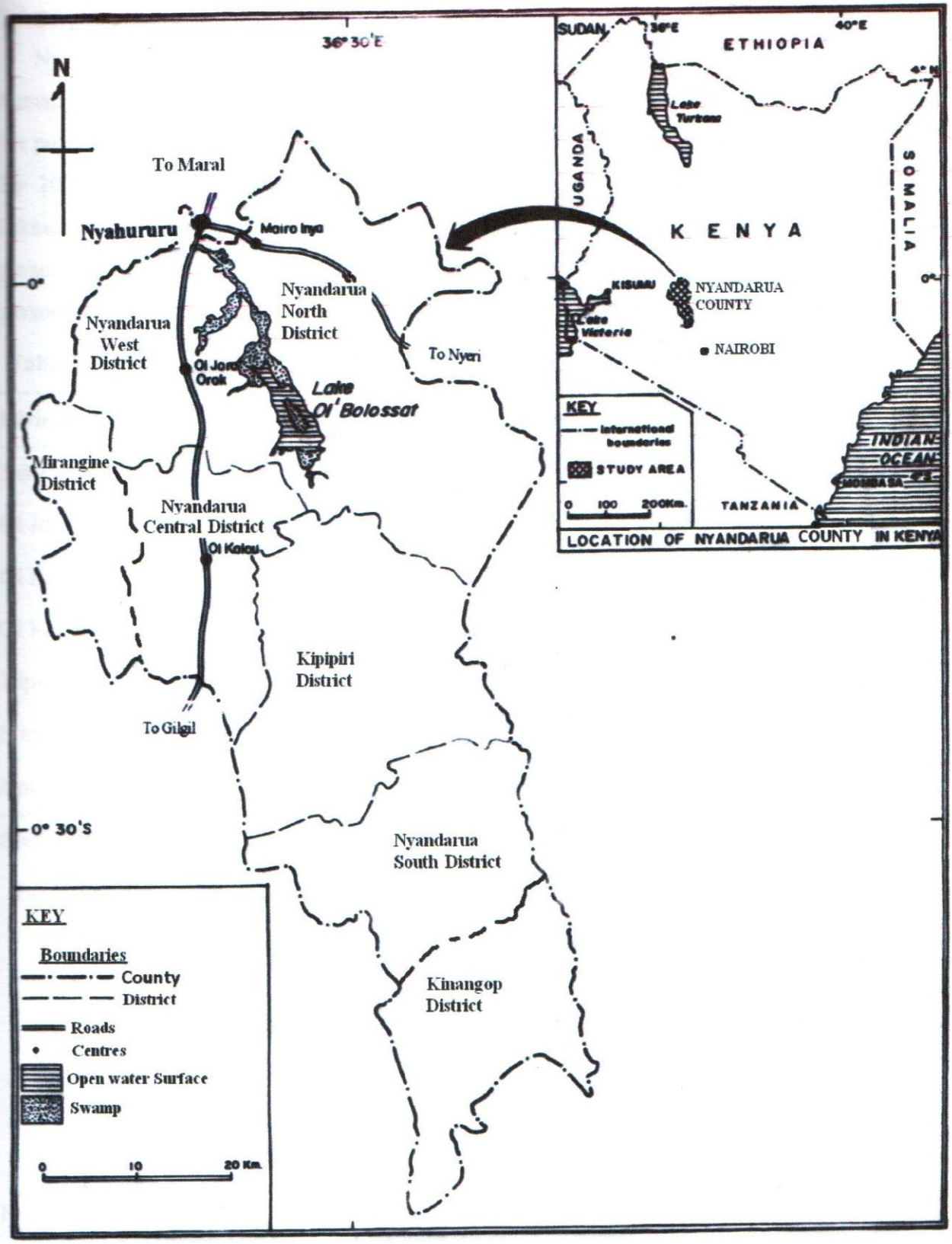


Figure 2: Location of Lake Ol'Bolossat in Nyandarua County in Kenya

Source: Survey of Kenya

2.8.2 *Demography*

Nyandarua County like most parts of the country has been experiencing rapid increase in human population. The population as per the 1969 census was 176, 928 persons. By 1999, the population stood at 479,902 persons with 104,401 households (Republic of Kenya, 2001). By 2009 the population stood at 592,628 (Kenya National Bureau of Statistics (2011). Likewise, the population density has been increasing in the last five decades. It was 52 persons per km^2 in 1969, 69 persons per km^2 in 1979, 102 persons per km^2 in 1989, 145 persons per km^2 in 1999 and 189 persons per km^2 in 2009 as shown in Tables 2.1 and 2.2.

Table 2.1: Population Distribution in Nyandarua County by Division in 1999

Division	Current District Name	Population	Area	Density
Ndaragwa	Nyandarua North	85245	683.6	125
Ol Joro Orok	Nyandarua West	65229	386.4	171
Ol Kalou	Nyandarua Central	98806	592.2	167
Ol Kalou	Mirangine	-	-	-
Kipipiri	Kipipiri	78893	543.8	145
South Kinangop	Kinangop	84394	348.1	242
North Kinangop	Nyandarua South	67356	475.3	145

Source: Republic of Kenya, 2001

Table 2.2: Population Distribution in Nyandarua County by Constituency in 2009

Constituency	Population	Area	Density
Ndaragwa	92,626	904	102
Ol Kalou	215,925	976	221
Kipipiri	95,338	544	175
Kinangop	192,379	822	234

Kenya National Bureau of Statistics, (2011)

2.8.3 Human Settlement

The current settlement patterns in the county have historical origins from colonial times.

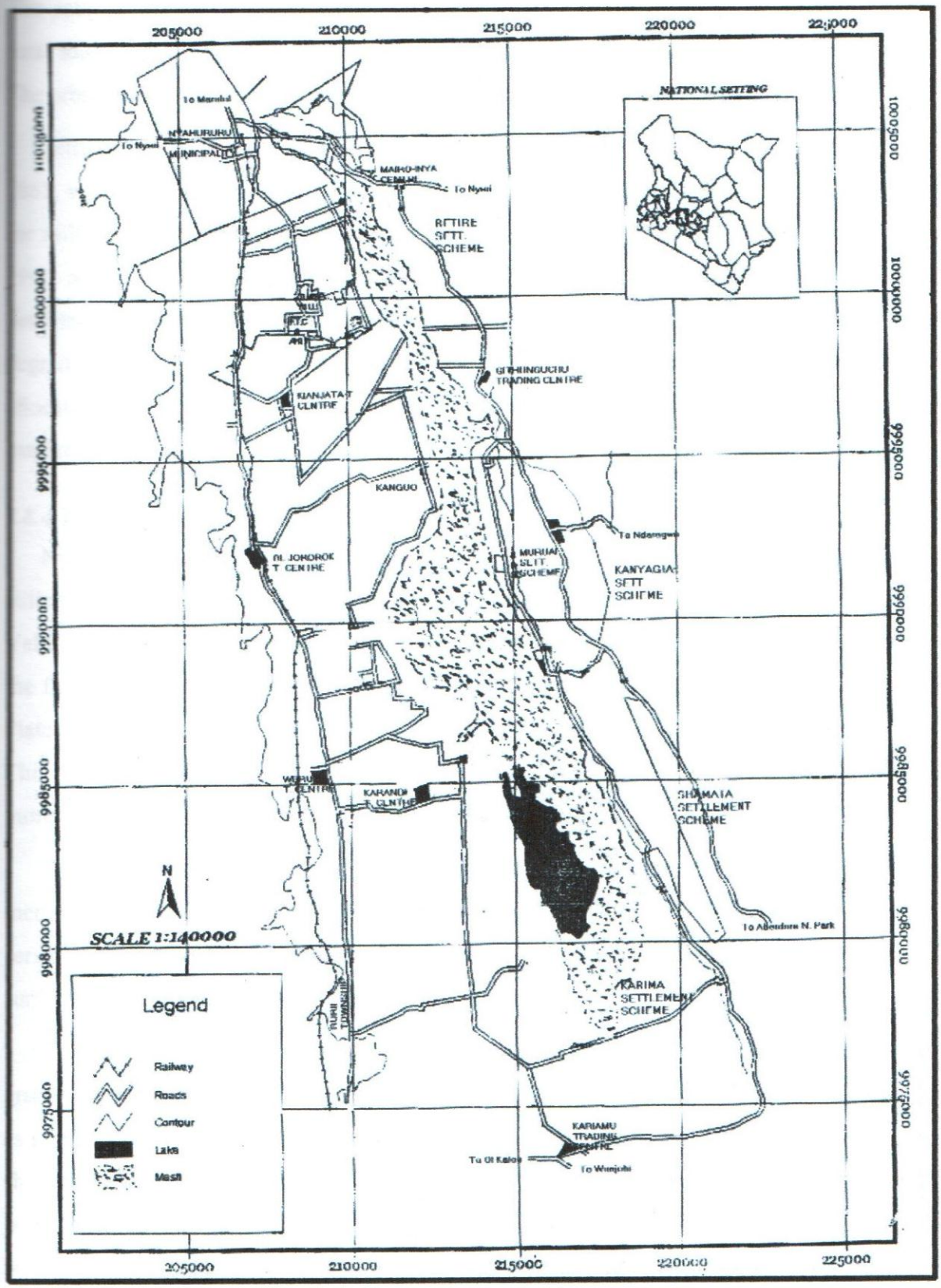


Figure 3: Settlement Schemes around Lake Ol'Bolossat

Source: County Survey Nyandarua

The pattern is dichotomous in nature with both urban and rural settlements (Figure 3). The rural settlements are generally homogenous and engage primarily in agricultural production. The urban settlements are heterogeneous and engage mainly in commerce and industry.

Settlement schemes in Nyandarua County were initiated in 1960s and 1970s. Before 1965, white settlers who practised large-scale production of cereals and rearing of livestock for milk and beef production owned much of the land around Lake Ol'Bolossat. Between 1965 and 1985 the large-scale farms were sub-divided into smallholdings under the Settlement Fund Trustee (SFT). Land use has intensified considerably and environmental degradation has continued to rise as the plot holders sub-divide their plots for sale or for allocation to relatives. Land tenure trend reveals that land sizes have been decreasing in the catchment area as a whole.

2.8.4 Topography and Geohydrology

Nyandarua County varies in altitude from 3,999 metres above sea level on the Aberdare Hills to the south east of the county to 1,828 metres towards the floor of the Great Rift Valley. Nyandarua is made up mainly of the Aberdare Range where land drops westwards to the floor of Rift Valley around Naivasha. Most of the county is composed of the Kinangop Plateau and Ol Kalou Salient. Both are situated in the rain shadow of the Aberdare Ranges. This makes the rains decrease rapidly from the west, with annual average diminishing from more than 1,400 mm at the foot of the ranges to 700 mm in the Valley of Malewa River.

The lake lies in a basin that is bound by a weak faulting on the west developing increasingly to the south. The Ol'Bolossat plain near Ol Kalou is bounded on the west by a series of tilted fault blocks separated by more than a dozen fault scarps, which drop the land surface from the Bahati uplands into the Bahati plain.

The phonolites are the main type of rocks surrounding and underlying the Ol'Bolossat graben. These rocks and the other geological strata as well as the superficial deposits behave as aquifers. The underground water table is shallow and fresh water is readily obtained from shallow wells and boreholes. The recharge of the aquifers is mainly from local sources by percolation of rainfall downwards though fissures (Gichuki, 2002). Hydrological data from boreholes in the area indicate that there is groundwater movement into the Ol'Bolossat valley from the eastern, southern and western highlands (Gichuki, 2002).

2.8.5 *Socio-Economic Characteristic*

Communities living around Lake Ol'Bolossat are mainly farmers who own small-scale farms where they practice mixed agriculture. The main crops grown include maize, beans, peas, potatoes, vegetables and carrots (food crops) and pyrethrum, wheat and flowers for cash crops. They also keep animals especially cattle, sheep, donkeys and goats. A few farmers with access to water also practice irrigation agriculture. Sprinkler irrigation was initiated in the 1980s to increase vegetable production in the area. This is widely practiced along the Satima escarpment. They produce cabbages, carrots and tomatoes mainly for the local markets.

Over the last three decades, there has been rapid growth in population and increased intensification and expansion of agriculture activities. As a result much of the land surrounding the lake has been opened up for agriculture. Livestock owners in the surrounding areas use the wetland as a grazing area. It has also traditionally been used as the dry season grazing area by pastoralists from as far as Kajiado County (Mangat, 2001). However in the recent past there has been an increase in livestock grazing around the lake all year round. This is likely to cause overgrazing if there is no control of livestock numbers grazing around the wetland.

The lake's catchment has also been experiencing rapid deforestation (Gichuki, 2004: KWS and NWP, 2000). This has affected the flow of streams entering the lake and increased soil erosion. In addition some of the streams entering the lake have been obstructed for irrigation. These changes have resulted in the degradation of the wetland with siltation, pollution by agrochemicals and encroachment on the riparian land. The obstruction of streams entering the lake has been blamed for the decline of the lake. As a result the government issued a ban on obstruction of streams entering the lake in 1998 (KWS and NWP, 2000). However it is not enough for the government to issue edicts and bans. The communities surrounding the lake should be enlightened on the need to conserve the wetland.

2.8.6 Climate and Lake Water Levels

The study area lies on the equator and like the rest of Central Kenya; its climate is influenced by the inter-tropical convergence zone and local variation in elevation. Between March and April the southeast monsoon winds, which pick moisture from the Indian Ocean,

bring rains to Central Kenya. In central Kenya rainfall distribution is bi-modal (Figure 4) with peaks separated by 2 to 5 dry months from June to October (Gichuki, 2002).

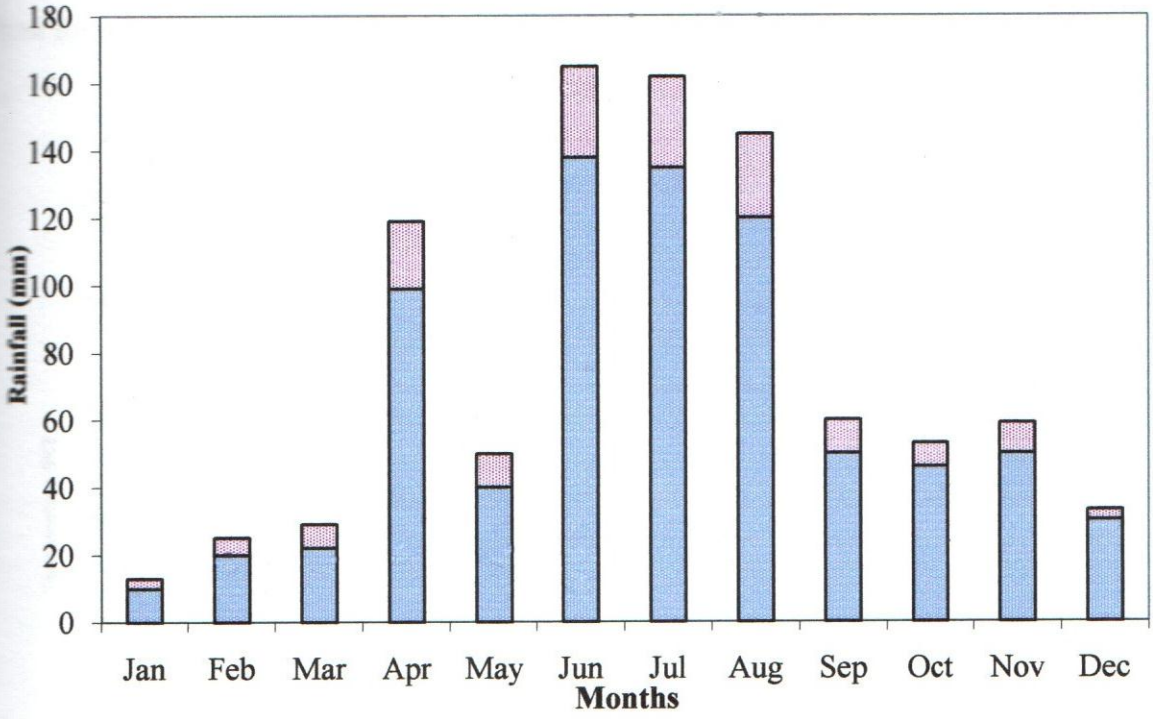


Figure 4: Mean Monthly Rainfall at Lake Ol'Bolossat

Based on a period of 10 years (1999- 2009). The Bars on top indicate rainfall standard deviation. Source Meteorological Department.

The study area is located in the rain-shadow of the Nyandarua Mountain Range. For this reason, the precipitation decreases from east to west with the annual average diminishing from more than 1400mm at the foot of the Nyandarua Range to 700mm in Malewa River Valley (Jaetzold and Schmidt, 1983). The northern part the region (Laikipia Plateau) is drier than the southern part, which is closer to the mountain range.

Temperatures vary with altitude and local wind patterns. Mean air temperatures decrease with increase in altitude. The period between January and March is usually the hottest with mean maximum temperatures of 23 to 25^{0}C while July, August November and December are the coolest with the mean maximum temperatures of 19 to 21^{0}C.(Figure 5) The corresponding mean minimum temperatures for the hot and cold periods are 6 to 8^{0}C and 4 to

7°C respectively. Extremely cold winds originating on the moorland of the Nyandarua Range flow to Ol'Bolossat valley and become hazardous to cultivated crops especially maize and other grasses. The cold winds are trapped in the valley and hence the area experiences night frost for nearly every month of the year (Gichuki, 2002).

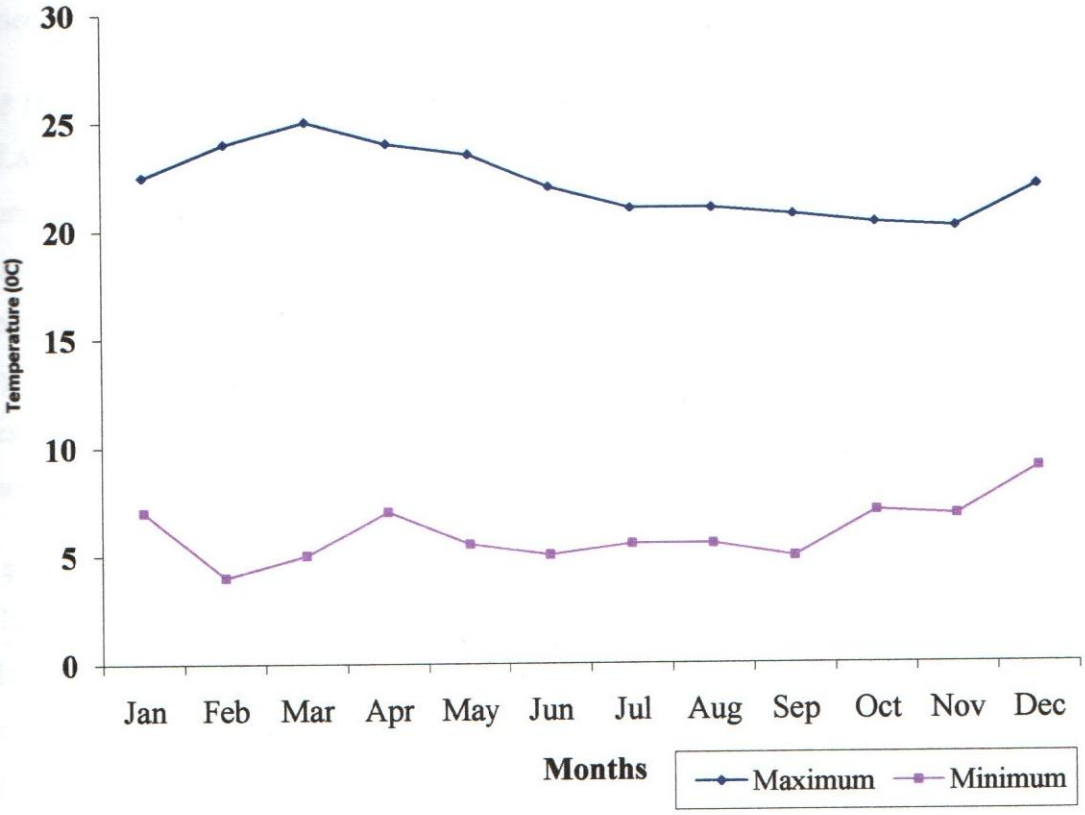


Figure 5: Mean Maximum and Minimum Monthly Temperatures at Lake Ol'Bolossat

Based on a period of ten years (1999-2009). Source: Kenya Meteorological Department, Nairobi

2.8.7 Vegetation

The area around the lake is dominated by grass vegetation. In the well drained areas grass vegetation is dominated by *Sporobolus* spp. In the poorly drained areas the swamp vegetation is the dominant plant community covering 46% of the total area of the basin (Gichuki, 2002). The main plant species here are *Pharalis arundinacea*, *Cyperas latifolia*, C. *stuhlmanii* and C. *rotundus*. *P. arudinacea* occurs in clumps. *Cyperas limmensus* grows on the mudflats.

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Water lilies *Nymphaea caerulea* and *Najas pectnata* grow in the open waters especially where streams enter the lake. Species of grass such as *Ludwiga stolonifera* grow suspended in water but rooted in mud. The noxious weed *Salvinia molesta* occurs in very small quantities in the northern part of the lake where water is available throughout the year. The slopes of Satima escarpment once covered by natural woody tree species such as Podo Spp and Red cedar vegetation are now dominated by bushes with large parts of the former forest opened up for crop farming.

2.8.8 Wild Life

Lake Ol'Bolossat is rich in biodiversity and over 185 bird species have been recorded around the lake (Gichuki, 2004). Among these were thirty Palaearctic and 15 Afro tropical migrant species (KWS and NWP, 2000). The lake is also home to a sizeable population of hippopotamus. Information obtained from key informants indicated that in the 1970s and early 1980s the area had large numbers of Thomsons Gazelles, zebras, warthogs, jackals, foxes, wild pigs, leopards and other wild herbivores which have however disappeared from the area.

2.8.9 Ownership of Lake Ol'Bolossat Wetland

Before independence the land around Lake Ol'Bolossat was owned by white colonial settlers who practices large scale wheat, dairy and beef farming. Just before independence, a number of the white settlers vacated the land to pave way for African settlers. Initially five settlement schemes, Ol Joro Orok, Kirima, Murai, Salient, and Ol'Bolossat were demarcated around the lake under the Settlement Fund Trustee (Figure 3). The Lake and the riparian land are owned by the Settlement Fund Trustee (SFT). There have been efforts to gazette the area as protected area but these have not been successful. There have also been efforts to transfer the land from SFT to Trust Land which have also not been successful (KWS and NWP, 2000).

2.9 Conceptual Framework

Figure 6 indicates the conceptual framework for the study. The arrow (⟶) indicates the direction of the effects and the (+) sign indicates positive impact on the other variable. The conceptual framework postulates a positive relationship between households' environmental

perception and awareness and the intervening variables (crop husbandry practices, irrigation practices, forest resource use, grazing practices and socio-economic status). A household with high environmental perception will undertake positive crop husbandry practices such as use of farmyard manure, contour cropping and soil conservation measures that would impact positively on the ecosystem and consequently on the wetland ecosystem. Households with higher disposable income are more likely to invest in soil conservation measures and hence impact positively on the ecosystem. Similarly household heads with higher levels of education will have a higher environmental perception and environmental awareness and therefore act positively towards the environment.

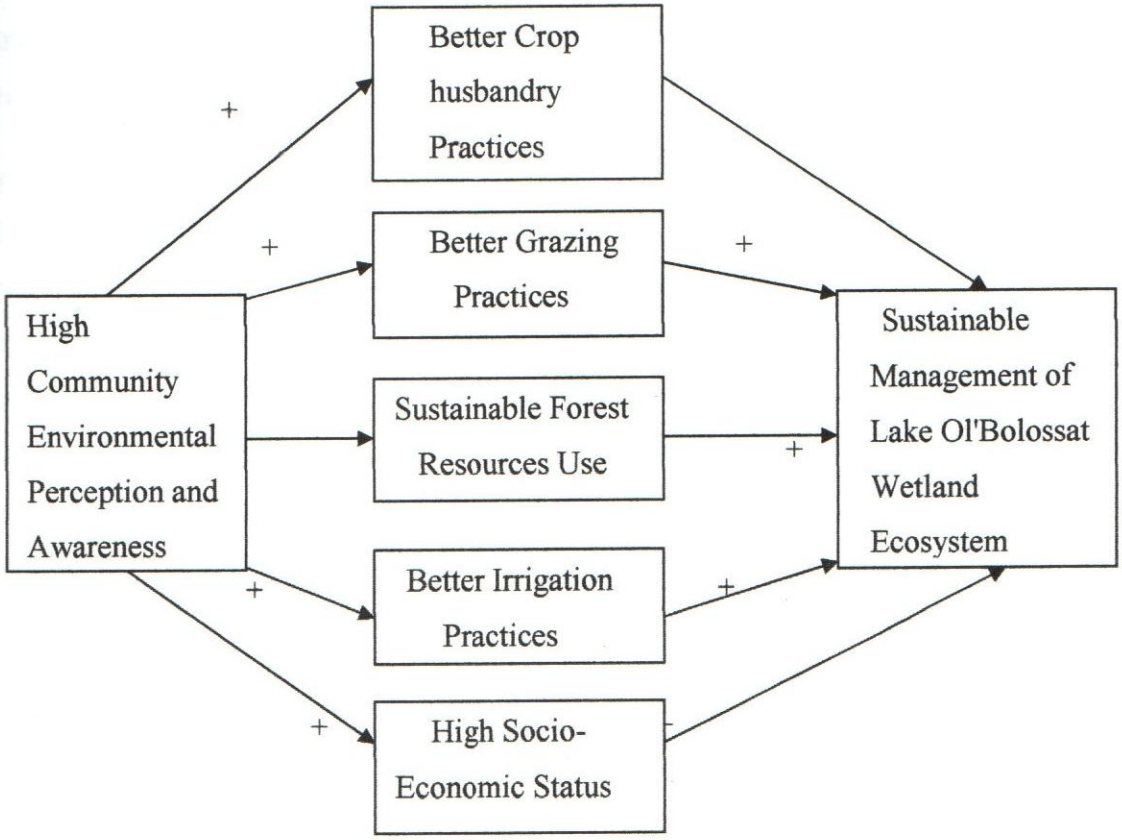


Figure 6: Conceptual Framework

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter gives a general description of the methodology used in data collection and analysis in the study

3.2 Research Design

The study was a cross-sectional survey that involved the administration of a semi-structured questionnaire to the sampled respondents. Key informants were also interviewed to elicit information on the issue under investigation. The study also involved personal observation and also integrated the use of satellite imagery to complement information collected through the survey.

3.2.1 Questionnaires

Questionnaires consisting of structured and semi-structured, open-ended and closed-ended questions were administered to household heads constituting the sample (Appendix 1). Through the use of questionnaires, socio-economic information was sought. They were used to collect information on land use, land tenure among other important issues. The questionnaires were also used to elicit information on environmental perception and awareness. The questionnaires were administered after being pre-tested to ensure that they elicited reliable, valid and fairly accurate data. The survey was conducted among households in localities adjacent to the wetland as these have a greater impact on the wetland.

3.2.2 Key Informant

Key informants were selected from stakeholders. They included prominent persons in the study area; holding key positions, with knowledge and experience of the history of the issues revolving around the wetland. These included the County Environmental officer, officers from KWS, SFT, community leaders, and representatives of Non Governmental Organisations among others. Key informants were interviewed using a semi-structured questionnaire. (Appendix 2)

3.2.3 Personal Observation

The researcher made observations in the study area. This approach was important in comparing the reported information with the actual occurrences on the ground. It was used to assess variables like slope, soil conservation practices among others.

3.2.4 Secondary Data

Collection of secondary data was done throughout the course of the research. This entailed collection of data from government sources, information on the wetland from books, and journals among others.

3.2.5 Satellite Imagery

This technique was used for comparison between the respondents' perception of the changes in their environment and the actual changes. The technique entailed comparing recent satellite images covering the study area for the year 2000, 2006 and images taken in 1986. Composite imageries were used to determine the changes in vegetation cover in the study area. Satellite imageries were analysed using ENVI computer software for image analysis.

3.3 Sampling

3.3.1 Sampling Frame

The total number of households surrounding the wetland constituted the sampling frame. The unit of analysis was the household and the subject of analysis was the household head.

3.3.2 Sample Size

According to Rees (1995) the sample size to be used should be based on the following formula:-

$$S = \frac{X^2NP(1-P)}{d^2(N-1)+X^2P(1-P)}$$

S=required sample size

N=Sample proportion which is favoured in the population to give 95% confidence level

d= Degree of accuracy which is reflected by the amount of error that can be tolerated in the fluctuation of sample proportion P

χ^2= Chi-square value corresponding to one degree of freedom relative to the desired confidence level

The two districts bordering Lake Ol'Bolossat wetland had a population of 150,474 people by 1999 (Table 2.1) with the average household size of 8 persons per household. This works out to a population of 18,810 households. The required degree of accuracy was 0.002, a sample proportion of 20% (0.2) and chi-square value of 0.016 at 0.01 or 99% confidence level. Substituting the values into the equation:-

$$\text{Sample size} = \frac{0.016(18,810)(0.2)(1-0.2)}{0.002^2(18,810-1)+(0.016)(0.2)(1-0.2)}$$

= 618.9 which adjusted upwards comes to 619

However owing to limitation of time and funds, 230 household were sampled which represents 37% of the calculated sample. After data collection 7 questionnaires were discarded due to errors which reduced the actual sample size to 223.

3.3.3 Sampling Procedure

Households in the two main districts within which Lake Ol'Bolossat is located constituted the population. Stratified systematic random sampling method was applied to obtain a sample of households to whom the questionnaire was administered. Settlement schemes neighbouring the lake and within 3 kilometres off the lakeshore in the two districts constituted the strata on which systematic random sampling was carried out. Every tenth farmer in the strata was sampled for interviewing. Where the farmer was not available the next farm was selected.

3.4 Operationalisation of Variables

3.4.1 Household Head

In this study the household head referred to the person whether male or female heading a given household. The questionnaire was administered to those household heads constituting the sample. Where the household head was not available, his wife was interviewed instead.

3.4.2 Environmental Perception

Environmental perception was the respondent's judgement of the changes in severity of specific environmental problem in the study area. It was assessed through their judgement of changes in following indicators relative to 10 years earlier. Change in soil fertility, soil erosion, water quality and availability, vegetation cover, fodder, abundance of birds and wild animals. These were scored at three levels as shown in Table 3.1.

Table 3.1: Environmental Perception Scores

Factor	Better/More	Same	Less
Soil fertility	1	2	3
Soil erosion	1	2	3
Water availability	1	2	3
Grass cover	1	2	3
Tree cover in forests	1	2	3
Forest resources (firewood, posts etc)	1	2	3
Abundance of birds	1	2	3
Abundance of wild animals	1	2	3

3.4.3 Environmental Awareness

This was the respondent's level of knowledge of environmental issues. It was based on local environmental issues rather than international environmental issues. An index was computed to assess the level of environmental awareness of the household heads living adjacent to Lake Ol'Bolossat on the environmental impacts of socio-economic practices on the lake's ecosystem and the environment in general. Each household head was asked some questions which examined their level of knowledge about the effects of selected socio-economic practices on the local environment (water, soil, wildlife). The responses were scored on a scale of 1 to 5. A score of environmental awareness index was computed by summing up the response to the component items

3.4.4 *Socio-Economic Status*

This was the respondent's social standing in the community. Six indicators were used to determine socio-economic status: level of education, community leadership roles, level of income and number of sources of income, land size and land tenure. The level of education was assessed by determining the number of years spent in schools for formal education, and was scored from 1 to 5. Land holding was categorised and scored into five levels. Land tenure was assessed on the basis of permanency of land ownership. Community leadership role was determined from selected types of roles performed by individuals at the community level. Sources of income were scored based on their number. Each source of income scored 1 point. From all these indicators an index of socio-economic status was generated for use as a single variable for regression and correlation analysis. Tables 3.2, 3.3, 3.4, 3.5, and 3.6 show the scoring of various indicators

1. **Scoring for Level of Income**

Table 3.2: Level of Income

Income per Year (KShs.)	Score
<15,000	1
15,001-30,000	2
30,001-45,000	3
45,001-60,000	4
>60,000	5

2. **Scoring for Community Leadership Roles**

Table 3.3: Community Leadership Roles

Role	Score
No Role	1
Community Leader	2
Religious Leader	3
Civil Servant\Teacher	4
Politician	5

3. **Scoring for Land Tenure**

Table 3.4: Scoring for Land Tenure

Land Tenure	Score
Squatter	1
Borrowed	2
Rented	3
Owned but no title Deed	4
Owned With Title Deed	5

4. **Land Holding**

Table 3.5: Land Holding Size

Land Size (acres)	Score
<0.5	1
0.6-5	2
5.1-10	3
10.1-15	4
>15	5

5. Level of Education

Table 3.6: Level of Education

No of Years	Score
0	0
1-4	1
5-8	2
9-12	3
13-14	4
>15	5

6. **Sources of Income:** Each source of income was scored 1 point

3.4.5 Crop Husbandry Practices

Crop husbandry practices referred to routine rain-fed crop management practices. These were measured based on their potential impacts on the environment. They included use or non-use of chemical fertilisers and pesticides, slope of main cultivated land, soil conservation measures, and the size of cropland. The slope of main cultivated land was the farmers' perceptions of the slope of his/her main cultivated land. This was scored at five levels ranging from 1 for flat land to 5 for very steep land. Soil conservation was evaluated depending on the measures a farmer had employed in his/her farm for the last five years. Each method used scored one point. Together these sub-variables made up an index for crop husbandry practices for use as a single variable. Table 3.7 shows how the slope of the cultivated land was scored.

1. **Fertilisers:** Use or non-use of fertilises (1-non-use, 2-use).

2. **Pesticide**: Use or non-use of pesticides (1-non-use, 2-use).

3. **Slope of Cultivated Land**

Table 3.7: Slope of Cultivated Land

Slope	Score
Flat	1
Gentle slope	2
Moderate slope	3
Steep slope	4
Very steep	5

4. **Soil Conservation Measures**

These included planting of trees, construction of terraces, grass and or napier-grass strips, fallow strips, intercropping, and trash lines. Each method used in the last five years earned a point.

3.4.6 Irrigation Practices

Irrigation practice in this study referred to the process of artificially providing water to a crop. Irrigation practice was assessed through five items: irrigation method, irrigated area and irrigation frequency, irrigation duration, and source of irrigation water. Irrigation methods

were scored based on their water wastage potential on a scale of 1 to 4. Irrigated area was the actual irrigated area in acres. Irrigation frequency was assessed on the number of days a farmer watered his crop per week. This had scores ranging from 1 to 7. Source of irrigation water had scores ranging from 1 to 4. Irrigation duration was measured the number of month irrigation was practiced per year. This had scores ranging from 1 to 12. An index of irrigation practices was computed from the five items. Tables 3.8 and 3.9 show how irrigation method and Source of irrigation water were scored.

1. **Irrigated area**: Acreage of irrigated land
2. **Irrigation frequency**: The number of days a farmer watered his crops in a week (1-7).
3. **Irrigation Method**

Table 3.8: Irrigation Method

Method	Score
Drip	1
Sprinkler	2
Flooding	3
Others	4

4. Source of irrigation water

Table 3.9: Source of irrigation water

Source	Score
Borehole/pan/well	1
River/stream	2
Lake/wetland	3
Others	4

5. Duration of irrigation: Number of month irrigation is practiced per year (1-12)

3.4.7 Grazing Practice

Grazing practices in this study referred to a household's livestock management activities within the lake's catchment. The amount of land a household had under pasture, the number

of Tropical Livestock Units (TLU) owned, the grazing system used and the main sources of feeds was used to compute a grazing practice index. One TLU equivalent was equal to mature cattle of 250 kg weight (Herlocker *et al,* 1994*)*. For small stock, 6 sheep or goats were considered the equivalent of one TLU. Sources of feeds were scored on a scale of 1 to 3. The acreage of pasture owned was used to measure pasture.

3.4.8 Forest Resource Use

Forest Resource Use (FRU) in this study referred to the household use of forest resources from within the lake's catchment. This was determined by parameters like whether a household had opened up land from forest for cultivation and the use or non-use of fuel wood, charcoal and construction material or other forest resources. Table 3.10 gives the scoring of various FRU indicators. An index of FRU was made from these indicators.

Table 3.10: Forest Resource Use

Item	No	Yes
Land opened from forest (acreage)		
Firewood	0	1
Charcoal	0	1
Construction materials	0	1
Others (specify)	0	1

3.4.9 Degradation Index

A degradation index was computed from the following five factors: soil fertility practices, distance of main farmland unit from the shores of the lake, grazing pressure, amount of cropland opened from forest and amount of land reclaimed from the swamp. Soil fertility practices were scored on a scale of 1 to 3. Distance of the main farmland unit from the shores of the wetland was scored on a scale of 1 to 3. Grazing pressure was based on the recommended stocking rates of 2 hectares per livestock unit in the area. TLUs in excess of a households land carrying capacity represented the grazing pressure the household exerted on the wetland. These scores combined constitute the degradation index. Tables 3.11 and 3.12 show how soil fertility and distance from the lake were scored.

1. **Amount of land opened from forest:** This was assessed by acreage of land opened.
2. **Soil Fertility Practices**

Table 3.11: Soil Fertility Practices

Soil Fertility Method	Score
Compost manure	1
Chemical fertilisers	2
Burning of litter	3

3. **Distance from the Lake**

Table 3.12: Distance from the Lake

Distance from the Lake	Score	Impact
<1 Km	3	High
1-3 Km	2	Moderate
>3 Km	1	Less

3.5 Data Analysis

After collection, the data was coded, entered and processed to remove outliers. Indices for various variables (EP, EA, CHP, IP, SES and DI) were computed for use in statistical analysis. The data was analysed using Statistical Package for Social Sciences (SPSS) version 10. Both descriptive and analytical procedures were used. Descriptive analysis included the use of frequency tables, cross-tabulations and measures of central tendency and dispersion (means, range, standard deviations and variances). Analytical procedures to determine relationships between and among variables were carried out. Correlation and regression analysis were carried out for continuous variables. Categorical variables were analysed using cross-tabulations. Independent sample t-test was used to compare means between different groups.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents both descriptive and analytical results of the data collected. The results of hypothesis testing are also presented.

4.2 Results of Descriptive Analysis

Descriptive analysis was carried out on some of important variables including socio-economic characteristics of respondents, environmental perception and environmental awareness among others.

4.2.1 Socio-economic Characteristics of the Respondents

A number of socio-economic aspects of the respondents were sought through the questionnaire. These included the age of respondents, gender, marital status, farm size, education level, and annual income.

4.2.1.1 Age

The age of the respondent was measured as the number of years lived. Their ages ranged from 17 to 80 with the mean age of 41 years. 46 % of the respondents were youth (35 years and below). Table 4.1 shows the ages in categories.

Table 4.1: Categorised Age

Age Categories (years)	Frequency	Percent	Cumulative Percent
<=25	31	14	14
26-35	72	32	46
36-45	45	20	66
46-55	28	13	79
56-65	31	14	93
66-75	13	6	99
>=76	3	1	100
Total	223	100	

Source: Field Data

4.2.1.2 Gender

In terms of gender there were 142 males and 82 females. The research had household heads as the subject of analysis. This would seem to suggest that 37 % of the households are female-headed households and only 63 % of the household to be male-headed households. However, only 7% of the households were female-headed households. The high number of female interviewees was due to the fact that some male household heads were away at the time of the interviews and their wives were interviewed instead.

Table 4.2: Sex of Respondents

Gender	Frequency	Percent	Cumulative Percent
Male	141	63	63
Female	82	37	100
Total	223	100	

Source: Field Data

4.2.1.3 Marital Status

Four categories of marital status were identified, single, married, divorced, and widowed. The majority (74 %) of the respondents were married as shown in Table 4.3.

Table 4.3: Marital Status of Respondents

Marital Status	Frequency	Percent	Cumulative Percent
Single	38	17	17
Married	166	74	91
Divorced	6	3	94
Widowed	13	6	100
Total	223	100	

Source: Field Data

Table 4.4 shows a cross tabulation of marital status with the sex of respondents. The Table shows that all the widowed respondents were females.

Table 4.4: Cross-Tabulation of Marital Status and Sex of Respondents

Marital Status	Sex of respondent		Total
	Male	Female	
Single	32	6	38
Married	107	59	166
Divorced	2	4	6
Widowed	0	13	13
Total	141	82	223
% Of total	63.2%	36.8%	100.0%

Source: Field Data

4.2.1.4 Education Level

Education was evaluated as the number of years completed in formal education. These were categorised into five groups. The average education level was primary class eight. Only a small proportion (23 %) of the respondents had more than primary education as shown in Table 4.5.

Table 4.5: Education Levels of the Respondent

Categorised levels	Frequency	Percent	Cumulative Percent
0-4	52	23	23
5-8	119	53	76
9-12	42	19	95
13-14	2	1	96
=>15	8	4	100.0
Total	223	100.0	

Source: Field Data

4.2.1.5 Farm Sizes

The amount of land owned varied from 0.25 acres to 15 acres with the mean farm size of 3.8 acres. Close to a half (47 %) of the respondents owned less than 2.5 acres. The majority (80 %) owned up to five acres and only a small proportion (8 %) of the respondents owned more than 7.5 acres as shown in Table 4.6.

Table 4.6: Categorised Farm Sizes

Land size (acres)	Frequency	Percent	Cumulative Percent
<=2.5	105	47	47
2.6-5.0	73	33	78
5.1-7.5	28	13	92
>7.5	17	8	100
Total	223	100	

Source: Field data

4.2.1.6 Annual Income

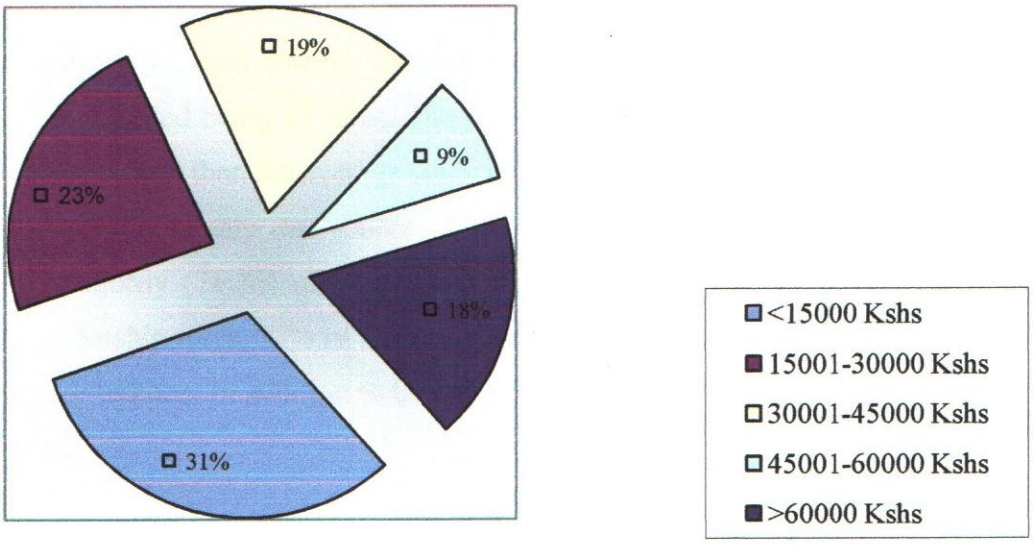


Figure 7: Distribution of Income in Categories

Figure 7 shows the percent distribution of income grouped in categories Annual income varied from a minimum of KShs. 2,000 to KShs. 387,000 with a mean of KShs. 42,632.

More than 55% of the respondents earned less than the mean annual income as shown in figure 7 below. From the data 31 % of the respondents lived below the poverty line (<15,000 Shillings annually). This compares well with the 1997 Welfare Monitoring Survey, which found 31% of the rural population in Central region living below the poverty line (Republic of Kenya, 2001.)

4.2.2 Socio-Economic Status (SES) Index

Socio-economic status referred to the respondents' social standing in the community. The socio-economic status (SES) index was constructed from the following six indicators: (1) Education level; (2) Annual income; (3) Number of sources of income; (4) Community leadership roles; (5) Amount of land owned and (6) Land tenure. Each of the indicators was organized into ordered categories with each category being coded to emphasize their relative value. The indicators were coded with scores ranging from 1 to 5 for the various categories.

In terms of education 23 % of the respondents had less than 4 years of formal education while only 4 % had more than 15 years of formal education. The average level of education was primary class 8 and only 5 % of the respondents had more than secondary school education. In terms of income the lowest annual income recorded was KShs. 2000 while the highest recorded was KShs. 387,000. The mean annual income was KShs. 42, 632 with 67% of the respondents below the mean and 33% above the mean.

On the amount of land owned, the minimum size of land was 0.25 acres with the maximum size recorded being 15 acres. The average land size was 3.8 acres and 57% of the respondents owned less than the average land size. For the number of sources of income,18% of the respondents had only one source of income while 8 % had 3 or more sources of income. The majority (74 %) of the respondents) had 2 sources of income. In terms of community leadership roles, 77% of the respondents were merely farmers and 7% were also civil servants or teachers in addition to being farmers. The rest were either church leaders or village elders

4.2.3 Environmental Perception Index (EP)

Environmental Perception referred to respondents' judgement of changes in the severity of selected environmental problems, that is whether the problem were worsening or not. Their perception was sought from a wide range of environmental problems including soil erosion, wild animal populations, and even forest cover. After factor analysis and reliability

analysis of the various items for which perception was sought, an index of environmental perception (EP) was constructed from six items, namely: farmers perception of changes in: (1) productivity of their cropland; (2) water quantity in rivers, streams, springs, wells and the lake; (3) forest cover; (4) soil erosion problem; (5) vegetation cover and (6) populations of wild animals. The variables had a Cronbachs alpha value of 0.70

Table 4.7: Respondents Perception of Selected Environmental Problems

Environmental factor	Increased (%)	Same (%)	Decreased (%)
Changes in soil erosion	57	13	30
Changes in vegetation cover	19	13	68
Change in productivity of cropland	13	18	69
Changes in water quantity	10	15	74
Changes in wildlife populations	13	10	77
Changes in forest cover	6	15	79

Source: Field data

The household heads were asked to report their perception of changes in severity of the problems from questions asking if the problem or environmental indicator had in their view increased, remained the same or had decreased over the last ten years. 57% of the respondents perceived an increase in soil erosion, 68% indicated a decline in the vegetation cover, and 70 % indicated perceiving a decline in productivity of their cropland. 74 % of the respondents perceived a decline in water quantity from various water sources, 77% perceived a decrease in wild animal populations and a majority of 79 % perceived a decline in forest cover (Table 4.7). The high perception of forest cover was confirmed by analysis of satellite images (Figure 8). The perception data based on the six items described above suggest a high perception of environmental problems by the farmers.

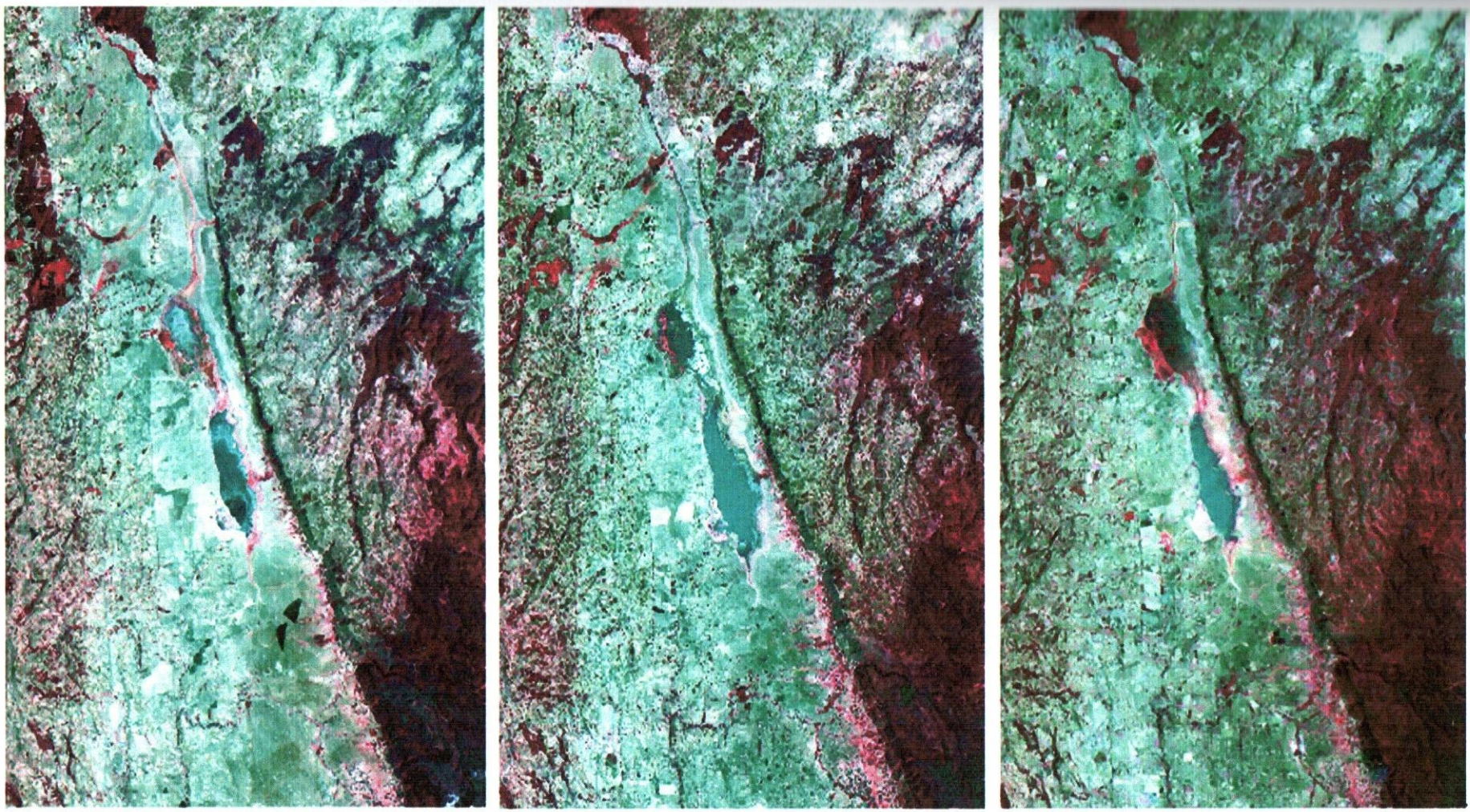
Table 4.8 shows the distribution of values of the environmental perception index. Since the six constituent items were re-coded from 0 to 2 with 0 for increase in the environmental indicator, 1 for no perceived change and 2 for a decline in the environmental indicator, the least value for the index can be 0 while the highest can be 12. The distribution of the index indicates that only 1 % respondents scored the lower environmental perception index of 2,

while 3 % of the respondents recorded the highest score of 12. The mean score was 8.6 with 57 % of the respondents scoring higher than the mean score. This indicates a slightly higher than average perception of environmental problems.

Table 4.8: Distribution of Environmental Perception Index

Value	Frequency	Percent	Cumulative Percent
2.00	2	1	1
3.00	3	1	2
4.00	6	3	5
5.00	12	5	10
6.00	17	8	18
7.00	27	12	30
8.00	29	13	43
9.00	36	16	59
10.00	33	15	74
11.00	51	23	97
12.00	7	3	100.0
Total	223	100.0	

Source: Field data



January 1986 January 2000 January 2006

Figure 8: Satellite Images of the Study Area for 1986, 2000 and 2006
Source: Global Land Cover Facility

4.2 Environmental Awareness

Environmental awareness in this study referred to the respondents' knowledge of local environmental issues. Environmental awareness had been sought from a wide range of issues including awareness on the effects of agrochemicals on the environment, effects of overgrazing among others. After factor analysis and reliability analysis of the various items for which awareness was sought, an index of environmental awareness was constructed from the following six indicators. Awareness of (1) Effects of obstruction of streams entering the lake; (2) Effects of overgrazing on soil erosion: (3) effects of use of pesticides on the environment; (4) effects of chemical fertilizer use on the environment and (5) effects of deforestation on the environment.

The respondents were asked to agree or disagree with statements touching on the indicators. Each correct answer earned a score of 2; every wrong answer scored a 0 while those not certain earned a score of 1. Table 4.9 shows results on environmental awareness.

Table 4.9: Respondent's Environmental Awareness

Awareness on	Correct%	Unsure%	Wrong%
Effects of overgrazing on soil erosion	38	15	47
Effects of obstruction of streams entering the lake	51	19	30.0
Effects of pesticide use on the environment	53	32	15
Effects of fertilizer use on the environment	56	22	22
Effects of deforestation on the environment	74.	16	10

Source: Field data

Of all the respondents 51% were aware about the effects of stream obstruction, 56% were aware of the effects of fertilizer use on the environment, 53 % were correct on the effects of pesticide use, 74 % were correct on the effects of deforestation and only 39 % were aware of the effects of overgrazing on soil erosion. From the data, on average more than 50% of the respondents scored correctly on most issues. However on the effects of overgrazing on soil erosion only 38 % were correct while 62 % of the respondents were either unsure or wrong. This indicates a lack of understanding of the relationship between overgrazing and soil erosion.

Table 4.10 shows the distribution of the environmental awareness index. Since each of the five indicators was re-coded to score from 0 to 2, the index can range from 0 for all wrong answers to 10 for all correct answers. 1% respondents scored the lowest index of 0, while 13% respondents scored the highest score of 10. The mean score for the awareness index was 6.7 with 57 % of the respondents scoring above the mean and 43 % scoring below the mean. This generally represents a slightly higher than average environmental awareness.

Table 4.10: Distribution of Environmental Awareness Index Values

Value	Frequency	Percent	Cumulative Percent
0	2	1	1
2	4	2	3
3	7	3	6
4	27	12	18
5	28	13	31
6	31	14	45
7	27	12	57
8	57	26	83
9	9	4	87
10	31	13	100
Total	223	100	

Source: Field data

4.2.5 Crop Husbandry Practices

Crop husbandry practices in this study refer to the routine crop management activities carried out by farmers. These were evaluated based on their potential negative impacts on the environment. The crop husbandry practices index was computed from five indicators. (1) Soil fertility practices, (2) Use of pesticides; (3) Slope of cultivated land; (4) Soil conservation practices and (5) The size of cropland. Table 4.11 shows the distribution of farms with different slopes.

Table 4.11: Slope of the Cultivated Farm

Slope	Frequency	Percent	Cumulative Percent
Flat	41	18	18
Gentle slope	109	49	67
Moderate slope	71	32	99
Steep slope	2	1	100
Total	223	100	

Source: Field data

Of the farms surveyed 18% had a relatively flat slope, 49% had a gentle slope, 32% had a moderate slope while 1% had a steep slope. Of the farmers interviewed 2% did not practice any soil conservation, 20% had only one measure, 34% had 2 measures, 31% had in place 3 measures, 12.% had 4 measures and 1% had in place 5 soil and water conservation measures. In terms of soil fertility practices, 74% used chemical fertilisers in their farms, 73% used organic manure, 53% used both manure and chemical fertilisers, while only 3% used neither chemical fertilisers nor farm-yard manure to improve soil fertility as shown in Table 4.12.

Table 4.12: Cross Tabulation of Farmyard Manure and Chemical Fertilizers Use

			Chemical fertilizers		Total
			No	Yes	
Farmyard manure	No	% Of Total	3	23	26
	Yes	% Of Total	21	53	74
Total		% Of Total	24	76	100

Source: Field data

From the data 18 of the farmers burned crop residues in addition to using either chemical fertilisers, farm yard manure or both. The sizes of cultivated land varied from 0.25 acres to 9.0 acres with an average of 2.7 acres. 64% of the farmers used no pesticides in their farms.

The crop husbandry practice index constructed from the above variables ranged from 4.25 to 21 with a mean of 11.9.

4.2.6 Irrigation Practice

Irrigation practices in this study referred to the routine activities associated with provision of water to crops in irrigated agriculture. Irrigation practice was assessed through five indicators: (1) Irrigated area, (2) Irrigation Method, (3) Irrigation Frequency, (4) Irrigation Duration and (5) source of irrigation water. Irrigated area was the actual size of land irrigated in acres. Irrigation methods were assessed based on their potential to waste water; irrigation frequency refers to the number of days an irrigated crop is watered in a week. Irrigation duration refers to the number of months irrigation is practiced in a year.

Out of the sample population, 22 % of the respondents practiced some form of irrigation. The irrigated area varied from 0.125 acres to 3.00 acres with a mean of 0.7 acres. 35 of the farmers practicing irrigation used sprinklers while 14 used a bucket. Of those practicing irrigation 32 % used water from shallow wells, 8 % used water from water pans while 59% used water from streams. In terms of irrigation frequency, this varied from 1 day to 7 days with the majority watering their crops for only three days in a week. Irrigation duration varied from 1 month per year to 9 months per year with the majority irrigating for 3 months. The irrigation practice index varied from 11.25 to 43.75 with a mean value of 18.1.

4.2.7 Grazing Practice

Grazing practice referred to the household's livestock management activities. The grazing practice index was constructed from the following indicators; (1) Number of tropical livestock units (TLU) owned; (2) Grazing system used (3) main sources of feed and (4) Grazing pressure. Grazing pressure referred to the number of livestock units a household has in excess of their land carrying capacity. This represents the grazing pressure the household exerts on the wetland. One TLU equivalent was equal to a mature cattle of 250 kg (Herlocker *et al,* 1994) and for small stock, 6 sheep or goats were considered to be the equivalent of one TLU.

The amount of land under pasture varied from 0 acres to 11 acres with 43% of the respondents having no pasture of their own. The average pastureland owned was 0.9 acres. The number of cattle owned varied from 0 to 30 with a mean of 3. Number of sheep owned varied from 0 to 60 with an average of 8 sheep per household. The number of goats varied

from 0 to 10. The number of donkeys varied from 0 to 5. 10% of the interviewees had no livestock. The grazing practice index varied from 0 for those who did not have any livestock to 47.67.

4.2.8 Forest Resource Use

Forest resource use (FRU) referred to the household's use of forest resources. The FRU index was constructed from the following indicators: (1) Amount of land opened from forest for cultivation, (2) Use of firewood from local forests, (3) Use of Charcoal from local forests and (4) use of construction materials from local forests. The amount of cultivated land opened from forest was assessed as acreage of such land. The other indicators were scored 0 for non-use and 2 for use of such materials from the local forest. From the field data the amount of cultivated land opened from forest varied from 0 acres to 5.0 acres (Figure 9).

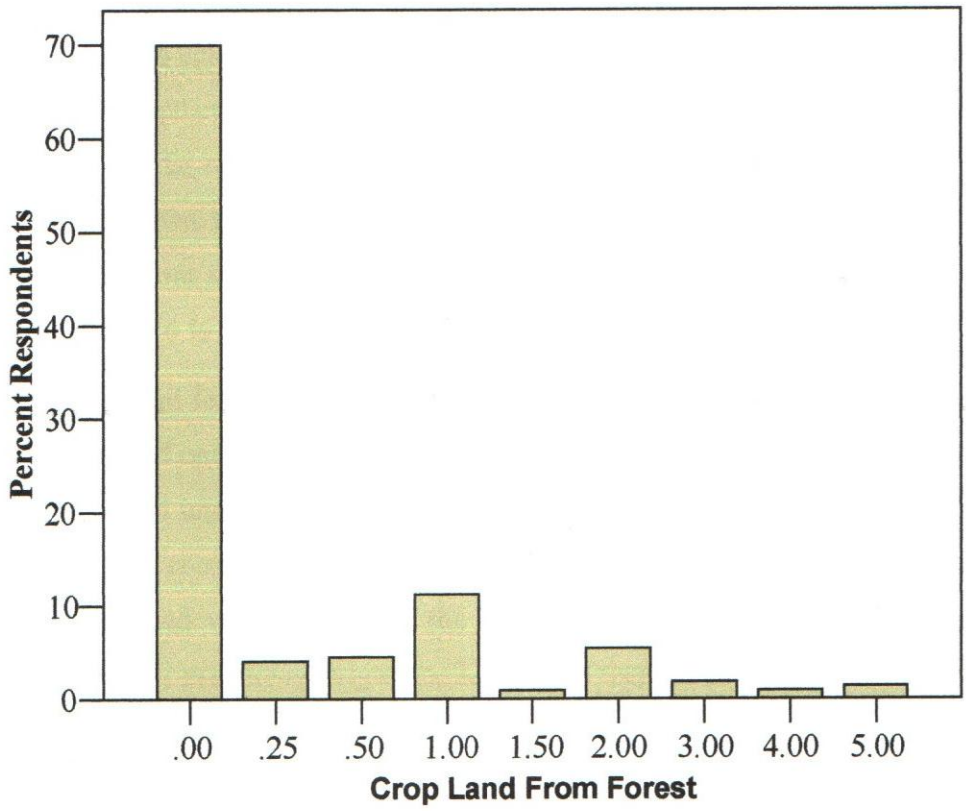


Figure 9: Distribution of Farmers (%) by Acres of Cropland Opened from Forest

Only a small proportion- 30% of the household sampled had some farms opened up from forest. 84 % of the respondents used one or the other of forest resource apart from land. The FRU index varied from 0 for those who had neither opened farm from forest nor used any

other forest resource from the public forest to the highest score of 7 with the mean value of 2.1

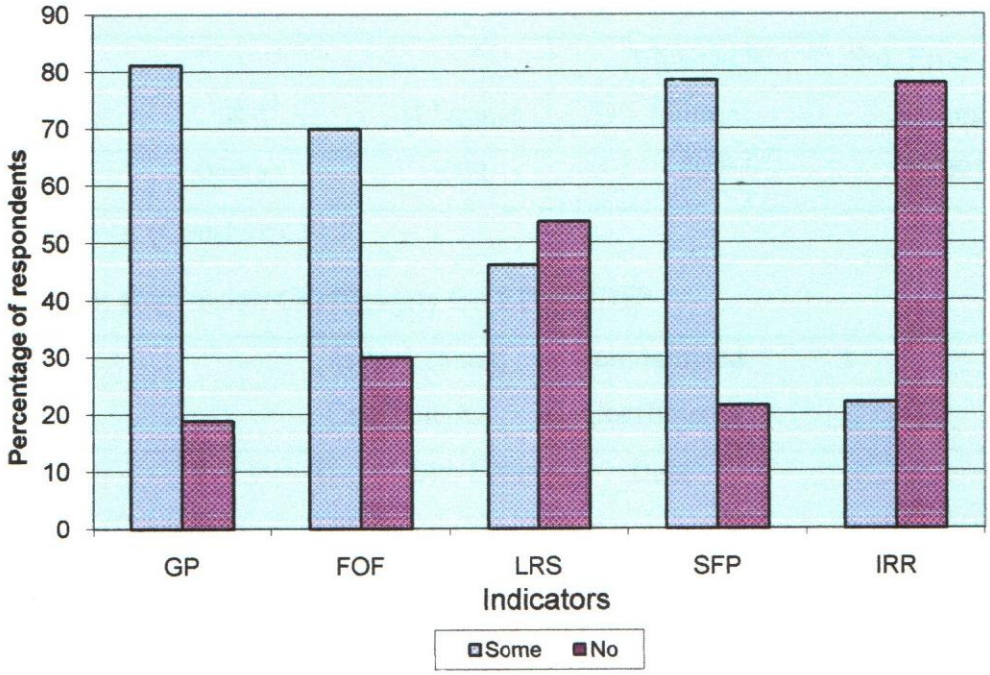
4.2.9 Degradation Index

Degradation index was derived from six indicators. (1) Soil fertility practice, (2) Distance of the main farmland unit from the wetland, (3) Grazing pressure, (4) amount of land reclaimed from swamp, (5) cropland opened from forest and (6) source of irrigation water. Distance of the main farmland unit from the shores of the wetland was re-coded and scored from 1 to 3. Grazing pressure was calculated based on the recommended stocking rates for the area. TLUs in excess of a household's carrying capacity represented the grazing pressure the household exerts on the wetland

The grazing pressure values ranged from 0 for those who did not own any livestock to 38.67 with a mean value of 4.2. Of the 223 interviewees, 81 % of them exerted some grazing pressure on the wetland. The amount of cultivated land opened up from forest ranged from 0 to 7.0 acres. Of the respondents interviewed, 70% of the respondents had not opened any farm from the forest while 30% of the interviewees had some land opened. The amount of land reclaimed from swamp ranged from 0 to 3.25 acres with a mean of 0.38 acres. Out of 223 respondents 46 % of them had some land reclaimed from swamp.

In terms of soil fertility, 22% of the respondent did not practice any form of soil fertility. All the others used one or several methods to improve soil fertility. In terms of the distance of the main farmland unit from the shores of the lake, 68% of the respondents lived within 1.0 kilometres off the shores of the lake, another 31 % lived within 2 kilometres from the wetland while the rest lived within 3 km of the lake. Irrigation was scored 0 for non-practice of irrigation and 2 for practicing irrigation. 22% of the respondents practiced irrigation.

Figure 10 shows the distribution of the respondents for various indicators for Degradation Index. The values of degradation index developed from these indicators ranged from 3 to 49. The mean value for the degradation index was 11.52 with 64% of the respondents below the mean.



GP-Grazing pressure: FOF-Farmland opened from forest: LRS-Land reclaimed from swamp: SFP-Soil fertility practice: IRR- Irrigation practice

Figure 10: Distribution of Respondents for Various Indicators of Degradation Index

4.3: Analytical Results and Hypotheses Testing

Five hypotheses were investigated in this study. To test these hypotheses regression and correlation analysis were done to evaluate relationships between the variables

4.3.1 Environmental Perception and Crop Husbandry Practices

The first study hypothesis postulated that households with high environmental perceptions would use crop husbandry practices that are less deleterious to the environment. To test the hypothesis a regression analysis of Crop Husbandry Practice (CHP) against Environmental Perception (EP) was done. Tables 4.13 and 4.14 show the results of the analysis. The analysis indicates that the model has standardized beta (β) coefficient of 0.06 which is not statistically significant ($p > 0.5$). From the results of the regression analysis, there is no significant relationship between Environmental Perception and Crop Husbandry Practice index. The negative sign on the coefficient of determination (R^2) indicates that with increased perception there is a decrease in deleterious crop husbandry practices despite not being significant.

Table 4.13 Model Summary Regression Analysis of EP on CHP

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.060(a)	.004	-.007	2.38974

(a) Predictors: (Constant), PEP

Table 4.14: Regression Coefficients for EP on CHP

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	9.994	.617		16.186	.000
	PEP	.063	.071	.060	.892	.373

Dependent Variable: Crop Husbandry Practice

To test this hypothesis further; a correlation analysis of the indicator items for environmental perception and constituent items for the crop husbandry practice index was carried out. The results of the correlation analysis are shown in Table 4.15. From the correlation analysis of the EP items with CHP items, some significant associations can be noted. One significant relationship is that between perception of changes in land productivity and soil fertility practices ($p < 0.05$ and $r = 0.125$). This positive association suggests that more farmers who perceive a decline in land productivity tend to practice some form of soil fertility. Other significant correlations include that between perception of changes in vegetation cover and water conservation practices ($p < 0.05$ and $r = 0.145$) and between perception of changes in forest cover and soil and water conservation practices ($p < 0.001$ and $r = 0.216$). This implies that those who perceived decline in vegetation cover or forest cover tended to undertake more water and soil conservation practices.

The relationship between soil erosion and soil and water conservation while insignificant ($p > 0.05$ and $r = -0.077$), suggests that high perception of soil erosion is associated with less soil and water conservation practices. This would on the surface appear contradictory. However this can be explained by the fact that those who had more soil and water conservation measures on their farms tended to experience less soil erosion on their farms and hence the less perception in soil erosion changes. Out of the thirty correlations between EP items and CHP items only ten are significant and only five are significant ($p < 0.01$.).

Table 4.15: Pearson Correlation Coefficients Between Indicator for EP and CHP

	Perception of Environmental Problems Items						Crop Husbandry Practice Items				
Items	1	2	3	4	5	6	7	8	9	10	11
1. Decline in land productivity	1.000										
2. Decline in water quantity	.167**	1.000									
3. Decline in vegetation cover	.122*	.231***	1.000								
4. Decline in forest cover	-.001	.180**	.107	1.000							
5. Decline in wild animal populations	.094	.100	.073	.238***	1.000						
6. Increase in soil erosion	.083	.211***	.280***	.078	.006	1.000					
7. Soil fertility practice	.125*	.027	-.069	-.160**	-.002	-.128*	1.000				
8. Cropland size	-.047	-.039	-.088	.247***	.091	-.090	-.017	1.000			
9. Pesticide use	.046	.109	.057	-.051	-.017	-.134*	.093	.253***	1.000		
10. Slope of cultivated farm	.071	.125*	.019	.256***	-.034	.169**	-.178**	.045	.063	1.000	
11. Soil and water conservation practices	.034	.057	-.050	.145*	.216***	-.077	.094	.208***	.267***	.145*	1.000

*** Significant at the 0.001 level (1-tailed).,**Significant at the 0.01 level (1-tailed).* Significant at the 0.05 level (1-tailed). N = 223

Based on the results regression analysis (Tables 4.13 and 4.14) and correlation analysis (Table 4.15) we fail to accept the alternative hypothesis (that Environmental Perception significantly influences Crop Husbandry Practices) and fail to reject the null hypothesis that there is no significant relationship between Environmental Perception and Crop Husbandry Practice.

4.3.1.1 Effects of Age and Education on EP

To determine whether there are any relationship between EP and Education level and the age of respondents, correlation analysis of EP, Education level and Age was carried out as shown in Table 4.16.

Table 4.16: Correlations of EP Index, Age and Education Level

Variables	Perception Index	Age in Years	Education Level
Perception Index	1.000		
Age In Years	-.176**	1.000	
Education Level	.193**	-.360**	1.000

** Correlation is significant at the 0.01 level (2-tailed).

The results of this analysis indicate a significant negative correlation ($p < 0.01$) between Environmental Perception index and Age. The negative (-) sign for this correlation indicates that perception decreases with age. This implies that the younger people have a higher perception of the changes in environmental problems than the older ones. This can probably be explained by the fact that the older people may have been experiencing these environmental problems for longer and therefore have become used to these problems such that they no longer perceive them as serious problems.

There is also a significant correlation between Environmental Perception and Education level. Those with more education tended to show higher Environmental Perception than those with lesser levels of education. The results also indicate a significant negative correlation between Age and Education level ($r = -0.360$ and $p < 0.01$). The younger people tend to have more education than the old. This could also explain the higher environmental perception among the young than among the old.

4.3.2 Environmental Perception and Household's Grazing Practices.

The second hypothesis postulated a significant relationship between Environmental Perception index (EP) and households' Grazing Practices (GP). To test this hypothesis regression analysis between EP and GP indices was done. The results of the analysis are shown in Tables 4.17 and 4.18

Table 4.17: Model Summary for Regression of EP on GP

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.068	.005	.000	5.72990

Predictors: (Constant), EP

Table 4.18: Regression Coefficients for EP on GP

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	6.654	1.480		4.495	.000
	PEP	.172	.169	.068	1.013	.312

Dependent Variable: Grazing Practice

From the results of regression analysis the beta (β) coefficient is not statistically significant ($p > 0.05$).

To test the hypothesis further, a correlation analysis between EP indicators and GP indicators was carried out. The results of the analysis are shown in Table 4.19. From the results of the analysis, only 5 out of 24 correlations were significant and only one at $p< 0.01$ and the other four at $p < 0.05$.

The results show a high positive association ($p < 0.01$) between perception of increased soil erosion and use of other sources of livestock feeds. The other significant associations are all negative indicating a decline in environment friendly grazing practices with increase in environmental perception.

Table 4.19: Correlation Matrix for Environmental Perception and Grazing Practice Items

	Perception of Environmental Problems Items						Grazing Practice items			
Items	1	2	3	4	5	6	7	8	9	10
1. Decline in land productivity	1.000									
2. Decline in water quantity	.167**	1.000								
3. Decline in vegetation cover	.122*	.231***	1.000							
4. Decline in forest cover	-.001	.180**	.107	1.000						
5. Decline in wild animal populations	.094	.100	.073	.238***	1.000					
6. Increase in soil erosion	.083	.211***	.280***	.078	.006	1.000				
7.Size of pasture land	-.008	-.003	-.111*	-.148*	.025	-.012	1.000			
8.Other sources of feeds	.012	.076	.028	.014	-.068	.162**	.040	1.000		
9.Tropical livestock units	-.043	.031	.100	.089	-.107	.002	.166**	.175**	1.000	
10.Grazing pressure	-.042	.034	.114*	.107	-.114*	.007	.061	.173**	.994*	1.000

*** Correlation is significant at the 0.001 level (1-tailed). ** Correlation is significant at the 0.01 level (1-tailed). * Correlation is significant at the 0.05 level (1-tailed). N (sample size) = 223

Based on the results of regression analysis (Tables 4.17and 4.18) and correlation analysis (Table 4.19) we fail to accept the alternative hypothesis that environmental perception significantly influences households' grazing practice and therefore fail to reject the null hypothesis that there is no significant relationship between environmental perception and a household's grazing practices. The correlation is however positive indicating an increase in households' grazing practices with increase in its environmental perception.

4.3.3 Environmental Perception and Forest Resources Use

The third study hypothesis postulates a significant relationship between environmental perception and a household forest resource use. To test this hypothesis a regression analysis between EP and FRU was carried. The results of the regression analysis are given in Tables 4.20 and 4.21.

Table 4.20: Model Summary for Regression of EP on FRU

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.118(a)	.014	.009	1.12999

a Predictors: (Constant), PEP

Table 4.21: Regression Coefficients for EP on FRU

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	.954	.292		3.267	.001
	PEP	.059	.033	.118	1.766	.079

a Dependent Variable: Forest Resource Use

The results of the analysis show a beta (β) coefficient of 0.118 which is however not significant ($p > 0.05$). From the result of the regression analysis there is no statistically significant relationship between EP and FRU. The beta coefficient is positive which implies that increased Environmental Perception results in more Forest Resource Use

Based on these results, we therefore fail to accept the alternative hypothesis that a households EP significantly influences on their FRU and its effects on the wetland quality and fail to reject the null hypothesis that a households Environmental Perception has no significant influence a household's Forest Resource Use and its effect on the quality of Lake Ol'Bolossat wetland.

4.3.4 Environmental Perception and Households' Irrigation Practices

The fourth hypothesis postulated a significant relationship between a household Environmental perception and a household irrigation practice. To test the hypothesis a regression analysis for EP on Irrigation Practice was carried out. The results of the regression analysis are given in Tables 4.22 and 4.23

Table 4.22: Model Summary for Regression Analysis for EP on IP

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.018(a)	.000	-.004	8.92852

a Predictors: (Constant), PEP

Table 4.23: Regression Coefficients for EP on IP

		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.477	2.314		1.935	.054
	PEP	-.072	.265	-.018	-.272	.786

Dependent Variable: Irrigation Practice

From the results of the regression analysis, there is no statistically significant relationship between Environmental Perception and a household's Irrigation Practices (β =-0.18) and ($p > 0.05$). However the negative relationship between EP and Irrigation Practice implies that household heads with high Environmental Perceptions tend to use irrigation practices that are less destructive to the environment.

Based on these results we fail to accept the alternative hypothesis that Households' Environmental Perception significantly influences the households' irrigation practices and

their effects on the quality of Lake Ol'Bolossat wetland and fail to reject the null hypothesis that a households Environmental Perceptions does not significantly influence the household's Irrigation Practice and its effect on the quality of Lake Ol'Bolossat wetland. An independent sample t-test was carried out to determine if there was any significance difference in the means of the degradation index between those who practiced irrigation and those who did not. The results of the analysis are shown in Tables 4.24 and 4.25. The results of independent sample t-test indicate that households that practice irrigation have on average higher degradation index than those who do not practice irrigation. The test is significant ($p < 0.01$) and a Levene's F value of 0.87.

Table 4.24: Group Statistics for Irrigation

	Irrigation	N	Mean	Std. Deviation	Std. Error Mean
Degradation Index	No	174	10.8821	6.5560	.4970
	Yes	49	13.8014	4.6178	.6597

Table 4.25: Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	df	Sig. (2-tailed)
Degradation Index	Equal variances assumed	.875	.351	-2.918	221	.004

4.3.5 Socio-Economic Status and Environmental Degradation

The fifth study hypothesis postulated a relationship between the households' socio-economic status and the degradation of the wetland. The assumption was that those with high socio-economic status would use more environmentally friendly practices. To test the hypothesis, a regression analysis between Socio-Economic Status and Degradation Index was done. The results are given in Tables 4.26 and 4.27.

From the result of the regression analysis SES had a significant relationship with the Degradation Index ($\beta = 0.479$ and $p < 0.001$) The R^2 of 0.122 implies that 12.7 % of the variability in the degradation index can be explained by SES.

Table 4.26: Model Summary for Regression Analysis for SES on DI

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	. 479 (a)	.126	.122	4.96891

a Predictors: (Constant), Socio-Economic Status

Table 4.27: Regression Coefficients for SES on DI

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.239	1.175		2.758	.006
	SES1	.496	.083	. 479	5.654	.000

Dependent Variable: Degradation Index

To test the hypothesis further a correlation analysis between Socio-Economic Status, Crop Husbandry Practices, Grazing Practices, Forest Resource Use, Irrigation Practice and Degradation Indices was carried out. The results of the correlation analysis indicate a significant relationship between a households' Socio-Economic Status and the Degradation index ($p < 0.001$ and $r = 0.479$) as shown in the Table 4.28.

From Table 4.28, SES is significantly and positively correlated to all the other variables (Grazing practices, Irrigation Practices, Crop husbandry Practices and Forest Resource Use). This implies that household's with higher economic status tended to cause more environmental degradation. The analysis also indicates livestock grazing practices to be the most significant cause of the wetlands degradation ($p < 0.001$ and $r = 0.746$). Based on the results of regression and correlation analysis (Tables 4.26, 4.27 and 4.28) we fail to reject the alternative hypothesis that a households' Socio-economic status significantly affects the quality of the wetland ecosystem and fail to accept the null hypothesis that a households SES does not significantly affect the quality of Lake Ol'Bolossat wetland.

Table 4.28: Matrix for Pearson Correlations Coefficients (r) for SES

Variable	1	2	3	4	5	6
1.Socio-economic Status Index	1.000					
2.Crop Husbandry Practice	.425***	1.000				
3.Grazing practice index	.382***	.168**	1.000			
4.Forest Resource Use Index	.277***	.095	.136*	1.000		
5.Irrigation Practice Index	.191**	.134*	.100	.280***	1.000	
7.Degradation Index	.479***	.403***	.746***	.253***	.214***	1.000

*** Correlation is significant at the 0.001 level (1-tailed).

** Correlation is significant at the 0.01 level (1-tailed).

* Correlation is significant at the 0.05 level (1-tailed).

N (sample size) = 223

4.3.6 Environmental Awareness (EA)

To analyse the effects of environmental awareness on the way socio-economic activities are carried out, a correlation analysis between EA and the other composite variable (CHP, GP, FRU, IP and DI) was done. Results of the analysis (Table 4.29) indicate that there are significant negative correlations between Environmental Awareness and Irrigation Practice ($p < 0.01$ and $r = -0.185$), between Environmental Awareness and Grazing Practice, ($p < 0.01$, $r = -0.180$) and between Environmental Awareness and Degradation Index ($p < 0.05$ and $r = -0.138$). However, EA was positively and significantly associated with Socio-economic status ($p < 0.05$; $r = 0.121$) and positively but insignificantly associated with crop husbandry practices. Based on these results we conclude that environmental awareness significantly influences socio-economic activities in the lake basin.

Table 4.29: Matrix for Pearson Correlations Coefficients (r) for EA

Variable	1	2	3	4	5	6	8
1. EA	1.000						
2. CHP	.001	1.000					
3. GP	-.180**	.168**	1.000				
4. FRU	-.77	.095	.136*	1.000			
5. IP	-.185**	.134*	.100	.280***	1.000		
6. SES	.121*	.425***	.382***	.277***	.191**	1.000	
7. DI	-1.38*	.403***	.746***	.253***	.214***	.479***	1.000

*** Correlation is significant at the 0.001 level (1-tailed).

** Correlation is significant at the 0.01 level (1-tailed).

* Correlation is significant at the 0.05 level (1-tailed).

N (sample size) = 223

4.3.6.1: Effects of Age and Education on Environmental Awareness

To test whether Environmental Awareness is influenced by age, and education level of the respondents, regression analysis with Environmental Awareness as the dependent variable and age, and education level as the independent variable was carried out. Table 4.30 gives the results of the analysis. The analysis shows that education level has a statistically significant relationship with environmental awareness ($\beta = 0.247$ and $p < 0.01$). This implies that education increases Environmental awareness. The β-coefficient implies that 24.7% of the variability in Environmental Awareness can be explained by education.

Table 4.30: Results of Regression Analysis for Age and Education Level on EA,

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.064	.655		7.725	.000
	Age	.003	.010	.017	.249	.803
	Edecation Level	.629	.175	.247	3.600	.000

a Dependent Variable: EA

The positive value of the β-coefficient indicates that respondents with higher education had a higher level of environmental awareness than those of lesser education. The results also show that EA was not significantly affected by age. This is indicated by the low β- coefficient which is not significant ($\beta = 0.017$ and $p > 0.05$).

4.6.3.2 Effects of Gender on Perception and Awareness

To investigate whether gender had any effect on EA an EP, an independent samples t-test was done with gender as the grouping variable and EA and EP as the test variables. The results of the analysis are given in Tables 4.31, 4.32 and 4.33. The results of the analysis indicate that there are no significant differences between the genders in terms of their Environmental Perception and Environmental Awareness. Both the F-value and the t- values are not significant ($p > 0.5$).

Table 4.31: Gender Statistics on EP and EA

	Gender	N	Mean	Std. Deviation	Std. Error Mean
EP	Male	141	8.5745	2.32143	.19550
	Female	82	8.2195	2.17746	.24046
EA	Male	141	6.6809	2.22428	.18732
	Female	82	6.1463	2.28858	.25273

Table 4.32: Levenes Test for Equality of Variances

		Levene's Test for Equality of Variances	
		F	Sig.
PEP	Equal variances Assumed	1.852	.175
EA1	Equal variances assumed	.285	.594

Table 4.33: Results Independent Samples t-test for Gender on EP and EA

	t-test for Equality of Means				
	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
EP	1.126	221	.261	.35496	.31522
EA	1.712	221	.088	.53451	.31221

4.3.8 Analysis of Satellite Imageries

As a complementary method, satellite images covering the study area were analyzed to assess changes in environmental parameters especially forest cover. The Landsat TM false composite images for the study area taken in January 1986, January 2000 and January 2006 were used (Figure 8). The satellite images were analyzed using ENVI version 3.5 computer package for image analyses.

Spatial subsets of the images were first created using map coordinates. Supervised digital image processing was adopted for 1986, 2000, and 2006 satellite image data. Analysis of the false colour composite showed that forest cover in the study area had declined by approximately 30% between 1986 and 2000 and by 2% between 2000 and 2006. This translates to an annual forest loss of 1.6% between 1986 and 2006. The images also indicate a decline in depth (shallowing) of the lake in the satellite image taken in 2000 compared to the 1986 image.

4.4 Discussion

4.4.1 Environmental Perception

The study found out that majority of respondents had more than average environmental perception. There was a very high perception on the changes in forest cover, which was also confirmed from analysis of satellite images covering the study area. Analysis of the satellite images showed a decline in forest cover by 30 % between 1986 and 2000 and 2% between 2000 and 2006 in the study area (Figure 8). On the other hand there was relatively low perception of soil erosion. This can be explained from the fact that, soil erosion in the study area had not reached the physically visible levels (as characterised by development of gullies) and was largely a passive process hence may not have been obvious to some of the farmers. Farmers tend to perceive soil erosion in its later stages when gullies start to form (Dissel *et al*, 1999). However the existence of soil erosion was confirmed by the high proportion of respondents who reported a decline in productivity of their croplands and those who had set up soil conservation structures.

The study anticipated that households' environmental perception would influence their socio-economic activities. It was envisaged that households with high environmental perception would carry out their socio-economic activities in an environmental friendly way

as compared to those with lower environmental perception. However contrary to this expectation and despite many of the respondents scoring higher than average environmental perception (57 % of the respondents scored higher than the mean score for perception of environmental problems), environmental perception had no statistically significant relationship to any of the other variables except the households' socio-economic status ($p < 0.01$, and $r = 0.165$). This implies that the respondents' perception of changes in their environment does not influence their socio-economic activities.

According to Mitchell (1989) the discrepancy between verbal and overt behaviour can be explained by the theory of cognitive dissonance. According to the theory individuals seek consistency between their cognitions of how they act and their cognition of how they should act based upon available information and experience. If a person is committed to a behaviour, which is inconsistent with, the information they receive, the resultant dissonance is reduced or eliminated by altering the behaviour or by altering the perception of the meaning, significance or validity of the information. As a result individuals who appear to be acting irrationally are in fact behaving in a manner that is consistent with a pattern resulting from cognitive dissonance.

Another explanation for the inconsistency between perception and how socio-economic activities are carried out may come from a closely related theory, the existence of hierchies of attitudes. According to this theory a person may fail to act based on his perception due to the presence of another more dominant attitude that overrides concern over preservation of the environment. In this case rather than different weights being given to available information and causing dissonance the explanation is found in a hierarchy of attitudes under which a given attitude (in this case, environmental perception) triggers action only if it is not dominated by a more pervasive attitude.

However, despite having no significant relationship with the other variables, some of the perception items had significant associations with items from the other variables (table 4.16 and table 4.18). The positive association between perception of changes in land productivity and soil fertility practices suggests that more farmers who perceive a decline in land productivity tend to practice some form of soil fertility. Similarly, the positive correlation between perception of changes in vegetation cover and water conservation practices and between perception of changes in forest cover and soil and water conservation practices implies that those who perceived decline in vegetation cover and or forest cover tended to

undertake more water and soil conservation practices. These results imply that although the overall environmental perception (EP) index has no correlation with the composite variables some environmental perception items do influence specific items in the other variables.

4.4.2 Environmental Awareness

Unlike environmental perception, environmental awareness had significant relationship with the other variables. EA was significantly correlated to forest resource use and irrigation practice ($p < 0.01$). The relationships were also negative (apart from that with crop husbandry practice and SES) indicating high environmental awareness results in less use of the forest resources and better irrigation practices. These findings agree with findings by Mccann *et al* (1997) who found out that farmers are generally concerned about the environment.

Comparing the levels of awareness between the female and male respondents indicated that there were no differences in their awareness levels. However education level significantly influenced the awareness levels of the respondents with those of higher educational levels having higher levels of awareness. This implies that improving the education levels improves awareness and results in better utilization of the natural resources.

The positive correlation between environmental awareness and crop husbandry practices suggest that respondents with higher EA tended to use more deleterious CHP. This can be explained by the fact that the need to increase crop production to meet both food and other economic needs normally involves the use of technologies that are relatively environment unfriendly such as the use of chemical pesticides and chemical fertilizers. Often the need to meet food, social and economic demands may far outride environmental concerns resulting from such practices. As Elliot (1994) notes, rarely do farmers fail, through ignorance, to effect land use decisions, which would raise productivity or conserve resources. Rather their behaviour is more regularly, rational in the light of their political-economic, social and environmental circumstances.

Environmental awareness was significantly and positively associated with socio-economic status ($p < 0.05$, $r = 0.121$). This implies that those respondents with higher socio-economic status are more environmentally aware than those of lower SES. This tends to suggest that improving the socio-economic welfare of an individual makes them more aware of their environment.

These findings confirm findings from earlier studies by Aboud, (1992), Anyango, (2000) and Rono, (2003) who found that farmers' environmental awareness influenced their choice of coping strategy or conservation measures they employed. This underpins the importance of creating environmental awareness among natural resource users in achieving natural resource conservation.

4.4.3 Socio-Economic Status and Environmental Degradation

The study found household socio-economic status to be significantly and positively correlated to all the other variables (Grazing practices, Irrigation Practices, Crop husbandry Practices and Forest Resource Uses). This implies that household's with higher economic status tended to cause more environmental degradation than those of lower SES. This appears to contradict the widely held notion that it's the poor who cause more environmental degradation (Elliot 1994: Bhuwneshwar *et al, 1992:* UNDP and EC, *1999).* However this contradiction can be explained on the bases of ownership of the resources under consideration. The resources for which information was sought in this study were mostly public/communal (public forest, common grazing land, streams and wetland) where no control of access was practiced. When resources are exploited as open resource (no limited access to the users) the capitalist attitude of profit maximization prevails. Each individual beneficially aims at maximizing the exploitation of these resources to obtain the highest returns possible. As a result those with higher socio-economic status -more likely to be financially endowed- are able to invest in technologies that maximize on the resource exploitation (for instance sprinklers as opposed to buckets) or use technologies that cause deleterious effect to the environment (for instance keep more livestock, cultivate large tracts of land and use agrochemicals) compared to those with lower SES and hence cause more degradation.

As Elliot (1994) notes, the defining characteristics of capitalism such as the need to maximize profits, and competition within a free market economy, have in many cases led to exploitation of environmental resources without sufficient concern for the long-term conservation of those resources or the negative impacts of such activities (which may not be seen in the short term). The pressure to raise productivity and sell goods on the competitive markets have led communities into production systems that do not look into the environmental concerns

Although it has been widely recognised that an inverse relationship exists between an individual's socio-economic situation and their environment, this may only be true where the environmental resource under consideration are private and may not apply to resources that are managed as open access resources. Nevertheless the role of poverty in environmental degradation cannot be underplayed. To the poor, the need to meet their basic necessities of food, shelter and clothing may be so immediate that meeting them becomes the only important consideration. It is only after meeting their needs that other concern such as conservation and sustainability follows. Findings from this study agree with findings by Ho and Azadi (2010) and Wakeel *et al* (2005) who found out that socio-economic factors play an important role in influencing environmental degradation.

4.4.4 Forest Resources

The decline in forest cover was the environmental problem most highly perceived by the respondents in the study (79 % of the respondents perceived a decline in forest cover -Table 4.7). This was further confirmed by analysis of satellite images, which showed a 30% decline in forest cover between 1986 and 2000. This represents a 2% annual conversion rate of the forest resource. For the management of natural resources, the land cover change should be less than 0.1 per cent per year on sustainability basis (Pahari, 1993). The rate of forest conversion in the study area was far above this recommended rate of conversion and reflects an unsustainable rate of exploitation. Indeed the problem of fuel wood scarcity was a serious problem in the study area. Most of the respondents indicated a shortage of forest resources especially fuel wood and construction material.

According to FAO (2002) approximately 60% of the world's total wood removal from forests and trees outside forests are used for energy purposes. This therefore implies that a wood fuel is one of main products of forest and trees (FAO, 2002). Globally the use of wood fuels has been growing in line with population leading to an annual growth of between 3% and 4% (ibid). In most of the developing countries like Kenya virtually every rural family use wood for all or part of its cooking and heating needs. Also in the majority of the third world cities and towns wood and charcoal remain the most predominant cooking fuel.the most important use of forest resources in the study area was as a source of fuel wood for the households cooking and warming purposes. Apart from fuel wood other forest uses such as opening up the forest for crop cultivation and extraction of construction were also common especially along the Satima escarpment. Results from the survey indicated that a total of 93.5

acres (from the respondents only) had been opened up cropland from part of their farms which had been forest. This represents a substantial area. These findings support findings by Wakeel *et al (2005)* who found out that expansion of agricultural activities, extraction of forest material and overgrazing were the prime contributors to deforestation

In addition frequent wild fires in the government owned forests had also contributed to opening up of the forest. Other factors that may have contributed to the rapid decline in forest cover included lack of or limited numbers of forest guards to control access and exploitation of the resources as well as laxity and or complacency from the few forest guards available.

Decline in forest cover was positively correlated to decline in wildlife populations ($p < 0.001$, $r = 0.238$) and increase in soil erosion as shown in Table 4.19. Decline in wild life populations can be partly attributed to loss of forest cover, which forms habitat for the wild animals. Creation of new settlement schemes, which have further encroached on the marshy part of the wetland, may have also driven some of the grass inhabiting animals away. Decline in forest cover was also positively correlated to water and soil conservation practices ($p < 0.05$ and $r = 145$). This would suggest that with a decline in forest cover, the resulting shortage in forest resources forces more household to plant trees both to meet household fuel needs and to control soil erosion. Tree planting has however been hampered by lack of tree seedlings and limited sizes of land owned as expressed by some farmers

Porter –Bollard *et al* (2012) comparing community managed forests with protected forest within the tropics found out community managed forest had a lesser annual deforestation rate than protected forest. This underpins the need to involve local communities in the management of the local forest resources. Such an approach would encourage sustainable utilization of the forest resources.

4.4.5 Conservation of Lake Ol'Bolossat Wetland Ecosystem

While ecosystems are naturally dynamic, when changes are accelerated by human activities, the integrity of the ecosystem is affected. Lambin *et al*, (2001) notes that anthropogenic activities are so pervasive that, when aggregated globally, they significantly affect key aspects of Earth System functioning. They directly impact biotic diversity worldwide; contribute to local and regional climate change as well as to global climate warming. They; are also the primary source of soil degradation; and, by altering ecosystem services, affect the ability of biological systems to support human needs This can be seen in

Lake Ol'Bolossat wetland where populations of wild animals that used to inhabit this area have virtually vanished and the ability of the riparian land to support livestock rearing by local farmers has been negatively affected by socio-economic activities around the lake.

Information from key informants indicated that there had been disappearance of wild animals such as the Thomson's gazelle (*Gazelle thomsoni)*, leopards (*Panthera pardus*), among others in the lake basin. The gazelles which were once common grazers around the wetland had virtually disappeared from the study area at the time of this study. According to the interviewees this was partly from encroachment of their habitat by human settlement, high livestock population around the wetland and from hunting. This was further confirmed from the respondent's perception on changes in wildlife populations. The decline in wild animals in the area was the second most perceived environmental issue with 77% of the respondents agreeing that there had been a decline in wildlife populations in the area.

The way socio-economic activities are carried out around Lake Ol'Bolossat wetland has a significant implication on the sustainable management of the wetland. From the study findings, all the variables (CHP, FRU, GP, IP) had a negative correlation to the degradation index indicating that the related activities resulted in the degradation of the wetland. There is need to promote sustainable agriculture (crop, irrigation and livestock farming) and forest resource conservation to enhance the sustainability of the wetland.

The need to conserve Lake Ol'Bolossat wetland ecosystem (including wildlife) should however be viewed broadly and should incorporate the need of the local residents to earn a living. It should be borne in mind that the success or failure of any conservation depends on the local people (Linell *et al*, 2010). And as Juliet and Maria (2010) noted, conservation of wildlife is a multifaceted problem with species facing pressure from competition for land, direct exploitation and from lack of effective management.

For conservation to be effective, the issue of who bears the cost of conservation and who enjoys the benefits thereof must be adequately addressed (Juliet and Maria, 2010). As Homewood *et al (2009)* found out, wildlife conservation does not always pay for the average rural dwellers that are close to the conservation area and the benefits received do not always match those available from alternative commercial activities that may utilise the same land. Bearing the cost of conservation without obtaining any significant benefits from it, results in negative attitude towards conservation. The local people should be informed of the benefits that would accrue from the wetland conservation and how they would benefit.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter comes up with conclusion from the study findings and provides some recommendations on the way forward based on the findings.

5.2 Conclusions

- The study found that environmental perception did not influence the way socio-economic activities were carried out by farmers around Lake Ol'Bolossat wetland.
- The study also found out that environmental perception declines with age with younger people being more perceptive.
- Both tree and forest cover in the study area had declined. Most of respondents agreed that forest and tree cover in the study area had declined. This was confirmed by analysis of satellite images which showed a decline in forest cover of over 32% in 20 years.
- The study area had experienced a decline in wild animals with some animals especially Thomson Gazelles (*G. thomsoni)* disappearing from the study area
- Environmental awareness had significant influence on how farmers carried out their economic activities. Farmers with high environmental awareness practiced less deleterious activities.
- The study found that education improves environmental awareness with individuals having higher education levels being more aware.
- The Gender of respondents did not affect their environmental perception or their environmental awareness. There were no significant differences between the genders in terms of their Environmental awareness and Environmental Perception
- Socio-economic status was found to be important in negatively influencing socio-economic activities around Lake Ol'Bolossat wetland. Respondents of better socio-economic status caused more degradation to the wetland than those of lesser status.
- Grazing practice was shown to be one of the major causes of the wetland degradation. The major reason for this was the fact that most farmers kept more livestock than their land could support. As a result the excess stock exerted pressure on the wetland.
- The use of the wetland provides as common grazing land gives no incentive to individual farmers to control stocking levels. This results in overstocking and overgrazing of the riparian land

5.3 Recommendations

At the centre of continuing problem of degradation of Lake Ol'Bolossat wetland is the ownership of the resource. Currently the Settlement Fund Trustee owns the lake and the riparian land. Over the years the fund has continued to expand settlements even on the marshy riparian zone of the wetland without regard to the deleterious effects of such settlement on the wetland. In addition no environmental impact assessments were carried out before creating these settlement schemes. Further, SFT has failed to provide any management for the exploitation of the remaining land and wetland resources. This has in effect rendered the wetland an open access resource prone to the "Hardin's tragedy of the commons". To avert this eminent environmental tragedy and in adherence to Environmental Management and Coordination Act, SFT should be compelled either to relinquish ownership of the wetland to a body more suited to manage the wetland or to effect appropriate environmental management practices (on the unsettled land) that would ensure sustainable exploitation of the wetland resource. Such practices should include controlling the number of livestock grazing around the lake, control of soil erosion and conservation of the lake's catchment.

An important consideration in trying to achieve any meaningful environmental conservation is creation of environmental awareness. Individuals of higher environmental awareness were found to undertake more environment friendly practices. This indicates the need to raise environmental awareness among the residents. In the absence of an organised system of delivering environmental awareness messages to the rural communities, such messages should be incorporated in the mainstream extension services such as agricultural extension, livestock extension and forestry extension. This would take advantage of the existing extension structures without the need to establish new structures. Considering that agricultural and livestock extension programmes are some of the few, and in some cases the only, public outreach programmes in the rural areas, such programmes should be strengthened and improved to includes relevant concepts on environmental themes. Extension agents in agriculture, livestock and forestry should be retrained to incorporate relevant environmental concern in their routine extension messages. Sustainable agricultural production systems -such as organic farming, agro-forestry, beekeeping, drip irrigation among others- should be vigorously promoted, as these do not cause any major harmful effects to the environment.

Grazing practice was shown to be one of the major causes of the wetland degradation. The major reason for this was the fact that most farmers kept more livestock than their land could support. As a result the excess stock exerted pressure on the wetland. The fact that the wetland provides a common grazing land gives no incentive to individual farmers to control stocking levels. This results in overstocking and overgrazing of the riparian land. In addition livestock destroy nests and chicks for ground nesting birds. There is therefore need to provide comprehensive grazing plan that should take into account the optimal number of livestock that the riparian land can support without causing any excessive degradation to the wetland.

A comprehensive grazing plan should be developed for the riparian land. This should first determine the amount of forage available naturally from riparian land. The number of wild herbivores grazing around the wetland and their forage needs should then be determined. Excess fodder after giving allowances for the wild herbivores would then be used to determine the number of livestock units that should be allowed to graze in the riparian land. The grazing plan should also come up with a rotation system that would allow regeneration in areas that are already overgrazed. Based on the determined stocking levels the number of livestock should not be allowed to exceed this limit. For the grazing plan to be effective the riparian land should be fenced off. The Settlement Fund Trustee (or any other management) would then enforce the required stocking densities

While the use of irrigation to boost food production and income is important in ensuring food security both at the household level and at national level and in alleviating poverty, there is need to ensure that such practices do not cause deleterious effects to the environment. The ministries concerned should advise farmers involved in irrigation on the best technologies available that will utilise the available water resources more efficiently and at the same time minimise environmental degradation

The area around the wetland is currently experiencing rapid growth in intensive floriculture and horticulture with greenhouses coming up all over. There is need to enforce appropriate environmental standards in their operation as these are both water intensive and agrochemical intensive farming systems. Without this enforcement they are likely to aggravate the situation further.

Promotion of intensive production practice such as use of chemical fertilisers and pesticides have largely emphasized on the positive aspects of these technologies in enhancing production. They have ignored providing farmers with information on the negative

environmental impacts of such practices. To make agricultural production more sustainable promotions of any technology should concomitantly inform the farmers the possible adverse effects to the environment that may result from using these technologies. There should be a greater emphasis on promotion of sustainable agriculture. This would enable the end users of such technologies to make better-informed decisions and choices on what technologies to adopt.

Given the link between environmental degradation and poverty any efforts to improve the socio-economic situation of the residents should be given the first priority, as this would have beneficial effects to the environment. Such efforts should include promotion of simple technologies such as energy saving stoves and use of biogas that do not only save on fuel wood but also reduce the time spent in collecting firewood thus availing more time for undertaking other economic activities.

Efforts to provide electricity to the rural household should be enhanced. Provision of electricity from the national grid for both lighting and for creation of light industries such as *Jua-kali* industries would also have the dual advantage of reducing stress on the forest resources and encouraging growth of informal employment.

A fair proportion of the respondents attributed their poor socio-economic situation to the poor road infrastructure in the area. As such they are unable to access markets in time and often receive lower prices for their produce. The government should improve roads in the area to enable farmers to access the markets and fetch good prices for their produce more easily. This would help improve the economic situation of the farmers.

Any efforts to conserve and manage Lake Ol'Bolossat should involve the local community and all the other stakeholders at all levels. Adequate participation of all stakeholders is important in determining the success or failure of such efforts. The local community should be involved from the onset in any efforts to conserve the wetland. To be widely acceptable the benefits of such efforts should be clear to all in order to gain their support.

A further study should be carried out in the study area to determine the actual causes of the low adoption of environmentally friendly practices despite the high levels of environmental perception and awareness shown.

REFERENCES

Aboud, A. A., (1992). Population Pressure, Environmental Degradation and Farmers Adaptive Strategy in Nakuru. PhD. Thesis, University of Illinois

Anyango, C., (2000). Awareness and Response by Smallholder Women Farmers to Soil Erosion: Case Study of Njoro, Kenya. M.Sc. Thesis, Egerton University.

Barbier, E. B., (1994). Valuing Environmental Functions: Tropical Wetlands. *Journal of Land Economics, 1994, Vol. 70(2): Pg. 155-73*

Bennun, I. and Njoroge P., (1999). Important Bird Areas of Kenya. East African Natural History Society. Nairobi

Berry, R. J., (1993). Environmental Dilemmas; Ethics and Decisions. Chapman & Hall, London, United Kingdom

Bhuwneshwar P. S., Shunji M, Kiyoshi H., Karl E. W., and Haja, A. (1992). Assessment of Watershed Degradation and Its Socio-Economic Impacts Using Remote Sensing And GIS: A Case Study Of Trijuga Watershed, Nepal. Asian Institute of Technology, Thailand

Botkin, D. B. and Keller, E. A., (1995). Environmental Science: Earth as a Living Planet, Second Edition. John Wiley & Sons Inc. Toronto, Canada

BP. Conservation Programme, (2003). Options in Yala Wetland Management for Sustainable Development and Biodiversity Conservation Kenya 2003. *www.conservation.bp.com* Accessed on 15th May 2004

Castilho, J. A. A., Fenzl, N., Guillen S. M. and Nascimento, F. S., (2000). Organochlorine and Organophosphorus Pesticide Residues in the Atoya River Basin Chinandega, Nicaragua. *Journal of Environmental Pollution.* Vol. 110 Pg. 523-533

Chamwada, L. H., (2001). An Evaluation of Land Use Dynamics and Soil Erosion in Kibaragoi Location, Keiyo District. M.Phil. Thesis, Moi University

Curry N., (1997). Providing New Environmental Skills to British Farmers. *Journal of Environmental Management, Vol. 50(2) Pg. 211-222*

Dissel S. G. and Graaf J., (1999). Differences between Farmers and Scientists in the Perception of Soil Erosion: A South African Case Study. *www.nuffic.nl.* Accessed on 5th Feb 2005

Doust, L. L, and Doust, J. L., (1995). Wetland Management and Conservation of Rare Species. *Canadian Journal of Botany, Vol. 73, Pg. 1019-1028.*

Fisher, D. S., Steiner, J. L., Endale, D. M., Schomborg, H. H., Franzlebbeurs, A. K., and Wilkinson, S. R., (2000). The Relationship between Land Use Practices to Surface Water Quality in Upper Oconee Watershed of Georgia. *Journal of Forest Ecology and Management. Vol. 128 (1/2) Pg. 39-48*

Gadhi, V. P. and Patel, N. T., (1997). Pesticide and Environment: A Comparative Study of Farmers Awareness and Behaviour in Andhra Pradesh, Punjab and Gujarati. *Indian Journal of Agricultural Economic. Vol. 52 (3) Pg. 519-529.*

Gerakis, A. and Kaburtji, K., (1998). Agricultural Activities Affecting The Functions And Values Of Ramsar Wetland Sites Of Greek. *Journal of Agriculture, Ecosystems and Environment, Vol. 70, Pg. 119-128*

Gichuki, C. M., (2002). Community-Based Wetland Management in Africa: A Case Study of Lake Ol'Bolossat, Kenya. www.wetland.org. Accessed on 17th May 2004

Gilliam, J. W., (1994). Riparian Wetlands and Water Quality. *Journal of Environmental Quality, Vol. 23, Pg. 896-900*

Government of Kenya, (1979). Results of National Population Census 1979. Ministry of Planning, Nairobi

Government of Kenya, (1989). Results of National Population Census 1989. Ministry of Planning, Nairobi

Government of Kenya, (1994). The Kenya National Environmental Action Plan (NEAP) Report. Ministry of Environment and Natural Resources. Nairobi, Kenya

Government of Kenya, (1997). Nyandarua District Development Plan 1997-2002. Ministry of Planning and National Development. Government Printers, Nairobi

Herlocker, D., Shaabani, S. B. and Buigott, K. S. A., (1994). Range Management Handbook of Kenya Vol. I1. An Introduction to Rangeland Development in Kenya. Republic of Kenya, Nairobi.

Ho, P. and Azadi, H. (2010): Rangeland Degradation in North China: Perceptions of Pastoralist. *Journal of Environmental Research, Vol.110, Pg.302-307*

Homewood, K., Kristjanson, P., Trench, P (2009): Staying Maasai? Livelihoods, Conservation and Development in East African Rangelands. Springer Science + Business Media

Irimu, W.P (1995), Towards Integrated Resource Management in Kenya. MPhil Thesis Moi University

Jaetzold, R., and Schmidt, H., (1983). Farm Management Handbook of Kenya. Vol. II. Natural Conditions and Farm Management Information. Part B, Central Kenya (Rift Valley & Central Regions). Ministry of Agriculture, Nairobi

Jarvie, H.P., Withers, P.J.A. Bowes, M.J., Palmer-Felgate, E.J., Harper, D.M., Wasiak, K., Wasiak, P, Hodgkinson, R.A., Bates, A., Stoate. C., Neal, M., Wickham, H. D., Harman, S.A., Armstrong, L.K. (2010): Stream Water Phosphorus and Nitrogen across a Gradient in Rural–Agricultural Land Use Intensity. *Journal of Agriculture, Ecosystems and Environment Vol 135 Pg 238–252.*

Juliet T. and Lanari, M. R. (2010): Profitability of Sheep Farming and Wildlife Management in Patagonia *Journal of Pastoralism, Vol. 1 No.2, pg 274-290*

Kammerbauer, J., and Moncada, J., (1998). Pesticide Residue Assessment in Three Selected Agricultural Production Systems in the Choluteca River Basin of Honduras. *Journal of Environmental Pollution, Vol. 103 Pg 171-181*

Kenya National Bureau of Statistics (2011): Results of 2009 National Population and Housing Census. www.knbs.or.ke. Accessed on 11th June 2012

Kenya Wildlife Service and Netherlands Wetland Project, (2000). Integrated Management Plan for Lake Ol'Bolossat Conservation Area (Draft). Unpublished

Kiai P. G. and Mailu, W. K. (2000). Wetland Classification for Agricultural Development in Eastern and Southern Africa. Kenya Country Paper. www.esok. Org: Retrieved on 5/6/04

Kreutzwiser, R. D., (1995). Water Resource Management: Canadian Perspectives and the Great Lakes Water Levels Issue: Pg. 259-285, In Bruce Mitchell (editor): *Resource and Environmental Management in Canada.* Oxford University Press. Ontario, Canada

Lambin, E F., Turner B.L., Geist, H. J., Agbola S B., Angelsen, A., Bruce, J. W., Coomes, O.T., Dirzo, R, Fischer, G., Folke, C., George P.S., Homewood, K., Imbernon, J., Leemans R., Li, X., Moran, E. F., Mortimore, M., Ramakrishnan, P.S., Richards J. F.,

Skanes, H., Steffen, W, Stone, G. D., Svedin, U., Veldkamp, T. A., Vogel C., Xu J. (2001): The Causes Of Land-Use and Land-Cover Change: Moving Beyond the Myths. *Journal of Global Environmental Change* Vol. 11 Pg 261–269

Lelo, F., Allen K., Bachelder, R., Ford, R., Foster, J., Haller, B., Manzi, K., Quintana, L., Ross, L., Thomas-Slayter, B., Valentin, E., (1999). Neighbourhood Taking Actions: Linking Community Action and Local Participation in Kenya and Massachusetts. Clark University, USA.

Linnell, J. D. C., Rondeau, D., Reed, D. H., Williams, Altwegg, R. R., Raxworthy, C. J., Austin J. D., Hanley, N. H., Fritz, Evans, D.M., Gordon, I. J., Reyers, B., Redpath, S. and Pettorelli, N. (2010). Confronting the Costs and Conflicts Associated With Biodiversity. *Journal of Animal Conservation Vol 13, Pg 429-431*

Mangat, R., (2001). "The Vanishing Lake." Daily Nation, Saturday Magazine January 13-19, 2001. Nairobi

Mather, A. S., (1992). Land Use. John Wiley and Sons, New York

McDowell, R. W., and Sharpley, A. N., (2001). Approximating Phosphorous Release from Soils to Surface Runoff and Subsurface Drainage*: Journal of Environmental Quality Volume 30(2) Pg. 508-520*

Mfudisi, K. B., (2003). Analysis of Carbon Pools and Human Impact in The Yala Swamp (Western Kenya): A Landscape Approach. www.zef.de, Accessed on 5th March 2004

Mitchell, B., (1989). Geography and Resource Analysis, Second Edition: Longman Group Limited. Essex , England

Mitchell, K. J., McIsaac, G. F., Walker, S. E., and Hirschi, M. C., (2000). Nitrate in River and Subsurface Drainage Flows from an East Central Illinois Watershed. *Journal of American Society of Agricultural Engineers. Vol. 43(2) Pg 337-342*

Muriithi, F. M. and Shiluli, M. C., (1993). Effects of Liberalisation of Fertiliser Markets on the Distribution of and the Use of Fertiliser on Food Crop Production; A study of Embu and Meru Districts of Kenya. In Mwangi W., Rohrbach D. & Heisy P. (editors) (1993). *Cereal Grain Analysis in the Natural Agricultural Research Systems of Eastern & Southern Africa.* Pgs 89-113.

OECD, (1986). Water Pollution by Fertilisers and Pesticides. Oxford & IBH Publishing Company PVT. LTD., New Delhi

Osienala, (2002). Activities of Osienala. Website: www.osienala.org Retrieved on 5/2/2005

Pahari, K.J. (1993), Soil Erosion Susceptibility by Using Remote Sensing and GIS: A Case Study of Andhikhola Watershed. Nepal, AIT Thesis No. NR-93-16, AIT, Bangkok.

Porter-Bolland , L., Ellis E.A., Guariguta, M. R , Ruiz-Mallen, I., Negrete-Yankelevich, S., Reyes-Garcia, V. (2012): Community Managed Forests and Forest Protected Areas: An Assessment of their Conservation Effectiveness Across the Tropics . *Journal of Forest Ecology and Management* . Vol. 216, Pg 6-17.

Pyrovetsi, M. and Daoutopoulos, G., (1999). Farmers' Need for Nature Conservation Education in Greece. *Journal of Environmental Management. Vol. 56, Pg 147-157*

Ramsar Convention Bureau, (2000). Ramsar Handbooks for the Wise Use of Wetlands. Ramsar Convention Bureau, Gland, Switzerland.

Rees, D. G., (1995). Essential Statistics (Third Edition). Chapman & Hall, New York

Republic of Kenya, (1999). Sessional Paper No. 1 of 1999 on National Policy on Water Resources Management and Development. Ministry of Water, Nairobi

Republic of Kenya (2001). 1999 Housing and Population Census. Ministry of Finance and Planning, Government Printers, Nairobi

Republic of Kenya (2002). Nyandarua District Development Plan 2002-2008. Ministry of Finance and Planning, Nairobi

Rono, S. K. (2003). Constraints to Community Participation in Ecosystem Management: A Case Study of Lake Solai, Kenya. A Masters Thesis of Egerton University

Scheren, P. A. G. M., Zanting, H. A. and Lemmens, A. M. C., (2000). Estimation of Water Pollution Sources in Lake Victoria East Africa. *Journal of Environmental Management,* Vol. 58(4) Pg 235-248

Sharpley, A. N., Gburek, W. J., Folmer, G., Pionke, H. H., (1999). Sources of Phosphorous Exported from an Agricultural Watershed. *Journal of Agricultural Water Management, Vol. Pg. 77-89*

Shimura, M. and Tabuchi, T., (2000). Characteristics of Nitrogen Outflow from a High Stock Density Area. *Journal of Rural and Environmental Engineering, Vol. 39. Pg. 94-103*

Stein, A. B., Fuller T. K., Damery, D. T., Sievert, L. and Marker, L. L. (2010). Farm Management and Economic Analyses of Leopard Conservation in North-Central Namibia. *Journal of Animal Conservation. Vol 13 Pg. 419-427*

Stone, K. C., Hunt, P .G., Coffey, S. W. and Matheny, T. A., (1995). Water Quality Status of a USDA Water Quality Demonstration Project on the Eastern Coastal Plain. *Journal of Soil and Water Conservation,* Vol. 50(5), Pg 567-571.

Thomas, D. B., (1997). Soil and Water Conservation Manual for Kenya. Soil and Water Conservation Branch, Ministry of Agriculture, Livestock Development and Marketing; Republic of Kenya

Tolba, M. K., (1988). Evolving Environmental Perceptions: From Stockholm to Nairobi. Butterworths, London, United Kingdom

UNDP and EC, (1999). Summary Report of Meeting of Experts on Poverty and the Environment (Brussels, January 19-21, 1999)

Wakeel, A., Rao, K.S., Muikhuri, R. K., and Saxena, K. G. (2005): Forest Management and Land Use/Cover Changes in a Typical Micro Watershed in the Mid Elevation Zone of Central Himalaya, India. *Journal of Forest Ecology and Management* . Vol. 213, Pg. 229-242

William, H. P., (1994). From Wastelands to Wetlands. *Journal of Environmental Quality* Volume 23:892-896, 1994

Williams, M., (1990). Wetlands: A Threatened Landscape. Blackwell Publishers, Oxford, UK

World Bank, (2002). Making Sustainable Commitments: An Environmental Strategy for the World Bank. World Bank, Washington DC.

Appendix 1: Survey Questionnaire

The questions in this questionnaire are for research purposes only. The information you provide was treated with utmost confidentiality. Your assistance in answering the questions truthfully and accurately was highly appreciated.

1. Division……..Location:……..Village……

2. Name☹optional)……

3. Age (years):……

4. Sex: (1) Male…… (2) Female……..

5. Marital Status: (1) Single (2) Married (3) Divorced (4) widowed (5) Others

6. For how long have you occupied this land?……..(years)

7. How many years have you been involved in farming?……(years)

8. What level of education did you attain? (1) < Std. 4 (2) Primary (Std) 4-8

(3) Secondary 1-4 (4) Secondary 5-6 (5) Tertiary level.

9. What is the size of your farm? ……(acres)

10. Under what land ownership is your land?

1) Own with title deed, 2) own land without title deed, 3) Communal

4) Borrowed 5) rented 6) squatter

11. What are your main sources of income?

a) Farming b) business c) employment d) Providing labour

e) Livestock and livestock product sales f) others (specify)_____

12. How much do you make from each of the above named sources (state whether on monthly/ annual basis)?

Source	**amounts (KShs.)**	**Source**	**amounts (KShs.)**
Farming	_____	Business	_____
Livestock	_____	Livestock product	_____
Employment	_____	providing labour	_____
Others (specify)	_____		

13. What community social roles do you play?

(1) Farmer (2) community leader (3) Church leader

(4) Civil servant\teacher (5) Politician (6) others (specify)……

14. How far is your farm from the lake?……Km.

15. What is the slope of your main cultivated land?

1) Flat (2) gentle slope (3) moderate slope (4) steep slope

16. How many acres of your farm have been opened up from forest?……(Acres)

17. What are the major land degradation problems in your farm?

1) Soil erosion 2) Overgrazing 3) Others (specify)_____

18. Have you reclaimed any land from the swamp? Yes / No

19. If yes how much?……..acres.

20. Is any part of your farm waterlogged? Yes/ no. If yes how much……..acres? What is it used for? _____

21. Which of the following soil fertility methods do you use in your farm?

(1) Organic manure (2) Chemical fertilizers (3) burning of trash

(4) Others……

22. Which of the following soil and water conservation measures have you used in your farm in the last five years?

(1) Planting of trees (2) construction of terraces (3) Grass/ Napier /Fallow strips

(4) Intercropping (5) others (specify)

23. What is the size of your cultivated land?…… (Acres)

24. Do you use chemical pesticides? (1) No (2) Yes

25. If yes, which ones? _____

26. Types of livestock kept and their numbers

a) Cattle…… (b) Sheep…… (c) Goats…… (d) Donkeys……

27. What is the size of your pasture land?……..(acres)

28. Which grazing system do you practise in your private farm?

(1) Zero Grazing/stall feeding, (2) tethering (3) Paddocking (4) Free ranging

29. Which grazing system do you use in the communal land?

(1) Tethering (2) Free ranging (3) Others (specify)_____

30. Do your livestock obtain all their feeds from the fields? Yes / No.

If no what are the other sources of feeds_____

31. Do you practice irrigation? (1) No (2) Yes

32. **If** yes, what is the source of the irrigation water?

1) Borehole\ well\ roof catchment 2) Earth pan\ Dam 3) River\ stream

4) Lake \ wetland

33. How much is the irrigated area?..... Acres.

34. What irrigation method do you use?

(1) Drip (2) Sprinkler (3) bucket (4) Flooding (5) Others (specify).....

35. a) How often do you irrigate your crop?.....(Number of days in a week)
(b).....(Number of months in a year)

36. For how long have you been using irrigation?.....(Number of years)

37. What materials do you obtain from the forests around?

Firewood, Charcoal, Posts, Timber, others specify.....

38. Of the problems you encounter in you farm and surrounding area how would you rank the following. Enter (1) Very Important (2) Important

(3) Less Important(4) Not important

Problem	**On the Farm**	**Around**
Soil erosion		
Steep gradient		
Low soil fertility		
Lack of fuel wood		
Lack of pasture		
Lack of water		
Low water quality		

39. What are the main sources of water for domestic consumption?

1) Rain 2) well 3) spring 4) Borehole 5) swamp

6) Dam 7) river/stream 8) Lake

40. How adequate is the supply?

(1) Very adequate (2) adequate (3) moderately adequate (4) Inadequate

(5) Very Inadequate

41. Has the productivity of your cropland been increasing or decreasing in the last ten years?

(1) Increasing (2) unsure (3) Decreasing

42. The amount of water in the streams, rivers and the lake has been reducing

(1) Strongly disagree (2) Disagree (3) unsure (4) agree 5) Strongly agree

43. The grass/vegetation cover around the lake has been reducing

(1) Strongly disagree (2) Disagree (3) unsure (4) agree 5) Strongly agree

44. The amount of tree cover in forests around has decreased compared to ten years ago

(1) Strongly disagree (2) Disagree (3) unsure (4) agree 5) Strongly agree

45. The number and types of birds has been decreasing in and around the lake

(1) Strongly disagree (2) Disagree (3) unsure (4) agree 5) Strongly agree

46. The number and type of wild animals (antelopes, hippos) in and around the lake has decreased compared to ten years ago

(1) Strongly disagree (2) Disagree (3) unsure (4) agree 5) Strongly agree

47. The availability of forest materials (fire wood, posts, etc) has been decreasing.

(1) Strongly disagree (2) Disagree (3) unsure (4) agree 5) Strongly agree

48. Soil erosion has been increasing.

(1) Strongly disagree (2) Disagree (3) unsure (4) agree 5) Strongly agree

49. Availability of livestock feeds (grass, browse) has decreased

(1) Strongly disagree (2) Disagree (3) unsure (4) agree 5) Strongly agree

50. The number of livestock grazing around the lake has increased

(1) Strongly disagree (2) Disagree (3) unsure (4) agree 5) Strongly agree

51. Use of water from rivers, streams and springs entering the lake for irrigation is causing the lake to dry.

(1) Strongly disagree (2) Disagree (3) unsure (4) agree 5) Strongly agree

52. Use of agrochemicals can affect water quality in streams, rivers and the lake.

(1) Strongly disagree (2) Disagree (3) unsure (4) agree 5) Strongly agree

53. Use of pesticides in the farms can affect other unintended organisms

(1) Strongly disagree (2) Disagree (3) unsure (4) agree 5) Strongly agree

54. Cutting of trees in the forests around can affects the flow of streams and rivers

(1) Strongly disagree (2) Disagree (3) unsure (4) agree 5) Strongly agree

55. Destruction of the forests around can increase soil erosion.

(1) Strongly disagree (2) Disagree (3) unsure (4) agree 5) Strongly agree

56. Grazing animals around the lake can affect the wetland ecosystem negatively

(1) Strongly disagree (2) Disagree (3) unsure (4) agree 5) Strongly agree

57. Overgrazing increases soil erosion.

(1) Strongly disagree (2) Disagree (3) unsure (4) agree 5) Strongly agree

58. Use of pesticides/herbicides/acaricides has no side effects on the environment

(1) Strongly disagree (2) Disagree (3) unsure (4) agree 5) Strongly agree

59. Are you aware of the new environmental legislation in the country? (1) Yes (2) No

60. Please rank in order of importance (using 1,2,3 with 1 being the most important) the benefits you[derive from the wetland.

Water (livestock)……Domestic……..Pasture……fish……..

Game meat[……recreation……..others (specify)……

Thank you

Appendix 2: Interview Guide to Key Informants

Name of Interviewee……

Date of Interview……

Respondents Occupation……

Interview Schedule

1. In your opinion who owns lake Ol'Bolossat?
2. In your opinion what do you think are the major environmental problems facing Lake Ol'Bolossat?
3. In your opinion how can the problems facing the lake be solved?
4. How do the communities around the lake benefit from the wetland?
5. In your opinion what are the main negatively impacts caused by the community to the wetland?
6. How does the lake negatively impact them?
7. In your opinion how can these negative impacts in 4 and 5 above be solved or reduced?
8. Which environmental organisations exist that are interested in the conservation of the lake?
9. Which of the se organisations are community based?
10. What roles do they play in the conservation of the lake?
11. What problems do they face?
12. Have there been any efforts to create environmental awareness among the communities around the lake?
13. How\what was the response?
14. What can be done to promote environmental awareness among these communities?
15. How best can the community be involved in the decision-making relating to the management and conservation of the lake?
16. What role(s) are you or your organisation willing to play in the conservation of the lake?

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