Investigation of Social Economic Activities and Their Implication for Wetland Conservation in Nyando Wetlands

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other University.

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

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DEDICATION

To my beloved parents, Mrs. Katuku Maithya and Mr. Maithya Kianga for their unending support, love and encouragement. God bless you.

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LIST OF ACRONYMS AND ABBREVIATIONS

ANCA Australian Nature Conservation Agency

CBA Cost Benefit Analysis

CBD Convention on Biological Diversity

CDF Constituency Development Funds

CDM Clean Development Mechanism

DAEO Divisional Agricultural Extension Officer

DNA Designated National Authority

EMCA Environmental Management and Co-ordination Act

ERDAS Earth Resource Data Analysis System

ESD Environmental Sustainable Development

GPS Global Positioning System

IUCN International Union for Conservation of Nature

MCDA Multi – Criteria Decision Analysis

MLC Maximum Likelihood Classification

MMC	Migrating Means clustering Classifier
NEAP	National Environmental Action Plan
NEMA	National Environment Management Authority
NGO's	Non-Governmental Organizations
PCA	Principal Component Analysis
RCMRD	Regional Centre for Mapping and Resource Development
SPSS	Statistical Package for Social Sciences
UNCCD	United Nations Convention to Combat Desertification
UNEP	United Nations Environmental Programme
UNFCC	United Nations Framework Convention on Climate Change
VIRED	Victoria Institute for Research and Development

ABSTRACT

Wetlands are vital parts of a watershed. The Nyando wetlands are multidimensional resources that provide the community with a range of inter-related environmental functions and socio-economic benefits, which support a variety of livelihood strategies. Because of the range of wetland use strategies at the local levels, there are often conflicting demands placed upon wetlands. The need to use these wetlands wisely is greatest as biodiversity is higher in these regions and basic human needs are most acute. Unfortunately, the exploitation of these wetlands around the Lake Victoria region of Kadibo has been extensive leading to their decline in quality and functioning. The threat from overuse and over exploitation, lack of application of new management technologies and weak institutional policies have resulted in reduction of the biodiversity within these wetlands.

The general objective of this study was to investigate and propose ways to enhance wetland resource utilization for sustainable livelihoods and ecosystem services. The specific objectives were; to establish the influence of social economic activities on wetland resource utilization at household level in Kadibo division; to quantify the trend and extent of land use/cover changes in the area of Kadibo division and to propose appropriate management practices to guide policy development on sustainable utilization of wetlands within the Lake Victoria basin.

The study methodology combined a questionnaire survey together with interviews and field observations which were subjected to sample population of households in three

agro-ecological zones of the division. The response variables were standardized by using a standard scale of 1 to 5. A square root transformation was performed on the data collected before the analysis since it was not normally distributed. The data was then subjected to nonparametric analysis of variance (ANOVA) using Kruskal-Wallis Test and Wilcoxon Scores using SAS Version 9.1 at 5% level of significance. Summary statistics analysis of means and frequencies was conducted. Principle Component Analysis (PCA) was conducted on some response parameters of the questionnaire. In addition, use of remotely sensed imageries was also applied for land use and land cover change analysis.

The research indicated degradation by unsustainable levels of resource extraction. The wetland resources were currently undergoing rapid transformation through diverse consumptive practices (crop production, fishing, grazing, craft materials, brick making, clay, water and wood fuel harvesting) by the communities for their daily survival. Large areas of the wetlands had been altered to other forms of land use. The area under swamps and wetland cover increased by 4.58 Km^2 (20.8 %) in 1985-1995 and then decreased at a rate of 0.65 Km^2 per year to 6.54 Km^2 (24.6 %) in 1995-2008 period. In addition, the area under dense agricultural land use increased by 37.71 Km^2 (53.9 %) in 1995-2008. Alternative sustainable development options have been studied to be of significant help in improving the livelihood of adjacent communities; some of which include eco-tourism and recreation, business, educational sites and agro forestry. The wetlands can be utilized sustainably through value addition techniques. Value addition

contributes significantly to sustainability of papyrus materials. Local involvement and participation should be present in all stages of their management.

Keywords: *Livelihoods, community perception, management options, biodiversity conservation, land use/cover changes*

CHAPTER I

1.0 INTRODUCTION

Wetlands provide many important services to human society, but are at the same time ecologically sensitive and adaptive systems. Wetlands are known for their abundant wildlife and are therefore important for emerging eco-tourism uses by locals in many parts of the world (ANCA, 1996). Some of the most biologically rich wetlands in the world are found in the Rift Valley in Tanzania and in the seasonally flooded Okavengo Delta in Botswana (ANCA, 1996).

Out of Kenya's total land mass area of 582,646km², wetlands occupy up to 6% of the land surface (Republic of Kenya, 2002). In the drive for economic growth, agricultural practices and development continue to threaten wetlands and their biota. For example, among the major threats facing papyrus wetlands are drainage, clearing, filling and reclamation for subsistence crop production, clay making, weaving, building of houses, road building, construction of dams or barrages for water storage, flood protection, irrigation and hydroelectric schemes, construction of waterways and irrigation channels, pollution, especially by pesticide and fertilizer residue, overgrazing by livestock, over fishing, and conversion to aquaculture ponds (Nasirwa *et al.*, 1995). Natural threats to wetlands, such as climate change, drought and floods may be unavoidable, but man-made threats can be prevented**.** Over exploitation of papyrus swamps along Lake Victoria has led to cascading negative impacts on wide range of biodiversity in this important ecosystem. These resources continue to be over-exploited but limited research work is being conducted to elucidate the problem (Nasirwa *et al.*, 1995). Past aerial surveys on changes in papyrus cover around the lake shows a remarkable loss and papyrus harvesting (Van de Weghe, 1981; Mafabi, 2000). A comparative aerial survey between 1969 and 2000 showed 50% loss in Dunga and 47% and 34% loss in Koguta and Kusa respectively in Kenya. Papyrus height and density are inversely related to human disturbance including footpaths, cutting, burning, grazing and farming (Owino, 2005). Further within the wetlands, there exist human-wildlife conflicts in addition to conflicts over papyrus and agricultural space which to the locals is a common resource (Hardin, 1968). Land use activities around papyrus swamps of Lake Victoria are dominated by cultivation, livestock grazing and settlements (Mafabi, 2000).

The Russians, Finns, Estonians, Irish, and even New Zealanders, among other cultures, have mined their peatlands for centuries, using peat as a source of energy and for horticultural purposes (Mitsch and Gosselink, 2000). The production of fish in shallow ponds or rice paddies developed several thousands of years ago in China and South East Asia, and crayfish harvesting is still practiced in the wetlands of Louisiana and the Philippines (Mitsch and Gosselink, 2000). Coastal marshes in Northern Europe, the British Isles, and New England were used for centuries and are still used today for grazing of animals and hay production. The coastal mangroves are harvested for timber, food, and tannin in many countries throughout Indo-Malaysia, East Africa, and Central and South America. Reeds and even the mud from coastal and inland marshes have been used for wall construction, fence material, and thatching for roofs in Europe, Iraq, Japan, and China (Mitsch and Gosselink, 2000).

Most developing countries depend heavily on the exploitation of wetland natural, especially biological resources. Most of these resources are found among very poor rural communities whose livelihood depends solely on the exploitation of these resources. Sustainable conservation and development depend heavily on strengthening the capacity of local individuals and communities to implement conservation initiatives (IUCN, 1996).

Globally, wetlands are under heavy pressure. Despite the increasing recognition of the need to conserve wetlands, losses have continued. One main reason is that wetlands throughout the world are considered by many to be of little or no value, or even at times to be of negative value. This lack of awareness of the value of conserved wetlands and their subsequent low priority in the decision-making process has resulted in the destruction or substantial modification of wetlands, causing an unrecognized social cost.

The wetlands of the Lake Victoria basin cover an extensive area and support a wide range of economic activities that sustain a significant proportion of the population (Johnstone and Githongo, 1997). First, the plant and animal material produced on the wetland is exported into the Lake, which becomes food for fish and crustaceans, the basis for commercial and recreational fishing. Second, these wetlands support a rich array of animals that inhabit the Lake throughout the year. Third, they provide physical stability to the shores and water level of the Lake. Forth, the wetlands have been shown to play an important role in the reduction of sediment loads and nutrients (Okungu and Sangale, 2003). Excessive nutrient and biocide loading to Lake Victoria would greatly affect the water quality and functioning of the lake's ecosystem. The swamp vegetation aids in the buffering function and will greatly be reduced by the removal of the swamp vegetation.

Effective systems of management can ensure that these wetland resources not only survive but their functions and services increase while they are being used, thus providing the foundation for sustainable development and stable regional economies. However, instead of conserving the rich resources of the region's wetlands, current processes of development are depleting these resources at such a rate that they are rendered in certain areas essentially non-renewable. Signs of change include the large-scale draining of swamps to create land for agriculture and settlement, reduction in fringing vegetation along river valleys and the Lake and also a reduction in fish populations (Government of Kenya, 1992). These problems threaten not only the ecology and potential recreational opportunities of the wetlands and the Lake, but also the lifestyle and livelihood of the local community.

1.1 Statement of the research problem

Nyando wetlands in the Lake Victoria region are experiencing rapid degradation and are, currently, considered to be some of the most threatened ecosystems in the world. Due to rapid increase in human population, high levels of poverty and unemployment, increasing numbers of people are moving and settling in fragile wetland areas, adjacent to river banks and waterbeds, in search of new means of livelihood. Consequently, wetland resources are increasingly being degraded through various consumptive uses including agricultural production, sand and clay extraction, pit sawing, papyrus harvesting and burning (Nyakaana, 2008).

Wetlands in River drainage systems that carry water into the Lake from the rich agricultural hinterland are recharged by over land flow. Under normal circumstances, nutrient loading from the catchment areas coupled with materials originating from biological activities within wetland ecosystems support flora and fauna of the Lake Victoria. However, once the ecological systems of wetlands are exceeded, input from the farms and urban areas; soil particles washed off the land by erosion, burning wood-fuels, and human and animal waste are major factors stressing the Lake systems and, impact on the quality of wetland resources differently. Some rivers drain highly productive agricultural areas, carrying many pollutants, such as silt, fertilizer, pesticide and other chemicals, from agricultural and industrial activities (Keya and Michieka, 1993; Government of Kenya, 1994, 1995).

Wetland ecology is also influenced by pollution originating from mining. The existing polices in different areas (environmental quality, nature protection, physical planning, e.t.c) are inconsistent or contradictory. Many human activities therefore result in external effects, such as pollution from industry or agriculture that may have an adverse impact on sites elsewhere.

The Nyando wetlands have been degraded in the recent past. The community living in the area has continually been exploiting the wetland resources unsustainably. This has been driven mostly by socio-economic needs of the local communities. Some of the activities which have led to increased degradation include wetland draining for agricultural production and settlement, pollution from pesticides and excessive fertilizers eroded from the farms, papyrus harvesting, brick making, fishing, grazing and burning of wood fuels. This degradation and exploitation of the wetlands' natural resources has significantly reduced its important role of reduction of sediment loads and nutrients. Excessive nutrient and biocide loading to Lake Victoria greatly affects the water quality and functioning of the Lake's and the wetland's ecosystem. In addition, this threat from overuse and over exploitation, lack of application of new management technologies and weak institutional policies have resulted to reduction of the biodiversity within the wetlands.

The study was conducted to investigate and propose ways to enhance wetland resource utilization for ecosystem services and sustainable livelihoods. The current wetland management skills of the user communities were evaluated for incorporation into modern management strategies.

1.2 Research objectives

1.2.1 General objective

The general objective of this study was to investigate and propose ways to enhance wetland resource utilization for ecosystem services and sustainable livelihoods.

1.2.2 Specific objectives

The specific objectives were:

1. To establish the influence of social economic activities on wetland resource utilization at household level in Kadibo division
2. To quantify the trend and extent of land use/cover changes in the area of Kadibo division
3. To propose appropriate management practices to guide policy development on sustainable utilization of wetlands within the Lake Victoria basin.

1.3 Hypotheses

- The various social economic activities have negatively impacted on the wetland resources in Kadibo division
- There has been a significant change in the area under different land use/cover in the area of Kadibo division

- There are poor management practices enforced for the conservation of Nyando wetlands

1.4 Justification

Unrelentingly, human beings have steadily reduced the natural environment and its biodiversity. Population growth translates in increased demand for food, which traditionally entails opening more land including the wetlands. Ninety percent of the land surface has been disturbed to some extent, and five percent is burned annually (Cincotta *et al*., 2000). Global fishing interests are rapidly depleting the oceans of most of the commercially valuable species. This in turn, is affecting other species that depend on the fish such as sea birds and other aquatic organisms. This destruction of natural habitats translates into a phenomenal loss of biological diversity.

Wetlands are important ecosystems, internationally recognized as exemplified by Ramsar Convention (http://www.ramsar.org/cda/en/ramsar-about/main/ramsar/1-36_4000_0_). They are diverse in terms of habitats, biota, distribution, functions and uses. Many of the wetlands have lost their pristine ecosystem quality and transformed to modified ecosystem. Their salient role in the ecosystem function cannot be replaced. Over exploitation and developmental activities are threatening wetlands existence. Protection and effective management is a Herculean task. The key to wetland protection lies in appreciating their values and functions, considering the differences within and between different wetlands. With fluctuating variables such as their differences in water levels, varying sources of water, changing biota, seasonal, annual, and migratory, these wetlands have vital physical, chemical, biological and socio-economic functions.

These wetlands of the Lake Victoria basin support a wide range of economic activities such as fishing, cultivation of crops, grazing, provision of thatching and weaving materials etc that sustain a significant proportion of the local population. These wetlands perform a myriad of functions. They recharge and discharge groundwater, control flooding, retain sediment, toxins and nutrients, export biomass, provide storm protection, help stabilize shorelines and prevent erosion, water transport, recreation and tourism. They can generate products such as forest, wildlife, fishery, forage and agricultural resources, as well as water supplies. They also perform ecosystem services such as soil stabilization, biological diversity, natural heritage and cultural uniqueness. In the past, wetlands have been undervalued because the ecological services, biological resources and amenity values they provide are not bought and sold and hence it is difficult to assign a monetary value (Barbier *et al.*, 1997)

Despite the many benefits associated with the wetlands, they have continuously been degraded year after year. This calls for research to come up with better management ways and to avail information to make and adopt policies that promote conservation, strengthen institutions that promote conservation of natural resources and enhance biodiversity for sustainable wetland utilization. This study addresses sustainable ways of wetland utilization by the local community of Kadibo division. This will benefit the local community and the future generations by empowering them socially and economically once the wetland resources are utilized sustainably and better conservation measures are undertaken.

CHAPTER II

2.0 LITERATURE REVIEW

2.1 Wetland definition

There is some disagreement among scientists on what constitutes a wetland, partly because of their highly dynamic character, and partly because of difficulties in defining their boundaries with any precision (Mitsch and Gosselink, 1993). For example, Dugan (1990) notes that there are more than fifty definitions in current use. Likewise, there is no universally agreed classification of wetland types. Classifications vary greatly in both form and nomenclature between regions. Some features of wetlands, nonetheless, are clear. It is the predominance of water for some significant period of time and the qualitative and quantitative influence of the hydrological regime that characterises and underlies the development of wetlands.

The Ramsar Convention definition of wetland, widely accepted by governments and NGO's world-wide, is as follows: 'areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt including areas of marine water, the depth of which at low tide does not exceed 6 m' (Matiza and Crafter, 1994). While lacking scientific exactness, this definition conveys much of the essential characters of wetlands, as well as implying the complexity involved. What it does not provide, however, is any guidance on the generic characteristics of wetlands that influence how wetlands actually function. Any integrated wetland research approach has somehow to make compatible the very different perceptions of what exactly is a wetland system, as seen from a range of disciplinary viewpoints (Maltby *et al.*, 1994, 1996).

2.2 Wetland losses

The loss of inland wetlands is the result of a number of causes, the most notable being drainage for agriculture, forestry, and mosquito control; filling for residential, commercial, and industrial development; filling for solid-waste disposal; and mining of peat. With over seventy percent of the world's population living on or near coastlines, coastal wetlands have long been destroyed through a combination of excessive harvesting, hydrologic modification and seawall construction, coastal development, pollution, and other human activities (Mitsch and Gosselink, 2000). It is probably safe to assume that we are still losing wetlands at a fairly rapid rate globally and that we have perhaps lost as much as fifty percent of the original wetlands (Mitsch and Gosselink, 2000). There are a number of areas where the loss rate has been documented (**Table 2.1**). The estimate of about fifty percent loss of wetlands since European settlement in the lower forty eight United States is fairly accurate as is the ninety percent loss of wetlands in New Zealand. Several regions of the world, for example, Europe and parts of Australia, Canada, and China, have lost an even higher percentage of regional wetlands.

Table 2.1: Percent loss of wetlands in various geographic locations in the world (Source: Mitsch and Gosselink, 2000).

Location	Percentage loss	Reference
NORTH AMERICA		
United States	53	Dahl (1990)
Canada		National wetlands working group
Atlantic tidal and salt marshes	65	
Lower great lakes- St. Lawrence River	71	
Prairie potholes and sloughs	71	
Pacific coastal and estuarine wetlands	80	
AUSTRALASIA		
Australia	>50	Australia Nature Conservation Agency (1996)
Swan coastal plain	75	
Coastal New South Wales	75	
Victoria	33	
River Murray basin	35	
New Zealand	>90	Dugan (1993)
Philippine Mangrove swamps	67	Dugan (1993)
CHINA	60	Lu (1995)
EUROPE	>90	Estimate

2.2.1 Causes of wetland degradation and loss

Wetlands are the only single group of ecosystems to have their own international convention. The call for wetland protection gained momentum in the 1960s, primarily because of their importance as habitat for migratory species. The Ramsar Convention, which came into force in 1975, is an inter-governmental conservation treaty, where a framework for international co-operation was provided for the conservation of wetland habitats to ensure their conservation and wise use. In November 1999, one hundred and sixteen countries were Ramsar Contracting Parties, with one thousand and five wetland sites included in the Ramsar List of Wetlands of International Importance (http:::www.ramsar.org:index.html). These sites cover about 71.7 million hectares, which correspond to about 0.5% of the world's land surface (Turner *et al.*, 2000). The focus of the convention on migrating birds was followed up in 1982 by the Bonn Convention (Convention on the Conservation of Migratory Species of Wild Animals), which was intended to promote international conservation measures for migratory wild animal species. Typical wetland species are also protected due to the Convention on Biological Diversity (http://www.cbd.int/iyb/doc/prints/factsheets/iyb-cbd-factsheet-cbd-en.pdf).

On a national level many countries have installed national parks and nature reserves to preserve wetlands. Governmental and non-governmental listings of threatened species ('Red Lists') have added another measure to help protect wetland species from a changing wetland environment. Most countries have indirectly helped wetlands in their physical planning at national, regional and local government levels. National environmental policies have also constrained the process of change in wetlands by encouraging the maintenance or restoration of clear water, maintaining the original hydrology, and fighting the problems of acid rain or the fragmentation of the ecosystems.

The present set of regulations in many countries does not, however, seem to be sufficient. While the integration of wetlands protection strategies into different national policies has occurred, local economic development at the expense of wetlands is still quite common (Turner *et al*., 2000). Local people have used their right to improve their own conditions, without often considering the effects on a wider geographical scale. What is typically seen is what Turner and Jones (1991) refer to as interrelated market and intervention failures, which derive from a fundamental failure of information, or lack of understanding of the multitude of values that may be associated with wetlands. The information problem results because politicians and the general public insufficiently understand the role and functions of wetlands as well as the indirect consequences of land use, water management, agricultural pollution, air pollution and infrastructure for the quality and sustainability of wetlands (Turner *et al*., 2000). This is partly related to the complexity and 'invisibility' of spatial relationships among groundwater, surface water and wetland vegetation. Moreover, existing policies in different areas (environmental quality, nature protection, physical planning, etc.) are inconsistent or contradictory. Many human activities, therefore, result in external effects, such as pollution from industry or agriculture that may have an adverse impact on sites elsewhere, but for which, due to a lack of enforceable rights, no compensation is paid to those affected. Pollution of wetlands, often regarded as natural sinks for waste, has been an important factor in their degradation. Many wetlands and their essential features, such as their ability to supply water, have traditionally been treated as public goods and exposed to 'open access' pressures, with a lack of enforceable property rights allowing unrestricted depletion of the resource (Turner *et al*., 2000).

2.3 Sustainable development

Sustainable development is one where resources are utilized to satisfy the livelihood needs of the present generation but bearing in mind that the future generations will use the same resources to satisfy their needs and aspirations (Serageldin, 1994). It is based on three pillars (3Ps) Profits, People and Place or planet (**Figure 2.1**) which evolves into Environment Sustainable Development (ESD) triangle (**Figure 2.2**) advocated by World Bank (Serageldin, 1994). The 2002 World Summit on Sustainable Development marked a further expansion of the standard definition of sustainable development with the widely used three pillars of sustainable development: economic, social, and environmental. The Johannesburg declaration created "a collective responsibility to advance and strengthen the interdependent and mutually reinforcing pillars of sustainable development, economic development, social development and environmental protection at local, national, regional and global levels" (http://www.housing.gov.za/content/legislation_policies/johannesburg.htm). In so doing, the World Summit addressed a running concern over the limits of the framework of environment and development, wherein development was widely viewed solely as economic development.

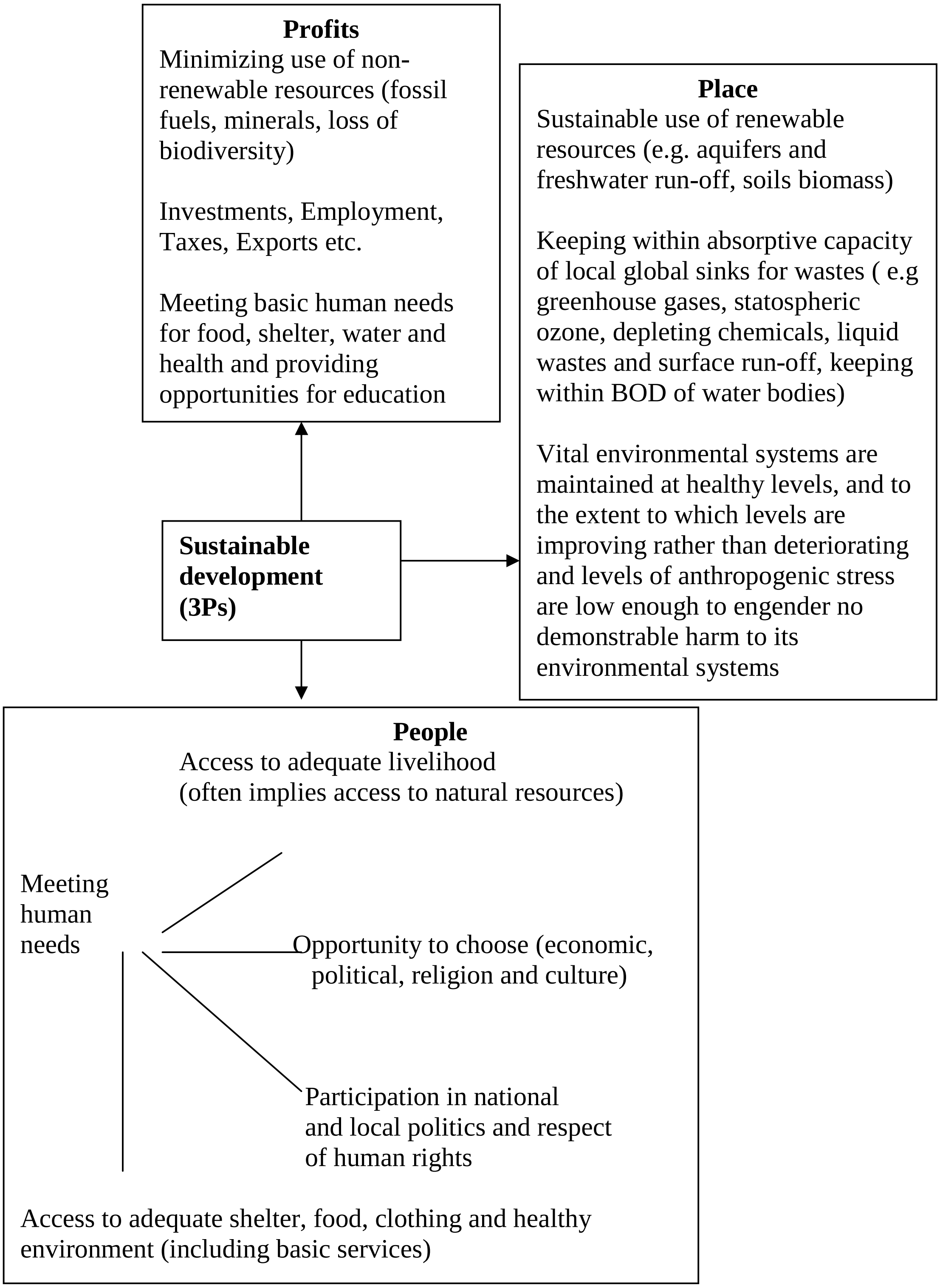


Figure 2.1: Goals of sustainable development; Source: Nyakaana (2008).

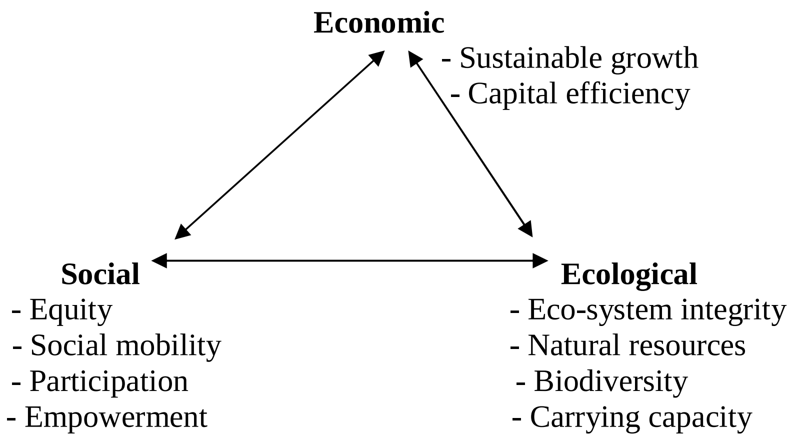


Figure 2.2: Environment Sustainable Development triangle; Source: Nyakaana (2008).

2.4 Small-scale farming and social environment

A sustainable society would provide its members with conditions for a long and healthy life. It is apparent that agriculture affects and is affected by the larger society. Farmer production decisions, for example, determine the diversity and quality of foods available to consumers; and farm size and technologies have been associated with the economic and social vigor of rural communities (MacCannell, 1988). This is also characterized in the Lake Victoria Region. Ong'or (2005) observed the daily lifestyles of people living within the Lake Victoria ecosystem as embedded in their interaction with the local resources. Their main natural resources include; land, wetlands, fisheries and water. The water demand for various uses is an issue of sustainability given the decreasing supply (Agwata, 2005). Water use efficiency (Waller, 2004) is an important aspect of horticulture crop production. Elsewhere, countries such as Israel, Cyprus, and Australia have overcome the limitation posed by their low levels of water resources by making use of their stocks of social resources (Earle and Turton, 2003).

Environmental awareness enables community members to develop the commitment to constructively participate in transformation of the environment (Baez *et al.,* 1987). The development of such an appreciation of environmental quality among wetland farmers promotes in them an attitude of care for their plots and a sense of responsibility for the well being of the wetland system as a whole. The rate of adoption of new technology and ideas by a community is influenced by a variety of factors, which include socio-cultural influence and social marketing strategies (Kolter and Zaltman, 1971). The number of adopters increases as awareness of the technology increases and the benefits become apparent. There are however, late adopters and laggards. The latter group of farmers is conservative and resists change (Rodgers, 1971). Adoption of good farm practices can help in soil conservation. Mulching cushions the ground from raindrop impact and conserves soil moisture (Muler - Saman and Kotschi, 1994). Crop rotation improves the nitrogen status of the soil by leguminous plants (Mukwada, 2000). It also enhances the nutrient status of the soil when deep rooted crops draw nutrients to top levels of the soil (Grant, 1981). Manure is a good source of phosphorus necessary for plant development; it also maintains good soil structure, proper soil aeration and biological activity within the soils (Svotwa *et al.,* 2008). Apart from maintenance of soil fertility, the manorial effect is important in the control of pests and diseases (Alwe, 1980; Grant, 1987). Application of manure would probably reduce the budgets for inorganic fertilizers and chemicals needed to control diseases also resulting to less environmental pollution (Svotwa *et al.*, 2008).

Technological efficiency in exploitation of natural resources is an important aspect of social resources since sustainable conservation and development depend heavily on strengthening the capacity of local individuals and communities to implement conservation initiatives (IUCN, 1996). These include addressing fundamental issues such as gender disparity since women are at an economic disadvantage to men in the rural work force. Allen (1994) acknowledged how worldwide, women's wages in agriculture are consistently lower than men's, sometimes as little as 63% of the male wage for comparable work. The gender of the farmer has been found to influence their selection and adoption of technology. Evidence from Ghana suggests that gender-linked differences in the adoption of modern maize varieties and chemical fertiliser resulted from gender-linked differences in access to complimentary inputs (Cheryl & Michael, 2001). This finding has important policy implications, because it suggests that ensuring more widespread and equitable adoption of improved technologies may require changes in the research system in order to allow introduction of measures that ensure better access for women to complimentary inputs especially labour, land and extension services.

2.5 Small-scale farming and biophysical environment

Agricultural practices ranging from the development of irrigation projects to the use of agrichemicals have often had negative environmental impacts such as wildlife kills, pesticide residues in drinking water, soil erosion, groundwater depletion, and salinization (Allen and Debra, 1990). Nonetheless, irrigation is considered by some to be the second most important factor responsible for the gains made in agricultural productivity since the advent of the green revolution (UNEP, 1993). Irrigation is a major input in increasing crop yields especially in areas with good quality soils, whose expected outcome is either increased household income and/or improved household food availability (Kirogo, *et al.*, 2007). The efficiency of irrigation water use varies greatly, high evaporative and seepage losses from unlined and uncovered canals in some places can mean that as much as 80% of water withdrawn for irrigation never reaches its intended destination (William and Mary, 2004). In addition, poor small-scale farmers may over irrigate because they lack the technology to distribute just the amount of water needed. Excessive use of water not only wastes it but also results in waterlogging. Water logged soils are saturated with water, and plant roots die from lack of oxygen, mineral salt may also accumulate in soils and are left behind when the water evaporates, this is unproductive to most plants.

In many developing countries, land continues to be cheaper than other resources, and new land is still being brought under cultivation, mostly at the expense of forests and grazing land (William and Mary, 2004). Many developing countries are reaching the limit of lands that can be exploited for agriculture without unacceptable social and environmental costs. These can be as a result of farmers invading fragile ecosystems.

Fragile ecosystems affect the status of land due to vulnerability to degradation (Calestous and Ojwang', 1996). This factor is closely related to other factors such as population growth and unequal access to land resources, which drive people into fragile or marginal areas. Fragile ecosystems include wetlands zones. Wanjogu *et al.*, (2005) demonstrated how opening up of a wetland for cultivation without taking into consideration the necessary management and conservation measures, reduces the buffering capacity of the wetland. Substituting environmentally sound inputs for those that are damaging is an important step in addressing these problems. But these notwithstanding, Allen and Debra, (1990) asserted that ecological sustainability requires intensive management and substantial knowledge of ecological processes that go far beyond substitution and cannot be achieved merely by substituting inputs. Such substitutions need to account for their complex and long-term ecological consequences otherwise they may engender secondary and perhaps more serious problems.

Studies on atmospheric concentrations of organo-chlorine pesticide in the north Lake Victoria watershed in Uganda (Wejuli, *et al.,* 2005) revealed how the quality of Lake Victoria waters and fisheries has been affected by land-based activities such as agriculture. This could be because most biological resources are found among very poor rural communities whose livelihoods depend solely on the exploitation of the resources (Abila, 2005). Use of agrochemicals is just one of the ways communities enhance productive capacities of their resources, however, these eventually may end up changing quality of ecosystem. Prescott (2001) described the quality of ecosystems to include their capacity to maintain themselves through cycles of growth, maturity, death, and renewal; their productivity; their chemical and physical integrity of soil, water and atmosphere. The opposite condition to these is ecosystem stress, in which the ecosystem loses its diversity and quality, and so becomes less able to support people and other life. This is against the backdrop of severe land and soil degradation that is often arguably the consequence of mis-management of natural resource base (Hudson and Harsch, 1991).

2.6 Multi-criteria evaluation for wetland conservation

Multi-criteria decision analysis (MCDA) offers one way to illuminate policy trade-offs and aid decision making in contexts where a range of, often competing, policy criteria are considered to be socially and politically relevant (Nijkamp, 1989; Janssen, 1992). MCDA typically includes multiple criteria, such as economic efficiency, equity within and between generations, environmental quality and various interpretations of sustainability. For example, various versions of ‘strong’ and ‘weak’ sustainability have been suggested in the literature (Ayres, 1993 and Turner 1993). Weights can reflect the relative importance of each criterion considered in a particular decision context. A MCDA may thus illustrate how a particular policy would impact on and influence various stakeholder groups (Turner *et al*., 2000).

Governments worldwide have now formally adopted sustainable development as a policy objective, as well as imposing a range of national conservation measures and designations, complementing the Ramsar Convention, to protect wetlands (Turner *et al*., 2000). Sustainability concerns can be introduced as a series of constraints on an otherwise market-oriented and Cost Benefit Analysis (CBA)-based decision-making process. For example, a practical means of dealing with uncertainty is to introduce a safe minimum standard criterion (Ciriacy-Wantrup, 1952; Bishop, 1978; Crowards, 1996). By introducing physical constraints on development options, opportunities for future wellbeing can be preserved rather than trying to impose a structure on future preferences which may be difficult to predict and to control. Under the sustainability principle, there is a requirement for the sustainable management of environmental resources, whether in their pristine state or through sympathetic utilization, to ensure that current activities do not impose an excessive cost and loss of options burden on future generations. It has been suggested that it is 'large-scale complex functioning ecologies' that ought to form part of the intergenerational transfer of resources (Cumberland, 1991).

Wetlands are complex multi-functional systems, and they are therefore likely to be most beneficial if conserved as integrated ecosystems (within a catchment) rather than in terms of their individual component parts (Turner *et al.*, 2000). Sustainability implies a wider and more explicit long-term context and goal than environmental quality enhancement. In this respect, concepts such as ecosystem health or integrity are useful in that they help focus attention on the larger systems in nature and away from the special interests of individuals and groups. The full range of public and private instrumental and non-instrumental values all depend on protection of the processes that support the functioning of larger-scale ecological systems. Thus when a wetland, for example, is disturbed or degraded, we need to look at the impacts of the disturbance across the larger level of the landscape (i.e. how the impacts of disturbance influence processes that support the functioning of the large scale ecological systems in the landscape rather than just focusing on the small area of the wetland) (Turner *et al*., 2000). This focus at the landscape level will be important to make and adopt policies harmonized for the whole landscape.

A strength of a MCDA is that it provides both ecological and economic information as a basis for decision-making. A separate issue is, however, to what extent this information would infact be taken into account in real policy-making situations. Ecological information may not adequately influence the final decisions in the socio-economic system. For example, short-term commercial interests and related financial gains may appear to be more persuasive than longer-term ecological conservation arguments (Turner *et al*., 2000).

2.7 Wetland and riparian zone policies

Numerous policies and programs have been developed to decrease the negative impacts on wetlands and improvement on the quality and quantity of wetland resources. Both national action and international cooperation have been encouraged to provide a variety of mitigation measures and wise use of wetlands and their resources (Mitra *et al.*, 2003).

Wetland mitigation policy has been considered as one of the approaches to address wetland loss (Grose *et al.*, 2000; Rubec and Hanson, 2008). Policy makers have established a wide variety of policies and regulations in order to meet wetland mitigation and compensation objectives. At a global scale, the following conventions/protocols have been put in place to decrease the negative impacts on wetlands and improvement on the quality and quantity of wetland resources.

a). The Ramsar Convention on Wetlands of International importance

The Ramsar Convention that was signed on February 2, 1971 in the Iranian city of Ramsar was ratified in Kenya in June 1990. The Ramsar Convention on wetlands is primarily concerned with the conservation and management of wetlands. Parties to the convention are also required to promote wise use of wetlands in their territories and to take measures for the conservation by establishing nature reserves in wetlands, whether they are included in the Ramsar list or not. The goal of the Ramsar Convention, as adopted by the Parties in 1999 and refined in 2002, is “the conservation and *wise use* of all wetlands through local, regional and national actions and international cooperation, as a contribution towards achieving *sustainable development* throughout the world” (Ramsar, 2007).

There are presently 159 Contracting Parties to the Convention, with 1,838 wetland sites, totaling 161 million hectares, designated for inclusion in the Ramsar List of Wetlands of International Importance (Ramsar, 2009).

b). The United Nations Framework Convention on Climate change (UNFCC)

Kenya became a party to the UNFCC thus binding herself to its terms. Article 4 part 2 subsection ‘a’ of the convention commits member states to participate in the mitigation of climate change as follows "*each of the parties shall adopt national policies and take corresponding measures on the mitigation of climate change, by limiting its anthropogenic emissions of greenhouse gas sinks and reservoirs*" (http://unfccc.int/resource/docs/convkp/conveng.pdf). This, therefore, calls for parties to address anthropogenic or manmade emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol and have measures to facilitate adequate adaptation to climate (http://unfccc.int/2860.php).

c). The Kyoto Protocol

The Kyoto protocol provides operational guidelines (Article 10) on how to implement the convention. Thus, relative to Article 4 of the convention, the Kyoto Protocol commits the member states to formulate where relevant and possible, cost-effective national programmes to improve on the quality of local emission factors. These programmes are in particular those which reflect the socio-economic conditions of each party for the preparation and periodic updating of national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal protocol. Under the Kyoto Protocol, member states should be prepared to undertake Clean Development Mechanism (CDM) projects, which are climate neutral and must have in place, a Designated National Authority (DNA), which is a national body, charged with overseeing climate change and carbon trade developments in each member state. Kenya adopted the terms, has established National Environment Management Authority (NEMA) as the DNA and has shown outstanding interest and effort in marketing for CDM projects both at national and international levels (http://unfccc.int/resource/docs/convkp/kpeng.pdf).

d). The United Nations Convention to Combat Desertification (UNCCD)

This convention aims to combat desertification and mitigate the effects of drought in countries experiencing serious drought and/or desertification, particularly in Africa. To achieve this goal, the convention calls for action involving international cooperation and a partnership approach. It focuses on improving land productivity, rehabilitation of land, conservation and sustainable management of land and water resources. Such action should also prevent the long term consequences of desertification, including mass migration, species loss, climate change and the need for emergency assistance to populations in crisis. The convention establishes a framework for national, sub regional and regional programmes to counter the degradation of dry lands, including semi-arid grasslands and deserts (http://www.unccd.int/).

e). The Convention on Biological Diversity (CBD)

The CBD is an international agreement adopted at the earth summit, in Rio de Janeiro, in 1992. It has three main objectives; to conserve biological diversity; to use its components in a sustainable way and to share fairly and equitably the benefits arising from the use of genetic resources. Article 11 of the CBD provides for incentive measures for the conservation of biological diversity. It states that “Each contracting party shall, as far as possible and as appropriate, adopt economically and socially sound measures that act as incentives for the conservation and sustainable use of components of biological diversity" (http://www.cbd.int/iyb/doc/prints/factsheets/iyb-cbd-factsheet-cbd-en.pdf).

Kenya, as a wetland holder has broadly committed itself to conserve wetlands in a number of international agreements as mentioned above. In addition, there are several national and sectoral laws that touch on wetland conservation including provision of incentives for their management. Such national and sectoral legislations include: the Environmental Management and Coordination Act (1999), The Water Act (2002), The Land Act (1963), Wildlife Act (1976), Forest Act (2005) and the recent Wetland Regulation (2008). In addition to these legislations, institutions have been put in place to carry out the implementation process. They include; Ministry of Water, Ministry of Environment and Natural Resources, National Environmental Management Authority, Ministry of Finance, and Planning and Economic development.

2.8 Remote sensing technology for land use/cover change analysis

Since the beginning of human civilization, mankind has lived in a close relationship with nature. While mankind's interdependence on environment is greater than that of any other organism; his/her restless pursuit of progress, comfort and security has resulted in increased stress on the environment which has led to land use/ cover changes over a period of time. Information on existing land use/ cover, their spatial distribution and change are essential prerequisite for planning (Dhinwa *et al.,* 1992). Thus land use planning and land management strategies hold the key for development of any region

(Anon, 1992). The conventional methods of detecting land use/ cover changes are costly, low in accuracy and present a picture of only a small area. Remote sensing, because of its capability of synoptic viewing and repetitive coverage, provides useful information on land use/ cover dynamics (Sharma *et al.,* 1989). Detection of changes in the land use/ cover involves use of at least two period data sets (Jenson, 1986). The changes in land use/ cover due to natural and human activities can be observed using current and archived remotely sensed data (Luong, 1993). Land use/ cover change is critically linked to the intersection of natural and human influences on environmental change. The change in the state of the biosphere and bio-geochemical cycles are driven by heterogeneous changes in land use and continuation of those uses (Turner, 1995).

2.8.1 Strategies for land use/ cover change detection

Change detection and monitoring involve the use of multi-date images to evaluate differences in land use/ cover due to environmental conditions and human actions between the acquisition dates of images (Singh, 1989). Several authors have attempted to better observe and define change features using remotely sensed data (Singh, 1986; Lambin, 1996). Chen (2001) presented the issues in change detection methods, by looking at the numerous algorithms that have been developed: multidate composite image change detection (Fung and LeDrew, 1987; Eastman and Fulk, 1993), image change algebra detection, image regression (Jensen, 1983; Singh, 1986), manual on-screen digitization of change (Light, 1983; Wang *et al.,* 1992) or post-classification comparison detection (Rutchey and Velchneck, 1994). As noted by Jensen (1996), the selection of an appropriate change detection algorithm is critical. Different methods introducing fuzzy logic, neural networks (Halls *et al.*, 2000) or knowledge-based vision systems (Wang, 1993) have also been tested to examine the likelihood of changes detected from remotely sensed data. Metternicht (1999) proposed a standard procedure using fuzzy sets and fuzzy logic, whereby the membership function of the fuzzy model can be adapted to identify the areas that have undergone changes during the period of observation.

A land use/ cover data, with the geometric accuracy of 1:30 scale cartography, may respond to several information needs, required on both national and regional administrative level, for sustainable resource management. Human induced land use/ cover change, occurring at an unprecedented rate and scale, is one of the major environmental concerns in many parts of Kenya. The changes are driven by rapid economic, social, environmental, and technological changes across the country. Land use/ cover change can have significant impact on the biogeochemical cycles, which in turn change the dynamics of greenhouse gas emissions. Land use/ cover change can also have an important impact on the water and energy balance, directly affecting climatic conditions. It also affects the floral and faunal biodiversity of the region and can have important consequences for food security. Thus, it is very relevant to assess and monitor the land use/ cover status of the ecosystem. A better understanding of the driving forces responsible for the change can help better understand the trends in land use/ cover changes. Such information is essential for land use planning and sustainable management of resources.

2.8.2 Supervised Classification and Unsupervised Classification

There are two broads of classification procedures: supervised classification and unsupervised classification. The supervised classification is the essential tool used for extracting quantitative information from remotely sensed image data (Richards, 1993). Using this method, the analyst has available sufficient known pixels to generate representative parameters for each class of interest. This step is called training. Once trained, the classifier is then used to attach labels to all the image pixels according to the trained parameters. The most commonly used supervised classification is maximum likelihood classification (MLC), which assumes that each spectral class can be described by a multivariate normal distribution. Therefore, MCL takes advantage of both the mean vectors and the multivariate spreads of each class, and can identify those elongated classes. However, the effectiveness of maximum likelihood classification depends on reasonably accurate estimation of the mean vector m and the covariance matrix for each spectral class data (Richards, 1993). What's more, it assumes that the classes are distributed unmoral in multivariate space. When the classes are multimodal distributed, we cannot get accurate results. Another broad of classification is unsupervised classification. It doesn't require human to have the foreknowledge of the classes, and mainly using some clustering algorithm to classify an image data (Richards, 1993). These procedures can be used to determine the number and location of the unimodal spectral classes. One of the most commonly used unsupervised classifications is the migrating means clustering classifier (MMC). This method is based on labeling each pixel to unknown cluster centers and then moving from one cluster center to another in a way that the SSE measure of the preceding section is reduced data (Richards, 1993). This research study adopts the use of maximum likelihood supervised classification. This is because some knowledge of the location and identity of land cover types that were in the images was known prior to classification.

CHAPTER III

3.0 RESEARCH METHODOLOGY

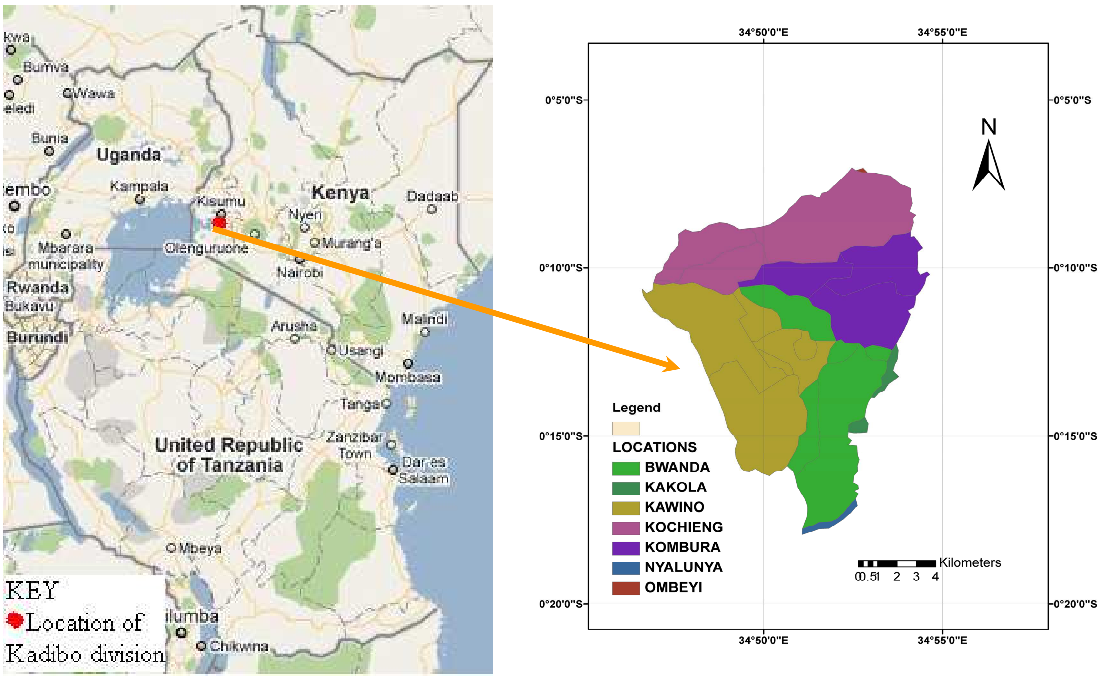
3.1 Research design

A research design was important in guiding the process of data collection, analysis, and interpretation of observations. It is a model of proof that allows the drawing of inferences concerning causal relations among the variables, eliminating spurious relations and establishing the time order of events (Zeisel, 1980).

This study adopted the use of survey design in a natural research setting. The research design enabled study of different groups of the total population dispersed over a wide geographical area of Kadibo Division through a sampling approach. Preliminary diagnostic studies were conducted before the final data collection instruments were settled on. A range of data collection techniques were employed to check on the others' completeness. These data collection techniques included use of questionnaires, interviews and observations (Zeisel, 1980).

3.2 Data collection tools

The research study was carried out in some parts of the Nyando wetlands of Kisumu East District within Nyanza province in Kenya (**Figure 3.1**). In order to achieve the stated research objectives and to ensure validity and reliability of the results, multiple data collection tools were applied and comparisons made. These data collection tools included use of remotely sensed images, use of questionnaires, interviews, photography and physical observations. Remote sensing because of its capability of synoptic viewing and repetitive coverage provides useful information on land use/ cover dynamics. Remotely sensed data was used inorder to observe and compare changes in land use/ cover due to natural and human activities. The remotely sensed data was important to compare with the primary sources of data such the questionnaires and field observations to enhance validity and reliability of the results. Primary and secondary data was collected from different sources.



a). b).

Figure 3.1: Map of Kenya showing the location of the study site (a) (Source: Google map) and map of Kadibo division showing the administrative locations (b).

3.3 Description of the study site

Kadibo division is one of the administrative divisions in Kisumu East District. Kadibo borders Lake Victoria to the West, Winam division (includes Kisumu city) to the North and North-West and Nyando district to the East and South. It occupies an area of 164.8 km^2 (KNBS, 2010) and lies along latitude $0^0 15' 30''$ South and longitude $34^0 46' 30''$ East (**Figure 3.1b**). In 2009, Kadibo population was estimated at about 57,859 people and about 11,048 households. The population as of 2010 was 61,326 people with 12,994 households (KNBS, 2010). The wetlands in the study site include lake shores, river banks, swamps and riverine areas but nearly all of the current agricultural land was formerly wetlands.

The area comprises mainly of Lower Midland Agro-ecological zones. These zones include Lower Midland zone 3, 4, and 5. The mean annual temperatures ranges between 20-30^{o}C while the mean annual rainfall range between 1,000 and 1800mm. The rainfall is bi-modal with long rains in March to June and short rains in October to November (Government of Kenya 2006, 2005).

3.4 Sampling methodology

A structured questionnaire combined with interviews to the farmers, other stakeholders and organizations, photography and physical observations were employed to collect primary data. These structured questionnaires were conducted face to face with the farmers with a view to establish the sustainability of the practiced agricultural activities.

The questionnaire had seven categories (**Appendix 1**). These were namely: Bio-data, the social economic activities, that is, the crops cultivated, their returns and other economic activities which the farmers were engaged in other than crop production. The third category was on wetland management, ownership and utilization while the forth and fifth categories were on community knowledge on the wetlands and biodiversity richness and changes respectively. The sixth category was on the emerging issues from the Nyando wetlands, that is, the factors threatening the existence of Nyando wetlands and the problems experienced by the people who live and work around the wetlands. The last category was on conservation and sustainable ways of the wetlands' utilization. A scoring system of 1-5 was used to rate responses to the questionnaires. Score 5 was the most important factor while score 1 was the least important factor.

A stratified random sampling approach was employed based on the Agro-ecological Zones (rainfall distribution, soil types/crop suitability, slope, temperature regime). It was assumed that Agro-ecological Zones would broadly classify the land cover and land use in more or less similar units for local extrapolation. The three Agro-ecological Zones (Lower midland zone 3, 4, and 5) formed the strata (**Figure 3.2**). Within each stratum, sampling areas (households) were chosen randomly. A total of three hundred and eighty four questionnaires were targeted from the total population of 11,048 households (Bartlett *et al.*, 2001). This number was based on Cochran's sample size formula for categorical data as shown below:

$$n_o = \frac{(t)^2 * (p)(q)}{(d)^2}$$

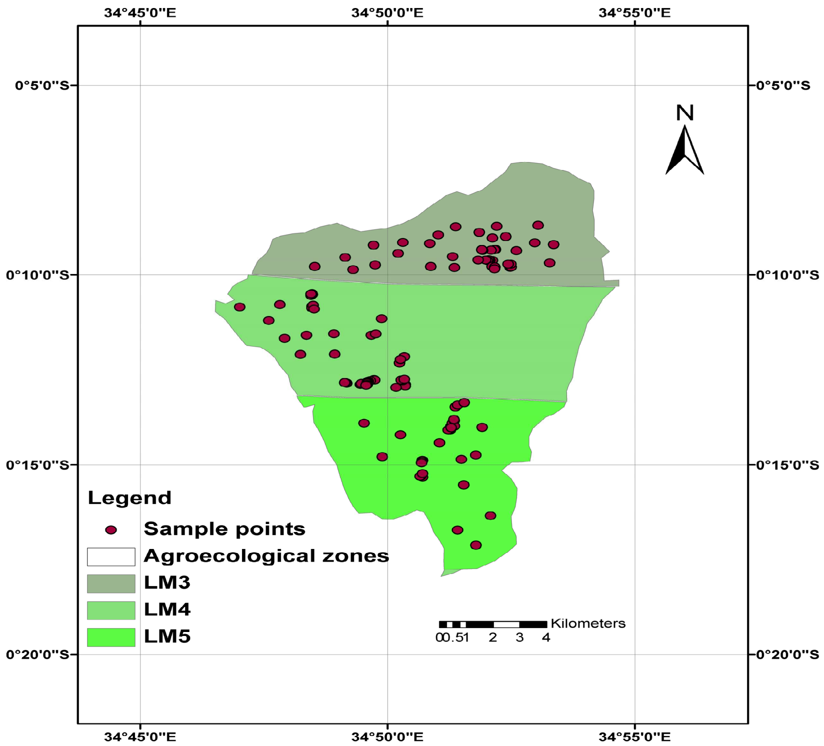


Figure 3.2: Study area; Kadibo division, the Agro-ecological Zones and the sampled household units

$$n_o = \frac{(1.96)^2 (0.5)(0.5)}{(0.05)^2} = 384 \text{ questionnaires}$$

Where t = value for selected alpha level of 0.025 in each tail = 1.96

(the alpha level of 0.05 indicates the level of risk the researcher is willing to take that true margin of error may exceed the acceptable margin of error).

(p) (q) = estimate of variance = 0.25

(maximum possible proportion (0.5)*1-maximum possible proportion (0.5) produces maximum possible sample size).

d = acceptable margin of error for proportion being estimated = 0.05

(error researcher is willing to except).

However, due to financial constraints and the fact that some respondents were not patient enough to complete all the sections of the questionnaire, the above target could not be realized. A total of two hundred and forty nine questionnaires were fully filled and used for the data analysis and this formed a good representative of the target population assuming the homogeneity of each of the Agro-ecological zone. Important data variables generated included the types of crops grown, incomes realized, method of land preparation, soil and moisture conservation measures, soil fertility management methods, current ways of wetland resource utilization/exploitation and suggestions for sustainable ways of wetland resource utilization.

Visual observations and photography of human activities carried out within the study site were made. The assessment of ecosystem/wetland disturbance levels was done focusing on burning, wetland vegetation cutting, livestock grazing, and cultivation. These factors directly affect wetland vegetation habitat conditions (Bennun & Njoroge, 1999). Relevant information was also obtained from literature review of similar experiences around Lake Victoria and other parts of the world. Personal in depth key informant interviews were conducted randomly with farmers, research personnel and government officers in the study area. The interview technique enabled probing the perceptions, attitudes, beliefs and feelings of key informants about sustainable wetland resource utilization.

Research assistants were employed and trained to conduct the questionnaires in the local language (Dholuo). They were briefed extensively on the intended use of the work and also provided invaluable input into the survey design.

Global Positioning System (GPS) was used to map the sampled areas.

3.5 Land use/cover change analysis

3.5.1 Data Acquisition

Land use/cover change quantification was done through the application of remote sensing. LANDSAT- TM imagery of 1985, 1995, and LANDSAT-ETM imagery of 2008 were obtained from the Regional Centre for Mapping and Resource Development (RCMRD), Nairobi, Kenya. The imagery data was captured on 16th January 1985, 17th March 1995 and 28th September 2008. These three months were chosen because they were dry months in the study area and thus possibility of getting imagery clear of clouds. The last interval in time, 1995-2008 however varied from that of 1985-1995. This was because of the need to get an image close to the current year the research was conducted which was also free from clouds. Due to challenges of finances and the fact that useful and adequate information for land use/ cover change detection within the area could be obtained from the LANDSAT satellite imageries, this justified the use of the 30 M spatial resolution data. Existing land use information was also collected from RCMRD geoportal and field survey using GPS and other terrestrial survey approaches of the landscape used for verification purposes.

3.5.2 Geometric corrections

In remote sense scanner, the images of the stationary grid on earth are not perfectly reproduced by the sensor. Instead the geometric characteristics of the scene change as a function of geodetic and results from these imperfections contribute to the over all geometric distortion of the image and are the essential motivation behind modeling of geometric correction algorithms. Geometric rectification was conducted using image-to-map and image-to image -technique. The images were georeferenced to existing map and Coordinate transformation (WGS_1984_UTM_Zone_36N) and Resampling performed in ArcMap Version 9.2 at a scale of 1:50,000.

3.5.3 Land use/cover classification

The images were then analysed for land cover composition, structure, and changes which have occurred within the stated time frame using ArcMap/ArcGIS Version 9.2 softwares. A supervised classification method was used. The broad categories used in this study were; swamps/wetlands, water bodies, dense agriculture and sparse agriculture. This was based on the broad vegetation categories that are in the area. The classification process started by first locating representative sample of each cover type that could be identified in the image or training sites. Polygons were then digitized around each training site using area of interest (AOI) tools in Earth Resource Data Analysis System (ERDAS) IMAGINE Version 9.1 and assigning unique identifier to each cover and saving in the spectral signature library. A supervised classification was then performed and the images were further reclassified in ArcMap into four broad categories of land use/cover namely; swamps/wetland, water bodies, dense agriculture and sparse agriculture. A land use/cover map of 1985, 1995 and 2008 was then generated in ArcMap and the area under different land uses quantified.

3.6 Data analysis

The questionnaire data collected had the following main categories of information: bio-data, social economic activities of the respondents, wetland management, ownership and utilization, biodiversity richness and changes within the wetlands. Threats to the wetlands, conservation and sustainable ways of their utilization also formed part of the data. Where necessary, non-parametric data collected was first standardized. Responses were standardized by using a standard scale of 1 to 5, where variables numbered 1 = 5 scores, 2 = 4 scores, 3 = 3 scores, 4 = 2 scores, and 5 = 1 score. Descriptive statistics analysis of means, frequencies, and standard deviation was conducted and the results presented in tables, bar graphs and pie charts. Since the data was not normally distributed, a square root transformation was performed on the data which was to be subjected to nonparametric analysis of Variance. The data was then subjected to nonparametric analysis of variance (ANOVA) using Kruskal-Wallis Test and Wilcoxon

Scores using SAS Version 9.1. This was conducted at 5% level of significance (SAS, 2002).

Principle Component Analysis (PCA) was conducted on the obtained questionnaire data. The number of indicators on some responses was large and therefore higher chances of redundancy. In this case, redundancy means that some of the indicators are correlated with one another, possibly because they are measuring the same construct. Because of this possible redundancy (Hatcher and Stepanski, 1994), it was important to reduce the observed indicators into a smaller number of principal components (artificial variables) that could account for most of the variance in the responses, thus making the results useful in identifying critical factors, their relations and advising policy formulation efforts to address the problem. PCA was conducted with a Varimax orthogonal rotation and new factors were selected that had an Eigen-value greater than unity and values greater than 0.3 flagged by an asterisk '*' (SAS, 2002). The individual factor loadings to a component which loaded 30 % and above are the ones which were flagged by an asterisk '*'. This flagging was important to show significant loadings in a given component. Eigen values were multiplied by 100 and rounded to the nearest integer. Kendal Tau correlation analysis was also conducted to establish which bio-physical and social factor/livelihood variables were significantly related.

CHAPTER IV

4.0 RESULTS AND DISCUSSIONS

4.1 Education, occupation and period of stay among the respondents

Out of the 249 respondents interviewed, 50.2% were females while 49.8% were males. The research findings in this study revealed that 68.5% of the respondents had primary level education, 15.9% had none, while those with secondary and college level education were 15.2% and 5% respectively. Education level is key to shaping and influencing community production and soil conservation strategies. In this study, it was found that those who did not apply any soil conservation measures had either no formal education or had primary level of education. Highly educated communities have always demonstrated better means of crop production, adoption of new technologies and better soil conservation as opposed to poorly educated communities (Michael *et al.,* 1998). This study also revealed that farming was the mainstay economic activity (77% of the respondents) of virtually all the respondents selected for this assessment (**Figure 4.1**). However, to supplement their incomes, those who were involved in farming, fishing and papyrus material weaving also practiced other economic activities (**Table 4.1**). For example those who were involved in farming were also found to be engaged in papyrus material weaving, fishing activities, (Boda boda) bicycle operation business as well as small scale business (such as kiosks). Those who were engaged in weaving and fishing activities were also found to be engaged in small scale livestock production, Boda boda

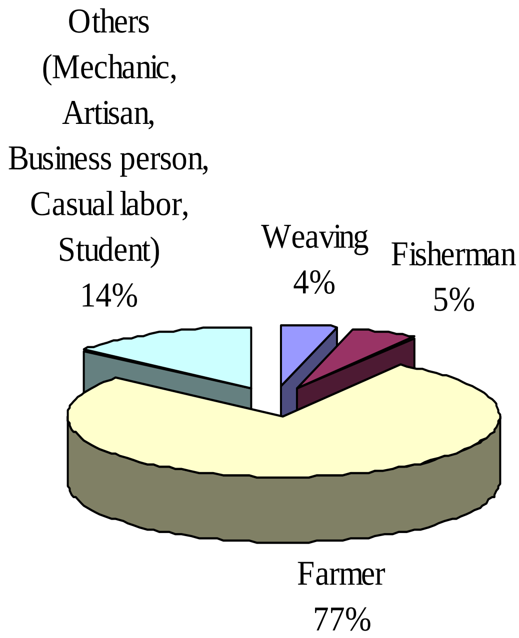


Figure 4.1: Occupation distribution of the respondents sampled

Table 4.1: Mean monthly income of other social economic activities practiced by the respondents apart from crop farming

Activity	**No. of respondents**	**Mean monthly income (Ksh.)**	**Std Dev**
Boda boda business	8	1495.00	729.13
Fishing	34	2761.76	2169.21
Others (Small scale business)	67	2464.03	2856.45
Livestock production	22	2197.73	2203.59
Papyrus weaving	53	1598.30	1731.18

business as well as small scale businesses (such as kiosks and groceries) (**Figure 4.1** and **Table 4.1**). These secondary income sources are important to the farmers' household.

They act as farmers safety nets incase of horticultural crop failure; they also help to avoid over dependence and over exploitation of wetland resources.

Majority of those sampled for the questionnaires were above 50 years of age (34.7%); 33.9% were between 36-50 years while those between 18-35 and less than 17 years of age were 31% and 0.4% respectively. In addition, majority of those sampled (69.9%) had stayed in the area for more than twenty years (**Figure 4.2**). This long duration of stay was important for the study as the respondents were able to state some changes on selected parameters which had happened within the area for the last twenty years.

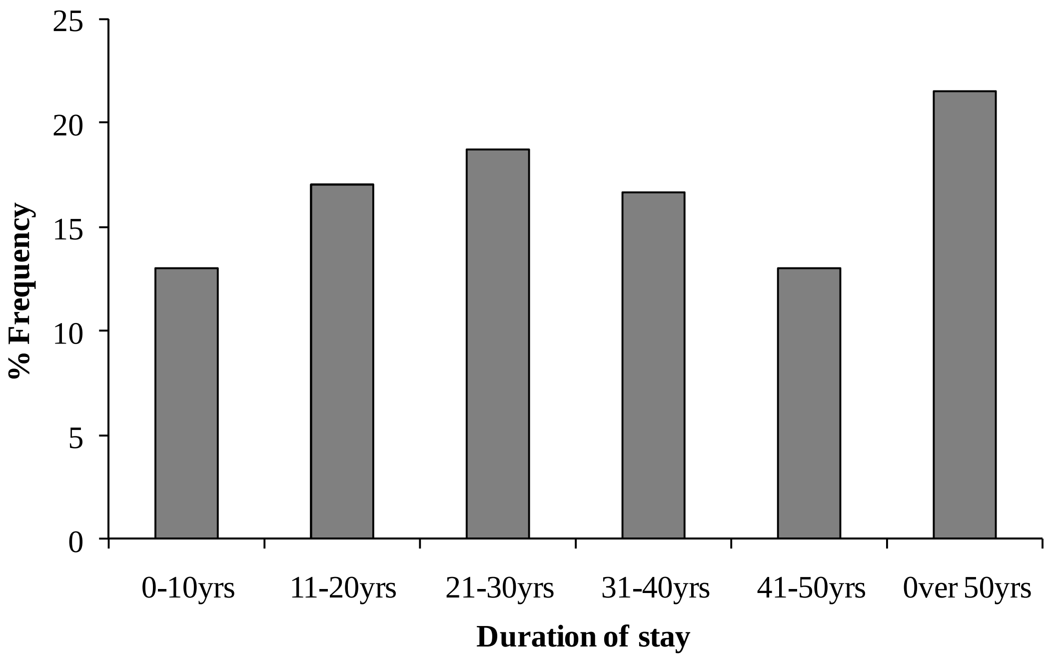


Figure 4.2: Period of stay among the respondents within the study area

4.2 Land use activities in the area

Land use activities around these wetlands were dominated by crop cultivation, livestock grazing and human settlements. These activities had intensified in the recent years and were of particular concern as they had led to other forms of degradation such as pollution, vegetation burning and papyrus harvesting as was also noted by (Van de Weghe, 1981; and Mafabi, 2000). In Kenya these activities have increased at an alarming rate (Keya and Michieka 1993; Government of Kenya 1994; 1995; Bennun and Njoroge 1999; Kairu, 2001) and these have had negative impacts on the overall biodiversity of swamps (Fishpool and Evans, 2001).

4.3 Main agro economic activities in the study site and sustainability

Within the Kadibo Division, both crop production and livestock farming was practiced. Majority of the farmers in the study area practiced both subsistence and commercial farming. Both commercial and subsistence crops were cultivated (**Table 4.2**). The major economic crops bringing high returns included sugarcane, rice and green grams (**Table 4.2**). Majority of the farmers practiced mixed cropping (67.6 %) while 37.4 % practiced mono cropping. In mixed cropping system, different crops were usually intercropped for instance maize and beans were always being intercropped. Mixed cropping was important for soil erosion control especially when ground cover crops were included in the intercropping system. One of the major problems in communal agriculture at present is the lack of agro-diversity.

Table 4.2: Average returns from a growing season in Kenya Shillings (Kshs.) for the different crops cultivated.

Crop	Average returns per growing season (Ksh.)
Arrow roots	6000.0±3175.4
Bananas	440.0±40.0
Beans	24755.6±15787.9
Butter nuts	57321.4±26430.7
Capsicum	17920.0±17080.0
Cassava	2985.7±1645.8
Coriander	180.0±0.0
Cotton	4500.0±0.0
Cow peas	2359.1±402.3
Green grams	90312.5±83908.6
Maize	25042.8±3448.9
Mangoes	1200.0±0.0
Millet	8100.0±2100.0
Pawpaw	890.0±710.0
Pepper	14666.7±12666.7
Capsicum (pili pili hoho)	2100.0±300.0
Potatoes	2600.0±334.7
Rice	114529.0±20293.7
Sorghum	12000.0±3464.1
Sugarcane	205166.7±109502.8
Sweet potatoes	1433.3±809.0
Tomatoes	27828.6±8775.7
Vegetables	3726.0±645.4
Water melons	48333.3±21941.4
Yams	3200.0±0.0

In the study, the agro scenario in these areas was characterized by the dominance of the maize crop (**Table 4.3**). This had to do with the levels of production that can be realized on small pieces of land as well as the little labor that was required in the form of post harvest technologies of storage and processing. The traditional crops are labor intensive and yields are low per hectare. The maintenance of crop diversity as shown within the Nyando wetland areas created the basis for sustainable rural livelihoods. Most horticulturists produced vegetables because the crop was highly marketable and

Table 4.3: The different types of crops cultivated and the number of respondents who are involved in their cultivation.

Crop	**No. of the respondents who cultivated the crop**	**Percent (%)**
Arrow roots	3	0.4
Bananas	3	0.4
Beans	50	7.3
Butter nuts	8	1.2
Capsicum	3	0.4
Cassava	24	3.5
Coriander	1	0.1
Cotton	1	0.1
Cowpeas	29	4.2
Green grams	13	1.9
Maize	237	34.4
Mangoes	1	0.1
Millet	44	6.4
Pawpaw	2	0.3
Rice	33	4.8
Sorghum	94	13.7
Pepper	3	0.4
Sugarcane	4	0.6
Sweet potatoes	13	1.9
Capsicum (Pili pili hoho)	2	0.3
Potatoes	9	1.3
Tomatoes	33	4.8
Vegetables	68	9.9
Water melon	7	1.0
Yams	3	0.4
TOTAL	**688**	**100.0**

offered high immediate financial returns (Rice *et al.*, 1986). The variety of crops grown by farmers (leaf, root, fruit and leguminous crops) formed the base for effective soil nutrient exchange. A well-planned rotation involving those crops could be useful in the prevention of soil erosion and maintenance of soil fertility.

Livestock production within the area included goats, sheep, cattle, rabbits and poultry. Livestock provide meat, milk, wool, draught power, and manure. In addition the farmers could as well sell them to supplement their family financial resources. There were challenges of land limitation and the long profit return period for cattle hence this could have been the reason why majority of the respondents did not practice cattle rearing.

There was a variation in the sizes of land under different crops cultivated by the farmers (**Table 4.4**). The small portions of land were indicative of the high rate of land fragmentation that was associated with the general increase in the population size and the number of households that needed to survive on the wetlands. The increase in the population density within the perimeter of the wetland could also be attributed to the fact that these wetland areas had fertile soils and had lots of moisture especially during the dry season. Waugh (2000) claimed that in Sub-Saharan Africa, due to rapid population expansion small plots were further divided. This provided a threat to sustainable utilization of the wetland and was at risk of degenerating into 'the tragedy of commons' as postulated by Hardin in 1968. The land sizes became too small for mechanization and their output were limited. The variation of sizes of farmers' land portions could be a result of unsystematic and uncontrolled fragmentation of fields as farmers traditionally shared their land portions with their next of kin. Farmers tend to densely populate areas whose physical environment support agricultural production (Whynne-Hammond, 1990). The physical conditions could include fertile soils for crop production, low slope angle, reliable rainfall and moderate temperatures. Such a scenario of increased land land fragmentation and farmers densely populating in fertile areas was associated with

Table 4.4: Average plot sizes in acres for the different crops cultivated by the respondents.

Crop	Mean acreage
Arrow roots	0.2±0.036
Bananas	0.4±0.083
Beans	0.8±0.087
Butter nuts	0.9±0.240
Capsicum	0.4±0.100
Cassava	0.5±0.155
Coriander	0.3±0.00
Cotton	1.0±0.00
Cow peas	0.8±0.088
Crotalaria Spps.	0.1±0.00
Green grams	0.8±0.181
Maize	1.1±0.053
Millet	0.8±0.074
Onions	0.3±0.100
Pawpaw	0.3±0.000
Pepper	0.5±0.000
Green pepper	0.2±0.025
Potatoes	0.3±0.037
Rice	2.3±0.267
Sorghum	0.9±0.067
Spider plant	0.3±0.000
Sugarcane	1.1±0.361
Sweet potatoes	0.4±0.065
Tomatoes	0.6±0.091
Vegetables	0.4±0.028
Water melons	0.7±0.237
Yams	0.6±0.083

reduced farm yields and financial income per individual farmer (Svotwa *et al.*, 2008).

4.4 Land preparation, soil fertility management and access to agricultural extension services

It was noted that majority of those interviewed used manual land preparation methods (manual tillage 30.9 %, slash and burn 29.6 %, others 0.6 %) and animal drawn power

32.1 % as opposed to mechanized land preparation methods (6.8 %). However, manual land preparation was found to be more expensive compared to mechanized land preparation methods (**Table 4.5)**. The fact that majority of the farmers used manual land preparation methods and oxen drawn power compared to mechanized power can be explained by the following. Firstly, it could be attributed to the small land acreages which most farmers owned. Secondly, majority of the farmers dependent on their families for the provision of cheap labor. Some respondents argued that they owned small land sizes and it was therefore uneconomical to hire tractor services hence only few farmers, those who owned big rice and sugarcane plantations could afford to hire the tractor services. Mechanized land preparation offers a deeper ploughing and breaks the hard pans which is good for root penetration. Oxen drawn plough made better planting lines hence many farmers preferred it despite it being more expensive than using tractor services for the same purpose. The increased use of manual land production methods by many of the farmers as compared to mechanized land production was a clear indication that subsistence agriculture was the common form of agriculture in the area. It was observed that subsistence farming was common though there was encouragement to the farmers to embark on commercial agriculture and agro forestry. In most cases and where farms have been subdivided to small portions, subsistence farming is not sustainable especially when a diversity of crops is not cultivated (Svotwa *et al.*, 2008). Farmers only got little produce from their small plots; they kept growing the same type of crops repeatedly for seasons and this resulted to land degradation through nutrient depletion and soil erosion.

Table 4.5: Cost of different land preparation methods in Kadibo Division

Land preparation method	**Cost per Acre (KSh.)**			
	Land Clearance	Ploughing	Harrowing	Making of planting lines
Mechanized (use of tractors)	1,000	4,200	3,500	2,400
Use of Oxen	1,000	3,300	3,200	2,700
Manual land preparation	1,000	5,000	4,200	3,500

Agricultural extension service was very important to farmers for improved production techniques. However, it was noted that majority of the farmers (55.8 %) did not have access to agricultural extension services. This demonstrated how vulnerable the farmers were to preventable crop production losses and lack of proper soil conservation measures resulting to poor crop yields. A shortage of agricultural extension workforce within the area was observed as compared to the large number of farmers. The Ministry of Agriculture officers provided extension services on demand basis. In this case, the farmers from a given location had to request the officers on technical advice on certain production techniques. Agents from the Ministry of Agriculture were the most common source of agricultural extension service providers (**Figure 4.3**) followed by Victoria Institute for Research and Development (VIRED). The results however showed a positive correlation between access to agricultural extension services and the method of land preparation and the cropping system used ($P < 0.0001$).

The greatest number of the farmers did not apply any soil fertility management practices (64.4 %) while 17.2 % used inorganic fertilizers, 13.4 % applied animal manure and only 5.0 % used green manure on their crops. Lack of application of soil nutrients on crops can result to poor soil structure and decline in crop yields. Table 4.6 shows maize

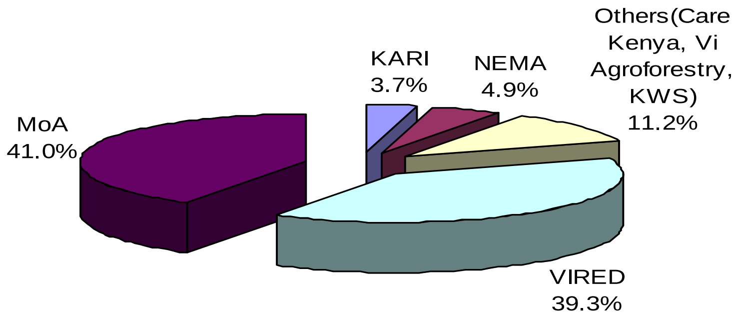


Figure 4.3: Proportion of extension service providers operating within Kadibo division

Table 4.6: Soil fertility management practices as relates to maize yield per acre of land

Soil Fertility management option	Maize Yield per Acre in bags
Fertilization	5.3
Animal manure	6.2
Green manure	5.3
None	3.4

yield under different soil fertility management options. The least yield can be seen to be realized when no fertilization was applied (**Table 4.6)**. The 17.2 % who applied inorganic fertilizers on their crops majority did it even without knowing the nutrition status of their soils. This practice can result in application of inappropriate fertilizers resulting in accumulation of nutrients in the soils and poor crop performance resulting in decline in crop yields. The accumulated nutrients will eventually leach to the surrounding wetlands and this will result in eutrophication. Addition of manure to the rotation seasonally can result in high maintenance of the productive capacity of the fields.

4.5 Soil conservation methods

The study area (Kadibo) lying on a relatively flat zone of the Kano plains, the challenge facing farmers was flooding. With many farmers involved in storm drain construction (23.2 %) and terracing (22.4 %) as shown in **Table 4.7**, awareness on need for soil and hence wetland conservation was high among farmers. Environmental awareness enables community members to develop the commitment to constructively participate in transformation of the environment (Baez *et al.,* 1987). The development of such an appreciation of environmental quality among wetland farmers promotes in them an attitude of care for their plots and a sense of responsibility for the well being of the wetland system as a whole. Storm drains direct water to collect at a defined place rather than accumulating within the farms causing floods. The farmers dug drainage canals to direct storm water into the storm drains. Mulching, as practiced by 13.0 % of the respondents cushions the ground from raindrop impact and conserves soil moisture (Muler - Saman and Kotschi, 1994). Terracing reduces runoff down slope. The survey also indicated that 6.8 % of the interviewed respondents practiced agro-forestry while 4.9 % practiced crop rotation. Some of the farmers (18.4 %) did not use any soil conservation method. This phenomena is however, not unusual in any situation of technology transfer. The rate of adoption of new technology and ideas by a community is influenced by a variety of factors, which include socio-cultural influence and social

Table 4.7: Erosion control measures employed by farmers

Method	No. of farmers	Percentage (%)
Others (dyking, furrowing)	2	0.5
Contour ridge use	10	2.7
Inter cropping	13	3.5
Fallowing	17	4.6
Crop rotation	18	4.9
Agro forestry	25	6.8
Mulching	48	13.0
None	68	18.4
Terraces	83	22.4
Storm drain construction	86	23.2

marketing strategies (Kolter and Zaltman, 1971). The number of adopters increases as awareness of the technology increases and the benefits become apparent.

The results showed a positive correlation (0.2183) between soil conservation and access to agricultural extension services. As noted from interviews with the farmers and through field observations, the farmers who did not apply soil conservation measures were vulnerable to crop losses resulting from disasters such as floods. Considering the physical environment of Kadibo division, adoption of construction of storm drains can help prevent crop losses resulting from flooding as the big portion of the land is plains. This could be combined with mixed cropping and use of agro-forestry to help conserve the soil from surface erosion. Fallowing will help in maintaining the soil structure while crop rotation will help in nutrient recycling.

4.6 Land ownership

Majority of the respondents 76.8 % owned land privately (**Table 4.8**). Private land ownership has the importance that the owners can embark on long term land development and conservation strategies. Farmers would invest more on land that they have secure rights over than in cases where land is communally owned and of lesser entitlement (Mose *et, al.,* 2000). Similarly, a study carried out by Kormawa *et, al.,* (2003), showed that farmers when assured of their land holdings were willing to invest in that given land hence can adopt a given technology with ease.

A major point of concern on land use was on the perception the respondents had towards utilization of wetland resources. There was a believe by 58.1 % of the respondents that the wetlands were a common resource and every community member had a right to access and use the wetland resources. This approach to utilization of resources can have a negative impact on the wetlands especially when no strict conservation policies are put in place and enforced as everybody tries to compete for their resources unsustainably. This could explain the high rate of wetland infestation for farming and papyrus harvesting by the local community to compete for its resources.

Table 4.8: Type of land ownership by the respondents

Ownership	Frequency	Percentages
Communal	3	1.4
Others (inherited, borrowed)	18	6.4
Rented	43	15.4
Private	215	76.8

4.7 Patterns of wetland resource utilization/benefits and major threats to the wetlands existence in Kadibo

A scoring system of 1-5 was used to rank the main wetland resource utilization. Score 5= highly important beneficial activity from the wetlands while score 1= was the least important beneficial activity. Some main wetland resource extraction activities by the community as shown in **Figure 4.4** were fishing, grazing, harvesting of papyrus materials for handcraft materials, thatching grass, water harvesting, land utilization for cultivation and brick making and wood fuel. There was a significant difference on the wetland resource utilization activities (social economic activities) at $P < 0.0001$ (**Table 4.9**). Due to the large number of the wetland resource utilization activities, it was important to conduct Principal Component Analysis (PCA) to reduce chances of

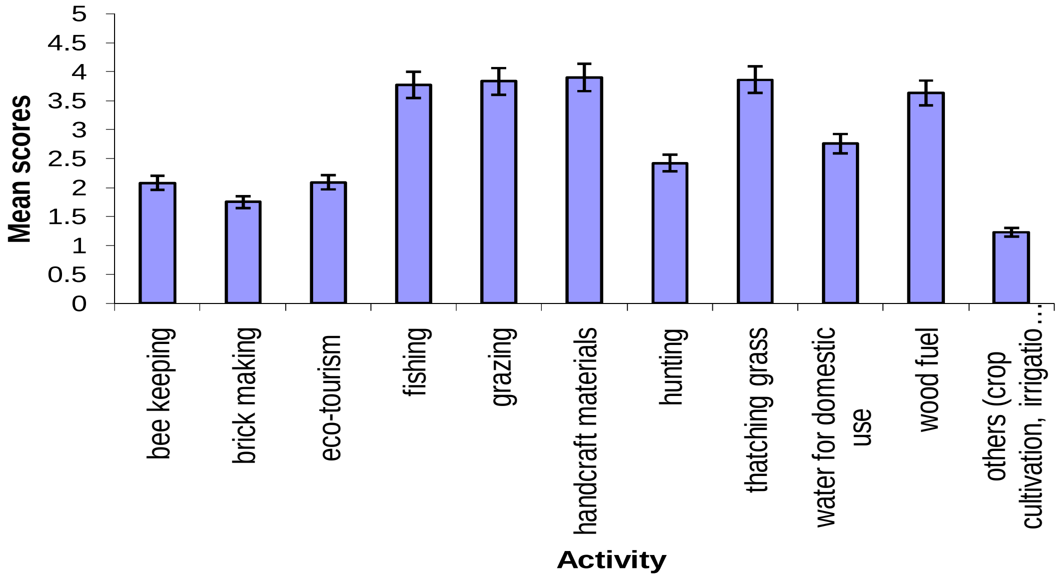


Figure 4.4: The types of wetland resource utilization by the community

Table 4.9: ANOVA table for social economic activities/wetland resource utilization by the local community at P < 0.05

(Source of variance)	**Kruskal-Wallis test**		
	Chi-Square	**DF**	**Pr > Chi-Square**
Social economic activities/wetland resource utilization activities	4654.1678	10	<.0001
Occupation	95.8404	16	<.0001
Education level	2.6929	3	0.4414

redundancy. In this case, redundancy means that some of the resource utilization activities were correlated with one another, possibly because they were measuring the same construct. Because of that possible redundancy, it was important to reduce the observed indicators into a smaller number of principal components (artificial variables) that could account for most of the variance in the responses.

PCA results determined that there were only four meaningful components which were worth retaining. These components were namely; consumptive and sustainable resource uses, social economic activities, consumptive resource uses and exploitive resources utilization. This was based on the Eigen value-one criterion and the interpretability criteria. The values were multiplied by 100 and rounded to the nearest integer. Values greater than 0.3 were flagged by an '*' (**Table 4.10**).

The wetland resource utilization activities loading significantly in component 1 (consumptive and sustainable resource uses) were; bee keeping, brick making, harvesting of wood fuel, water for domestic use and ecotourism benefits. The wetlands had many resources and majority of the community members were finding their livelihoods through diverse consumptive uses (brick making, harvesting of wood fuel and domestic water). Some of the wetlands (Nduru, Nyamware and Ogenya singida)

Table 4.10: Eigen scores and the variance of first four components of PCA on wetland resource utilisation/benefit by the community

	Component 1 (Consumptive and sustainable resource uses)	**Component 2 (Social-economic activities)**	**Component 3 (Consumptive resource uses)**	**Component 4 (Exploitive resource uses)**
Eigen values	2.49	1.68	1.46	1.14
% Variance	25.0	16.5	10.8	9.2
% Cumulative variance	25.0	41.5	52.3	61.5
Mode of exploitation				
Grazing	10	72*	8	4
Harvesting of handcraft materials	-12	52	55*	-9
Fishing	-2	66*	-10	-4
Hunting of wild animals	-7	-5	88*	2
Harvesting of thatching grass	-5	37*	21	71*
Bee keeping	75*	-32	6	2
Brick making	66*	14	-31	-8
Harvesting of wood fuel	61*	2	-45	-9
Water for domestic use	76*	29	3	-16
Ecotourism benefit	70*	-5	-3	25
Others (crop cultivation, irrigation water)	4	-33	-16	72*

were however being utilized as fish landing beaches which had a potential of being converted to eco-tourist sites. Bee keeping, a non-consumptive/sustainable wetland resource utilization could be an alternative sustainable wetland resource utilization. Some community members were engaging themselves in bee keeping after they had been trained by the VIRED personnel. This was however done at a small scale and there was need to train more people, facilitate them with the necessary equipment and facilitate on the marketing of the honey and its products. The wetland resource utilization activities loading significantly in component 2 (social economic activities) included grazing and fishing. The wetlands were particularly important for grazing during drought and the dry seasons when the water levels receded. The community was allowed to graze their cattle in the wetlands which were free access properties thus grazing was not controlled. An interesting observation made during this study was the free range grazing of animals on the wetlands (**Plate 1**). Large herds of cattle were always allowed to range freely in the wetland areas. Free ranging and over-grazing of livestock on such areas of land can have a negative impact on the environment. Overgrazing by livestock on any piece of land leads to compaction of the soils and this negatively affects the soil structure and its biological activity. Fishing was a major livelihood of the local community. Nduru, Nyamware and Ogenya singida were some of the main fish landing points in the study site. There was some evidence that the wetlands suffered some cutting and burning of papyrus to allow access for fishing of swamp fish species **(Plate 2).** If not controlled, fishing can lead to over exploitation and loss of biodiversity.

Finally those wetland resource utilization activities loading significantly in component 3 (consumptive resource uses) were harvesting of handcraft materials and hunting of wild animals. Component 4 (exploitive resource uses), had harvesting of thatching grass, crop cultivation and water for irrigation loading significantly into it. Agriculture, which was one of the most important agro economic activities within the area had been intensified in the last decade and most people were draining the wetlands for crop production. This

Plate 1: Grazing within the wetlands

Plate 2: Area where papyrus had been cut down to pave way for fishing

was mostly attributed to rapid increase in human population, high levels of poverty and unemployment. The increasing numbers of landless and unemployed people were moving and settling in fragile wetland areas in search of new means of livelihood. This led to decrease in the wetland sizes and hence decreased biodiversity within the wetlands. The local communities were also turning to alternative sources of income such as papyrus-based products such as mats, chairs and baskets. Given the existing pressure on papyrus, this resource could soon be harvested beyond its regenerative capacity. Wood fuel, which was one of the main reasons for papyrus harvesting was not sustainable. Fuel from papyrus cannot burn for long and hence one may need to harvest a lot for just simple cooking. There was, therefore, need to find alternative means of fuel for cooking such as firewood or biogas. These wetland resource utilization activities had intensified in recent years and were of particular concern as they had led to other forms of disturbance to papyrus such as pollution and burning **(Plate 3)**.

A Principal Component Analysis (PCA) was conducted to determine the main factors threatening the wetland existence as perceived by the respondents. PCA results determined that there were only two meaningful components which were worth retaining. These components were namely; human induced threats and a combination of natural threats and sustainable resource uses. This was based on the Eigen value-one criterion and the interpretability criteria. **Table 4.11** shows Eigen scores and the variance of the first two components of PCA. There was a significant difference between the factors threatening wetland as perceived by the local community at $P< 0.0001$(**Table 4.12**).

Plate 3: Wetland clearance through burning and papyrus harvesting for wood fuel

Table 4.11: Eigen scores of first two components of PCA on the factors threatening wetland existence as perceived by the community

	Component 1 (Human induced threats)	**Component 2 (Natural threats and sustainable resource uses)**
Eigen values	2.64	1.10
% Variance	37.9	15.5
% Cumulative variance	37.9	53.4
Factors threatening wetlands		
Fishing	74*	-7
Farming	81*	10
Eco-tourism	8	61*
Harvesting of thatching grass	84*	11
Harvesting of handcraft materials	84*	-2
Droughts	-8	66*
Others (floods, climate change)	-8	51*

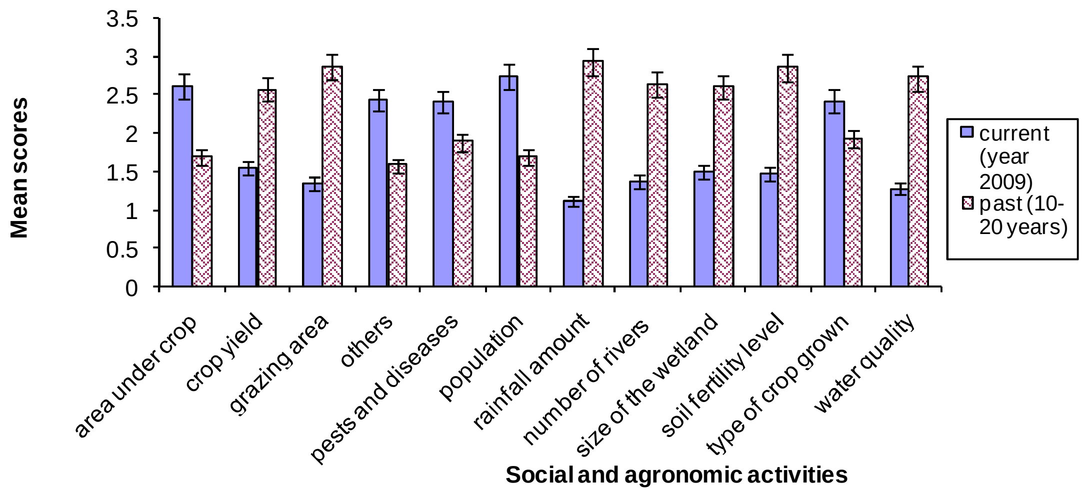
Table 4.12: ANOVA table for factors threatening wetland existence as perceived by the respondents at $P < 0.05$

(Source of variance)	**Kruskal-Wallis test**		
	Chi-Square	**DF**	**Pr > Chi-Square**
Factors threatening wetlands	2485.0538	6	<.0001
Location	304.9418	3	<.0001
Education	18.2071	3	0.0004

The factors perceived to threaten wetland existence which significantly loaded into component 1 (human induced threats) were fishing, farming, harvesting of thatching grass and handcraft materials. These were generally human induced exploitive activities which had resulted to decrease in wetland sizes as well as habitat losses. Meanwhile, the second group of factors threatening wetland existence which significantly loaded into component 2 (natural threats and sustainable resource uses) were eco-tourism benefit, droughts, floods and climate change. Natural threats to wetlands, such as climate change, drought and floods may be unavoidable, but human-induced threats such as the wetland consumptive activities discussed above could be prevented through sustainable and non consumptive ways of wetland resource extraction.

4.8 Changes in social and agronomic activities

The area under crop production had increased (**Figure 4.5**) and this implied that more people were opening up new areas including wetlands for cultivation **(Plate 4)**. This increase in the area under crop production had occurred at the expense of the grazing area and the size of the wetlands which had reduced over the years (**Figure 4.5**). The respondents, many of who depended on rain fed agriculture for crop production said that the amount of the rainfall had drastically reduced over the years and that contributed to poor crop yields due to droughts. Most of the farmers said that their crops were experiencing poor growth rate and low yields especially when they did not use any fertilization. This supported the fact that majority of the respondents had acknowledged that the soil fertility levels in their farms had reduced due to over cultivation of the farms which contributed to poor crop yields (**Figure 4.5**). However, the decline in crop yields could also have been brought about by the increased incidences of pests and diseases (**Figure 4.5**) which had occurred in the last twenty years.



KEY: 3= high/big 2=medium 1= low/small

Figure 4.5: Comparison of the changes in social and agro-economic activities both at the current (2009) and past (10-20 years)

Plate 4: Part of the wetland drained for agricultural crop production

4. 9 Conservation efforts

4.9.1 Utilization, conservation and management of the Nyando wetlands

Majority of those interviewed 98.8 % believed that there was need to conserve the wetlands. 38.2 % of the respondents said that the local community was responsible for the wetland conservation while 36.6 % believed that both the local community and the government should participate in the conservation. This was a clear indication that the local community should not at all be left out in any conservation efforts. Infact, they should be empowered and be involved at every stage of conservation. Despite some environmental based organizations having been operational in the area, a considerable number 61.7 % said that they did not get any training on wetland conservation from the government or NGO’s. However, there were those who said they got training on wetland conservation (38.3 %). This signified that either there was not enough workforce to offer those training or the community might have been reluctant to be trained. There were some environmental based Non-Governmental Organizations (NGO’s) operational in the area. Victoria Institute for Research on Environment and Development (VIRED) was one of the significant organizations operational in the area involved in wetland conservation. VIRED acted as a catalyst to bridge gaps between technical environment concerns and basic community needs. VIRED in collaboration with the Kenya Wildlife Service were conducting research, mobilizing communities, creating awareness, and empowering the local communities to sustainably manage wetland resources within the Lake Victoria Basin. It offered various training programmes to the local community on sustainable utilization of the wetland resources which covered horticultural production, fish farming, bee keeping and the production of quality wetland products. Their focus was placed on prudent utilization of wetland products for improving livelihood of the communities. Through collaboration with CARE Kenya, they also undertook flood water mitigation management projects (http://viredinternational.org/).

One of the most prominent factors underlying wetland management problems in Kenya as observed elsewhere has been the lack of or insufficient awareness of the functions and benefits of wetlands leading to inappropriate use of their resources (Mafabi, 2000). There is need for the government through relevant bodies concerned with environmental conservation to embark on educating the local communities on sustainable ways of wetland resource utilization. However, through NEMA and VIRED, the local community of Kadibo acknowledged that they got education on the value of wetlands and on their conservation. The Innovative co-operative ways needed to be devised to sustain the conservation of biodiversity while addressing their needs and development issues. Other communities adjacent to the lake needed to be encouraged in conservation oriented enterprises for instance monitoring activities and ecotourism. Locals can only benefit directly by participating in conservation efforts. Activities like ecotourism among many, with the help of the government can enlist the support of the local people in conservation. Rural development programmes and Constituency Development Funds (CDF) from the government should support their needs. Diversification and investing in conservation of the wetland resources, while enhancing rural economy of the local population by development assistance and other conservation oriented groups will go along way in the Lake conservation. Use rights of wildlife (their protection and conservation) will go along way towards creating sustainable development like fishing (Leakey, 1991).

4.9.2 Sustainable conservation strategies

A Principal Component Analysis (PCA) was conducted to determine the main sustainable conservation strategies as proposed by the respondents. PCA results determined that there were only three meaningful components: consumptive resource uses, sustainable resource uses, and non-consumptive resource uses, which were worth retaining. **Table 4.13** shows Eigen scores of the first three components of PCA. There was a significant difference between the conservation strategies proposed by the respondents at $P < 0.0001$ (**Table 4.14**).

Table 4.13: Eigen scores of first three components of PCA on sustainable conservation strategies proposed by the respondents

	Component 1 (consumptive uses)	**Component 2 (sustainable uses)**	**Component 3 (non-consumptive uses)**
Eigen values	1.73	1.32	1.14
% Variance	30.3	21.2	18.2
% Cumulative variance	30.3	51.5	69.7
Conservation strategies			
Eco-tourism center	-6	80*	-24
Bee keeping	37*	46*	62*
Conservation for handcraft materials	78*	-20	-5
Grazing	84*	10	-23
Practicing agro-forestry	-14	-3	93*
Others (educational/research site)	3	65*	14

Table 4.14: ANOVA table for the proposed conservation strategies by the respondents at P < 0.05

(Source of variance)	**Kruskal-Wallis test**		
	Chi-Square	**DF**	**Pr > Chi-Square**
Conservation strategies	2772.8137	5	<.0001
Education level	9.6236	3	0.0221
Location	302.1410	3	<.0001

Significant loadings into component 1 (consumptive resource uses) consisted of wetland conservation for hand craft materials and grazing. These were generally consumptive wetland resource utilization methods which may not be sustainable hence loadings into component 2 and 3 were recommended. Component 2 (sustainable resource uses) loadings were eco-tourism center and others (educational/research sites). These loadings into component 2 were the alternative and sustainable methods of non consumptive wetland resource utilization. Eco-tourism was the least developed activity despite being a sustainable and a viable economic activity. Finally, a significant loading into component 3 (non-consumptive uses) was conservation through the practice of agro-forestry and bee keeping. Bee keeping was a non consumptive wetland resource utilization which was also sustainable. The practice of agro-forestry is a combination of consumptive and non consumptive wetland resource utilization (that is, through cultivation of crops and planting of trees). The locals had been involved in agro-forestry practices in the last decade. This was a significant boost not only to conservation of soil but also to wise use of wetland resources. As seen from Figure 4.4, harvesting of papyrus for wood fuel was amongst the main wetland resource consumptive use method by the locals. Through some organizations operating in the area, the community was educated on the importance of agro-forestry as well as sometimes being given some tree seedlings by the Vi Agro-forestry organization. Trees could help as alternative sources of wood fuel and reduce on dependence on wetland resources particularly papyrus whose fuel wood was not sustainable. Trees could also sequester carbon from agricultural activities thus reducing carbon dioxide emissions into the atmosphere.

Nyando wetland resources were undergoing rapid transformation through diverse consumptive practices by the local communities for their daily survival. Despite the increased consumptive utilization of wetlands in Kadibo division, the living standards of the people had remained low. Ecotourism as a sustainable conservation strategy is discussed below.

4.9.3 Alternative methods of wetland utilization

Eco-tourism which was least developed in Kadibo is an alternative sustainable method of wetland utilization. A research contacted in Sango Bay wetland showed that eco-tourism will enjoy more strengths and opportunities than weaknesses and threats (Nyakaana, 2008). Income could be generated through charging of tourists visiting the wetland. The wetland could be promoted as a locally controlled, people-centered tourist destination. This is sustainable tourism, which is nature based and incorporates a desire to minimize negative social and environmental impacts (Swarbrooke, 1999) and embrace economic, environmental, social, community and visitor benefits (Herath, 2002). Most communities perceived wetlands as sources of direct benefits (crop production, grazing, fishing, craft materials, clay and water harvesting) but failed to appreciate the ecological functions and other life support non-tangible benefits like filtering of polluted water, reduction of river flooding and siltation and environmental benefits. Consumptive utilization of wetland resources degrades them and, therefore, is not sustainable. However, the diverse resources could be used for eco-tourism development which not only helps in conserving them but also provide sustainable income for the communities. Tourism has a comparative advantage of a "flow through" or "catalyst effect" across the economy in terms of employment creation and production. Tourism creates employment, demand for transport, telecommunication, financial services, handicrafts, consumption of local products (foods), accommodation, linkages to agriculture, fisheries, food processing, light manufacturing and the informal sector (Nyakaana, 2008).

The development and promotion of ecotourism was crucial for sustainable management and utilization of wetland resources in Kadibo division for poverty alleviation and sustainable socio-economic development. This non-consumptive utilization of wetland resources has more advantages over most forms of consumptive uses like agriculture, sand and clay harvesting. This is because ecotourism initiatives endeavor to respect and maintain environmental integrity while at the same time improving existing social and cultural manifestations for community livelihoods (Nyakaana, 2008). Furthermore, ecotourism initiatives are centred on attracting small numbers of high-spending tourists willing to stay longer in a destination, thus maximising the economic benefits to the stakeholders while minimizing the negative impacts on the environment and society as a whole (Jones, 2007; Hwey-Lian *et al.,* 2004; Pemberton and Mader, 2004; Shores, 2003).

4.9.3.1 Existing and potential eco-tourism resources and development

Wetlands in Kadibo division were endowed with diverse and unique natural and cultural resources that were suitable for ecotourism development and promotion. The respondents were asked to name the floral and faunal species which existed in the wetlands and to state whether their occurrence was extinct, rare or abundant. Different plant and animal species were found to exist within Kadibo division (**Table 4.15)**. Floral diversity in any one eco-system as evident in Nyando wetlands (**Table 4.15**) was important for supporting diverse fauna especially herbivores and birds and this was important for ecotourism development, which could be used to positively change the livelihoods of the local community. As nature and cultural tourism in developing countries are among the fastest growing sub-sectors of the tourism industry (Ceballos-Lascurai, 2003) and tourism is itself the world's largest and fastest growing industry. Worldwide tourism generates 11% of world income, employs 200 million people, transports 700 million international travelers per year and is expected to double in size by the year 2020 with an anticipated one billion tourists per year (Roe and Khanya, 2001). The development of eco-tourism could be more beneficial to the community as a whole than the present consumptive use of resources that has led to resource degradation and continued high levels of poverty. When developing eco-tourism, the main guiding principle is to compliment rather than undermine livelihood and social security of the

Table 4.15: Some floral and faunal composition within Kadibo wetlands

Plants	Use/harm	Current status (2009)
Papyrus (*Cyperus papyrus*)	Weaving, thatching, fuel wood	Rare
Reeds *(Phragmites australis)*	Thatching, weaving, fuel wood	Rare
Sesbania (*Sesbania sesban*)	Fuel wood	Rare
Sedge plant (*Lippia javanica*)	Thatching, animal feed	Rare
Lantana (*Lantana camara*)	Weed, fuel wood	Rare
Scented-pod Acacia (*Acacia nilotica*)	Fuel wood	Rare
Bananas (*Musa spp.)*	Human food, animal food	Rare
Animals		
Tilapia (*Oreochromis mossambicus*)	Human food	Rare
Nile perch (*Lates niloticus*)	Human food	Rare
Mud fish (*Neochanna spp.)*	Human food	Rare
Channel Cat Fish (*Ictalurus punctatus*)	Human food	Rare
Common Frog *(Rana temporaria)*	Prediction of rainy seasons	Rare
African Rock Python *(Python sebae)*	Harmful to people and domestic animals	Rare
Nile Monitor Lizard *(Varanus niloticus)*	Eats chicken, destroys crops	Rare
Common Crocodile *(Crocodylus niloticus)*	Harmful to people	Rare
Hippopotamus *(Hippopotamus amphibius)*	Destroys crops, human food	Rare
Thomson's Gazelle *(Gazella thomsoni)*	Human food, crop destruction	Rare
Sitatunga (*Tragelaphus spekii*)	Human food	Rare
Vervet Monkey *(Cercopithecus aethiops)*	Destroys crops	Rare
Brown Hare (*Lepus capensis)*	Destroys crops, human food	Rare
African Spurred Tortoise *(Geochelone sulcata)*	Eat insects and crops	Extinct
Hyena *(Crocuta spp.)*	Eat domestic animals	Extinct
Social Weavers *(Philetairus socius)*	Destroys crops	Rare
Greyish Eagle-owl *(Bubo cinerascens)*	Eats chicken	Rare
Papyrus yellow warbler *(Chloropeta gracilirostris)*		Rare
Papyrus gonolek *(Laniarius mufumbiri)*		Rare
Papyrus canary (*Serinus koliensis*)		Rare
White-winged warbler *(Xenoligea montana)*		Rare

community. Ecotourism could face challenges such as cultural degradation, continued consumptive use of wetland resources hence wetland degradation as well as political interference. Poor infrastructure, lack of investment funds by the communities and illiterate/ semiliterate communities are some weaknesses to ecotourism development. If the weaknesses and challenges of eco-tourism development were addressed, then eco-tourism as a sustainable use of wetland resources could assist in the reduction of poverty among the rural communities living in areas adjacent to wetlands. The resources of the wetlands within Kadibo division should be used to develop different eco-tourism activities as proposed in **Table 4.16**. In Kenya and Namibia community-based tourism development has transformed the livelihoods of communities through both full-time and casual employment by making the cash strapped households meet their economic needs (Ashley, 2000).

4.10 Land use/cover changes

4.10.1 Changes in wetland and the water bodies cover

Area under major land use/cover categories was calculated for the year 1985, 1995 and

Table 4.16: Possible eco-tourism activities in Kadibo wetlands

- Bird watching (from diverse papyrus endemic bird species e.g. Papyrus yellow warbler, Papyrus gonolek, Papyrus canary & White-winged warbler) - Wildlife viewing (from different mammals, amphibians and reptiles) - Recreational/sport fishing and boat riding from Lake Victoria - Cultural tourism (through cultural resource attractions such as pottery, basketry, local cuisine, performing of traditional songs and dances and traditional cleansing ceremonies) - Sight seeing and nature walks. - Sports tourism

2008 (**Table 4.17** and **Figure 4.6**). The area under swamps and wetland cover increased by 4.58 Km^2 (20.8 %) in 1985-1995 and then decreased at a rate of 0.65 Km^2 per year to 6.54 Km^2 (24.6 %) in 1995-2008 period (**Table 4.17**). This decrease could be attributed to four principal causes, often in relationship with each other, namely; clearance and draining of the wetlands for cultivation, overgrazing, unsustainable harvesting of papyrus and drought periods. The area under water bodies increased from 4.30 Km^2 in 1985 to 9.40 Km^2 in 2008. This increase could be attributed to the consumptive uses of the wetlands by the communities who cleared them up especially during the dry months the images were taken leaving the water exposed. This could be true as the wetland area decreased from 1995-2008. However, despite the trend of increase in the area under

Table 4.17: Land use/cover types in Kadibo division showing the change and the rate of change in the area under the different land cover types for 1985, 1995 and 2008

Land Use/ Cover type	Area (Km^2) 1985	Area (Km^2) 1995	Change in area (Km^2) 1985-1995	Rate of change in area (Km^2/yr) 1985-1995	Area 2008 (Km^2)	Change in area (Km^2) 1995-2008	Rate of change in area (Km^2/yr) 1995-2008
Swamps/ wetlands	22.02	26.60	4.58 (20.8 %)	0.46	20.06	-6.54 (-24.6 %)	-0.65
Dense Agriculture	68.55	69.91	1.36 (2.0 %)	0.14	107.61	37.71 (53.9 %)	3.77
Sparse Agriculture	71.80	63.23	-8.57 (-11.9 %)	-0.86	29.60	-33.63 (-53.2 %)	-3.36
Water bodies	4.30	6.98	2.68 (62.5 %)	0.27	9.40	2.42 (34.6 %)	0.24
TOTAL	**166.7**	**166.7**			**166.7**		

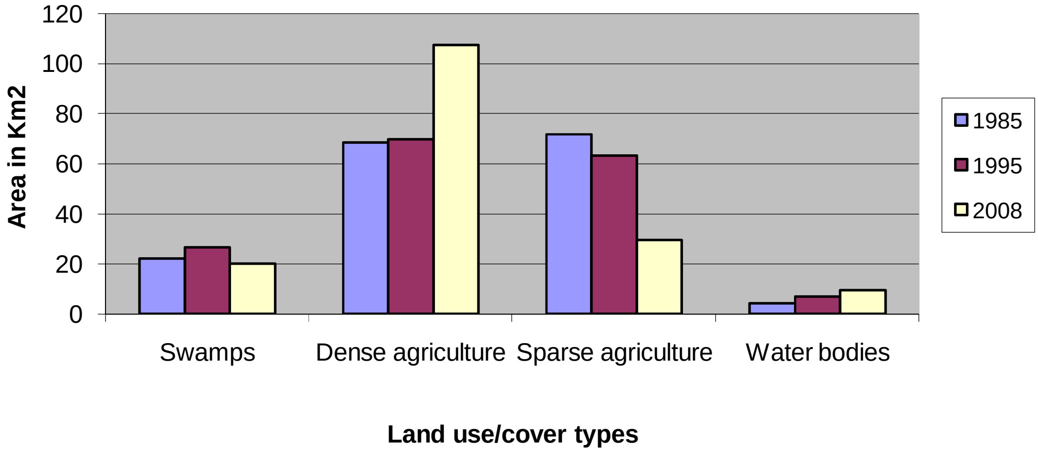


Figure 4.6: Comparison of the area under different land use/cover types in Kadibo Division

water bodies over the three years, increase rate could be seen to decrease from a rate of change in the area by 0.27 Km^2 per year in 1995 to 0.24 Km^2 per year in 2008. This change could be attributed to consequences of climate change such as droughts.

4.10.2 Changes in the land under crop cultivation cover

A major factor for the disappearance of the wetlands has been search for new agricultural land due to increasing population pressure and the need to generate more income. The area under sparse agricultural land reduced by 8.57 Km^2 (11.9 %) in 1985-1995 and then further decreased at a rate of 3.36 Km^2 per year to 33.63 Km^2 (53.2 %) in 1995-2008 (**Table 4.17** and **Figure 4.6**). This reduction in the area under sparse agriculture had happened at the expense of increase in the area under dense agricultural land cover (**Figure 4.6**). This showed that the local community members had shifted from less intensive to more intensive agricultural production. This increase in dense agricultural land had also happened at the cost of the surrounding wetlands.

The information obtained from land cover change analysis was important to support the social survey data discussed earlier in this study hence increasing reliability and validity of the results. As earlier noted from the social survey data about decrease in the sizes of the wetland, from the analysis of land use/cover change within Kadibo, the area under the wetlands was also found to decrease. From the social survey, it was found out that crop cultivation had intensified in the last 10-20 years. An increase in the same area was also found from land use/cover change analysis. These results indicated that there was need for the local community of Kadibo to embark on sustainable methods of wetland resource utilization. This was important to conserve the wetlands from extinction and also aid in biodiversity conservation and sustainable livelihoods.

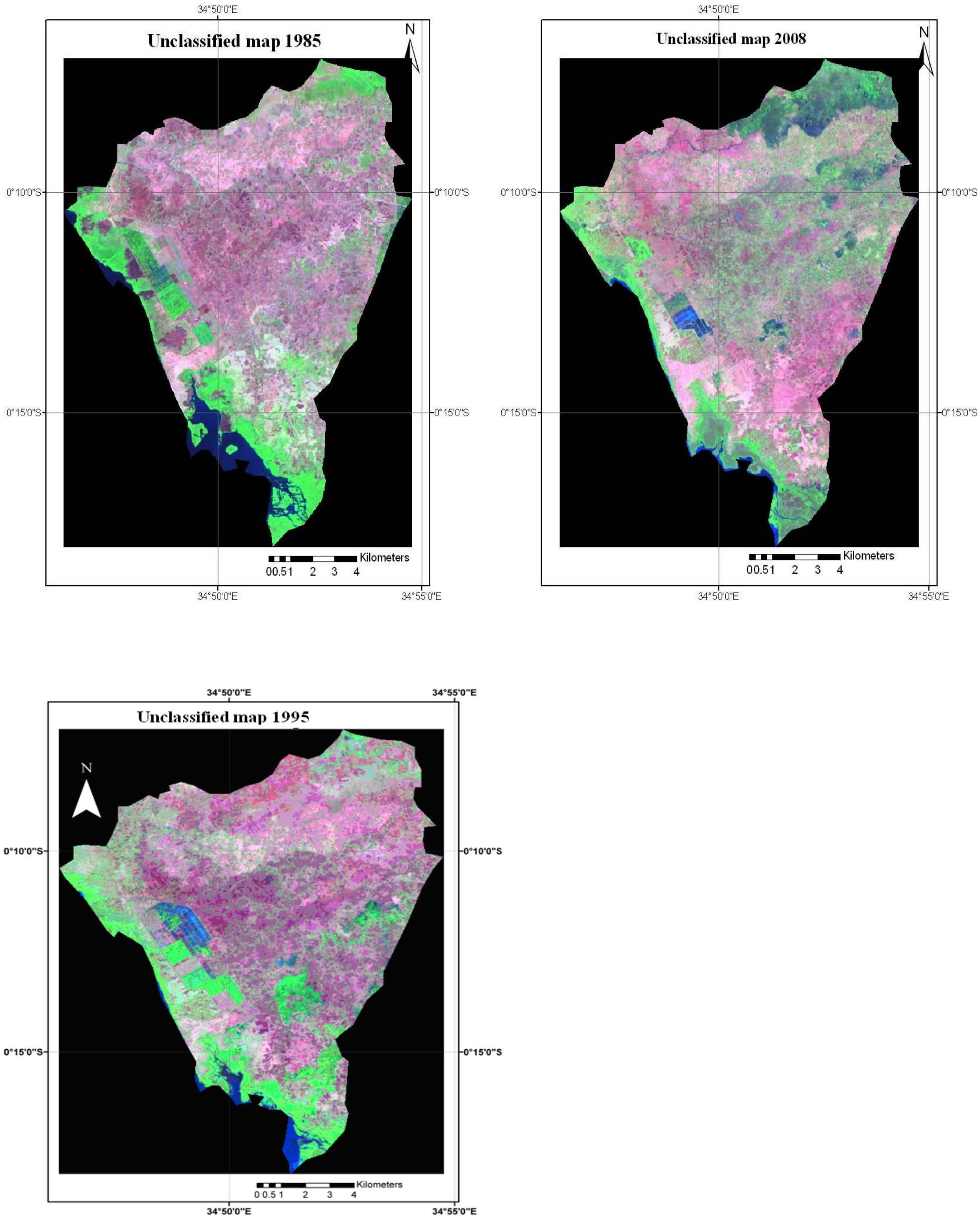


Figure 4.7: Unclassified satellite images of Kadibo division in 1985, 1995 and 2008

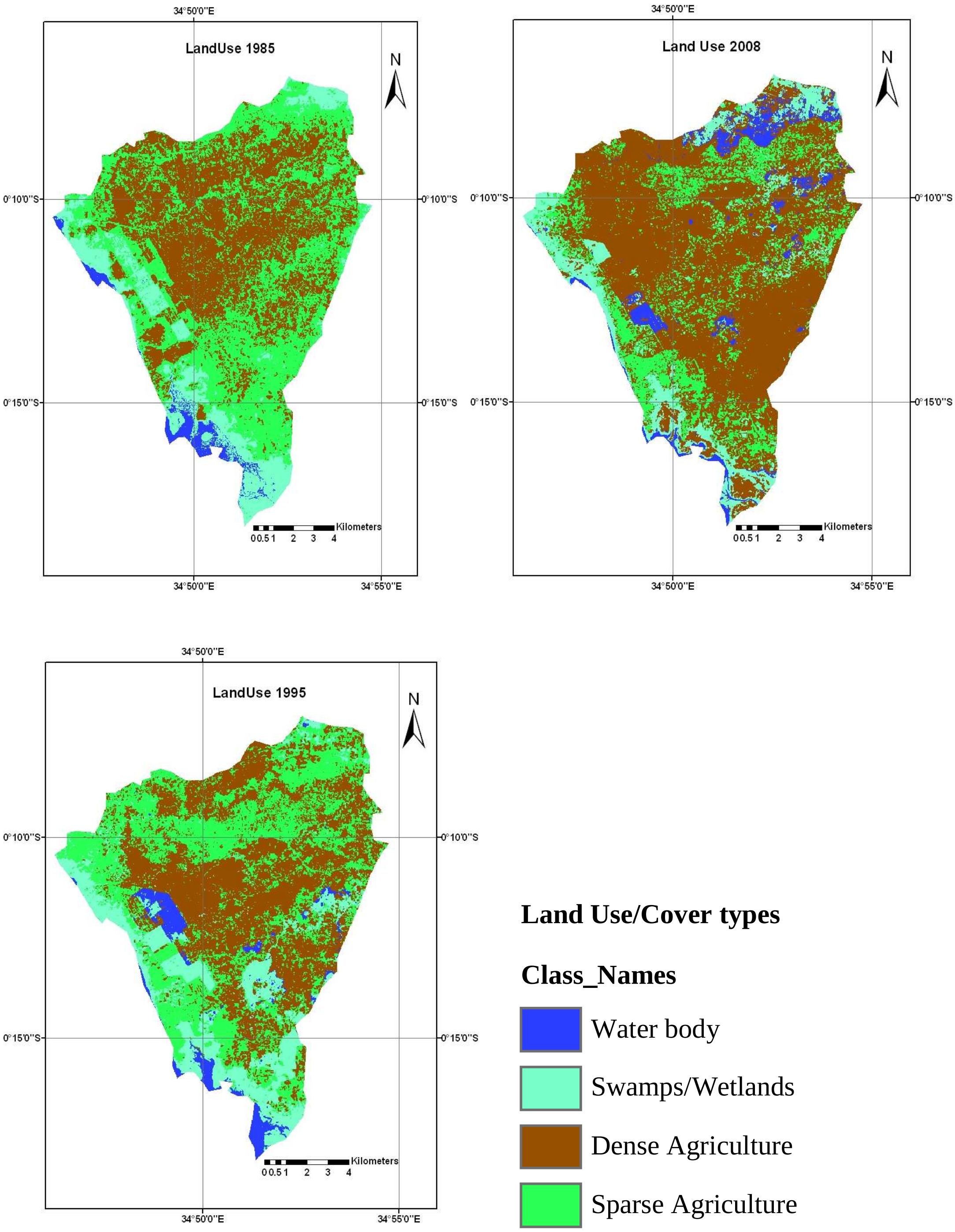


Figure 4.8: Satellite images of land use/cover of Kadibo division in 1985, 1995 and 2008

CHAPTER V

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The Nyando wetlands were multidimensional resources that provided the community with a range of inter-related environmental functions and socio-economic benefits. Because of the range of wetland use strategies at the local levels, there were often conflicting demands placed upon these wetlands. Presently the wetlands have been degraded and their area reduced in size. Long lasting sustainable utilization, conservation and management of this resource therefore hinges on addressing the seemingly conflicting demands of biodiversity conservation, community utilization and agro-industrial development. The high economic potential of the Kadibo wetland, the wetland being non-protected area and the lack of a proper enforcement of the wetland policy made them vulnerable ecosystems. Conversion of the wetland through either draining or reclamation may give short term gains with long term economic, social and environmental problems such as inflated costs and reduction of yields after irreversible soil fertility exhaustion.

All the objectives in this study were achieved. The first objective was to establish the influence of social economic activities on wetland resource utilization at household level in Kadibo division. The wetland resources were undergoing rapid transformation through diverse consumptive practices by the local communities for their daily survival. The local communities perceived the wetlands as sources of direct benefits (crop production, fishing, grazing, craft materials, brick making, clay, water and wood fuel harvesting) but failed to appreciate the ecological functions and other life support non-tangible benefits like filtering of polluted water, reduction of river flooding and siltation. This resulted in decline in the biological diversity and reduction in wetland sizes. The broad range of crop varieties grown within Kadibo division could imply economic sustainability for the farmers; however, there was need to boost access to agricultural extension services by the farmers. This could help the farmers to embark on proper soil conservation techniques, use improved seeds for increased crop yields and proper and wise use of farm inputs for example fertilizers and chemicals to avoid environmental pollution.

The other objective was to quantify the trend and extent of land use/cover changes in the area of Kadibo division. Large areas of the wetlands had been altered to other forms of land use. The area under swamps and wetland cover had increased by 4.58 Km^2 (20.8 %) in 1985-1995 and then decreased at a rate of 0.65 Km^2 per year to 6.54 Km^2 (24.6 %) in 1995-2008 period. In addition, the area under dense agricultural land use increased by 37.71 Km^2 (53.9 %) in 1995-2008 while the area under sparse agricultural land use was found to decrease by 33.63 Km^2 (53.2 %) in the same period. The area under water bodies was also found to increase from 4.30 Km^2 in 1985 to 9.40 Km^2 in 2008. This increase in the water bodies could be attributed to the consumptive uses of the wetlands by the local communities who cleared them up especially during the dry months the images were taken leaving the water exposed. However, there was a decrease in the rate at which the area under water bodies was increasing in 1985-2008. This decrease in the rate of change in the area under water bodies could be attributed to changes in climatic factors such as poor rainfall.

The last objective was to propose appropriate management practices to guide policy development on sustainable utilization of wetlands within the Lake Victoria basin. With the rapid increase in human population in recent years, increasing numbers of people were moving and settling in the wetlands in search of new means of earning a living. Within this broad socio-economic and environmental context, wise use and conservation of wetland resources and the development and promotion of ecotourism and other forms of recreational non-consumptive uses of the wetland was crucial for long-term conservation of resources and poverty reduction. There was high dependence on use of papyrus material for wood fuel which was not sustainable. Sourcing for other alternative sustainable sources of fuels (for example, use of biogas) would greatly contribute to conservation of the wetland resources. Encouraging the farmers to embark on agro-forestry practices would help in soil conservation and also provide alternative sources of energy for fuel by the local community. In addition, the practice of agro-forestry would aid in the recovery of the drained nutrients by the deep rooted trees; enrichment of the soil organic matter by the tree litter and by the dead roots of the trees which could have resulted to increased crop yields.

Value addition contributes significantly to sustainability of papyrus. Value addition on papyrus products would ensure high income returns from the use of small quantities of papyrus materials. The main value addition strategies for the papyrus based products include: variety in patterns and designs, use of paints, improved grading systems especially on the mats, use of dyes and preservatives, improved density, use of nails and metals. However, the kind of value addition would depend on the type of product being processed. The community could have benefited from consultations with the NGOs and development partners to give technical assistance geared towards improving and diversifying the papyrus products and to explore better marketing strategies.

Eco-tourism is a sustainable form of tourism that is small in scale and in which local control and benefits are of primary importance to the communities. It should be encouraged or introduced to conserve the resources and provide an alternative sustainable livelihood strategy to reduce poverty in the community.

Finally, the success of an integrated natural resource management depends on developing and implementing a comprehensive management plan drawn up by all the stakeholders. A major drawback to wetland conservation in Kenya has been lack of proper enforcement of the policies guiding their utilization (Abila, 2005). It is therefore important that the various stakeholders to the Nyando wetlands be identified and their needs assessed. Such a management plan would identify the various interest group needs and will spell out how the resources will be utilized to ensure sustainability and minimize resource access and use conflict.

5.2 Recommendations

There is need to establish proper and clear wetland area demarcation boundaries within the wetlands. The community should be educated and encouraged to adopt high value crop agriculture (non-staple agricultural crops) such as vegetables and fruits. A soil nutrient analysis to ascertain the nutrient status of the soils so as to make an informed choice on the type of fertilization required is therefore recommended. In addition, correct use of agricultural inputs is essential, and safe alternatives to toxic chemicals should be preferred and encouraged. There is need to encourage and incorporate environmental education on soil and conservation works for those individuals not using conservation farming. Strict enforcement of national policies on wetland conservation and management which conform with agricultural development policies is needed.

Management programmes need to be implemented and developed. A Site Action Plan should seek to gain better formal protection for the sites, promote environmental awareness through an education programme and develop alternative forms of local land-use and employment, including developing its considerable potential as sites for recreational fishing, other water sports and eco-tourism. Successful eco-tourism development will require government participation through training the communities on environmental conservation and development of eco-tourism enterprises and also empowering them through partnerships with CBOs, stimulating micro and small eco-tourism private enterprises and boosting craft and tourism shopping. Economists, planners and decision makers need to be trained in wetland valuation techniques as part of a broad based environmental management courses. There is need for creation of appropriate tools necessary to manage and monitor the natural potential of the region's wetlands without compromising the future availability of these resources. Innovative approaches to monitoring of wetlands should be developed and tested using state of the art monitoring techniques combined with remote sensing capabilities. In promoting and implementing wetland management programmes, which are environmentally, economically and socially sustainable, it is important to engage all stakeholders in discussions to facilitate effective co-operation, communication and participation of different interest groups. This is essential in raising awareness on crosscutting issues of wetland management. This could be done through the use of participatory research and implementation approaches. There is need for more research to be carried out among all communities surrounding the Lake Victoria in order to come up with a recommended carrying capacity that is in line with proper conservation measures for purposes of safeguarding the wetlands. More research is also needed to establish the viability of establishing eco-tourism within the Nyando wetlands so as to asses its strengths, opportunities, weaknesses and threats.

REFERENCES:

Abila, R., 2005. Biodiversity and Sustainable Management of a Tropical Wetland Lake Ecosystem: A Case Study of Lake Kanyaboli, Kenya: In Topics of Integrated Water Management. University of Siegen, Siegen, Germany.

Agwata, F., 2005. Water Resource Utilization, Conflicts and Interventions in the Tana Basin Kenya: In Topics of Integrated Watershed Management; Gerd F et. Al(eds). FWU Water Resource Publication. University of Segen, Segen, Germany (pp.13-23).

Allen, P., 1994. The Human Face of Sustainable Agriculture. Adding People to the Environmental Agenda. Center for Agroecology and Sustainable Food Systems University of California, Santa Cruz, USA.

Allen, P., and Debra, D., 1990. Sustainability in the Balance. Raising Fundamental Issues. Summary Paper of the Conference Sustainable Agriculture. Balancing Social, Economic, and Environmental Concerns, Sponsored June 1990 by the Agroecology Program, University of California, Santa Cruz, USA.

Alwe, H. A., 1980. Design of Safe Rotational Systems, Department of Conservation and Expansion, Harare, Zimbabwe.

Anon, 1992. Macro-level Urban Information System - A GIS Case Study for BMR. SAC/ISRO, BMRDA. Project Report No. SAC/RSAMRIS-URIS/PR-18/March, 1992.

Ashley C., 2000. Applying Livelihood Approaches in Natural Resource Management Initiatives: Experiences in Namibia and Kenya. Overseas Dev. Institute Working Paper 134. London,UK.

Australian Nature Conservation Agency, 1996. Wetlands are Important. 2 Page Flyer, National Wetlands Program, ANCA, Canberra, ACT, Australia.

Ayres, R. U., 1993. Cowboys, Cornucopians and Long-run Sustainability. *Ecol. Econ. 8: 189 - 207.*

Baez, A. V., Knamiller, G. and Smyth, J. C. (eds), 1987. The Environment and Science and Technology Education, Pergamond Press, Oxford.

Bennun L. A and Njoroge P., 1999. Important Bird Areas in Kenya. The East Africa Natural History Society, Nairobi, Kenya.

Barbier B. E., M. Acreman and Knowler D., 1997. Economic Valuation of Wetlands, A Guide for Policy Makers and Planners, Ramsar Convention Bureau, Gland, Switzerland.

Bartlett E., Kotrlik W., and Higgins C., 2001. Information Technology, Learning and Performance Journal, *Vol. 19 No. 1.*

Bishop, R. C., 1978. Endangered Species and Uncertainty. The Economics of a Safe Minimum Standard. *Am. J. Agric. Econom. 60, 10 - 18*

Calestous J., and J. B Ojwang 1996. In Land We Trust; Environment, Private Property and Constitutional. Nairobi, Change Initiatives Publishers

Ceballos – Lascurain H., 2003. Preface. In M Luck and T Kirstges (eds). Global Eco-tourim Policies and Case Studies. Perspectives and Constraints. Clevedon, Channel View Publications

Chen X., 2001. Using Remote Sensing and GIS to Analyze Land Cover Change and its Impact on Regional Sustainable Development. *International Journal of Remote Sensing, 22, pp. 1–18.*

Chery R. D., and Michael L. M., 2001. How does Gender affect the Adoption of Agricultural Innovations: The case of Improved Maize Technology in Ghana. Economics Program, International Maize and Wheat Improvement Center (CIMMYT). APDO. Postal 6-641, Mexico, D. F. 06600 Mexico. Copyright 2001 Elsevier Science B.V.

Cincotta R., Wisnewski J., Engleman R., 2000. Human Population in the Biodiversity Hotspots. *Nature, Vol. 404, 990-992.*

Ciriacy-Wantrup S. V., 1952. Resource Conservation. Economics and Policies. University of California Press, Berkeley, USA.

Crowards T. M., 1996. Addressing Uncertainty in Project Evaluation. The Costs and Benefits of Safe Minimum Standards. Global Environmental Change Working Paper GEC 96-04, Centre for Social and Economic Research on the Global Environment (CSERGE), University of East Anglia, Norwich, England.

Cumberland J. H., 1991. Intergenerational Transfers and Ecological Sustainability. In Costanza R. (Ed.), Ecological Economics. The Science and Management of Sustainability. Columbia University Press, New York, USA.

Dhinwa P. S, Pathak S. K, Sastry S. V. C, Rao M, Majumdar K. L, Chotani M. L, Singh J. P and Sinha R.L P., 1992. Land Use Change Analysis of Bharatpur District Using GIS. Photonirvachak: J. Indian Soc. *Remote Sensing, 20 (4): 237-250.*

Dugan P. J., 1990. Wetland Conservation. A Review of Current Issues and Required Action. IUCN, Gland, Switzerland.

Earle A., and Turton A. R., 2003. The Virtual Water Trade Amongst Countries of SADC. In Hoesksta, A (ed) Virtual Water Trade. Proceedings of the International Experts Meeting on Virtual Water Trade. Delft, the

Netherlands 12-13 December 2002. Research report No.12 Delft:IHE. Pp.183-200

Eastman J. R. and Fulk M., 1993. Long Sequence Time Series Evaluation Using Standardized Principal Components. *Photogrammetric Engineering and Remote Sensing, 59, pp. 991–996.*

Fishpool L. D. C and Evans M., 2001. Important Birds Areas in Africa and Associated Islands. Priority Sites for Conservation. Pisces Publications and Birdlife International, Newbury and Cambridge, UK.

Fung T. and Ledrew E., 1987. Application of Principal Components Analysis for Change Detection. *Photogrammetric Engineering and Remote Sensing, 53: 1649–1658.*

Government of Kenya. 1992. *The study on the National Water Master Plan*. Sectoral Report (N)

Government of Kenya, 1995. District Agricultural Office. Annual Report for the Kisumu District. Government Printer, Nairobi8

Government of Kenya, 1994. District Agricultural Office. Annual Report for the Kisumu District. Government Printer, Nairobi

. Government of Kenya, 2006. District Agricultural office. Annual Report, Ministry of Agriculture and District Information and Documentation Center, Kisumu District.

Government of Kenya, 2005. District Agricultural office. Annual Report, Ministry of Agriculture and District Information and Documentation Center, Kisumu District.

Grant P. M., 1981. The Fertilization of Sandy Soil in Peasant Agriculture. *Zimbabwe Agriculture Journal, Vol. 78 No.5: 169-175.*

Grose A., R. O. Bailey and K. W. Cox., 2000. Wetland Mitigation in Canada. In Cox, K. W. and A. Grose (Eds). Wetland Mitigation in Canada: A Framework for Application. Sustaining Wetland Issues Paper 2000-1. Secretariat to the North American Wetlands Conservation Council (Canada). Ottawa, ON, 1-14.

Halls P. J., Polack F. and Kefe S., 2000. A New Approach to the Spatial Analysis of Temporal Change Using Todes and Neural Nets. Cybergeo (http://cybergeo.presse.fr/ dwham.htm).

Hardin G., 1968. The Tragedy of the Commons, *Science 16: 1243 – 8.*

Hatcher L. and Stepanski E., 1994. A Step-by-Step Approach to Using the SAS System for Univariate and Multivariate Statistics. Cary, NC: SAS Institute Inc.

Herath G., 2002. Research Methodologies for Planning Eco-tourism and Nature Conservation. *Tourism Econ. 8: 77- 101.*

Hudson W. J and Harsch J., 1991. The Basic Principles of Sustainable Agriculture Harworth Press Inc Washington DC, USA.

Hwey-Lian H., Chang-Po C., Yaw-Yuan L., 2004. Strategic Planning for Wetland Conservation Greenway along the West Coast of Taiwan. *J. of Ocean and Coastal Manage. 47 (5 – 6): 257 – 272.*

IUCN, 1996. Pan AFRICAN Symposium on Sustainable Use of Natural Resources and Community Participation. Harare, Zimbabwe, June 24 – 27, 1996.

Janssen R., 1992. Multiobjective Decision Support for Environmental Management. Kluwer Academic Publishers, Dordrecht, Netherlands, pp 232.

Jensen J. R., 1983. Urban/suburban Land Use Analysis. In Manual of Remote Sensing, R. N. Colwell (Ed), pp. 1571–1666 (Falls Church, VA: American Society of Photogrammetry).

Jensen J. R., 1996. Introductory Digital Image Processing—A Remote Sensing Perspective, 2nd edn (Upper Saddle, NJ: Prentice-Hall).

Johnstone F. and Githongo J., 1997. Killer Weed. *Swara , 20 (4) : 28-29.*

Jones S., 2007. Community-Based Eco-Tourism. The Significance of Social Capital. *Annaals of Tourism Res. 32(2): 302 – 324.*

Kairu J. K., 2001. Wetland Use and Impact on Lake Victoria, Kenya Region. *Lakes Research and Management, 6: 117-125.*

Keya S. O. and Michieka R. W., 1993. Agricultural Sector Development. In: *Provincial Monitoring and Evaluation Committee (PMEC) Workshop Proceedings. Nyanza 30 Years After Independence: Where It Was, Where It Is, and Where It Is Going* 9-10 December 1993, Tom Mboya Labour College, Kisumu, Kenya (eds F. M. Rugenyi & J. A. Odondi) pp. 33-42. Provincial Commissioner, Nyanza Province, Kisumu.

Kirogo V., Wambui K. M and N. M. Muroki., 2007. The Role of Irrigation on Improvement of Nutritional Status of Young Children in Central Kenya. *African Journal of Food Agriculture Nutrition and Development, Vol. 7 No. 2.*

Kenya National Bureau of Statistics, 2010. Kenya Population and Housing Censeus Vol. 1a. pp 6.

Kormawa, P., Okike, I., Okechukwu, R., and Akande S. O., 2003. African Food Crisis – The Nigerian Case Study. African project. International Institute of Tropical Agriculture. Nigeria.

Kotler P. and Zaltman G., 1971. “Social Marketing: An Approach to Planned Social Change”, *Journal of Marketing: 35: 3-12.*

Lambin E., 1996. Change Detection at Multiple Scales. Seasonal and Annual Variation in Landscape Variables. *Photogrammetric Engineering and Remote Sensing, 62: 931–936.*

Leakey R. E., 1991. Kenya’s Policy on Wildlife Research and Commercial Use of Wildlife, Wildlife Research for Sustainable Development. KARI, KWS and NMK. Major Printing Works Ltd, Nairobi, Kenya.

Light D., 1983. The National Aerial Photography Program. A Geographic Information System Resource. *Photogrammetric Engineering and Remote Sensing, 59: 61–65.*

Luong P. T., 1993. The Detection of Land Use/Land Cover Changes Using Remote Sensing and GIS in Vietnam. *Asian-Pacific Remote Sensing J., 5 (2): 63-66.*

MacCannell D., 1988. Farm and Community Change. A Brief Introduction to the Regional Studies. In Agriculture and Community Change in the U.S.: The Congressional Research Reports. Louis E. Swanson, ed. Boulder, Colorado: Westview Press, USA.

Mafabi P., 2000. The Role of Wetland Policies in the Conservation of Water Birds: The Case of Uganda. *Ostrich 71:96-98.*

Maltby E., Hogan D. V., Immirzi C. P., Tellam J. H., van der Peijl M. J., 1994. Building a New Approach to the Investigation and Assessment of Wetland Ecosystem Functioning. In: Mitsch W. J. (Ed.), Global Wetlands: Old World and New Elsevier, Amsterdam, Netherlands, pp. 637–658.

Maltby E., Hogan D. V., McInnes R. J., 1996. Functional Analysis of European Wetland Ecosystems — Phase I (FAEWE). Ecosystems Research Report 18. Office for Official Publications of the European Communities, 448 pp, Luxembourg.

Matiza, J. and Crafter, S.A., 1994. Wetland Ecology and Priorities for Conservation in Zimbabwe, IUCN, Harare.

Metternight G., 1999. Change Detection Assessment Using Fuzzy Sets and Remotely Sensed Data: An Application of Topographic Map Revision. *ISPRS Journal of Photogrammetry and Remote Sensing, 54: 221–233.*

Mitra S., R. Wassmann P. L. G. Vlek., 2003. Global Inventory of Wetlands and Their Role in the Carbon Cycle. ZEF – Discussion Papers on Development Policy no. 64, Center for Development Research, Boon, pp. 44.

Mitsch W. J., Gosselink J. G., 1993. Wetlands, Second ed. Van Nostrand Reinhold, New York, USA, 722 pp.

Mitsch W. J. and J. G. Gosselink, 2000. Wetlands, 3rd Ed. John Wiley & Sons, New York, USA, 920 pp.

Mose, L.O., Onyango, R., Rono, S., Kute, C. and Ruto, C.K., 2000. Factors Influencing the Adoption of Organic and Inorganic Fertilizers in Maize and Kale in North Rift Valley Region of Kenya. In J.G. Mureithi, C.K.K. Gachene, F.N. Muyekho M. Onyango, L. Mose and O. Magenya (Eds). Participatory Technology Development for Soil Management by Smallholders in Kenya. Proceedings of the Second Scientific Conference of the Soil Management and Legume Research Network Projects, June 2000, Mombasa, Kenya: KARI.

Mukwada G., 2000. Natural Resource Conservation and Management, Module GED 404, ZOU, Harare, Zimbabwe.

Muller - Samann K. M. and Kotshi, 1994. Sustaining Growth; Soil Fertility Management in Tropical Small Holdings, Margraf Verlag, Weikersheim.

Nasirwa O., Oyugi J., Jackson C., Lens L., Bennun L., and Seys J., 1995. Surveys of Waterbirds in Kenya, 1995; Lake Victoria Wetlands, South Kenya Coast and Tana River Dams. Research Reports of the Centre for Biodiversity, National Museums of Kenya: Ornithology Department of Ornithology, 28.

Nijkamp P., 1989. Multi-criteria Analysis. A Decision Support System for Sustainable Environmental Management. In: Archibuqi, F., Nijkamp, P. (Eds.), Economy and Ecology. Towards Sustainable Development. Kluwer, Dordrecht, The Netherlands.

Nyakaana J.B., 2008. Sustainable Wetland Resource Utilization of Sango Bay Through Eco-tourism Development. *African Journal of Environmental Science and Technology Vol. 2 (10):326-335.*

Okungu J. O. and F. D. Sangale, 2003. Water Quality and Hydrology of Yala Wetlands. Paper presented at ECOTOOLS Scientific Workshop on Yala Swamp. Switel Hotel, Bondo, Kenya. 9th–10th December.

Ongo'or D. O., 2005. Community Participation in Integrated Water Resource Management. The Case of Lake Victoria Basin: In Topics of Integrated Watershed Management: Gerd. F., et. al (eds) University of Siegen, Siegen, Germany.

Owino A. O., 2005. Papyrus Swamp Habitat Loss and Degradation: Impacts on Endemic Birds in Kenya. (Msc Theisis) Percy FitzPatrick Institute of African Ornithology, University of Capetown, Rondebosch, 7701 South Africa.

Pemberton C. A, Mader C. K., 2004. Eco-tourism as a Means of Conserving Wetlands.”http://www.wetlands.org/RDB/Ramsar_Dir/Trini dad&tobago/TTOOlD02.htm).

Prescott A. R., 2001. The Wellbeing of Nations. A Country by Country Index of Quality of Life and the Environment. Island press, USA

Ramsar, 2009. The Ramsar Convention on Wetlands. http://www.ramsar.org/ Reviewed: April 2009

Ramsar Information Bureau, 2007. What are Wetlands? Ramsar Information Paper no.1. http://www.ramsar.org/about/info2007-01-e.pdf Reviewed: November 2007.

Rice R. P., Rice L. W., and Tindall H. D., 1986. Fruit and Vegetable Production In Africa, Macmillan, London.

Richards, J. A., 1993. *Remote Sensing Digital Image Analysis*. Springer, Heidelberg, New York, 1993

Rodgers E. M., 1971. Diffusion of Innovations, 3rd Ed. The Free Press, New York, USA.

Roe D, Khanya P. U., 2001. Pro-Poor Tourism. Harvesting the World's Industry for the World's Poor. International Institute for Environment and Development. London.

RoK, 2002. State of Environment Report. National Environmental Management Authority. Government Printer. Nairobi, Kenya.

Rubec C. D. A., A. R. Hanson, 2008. Wetland Mitigation and Compensation. Canadian Experience. Springer Science + Business Media, Wetlands Ecol Manage.

Rutchy K. and Velchneck L., 1994. Development of an Everglades Vegetation Map Using a Spot Image and the Global Positioning System. *Photogrammetric Engineering and Remote Sensing, 60: 767–775.*

SAS Institute Inc., 2002. Cary, NC, USA.

Serageldin I., 1994. Sustainability and the Wealth of Nations: It Steps in an On-going Journey. The World Bank Washington, D C, USA.

Sharma K. D, Singh S, Singh N and Bohra D. N., 1989. Satellite Remote Sensing for Detecting the Temporal Changes in the Grazing Lands Photonirvachak:.*J. Indian Soc. Remote Sensing, 17 (4): 55-59.*

Shores J. N., 2003. The Challenges of Eco-tourism. A Cell for Higher Standards. http://www.mtnforum.org/resources/library/shorjaba.htm.

Singh A., 1986. Change Detection in the Tropical Forest Environment of Northeastern India Using Landsat Data. In Remote Sensing and Tropical Land Management, M.J. Eden and J.T. Parry (Eds), pp. 237–254 (London: Wiley).

Singh A., 1989. Review Article—Digital Change Detection Techniques Using Remotely-Sensed Data. *International Journal of Remote Sensing, 10: 989–1003.*

Svotwa E., Manyanhaire I. O and Makombe P., 2008. Sustainable Gardening on Wetlands in the Communal Lands of Zimbabwe. *Electronic Journal of Environmental, Agricultural and Food Security. 7(3)*

Swarbrooke J., 1999. Sustainable Tourism Development. CABI Publishing, Cambridge, UK

The Johannesburg Declaration on Sustainable Development, 4 September 2002, http://www.housing.gov.za/content/legislation_policies/johannesburg.htm.

Turner II, B. L, 1995. Linking the Natural and Social Sciences. The Land Use/Cover Change Core Project of IGBP. IGBP Newsletter, No. 22.

Turner R. K. (Ed.), 1993. Sustainable Environmental Economics and Management: Principles and Practice. Bel-haven Press, London.

Turner R. K., Jeroen C. J. M., Van Den Bergh, Tore Soderqvist, Aat Barendregt, Jan Van Der Straaten, Edward Maltby, Ekko C. Van Ierland, 2000. The Values of Wetlands. Landscape and Institutional Perspectives. Ecological-economic Analysis of Wetlands: *Scientific Integration for Management and Policy. Ecological Economics 35, 7 - 23*

Turner R. K., Jones T. (Eds.), 1991. Wetlands, Market and Intervention Failures. Earthscan, London, 202 pp.

UNEP, 1993. United Nations Environment Programme Environmental Data Report 1993/94, Basil Blackwell, Oxford, England.

Van Der Weghe, J. P., 1981. Avifauna of Papyrus in Rwanda and Burundi. *Gerfaut 71:489-536.*

Wang J., 1993. A Knowledge-based Vision System for Detecting Land Changes at Urban Fringes. *IEEE Transactions on Geoscience and Remote Sensing, 31: 136–145.*

Wang J., Treitz P. M. and Howarh P. J., 1992. Road Network Detection from SPOT Imagery for Updating Geographical Information System in Rural–Urban Fringe. *International Journal of Geographical Information Dystems, 6: 141–157.*

Wanjogu S. N and C. R. K., 2005. The Distribution Characteristics and Utilization of Wetland Soil in Sio Basin, Western Kenya. In: Gasper A.M.,(eds) Knowledge and Experiences Gained from Managing the Lake Victoria Ecosystem; LVMP. Dar es Salaam, Tanzania.

Waugh D., 2000. Geography: An Integrated Approach, 3rd Ed. Nelson Thornes, London.

Wejuli M. S, D Muir, R. E Hecky, M. K Magunda and P. Fellin, 2005. Atmospheric Concentrations of Organochlorine Pesticide in the North Lake Victoria Watershed, Uganda. In Gasper A.M (eds) Knowledge and Experiences Gained From Managing the Victoria Ecosystem. LVMP Dar es Salaam, Tanzania.

Whynne-Hamond C., 1990. Elements of Human Geography, 2nd Ed.Unwin Hyman, London.

Waller S., 2004. Sustainability, Abiotic and Biotic Stress; In Synthesis Workshop on Global Horticulture Challenges. University of California-October 18-19, 2004

William P. C., and Mary A. C., 2004. Principles of Environmental Science; Inquiry and Applications. McGraw-Hill. US

Zeisel J., 1980. Inquiry by Design: Tools for Environment – Behavior Research. Brooks/Cole Publishing Company, Monterey California, Pg 65-69.

WEBSITES

http://www.academicjournals.org/AJest (Reviewed February 2009)

http://www.cbd.int/iyb/doc/prints/factsheets/iyb-cbd-factsheet-cbd-en.pdf (Reviewed May 2009)

http://www.ramsar.org/cda/en/ramsar-about/main/ramsar/1-36_4000_0_

http: www.ramsar.org:index.html (Reviewed April 2009)

http://unfccc.int/resource/docs/convkp/kpeng.pdf (Reviewed April 2009)

http://unfccc.int/resource/docs/convkp/conveng.pdf (Reviewed April 2009)

http://unfccc.int/2860.php (Reviewed November 2009)

http://www.unccd.int/ (Reviewed November 2009)

http://viredinternational.org/ (Reviewed September 2009)

APPENDICES

Appendix 1: Questionnaire guide for sustainability of wetland management for biodiversity conservation

Enumerator………………………………………………………………………………….

Date of interview……………………………………………………………………………

1. BIO-DATA

1. Name of the respondent	
2. Gender	
3. Age	
4.Occupation	
5.Education level	
6. Location	
7. Sub-location	
8. Village	
9. Family size	
10. Contacts	

11. Gross income per month (please tick as appropriate)

a). Below KSh. 2000

b). KSh. 2000 – 10000

c). KSh.10001 – 20000

d). KSh.20001 – 40000

e). Above KSh. 40,000

12. For how many years have you been in this area? …………………………..

2. SOCIO- ECONOMIC ACTIVITIES

1. What crops do you produce/cultivate?

Crop	Farm/ plot size	Quantity harvested	Use			cost per unit
			Subsistence	commercial	both	

2. What other activities do you involve yourself with other than crop production? Please tick as applicable

Activity	**Income per month**
Fishing	

Boda boda business	
Livestock production	
Papyrus material weaving	
Others(please specify)	

3.0 WETLAND MANAGEMENT, OWNERSHIP AND UTILISATION

1. How do you usually prepare your land for cultivation? Please tick as appropriate

Method	
Slash and burn	
Animal drawn power	
Manual tillage	
Mechanized	
Others (specify)	

2. How do you manage soil fertility for your crops? Tick as applicable

Fertilization	
Animal manure	
Poultry manure	
Green manure	
Nothing	

3. Indicate who usually provides labor for the following activities

Activity	**Gender**	**Children**	**Why**
Land preparation			
Planting			
Weeding			
Harvesting			
Marketing			

4. How do you do your cropping? 1= mixed cropping 2= single crop

5. Tick the measures you use to control soil erosion

Measure	
Crop rotation	
Mulching	
Furrowing	
Contour ridge use	
Storm drain construction	
Terraces	
Agro forestry	
Inter cropping	

None	
Others (specify)	

6. Do you have access to agricultural extension services about crop production?
Yes…… No …….

7. How available can you rate the availability of agriculture related extension services to offer skills required for horticulture crop production in your village?
5= highly available 4= available 3= moderately available 2= not available 1= don't know

8. How do you acquire land for agricultural production?
1= Own/private land 2= Rent from owner 3= Use communal land 4= Use the land near wetlands 5= Others (specify)…………………………………………………..

9. According to you, who would you say the wetland belongs to? 1= Local community 2= People bordering it 3= Any body 4= Government 5= Don't know

10. How do you benefit from the wetland near you? Please tick as appropriate in order of importance

Activity	**Highly import-ant**	**Impo-rtant**	**Modera-tely important**	**Not import-ant**	**Don't know**
Grazing					
Handcraft materials					
Fishing					
Hunting					
Thatching grass					
Bee keeping					
Brick making					
Wood fuel					
Water for domestic use					
Benefit from eco-tourism					
Others(specify)					

4. COMMUNITY KNOWLEDGE ON THE WETLANDS

1. What are some of the plants and animal species found in the wetlands near you?

a).Plants

Name	**Use/importance/ harm**	**Current status**		
		Abundant	**Rare**	**Extinct**

b).Amphibians and reptiles

Name	Use/importance/harm	Current status		
		Abundant	Rare	Extinct

c). Mammals

Name	Use/importance/harm	Current status		
		Abundant	Rare	Extinct

d). Birds

Name	Use/importance/harm	Current status		
		Abundant	Rare	Extinct

e). Fish

Name	Use/importance/harm	Current status		
		Abundant	Rare	Extinct

2. What is the name of the wetland in which you perform many activities on and derive services from? ....

5. BIODIVERSITY RICHNESS AND CHANGES

1. Do you usually plant trees in your farm? Yes …… No ……..

If No skip next question

2. What plant species have you planted in your farm? Mention them

……………………………………………………………………………………
……………………………………………………………………………………
……………………………………………………………………………………

3. How many plants of each species do you own in your farm?

Plant species	Numbers

4. What other plant species would you want to plant in your farm?
....
....
....
......
5. Give a reason for your answer in question four above
……………………………………………………………………………………
……………………………………………………………………………………
…….
6. Given the seedlings, would you be willing to plant more tree species in your farm? Yes …… No …….

7. What are the changes in the following situations as it relates to past and present times?

Situation	**Past(10-20 years)**	**Present**	**Reason**
1. Size of the wetland			
2. Crop yield			
3. Grazing area			
4. Water quality			
5. Area under crop			
6. Soil fertility			
7. Type of crop grow			
8. Rainfall			
9. Rivers			
10. Pests and diseases			
11. Population			
12. Others (specify)			

6. EMERGING ISSUES FROM NYANDO WETLANDS

1. Rank the main factors threatening the existence of Nyando wetlands
5= Highly important 4= Important 3= Moderately important 2= Not important 1= Don't know

Factor	**Rank**				
	Highly important	**Important**	**Moderately important**	**Not important**	**Don't know**
Fishing					
Farming					
Eco-tourism					

Thatching grass					
Handcraft materials					
Droughts					
Others(specify)					

2. Tick the problems experienced by the people who live around and work in the wetland?

Problem	Explain
Animal attacks	
Water related diseases (malaria, cholera, Typhoid, Dysentery)	
Floods	
Others (specify)	

7. CONSERVATION AND SUSTAINABLE UTILISATION

1. According to you, is there a need to conserve Nyando wetlands? Yes… No…

2. According to you, who is responsible for the wetlands conservation?
   a).Government b). Local community c). Both

3. Do you get any training from the government or NGO's on wetland Conservation? Yes… No ….. **If yes please give some of the organizations**
…………………………………………………………………………………………………
…………………………………………………..…………………………………………
…………………………………………………………………………………………..
..

4. Do you know of any policies governing the wetland conservation? Yes…. No ….

5. Do you usually follow the rules governing utilization and conservation of the wetlands? Yes … No …. **If No please explain why**
…………………………………………………………………………………………
…………………………………………………………………………………………
……………………………………………………………………………………

6. In what ways do you think the community can be in-cooperated in the safe planning for the sustainable wetland conservation? ……………………………….

…………………………………………………………………………………………
…………………………………………………………………………………………
..

7. Of the following ways, in order of importance, which ones would you suggest for conservation and sustainable utilization of the wetland?

Conservation strategy	**Highly import-ant**	**Import-ant**	**Moder-ately importa nt**	**Not import-ant**	**Don't know**
Eco-tourism center					
Bee keeping					
Handcraft materials					
Grazing					
Practicing of agro-forestry					
Others(specify)					

8. Tick the applicable organizations operating in your division and their role(s)

Organizations	**Role**
NEMA	
KARI	
Ministry Of Agriculture	
VIRED	
Others(specify)	

Thank you very much