INTEGRATED ENVIRONMENTAL PLANNING OF WETLAND ECOSYSTEMS FOR SUSTAINABILITY: THE CASE OF OKANA WETLAND IN THE LOWER NYANDO RIVER BASIN, KENYA

BY

ODARO DANIEL OPIYO

A THESIS SUBMITTED TO THE SCHOOL OF ENVIRONMENTAL SCIENCES AND NATURAL RESOURCE MANAGEMENT IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN ENVIRONMENTAL PLANNING AND MANAGEMENT, UNIVERSITY OF ELDORET, KENYA

OCTOBER, 2023

DECLARATION

Declaration by the Candidate

This thesis is my original work and has not been presented for a degree or any other award in this or any other university. No part of this thesis may be reproduced without the prior written permission of the author and/or University of Eldoret.

Odaro Daniel Opiyo ----------

SES/D.PHIL/03/06 Date

Declaration by the Supervisors

We append our signatures as confirmation that this thesis has been submitted with our approval as university supervisors.

_____ **Date** _____

Prof. Elias K. Ucakuwun

Department of Environmental Sciences

School of Environmental Sciences and natural resource management

University of Eldoret, Kenya

_____ **Date** _____

Dr. Daudi Fatuma

Department of Environmental Planning, Sustainability and Geoinformatics

School of Environmental Sciences and Natural Resource Management

University of Eldoret, Kenya

DEDICATION

This thesis is dedicated to my late mother, beloved wife and children. Your moral support always carried me along throughout the entire work. May the Almighty God bless you all.

ABSTRACT

Wetlands are areas, which are temporarily or permanently waterlogged by either saline, brackish or freshwater. They have provided socio-cultural, economic and ecological values to the local communities since time immemorial. They have been utilized as sources of food, water, building and construction materials, handicrafts, medicinal herbs as well as grazing fields for both wild and domesticated animals. The wetlands in the Lake basin in particular have supported millions of livelihoods of the communities living within the basin. However, the utilization of the localized small wetlands has not been guided by appropriate management strategies despite the existing national wetlands conservation and management policy. This has given leeway to unregulated wetland utilization and ad-hoc management of the ecosystems. The situation has been exacerbated by the destruction of the basins' catchment, which is likely to impact significantly on the wetland ecosystems due to a possible change in their distribution, utilization and management. The apparent change coupled with the rapid urbanization and increasing economic demand and human populations in the basin may result in degradation of the ecosystems. This puts the livelihoods of the adjacent local communities that directly rely on them at risk. An analysis of land use land cover change – cause and effects –in Okana wetlands is necessary if their numerous socio-cultural, economic and ecological values are to be enhanced now and in the future. The study focused on the Okana wetlands in the lower Nyando River basin in western Kenya and was guided by the Natural Resource Use theory. The objectives of the study included: Analysing land use changes in Okana area; determining the contribution of wetland resources to the household income in Okana area; determining the impacts of wetland resources utilization in Okana area, and assessing the effectiveness of wetland management regimes in Okana area. The methods of data collection used in the research study include informal interviews, structured questionnaires, observation, Focused Group Discussions (FGDs), Participatory Rural Appraisal (PRA), photographs, remote sensing and review of related literature. Both random and purposive sampling techniques were used to ensure that the whole population is represented. The data was analysed using both qualitative and quantitative techniques such as content analysis, Statistical Package for Social Sciences (SPSS), Barbier's Economic Valuation Tool as well as ArcGIS software for the geo-referenced data. The results are presented in form of tables, charts, percentages, plates and discussions. The study has established that the wetland ecosystem has been encroached upon and converted into agricultural farmlands thereby reducing in size and resulting in decline in biodiversity due to habitat destruction; and that the riparian communities mostly depend on the wetland resources for their livelihoods. The findings of the study will help to enhance sustainable utilization and management of wetland resources in the study area and other regions through adoption of Bottom-Up strategy. The findings will also help policy makers and conservationists in reviewing the existing wetland conservation and management policy in Kenya. This will be based on the generated data and/or information on the status of the wetland, its current use and potential threats.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF PLATES

ABBREVIATIONS, ACRONYMS AND SYMBOLS

AIDS	Acquired Immune Deficiency Syndrome
BOD	Biological Oxygen Demand
CBO	Community Based Organization
CBR	Crude Birth Rate
CDF	Constituency Development Fund
CDR	Crude Death Rate
CWDS	Cowardin Wetland and Deepwater Systems
DAO	District Agriculture Office
DDO	District Development Office
DIDC	District Information Documentation Centre
DLPO	District Livestock Production Office
DWO	District Water Office
EASWN	East African Sustainability Watch Network
EMCAR	Environmental Management and Coordination Act Ammendment Regulations
GIS	Geographic Information System

GOK	Government of Kenya
HIV	Human Immunodeficiency Virus
IIED	International Institute for Environment and Development
IMR	Infant Mortality Rate
IUCN	International Union for the Conservation of Nature
JICA	Japanese International Cooperation Agency
KEFRI	Kenya Forestry Research Institute
KFS	Kenya Forest Service
KFWG	Kenya Forests Working Group
KICD	Kenya Institute of Curriculum Development
KLA	Kenya Land Alliance
KNBS	Kenya National Bureau of Statistics
KPHC	Kenya Population and Housing Census
KWAHO	Kenya Water and Health Organization
KWS	Kenya Wildlife Service
KWWG	Kenya Wetlands Working Group
LATF	Local Authorities Transfer Fund

LBDA	Lake Basin Development Authority
LULC	Land Use Land Cover
LVB	Lake Victoria Basin
LVEMP	Lake Victoria Environmental Management Programme
MEA	Millennium Ecosystems Assessment
MENR	Ministry of Environment and Natural Resources
MEWNR	Ministry of Environment, Water and Natural Resources
MOA	Ministry of Agriculture
NBI	Nile Basin Initiative
NEMA	National Environment Management Authority
NGO	Non-Governmental Organization
NMK	National Museums of Kenya
OCWSHG	Okana Community Wetland Self Help Group
PRA	Participatory Rural Appraisal
RIO	Regions of Interest
SANA	Sustainable Aid in Africa International
SIDA	Swedish International Development Agency

SPSS	Statistical Package for Social Sciences
TDS	Total Dissolved Solids
TNTC	Too Numerous To Count
U5MR	Under 5 Mortality Rate
USFWS	US Fish and Wildlife Services Systems
USGS	United States Geological Survey
VIRED	Lake Victoria Research on Environment and Development
	Water Resources Authority – WRA)
WRMA	Water Resources Management Authority (Currently has changed to

DEFINITION OF OPERATIONAL TERMS

Conservation- It refers to care and management of wetland resources

Hunting- It is the act of killing, wounding, injuring or capture of any animal or willful interference with any nest or other place where a dependent young animal is born, hatched or reared.

Inland Wetlands- Include rivers, floodplains, swamps, pans, streams and rice paddies.

Integrated Management Plan- Refers to a management plan for a wetland that incorporates all stakeholders including governmental and non-governmental institutions, agencies, civil society and members of the community as well as the stakeholders in the upstream and downstream catchment.

Land Use- It refers to land cover and actual land use.

Restoration- Refers to the regeneration or putting back a wetland to its original state or near to what it was before being modified.

Riverine Wetlands- Include wetlands along rivers and streams.

so that the resources can maintain their ability to fulfill their functions and values and provide goods and services for present and future generations.

Stakeholder- It refers to an interested person, group or institution that may or may not be affected directly or indirectly by decision making on the wetland resource.

Sustainable Use- Refers to present use of wetland resources which does not compromise the ability to use the same resources by future generations.

Wetland Degradation It refers to the impairment of wetland functions through hydrologic alterations, wetland vegetation clearance or other mechanisms due to anthropogenic activities.

Wetland Loss- It refers to conversion of wetland either by draining, dumping of wastes or land filling to non-wetland areas by anthropogenic activities.

ACKNOWLEDGEMENT

I would like to register my sincere thanks to many people, organizations and institutions for their significant contributions to the successful completion of this thesis. First, I sincerely thank the University of Eldoret in general and the School of Environmental Sciences and Natural Resource Management (SENR) in particular for the opportunity to pursue the degree programme at the institution. I also thank Maseno University and the School of Environment and Earth Sciences (SEES) for releasing me to pursue my studies at the University of Eldoret. The opportunity was quite valuable especially during course work when I had to be at the University of Eldoret to attend lectures.

I am greatly indebted to my supervisors Prof. Elias K. Ucakuwun and Dr. D. Fatuma both from University of Eldoret for their relentless and unwavering assistance they accorded me throughout the study. Their guidance was invaluable to the successful completion of the work. I am grateful to Mr. George Anyona, Mrs. Jennifer Otieno, Mr. Charles Keya and Mrs. Ruth Ingutia of Maseno University and Mr. Geofrey of Kisumu Municipal for their technical assistance during data analysis and thesis writing. My special thanks go to Okana Wetland Self Help Group (OWSHG) for their cooperation during the execution of research study surveys and Participation Rural Appraisal (PRA) exercise. I also thank my fellow students at the School of Environmental Sciences and Natural Resource Management (SENR) at the University of Eldoret for the encouragement, support and cooperation they accorded me during the entire study period.

Sincere thanks also goes to my late mother Rusalina, wife Anne and children Chelsea, Phelistus, Derrick and Cedrick for their constant prayers and encouragement. Finally,

I am grateful to Mr. Andrew Obong' Okal, Chairman of OWSHG, Mr. Dalmas Ojwang' Omondi and Mr. Kennedy Odhiambo Okoyo, my field research assistants, for their substantial help during the fieldwork.

CHAPTER ONE

INTRODUCTION TO THE STUDY

1.1 Background to the study

Wetland ecosystems are diverse habitats, which are permanently or temporarily waterlogged by either saline, brackish or freshwater. They include mangroves, marshes, swamps, lake and riverine edge swamps, ponds, dams, coral reefs, flood plains, swamp forests, peat land, sea grasses, sandy beaches, deltas and estuaries. These wetlands have been classified differently under different classification systems. Mistch and Gosselink (2007) outline two systems of wetland classification namely the US Fish and Wildlife Services Systems (USFWS) and the Cowardin Wetland and Deepwater Systems (CWDS). Under these classifications there are coastal, inland, marine, estuarine, riverine, lacustrine and palustrine wetlands. In East Africa, wetlands have been classified on the basis of whether freshwater or saline. Harper & Mavuti (1996) and Ruwa (1996) have identified several categories of freshwater and intertidal wetlands such as swamps, estuaries, deltas, mangroves, floodplains and riverine wetlands.

Wetlands have been broadly defined by the Ramsar Convention on Wetlands of International Importance in 1971 as areas of marsh, fen, peat land or water whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salty, including areas of marine water, depth of which at low tide does not exceed six metres (Kasoma, 2003; Mwanuzi, 2003; Mitsch & Gosselink, 2007). A simplified definition of wetlands has been given by Awange & Ong'ang'a (2006) as areas where the land is saturated with water long enough to support and that do support poorly drained soils, plants and animals, which have been adapted to such

environment, and biological processes suited to wet areas. In the East African context, wetlands are defined as areas of land that are permanently or occasionally waterlogged with fresh, saline, brackish or marine waters at a depth not exceeding six metres, including both natural and man-made areas that support characteristic biota (McClanahan & Young, 1996; GOK, 2005; GOK, 2007).

Kenya's wetlands are diverse in type and distribution. They cover a total surface area of about 2,737,790 ha, which is approximately 3-4% (14,000 km^2) of the country's surface area, which is about 583,000 km^2 (Crafter et al. 1992; Raburu et al. 2012). The wetlands often increase upto 6% during rainy seasons (GOK, 2008; Raburu et al. 2012). Some of the larger wetlands of Kenya include shallow lakes such as Nakuru, Naivasha, Magadi, Kanyaboli, Jipe, Chala, Elementaita, Baringo, Ol Bolossat, Amboseli and Kamnarok; the edges of Lake Victoria; Lorian, Saiwa, Yala, Ondiri, Shompole Swamps; Lotikipi (Lotagipi) and Kano plains; Kisii valley bottoms and Tana delta and Coastal wetlands including the mangrove swamps, sandy beaches, sea grass beds and coral reefs.

Wetland types and their distribution in the tropics, temperate and coastal zones vary continuously and mutually along several axes namely latitude and plant growth form, mineral nutrient supply, salinity and hydrology (Moss, 1992). These axes generate enormous wetlands with unique and distinct ecological characteristics in the Lake Victoria Basin (LVB) in western Kenya, which needs to be studied with a view to establishing the basis of their distribution. For example, in the LVB, wetlands are found along the shore of Lake Victoria, flood plains and deltas of rivers and streams within the basin (Okeyo-Owuor et al. 2012).

Wetlands are one of the most productive ecosystems in the world supporting high biological diversity and economic importance (Mitsch & Gosselink, 2000; Crafter et al. 1992; Okurut & Weggoro, 2011). They support high biodiversity of fish, birds, macro-invertebrates and micro-organisms, which maintain and support life systems on the planet earth. Wetlands have provided great socio-cultural and economic values to the riparian communities living around these ecosystems since time immemorial. Both rural and urban populace obtain food, water, handicrafts, fuel wood, medicinal products and building materials from the wetland habitats (Kareri, 1992).

Despite the socio-cultural, economic and ecological importance, wetlands have been and/or are being modified mainly because their resources are overexploited and their lands converted to other uses as well as implementation of upstream developments, which alter the quality and flow of water. This is attributed to the fact that the economic values of wetland goods and services are poorly understood (Breen et al. 1997; Emerton et al. 1999; Crafter et al. 1992; Kamukala & Crafter, 1993). Both freshwater and marine wetlands, their resources and hydrological functions have been modified, degraded and interfered with because they are considered less valuable compared to other 'developments', which yield immediate and obvious profits (Emerton et al. 1999).

Wetland loss and/or degradation, which may emanate from anthropogenic activities such as infrastructure development, channelization, canalization and draining for agriculture and mosquito control, pollution (Mitsch & Gosselink, 2000; Okurut & Weggoro, 2011; Rongoei et al. 2013), and natural factors such as invasion by both alien and native species (Howard & Matindi, undated), may result into adverse environmental impacts. Besides, the livelihoods of the riparian communities that

directly rely on the wetland resources for sustenance will be in jeopardy. In the long run, the benefits so derived may decline drastically or become exhausted altogether.

Wetlands are very valuable multifunctional environmental resources. Despite this fact, they have been disappearing at an alarming rate all over the globe (Turner, 1991). Globally, wetland ecosystems are estimated to cover about 1,280 million hectares (MEA, 2005). However, most of the wetlands are under threat from a variety of local or regional human activities which have resulted in rapid degradation and/or loss. Examples of wetland degradation and/loss are many. In the Dakotas and Minnesota, USA, about 56,000 ha of wetland is drained annually. The US Army Corps of Engineers estimates that about 90 square kilometers of Louisiana's wetlands are lost annually due to both natural change and human activity (Lutgens & Tarbuck, 2000). Mexico City, in fact, is the site of a wetland or lake that disappeared during the past 400 years as a result of human influence (Mitsch & Gosselink, 2000). Besides, major cities in the world such as Chicago and Washington DC in the United States and Christchurch, New Zealand and parts of Paris, France, as well as many of the large airports such as Boston, New Orleans, and J.F. Kennedy in New York among others are situated on former wetlands (Mitsch & Gosselink, 2007). In fact, even Nairobi City was once a wetland! In Finland, about 90% of the peat land, which covered 11 million ha is drained and planted much for forestry; while in the Netherlands, drainage of peat lands has affected about 180,000 ha of land, leaving only about 3,600 ha undisturbed (Briggs & Courtney, 1989). In Japan, 35% of its mudflats have been reclaimed since 1945; while in Summatra, as little as 7% of the estimated original peat swamp forest remained intact by the late 1980s (Anonymous, 1997). In the Ganges-Brahmaputra flood plain in Bangladesh, an estimated 2.1 million ha (26.3%) of wetlands have been lost to flood control, drainage and irrigation

(Khan et al. 1994). In Uganda, about 5% of the wetlands had been lost during the period between 1950/60 and 1993 due to human activity (Kasoma, 2003). In Nakivubo wetlands in Kampala, 2.39 km^2 (45% of the original 5.29 km^2) had been modified or reclaimed by 1998 (Emerton et al. 1999). In Rwanda, nearly 9,400 km^2 of the seasonally flooded wetlands (16,800 km^2) have been officially reclaimed for agricultural use (Okurut & Weggoro, 2011). Kenya's wetlands have not been spared. For instance, sections of the Yala, Nyando and Sondu-Miriu wetlands are being reclaimed for agricultural use. Wetlands in the Nyando River Basin have been lost due to the establishment of sugarcane factories in the middle catchment of the basin as well as the horticultural farming to meet the growing demand for food in the Lake Victoria Basin (Masese et al. 2012). The sugar factories include Kibos, Chemelil, Muhoroni and Miwani. About 230 km^2 of the Yala wetland has been reclaimed by Dominion Farm mainly for rice cultivation (Okurut & Weggoro, 2011). Ombeyi wetland has also been degraded due to human activities such as deforestation, overgrazing as well as unsustainable harvesting of wetland products (LVEMP, 2014).

Wetlands have also suffered from other factors apart from conversion into other uses. Climate change has impacted negatively on the ecosystems. For instance, rainfall variability due to climate change on one hand, has led to the drying up of seasonal streams, ponds and wetlands in the Lake Victoria Basin (LVB), study area included (EASWN, 2013). On the other hand, climate change phenomenon may also cause excessive rainfall, which in turn can lead to flooding and subsequent inundation of low elevation wetland areas. For instance, in the Ganges-Brahmaputra and Zambezi deltas, multiple risks of storm surges and inland river flooding severely affect the cities and settlements within the deltas (Reckien, et al. 2017).

In order to reverse the scenario through sustainable utilization of wetlands, an integrated planning is a prerequisite since wetland habitats are diverse, ubiquitous and complex ecosystems. Integrated planning focuses on different actors and sectors working together under a commonly designed agenda to produce a commonly defined or desired objective (Auriacombe & Ackron, 2015). Besides, the approach, when properly developed and implemented, is quite effective and efficient in enhancing and sustaining rural livelihoods through sustainable use of natural resources such as wetlands (Pycroft, 2010). This study therefore aims at investigating land use-land cover changes, the contribution of wetland resources to household income, wetland management regimes in Okana and the potential social and environmental impact of wetland resource utilization in the lower Nyando River basin. An understanding of these will help in designing a framework for planning and management of wetland resources in the basin as well as in other regions.

1.2 Statement of the problem

Wetland ecosystems have sustained the livelihoods of the riparian communities since time immemorial. This is through the socio-cultural, economic and ecological values that the local communities have derived from the ecosystems. Despite these benefits, the wetland resources are continuously being exploited unsustainably. Poor agronomic practices including overgrazing, wild fires, indiscriminate cutting of macrophytes for fuel, housing and commercial activities, pollution by domestic and industrial effluents and agro-chemicals, and introduction of non-traditional or alien species into wetlands are some of the threats to the wetlands (Maskini & Hongo, 2005).

Preliminary survey reports by the Lake Victoria Environmental Management Project (LVEMP) on the status of the environment in the Lake Victoria basin indicate that real environmental issues exist in the catchment which need to be addressed (Okungu, 2004). The report however, has not linked the environmental problems in the basin to wetland resource utilization. There is need to investigate if such associated impact exists and how it can be ameliorated.

Studies by NBI (2018) reveal that a lot of information gaps on wetlands still exist especially on the goods and services that the wetland ecosystems provide to the riparian communities. Such lack of awareness and a large insufficiency in information concerning the wetlands values and functions by local communities living adjacent to the ecosystems result into a scenario where the communities may not even know appropriate conservation measures to take to protect the wetlands. Research that seeks to generate information on the values of wetland ecosystems, their conservation and management is necessary.

In the case of Okana wetland, the local communities that live in proximity to the wetland are highly dependent on the wetland resources to support their livelihoods and given that they do not have enough pieces of land to support their families, they end up encroaching into the wetlands. The residents convert the wetland ecosystem into agricultural farmland. This leads to destruction of the ecosystem. Besides, the area has also experienced continuous increase in the growth of human populations over the years. For example, the 1999 national population and housing census indicated that the area had a population density of 256.7 persons per km^2 with a population growth rate of 3.4% (GOK, 2002). This had increased to 284.3 persons per km^2 by 2002 and was projected to be 348.6 persons per km^2 in 2008. By 2012, the

population density had increased to 368 persons per square kilometer with a population growth rate of 4% (GOK, 2009a&b; GOK, 2010). In 2020, the population density had increased to 454 persons per km^2 and was projected to be 478 persons per km^2 in 2022 (GOK, 2018; GOK, 2019a; GOK, 2019b). This phenomenon of rapid population growth has put pressure on the wetland resources due to demand for space for human settlement and agriculture (Masese et al. 2012). Consequently, the wetland ecosystem has been steadily declining in size due to clearance to give room for the above land use practices.

The climate change phenomenon, which leads to frequent floods and droughts thereby causing damage to crop production (EASWN, 2013), has also exacerbated the situation to the worse. The encroachment of the wetlands due to overexploitation of its resources as well the effects of climate change are likely to affect the sustainability of the wetlands to support the livelihoods of the local communities who rely on them. It is therefore imperative to come up with a land use or management plan that regulates the utilization of the wetland resources in the basin if their numerous socio-cultural, economic and ecological values are to be enhanced now and in the future. Such a plan should be initiated and embraced by the wetland resources users who are bound to benefit if the resources are well managed or suffer if the resources are depleted. The proposed activity is aimed at protecting the wetland ecosystems, which are on the verge of depletion. Depletion of the ecosystems will thus compromise the livelihoods of the Okana residents.

1.3 Objectives of the study

1.3.1 General objective

The general objective of the study was to investigate the utilization of Okana wetlands over time, impact of such use and effectiveness of existing management regimes, if any, for sustainability. The specific objectives of the study are to:

i. Analyze land use changes in Okana between 1960 and 2020
ii. Determine the contribution of wetland resources to the household income in Okana area
iii. Determine the environmental and social impacts of wetland resources utilization in Okana area
iv. Assess the effectiveness of wetland management regimes in Okana area

1.3.2 Research questions

In order to achieve the study objectives, a number of fundamental research questions in wetland planning and management were considered. The research questions focused on the following aspects:

i. What are the wetland resources available in Okana?
ii. Which land use land cover (LULC) changes are taking place in Okana?
iii. What is the trend of the LULC changes in Okana?
iv. To what extent are the wetland resources contributing to household income?
v. Who should be involved, why and at what stage in the planning and management of wetland resources based on gender participation?
vi. How is the wetland currently being managed?

vii. What problems pertain to the current management system?

viii. Which planning interventions are in place and how effective are they?

ix. What environmental considerations are to be taken into account in the

x. planning and management process based on the environmental impacts of the wetland resource utilization?

xi. What are the social impacts associated with wetland resource utilization and possible mitigation measures to be considered in the planning and management of the resources?

1.4 Justification of the study

Okana wetlands in the lower Nyando River basin are riverine wetlands, and comprise riverine edge swamps, valley swamps, floodplains, ponds and dams. These wetlands are vulnerable to adverse impacts of anthropogenic activities both in the upper and lower catchments. Human activities such as agriculture, vegetation clearance among others are likely to impact significantly on the physical and human environment like biodiversity habitat, creation of micro climate, control of soil erosion and flooding, water recharge, water purification and provision of wood fuel. A wetland management plan that provides a guideline on the utilization of wetland resources is very crucial for their continued exploitation. For effectiveness of such a plan, its formulation should involve the resource users including riparian communities through collaboration, partnership, or round table discussion.

Kenya's wetlands cover about 3-4% (14,000 km^2) of the country's surface area (Crafter et al. 1992; GOK, 1994; Raburu et al. 2012). These ecosystems have supported millions of livelihoods of the riparian communities of the Kenya's

populace. For example, in the Lake Victoria Basin, the ecosystems support about 12 million people (Okeyo-Owuor et al. 2012). Despite the significance of these habitats, there is no uniform framework or a single management plan that guides the stakeholders or resource users on sustainable utilization of wetlands. There is sectoral management of the ecosystems by different government departments. This scenario is likely to impact significantly on the wetland ecosystems, which are quite fragile as well as the physical environment. In order to conserve the wetland biodiversity and protect the physical environment from a possible degradation, the study outlines a management plan, which provides forum for both the resource users and the state, for establishment of relevant guidelines on proper wetland utilization and management.

Research has established that local level management of natural resources, including wetlands, can lead to sustainable use of the resources as well as protection of the environment. For example, Bakema & Iyango (2000) have pointed out that decentralizing of wetlands management can contribute significantly to maintaining or restoring the ecological integrity of wetlands as well as contributing to community well-being and more equitable access to resources. In the Kenyan context, collaborative management will provide a bottom-up management approach. Besides, given the spatial nature of the Kenya's wetlands (3-4% of the country's surface area and their spatial distribution), no centralized management body will be in a position to exert effective management on such a widespread and inaccessible resource as the wetlands.

In Kenya, wetlands have not been left intact or undisturbed since most of them do not have well outlined management strategies (AMCEN, 1994; GOK, 1994). Kenya's wetlands are under threat from pollution, siltation, reclamation, damming,

overexploitation, land degradation, drainage, use of agricultural chemicals and other human activities (Abira, 1997; Onyango et al. 1997). For example, the introduction of exotic species such as Nile Perch (*Lates niloticus*) to Lake Victoria in 1958 has also resulted in drastic reduction of fish biodiversity (Ole Nkako, 1992). Besides, the damming of the upper catchment of the Tana River affects the riverine forest (the Tana River Primate National Reserve), which is the home of the endangered Tana River Red Columbus and the Tana River Crested Mangabey. Wetlands associated with River Nyando, study area included, are also rapidly shrinking because of human encroachment (LVEMP, 2000a; LVEMP, 2001).

The most recent large scale wetland conversion to agriculture in the Lake Victoria Basin was the rice growing in Yala Swamp by the Dominion Groups of Companies. The activity however is nolonger operational. Other agricultural activities on wetlands in Kenya include the sugar cane plantation in Bura and Tana delta wetlands by the Tana and Athi River Development Authority (TARDA) and Mumias Sugar Company. The rationalization of such projects is creation of job opportunities for the local communities. Urban wetlands have not been spared either. For example, Dunga and Nyamasaria wetlands are currently threatened with destruction due to the expansion of Kisumu City. Protection of these ecosystems is therefore a matter of great priority for their survival.

Studies have shown that localized wetlands, which are small in size are easily abused, never inventoried nor given the importance like the larger or more extensive wetlands (Ng'eno, 1992). Besides, such small wetlands usually occur in private or communally owned land. The factors combined or put together make the conservation and

sustainable use quite hard. Okana wetlands fall in this category of small wetlands and thus likely to continue facing degradation and/or loss due to anthropogenic activities.

Wetland ecosystems are also under threat from both alien and indigenous invasive species. These species crowd wetlands, cause problems with water movements and wetland biodiversity and have impact on people's uses of wetlands (Howard & Matindi, undated). Invasive species which have been identified include Water Hyacinth (*Eichhornia crassipes*), Red water fern (*Axolla filiculoides*), Water lettuce (*Pistia stratiotes*), Water fern (*Salvinia molesta*), Giant sensitive plant (*Mimosa pigra*), Lousiana Crayfish (*Procambarus clarkii*), Common Carp (*Cyprinus carpio*), Hippo grass (*Vossia cuspidate*), and Bulrush, Reed menace (*Tyha capensis* and *Typha domingensis*) (Howard & Matindi, undated). Potential wetland invasive species include Water milfoil (*Myriophyllum aquaticum*) and Pickerel weed (*Pontederia cordata*). The invasive species have degraded the wetland ecosystems by causing decline in both fish stocks in lakes and use of such lakes for recreational activities. In Kenya, the lakes which have fallen prey to invasive species especially water hyacinth include Victoria, Nakuru and Naivasha (MEA, 2005). There is therefore an urgent need to protect the wetland ecosystems from such threats if their multiple-user values are to be sustained.

The study is in pursuit of the seminar recommendations (No.10) of the Proceedings of the Kenya Wetlands Working Group (KWWG) on wetlands of Kenya held at National Museum of Kenya, Nairobi on 3rd–5th July, 1991. Concerning research on Kenyan wetlands, the seminar recommended that:

There should be socio-economic research and assessment of the traditional values and uses of wetlands, how the wetlands are perceived by traditional users and the

possibilities for use of these findings in future planning and management of wetlands (KWWG, 1992).

Finally, the findings of the study will form part of the existing body of knowledge found in the works of Kareri (1992), Emerton et al. (2000) and Mistch and Gosselink (2000) among others through addition of socio-economic and ecological information of wetland values. The study will generate data on wetlands that aim at improving scientific information as well as knowledge base on the wetland ecosystems of Kenya. The output or findings will therefore fulfill the core objectives of the National Wetlands Conservation and Management Policy, 2015 in knowledge generation of wetland ecosystems (NBI, 2018). Other objectives of the wetlands policy are to protect the benefits of the wetlands, to provide legal framework to address the adverse challenges which affect the wise use and conservation of wetlands in Kenya, to fulfill the obligations of Kenya under the Ramsar Convention as well as those of the East African Community, to enhance and maintain the values of wetland ecosystems by sustaining their goods and services, and to preserve biological diversity of the ecosystems (NBI, 2018).

Besides, the study will generate vital information on the various groups, both adults and young people of either gender, in the wetland resources utilization. The information is important in the assigning of roles or tasks to various groups in the planning and management of the ecosystems.

In summary, wetlands management in Kenya has been sectoral where different departments or sectors come up with their own management strategies. However, there is need for single management framework that involves the resource users through collaboration, partnership or round table discussion. The study provides a

bottom-up management approach that will effectively enhance sustainable utilization of such widespread and inaccessible resources as wetlands.

1.5 Scope of the study

The study is limited to Okana wetland in the lower Nyando River basin. The confinement of the study to the lower catchment of the basin is because it is the region where active utilization of the wetland resources occurs mostly. In the upper catchment, emphasis is on large scale tea and sugar cane plantations and wetland ecosystems are least utilized. The extensive commercial agriculture in the upper catchment may impact on the ecology of the wetland ecosystem in the lower catchment. However, such impacts are not within the scope of the study.

The study was conducted within the frameworks of Co-management and Livelihood Approach as well as Natural Resource Use and Bottom-Up theories as alternative management strategies. The focus of the study was on the socio-economic aspects of wetlands as a basis for designing a management plan for sustainable utilization of the resources. It has not dealt with the valuation of the ecological functions of wetlands.

1.6 Study Area

The study focuses on the Okana wetlands in the lower Nyando River basin. Wetlands in the basin are generally riverine wetlands. Riverine wetlands form along the course of a river upstream of its delta (Nyamweru, 1992; Ojany and Ogendo, 1982). The largest area of such wetlands is usually on the flood plain or lower course of river, where it is flowing relatively slowly across a wide valley underlain by fine sediments laid down by the river while in flood. Across its flood plain, a river usually follows a sinuous, meandering course and swampy areas develop on one or both banks.

Wetlands, which have formed on the lower Nyando River basin apart from Okana include Ombeyi riverine swamps and Nyando delta.

The Okana wetlands form part of the extensive wetland system of Lake Victoria, which comprise about 37% of the total surface area of wetlands in Kenya (Awange & Ong'ang'a, 2006). In the wider Lake Victoria Basin, they form part of the vast wetlands estimated to be about 73,994 km^2 (Okurut & Weggoro, 2011).

1.6.1 Location and Size

Nyando River is one of the six major rivers, which drain into the Kenyan part of Lake Victoria. Other rivers are Kuja-Migori, Sondu-Miriu, Yala, Nzoia and Sio. The Nyando River basin covers an area of about 3,517 km^2 in western Kenya (Mungai et al. 2004). It traverses four districts namely Nandi South, Nandi North, Nyando and Kisumu East.

It originates from Nandi Hills, where relatively high rainfall is received and drains into Lake Victoria through Kano Plains. The catchment of Nyando River system has an elevation, which ranges from 1800 m above sea level in Nandi Hills to 1100 m along the Kano Plains (GOK, 2002).

The entire catchment has several pockets of wetlands. However, the specific study area is Okana wetland in the lower catchment (Fig 1.1). It has an estimated area of about 40 km^2 (GOK, 2009b). The Okana wetland system lies in West Kano in Nyando Sub-County in Kisumu County. Administratively, it is situated in Kochieng' East sub location, Ombeyi location, Kadibo division, Kisumu East district. Politically, it falls in Nyando constituency.The wetland system is in the western part of Kano Plains where the soils are of the gleysols type, commonly associated with swamps (LVEMP,

2000). It is located at the confluence of rivers Ombeyi-Oroba, Luanda, Nyangeta, Lielango and Miriu (Fig 1.1).

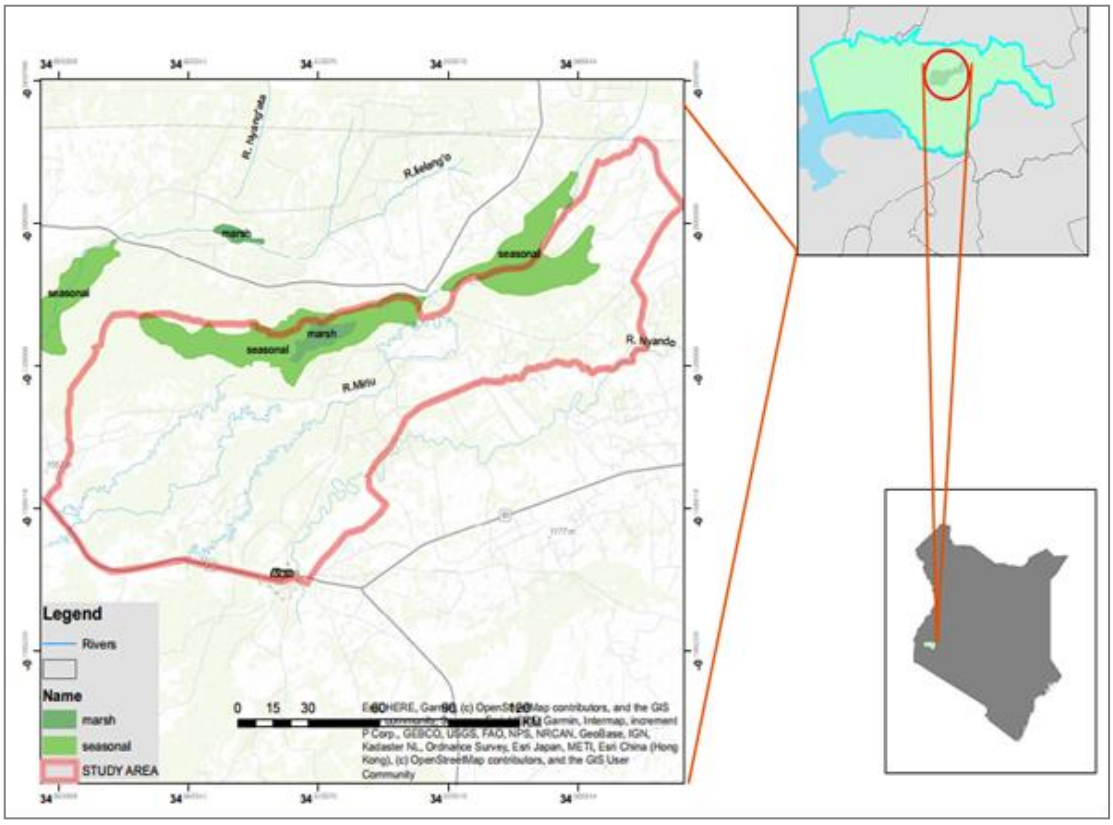


Figure: 1.1 Study Area.

(Source: Kisumu East Topographical Map 1:50,000)

1.6.2 Climate

The study area experiences a bimodal rainfall with the long rains received from March to May and the short rains coming from September to November (GOK, 2002; GOK, 2009b). The area forms a trough of low rainfall, receiving a mean annual rainfall which ranges between 600 mm to 1,630 mm (GOK, 2002; GOK, 2009b). The reliability of rainfall in the study area is quite low and the rains are distributed over a long period thereby making cultivation of second crops or season difficult. The

temperature ranges between 20ºC to over 35ºC with a mean of 24.5ºC (GOK, 2002; GOK, 2009b). The basin is prone to flooding with devastating effects on infrastructure, agricultural resources and human settlements.

1.6.3 Physiography

The study area lies in the eastern part of a large lowland surrounding the Nyanza Gulf (Fig 1.2). It is generally a flood plain area with an altitude of about 1100 m above sea level and slope gradient, which is estimated at 1-2% (GOK, 2002; LVEMP, 2000b).

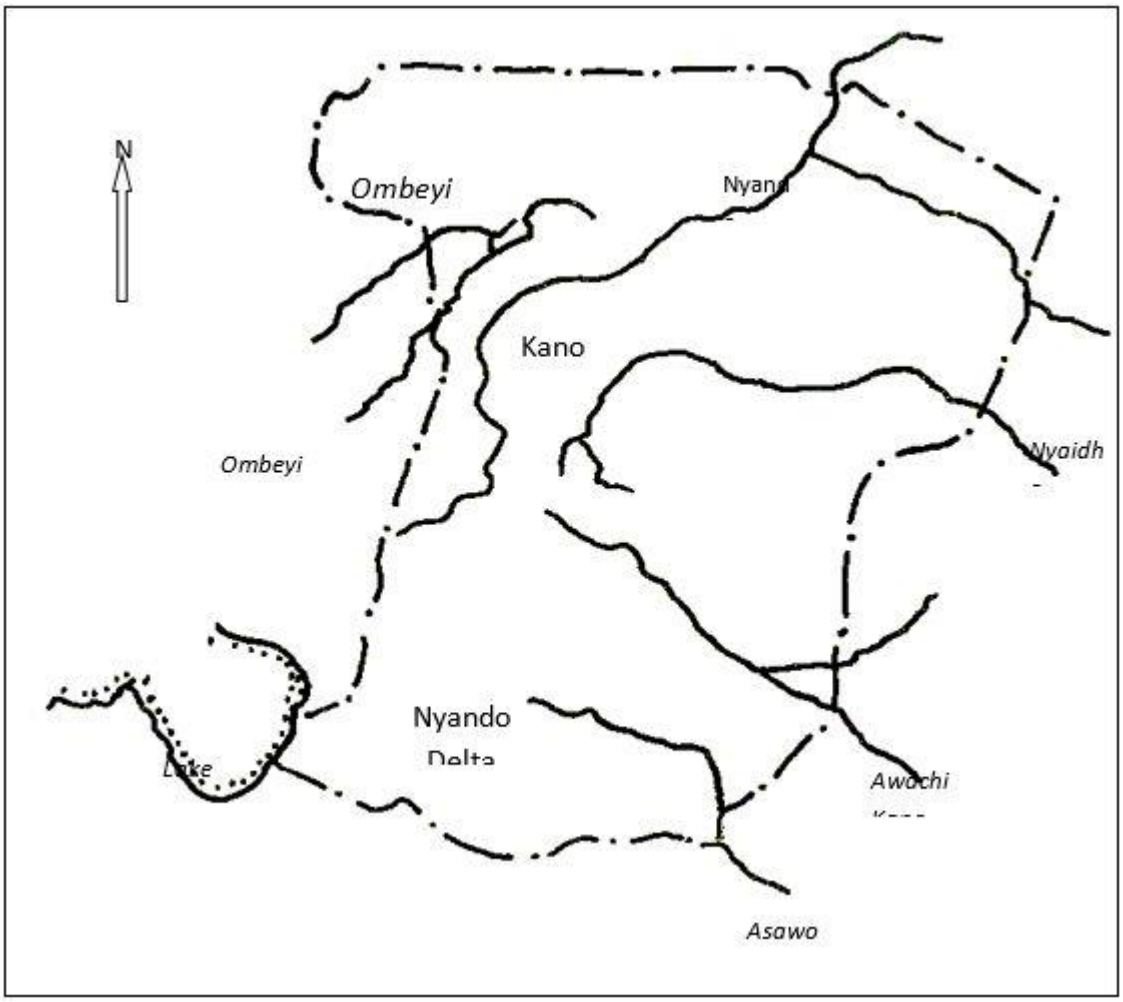


Figure: 1.2 Physiography of Okana Area.

(Source: GOK, 2009b)

1.6.4 Soils and Hydrology

The Kano Plains comprise predominantly dark brown, grey and black cotton clay soils with moderate fertility and poor drainage (GOK, 2013c). The soils are generally very deep and firm. Nyando River has an annual discharge of 247 m^3x10^6 and sediment load of 82 tones (Okidi & Olindo, 1982).

The wetland ecosystem is a component of the 71 km^2 water mass in the wider Nyando catchment (GOK, 2009b; Fig 1.3). It is served by several rivers namely Ombeyi-Oroba, Luanda, Nyangeta, Lielang'o and Miriu. These rivers originate from the Nandi hills where gradient is very steep. As they enter the Kano Plains where the gradient is relatively low and their depths are shallow, the speed of flow is greatly reduced causing extensive flooding in the Kano Plains as the rivers overflow their banks. The flooding is normally a seasonal phenomenon occurring only during heavy rains.

The total groundwater potential for the area has been estimated at $15.8x10^6$ m^3/yr (LVEMP, 2000b). However, water deficiency persists in this wetland area during the dry season. The soils in the study area are generally black cotton, which are suitable for cotton production. The wetland soils are mainly planosols, gleysols, solonets, vertisols and florisols. They vary from imperfectly drained, very deep to poorly drained soils (LVEMP, 2000b).

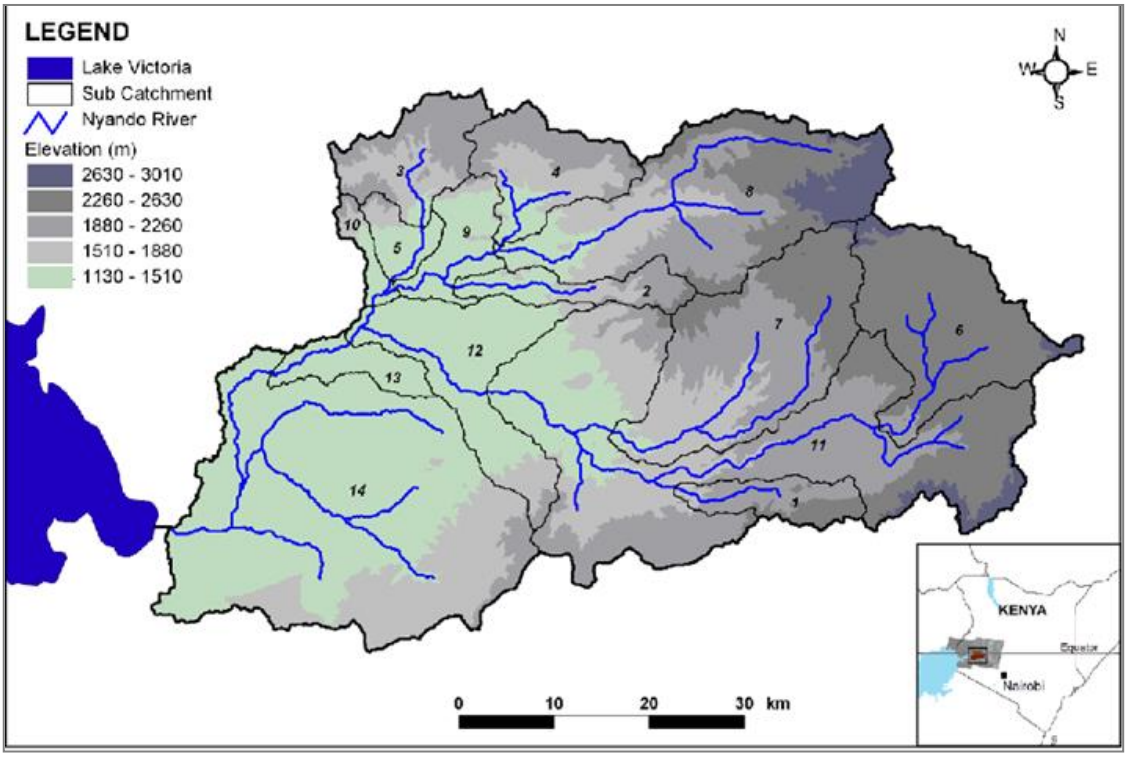


Figure: 1.3 Nyando River Catchment where study area forms part.

(Source: GOK, 2009b)

1.6.5 Ecology

The study area comprises both primary and secondary macrophytes, which together characterize plant community in the wetland ecosystem. The swamp vegetation mainly consists of *Cyperus papyrus*, Phragmites spp., Typha spp., sedge grass, water lily, swamp amaranth, Azolla spp. and climbers (LVEMP, 2000a). Secondary vegetation is evident in the reclaimed areas. Outside the swamp, the vegetation is dominated by Acacia spp. and scattered *Balanites aegytiaca*, which are found on the Kano Plains.

The wetland is rich in fauna. The most common species include quellea quellea, weaver birds, squarco heron, white necked cormorant, egret, jacana, black ibis, grey

headed king fisher, mouse bird and wag tail (LVEMP, 2000a). The wetland is also home to fish species such as lung fish and mud fish as well as tilapia. Besides, it provides habitat to numerous species of mammals, reptiles, insects, moluscs and micro-organisms.

1.6.6 Land Use

The residents of the study area practise both crop and livestock husbandry. Food crops grown include maize, beans, bananas, cassava, sweet potatoes, sorghum, vegetables while cash crops are rice, sugar cane and cotton. Livestock breed in the study area include zebu cattle, dairy, beef, cross breeds of Ayrshire, Guernsey and Friesian, sheep, poultry, bee, pigs and goats. The whole area of wetland is important for grazing and watering of livestock especially during dry seasons. The local communities also undertake fishing. Fish species caught include Tilapia, Clarias, Protopterus spp., Labeo, Catfish, Synodontis and Schillbe.

1.6.7 Population Characteristics

The study covered Kadibo division of the Kisumu East Sub-County. The division has eight (8) locations and nine-teen (19) sub locations. The study area manifests a rapidly and steadily increasing population, with a growth rate of 4%. In the 1999 national population and housing census, it had a population density of 216 persons per km^2 (GOK, 2009b). The population density had increased to 360 and 375 persons per km^2 in 2008 and 2010 respectively while by 2012, the density had shot to 390 persons per km^2 (Table 1.1). In 2020, the population density had increased to 454 persons per km^2 and was projected to be 478 persons per km^2 in 2022 (GOK, 2018; GOK, 2019a; GOK, 2019b).

Table 1.1: Demographic Profile of Okana

Characteristic	Statistics
Population Size 1999	48,914
2008	58,561
2010	60,951
2012	63,438
Male/Female Ratio	100:99.5
Dependency Ratio	100:99
Population Growth Rate	4%
Population Density 1999	256
2008	360
2010	375
2012	390
2020	454
2022	478
Crude Birth Rate (CBR per 1,000)	39
Crude Death Rate (CDR per 1,000)	29
Life Expectancy Males	58
Females	61
Average	60
Infant Mortality Rate (IMR per 1,000)	54
Under 5 Mortality Rate (U5MR per 1,000)	79
Average Household Size	4.2
Poverty Index	60.5

Source: GOK (2009b); GOK (2010); GOK (2018); GOK (2019a &b)

1.7 Limitations of the study

A number of hiccups were encountered in the course of the research study especially from field surveys to data analysis. Some of the constraints during the research study are detailed below.

1.7.1 Data acquisition

Data on LULC changes between 1960s and 1970s were not obtained since satellite images for the area during the stated period were not available. The shortcoming was thus addressed by Participatory Rural Appraisal (PRA) exercise that targed elderly persons that could provide information on the LULC changes for the period.

Statistics on the number of wild game killed was quite scanty. This is probably due to the sensitivity of the matter on the threats concerning wildlife given that hunting is illegal. The respondents were perhaps reluctant to divulge the information in fear of dire consequences should the data reach the Kenya Wildlife Service (KWS). The shortcoming was thus addressed by Participatory Rural Appraisal (PRA) exercise on the abundance of the species of fauna in the study area. The data was thus basically qualitative without any statistical proof or evidence.

1.7.2 Cash allowances (Out of pockets)

Some respondents expected monetary reward or token from the researcher and the three research assistants engaged before they could disclose any information. However, this problem was overcome when both the researcher and the Chairman of the OWSHG explained to them the purpose of the research study. Besides, a village or clan elder –*Nyumba Kumi* - was attached to us to assist in the explanation of the purpose of the activity.

1.7.3 Valuation of wetland benefits

There were generally no records on wetland resource utilization at the household level, which indicated income from the wetland products and expenditure of the income accruing. The limitation was overcome by adopting the market prices of the wetland products at the time of study. All the values given in the text are estimates based on total economic value of a resource by Barbier (1994). Nevertheless, they are important indicators for analysis and subsequent interpretation and policy recommendations for sustainable use.

1.7.4 Limited funds

The researcher, unfortunately, did not receive any financial support from other sources. The study was entirely self-sponsored, and given the colossal sums of money it required, the pace of work greatly slowed down. Furthermore, the researcher was never granted study leave given the terms of service – contract – which does not qualify for such leave of absence.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The literature reviewed is based on the following broad themes namely ecological characteristics and distribution of wetlands, socio-economic values of wetlands, gender participation on the wetland resource utilization, planning and management of wetland resources, and impact of wetland resource utilization on the physical and human environment.

2.2 Ecological Characteristics and Distribution of Wetlands

Distribution of wetlands varies continuously and mutually along several axes such as latitude and plant growth form, mineral nutrient supply, hydrology and salinity (Moss, 1992). In the study about classification on wetlands distribution in Kenya, Abira (1997) observed that precipitation is a major determinant factor in the distribution of wetlands. She observed that majority of wetlands are located in the higher rainfall areas in central, western and coastal parts of the country, and only few are found in the low rainfall areas.

Harper & Mavuti (1996) concede that East Africa contains wetlands that are smaller in size though important in terms of variety and diversity. They classify these as lowland valley swamps on the fringes of Lake Victoria, high altitude peat lands and wetlands on the mountain ranges, inland deltas and flood plains, small lacustrine wetlands in the rift valley and new wetlands associated with reservoirs. However, their scale of classification (East Africa) of wetland distribution is too broad to explicitly describe the ecology of upland and lowland wetlands. Their findings are

fundamental in the categorization of Okana wetland based on its formation and/or occurrence in the Kano Plains.

Britton & Crivelli (1993) in their study of Mediterranean wetlands observe that distribution of wetlands is determined by three environmental factors namely climate, topography and geology, and tides. Their study area was however restricted to a generally non-tropical climatic region with very mountainous topography and not in a tropical climatic region with a generally plain topography like in the study area.

2.3 Socio-eonomic Value of Wetlands

Research has shown that wetlands have the potential to sustain livelihoods of the riparian communities (Kareri, 1992). This is through the socio-cultural and economic values that local communities have drawn from them since time immemorial. Wetlands have been utilized as sources of food, water, building materials, handicrafts and medicinal herbs as well as grazing fields for both wild and domesticated animals especially during dry seasons. However, a comprehensive economic valuation of wetland products in Okana is very necessary in order to understand the role of wetlands in enhancing household income. This will also help to increase the community appreciation of the wetland resources hence their zeal or commitment to participate in the protection and management of the ecosystems if given chance through corporate management.

Despite the historical associations of wetlands with people since time immemorial, very little still exists on the socio-cultural and economic values of wetlands in the Lake Victoria basin (Kareri, 1992; Kasoma, 2003). In his review of the wetland researches in the Lake Victoria region, Kasoma (2003) concedes that the bulk of

research in the last decade and a half have emphasized on the scientific fields such as Biodiversity, Ecology, Limnology, Filtering capacity and Fisheries Biology among others. Some of such studies include Mwashote & Shimbira (1994) on the limnological characteristics of Lower Sondu-Miriu River, Manyala (1994) on floodplain fishery of the Lower Sondu-Miriu River, Lungayia (1994) on African Catfish (*Clarias gariepinus*) in the Sondu-Miriu River of Lake Victoria and Omondi & Ogari (1994) on food and feeding habits of *Schilbe mystus* in River Nyando. Research studies on socio-economic aspects of wetlands have generally been very few in comparison. Raburu et al. (2012) also concede that the the enormous socio-economic potential of wetlands in Lake Victoria Basin has not been fully exploited due to limited knowledge of the wetland ecosystems and little appreciation of their role in alleviating poverty and sustaining development. The current study forms the latter category to generate information on the same. Such information is quite crucial in the planning and management of wetland resources.

Awange & Ong'ang'a (2006) further concede that although research has been undertaken to address gaps in knowledge of wetlands and develop suitable strategies for monitoring and managing them in the Lake Victoria Basin (LVB), study area included, a lot more still is unknown. Proper planning and management (sustainable utilization) of wetlands therefore can only be achieved if all aspects concerning the ecosystems are unraveled through research.

Wetland ecosystems have been subjected to degradation by both anthropogenic and climatic factors for a long time in history (NBI, 2018). Despite the evolution in information on their importance to humanity and the environment, the degradation still continues. This is attributed to the lack of sufficient information on the true value

of wetlands especially in Kenya (NBI, 2018). The true value of the wetland ecosystems can only be achieved through comprehensive economic valuation of wetland resources such as the current study.

Although socio-economic activities in the wetlands such as fishing, papyrus harvesting, brick making, agriculture, craft making among others may not be the economic main stay of the wetland adjacent communities, they constitute a moderate cash contribution to the household subsistence production. An interview with wetland rice farmers and small-scale brick makers in Uganda, (Bakema & Iyango, 2000) revealed that household sustenance would be affected significantly if the wetlands were depleted. However, the situation is different with rattan cane craft makers, who would have no problem shifting to other products to make their crafts from. This indicates that wetland resources sustain household livelihoods for riparian communities, and hence provide an incentive for participation in the management of the resources. It is necessary to investigate the level of contribution of wetland resources to household income in Okana area in the lower Nyando River basin, with a view to establishing their willingness to participate in collaborative wetland resources management. The information will also enhance appreciation by people or communities who take the services that wetlands perform for granted.

Significant scientific research has been done about the nature, character and distribution of wetland resources in the Lake Victoria basin. Some of these researches include Ochumba & Manyala (1990) on distribution of fishes in the lower Sondu-Miriu River of Lake Victoria, Okemwa et al. (1994) on the trends of research on Lake Victoria fisheries, Gichuki et al. (2001) on the species distribution of wetland plants in the lower Sondu-Miriu River, Kapiyo et al. (2003) on the status of fisheries and

fishing activities of the Sondu-Miriu River, Owiti & Kapiyo (2003) on the ecology of the vertebrates and higher plant communities of Sondu-Miriu River basin, Raburu (2003) on water quality and the status of aquatic micro-invertebrates and ichty of fauna in River Nyando, Otieno (2004) on the spatial distribution of landscape characteristics of Yala Swamp, and Abila (2005) on the local adaptations, comparative trophic ecology and phylogenetic analysis of the haplochromine cichlids of lake Kanyaboli, a satellite Lake of Lake Victoria, Kenya. Kasoma (2003) also concedes that there have been a lot of scientific researches on wetlands in the Lake Victoria basin as compared to socio-economic researches. By 2000, there were a total of seventy two (72) scientific researches against only eight (8) socio-economic investigations (Kasoma, 2003). It is therefore important to emphasize and document the economic value of wetland resources. This will help in understanding the contribution of the resources to household income. Besides, it will hopefully increase the community's appreciation of the wetland resources, hence their planning and management for sustainable utilization.

Research surveys by LVEMP between 1998 and 2001 on the wetlands in Western Kenya indicate that the riparian communities derive socio-cultural and economic benefits from the habitats. Kareri (1992) also underscored the socio-cultural and economic values of the wetlands to the adjacent communities (Luos and Luhyas) of the Nzoia riverine wetlands. However, these reports have not explicitly established the extent to which wetland resources contribute to household income. This study intends to carry out a comprehensive valuation of wetland products made from wetland materials such as papyrus, clay, reeds, water hyacinth, and grass among others in order to determine the extent to which the wetland products contribute to household income.

Research indicates that there is a general lack of available information in the literature concerning tropical wetlands and their valuation (Turner, 1991). Besides, economic value of wetland goods and services is poorly understood (Emerton et al. 1999). Consequently, wetlands, their resources and hydrological functions are modified, degraded and interfered with because they are seen to have little or no value as compared to other 'developments,' which yield more immediate and obvious profits. This further affirms that socio-economic literature on wetlands is still limited and hence need for more research in the area especially in the tropical region.

Since early civilization, many cultures have lived in harmony with wetlands and have benefited economically from surrounding wetlands. Examples include food production (fish and rice) in the shallow ponds or rice paddies, harvesting of plant and animal products from wetlands in China; harvesting of cranberries from bogs in US; mining of peat lands to obtain fuel in Russia and Ireland; extraction of timber, food and tannin from mangrove wetlands in Indo-Malaysia, East Africa, and Central and South America; utilization of salt marshes in Northern Europe and the British Isles for grazing, hay production, fences and thatching for roofs; harvesting of reeds for fencing and thatching in Romania, Iraq, Japan, and China; and fishing in shallow ponds or rice paddies in China, South east Asia, Louisiana and the Philippines (Mitsch & Gosselink, 2000; Mitsch & Gosselink, 2007).

Despite these values and uses of wetland resources, wetlands have been depicted as sinister and forbidding, as having little economic value throughout most of history. They have been described or portrayed negatively. Mitsch & Gosselink (2000) describe some of these negative attributes thus:

> *We get bogged down in detail; we are swamped with work….*

Mythical bogeyman…. Creature from the Black Lagoon…..

Swamp thing….. return of the Swamp thing……

These negative connotations give the impression that wetlands do not have any significant value to the communities around and/or within which they are found. However, this is not true based on the findings of Kareri (1992) and Emerton & Kekulandala (2003) on the socio-economic values of wetlands. There is need for more research on the same to further prove the socio-economic values of wetland products so as to enhance public advocacy or campaigns on the importance of wetlands and hence the need for their management so as to ensure sustainable use of the habitats.

Wetlands are often thought of as "wastelands", which have no significant economic values. However, studies by the International Union for Conservation of Nature (IUCN) in Africa, Asia and Latin America have shown again and again that wetlands goods and services actually have a high economic value, and this underlines the need for their conservation and sustainable use (Emerton & Kekulandala, 2003). A study by the two authors in Sri Lanka revealed that wetlands have significant economic value not only to the riparian communities, but also to the national economy. For instance, study of the Muthurajawela wetland in the same country showed that the ecosystem's goods and services provide benefits at a total value exceeding SFR 10 million (US $ 7.5 million) per year (Emerton & Kekulandala, 2003). This, therefore, implies that sustainable utilization of the wetlands enhances continued economic benefits while at the same time helps in the maintenance of the natural properties of the ecosystems.

2.4 Planning Interventions and Management of Wetlands

Different institutions or groups either from governmental or NGOs have visited the study area with specific but different objectives. Some of the organizations include SANA International, GWAKO, VI-AGRO, VIRED International and LVEMP among others. Apart from VIRED International, which appeared to be holistic in its activities, all the other organizations tended to be specific on particular wetland resource(s). For example, SANA International was interested in water resource while VI-AGRO emphasized forest resource development. This ad-hoc kind of management has a potential of compromising other resources, which are not of immediate interest. Consequently, the "neglected" resources may eventually be degraded and/or lost altogether. A holistic management plan is necessary where different relevant sectors or Departments cooperate and harmonize intended activities or tasks. Otherwise ad-hoc or "hop and jump" kind of management would be the order of the day, whereby resource users focus on a particular resource for sometime then leave it for another whenever a different group or sector comes in with a different emphasis. The phenomenon is however disastrous for sustainable resource utilization.

Wetlands, like any other wild habitats, need to be well planned and managed. According to Helliwell (1985), planning and management of ecosystems would counter any losses and/or degradation that would be difficult, and often impossible to recover. Such losses and/or degradation would be not only detrimental for us but also to all subsequent generations. Therefore it is prudent to conserve as much wildlife as nature may offer. Other reasons for conserving wildlife habitats such as wetlands include actual production, potential production and for recreation purposes (Helliwell, 1985). Actual production involves the provision of meat, fish, fruits or pharmaceutical

materials while potential production is where wetlands are used as reserve of material for breeding new varieties of edible plants or producing new breeds a means of controlling pests, and pollinating food crops and facilitates for research work and the training of scientists. Recreation purposes include generation of education to broaden one's mind and increase one's understanding of the world, hobbies such as amateur photography or natural history studies and contribution to the character of the visually perceived landscape (Helliwell, 1985). All these functions of wetlands justify their conservation.

Wetlands are potentially vulnerable to changes in climatic parameters such as air, temperature, precipitation and other meteorological components (DMCN, 2002). Variations in these parameters cause changes in evaporation, water balance, hydro-chemical and hydro-biological regimes hence entire wetland ecosystem. The variations in climatic parameters are bound to exist in the Lake Victoria basin due to the anthropogenic activities such as deforestation, overstocking, overgrazing among others. All these impact directly or indirectly on the wetlands, and hence the physical environment. Besides, the difference in altitude between the upper and lower catchments of the basin also results in climatic variations. It is therefore imperative that the planning and management of wetland resources should incorporate climate considerations, particularly when dealing with wetlands in varying climatic and ecological regions.

Many communities of the Lake Victoria Basin, the study area included, derive their livelihoods from exploitation of wetland resources. They draw traditional food, herbal medicine, building and construction materials, water and handicrafts from the wetlands. Besides, the ecosystems provide green grazing fields especially during dry

seasons. They also form important sites for ceremonies such as circumcision, ash drive and baptism. These ecosystems should therefore be protected for sustained livelihoods. However, an assessment report by LVEMP (2002) confirms that there is very little effort to manage wetland resources in the Lake Victoria basin.

Studies have shown that wetland ecosystems face myriad of challenges which affect their management. In the East African region, for instance, the ecosystems face challenges such as too many sectoral laws, policies and institutional frameworks, inadequate funding for wetlands survey and research leading to inadequate scientific information on the wetlands, inadequate education and dissemination of information to riparian communities on wetland values, functions and how to manage them, ownership of the wetlands as well as access and use rights of the same (MEA, 2005; Kibwage et al. 2008).

Research has indicated that many wetlands in the Lake Victoria basin are communally owned (LVEMP, 1998; LVEMP, 2000a; LVEMP, 2001). At the community level, wetlands are thus common property areas for fishing, grazing and harvesting of natural products. Community regulations for wetland use stipulate free access and user rights for all community members. Exclusive user rights are only exerted during wetland cultivation where real parcel owners have to grant permission. This implies that basically, community level management alone does not offer effective management regime to protect wetlands and their associated resources especially in the absence of policy framework regulating wetland utilization. A management plan where relevant stakeholders in wetland resource use collaborate in the management of the resources is necessary.

Wetlands, both in rural and urban areas, have had considerable pressure from socio-economic developments over time. In urban areas, wetlands have been converted into industrial sites and residential settlements. In Kampala for instance, wetlands were the last "free" or cheap areas for infrastructure developments, and despite the designation of most wetlands as "green corridors" in the Kampala Structural Plan of 1994, wetlands were still turned into industrial sites or were slowly filled in with semi-slumps in the 1990s (Iyango & Ndayabarema, 1995; Bakema & Iyango, 2000). In fact, Munyonyo beach in Uganda was built at the expense of wetlands for the purpose of eco-tourism. This is despite the fact that Uganda's wetlands are protected ecosystems. In total, 75% of the wetland area in Uganda has been significantly affected by human activity and about 13% severely degraded (Awange & Ong'ang'a, 2006).

In Kenya, wetlands have not been spared. The wetlands have been converted into farmlands, residential areas and/or enterpreneural premises. For example, Yala Swamp was converted into rice irrigation farming while Bura and Tana River Delta into sugar cane farming. However, the large-scale rice irrigation farming in Yala Swamp by the Dominion Groups of Companies has since stopped. Nyalenda wetlands (including Dunga) in Kisumu City have been reclaimed and converted into residential settlements, social amenities and premises for business enterprises (NBI, 2018). Besides, Kimana wetland in Kajiado County has also been drained and converted into agricultural farmland and urban settlement (Njagi, 2016). The rationalization of these development projects is creation of job opportunities for the local communities. However, such rationale is still in doubt. For instance, in the case of Yala Swamp, the Kenya Land Alliance (KLA) holds that the operations would lead to ecological disaster. Thus:

"…….KLA is constrained to conclude that the activities of Dominion Farms (K) Ltd in Yala swamp are environmentally degrading and destructive of Kenya's largest, rich and fragile wetland ecosystem in the name of development……" (KLA, 2005; KLA, 2008).

It is worth noting that Kenya has established the Wetlands Policy (The National Wetlands Conservation and Management Policy, 2015) as part of her obligation under Ramsar Convention as well as those of the East African Community. However, localized wetlands such as Okana, which are small in size and hardly inventoried, are easily abused. Formulation of localized management strategies based on the main policy to enhance wise use of the local wetlands is necessary.

The importance of wetlands in Kenya was first stated by the Kenya Government in its 1963 Manifesto on conservation of natural resources (Ole Nkako, 1992). As a result, several areas have been designated as parks or reserves. Examples of such protected areas include Lake Nakuru National Park, Lake Naivasha, Lake Bogoria National Reserve, Lake Baringo, Lake Elementaita and Tana River Delta. In order to show its commitment in the conservation and management of wetlands, the Kenya Government ratified the Ramsar Convention in June 1990 in Montreux, Switzerland. However, laws to protect wetlands outside and within protected areas have not been enforced (Ole Nkako, 1992). Research on wetlands is therefore necessary in order to generate findings and relevant recommendations to be adopted by land use planners.

Wetlands around Lake Victoria including the study area are increasingly threatened by agricultural activities such as crop farming, grazing on lush wetland pasture, excessive harvesting of wetland products and frequent fires. All these phenomena lead to loss and/or decline of biodiversity, which subsequently reduce the capacity of

wetlands to filter and reduce the amounts of pollutants reaching the Lake (Awange & Ong'ang'a, 2006). Sustainable utilization of the wetland ecosystems is necessary in order to enhance ecological sustenance of the ecosystems and sustain the livelihoods of the riparian communities who depend on the wetland resources.

2.5 Environmental and Social Impact of Wetland Resource Utilization

Studies on environmental status in Nyando River basin have indicated that there is a general environmental decline in the basin. Okungu (2004) observed that LVEMP's preliminary reports reveal that there were real environmental issues in the catchment, which need to be addressed with a view to reversing the trend. The study however, did not explicitly explain or unveil the causes of such environmental deterioration. Apart from investigating general causes of environmental decline in the basin, it is imperative to conduct a research on a specific variable such as wetland resource extraction on the environment. This will generate important insight or knowledge on the phenomenon under study and hopefully help to come up with appropriate planning and management strategies to ameliorate the situation for sustainable wetland utilization.

Wetlands provide important habitat for numerous biota component. However, the ecosystems have been reclaimed for agriculture, which has led to their contraction. Besides, water hyacinth has been consistently harvested for the production of various kinds of crafts such as floor mats, furniture, baskets, necklaces, door mats. Sites for water hyacinth harvesting in the Lake Victoria basin include Dunga Swamp and Kusa Wetland in Kisumu and Nyando Sub-Counties, respectively. One therefore wonders whether the wetland resources such as vegetation are less significant in terms of

environmental sustainability that they are unworthy of protection or sustainable use! A study is necessary to unveil such gaps.

The conversion of 6,500 ha of wetlands to irrigation agriculture in the Nyando basin since 1980s has reduced the filtering effect of the wetland ecosystems considerably thereby contributing to the major sediment plume in Winam Gulf and eutrophication of Lake Victoria (Swallow, 2004). This is just but one aspect of wetland resource utilization and its resultant environmental impact. It is probable that adverse environmental consequences could be in the offing due to numerous wetland resource extractions in the basin, which is worth studying.

Studies on the utilization of wetland resources such as papyrus (*Cyperus papyrus*) have shown that wetlands have multiple socio-economic values on which local communities are increasingly dependent for earning their income as well as meeting other social needs. Katondo (2005) in his analysis of the traditional uses of *Cyperus papyrus* and associated problems at Simiyu fringing wetland of Lake Victoria, Mwanza region, Tanzania, established that papyrus plant has diverse uses ranging from commercial, subsistence to non-commercial ones. Some of the uses include mat making, packaging materials, broom making, fuel wood, ropes, house construction, fencing, medicine, utensils and cooking. He also noted that utilization of papyruses results in social impacts such as drowning, attacks of harvesters by snakes, hippopotamuses, crocodiles, mosquitoes and leeches as well as stakeholders conflicts. However, the study did not consider the environmental impacts of wetland resource utilization. Besides, the study analysed only one wetland resource – papyrus – leaving a host of other resources of possible similar values. It is therefore necessary

to consider all possible impacts of utilization of various wetland resources in order to develop all-inclusive strategies for planning and management of the resources.

Research has established that unsustainable use of wetland resources results into adverse environmental impacts, which impact negatively on the socio-economic activities that humans depend on. Maskini & Hongo (2005) observed that overgrazing results into decreased plant species composition, loss of forage yield, and soil moisture content, increased runoff and erosion hazard, poor range condition, encroachment of undesirable (poisonous plant) species, siltation and eutrophication. The study focused on the impact of livestock grazing on wetland ecosystems. It is probable that other aspects of wetland utilization such as brick making, sand harvesting, clay excavation, macrophytes harvesting among others, other than livestock grazing, could also impact negatively on the environment. Investigation of such impacts is crucial for sustainable utilization of wetland resources.

Preliminary results of International Centre for Research on Agro forestry (ICRAF) studies on ecological functions of Lake Victoria wetlands as sinks of sediments indicate that the Nyando River basin, which houses the study area, has high erosivity index (Awange & Ong'ang'a, 2006). This finding implies a possible environmental degradation probably caused by land use change. An investigation on land use changes, their causes and impacts on the environment is quite crucial, especially in the study area where significant changes have occurred.

2.6 Theoretical Framework

The research study was anchored on Walter Firey's theory of Natural Resource Use in 1961, which incorporates ecological, historical, cultural, socio-economic and political

aspects of natural resources into the management and development programmes. According to the theory, any proposed planning and management strategy for whichever resource must address three components namely ecology, culture and economics (Fig 2.1). That is, the utilization of a resource in question must outline how the ecological processes would be maintained, how the residents like riparian communities would benefit economically and whether the operations or activities are compatible with the local cultural values and behavioural patterns of the people.

The Firey's theory therefore provides a leeway for the development of a management plan (Fig 5.2) and a model (Fig 5.3) that would enhance sustainable utilization of wetland resources both in the study area and elsewhere if implemented. The model or management plan embraces the three fundamental pillars of sustainable natural resource use viz ecological possibility, economically gainful and culturally adaptable. The incorporation of the three facets would lead to Sustainable Development (Fig 2.1).

The study also used Bottom-Up Model or Approach by Charles William Maynes in 1996 where the opinions or ideologies of the local resource users are incorporated in the development and implementation of management plans (Maynes, 1996). The inclusion of the wetland resource users is imperative since they are the direct beneficiaries or losers

if the ecosystems are sustainably utilized or degraded respectively. Their inclusion also empowers them as they own the process.

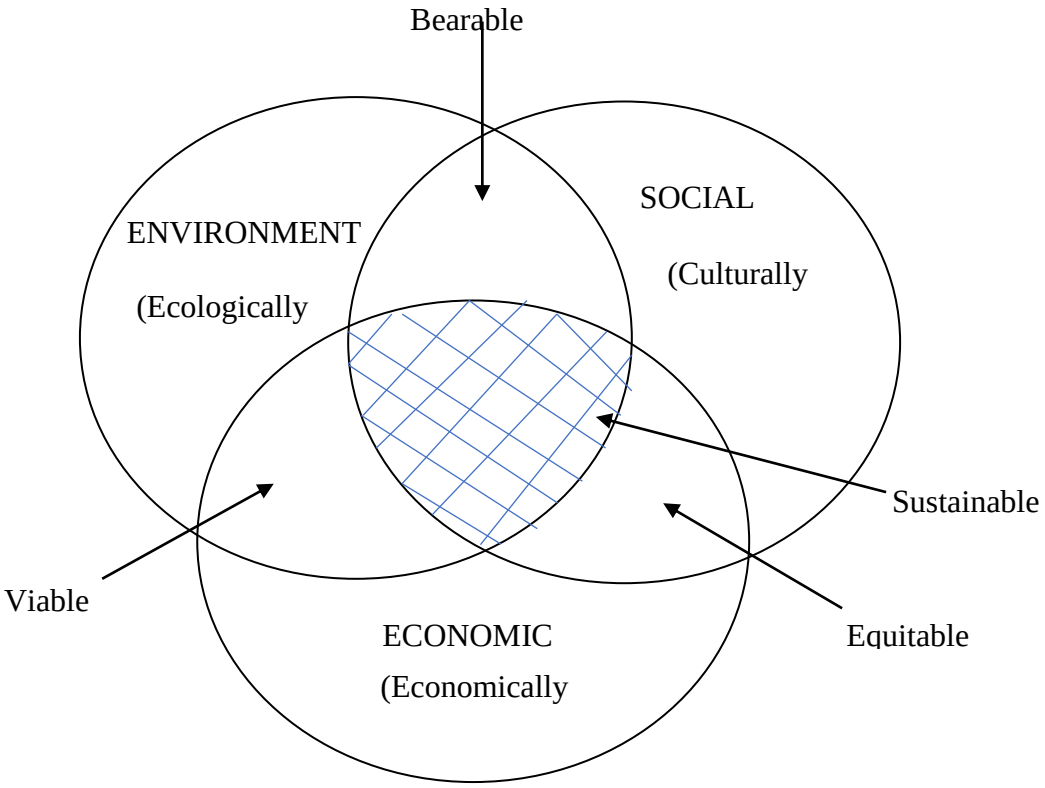


Figure: 2.1 Sustainable Use of Wetlands.

(Source: Modified from Firey, 1961)

2.7 Conceptual Framework

Wetland resources sustain livelihoods of riparian communities through provision of socio-cultural, economic and ecological values. A livelihood comprises the assets (including access to them) and activities, both mediated by institutions and social relations that together determine the living gained by the individual or household (Ellis, 2000; DFID, 2001). According to DFID (2001), a livelihood is sustained when it can cope with and recover from stresses and shocks and maintain or enhance its

assets and capabilities to access the assets both now and in the future, while not undermining the natural resource base.

The resources, when well utilized by adherance to the regulations, then the livelihoods are sustained since they contribute to household income. However, when the regulations are disregarded, then the wetlands are lost or degraded leading to loss of livelihoods. In order to achieve sustainable utilization of the wetland resources, the exploitation of the resources must be guided by properly defined planning and management procedures. This involves cooperation or collaboration between the resource users, the government, external agents and other stakeholders who may not depend directly on the wetland resources (Fig 2.2). The entire arrangement covers various degrees of power sharing and integration of resource users, government in both national and county as well as other interest groups. Collaboration is essential since it a scenario where the capabilities and interests of the resource users are outlined. The ability of the state to complement the capabilities and interests of the riparian communities through provision of enabling legislation, enforcement and other technical assistance is also indicated. Besides, the role of external agents such as Non-governmental Organizations (NGOs), academics, researchers and Community Based Organizations (CBOs) as well as other stakeholders such as environmentalists, traders and political groups is defined. All these groups complement each other in the planning and management activity for sustainable utilization of wetland resources hence sustainable development (Fig 2.1).

In the current study, the involvement of the wetland resource users (riparian communities) is fundamental due to the overlapping and varying property regimes of wetlands and their significant socio-cultural, economic and ecological values to the

adjacent local communities and even beyond. The wetlands tenure systems comprise both communal and private ownership. It is therefore important that both the riparian communities and the government collaborate in the management of these vital wetland resources. Wetland resource users are represented at different levels namely primary, secondary and tertiary stakeholders. The government is represented at both county and national levels. Other partners in the collaboration include environmental groups, academic and research institutions, non-governmental organizations as well as other representatives from the civil society (Fig 2.2).

The study used stakeholder analysis to analyse the role of individual partner and/or stakeholder in the wetland resource use, planning and management in Okana in the lower Nyando River basin. It also helped to identify or delineate group(s) involvement or incorporation in the entire process of planning and management of wetland resources in the basin. The resources users, especially the riparian community, derive their livelihoods from the wetland resources and are therefore suited in the implementation of the agreed tasks like selective harvesting of wetland products, proper waste management, planting of appropriate tree species and taking part in rehabilitation activity. Besides, they also reprimand those who violate the regulations since they know one another both by names and traits.

The government, both at county and national levels, provides the necessary facilitation in terms of guidelines, training, sensitization and evaluation of the implementation or compliance by the resource users. Stakeholders like environmentalists and opinion leaders undertake advocacy and sensitization on the importance of sustainable utilization of the wetland resources. Traders on the other hand provide information on the market viability of the wetland products.

External agents such as researchers and academics take part in awareness campaigns on the values of wetlands and their products, value addition and also on market information. NGOs and CBOs provide both financial facilitation and information on value addition, market feasibility as well as awareness campaigns and training on the changing skills and expertise. The different groups therefore work in harmony and complement each other for the achievement of same goal, mission and objective – Sustainable wetlands utilization and management.

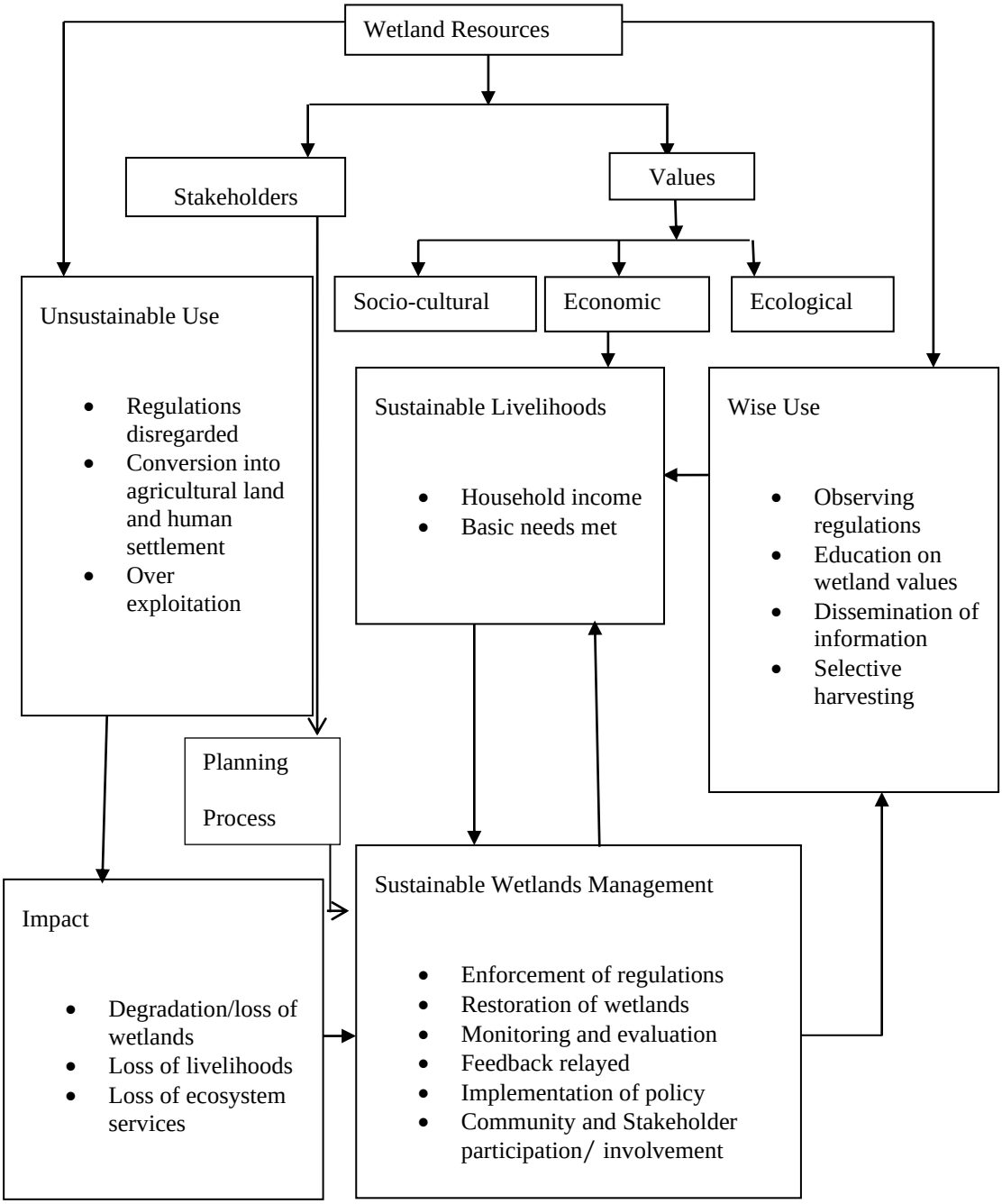


Figure: 2.2 Integrated Planning and Management of Wetlands.

(Source: Author, 2023)

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter examines the various research methods and materials used in the collection, processing, analysis and presentation of data. Given that wetland ecosystems are quite diverse in nature and scope, and their planning and management involves numerous stakeholders and sectors, a number of methodological procedures and techniques were adopted to obtain relevant data for the various aspects of the study.

3.2 Methods

The study used a number of procedures and techniques in collecting, processing, analyzing the field data and presenting the results. These include direct observation, photography, remote sensing and Geographic Information System (GIS), pilot and field surveys and Participatory Rural Appraisal (PRA). These techniques were used to obtain various information as outlined in the following sections.

3.2.1 Pilot Surveys

Reconnaissance surveys were carried out prior to the main field research. The purpose of the surveys was to familiarize with the study area and current situation on the ground in order to identify respondents to be contacted in the sampling frame. During the exercise, informal interviews were conducted. Three (3) Research Assistants were trained on the aspects of the study. Besides, structured questionnaires to be used in the

main field research were tested and reviewed. The testing of the questionnaires was done by the Researcher and the three (3) Research Assistants.

The survey revealed that the activities of the local community on the wetlands are almost similar. However, some residents engage in wetland resource utilization as individuals while others as groups (Community Based Organizations – CBOs). This finding helped in revising the questionnaires for local community to suit particular groups. The homogeneity in terms of wetland resources utilization was thus essential in designing sampling frame.

On the wetland resource management aspect, the surveys revealed that some institutions or organizations have played key role in initiating wetland based projects in the study area. Some of these include Lake Victoria Research on Environment and Development (VIRED International), VI- AGRO, World Vision, CARE – Kenya International and Okana Wetland Self Help Group (OWSHG). The revelation led to designing of another questionnaire for key informants (Appendix A-II), which targeted the various institutions or organizations, whether governmental or Non-Governmental Organizations (NGOs).

3.2.2 Sampling Procedures

The study used two sampling techniques namely simple random sampling and purposive sampling. Simple random sampling was used during the administration of three hundred and eight (308) structured questionnaires while purposive sampling was used to administer forty (40) key informant questionnaires. Thirty six (36) participants were also used during Participatory Rural Appraisal (PRA) exercise. The total number of sample size for the study was three hundred and eighty four (384). The number of

the respondents is thus in tandem with the conventional sample size of a minimum of thirty (30) respondents or three hundred and seventy (370) for a population size of about ten thousand (10,000) as in the case of the current study (Kasomo, 2007). It also agrees with the recommended sample size of three hundred and eighty four (384) as expounded by Mugenda and Mugenda (2003) for a population size of about ten thousand (10,000) as shown in the formula below. The target population of the study area is thirteen thousand, four hundred and sixty seven (13,467) with a total number of households of nine hundred and thirty eight (938) (GOK, 2019b). The reconnaissance visit of the study area and the subsequent pilot surveys of the same revealed that the wetland area covers twelve (12) villages. The villages include Kowuor, Kabina-Kodeyo, Kagaya, Kaluga, Kosimbo, Kawuor, Kodhiambo, Kokal, Kanyang'anyi, Kanyaoma, Kadeya and Kathina (Fig 3.1). Besides, there was homogeneity of the population in terms of activities that the residents engage in, in the wetland. In summary, the total sample size for the study was guided by the formula:

$$n = \frac{Z^2 pq}{d^2}$$ (Mugenda and Mugenda, 2003)

Where: n= the desired sample size

Z= the standard normal deviate at the required confidence level (marginal error); at 95%, z=1.96

p= the proportion of target population

q= 1-p

d= level of statistical significance

Thus: at 0.05 confidence level, Z =1.96, p= (50% =0.5);

$$n = \frac{(1.96)^2 \times (0.5 \times 0.5)}{(0.05)^2} = 384.$$

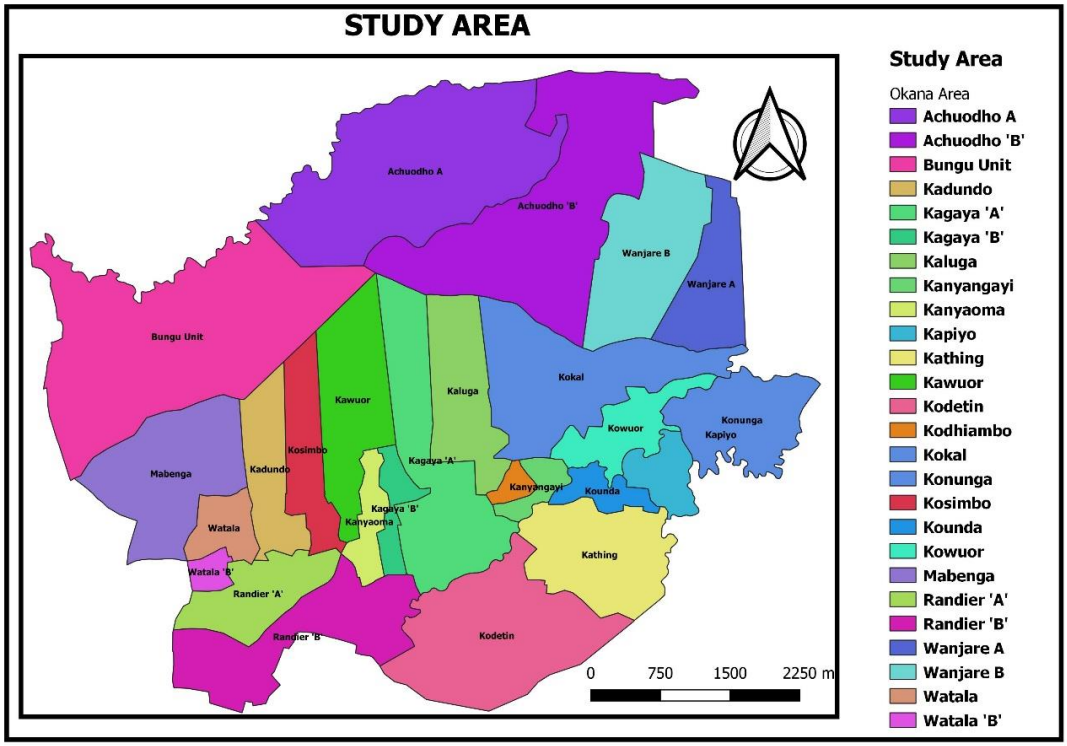


Figure: 3.1 Okana Area (Villages).

(Source: Modified from GOK, 2009b)

Purposive sampling was used to obtain information from key informants. These were persons or officers in the various institutions in the study area that deal with wetland and wetland related activities either directly or indirectly. The institutions, which were visited, included Lake Victoria Research on Environment and Development (VIRED) International, UHAI (Livelihood) Lake Forum, Lake Basin Development Authority (LBDA), Ahero Pilot Irrigation Scheme, Ministry of Environment and Natural Resources (MENR), National Environment and Management Authority (NEMA),

Okana Wetland Self Help Group (OWSHG), and Lake Victoria Environmental Management Project (LVEMP). The technique was useful in obtaining data on existing wetland management regimes, the trend and extent of wetland encroachment in the basin since 1960s, changes in land use, by-laws regulating wetland use, conservation, past and current planning and management interventions or strategies and their effectiveness. In each of the institutions above, five (5) questionnaires were administered. In a nutshell, a total of forty (40) questionnaires were administered to the key informants.

Participatory Rural Appraisal (PRA) of wetland resources utilization and their changes over time was also conducted during field study. The technique helped to verify the results of the household surveys carried out. It also enhanced the development of both management plan and community action plan for the Okana wetland resources since the process is to a large extent interactive. A total of thirty six (36) wetland resource users participated in the PRA exercise (Appendix B-I). The participants were selected on the basis of engagement or activity that one takes part in, in the wetland such as craft making, fishing, apiculture or farm forestry.

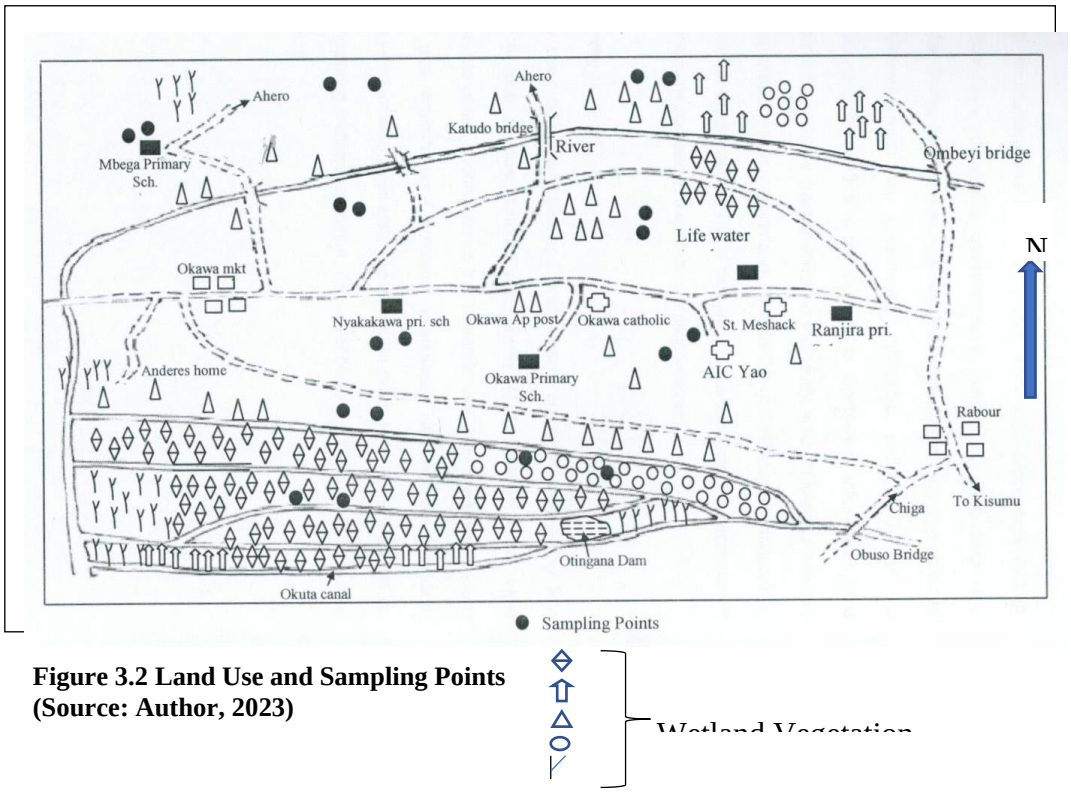


Figure 3.2 Land Use and Sampling Points (Source: Author, 2023)

3.2.3 Methods of Data Collection

The contribution of wetland resources to household income cannot be fully valuated either qualitatively, quantitatively or both until comprehensive information on the utilization of the resources is obtained. To achieve this, the study used both primary and secondary data collection techniques.

First hand information was obtained directly from the respondents through informal interviews, structured questionnaires, participant observation and photographs. During field surveys, relevant documented data were also collected from institutions such as Government Ministries and NGOs at the District/Divisional Headquarters in the study area. Sources of information listed above include households (respondents) in the study area, officials of relevant Government Ministries or Departments at Sub-County/Divisional Headquarters, NGOs, Research Organizations, CBOs and Public Libraries. Remote Sensing (RS) was also used to acquire satellite images for geo-referenced data. Detailed discussion of particular instruments used in the study is outlined below.

Survey

The study used both structured and unstructured questionnaires during field research. A total of three hundred and eight (308) questionnaires were administered to the local community to obtain information on the wetlands use, their ownership as well as social and environmental problems associated with wetland utilization. Random sampling technique was used to administer the questionnaires in the twelve (12) villages. Twenty six (26) respondents were were drawn from each of the eight (8) villages while twenty five (25) were drawn from each of the four (4) villages. The

disparity in the number of respondents per village was based on the variation in population of the villages as established during reconnainessence and pilot survey conducted. The sampling was therefore representative. Besides, forty (40) questionnaires were administered to key informants to solicit information on by-laws regulating wetland utilization, conservation, past and current planning and management interventions or strategies, and their effectiveness.

Questionnaires (Appendix A) were the major research instrument used in the surveys. They were administered to the residents of the study area. The aim of the instrument was to obtain comprehensive information on wetlands use, their ownership and management regimes or programmes as well as social and environmental problems associated with wetland utilization. The instruments were both open ended and closed structured questions. The former type was particularly helpful as it gave respondents opportunity to give more elaborate information on topic (s) of interest. However, focus on the study objectives was maintained throughout since the questions were tailored towards specific objectives.

Key informant interviews were used on selected persons who were knowledgeable on wetland ecosystems. The instrument solicited information on by-laws or frameworks regulating wetland utilization, conservation and management, programmes on management of the wetlands and their effectiveness. The persons targeted included individuals carrying out research(es) on wetlands such as VIRED International and UHAI Lake Forum, those involved in wetland management such as LVEMP and VIRED International, those involved in policy aspects of the ecosystems such as National Environment and Management Authority (NEMA), Kenya Land Alliance (KLA), Ministry of Lands, Lake Basin Development Authority (LBDA) as well as

groups particularly Community Based Organizations (CBOs) whose activities revolve around wetland resources such as Okana Wetland Self Help Group (OWSHG).

In summary, the questionnaires were designed to collect data on:

i. Land use changes in the study area between 1960 and 2020, their causes and effects,

ii. Wetland types and associated resources available in the study area,

iii. Socio-economic values of wetlands in the study area to the local communities,

iv. Management regimes and planning interventions in place,

v. Wetland resources being managed,

vi. Problem(s) encountered in (iv) above and copying strategies.

Secondary Data

Related literature on wetlands from textbooks, journals, articles, periodicals, academic reports, government reports, project reports, conference proceedings, dissertations and theses were reviewed critically to obtain information on the status of wetlands, their values to the riparian communities and even beyond, and the existing policy, institutional and legal frameworks on wetland ecosystems. These documents were obtained from various libraries, documentation centres, Government and Non-Governmental Organizations (NGOs) offices. The libraries included Maseno University Library, School of Graduate Studies (SGS) Library at Maseno University, Moi University Library, University of Eldoret Library, The World Conservation Unit

(IUCN) Library in Nairobi, The United Nations Environmental Programme (UNEP) Library, Gigiri in Nairobi, and the National Libraries in Kisumu and Nairobi. The documentation centres visited included the School of Environmental Studies (SES) Documentation Centres at Moi University and University of Eldoret and the Lake Victoria Environmental Management Project (LVEMP) Documentation Centre in Busia and Kisumu. The government and NGO offices included the Lake Victoria Research on Environment and Development (VIRED International), the UHAI (Livelihood) Lake Forum, the Lake Basin Development Authority (LBDA) in Kisumu, the Ahero Pilot Irrigation Scheme, the Ministry of Environment and Natural Resources (MENR) in Nyando District, and the Okana Wetland Self Help Group (OWSHG).

The documents from the institutions mentioned above were meant for data on:

i. Changes in land use between 1960 and 2020 in the study area,

ii. Types of wetlands and their associated resources available in the study area,

iii. Ecological characteristics of wetlands in (ii) above,

iv. Socio-economic values of the wetland resources in (ii) above,

v. Management regimes existing in the wetlands,

vi. Past and present planning interventions.

Photography and Participant Observation

Direct observations, participation and taking of photographs were used during the survey. These techniques helped in the capturing and understanding of the activities carried out in the wetlands. Direct observation of the activities was particularly useful in cross checking or validation of the respondents' answers.

Photographs were taken to capture salient features relevant to the study such as actual processes of wetland resource utilization like harvesting, craft making, animal grazing on wetlands, excavation of clay, and wetland products. Selected photographs were scanned and pasted as plates in various sections of the thesis.

Participatory Rural Appraisal (PRA)

The PRA tool was used to obtain information on the changes in the abundance of wetland resources overtime, types of institutional frameworks on wetlands, their implications, roles and limitations on the wetland utilization, conservation and management. The technique provided a forum necessary for the development of a wetland management plan for the study area where the community members were invoved. Besides, it provided opportunity to validate the repondents' answers during survey exercise. A schedule for the exercise is provided (Appendix B-II).

A total of forty one (41) persons participated in the PRA exercise (Appendix B-I). PRA team were five (5) persons while the participants (community members) were thirty six (36) in number. The selection of the participants was based on the direct involvement in tasks or activities using wetland resources such as pottery, weaving, fishing among others. Three (3) members were selected from each of the twelve (12) villages. The four (4) team members were selected on basis of their expertise and experience in PRA exercise. The PRA conducted sought the following information.

Community Social and Resource Map

The PRA team guided the process of construction of community social and resource map. The map indicated the study area's geographical boundaries and major resources at a glance such as wetlands (rivers, water pans, fish ponds, rice paddies and flood plains), forests, markets, posho mill, rice mill, road network, churches among others (Fig 3.2). The community members took lead in the construction or drawing of the Okana base map.

Historical Time Lines

A historical profile is a list of key events in the life of a community's past trends, events, problems and achievements such as historical farming practices, famine, flooding incidences, drought, bumper harvests and flood management. These phenomena provide a heritage of experience and knowledge that in turn influences the present attitude and behaviour in the community.

The tool helped to trace significant events in the study area. It documented the major events, which have influenced the community life in the study area, the various kinds of interventions tried in the past and their present impact, both positive and negative, on the lives of the community. Knowledge of such events is invaluable in coming up with a resource management plan, which is pragmatic and realistic since the plan would be based on past successes or achievements and failures.

Seasonal Calendar

A seasonal calendar is a detailed and comprehensive task, which attempts to establish cycles or patterns and occurrences of activities within a community. These cycles or

patterns of occurrences would be very crucial in the implementation of resource management plan in the community. For instance, the cycles would determine labour availability, correct timing for project activity and potential absorptive capacity for new activities. Besides, it presents at a glance the occurrence of social and environmental shocks such as floods, drought, famine, epidemics as well as variations in cash flow in the community.

Historical Resource Analysis

Historical analysis tool shows the availability of resources in the community over time. It also indicates reasons for changes of valuable resources. The tool is an important planning tool since it clearly showed the residents the changes on the wetland resources on whose planning and management would be based.

Farm Sketches

A farm sketch shows individual farm practices. It depicts at a glance household level land use practices in general and resource planning and management in particular in the community. The tool provides a basis on which macro zone or broad-based planning and management of resources can be anchored.

Resource Flow Matrix

A resource flow matrix indicates visually the inflow and outflow of different resources in a community. Besides, it shows where and in what form (whether raw or processed) the resources are exported to and imported from. The PRA tool was important in the study since it indicated the extent to which the community in the study area depends on wetland resources such as land/soil, water, flora and fauna to

meet their basic household needs (livelihoods). Detailed discussion on the dependence on the wetland resources or the contribution of the resources to livelihoods is presented in chapter four under section 4.2.

Livelihood Mapping

Livelihood mapping is basically the process of identifying the resources used by the community. It involves the identification of all the basic life support resources of the community, and the community's perception of the level or degree of importance of these resources to their livelihoods. The tool was useful in the study as it helped in ranking of community resources, problems and opportunities.

Institutional and Stakeholders Analysis

Institutional and stakeholder's analysis tool helps in identifying the various groups and organizations, whether local or international, governmental or non-governmental organization (NGO) as well as their respective activities or roles in a community. The tool is useful in assessing the impact of these groups or organizations in a community development. This is achieved through focused group discussions with selected community members on the group's or organization's contribution to development.

The tool was important for the study in the identification and evaluation of the various roles of institutions in the study area. This was an imperative since the implementation of the wetland resources management plan designed (Fig 4.7 in section 4.4) would require involvement of a number of groups and/or organizations given that wetlands are diverse ecosystems. The success of the management plan

would only be ascertained if the performance of the institutions and how they interact with each other is known before hand.

Gender Daily Calendar

The gender daily calendar indicates the level of involvement, engagement or commitment of men and women, both young and old, in the community on a daily basis. It indicates the roles of each gender across the age cohorts. The analysis of the gender calendar was fundamental in the study since it clearly indicated which gender should be involved in what stage or phase of planning and management of the wetland resources. The allocation of any gender in the planning and management task must take cognizant of the already existing gender differential roles. This is the essence of an investigation on the gender dynamics in the wetland resources utilization.

Transect Walk

Transect walk is a PRA tool that involves actual observation of focal or lead points within the study area. It covers a cross-section of the study area. The tool provides mapping information which validates data obtained during surveys as well as social and physical features indicated in the community base map. It provides detailed information on specific characteristics or features within the study area such as slope, vegetation, site and situation, soils, water sources, infrastructure, settlement patterns, cropping systems, farming techniques, average farm sizes, land use practices, community problems and opportunities. The information on these features is quite important in understanding the human and physical environment interactions, which were instrumental in the designing of a wetland management plan for sustainable utilization and development.

Problem Analysis

Problem analysis is the last tool or phase of PRA exercise. It provides both explicit and implicit information concerning the social, economic and environmental problems, their specific causes and coping mechanisms that the community in the study area has adopted in their day- today discourse. It also provides vivid opportunities, which are within the community's disposal directly or indirectly that would address respective problem(s). The opportunities identified during problem analysis formed the basis on which the wetland management plan is anchored.

In summary, the technique was used to obtain data on the changes of the wetland resources over time, the awareness of the residents (wetland resource users) of the institutions that deal with the wetland protection and their effectiveness. Besides, it helped to validate the responses during survey exercise. The selection of members was based on their involvement in wetland resources.

3.2.4 Techniques for Data Analysis, Interpretation and Presentation

The study used households as unit of analysis. Both qualitative and quantitative techniques were used in the processing and analysis of data. Quantitative data was analyzed using simple statistical technique given their univariate nature. The technique thus generated percentages and frequencies of the respondents based on their involvement or utilization of the wetland products. Qualitative data on the other hand, was analyzed using content analysis technique. This technique was specifically applied to secondary data on the formation of wetland ecosystem. For the land use change related data, however, remote sensing was used in the data acquisition while ArcGIS was used in the analysis. This helped to detect the land use land cover

(LULC) changes which have occurred in Okana area over time based on the LANDSAT satellite images generated. The two tools are known and are gaining recognition in the developed and developing countries as powerful and cost effective tools for monitoring, characterizing, and mapping LULC changes (Zhang et al., 2017). Remote sensing is used because it has large geographic coverage and high temporal availability of data while GIS is used for mapping, analysing and presenting the data. The knowledge generated is used for monitoring and making informed decisions on the management, conservation and planning for future use. The tools also create consistent awareness of the locational challenges within the area under study.

A combination of the two techniques was preferred because they enhance both the reliability and validity of the study results. Qualitative methods tend to be strong in validity but weak in reliability while quantitative techniques tend to be strong in reliability but weak in validity. The use of the two techniques therefore is in compliance with social science principle that the methods combined do balance the strengths and weaknesses of the two in order to achieve a higher degree of validity and reliability for effectiveness of research (Babbie, 1986; Bryman, 2004; Kasomo, 2007; Medina, 1998). Besides, quantitative technique enhances objectivity while qualitative technique permits contextual understanding of research findings through accurate description of phenomena (Blanche et al., 2006; Neuman and Robson, 2009). Descriptive or qualitative methods have been used to outline non-quantifiable or complex aspects of wetland resource use such as animal grazing. Quantitative data on the other hand was processed using the Microsoft – Excel 2003 and SPSS computer packages. Computer programs such as Photo Express and Microsoft Word 2010 were also used for scanning of photographs taken during field data collection and presentation of the text respectively.

Results of the study, their analysis and subsequent discussions have been presented in chapter four. They are organized according to the study objectives. The results are presented in form of frequency tables, charts, percentages, plates, maps, graphs, simple statistical ratios and discussions or text.

3.3 Materials

The study used the following equipment in the collection, processing, analysis and interpretation of data, and presentation of results.

Interview schedules and questionnaires

The study used both standard questionnaires and key informant interviews so as to obtain data on socio-economic value of wetland resources to the community in the study area. The tools were used during reconnaissance and pilot surveys as well as in the main field research.

A simple weighing machine

Bundles of harvested wetland materials such as papyrus, reeds, grass were weighed using a simple weighing machine. The task was necessary in order to estimate the cost of the resources per unit.

A camera

A digital camera was used for taking relevant photographs of selected wetland sites, resources and features as well as actual activities or tasks in the utilization of wetland resources such as harvesting of wetland products, extraction or excavation of clay,

craft making and pictures of finished products or handicrafts. Besides, the equipment was used to capture various activities of PRA exercise.

Satellite Images

The materials were instrumental in the analysis of land use land cover changes in the study area within the specified period (between 1960 and 2020). They were complemented with topographical maps.

Topographical Maps

Topographical maps of between 1: 10,000 and 1: 100,000 scales were used in order to obtain detailed baseline information about the study area particularly the socio-economic dynamics as well as the physiographical features.

GPS and Clinometer

Hand held GPS equipment and clinometer were used to record accurate readings of locations and elevations of various selected wetland sites, resources and features in the study area.

Computer

The equipment enhanced the analysis of both quantitative and qualitative data by use of relevant computer packages such as Photo Express, SPSS and Microsoft Excel. Microsoft Word Windows 2003 was also used in the presentation of the text.

3.4 Results

In summary, the study generated the following output at a glance. The results and discussion have been presented comprehensively in chapter four.

i. Data and information on land use changes, their causes and impacts,

ii. Data and information on the contribution of wetland resources to household income,

iii. Data and information on the nature of relationship between wetland resource utilization and environmental sustainability,

iv. Establishment of strategies to ameliorate social and environmental problems, which are associated with wetland resource use,

v. Integrated wetland resource management plan where both the wetland resource users, government and other stakeholders within the wetland area and in the upstream catchment are involved in the problem identification, objectives and goal formulation, decision-making and implementation processes,

vi. Recommendations tailored towards protection of wetland ecosystems for sustainability.

CHAPTER FOUR

RESULTS

4.1 Introduction

This chapter presents the findings of the study and discussion of the same. The results are presented first then followed by the discussion. The presentation is done asper the objectives of the study.

4.2 Objective One (1): Land Use Land Cover Change in Okana

Land use comprises two terms namely land cover and land use. The former refers to the observable vegetation type on the earth surface such as grassland, scrub, shrub or wetland macrophytes while the latter is defined as the actual use to which the land has been put (Koomen, 2008). The techniques used include remote sensing analysis using LANDSAT satellite images and Geographic Information System (GIS) analysis using ArcGIS software.

Results

The study established a declining trend of wetland macrophytes over the years from 1960s to 2000s. At the time of study, satellite images for the study area between 1960s and 1970s were not available. PRA exercise was thus relied on for the information on LULC changes. In 1960s and 1970s, the area had very dense vegetation of macrophytes. But between the years 1980s and 1990s, the vegetation cover had declined greatly. In the year 2000 to 2010, the scenario had deteriorated further and the ecosystem had been reduced to bare grazing land and rice fields. The

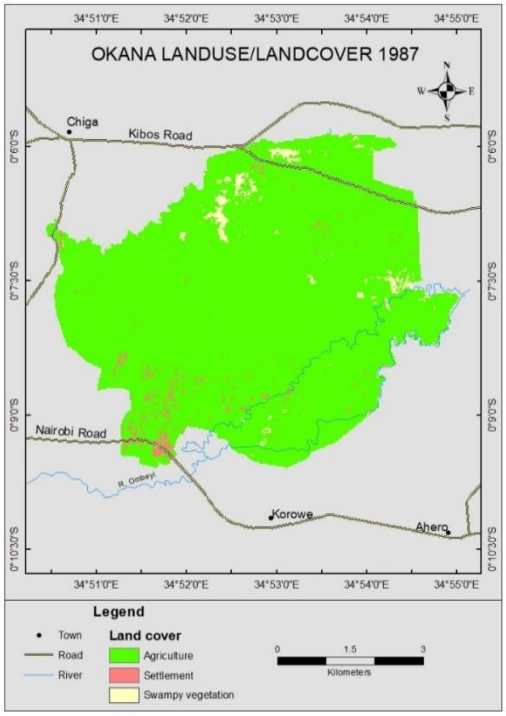
trend is similar to the subsequent years between 2011 and 2020. Increasingly large portion of the wetland is now converted into agricultural farmland especially rice cultivation. This is depicted in the LANDSAT images (Table 4.1, Plates 4.1) and PRA resource analysis (Fig 4.1).

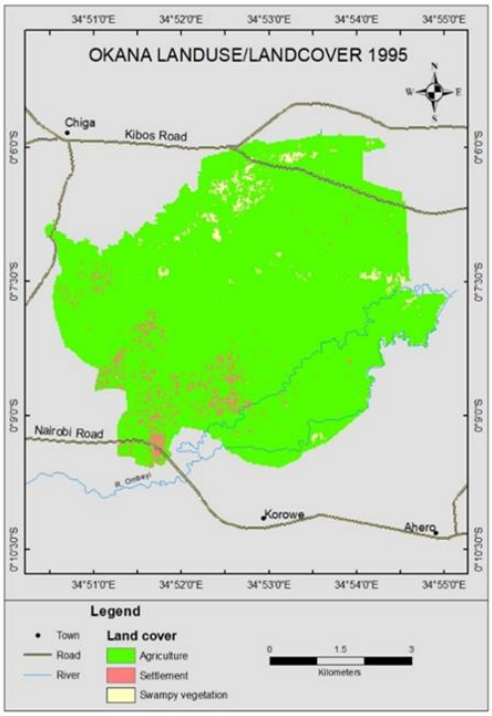
Table 4.1. Satellite Images covering Okana

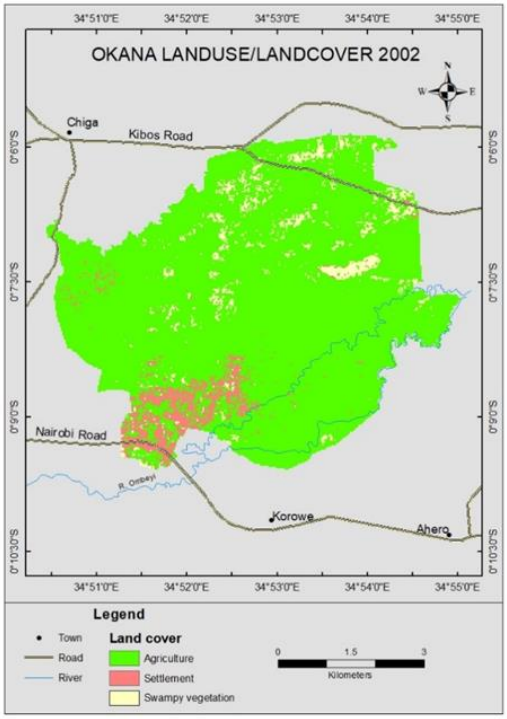
Year	Satellite	Path	Rows	Date of Acquisition
2020	Landsat 8	WRS path 170	WRS row 060	02/8
2011	Landsat 5	WRS path 170	WRS row 060	07/03
2002	Landsat 7	WRS path 170	WRS row 060	03/27
1995	Landsat 5	WRS path 170	WRS row 060	03/27
1987	Landsat 5	WRS path 170	WRS row 060	01/22

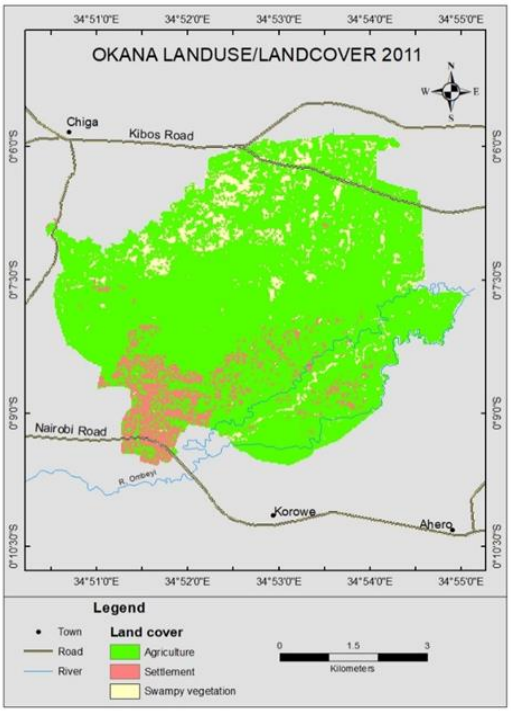
Table 4.2. LULC categories used in Okana

LULC Type	Description
Agriculture	Agricultural fields with crops, those under cultivation and those where crops had been harvested. Exposed soil surfaces were also combined into this class in order to avoid confusion with cultivated lands that have similar spectral reflectance.
Settlements	Consists of mixed urban built-up areas, residential, industrial, commercial developments, communication and transportation infrastructure.
Swampy vegetation (Wetland)	Consist of macrophytes, wetland grasses and rice paddies.


OKANA LANDUSE/LANDCOVER 1987
34°51'0"E
34°52'0"E
34°53'0"E
34°54'0"E
34°55'0"E
0°9'0"S
0°7'30"S
0°6'0"S
0°10'30"S
Chiga
Kibos Road
Nairobi Road
R. Ombeyi
Korowe
Ahero
Legend
Town
Road
River
Land cover
Agriculture
Settlement
Swampy vegetation
0
1.5
3
Kilometers


OKANA LANDUSE/LANDCOVER 1995
34°51'0"E
34°52'0"E
34°53'0"E
34°54'0"E
34°55'0"E
0°9'0"S
0°7'30"S
0°6'0"S
0°10'30"S
Chiga
Kibos Road
Nairobi Road
R. Ombeyi
Korowe
Ahero
Legend
Town
Road
River
Land cover
Agriculture
Settlement
Swampy vegetation
0
1.5
3
Kilometers


OKANA LANDUSE/LANDCOVER 2002
34°51'0"E
34°52'0"E
34°53'0"E
34°54'0"E
34°55'0"E
0°9'0"S
0°7'30"S
0°6'0"S
0°10'30"S
Chiga
Kibos Road
Nairobi Road
R. Ombeyi
Korowe
Ahero
Legend
Town
Road
River
Land cover
Agriculture
Settlement
Swampy vegetation
0
1.5
3
Kilometers


OKANA LANDUSE/LANDCOVER 2011
34°51'0"E
34°52'0"E
34°53'0"E
34°54'0"E
34°55'0"E
0°9'0"S
0°7'30"S
0°6'0"S
0°10'30"S
Chiga
Kibos Road
Nairobi Road
R. Ombeyi
Korowe
Ahero
Legend
Town
Road
River
Land cover
Agriculture
Settlement
Swampy vegetation
0
1.5
3
Kilometers

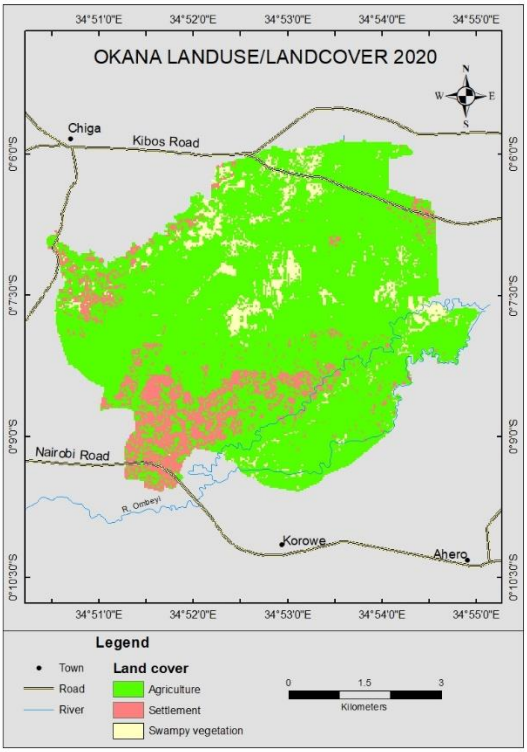


Plate: 4.1a Satellite Images of LULC in Okana between 1980s and 2020.

(Source: Downloaded from USGS Website)

Table 4.3 Area and percentage of land occupied by the three LULC classes in Okana

LULC	1987 area (Ha)	%	1995 area (Ha)	%	2002 area (Ha)	%	2011 area (Ha)	%	2020 area (Ha)	%
Swampy vegetation	70.2	1.9	66.9	1.8	264.3	7.0	213.3	5.7	335.3	8.9
Agriculture	3641.8	96.8	3605.5	95.9	3225.9	85.8	3208	85.3	3063.9	81.5
Settlements	49.7	1.3	88.3	2.3	270.5	7.2	339.8	9.0	361.5	9.6
Totals	3,761.7	100	3,760.7		3,760.7		3,761.2		3,760.7	

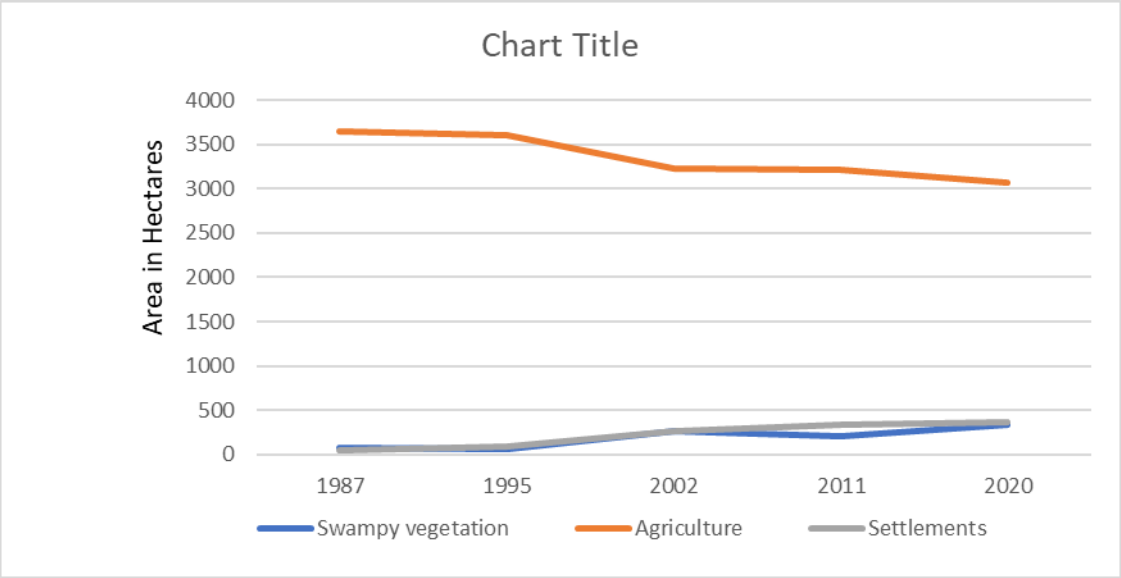


Figure: 4.1 Trend in LULC changes in Okana.

(Source: Author, 2023)

The study established that there are different land uses that have occurred in Okana since 1960s. These include farm forestry, fish farming (aquaculture), crop and animal production as well as apiculture. These land uses have emerged as coping mechanisms due to the declining wetland resources over the years. The emerging land uses equally encounter numerous constraints that often put the livelihoods of the Okana residents at stake. The constraints as well as their possible interventions are detailed in table 4.2.

Discussion

Analysis of the natural resource use in the study area has revealed a significant land use change over the years. The study considered the period between 1960 and 2000s. The year 1960 was chosen as the base year since it was the period when satellite images were first taken in the region. At the time of study, however, LANDSAT

images for 1960s and 1970s were not available hence the use of 1980s, 1990s and 2000s images only. The analysis for the first two (2) decades (1960s and 1970s) was thus based on PRA exercise conducted in the study area.

The land uses at the time of study include crop and livestock production (agriculture), craft making, fishing, farm forestry and apiculture. The analysis showed that before and during 1960s, the land use activities were crop and livestock production, fishing and craft making. While fishing was a seasonal activity as it is to date, crop and livestock production were the predominant activities. Fishing is done on the floodplain and only active during rainy seasons. Crop farming was done about 2-3km away from the wetland areas. The latter site was densely vegetated with macrophytes as revealed by the LANDSAT images (Plates 4.1) and PRA resource analysis (Table 4.4). The situation of the wetland area then contrasts its present state where the ecosystem has been reduced to bare grazing land and rice fields with only a few macrophytes along the river banks. The clearance of wetland vegetation is due to increasing human population, which demands for more space for human settlement and agricultural land as indicated in the trend of LULC in Fig 4.1. The wetlands have therefore been cleared to provide space for the two land uses.

Table 4.4 Historical resource analysis in Okana

Product	1960s	1970s	1980s	1990s	2000s	Future
Harvest	5	5	4	3	2	2
Land	5	5	4	3	2	2
Livestock	5	5	5	4	3	2
Trees	5	5	4	3	2	2
Grass	5	5	5	4	3	2
Firewood	5	5	4	3	2	2
Fish	5	5	5	4	2	2
Water	5	5	5	4	2	2
Birds	5	5	5	4	3	2
Papyrus and Reeds	5	5	5	5	4	2
Wild game	5	5	5	4	3	2

KEY

5	Very many resourses
4	Many resources
3	Few resources
2	Ver few resources
1	No resources

Table 4.3 shows the area percentages of the three LULC classes in Okana within the study period. There is a negative relationship between agricultural land and settlements showing that there is a possibility of agricultural land turning to settlements which could be a conversion from agriculture to residential and commercial uses. That is, as human population increases over time, more agricultural land is converted into settlements. This trend in the reducing agricultural land is an indicator that agricultural production in Okana will significantly reduce by the year 2030 if no remedial action is taken to improve the situation. The other observation is on wetland (swamp vegetation) which is increasingly being encroached for both agricultural and settlement activities over the years. More rice paddies now occupy most of the wetland areas. This is what is depicted as an apparent increase in hectares of land under swampy vegetation (wetland) in table 4.3 and Fig 4.2. The trend is likely to lead to depletion of the wetland ecosystem altogether if left unchecked. The

level of accuracy in the results obtained during analysis was 86.67%. This accuracy percentage is within the standard accuracy of 85% stipulated by the United States Geological Survey (USGS). The accuracy was evaluated using ground truth Regions of Interest (RIO) that were randomly sampled. The classification results and ground referenced test pixels of the study area were statistically carried out using contingency tables.

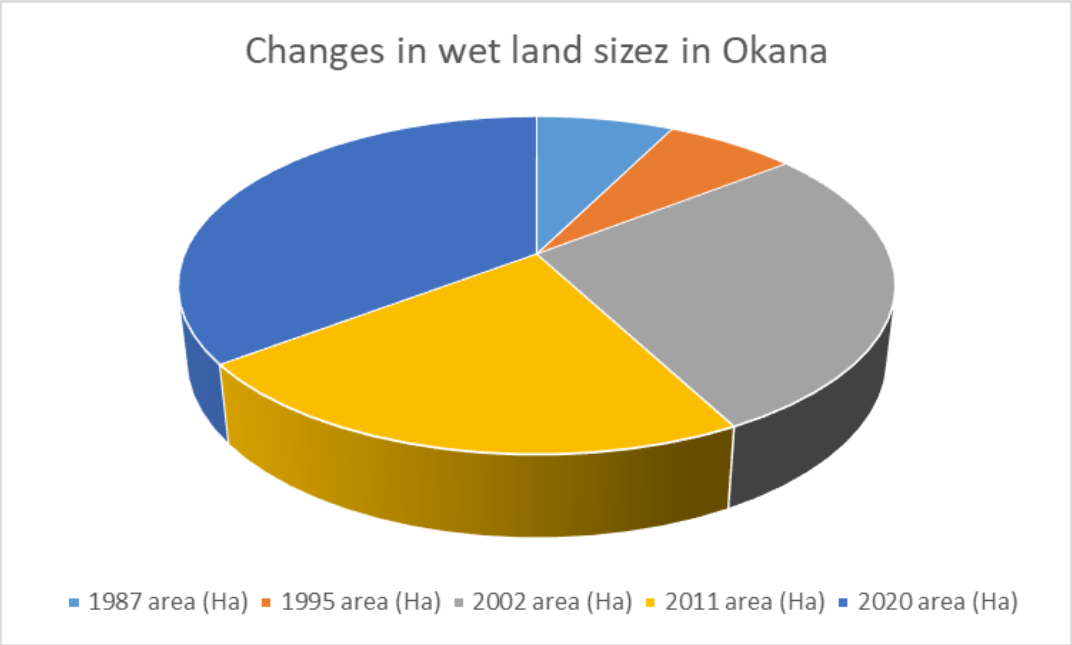


Figure: 4.2 Changes in wetland area under cultivation.

(Source: Author, 2023)

The study established that there is a significant change in vegetation cover in Okana area. The vegetation cover in the wetland that comprises mostly macrophytes especially papyrus and reeds and other wetland plants has shown a declining trend. In 1960s, there were plenty of macrophytes as well as other wetland plants for fuelwood (Table 4.4). This is because during the period, papyrus was not being exploited. The human population was equally low and minimal cutting of trees occurred. In 1970s, the use of papyrus and reeds to make handicrafts such as ropes, furniture, fishing

gears, mats and building and construction materials such as thatches, rails (fittoes) among others began in earnest. At the same time human population started to increase and this reduced the fuelwood supplies.

Table 4.4 shows a declining trend of wetland resources with time. From the PRA discussions, it was observed that the declining trend was due to the increase in human population. According to the participants, population pressure surged on from 1980s. Quest for space for both human settlement and farmland saw the clearance of wetland macrophytes. The observation of the participants during PRA exercise has been established by the satellite images shown below. It is clear from the maps that population is increasing over time as depicted by the increasing trend of human settlement. The increasing human population over time is also confirmed by the statistics of the Kenya National Population and Housing Census. For example, in 1999, the population density was 256 persons per square kilometer, in 2008, it had increased to 360, in 2010, it was 375, in 2012 it was 390, in 2020, it had risen to 454 and it was projected to be 478 persons per square kilometer in 2022 (GOK, 2009b, GOK, 2018; GOK, 2019a&b). Besides, more conversions of wetland into rice paddies are taking place as shown by the increasing trend of swampy vegetation. Massive vegetation clearance started and the phenomenon reduced fuelwood supplied. The trend continued in 1990s and early 2000s. This therefore explains why dense wetland macrophytes have been reduced to grazing and rice fields and the emergence of farm forestry to address the critical problem of biting fuelwood supplies. In fact, majority of craft makers predict extinction of papyruses and reeds if urgent wetland reclamation is not done. It is predicted that by 2030, the wetland will diminish further if the situation is not addressed by adopting effective management startegies (Plate 4.2, Fig. 4.3).

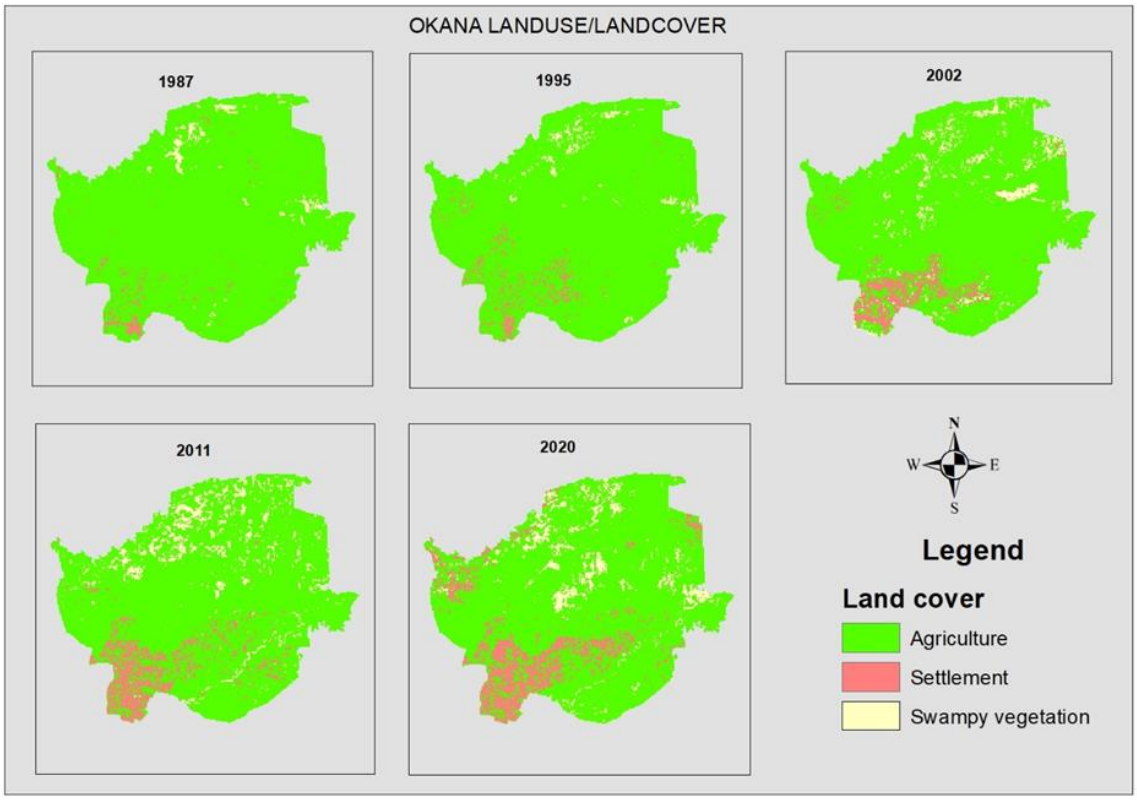


Plate: 4.1b Satellite Images of LULC in Okana between 1980s and 2020.

(Source: Downloaded from USGS Website)

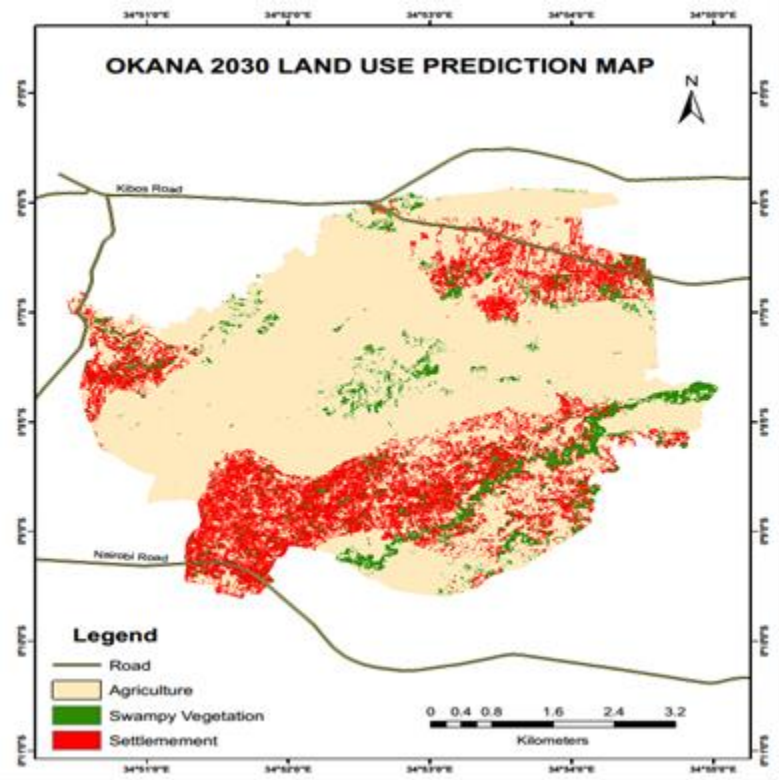


Figure 4.3 Land Use Projection Map in Okana by 2030.

(Source: Author, 2023)

The phenomena of demographic pressure and increasing economic demand over the years in the study area have put pressure on wetland resources since 1980s. Consequently, a number of land uses have emerged to cope with the declining resource base involving wetland macrophytes in the area so as to sustain livelihoods. The first land use change is the practice of farm forestry. This is a new activity that has emerged due to the declining trend of natural trees for building and construction, source of fuelwood, charcoal as well as timber for sale among other tree uses and functions. Besides, the residents have also been sensitized on other uses of various tree species apart from the conventional ones. Such uses include medicinal, livestock

feeds (fodder) as well as attraction of well water and milk fermentation. Different tree species have been grown in the study area for different purposes (Table 4.5).

Table 4.5 Tree species grown in Okana

Local Name	Botanical Name	English/Common Name	Uses
Asao	*Sesbania sesban*	River bean	Fuelwood, livestock medicine and livestock feed
Okinga	*Ocimum basilicum*	Sage bush	Decoration of pots and medicine
Odundu	*Phragmites maximum*	Reed	Fish traps and construction of granaries
Obong'	*Cajanus cajan*	Congo pea	Medicine and fuelwood
Okaka	*Aloe* spp.	Cactus	Medicine
Ayucha	*Achyranthes aspera*	Devil's horsewhip	Medicine, livestock feed and toilet use
Nyanyodhi	*Leonotis* spp.	Lion's tail	Medicine and fuelwood
Obino	*Senna didymobotrya*	Candle bush	Building, medicine, timber and fuelwood
Machunga	*Citrus sinensis*	Citrus tree	Fruits, milk fermentation and medicine
Mapera	*Psidium quajava*	Guava	Fruits, fuelwood and making farm tools
Mawembe	*Mangifera indica*	Mango tree	Fruits, fuelwood and medicine
Matata	*Caesalpinia decapetala*	Mauritius thorn	Fencing
Siala	*Markhamia lutea*	Markhamia	Building, fuelwood and timber
Jamna	*Syzygium cuminii*	Java plum jum	Fruits and shade
Chwaa	*Tamarindus indica*	Tamarind	Fruits, food flavouring and shade
Konga	*Agave sisalana*	Sisal leaves	Building, ropes, fibre and fuelwood
Kaladari		Mustard seed	Building, fuelwood, timber, fencing poles and fish traps

All these tree species in table 4.5 were planted as a coping strategy in the face of the steadily declining wetland vegetation (macrophytes) for continued livelihood sustenance. They provide medicinal products for humans and livestock, livestock

feeds as well as fuelwood, fruits and materials for craft making, building and construction.

Tree planting as a new activity, has faced numerous constraints just like the conventional land uses in the study area. Some of the problems include inadequate desired seeds and seedlings, drought, negative traditional beliefs (taboos) about some tree species and pests and disease infestations (Table 4.6). The residents however, have been coping with the constraints in various ways since they have been trained on basic aspects of forestry and forest management as well as agroforestry practices. The institutions that have offered training and/or sensitization include VI-AGRO, World Agroforestry (ICRAF) and Kenya Forestry Research Institute (KEFRI). Table 4.6 summarizes the constraints and possible interventions.

Table 4.6: Constraints and interventions in farm forestry in Okana

Constraints	Possible Interventions
Lack of desired tree seeds and seedlings	• Identifying sources of quality tree seeds • Establishing tree nurseries to raise seedlings
Floods	• Making proper drainage canals • Planting tree species that can survive flooding conditions
Drought	• Practice bucket irrigation • Constructing water pans • Constructing shallow wells
Pests and Diseases	• Use of appropriate pesticides
Destruction of tree seedlings by livestock	• Fencing farms • Controlled grazing
Myths against some tree species	• Avoid planting prohibited trees
Inadequate land for farm forestry	• Develop farm plans to accommodate as many tree species as possible
Waterlogging	• Making proper drainage canals

Fish farming as an economic and livelihood activity is an emerging land use practice. It is at its nascent stage since the residents have not tapped it. Lack of knowledge on

its potential and skills on how to undertake the activity are some of the reasons why it has never been practiced. The land use practice in the study area is attributed to VIRED International initiative in order to improve livelihoods of the residents. The residents have embraced it and some of them have been trained on how to undertake it. At the time of study, one fish pond was on trial.

The viability of the activity is based on the availability of river water that supplies the pond and fingerlings provided by VIRED International. Ready market is also assured since demand for fish is very high in the study area and its environs. Besides, the Okana Community Wetland Self Help Group (OCWSHG) is willing and committed to the activity.

Apiculture is the third land use practice in the study area. Like fish farming, apiculture is also an initiative by VIRED International. The Okana wetland group has been trained on the activity and has already started the project.

The three emerging land use practices namely farm forestry, fish farming and apiculture face one constraint of inadequate land to rollout the projects both intensively and extensively. The activities have been started on small pieces of land owned by individuals. The situation is likely to affect the sustainability of the activities since they operate on the basis of the willingness of the land owners. The phenomenon therefore calls for a community-based land use plan if the projects and livelihoods have to be sustained. A community-based land use plan has been proposed in Chapter Five (Fig 5.2).

4.3 Objective Two (2): Contribution of wetland resources to household income

The wetlands of Okana constitute an important natural resource base upon which the riparian communities depend. They have sustained livelihoods in the study area

through food production, hydrological stability and ecological productivity. The wetlands are thus important for various socio-economic values. The section examines the contribution of wetland resources to household income in Okana.

Results

The Okana wetlands include floodplains, riverine swamps, shallow rivers and sreams, pans, wells and irrigated rice paddies (Table 4.7). These provide significant values and functions to the residents of Okana. The wetland resources include water, numerous flora and fauna (birds, reptiles, mammals, insects, fish and amphibians) as well as clay and land or soil. The riparian communities exploit or use these resources to derive their livelihoods. A detailed inventory of the resources is provided in section 4.2.3.

The study has also revealed that the residents of Okana earn significant income from the sales of wetland resources such as water, fish, dry macrophytes (as woodfuel), reeds, papyruses among others or wetland products (handicrafts) such as mats, baskets, ropes and fishing gears (Plate 4.2). Besides, some resources are used as building and construction materials thereby reducing the overall household expenditure on such activities. Detailed discussion on the valuation of wetland resources in the study area is presented in section 4.2.4.

Plate: 4.2 Fishing gears used in Okana.

(Source: Author, 2023)

4.3.1 Wetlands in Okana

The study area comprises several types of wetlands from where the riparian community derives its livelihoods. The classification of the wetlands is based on Crafter, et al. (1992) and McClanahan & Young (1996). The Okana wetlands include shallow rivers and streams such as Landi, Ombeyi, Lielang'o, Oroba, Luanda and Nyangeta; floodplains, riverine swamps, canals, pans, wells, ponds and irrigated rice fields or paddies (Fig 1.1). The wetlands provide numerous goods and services to the residents of Okana. The functions and values of the wetlands are outlined in Table 4.7. However, detailed valuation of the wetland resources is presented and discussed in section 4.2.4.

Table 4.7 Functions and Values of Okana Wetlands

Wetland Type	Functions and Values
Floodplains	• Temporal/seasonal fishing grounds during long rains, • Support crop farming, • Grazing fields for livestock and wildlife, • Space for human settlement.
Riverine swamps	• Water purification and supply, • Habitats for fish breeding, • Sources of building and construction materials, • Habitats for wildlife, • Flood and erosion control, • Grazing fields for livestock and wildlife, • Support horticulture farming.
Shallow rivers and streams	• Habitats for fish breeding, • Sources of building and construction materials e.g sand, • Water supply, • Sites for social ceremonies e.g baptism, • Habitats for aquatic life.
Pans and Wells	• Water supply, • Habitats for aquatic life.
Irrigated rice fields (paddies)	• Support rice production, • Habitats for flora and fauna.

4.3.2 Inventory of Okana Wetland Resources

The Okana wetlands provide habitat for diverse flora and fauna including both endemic and migratory species. The flood plains, rivers, streams, canals, water pans and wells, which comprise the vast wetland ecosystem host numerous microphytes, macrophytes, higher plants, micro-organisms, birds, reptiles, amphibians and mammals. These species often interact and interdepend on each other continuously so as to regulate and sustain the functions of the ecosystem. The inventory was conducted in line with the internationally recommemnded outline for the exercise as provided by Granger (1989) (Fig. 4.4).

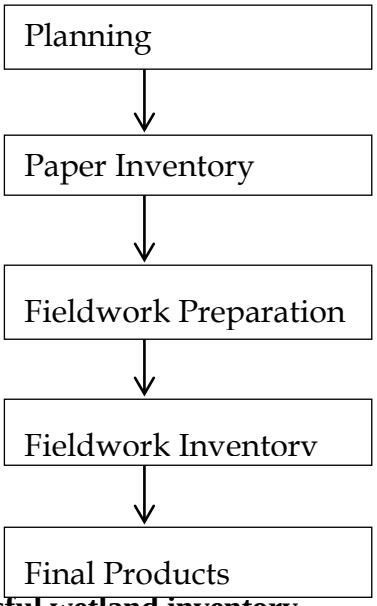


Figure: 4.4 Phases of successful wetland inventory.

(Source: Adopted from Granger, 1989)

A number of guides were used to identify the flora and fauna in the study area. However, the species which could not be observed by the researcher during the survey period were identified on the basis of descriptions given by the respondents and further verified by the PRA participants. The reference materials used in the identification included Ivens (1967), Burton & Burton (1969), Kokwaro (1972),

Brown (1979), Williams (1981), Hedges (1983), Teel & Hirst (1984), Moore (1984), Guggisberg (1986), Blundel (1987), Corbet & Hill (1991), Richards (1991), Branch (1992), Guggisberg (1994), Horward & Moore (1994), Beentje (1994), Kokwaro (1994), Skinner (1994), Olembo et al. (1995), Williams (1995), Bennun & Njoroge (1999), Maundu et al. (2000), Gichuki et al. (2001) and Kokwaro (2009).

The inventory of the wetlands is vital for the understanding of the biodiversity richness of the study area and also for puposes of informed decisions concerning the conservation and management of the ecosystem. It thus provides an insight or a basis for conservation and management as a possible eco-tourism site.

Birds

The dense wetland vegetation comprising mainly papyruses, reeds and grasses, the vast flood plain, rice fields, rivers and streams provide both shelter and conducive patching grounds for various bird species. The flood plains, rice fields and rivers form feeding grounds where birds prey on insects, worms and small fishes at day time.

The common types of birds in the wetlands include pelicans, kingfishers, little egrets, African fish eagles, cranes, herons, warblers and weavers. A complete list of birds in the wetland ecosystem is shown in Table 4.8. Some of the bird species such as the weavers are quite troublesome on the adjacent crop lands. They destroy crops especially during planting and just before harvesting seasons. Labour force has to be deployed on the farms as has been examined in subsection 4.3.2.1.

Table 4.8 Bird species in Okana Wetland

Local Name	Scientific Name	English/Common Name
Osogo	*Ploceus* spp.	Weaverbird
Osou	*Alcedo cristata*	Kingfisher
Okok	*Bubulcus ibis*	Egret
Ongo	*Haliaeetus vocifer*	African fish eagle
Ongowang'	*Belearica rogulorum gibbericeps*	Crowned Crane
Manaha	*Ardea cinerea*	Heron
Odit	*Camaroptera simplex*	Warbler
Aluru	*Coturnix delegorguei*	Harlequin quail
Agak	*Corvus brachyrhynchos*	Crow bird
Ng'ang'a	*Bostrichya hagedash brevirostris*	Hadada Ibis
Akuru	*Streptopelia perspicillata*	Dove/Pigeon
Atudo	*Alopochen aegyptica*	Egyptian Geese
Otenga	*Hieraaetus spilogaster*	African hawk eagle
Olit	*Accipter brevipes*	Sparrow hawk
Nyanyodhi	*Nectarinia* spp.	Sunbird
Tel-tel	*Capethera* spp.	Wood pecker
Awendo	Acryllium vulturinum	Guinea fowl
Mire	*Quelea quelea*	Sudan Dioch
Achuth	*Pseudogyps africanus*	Vulture
Magungu	*Anastomus lamelligerus*	Open billed stork
Opija	*Apus niansae*	Swift
Tula	*Asio abyssinicus graueri*	Owl
Odiero	*Corasina newtoni*	Shriek bird
Odiero	*Corasina newtoni*	Shriek bird
Oyundi	*Lagonosticta rubricata*	African Firefinch
Dharna	*Buphagus* spp.	Tick bird
Oseng'	*Euplectes oryx capensis*	Red bishop
Aywer	*Francolinus* spp.	Spurfowl
Tutu	*Centropus superciliosus*	White Browed coucal
Ochimbo	*Euplectes progne*	Long tailed widow bird
Onjinyo	*Corvinella melanoleucus*	Magpie Shrike
Orweda	*Charadrius hiaticula*	Ringed plover
Ogugra	*Tringer hypoleucos*	Common sandpiper
Oluru	*Colius kikuyuensis*	Mousebird
Hundhwe	*Cossypha* spp.	Robin chat
Asisiro	*Uraeginthus bengalus*	Cordon Blue
Kwogo	*Gymnoschizornis* spp.	Barefaced go-away bird
Okune okune	*Stephanoeatus coronatus*	African crowned eagle
Ochongoriyo	*Pycnonotus golavier*	Yellow vested bulbul
Nyakwadha	*Macronyx croceus*	Yellow throated long claw
Anam	*Scopus umbretta*	Heammerkorps
Abang' chieth	*Pycnonotus barbatus*	Common bulbul
Ochol	*Myrmecocichla* spp.	Anteater chat

The identification of the birds was done during the field survey exercise and verified during PRA exercise. The names were provided in both local dialect and common English. Kokwaro (1992) was then used to obtain the corresponding scientific names.

Reptiles

The wetland ecosystem hosts numerous species of aquatic snakes and lizards (Table 4.9). Some snakes are however poisonous and therefore pose danger during wetland resources use (Subsection 4.3.2.3). Whereas the birds destroy farms crops, monitor lizards prey on poultry and hence are potential pests.

Table 4.9 Reptiles in Okana Wetland

Local Name	Scientific Name	English/Common Name
Ng'ielo	*Python sebae*	Python
Fuu	*Bitis arientans*	Puff udder
Ng'ech	*Veranus* spp.	Monitor lizard
Randier	*Mabuya striata*	Skinks
Olele	*Hemidactylus mabovia*	Gecko
Opug pi	*Pelomedusa subrufa*	Marsh terrapin
Rachier	*Dendroapspis* spp.	Black mamba
Ong'ongruok	*Chamaeleo delepis*	Chameleon
Ogwe	*Agama agama*	Lizard
Olueru	*Mehelya* spp.	Brown mamba
Opug oko	*Testudo pardalis*	Land tortoise
Ndemu	*Mehelya* spp.	Brown mamba
Alum	*Phylothamnus* spp.	Green mamba
Rachier	*Naja nigricolis*	Black spitting cobra

Mammals

A high diversity of mammals finds habitation in Okana wetlands (Table 4.10). Some of the mammals such as the antelope are endemic and need protection from illegal hunting or poaching. Most of the mammals like the African hare, antelopes and rodents among others are hunted for game meat. The phenomenon has impacted negatively on their abundance in the ecosystem as indicated in Table 4.22a & b.

The mammals are the major pests on farm crops. They destroy crops at all stages of propagation and therefore contribute significantly to poor harvests leading to food insecurity in the study area. A coping mechanism is deployment of human labour on

the farms to scare them a way during day and night. Human-wildlife conflict (section 4.3.2.1) thus emerges due to destruction of crop farms by the mammals. The most common ones in the wetland include foxes, African hares, antelopes, mongooses, African civet cats, moles, rats and warthogs (Table 4.10).

Table 4.10 Mammals in Okana Wetland

Local Name	Scientific Name	English/Common Name
Apuoyo	*Lepus capensis*	African hare
Mwanda	*Tragelapus* spp.	Antelope
Nyamanduklu	*Lutra maculicoli*	River Otter
Muok	*Orycteropus afer*	Antbear
Oyieyo	Rattus rattus	Rat
Ogwang'	*Civettictus civetta*	African civet cat
Chiewo	*Hystix galeata*	Porcupine
Oliktiga	*Hipposideros megalotis*	Bat
Ong'er	*Ceropithecus mitis*	Monkey
Ondiek	*Crocuta crocuta*	Hyena
Dwe	*Tragelapus spekei*	Sitatunga
Aidha	*Paraxerus ochraceus*	Bush Squirrel

Amphibians

The river and stream waters provide shelter for water turtles as well as other types of amphibians found in the wetland such as frogs, newts, tortoises (Table 4.11). The frogs are usually used as baits during fishing when line and hook fishing gear is used.

Table 4.11 Amphibians in Okana Wetland

Local Name	Scientific Name	English/Common Name
Ogwand oko	*Bufo* spp.	Toad
Ogwand pi	*Ptychadena mascareniensis*	Mascarene frog
Ogwand pi	*Pyxicephalus adspersus*	Bull frog
Ogwand pi	*Rana* spp.	Common Rana
Oluk	*Raniceps raninus*	Tadpole

Invertebrates

The wetland ecosystem hosts numerous terrestrial and aquatic invertebrates such as worms, insects, snails and slugs. Their abundance is incomprehensive. However, evidence of their presence is established by the birds, which feed on them and processes such as decomposition and pollination, which they facilitate as well as young boys who use them as baits to fish. Invertebrates, which find habitation in the ecosystem, include the arthropods, arachnids and moluscs (Table 4.12). Like the insects, these are too many to be listed by name.

Table 4.12 Invertebrates in Okana Wetland

Local Name	Scientific Name	English/Common Name
Ogonglo	*Planorbis corneus*	Snail
Kamnio	*Aeolidia papillosa*	Slug
Ongogo	*Locusta migratoria*	Locust
Kich	*Apis mellifera adansonii*	African wild Bee
Suna	*Anospheles maculipennis*	Mosquito
Dede	*Schistocerca americana*	Grasshopper
Bie	*Termes bellicosus*	White ant
Oguyoguyo	*Papilio dardanus*	Butterfly
Maugo	*Glossina morsitans*	Tsetse fly
Tik jodongo	*Aeschna multicolor*	Dragon fly
Onjiri	*Anabrus simplex*	Cricket
Mbui	*Araneus diadematus*	Spider
Dembu/Oniambo	*Lumbricus terrestris*	Earthworm
Okolo	*Scaphiostereptus parilis*	Millipede
Nyatiende ng'eny	*Lothobius forticatus*	Centipede
Lwang'ni	*Musca domestica*	Common house fly
Amilo/Nyamilmil	*Dichelonyx backi*	Water beetle
Otit mach	*Lampyris noctiluca*	Fire fly
Thoromorni	*Dorylus gribodoi*	Red safari ant
Oyal	*Kalotermes flaricollis*	Termite
Okuodo	*Ixodes ricinus*	Tick
Nyang'inja	*Agrotis ipsilon*	Cut worm
Kungu	*Laphygma exigua*	Army worm
Thuth	*Myzus* spp.	Aphid
Ochunglo	*Lasins niger*	Black safari ant
Pino	*Andricus californicus*	Wasp
Okela	*Carcinus maenas*	Crab
Kundi	*Busseola fusca*	Maize stalk borer

Fish Species

The wetland is habitat to high diversity of fish species, most of which are indigenous and endemic in the major lakes in the country. Fish provide the main source of protein to the local people particularly during long rains when fish is in abundant supply (section 4.2.5). A full list of fish species in Okana wetland is shown in Table 4.13 below. Fish caught in the wetland find market in the nearby markets such as Ahero, Rabour, Oile and Jublee.

Table 4.13 Fish Species in Okana Wetland

Local Name	Scientific Name	English/Common Name
Fulu	*Haplochromis* spp.	Mouthbrooding Cichlids
Fuani	*Barbus artianalis*	Ripon Fall barb
Ningu	*Labeo victorianus*	Golden mudsucker
Adel/Rachar	*Barbus cercops*	Luambwa barb
Mumi	*Clarias gariepinus*	Catfish
Okoko	*Synodontis afrofischeri*	Catfish
Sire	*Schilbe mystus*	African Butter Catfish
Ndhira	*Xenoclarias* spp.	Mudfish
Opat	*Oreochromis leucosticus*	Tilapia
Mbiru	*Oreochromis variabilis*	Tilapia
Osoga	*Alestes jacksonii*	Pebbly fish
Nyapus	*Oreochromis spp.*	Tilapia
Rawa	*Schilbe intermedius*	Silver Catfish
Odhore	*Gnathonemus petersii*	Elephant Nose fish
Okunga/Nyamlor	*Mastacembalus frenatus*	Spiny eel
Kamongo	*Protopterus aethiopicus*	Lungfish

Wetland Plants

The Okana wetland provides habitat to a wide range of flora, which are classified into various categories as aquatic microphytes, aquatic macrophytes, emergents, free-floating plants, floating leaved plants and submergents (Table 4.14). The plants and plant products are utilized by the local community as building and construction materials such as ropes, thatches, poles and rails (*fitos*). They are also extracted as

medicinal herbs as well as grazing pasture or fields especially during dry periods. Besides, the wetland vegetation provides habitat to numerous species of fauna, which has been discussed in the previous sections.

Table 4.14 Wetland plants in Okana

Local Name	Botanical Name	English/Common Name
Odundu	*Vossia cuspidate*	Hippo Grass
Odhong'	*Typha latifola*	Cattail bulrush
Anyuongi/Ford	*Eichhornia crassipes*	Water Hyacinth
Yunga	*Nymphaea* spp.	Water Lilly
Togo	*Cyperus papyrus*	Papyrus
Asao	*Sesbania sesban*	River bean
See	*Cyperus esculentus*	Yellow Nut Grass
Oboro	*Andropogon virginicus*	Broom Sedge
Modhno	*Cynodon dactylon*	Star Grass
Osiri	*Scutia myrtina*	Acacia tree
Ochok	*Solanum incanum*	Sodom Apple
Ondoga	*Cyperus rotundus*	Nut Grass/Sedge
Okinga	*Ocimum basilicum*	Sage bush
Obuya	*Carex* spp.	Tussock Sedge
Osinde	*Carex stricta*	Tussock Sedge
Odielo	*Commelina benghalensis*	Wandering Jew
Anyuongi	*Nymphaea caerula*	Morning swamp glory
Ombugu	*Digetaria scalarum*	Couch Grass
Obalandago	*Datura stramonium*	Thorn Apple
Onyalobiro/Nyabende	*Lantana camara*	Tick Berry
Otho	*Balanites aegyptica*	Acacia
Odundu	*Phragmites maximum*	Reed
Obong'	*Cajanus cajan*	Congo pea
Okaka	*Aloe* spp.	Cactus
Kuth Ali	*Acacia lahai*	Fig tree
Oyungu	*P. stratiotes*	Water lettuce
Ayucha	*Achyranthes aspera*	Devil's horsewhip
Nyanyodhi	*Leonotis* spp.	Lion's tail
Obino	*Senna didymobotrya*	Candle bush
Machunga	*Citrus sinensis*	Citrus tree
Mapera	*Psidium quajava*	Guava
Mawembe	*Mangifera indica*	Mango tree
Matata	*Caesalpinia decapetala*	Mauritius thorn
Siala	*Markhamia lutea*	Markhamia
Jamna	*Syzygium cuminii*	Java plum jum
Chwaa	*Tamarindus indica*	Tamarind
Ng'owo	*Ficus valis choudae*	Fig tree
Konga	*Agave sisalana*	Sisal leaves

Kokwaro (1972), Kokwaro (1994) and Kokwaro (2009) were used in the identification of the species

Abiotic Components

Wetland ecosystems in the study area do not comprise the biotic features only. A comprehensive inventory would be incomplete if the abiotic components are ignored. The ecosystems also have typical soil and water, which form a unique characteristic of the habitat. The wetland has black cotton, clay soil, which supports agriculture and pottery industry. Mud, semi-saturated clay, is used to smear houses.

The wetland water is generally saline and has a potential of causing dental ailment called flourisis at an early age. However, the resource supports small scale (bucket) irrigation, livestock husbandry, domestic uses as well as religious ceremonies like baptism and prayer or worship especially by the *Roho* and *Legio Maria* sects and Seventh Day Adventist (SDA) denomination.

The foregoing discussion has established that Okana wetland is habitat to a rich biodiversity of flora and fauna as well as abiotic features, which enhance its self regulation and sustenance. However, disturbances to the ecosystem by human activities such as conversion of the wetland into agricultural farmlands, grazing fields, harvesting of wetland resources for craft making, building and construction, pottery among other uses threaten its survival. These activities are evident in sections 4.1 and 4.2.3. Proper planning of wetland use is therefore essential for the benefit of the local people who live in the catchment and even beyond. Such planning and management of wetlands will help to achieve environmentally sustainable development within the catchment as well as in the wider Lake Victoria Basin and beyond.

4.3.3 Socio-economic values of wetlands in Okana

The livelihoods of the riparian community of the study area either directly or indirectly depend on the utilization of the wetland resources. The local people meet their basic needs such as food, shelter, clothing, health care and education from the revenues or incomes that accrue from wetland products. The products are either sold at the nearby market/trading centres to obtain income, which is then used to meet such needs or used directly by the residents. The assessment of household income has been done by valuation of the products. An economic valuation is fundamental since it helps to establish the levels of incomes accruing from particular product (s) and hence the proportion of contribution of the resources in livelihood sustenance.

A number of techniques were used to assess the contribution of wetlands to household income. These include random sampling, photography, Statistical Package for Social Sciences (SPSS) and Barbier's tool for total economic value of reosurces. Random sampling technique was used in the administration of three hundred and eight (308) questionnaires in the study area. Photographs of various wetland uses and/or activities as well as products were taken during field survey exercise. SPSS software was used to obtain percentages in the involvement of wetland use, gender participation and proportion of crafts made using wetland materials. Barbier's equation or formula for total economic value of resources was used to estimate the economic value of the wetland resources. According to Barbier (1994), total economic value refers to the value derived from a resource to a society and comprises use, non-use and optional values. Barbier's equation of the total economic value of a resource has several components as depicted in fig. 4.5 below. Thus:

Total Economic Value (TEV) = Use Value + Non-Use Value + Option

Value

Where: *Use Value* = Direct (Consumptive uses) and Indirect (Non-consumptive/Ecological uses).

Non-use Value = Value gained or attained from the knowledge of protection of a resource.

Option Value = Value placed on the ability to use the resource in future.

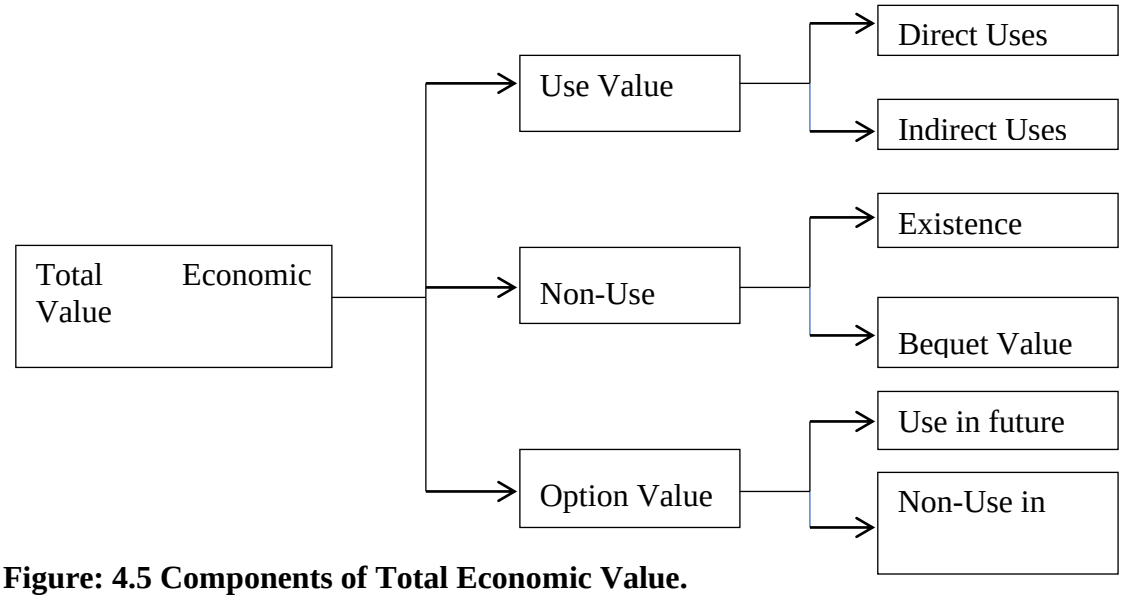


Figure: 4.5 Components of Total Economic Value.

(Source: Adopted from Babier, 1994)

Source of building and construction materials

The riparian community has always obtained numerous building and construction materials from the wetlands. Materials obtained include thatches from papyruses and sedge grasses, reeds which are used as rails, sand, clay or mud, building poles or posts and ropes made from sisal leaves and papyruses. The materials therefore constitute a major proportion in building and construction of any kind ranging from fencing, building own house, bathroom, pit latrine and bans. Materials obtained from elsewhere constitute a very small percentage and these are mainly hardware materials. A typical house or hut constructed from wetland materials is shown in Plate 4.3. Table

4.15a indicates wetland materials which are used for various building and construction activities. Sustainable use of such building and construction materials results when selective harvesting of the materials is done. Harvesting of mature wetland materials such as papyruses, reeds and grasses allows for natural regeneration of such wetland resources to occur.

Table 4.15a. Wetland materials used in building and construction in Okana

Wetland materials	Use
Grasses	Thatching
Papyruses	Thatching and making of ropes which are used to fix rails on building posts
Reeds	Used as rails in fencing, house/hut, pit latrine, bath room and ban construction
Poles	Used as posts in building and construction activities
Sand	Plastering of walls and floors of houses/huts
Clay/Mud	Plastering of walls and floors of houses/huts

On the average, the total cost of wetland materials used in building and construction of a one (1) bed roomed, mud and grass thatched house/hut is about KES. 167,910 (Table 4.15b). A household would spend an equivalent amount in purchasing the materials from other places. However, if the materials were obtained from the wetland freely, such a household would save the amount. The estimated costs however have not included hardware materials, which are equally required in house/hut building and construction.

Plate: 4.3 Hut constructed from wetland materials.

(Source: Author, 2023)

Table 4.15b. Cost of constructing a mud walled/grass thatched house

Material	Quantity	Price/Unit (KES)	Total Cost (KES)
Thatches/Grasses	250 Bundles	50	12,500
Rails	200 Bundles	20	4,000
Poles	815	70	57,050
Sand	556 Buckets	10	5,560
Clay/Mud	1,220 Buckets	10	12,200
Papyrus ropes	870 Bundles	20	17,400
Roofing trashes	570	60	34,200
Sisal leaves	1,250 Bundles	20	25,000
Total	**5,731**	**260**	**167,910**

The findings established that 30.8% of the respondents use wetland materials for building and construction purposes (Table 4.16). In terms of gender participation, roles usually vary depending on who heads a household, whether a husband, widow or single mother. Generally, men take part in the harvesting of thatches, building poles and rails as well as transportation of the harvested materials. Women on the other hand, excavate clay or mud. However, in the female headed households, women bear the brunt of the entire tasks and occasionally, well wishers lend hand. On the

average, 75.7% of men are involved in primary harvesting of the materials from the wetland while 18.9% and 5.4% of women and others (children, casual labourers and relatives), respectively, undertake the same as shown in Figure 4.6.

Table 4.16. Level of engagement in wetland resource utilization in Okana

Activity	Percentage (%)
Agriculture	95.8
Fishing	65
Fuel wood collection	97.5
Extraction of medicinal herbs	9.2
Water supply	100
Construction activities	30.8
Craft making	80

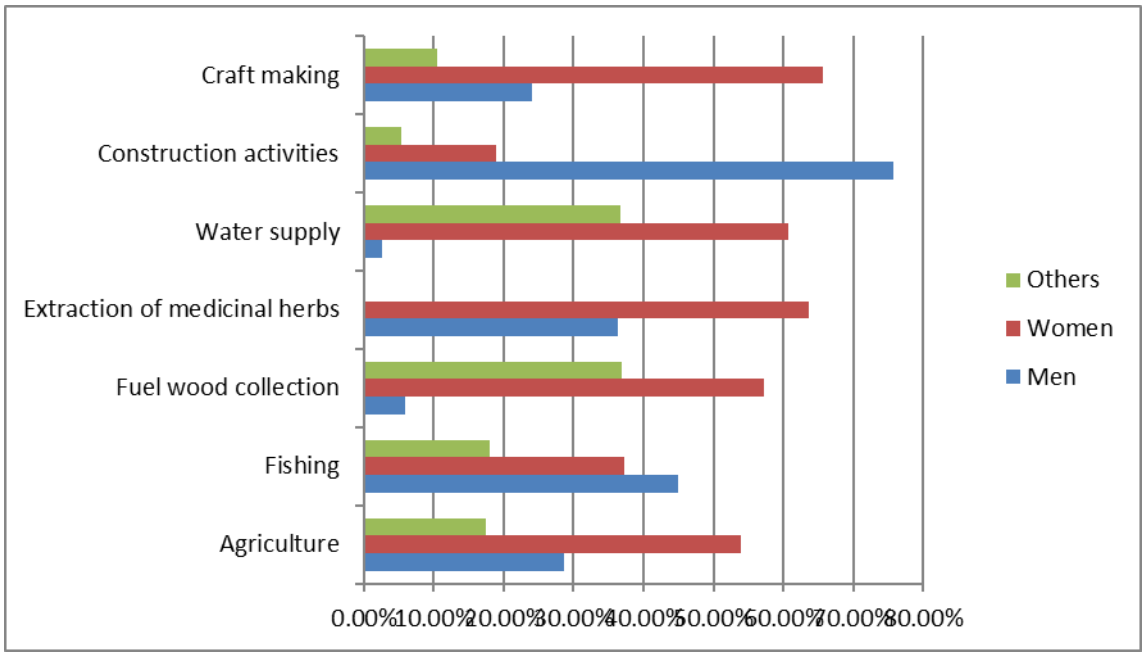


Figure: 4.6 House member participation in wetland resource utilization in Okana.

(Source: Author, 2023)

Fishing

Okana wetlands support diversified fisheries resources. The wetlands provide suitable breeding ground for numerous fish species. However, fishing as an economic activity at Okana is seasonal. It tends to coincide with the onset of both long and short rains, which occur between April and June, and August and October respectively (Table 4.17). During the wet seasons, residents usually fish in the rivers, streams, canals and vast flood plains. Fishing activity is at its peak during this time and the proceeds are processed and consumed immediately and/or stored for future consumption while the rest are sold at the nearby trading centres and markets such as Okana trading centre, Ahero, Rabuor, Orongo and Korowe. Fishing gears used include fishing traps (*Kira, Ounga, Sienyo, Ngaha and Osedho*), hook and line, baskets and pangas (Plate 4.2).

The activity is undertaken by all members of the household including young boys and girls who are twelve (12) years and above. Fishing activity gradually declines as rains subside and flood water recedes. However, young boys always fish irrespective of the season by use of fishing lines. Fishing in the wetland is practiced by 65% of the respondents. Gender involvement in the activity is 44.9%, 37.2% and 17.9% of men, women and others (children and relatives), respectively.

Table 4.17 Seasonal Calendar of Okana Community (It shows the occurrences of different activities in the study area during a year)

Event	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Rainfall				■	■	■		■	■	■		
Land prep.	■	■					■				■	■
Planting rice				■	■	■	■	■	■	■	■	■
Planting other crops			■	■	■	■	■	■	■	■	■	■
Weeding rice					■	■	■	■				
Weeding other crops				■	■	■		■	■	■		
Harvesting rice							■	■	■	■	■	■
Harvesting other crops	■						■	■				■
Human disease (Cholera/Amoebic dysentery)	■			■	■	■	■	■				■
Fishing				■	■	■		■	■	■		
Animal disease (Foot and mouth)	■			■	■	■	■	■	■	■	■	■
Flooding				■	■	■						
Drought	■										■	■

■ Occurence

Fish species caught in Okana wetlands include catfish, mudfish, luambwa barb and a number of species of Tilapia (Table 4.13). On the average, income accruing from fishing in the wetlands is estimated at KES. 843,550 per week (Table 4.18). A household uses the income to meet its basic needs such as payment of school fees or levies, purchase of clothing items, payment of medical services as well as other food items among other expenditures.

Table 4.18. Income from fishing at Okana wetlands per week

Fish species	Quantity caught/Day (kg)	Quantity caught/Week (kg)	Price/Unit (KES)	Total Income (KES)
Xenoclarias spp.	505	3535	70	274,450
Clarias mossambica	317	2,219	100	22,190
Barbus cercops	403	2,821	100	282,100
Labeo victorianus	40	280	100	28,000
Oreochromis leocosticus	20	140	50	7,000
Haplochromis spp.	35	245	20	4,900
Mastacembalus frenatus	10	70	10	700
Synodontis afrofeseires	45	315	50	15,750
Barbus altrialis	25	175	50	8,750
Total	**1,400**	**9,800**	**550**	**843,550**

Grazing on Wetland Pasture

The vast flood plain of Okana, known locally as place of plenty of water ("*Nam*") provides green lash pasture that local communities graze their livestock. The flood plain is particularly important during dry seasons when grazing pastures on higher

grounds have dried up. The wetland thus becomes a common grazing field (*Lek*) for the adjacent riparian community and even beyond (Plate 4.4). Herders come from as far places as Sidho and Ombeyi, which are about 5 km away from the flood plain.

Plate: 4.4. Animals grazing in flood plain of Okana wetlands.

(Source: Author, 2023)

Generally, there is no restriction as per how many animals should graze on the wetland, which results in overgrazing. The phenomenon consequently results in severe animal health problems as well as environmental impact as discussed in section 4.3.1. The frequent interaction and mixing of different heads of livestock often lead to infections by contagious diseases such as anthrax and foot and mouth. Environmentally, the concept of tragedy of the commons as advanced by Garrett Hardin in 1998 comes on the fore. The relevance of the concept to the findings of the study is discussed in detail later in the text (section 4.3).

On the average, an estimated cost of hay or livestock feeds (grass, rice husks or maize husks) per week would be KES. 409,640 (Table 4.19). However, the residents of the study area seldom buy the feeds from elsewhere. Moreover, they do not sell wetland grass to farmers from other places. Besides, restricted grazing of livestock (zero grazing or paddocking) is hardly practiced.

Table 4.19. Cost of livestock feed per week

Livestock	Average no./household	Quantity used/Day (kg)	Quantity used/Week (kg)	Price/Unit (KES)	Total Cost (KES)
Cattle	7	700	4900	70	343,000
Goats	8	80	560	70	39,200
Sheep	7	56	392	70	27,440
Total	**22**	**836**	**5852**	**210**	**409,640**

Agricultural Production

Crop farming and animal husbandry are the major economic activities in Okana wetlands. In fact, 95.8% of the respondents surveyed engage in primary or subsistence agricultural production (Table 4.16). However, the involvement in agriculture still remains at a small-scale level. This is perhaps partly attributed to the relatively small farm sizes, which would be uneconomical for mechanization and partly explained by the high poverty index rated at 60.5% in the study area (GOK, 2019a&b).

On the average, farm sizes generally range from one (1) to three (3) acres of land. The sizes would therefore not permit mechanized farming if meaningful economic returns are expected. The high poverty index (60.5%) implies that modern agronomic practices such as use of agricultural chemicals like herbicides, pesticides and

fertilizers as well as certified seeds are quite minimal. Residents of Okana still embrace the conventional or traditional farming practices which are characterized by poor harvest. The phenomenon therefore explains the food insecurity in the study area which was revealed during PRA exercise. Food insecurity involving poor harvest was ranked fifth in the problem analysis using pair wise ranking method (Table 4.20).

Table 4.20 Problem Analysis using pair wise ranking technique

Problem	DR	FL	PI	ITRM	LMG	IH	Score	Rank
Drought		DR	DR	DR	DR	DR	5	1
Floods			FL	FL	FL	FL	4	2
Poor Infrastructure				PI	PI	PI	3	3
Inadequate training on Resource Management					ITRM	ITRM	2	4
Lack of Marketing Group						IH	0	6
Inadequate Harvesting							1	5

KEY

DR Drought

FL Floods

PI Poor Infrastructure

ITRM Inadequate Training on Resources Management

During dry periods, vegetable and other food crops can be planted. Crops grown in Okana wetlands include maize (*Zea mays*), sorghum (*Sorghum vulgare*), bananas (*Musa* spp.), beans (*Phaseolus vulgaris*), vegetables (tomatoes, kales, onions, arrow roots, brinjals and pepper), rice (*Oryza sativa*), sweet potatoes, sugarcane, cotton, cassava, peas, green grams, and fruits (water melons, citrus and mangoes). Of these crops, maize and sorghum are the most predominant crops in the study area, with a rating of 85% in terms of crop proportionality in the wetlands. This is perhaps due to ecological requirement of the crops in relation to other crops as well as residents' preference of the crop as staple food to other crops. However, at the time of study, rice was the dominant crop in the wetland (Plate 4.5). Horticultural crops such as kales, tomatoes, brinjals and legumes like beans and cow peas are valued for their cash income.

a: A mature rice ready for harvesting.

b: Harvesting of rice

Plate: 4.5.: Rice fields in Okana.

(Source: Author, 2023)

The crops grown are for both household consumption and sale (Table 4.21a). The residents mostly sell the farm proceeds to meet their cash needs such as school fees, health care and other basic needs. Poor and inadequate storage facilities also compel them to sell most of the produces soon after harvesting lest they run into huge post-harvest losses.

Table 4.21a. Income from Crop farming at Okana wetlands per season

Crop	Quantity harvested/Season (Bags)	Price/Unit (KES)	Total Income (KES)
Maize	416	2,500	1,040,000
Sorghum	189	2,500	472,500
Peas	38	6,000	228,000
Beans	123	3,000	369,000
Tomatoes*	186	1,000	186,000
Cassava	51	1,200	37,200
Rice	573	2,500	1,432,500
Kales	87	1,000	87,000
Green grams	3	3,000	15,000
Sweet potatoes	20	1,000	20,000
Pepper	3	2,500	7,500
Arrow roots	11	1,000	11,000

Water melons**	1	60,000	60,000
Brinjals*	1	2,000	2,000
Cotton	4	3,325	13,300
Total	**1,686**	**92,525**	**3,981,000**

KEY

* Unit of Measurements in Crates

Crop propagation in the study area experiences myriad of problems that hinder higher production. These include inadequate farming equipment, pests and diseases, drought, poor infrastructure, inadequate certified seeds, inadequate capital and inadequate market information. These constraints can be addressed in various ways (Table 4.21b) if maximum production is to be realized.

Table 4.21b. Constraints to crop production and possible interventions

Constraints	Possible Interventions
Inadequate farming equipment	• Keeping more oxen for ploughing • Initiating group ownership of ploughing sets • Provision of local tractor hire service
Drought	• Provision of irrigation facilities • Promotion of bucket irrigation • Planting drought tolerant cops • Planting more trees to attract rainfall
Floods	• Building dykes • Channeling of run-off water to water pans
Waterlogging	• Construction of proper drainage channels in each farm
Inadequate certified seeds	• Stocking of appropriate seeds • Provision of credit facilities
Pests and diseases	• Educating farmers on appropriate pesticides • Stocking of appropriate pesticides
Poor infrastructure	• Repair and upgrading of rural access roads • Use of motorcycles and bicycles for

	transportation
Lack of organized markets for farm produce	• Conducting market research • Timed production based on demands
Inadequate capital	• Provision of credit facilities • Encouraging farmer group formation • Building capital for lending to one another

Insects and worms are destructive to farm crops in the study area. The insects destroy crop plants by either biting and chewing or piercing and sucking depending on their feeding habits, which are determined by the type of their mouth parts. The insects which destroy crops by biting and chewing include; locusts, grasshoppers, crickets, maize stalk borers, army worms, cutworms, bollworms, termites and beetles, while those which pierce and suck crops are aphids, butter flies, moths, cotton seed bugs, cotton leaf hoppers, mealy bugs and thrips (Table 4.21c). The inadequate harvest in the study area is therefore partly due to crop damage by insect pests.

Table 4.21c. Insect Pests in Okana

Name of Pest	Crop (s) Attacked	Part (s) Damaged
White fly	Cassava	Leaves
Cotton stainer	Cotton	Flowers
Maize stalk borer	Maize and sorghum	Leaves, stems and cobs
Locust	Maize and sorghum	Leaves
Army worm	Maize and sorghum	Shoots
Cutworm	Kales	Stems (Seedlings)
Bollworm	Tomatoes	Fruits
Termites	Maize and sorghum	Roots
Cricket	Tomatoes and kales	Leaves
Beetles	Maize and beans	Grains/Seeds
Grasshoppers	Maize and sorghum	Leaves
Aphid	Kales and maize	Leaves and husks

Despite the constraints to crop production in Okana, land is fairly fertile. In fact, the residents rarely use fertilizers. This is probably due to the rich silt transported by

surface run offs and rivers from the upper catchments and deposited as sediments in the region.

Livestock reared at Okana comprises mostly the indigenous breeds. They include the African zebu cattle, goats, sheep, poultry, bees and donkeys. Others are pigs and rabbits. Like the crops, the animals and their products are for both household consumption and sale (Table 4.21d). Pests and diseases, drought, limited access to veterinary services, inadequate capital to invest in improved breeds, theft, floods and inadequate grazing pasture are the major constraints to livestock production (Table 4.21e). Floods are particularly problematic because they drown and carry away livestock and also submerge grazing pastures. Besides, the study area lacks a cattle dip for regular treatment of external livestock pests or parasites. Construction of a dip and water pans, posting of a veterinary expert, training of para-veterinary personnel and starting a community based loan scheme for purchasing improved breeds are possible interventions that would overcome the challenges (Table 4.21e).

Table 4.21d. Income from Livestock production at Okana wetland

Livestock	Product (s)	Average no./Household	Price/Livestock (KES)	Total Income/Household (KES)
Cattle	Milk, meat and hide	7	10,000	70,000
Goats	Milk, meat and skin	8	1,200	9,600
Sheep	Meat and skin	7	1,000	7,000
Poultry	Meat and eggs	15	300	4,500
Total		**37**	**12,500**	**91,100**

Table 4.21e. Constraints to livestock production and possible interventions

Constraints	Possible Interventions
Pests and diseases	• Constructing a dip • Posting a veterinary officer • Training paravets to assist veterinary officer
Inadequate pasture	• Planting more pasture • Practicing paddocking • Practicing zero grazing
Drought	• Constructing water pans • Constructing shallow water wells
Floods	• Constructing dykes along Landi and Ombeyi rivers • Desilting areas along the rivers that are blocking the smooth flow of water
Inadequate capital	• Starting community based loan scheme for purchasing improved animals
Theft	• Building strong livestock sheds • Community policing • Keeping dogs to alert owners when thieves come

Hunting and Gathering

The Okana wetlands provide habitat for numerous wildlife species. This is through the provision of essential requirements such as water, food cover, and reproductive or breeding areas. A comprehensive inventory of the wildlife species existence, abundance and values in Okana wetlands has been examined in the previous section (4.1.3).

Hunting and gathering of wild game and wild greens respectively is conducted basically for subsistence and not for commercial purposes. The Common Rana (*Rana* spp.) is used as bait for fishing and not edible in the study area. There are clearly defined roles according to gender in hunting and gathering. Whereas hunting is

mainly conducted by the men, gathering remains a preserve for women. This is probably due to the nature of the activities involved in the two.

The wild game hunted in the study area include, the African hares, antelopes, Sitatunga, rodents and numerous bird species (Table 4.22a). Women usually gather wild greens from the wetlands especially during dry seasons when grown vegetables are out of season. Some of the greens gathered in the wetlands include *Commelina berghalensis, Nymphaea caerula, Ipomea aquatica, portulaca oleraceae* (Table 4.22b).

Table 4.22a. Hunted Wild game at Okana wetlands

Class	Local Name	Scientific Name	English/Common Name
Mammals	Mwanda	*Tragelapus* spp.	Antelope
	Dwe	*Tragelapus spekei*	Sitatunga
	Apuoyo	*Lepus capensis*	African Hare
	Oyieyo	*Rattus rattus*	Rat
	Muok	*Orycteropus afer*	Antbear
	Chiewo	*Hystix galeata*	Porcupine
Birds	Akuru	*Streptopelia perspicillata*	Pigeon/Dove
	Oyundi	*Lagonosticta rubricata*	African Firefinch
	Awendo	*Acryllium vulturinum*	Guinea fowl
	Oluru	*Colius* spp.	Mouse bird
	Aluru	*Coturnix delegorguei*	Harlequin quail
	Osogo	*Ploceus* spp.	Weaverbird
	Nyanyodhi	*Nectarinia* spp.	Sunbird
	Atudo	*Alopochen aegyptica*	Egyptian geese
	Mire	*Quelea quelea aethiopica*	Sudan Dioch
	Odit	*Camaroptera simplex*	Grey wren warbler
	Ogugra	*Triner hypoleucos*	Common Sandpiper
	Oseng’	*Euplectes oryx capensis*	Red Bishop
Amphibians	Ogwal pi	*Rana* spp.	Common Rana

Table 4.22b. Wild greens gathered from Okana wetlands

Local Name	Botanical Name	Part (s) edible
Odielo	*Commelina berghalensis*	Leaves and young shoots
Anyuongi	*Nymphaea caerula*	Rhizomes
Obwanda	*Portulaca oleraceae*	Leaves, stems, seeds
Jamna	*Syzygium cuminii*	Fruits
Apuoyo	*Bothriochloa insculpta*	Fruits and leaves
Mapera	*Psidium quajava*	Fruits
Ng'owo	*Ficus valis choudae*	Fruits
Nyayado	*Cassia floribunda*	Leaves
Raywe	*Indigofera* spp.	Leaves and stems
Achak	*Sonchus schweinfurthii*	Leaves
Chwaa	*Tamarindus indica*	Fruits

Source of water supply

The Okana wetlands are important source of water for domestic and agricultural purposes. Residents draw water from ponds, streams, canals and rivers for horticultural production, livestock watering and general domestic uses such as cleaning and washing. It is only drinking water, which is obtained from boreholes constructed by Sustainable Aid in Africa (SANA) International. However, residents who do not have boreholes or whose homesteads are far away from the boreholes entirely depend on the wetland water supply.

Abstraction of water for agricultural use like horticultural production and livestock watering is carried out by both gender as well as young boys and girls when they are not in school. However, for the domestic use, it is the sole responsibility of women and young girls to draw water. Exceptional cases where men engage in the activity

are when their spouses are sick or unavailable. Gender role is therefore clearly defined. In summary, 2.5% of men usually abstract water for various uses while 60.8% and 36.7% of women and others (young boys and girls) undertake the activity (Fig 4.6). Besides, only 30% of the respondents buy and sell water while 70% abstract water for own use and free of charge. The cost of water in the study area varies from KES. 2.00 per twenty (20) litre container to KES. 5.00 of the same capacity. On the average, the residents of Okana save a total of KES. 192,031 per week if they were to buy water from elsewhere (Table 4.23).

Table 4.23. Cost of water consumed at Okana wetlands

Source	Quantity used/Day (l)	Quantity used/Week (l)	Price/20l (KES)	Total Cost (KES)
River	7,300	51,100	2	5,110
Pond	8,930	62,510	2	6,251
Well	207,540	1,452,780	2	145,278
Borehole	42,100	294,700	5	29,470
Water pan	8,460	59,220	2	5,922
Total	**274,330**	**1,920,310**	**13**	**192,031**

The water supply constraints experienced include breakage of water pumps, inadequate shallow wells, drying up of ponds, seasonal rivers and some wells during dry seasons as well as collapse of well walls. The problems can be addressed by increasing the number of shallow wells, deepening the shallow ones, lining the walls of the wells with concrete culverts and undertaking proper and regular maintenance of the water pumps and wells.

Medicinal values

The study revealed that Okana wetlands host numerous flora, which have medicinal values. Medicine men and women (herbalists), popularly known locally as "*Nyamrerua"*, gather some of these plants and administer them for treatment of different diseases at a cost. The plants may also be gathered and used by individuals to treat certain ailments, without necessarily consulting a medicine man or woman. Part(s) of the plant(s) such as roots, stems, leaves or whole plant(s) may be used in the treatment of specified illnesses (Table 4.24).

Income derived from sale of medicinal plants is sufficient enough to sustain livelihood. The cost of drug (herb) usually varies from herb to herb depending on its availability as well as the type of illness to be treated. On the average, an estimated income of about KES. 582,250 per week (Table 4.24) would be realized if all the herbs were administered and payments for the same made promptly. However, the estimated income is hardly earned since different types of herbs of varying costs can be used for treating same illnesses or diseases. One would thus opt for a cheaper or affordable herb or drug based on his/her finances. For example, diseases like stomachache, boils and neurotic illnesses can be treated using different herbs (Table 4.24). Besides, treatment for some illnesses or diseases like *Chira*, takes longer time and payments for the same equally lag for longer period.

The study has also established that very few residents engage in the extraction of medicinal plants as an economic activity. In fact, only 4.2% of the respondents extract and sale the herbs. The majority (95.8%) of the residents collect the herbs for their own household use. In terms of gender participation, 36.4% and 63.6% of men and women respectively extract the medicinal plants from the wetlands. The higher

involvement of women in the activity indicates the latter's role in the provision of medicare services to infants and under five (5) children, who often suffer from ailments such as measles, skin diseases, pneumonia and colds.

Table 4.24. Cost of medicinal herbs at Okana wetlands

Type of herb	Part(s) used	Disease(s) treated	Quantity sold/Week (Pkt)	Price/Unit (KES)	Total (KES)
Polygnum pulcheria	Roots	Tropical ulcers	4	100	400
Pentas longiflora	Leaves	Fever	3	100	300
Adenia umicifolia	Whole plant	Neurotic illness	2	500	1,000
Vernonia amigdalina	Leaves	Stomachache	1	200	200
Balanites aegyptica	Leaves	Boils	2	200	400
Melia azedarach	Leaves	Stomachache	7	100	700
Nim	Leaves	Boils	2	200	400
Vernonia aurculifera	Leaves	Stomachache	4	80	320
Obara	Leaves	Stomachache	4	100	400
Nyanam	Leaves	Stomachache	7	60	420
Terminali brownii	Bark	Neurotic illness	7	20,000	140,000
Ochna ovata	Roots	Stomachache	2	1,200	2,400
Olasi	Roots	Stomachache	3	20,000	60,000
Nymphaea caerula	Roots	Stomachache	7	3,000	21,000
Obuya	Roots	*Chira*	7	50,000	350,000
Aloe vera	Succulent leaves	Many ailments (STDs, Amoeba, etc)	2	100	200
Fuya Dawa	Roots	Livestock medicine	10	20	200
Solanum incanum	Leaves and fruits	Wound (fresh cuts), milk treatment	5	2	10
Ocimum basilicum	Leaves	*Chira*	2	800	1,600
Cassia floribunda	Leaves	Stomachache	2	200	400
Achyranthes aspera	Leaves	Stomachache	4	150	600

Sesbania sesban	Leaves	Livestock medicine	5	100	500
Cissus rotundifolia	Leaves	Stomachache	2	100	200
Dracaena steudneri	Dry bark crushed in powder form	Common cold	2	50	100
Indigofera spicata	Leaves and roots	Skin diseases	1	100	100
Tylossema tassoglensis	Leaves and seeds	Stomachache	2	200	400
Total			**99**	**97,662**	**582,250**

Identification of the medicinal herbs was based on Kokwaro (2009)

Source of handicrafts

Raw materials from Okana wetlands such as papyruses, grasses, clay, reeds and macrophytes have been harvested and processed by the riparian communities to make numerous handicrafts. The handicrafts made are mostly sold to earn income, which in turn is used to meet several household financial or basic needs such as food, clothing, healthcare and education. In some cases, the income accrued is invested in other household enterprises like farming, small scale businesses or remitted to Community Based Organizations (CBOs) such as self-help groups, youth groups, women groups and *Mary Go Rounds*.

The handicrafts are either made by individuals or as a group. The most commonly made handicraft is mat, which accounts for 48.3% of all crafts made (Table 4.25). Other handicrafts made using wetland materials from Okana include ropes and strings, ceramics, furniture, table mats, wall hangings, floor mats, baskets, sisal fibres, *ondhuaro, osera, otete* and fishing gears such as *osedho, kira, ngaha, sienyo and ounga* (Plate 4.6). These handicrafts fetch a lot of income to the community when

sold locally or in the markets outside the study area like Ahero, Rabuor, Kibuye, Kiboswa and Awasi. Income estimates of the handicrafts made per week are shown in Table 4.26. There is a potential of higher incomes accruing from the craft making industry since the income estimates in Table 4.26 do not include value addition

Plate: 4.6. Ceramics made from wetland materials.

(Source: Author, 2023)

Table 4.25. Handicrafts made at Okana using wetland materials

Craft	Percentage (%)
Mats	48.3
Ropes	16.7
Baskets	1.7
Furniture	4.2
Fishing gears	15.8
Ceramics	6.6
Other crafts	6.7

The overall engagement in the craft making related activities by the residents is 80%. However, in terms of gender participation, men trail women at 24% and 65.6% respectively while others (children, relatives and casual labourers) make up 10.4%

(Fig 4.6). Whereas men are involved in the harvesting of the materials such as papyruses, sisal leaves, twigs, reeds and grasses, women undertake the actual weaving of the crafts especially mats, ropes and baskets. Besides, the latter gender also harvests the materials and at times assisted by children, relatives and casual labourers. Making of fishing gears and other crafts like *osera*, *ondhuaro* and *otete* is dominated by men due to complexity of art involved in the activity.

Table 4.26. Income from handicrafts in Okana wetlands

Handicraft	Material(s) used	Quantity/Week	Price/Unit (KES)	Total Income (KES)
Mats	Papyruses and sisal leaves	11,780	50	589,000
Ropes	Sisal leaves	555	15	8,325
Baskets	Papyruses, sisal leaves and grasses	9	60	540
Furniture	Papyruses, reeds and sisal leaves	37	150	5,550
Fishing gears	Papyruses, reeds and sisal leaves	211	120	25,320
Pots	Clay	100	50	5,000
Sisal fibres*	Sisal leaves	38	40	1,520
Others crafts	Papyruses, reeds, sisal leaves, twigs and grasses	46	150	6,900
Total		**12,776**	**635**	**742,155**

KEY

Craft making activity experiences three (3) main constraints namely difficulty of getting raw materials by clearing the papyrus thickets, poor roads to transport the handicrafts to the market and lack of organized markets for the products. Besides, the craft makers also lack skills in value addition of the handicrafts made. The problems can be ameliorated by buying materials from experienced papyrus harvesters, forming groups to enable them hire lorries to transport the crafts to the market, seeking market

information in other places and lobbying for repair or upgrading of the roads by the County Government. An expertise on value addition should also be invited to train the craft makers on the skill.

Energy Source

Fuel wood forms the major source of energy in most rural areas in the developing countries such as Kenya. The fuel wood may be collected from the surrounding thicket, bush or forest. For the people of Okana, fuel wood is derived from the dry wetland macrophtyes or vegetation such as papyruses, *Asao* (*Sesbania sesban*), *Osiri (Scutia myrtina), Omburi (Aeschinomene elaphroxylon), Obong' (Cajanus cajan),* Oturbam (Albizia zygia), planted cyperus (eucalyptus or blue gum), *Acacia* spp., sisal stock, *Owich (Dombeya burgesiae)*, reeds, grass, euphorbia as well as crop residues or detritus from crop farms such as maize stalk, sorghum stalk, banana leaves and stalk, and sugar cane bargasses. However, due to increasing demand for land for agriculture and human settlement, most of wetland vegetation has been cleared to give room for the same. The scenario has been depicted in the PRA report, which indicated a general decline in abundance of natural resource base, of which wetlands are one (Fig 4.2). Nevertheless, residents of the study area save an estimated amount of KES. 267,420 per week, which would have been spent on fuel wood from nearby markets (Table 4.27).

Generally, majority of the respondents (97.5%) depend entirely on the wetland as source of fuel wood for their domestic use (Table 4.28). A paltry 2.5% of the respondents buy fuel wood from the nearby market/trading centres in order to supplement the wetland source. The latter group comprises vendors in consumables such as tea, porridge, cakes, *mandazi* and *chapattis*. These vendors have relatively

higher demand for fuel wood. In terms of gender participation, women dominate the activity at 57.3% while only a handful 5.9% of men take part in the same. Children, relatives and casual labourers make up 36.8%. The apparent least engagement of men in the fuel wood is due to their involvement in herding of livestock. The latter activity coincides with the time when fuel wood extraction is undertaken. Besides, cooking is in the domain of women.

Table 4.27. Cost of fuel wood per week at Okana

Wetland tree	**Quantity/Week (Bundles)**	**Price/Unit (KES)**	**Total Cost (KES)**
Papyruses	413	100	41,300
Reeds	705	50	35,250
Sesbania sesban	65	50	3,250
Eucalyptus	84	150	12,600
Aeschinomene elaphroxylon	28	50	1,400
Scutia myrtina	73	100	7,300
Sisal stalk	154	40	6,160
Acacia	280	100	28,000
Grass	50	100	5,000
Dombeya burgesiae	196	60	11,760
Cajanus cajan	55	50	2,750
Maize stalk	434	50	21,700
Sugar cane bargasses	329	100	32,900
Euphorbia	161	200	32,200
Banana stalk	42	100	4,200
Lantana camara	435	40	17,400
Albizia zygia	85	50	4,250
Total	**3,589**	**1,390**	**267,420**

Table 4.28. Sources of woodfuel in Okana wetland

Source	**Percentage (%)**
Wetland	97.5
Nearby Trading Centre	2.5

Non-consumptive Uses

The values of wetland ecosystems are seldom limited to the social and economic benefits only as explained in the Barbier's total economic value of a resource (Fig. 4.5). The ecosystems also have numerous ecological functions which are worth mentioning, even though they were not within the scope of the study. Wetlands contribute towards balancing of the hydrologic cycle thereby maintaining both surface and underground water supply through water recharge and discharge; act as Carbon dioxide (CO_2) sinks which reduce the greenhouse effect; provide habitat for wildlife, such as the waterfowl, share birds and other birds and animals which depend on wetlands for their survival; purify water through removal of nitrogen, phosphorus, heavy metals and other chemicals and pollutants from water and this leads to improved water quality through filtration process; control flood, erosion and sedimentation by reducing the flood and erosion velocities as well as trapping water-borne sediments; and protect shorelines by breaking the speed of winds and strength of waves.

Besides, the ecosystems also provide important sites for cultural or religious rituals and/or ceremonies like baptism, prayers, circumcision and ash drive (*tero buru* conducted on the flood plains) among others. For instance, in the study area, baptism is usually conducted in the wetland by the Seventh Day Adventist (SDA) and *Roho* sect faithfuls who baptize by water immersion. Ash drive was conducted in the past but has since been discarded following the influence of Christianity.

In conclusion, the utilization of the wetland resources has been shown to contribute significantly to the household income in the study area and thus sustaining livelihoods of the riparian community in the study area and even beyond. This is through the

social and economic values that they provide to the residents. The community has utilized the ecosystems as sources of food, water, building and construction materials, energy and handicrafts, medicinal herbs as well as grazing fields for domesticated animals especially during dry seasons. In fact, more than 95% of the residents of Okana depend either directly or indirectly on the wetland resources for the sustenance of their livelihoods. Livelihoods would be deplorable if the wetland ecosystems ceased to exist through overexploitation, degradation and loss.

The study findings therefore adequately answer the first two (2) fundamental research questions, which sought to identify or outline the wetland resources in Okana and determine the extent of wetland resources contribution to household income in the study area. The questions were: What are the wetland resources in Okana? To what extent are the wetland resources contributing to household income? The resources thus have significant contribution to household income in the study area. In fact, total estimated earnings of about KES. 7,277,056 per season from wetland resources obviously depict the socio-economic value of wetlands to the community. The estimated value only refers to the consumptive or direct uses of the resources. It excludes the valuation of the non-consumptive uses, which was not within the scope of this study. The study thus has sufficiently addressed objective two (2) that sought to determine the contribution of the wetland resources to household income in Okana area. The findings of the study agree with Rongoei et al. (2013) that wetlands contribute to the improvement of human well-being and economic development through their role in enhancing household income.

4.4 Objective Three (3): Impact of Wetland Resources Utilization in Okana

The continuous interaction of humans and the physical environment such as wetland ecosystems is quite essential, natural and inevitable. It is through such interactions that human kind derives his livelihoods from the environment, while the latter is modified for the better or worse. The discussion on the interactions between humans and wetland ecosystems in the study area has been presented in section 4.2.4. The current section is based on objective three (3) of the study and focuses on the consequences of such interactions with specific emphasis on the social and environmental perspectives.

Several techniques were used to collect and analyze data on the impact of wetland resources utilization in the study area. These include random sampling, photography, SPSS and Participatory Rural Appraisal (PRA). Random sampling technique was used in the administration of three hundred and eight (308) questionnaires in the study area. Photograph of clay excavation site was taken during field survey exercise. PRA was used to validate responses obtained during field survey. SPSS was used to obtain percentages in the incidences such as accidents, injuries, social conflicts and fatalities if any during wetland use.

Results

Normally, wetlands naturally thrive on their own through autogenic community succession. However, their development may be hampered by anthropogenic activities as has been discussed in section 4.2.3. The study revealed that the utilization of wetland resources results in numerous adverse social and environmental impacts. The environmental consequences include decline and loss of various species

of flora and fauna, creation of micro-habitats for disease vectors, water pollution as well as waste generation.

Socially, the study established that harvesting and extraction of wetland resources often result in human-wildlife conflicts, social conflicts among wetland resources users, accidents and injuries of the users during harvesting and extraction of the resources. Besides, the study showed that the residents of Okana also encounter other livelihood constraints which may directly or indirectly affect sustainable utilization of the wetland resources. These include poor infrastructure, food insecurity, networking on market information as well as capacity building on value addition of the wetland products or crafts made. These findings have been discussed in the following successive sections. The survey revealed the following results on the utilization of wetland resources (Table 4.29).

Table 4.29. Impacts of wetland resources utilization in Okana

Resource Use	Impact	Category of Impact
Harvesting of macrophytes	• Waste generation	• Environmental
	• Decline and loss of biodiversity	• Environmental
	• Destruction of habitats	• Environmental
	• Human-wildlife conflicts	• Social
	• Snake bites	
	• Cuts and injuries	• Social
		• Social
Hunting and gathering	• Decline and loss of biodiversity	• Environmental
Clay excavation	• Creation of micro-habitats for disease vectors	• Environmental
		• Social
	• Accidents and injuries	• Social
Craft making	• Waste generation	• Environmental
Agriculture	• Waste generation	• Environmental
Water abstraction	• Pollution	• Environmental
Grazing pasture	• Social conflict	• Social

Discussion

The section has two (2) parts namely, environmental impact of wetland resource use (section 4.3.1) and the social consequences of wetland resource use (section 4.3.2).

4.4.1 Environmental Impact of Wetland Resources Utilization

Anthropogenic activities in the study area such as clearance of vegetation, clay excavation, harvesting of medicinal herbs and wetland macrophytes from the wetland have accelerated the vulnerability of the area to numerous environmental problems, some of which are hazardous. This section outlines the consequential environmental issues.

Biodiversity decline and loss

Human activities such as clearing of wetlands, burning of wetland vegetation, deforestation and hunting often lead to negative impact on the abundance of flora and fauna. It has been examined that wetlands provide habitat for numerous species of fauna. The ecological function therefore ceases if the wetland ecosystems are cleared for different purposes. Whereas some may relocate or migrate to other habitats (especially mobile biota), some species would perish since typical wetland biomes such as shorebirds may not easily adapt to new ecosystems. Immobile biota (flora) and other species, which might not be tolerant to fire, would die hence becoming extinct.

Anthropogenic activities in Okana have had an overall impact of reduced and/or loss of biodiversity in the wetland ecosystem. In fact, 83.3% of the respondents indicated that some species of flora and fauna have disappeared from the area in the recent past. The information was further confirmed during PRA exercise. The participants, who were residents of the study area, confirmed that species such as *Crocuta crocuta,*

Trangelapus spekei, Python sebae and *Francolinus* spp. among others are no longer found in the area. They attribute the disappearance of the species to the clearance and burning of the wetland ecosystem to provide space for agriculture and human settlement. A complete list of species of flora and fauna which have either declined or disappeared altogether in the recent past according to the residents is in tables 4.30a & b. Evidence of wetland clearance (land use change) is shown in the satellite images in section 4.1.

Table 4.30a. Species of plants that have declined/disappeared in Okana wetlands

Local Name	Botanical Name
Adugo	*Acacia drepanolobium*
Okaka lang'o	*Aloe secundiflora*
Keyo	*Combretum* spp.
Ochol	*Diospyros abbysinica*
Powo	*Grewia bicolor*
Pedo	*Caesalpinia sepiana*
Atego	*Keetia gueinzii*
Sangla	*Rhus natalensis*
Saa	*Oncoba spp.*
Achak	*Pittoasporum spp.*
Nyayado	*Cassia floribunda*

Table 4.30b. Species of animals that have declined/disappeared in Okana wetlands

Local Name	Scientific Name	English/Common Name
Ondiek	*Crocuta crocuta*	Hyena
Bim	*Papio anubis*	Olive baboon
Ong'er	*Ceropithecus mitis*	Monkey
Dwe	*Tragelapus spekei*	Sitatunga
Nyang'	*Crocodilus niloticus*	Crocodile
Tula	*Asio abyssinicus graueri*	Owl
Ng'ielo	*Python sebae*	Python
Muok	*Orycteropus afer*	Antbear
Awendo	*Acryllium vulturinum*	Guinea fowl
Ndemu	*Mehelya spp.*	Brown mamba
Tel-tel	*Capethera spp.*	Wood pecker
Aywer	*Francolinus spp.*	Spurfowl
Chiewo	*Hystix galeata*	Porcupine
Aluru	*Coturnix delegorguei*	Harlequin quail
Magungu	*Anastomus lamelligerus*	Open billed stock

The findings on the declining biodiversity are in agreement with other studies in the wider Nyando River Basin. For instance a study by Obiero et al. (2012) on Nyando wetland indicated that there are species of plants which have become rare or declined in abundance. Some of the tree plants include *Bondo*, *Ng'ou*, *Dwele*, *Siala*, *Ober*, *Omburi*, *Obino* and *Ojuok* (Euphorbia).

Creation of micro-habitats

Pottery is a well-known wetland activity in the study area as has been indicated in section 4.2.3.8 (Table 4.23). The famous centre for the craft in the area is at *Bungu Koraga* where women engage in pottery either as individuals or groups. Clay excavation for pottery in the area results into open pits, which often become health hazards to the surrounding population. The micro-habitats created normally form breeding grounds for disease vectors such as mosquitoes and snails. The open pits

may also be filled with surface run off during rainy seasons leading to drowning incidences (Plate 4.7). Besides, excavation often leaves behind hanging walls or debris, which are quite vulnerable to subsidence or collapse and landslides thereby causing loss of lives particularly to women who may be in the pits harvesting clay at the time. Furthermore, clay excavation leaves a barren land, which is completely inhabitable unless reclaimed. The scenario eventually leads to land degradation if no immediate remedial measures are undertaken.

Plate: 4.7 Clay excavation site at Okana wetland (It shows an open pit, left after excavation, that has been filled with wtater)

(Source: Author, 2023)

Water Pollution

The residents in the study area abstract water from both surface and groundwater sources. The sources of water include rivers, ponds, water pans, wells and boreholes. On the average, abstraction from the wells outstrips the other sources and account for up to 91.7%. Thanks to SANA International and GWAKO – Non-Governmental Organizations – that facilitated construction of the wells. It is however important to note that any single household may abstract water from two or three sources depending on the purpose for the water – whether for drinking, general domestic cleaning, bucket irrigation or watering of livestock. The choice is dictated by the apparent varying water quality from the sources.

Surface water sources like rivers, ponds and water pans are subjected to both point and non-point sources of pollution such as run-offs of urban and domestic wastes and from large scale farms in the upstream such as Chemelil, Miwani and Muhoroni sugar cane plantations as well as from nearby small scale farms. Massive soil erosion due to clearance of vegetation over the years also contributes to poor quality especially turbidity of surface water sources. Besides, industrial discharges in the upstream catchment further contribute to pollution in the area. Though the current study did not undertake water quality analysis, the inference of pollution of the water sources in the study area is likely to be true on the basis of LVEMP findings on the analyses of water quality status, physio-chemical materials and heavy metals of the rivers draining into Lake Victoria between 1998 and 2001. Results of analyses of the parameters of water quality for River Nyando wetlands, study area included, are shown in Tables 4.31a-c (LVEMP, 2000a & b).

Groundwater sources namely wells and boreholes are equally polluted. Water tapped from the two sources is saline due to high concentrations of fluoride. The presence of fluoride in the water is explained partly by leaching of soda from subterranean sources when groundwater circulates along fissures and partly associated with the late-stage silification (Le Bas, 1977).

The evidence of water pollution adduced from the findings of LVEMP clearly confirms the fact that the wetlands in the study area have been degraded. The phenomenon has consequently impaired the role of the wetland ecosystems in water purification and prevention of salt intrusion. The ecosystems therefore fail to purify water through removal of nitrogen, phosphorus, heavy metals and other chemicals and pollutants from water and this leads to lowering of water quality as depicted in the findings.

Table 4.31a. Water quality status in R. Nyando (Extracted from LVEMP, 2000 a & b)

Site Code	Nutrients	Faecal Coliform Contamination	Remarks
01	Nearly eutrophic	Contaminated	Continued nutrient loading will lead to eutrophication
02	Uncontaminated freshwater	Not contaminated	Has non faecal coliforms
03	Uncontaminated	Uncontaminated	Has non faecal coliforms
04	Uncontaminated	Uncontaminated	Has non faecal coliforms
05	Uncontaminated	Uncontaminated	Has non faecal coliforms
06	Uncontaminated	Contaminated	Has non faecal coliforms
07	Uncontaminated	Contaminated	Has non faecal coliforms
08	Uncontaminated	Contaminated	Has TNTC
09	Uncontaminated	Contaminated	Small quantities of non faecal coliforms
10	Uncontaminated	Contaminated	Small quantities of non faecal coliforms
11	Nearly eutrophic	Contaminated	TNTC and non faecal coliforms
12	Uncontaminated	Contaminated	TNTC and non faecal

			coliforms
13	Nearly eutrophic	Contaminated	TNTC and non faecal coliforms
14	Eutrophic	Contaminated	High chloride value indicates domestic sewage High BOD implies large quantities of organic matter
15	High quantities of Nitrate-Nitrogen	Contaminated	TNTC and non faecal coliforms
16	High quantities of Nitrate-Nitrogen	Contaminated	Small quantities of non faecal coliforms
17	Uncontaminated	Contaminated	TNTC and non faecal colifroms

Table shows level of contamination of River Nyando wetlands by nitrate/nitrogen compounds and faecal coliforms.

Table 4.31b. Physio-chemical analysis in R. Nyando (Extracted from LVEMP, 2000 a & b)

Site Code	Temp ^{0}C	pH	TDS	Condus/cm	Cl mg/l	NO^-_3 N mg/l	PO^-_4 P mg/l	F. Colf.	T. Colf	BOD
01	19.7	6.0	57	117.2	3.5	0.76	0.06	4	10	-
02	21.4	6.5	48.2	98	2.0	0.4	0.023	Nil	46	-
03	22.5	6.5	14	30.1	4.1	0.4	0.01	Nil	18	-
04	19.5	6.0	17	35.0	4.3	0.47	0.015	Nil	10	-
05	19.0	6.5	15	39.9	2.6	0.54	0.025	Nil	12	6.0
06	19.5	6.5	23	49.3	4.8	0.44	0.034	10	34	-
07	20.5	6.5	25	52.4	5.5	0.53	0.025	TNTC	120	-
08	21.5	6.5	16	35.5	5.7	0.47	0.016	4	TNTC	-
09	18.8	6.5	17	33.1	4.2	0.59	0.12	28	30	-
10	18.7	6.5	15	31.3	4.7	0.44	0.006	Nil	16	-
11	19.6	6.5	17	30.4	5.9	0.38	0.08	TNTC	TNTC	-
12	21.5	6.5	16	33.4	4.5	0.48	0.016	56	TNTC	8.0
13	21.0	7.0	17	34.9	4.8	0.47	0.079	30	TNTC	-
14	25.1	6.0	367	765	10.5	1.78	0.178	TNTC	TNTC	-
15	20.5	6.5	54	171.1	5.4	1.11	0.11	32	TNTC	10
16	20.5	6.5	54	112.5	3.8	1.33	0.038	48	12	6.5
17	24.2	6.5	25	52.5	2.5	0.83	0.016	TNTC	TNTC	4.0

Table shows level of contamination of River Nyando wetlands by physical impurities and chemical substances.

KEY: **BOD** Biological Oxygen Demand
NIL Absence of faecal coliforms
TDS Total Dissolved Solids
TNTC Too Numerous To Count

Table 4.31c. Analysis of selected heavy metals in R. Nyando (Extracted from LVEMP, 2000a & b)

Site Code	Cd	Mn	Cu	Pb	Ni	Zn	Fe	Al
01	0.0000	1.38	0.00	0.018	0.008	0.005	18.38	0.00
02	0.0000	0.205	0.005	0.00	0.003	0.05	1.45	-
03	0.0000	0.015	0.003	0.008	0.01	0.018	0.35	0/00
05	0.0000	0.093	0.003	0.008	0.005	0.095	1.20	0.375
06	0.0050	0.083	0.005	0.003	0.013	0.023	0.775	0.05
07	0.0025	0.25	0.00	0.00	0.013	0.00	3.80	0.475
08	0.0000	0.153	0.00	0.00	0.008	0.018	2.55	0.40
09	0.0000	0.66	0.003	0.00	0.008	0.038	2.53	1.025
10	0.125	0.043	0.00	0.01	0.01	0.00	0.40	0.00
11	0.0050	0.083	0.00	0.00	0.013	0.00	0.00	0.00
12	0.0025	0.158	0.01	0.005	0.015	0.028	1.75	1.05
15	0.0025	0.61	0.003	0.003	0.023	0.025	5.60	2.025
16	0.0050	0.10	0.00	0.00	0.018	0.010	5.50	4.175
17	0.0025	0.17	0.00	0.00	0.015	0.010	2.78	1.60

Table shows level of abundance of selected heavy metals in River Nyando wetlands.

KEY: **Al** Aluminium **Fe** Iron **Pb** Lead
Cd Cadnium **Mn** Manganese **Zn** Zinc
Cu Copper **Ni** Nickel

Waste Generation

The utilization of wetland resources plays a significant role in waste generation in the study area. For example, activities such as harvesting of wetland macrophytes (reeds, papyruses, grass, etc), crafts making (mats, baskets, sisal fibres, ceramics, furniture

and fishing gears), agriculture, water abstraction and use among others often lead to waste generation. Crop residues, husks from craft making processes, waste water and agricultural chemicals used in crop and livestock husbandry as well as human faecal matter normally constitute liquid and solid wastes, which are pollutants. Other wastes include spoilt or stale products like vegetables in the nearby market/trading centres, packaging materials like papers and plastic bags and other assorted urban wastes.

In the entire study area including market/trading centres there are no properly developed formal dumping sites, which meet Waste Management regulations developed by the National Environment and Management Authority (NEMA) and gazetted in 2007. Besides, there are no waste collection and disposal facilities. Furthermore, awareness on waste management is quite minimal. Consequently, the residents either burn the wastes or dump them in the water ways, particularly rivers.

4.4.2 Social Impact of Wetland Resources Utilization

The section examines the social implications of the continuous utilization of wetland resources for sustained livelihoods by the local residents. An assessment of the social impact is fundamental in order to unravel potential risks involved in such utilization since emphasis has been on the environmental aspects yet proper planning for sustainable use of the resources requires comprehensive knowledge in all spheres.

Human – Wildlife Conflict

It has been outlined that Okana wetlands are quite productive and support substantial agriculture (Table 4.21a & d). However, the crop farms are often destroyed by wild game, which find habitation in the wetlands. A wide range of wild game considered as pests and predators in the adjacent farms are listed in Table 4.32. In response to scare the pests (wild game) away from the crop farms, farm owners often keep vigil at the

farms during the day and night to drive them away. At times, traps are used to bait the animals thereby killing the latter. Sometimes scaring methods such as use of fire and scarecrow are deployed. Statistics on the number of wild game killed was quite scanty. This is probably due to the sensitivity of the matter on the threats concerning wildlife given that hunting is illegal. The respondents were perhaps reluctant to divulge the information in fear of dire consequences should the data reach the Kenya Wildlife Service (KWS). Conflict therefore arises as farm owners strive to protect their farms from destruction while the animals roam about to fend for their survival.

Table 4.32. Troublesome wild game in Okana wetlands

Class	Local Name	Scientific Name	English/Common Name
Mammals	Mwanda	*Tragelapus* spp.	Antelope
	Ong'er	*Ceropithecus mitis*	Monkey
	Aidha	*Paraxerus ochracerus*	Bush squirrel
	Oyieyo	*Rattus* rattus	Rat
	Ogwang'	*Civettictus civetta*	African civete cat
	Nyamanduklu	*Lutra maculicoli*	River Otter
	Chiewo	*Hystix galeata*	Porcupine
	Ondiek	*Crocuta crocuta*	Hyena
Birds	Osogo	*Ploceus* spp.	Weaverbird
	Awendo	*Acryllium vulturinum*	Guinea fowl
	Akuru	*Streptopelia perspicillata*	Pigeon
	Dharna	*Buphagus erythrorynchus*	Tick bird
	Ongo	*Haliaeetus vocifer*	African fish eagle
	Olit	*Accipter brevipes*	Sparrow hawk
	Oluru	*Colius* spp.	Mousebird
	Aywer	*Francolinus* spp.	Spurfowl
	Ongowang'	*Belearica rogulorum*	Crowned crane bird
	Mire	*Quelea quelea*	Sudan Dioch
	Otenga	*Hieraaetus spilogaster*	African hawk eagle
Reptiles	Ng'ech	*Veranus* spp.	Monitor lizard
	Ng'ielo	*Python sebae*	Python
	Olueru	*Mehelya* spp.	Brown mamba
	Fuu	*Bitis* spp.	Puff udder
	Rachier	*Dendroapspis* spp.	Black mamba
	Alum	*Philothamnus* spp.	Green mamba
	Ndemu	*Mehelya* spp.	Brown mamba

The wild game, which are considered troublesome by the local residents are serious pests to cultivated crops especially during planting and just before harvesting seasons. For instance, animals such as monkeys, porcupines, bush squirrel and antelopes often destroy crops. Bush squirrels are notorious during planting seasons while monkeys cause havoc just before harvesting periods. Bird species such as guinea fowls and weaverbirds are equally destructive to crop farms during planting and just before harvesting seasons, respectively.

Resource Use Conflict

Whereas wetland resources are common property to all local people, uses to which the resources are put vary considerably. In Okana, there are several users of wetlands namely farmers, pastoralists, craft makers, herbalists and those dealing with ceramics. Each of these groups seeks to derive maximum gains regardless of their counterparts. For example, whereas farmers would wish to put larger portions of the wetlands under cultivation, both the pastoralists and craft makers would prefer the wetland ecosystems to remain intact (fallow) for grazing pasture and macrophyte (especially papyruses, reeds and grasses) harvesting, respectively. Though the conflict has not been on the fore or so grave like in other areas in the country such as Samburu and West Pokot, where communities or clans fight due to limited grazing pasture and water resources, there is a potential of the phenomenon in the near future given the ever increasing human populations and economic demands over the years against steadily declining resources in the community (Table 4.4).

Accidents and Injuries

Anthropogenic activities such as clay excavation, harvesting of wetland plants for craft making and building and construction often endanger the resource users. The

dangers of clay excavation have been discussed in sub-section 4.3.1.2. Apart from vulnerability to land subsidence or collapses hence leading to deaths, the open pits are potential sites for accidents especially to the unsuspecting herdsmen, young girls during fire wood collection or anyone at dusk. The women who undertake excavation confess several incidences of bodily injuries like bruises and joint dislocations when they slip in the pits accidentally. In fact, 35% of the women have become casualties in one incident or another. The respondents were, however, hesitant or denied categorically any fatal incident related to the activity. The denial is perhaps due to fear that the activity would be outlawed if information reached authorities.

Incidences of accidents and injuries, which arise from macrophyte harvesting, were also reported. Forty percent (40%) of the respondents have had bodily injuries such as cuts, joint dislocations and bruises from tools used and twigs while harvesting. The harvesters have high risk of such injuries since most of the time they do not have protective devices such as footwear/gum boots and arm gloves when getting into the wetland to harvest. Besides, the wetland harbours pest and disease vectors like leeches and tse tse flies, which often expose the harvesters to high risk of infection. The residents who make mats usually have an occupation risk of being pierced by the needles. They often apply jelly or soap to improve slipperiness thereby reducing the risk of getting hurt.

However, only 5% have had incidences of snake bites and ambush, with the latter case leading to the above mentioned injuries. Like in the case of clay excavation activity, no death incident had been encountered as a result of snake bites. All casualties including victims of snake bites were duly treated especially using medicinal herbs.

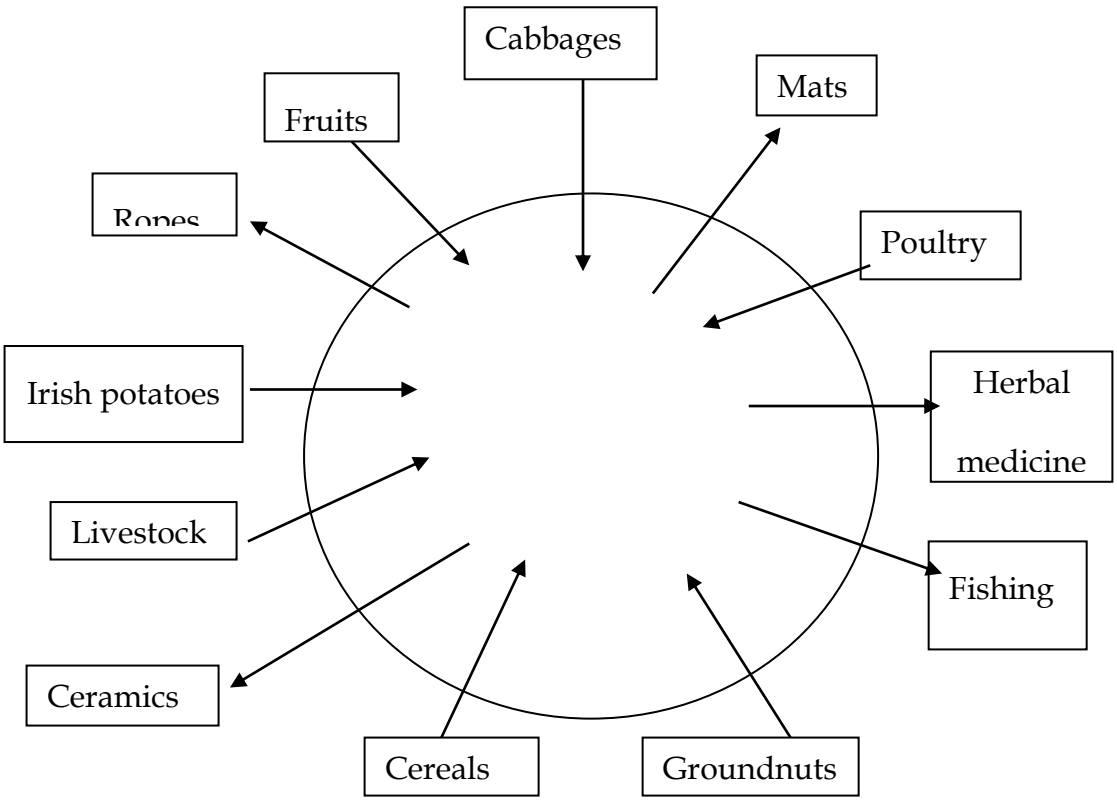
4.4.3 Other Problems/Impacts

The study area faces other livelihood constraints, which do not necessarily arise from wetland resource use but nevertheless may hinder sustainable utilization of the resources. The problems range from infrastructure, food insecurity, networking on market information to capacity building on wetland resources (Table 4.20). The state of the only all-weather road that connects the study area to the Kisumu – Ahero Highway is quite pathetic and greatly impedes transportation of products to the markets. Tracks and rural access roads, whose construction was facilitated by VIRED International, are largely impassible especially during rainy seasons. Besides, health facilities are few despite the high health risks given the status of water quality and waste management.

The study area is a food deficient region since it is a net importer of most agricultural products as well as livestock commodities (Fig 4.7). Food poverty index in the area is estimated at 61% (GOK, 2013c). Some of the causes of food insecurity in the area include unfavourable climatic conditions, poor disaster preparedness, low absorption of modern technology, high costs of inputs and HIV/AIDS, whose prevalence rate is 14.6% (GOK, 2013c). The food poverty challenge can be mitigated through subsidized farm inputs, enhancing the capacity of small scale producers and exporters especially with regard to ways of value addition, promotion of technology and accessibility to suitable credit facilities. Other possible interventions to enhance food production in the area have been outlined in section 4.2.3.4 and summarized in tables 4.21b & e.

Despite the fact that a number of organizations, both Governmental and NGOs have initiated and facilitated numerous projects, the area still requires more capacity

building as well as networking with other institutions on wetland resources management. The necessity is evident in the poor maintenance of projects initiated by the organizations especially by the VIRED International and SANA International, which are the leading NGOs in the area based on their activities.



KEY

Wetland products sold/exported to other regions

Food items residents obtain/import from other regions

Figure: 4.7 Resource Flow Matrix of Okana.

(Source: Author, 2023)

In conclusion, the study has established that environmental and social problems or issues that arise from wetland resources utilization are numerous and interactive. They can hardly be examined comprehensively in isolation since some of them emerge as cause and effects. Their current status, coping mechanisms and planning and management strategies have been summarized in Table 4.33. The study findings have therefore adequately addressed objective three (3) which sought to investigate environmental and social impacts of wetland resources utilization in Okana area.

Table 4.33. Summary of Environmental and Social Issues in Okana

Issue	Current Status	Interventions	Planning Aspect
Clearance of vegetation	Vast areas have become bare or with scanty vegetation	Planting of wetland macrophytes and exotic trees, Buying timber for building and construction, Buying of fuel wood to supplement available ones.	Afforestation, Reafforestation, Agro forestry, Reservation of 10% of land under forest cover.
Flooding	Not controlled	River dredging, Desilting canals.	Afforestation, Reafforestation, Construction of huge dams and dykes, Training on disaster preparedness and early warning systems, Floodplain management.
Biodiversity loss	No control of hunting and gathering	Wild game hunted for meat, Wild greens gathered, Medicinal herbs extracted.	Declaration of wildlife sanctuary protected area by KWS, Development of eco-tourism. Establishment of private sanctuaries, Planting of identified medicinal plants.
Water	Point and non-	Boiling drinking	Training on rainwater

pollution	point not controlled	water. Rainwater harvesting, Treating water using chlorine and PUR chemicals.	harvesting, Construction of pit latrines in homesteads, Develop alternative uses of wastes.
Land degradation	Excavated areas not filled up	Open pits neglected.	Re-filling up of open pits, Fencing off of open pits as buffer zones, Putting up posters indicating danger zones.
Waste Management	No dumping sites in all market/trading centres. Few homesteads have pit latrines.	Burning of solid wastes, Disposing wastes in nearby bushes and water sources.	Construction of pit latrines in homesteads, market/trading centres, churches and schools, Recycling and reuse of wastes, Designation of licensed dumping sites in the villages, social and educational institutions, Installation of waste bins in schools, churches and market/trading centres.
Resource Use Conflicts	No harmonization frameworks by different sector groups. No control of human-wildlife conflict.	Different sector groups train and undertake own initiative of resource management independent of any other, Activities are never complementary, Wild game killed when stray in crop farms.	Harmonization of activities by different sector groups, Development of eco-tourism, Fencing off of wildlife sanctuary and crop farms, Declaration of wildlife sanctuary as protected area.
Drought	Not controlled	Grazing livestock in the wetland, Abstraction of water from wells.	Afforestation, Reafforestation, Rainwater harvesting, Construction of silage, Construction of water pans, Sinking of wells.

4.5 Objective Four (4): Wetland Management Regimes and Planning Interventions in Okana

The section is based on objective four (4) of the study and focuses on the wetland management strategies at Okana and their effectiveness. A number of techniques were used in the assessment of the wetland management regimes in the study area. These include random sampling, purposive sampling and PRA. Random sampling technique was used in the administration of three hundred and eight (308) questionnaires in the study area. Purposive sampling technique was used to obtain information from key informants. A total of forty (40) questionnaires were administered. PRA was used to validate responses obtained during field survey. A total of thirty six (36) members participated in the exercise.

Results

The various wetland resources in the study area and their importance to the local riparian community have been examined in the previous section. The study findings have shown that the resources are quite invaluable to the livelihoods of the local people that their degradation and/or loss would be disastrous. The study has also revealed that the local people have recognized the values of the wetlands to them. This is evident by the formation of a community based self-help group – Okana Community Wetland Self Help Group – that focuses on wetland protection.

The awareness is mainly attributed to the sensitization sessions conducted by VIRED International. Other organizations, which had interacted with the community earlier had minimal impact on the wetland ecosystems since they were task or activity specific and did not link their activities to wetlands. Some of the organizations included VI-AGRO, SANA International, GWAKO and Red Cross among others. In

order to enhance sustained livelihoods, the wetlands must be properly managed. This section examines the various management regimes of the wetland resources with a view to evaluating their effectiveness.

In terms of management of the wetlands in Okana area, the study has established that two (2) management strategies exist. These include rehabilitation of wetland ecosystem and economic diversification initiatives. The rehabilitation of the ecosystem is undertaken by individual members who own land in the wetland area. The alternative economic activities on the other hand are carried out by the members of the Okana Community Wetland Self Help Group. Planning interventions that have existed include the land adjudication, registration and subdivision. While these exist and evident by the presence of Land Title Deeds, the interventions have not been translated into pragmatic management strategies of the wetland resources.

Discussion

This section examines the two (2) existing management strategies of the wetland resources with a view to evaluating their effectiveness in sustaining the livelihoods of the riparian community.

4.5.1 Rehabilitation of Wetland Ecosystem

The analyses of land use changes and the abundance of wetland resources in the study area have indicated a downward trend over the years (Table 4.4). Wetland vegetation has been cleared to give room for agricultural production, particularly rice growing. The activity has seen a vast proportion of the wetland macrophytes cleared through burning, clear cut and uprooting. In fact, a visit or a ride to the site confirms this, and one hardly believes that the open rice fields (Plate 4.5) that stretches to Landi River

towards Sidho, a neighbouring clan, was initially a dense thicket of wetland macrophytes and habitat of numerous fauna.

The clearance has led to the decline of biodiversity either through emigration, extinction or both (Tables 4.30a & b). Given the values of the ecosystems through provision of various goods and services estimated at about KES. 7,277,056 per season, the resources users including riparian community have sensed danger of losing their "glory". Consequently, they have initiated restoration programme of the wetlands. The rehabilitation programme started in the early 2000s by one resident and with time a few members have embraced the initiative. The activity is however confined to one's own land parcel since one is prohibited to undertake the activity in another person's parcel due to both access and use rights.

The programme involves planting of wetland plants (papyruses) on the sites, which have been cleared and selective harvesting of the products, whereby only mature ones are cut. The initiative has been successful and since its launch, residents confess continuous availability of water at the site even during dry seasons. This is due to wetland ecological function of water recharge.

Prior to the initiative, the local people were sensitized on the value of wetlands and trained on the propagation practices of the wetland macrophytes by VIRED International. Though a success, the programme may not last for long and hence complete rehabilitation or restoration of the ecosystem is still in a limbo. Two setbacks are likely to hinder the progress.

First, the programme has not been embraced by all wetland users in the study area. In fact, it is only one resident, who is a member of Okana Wetlands Management Self Help Group, has taken the pain to undertake the initiative. The other members are yet

to take part or show commitment in the restoration programme despite the sensitization and training as well as the fruitful attempts by one of them. The phenomenon confirms the findings of Pomeroy (1995) in the analysis of community participation in resource management. He observes that many communities or people may not be willing to or capable of taking on the responsibility of management of a resource in question. This is due to a long history of dependence on the government to take charge. It therefore requires sometime to be reversed. Besides, there is no guarantee that a community or resource users will organize themselves into an effective governing institution.

To this end, it can rightly be concluded that the rehabilitation initiative is still at an infant or experimental stage and cannot therefore be relied on to offer an effective wetland ecosystem management that would sustain livelihoods. A proper organizational structure that compels all users to participate in a management task is thus necessary. Such a structure should explicitly outline individual member's responsibilities in a larger integral unit.

The second setback concerns ownership of the wetland. Whereas wetlands are trust lands in Kenya, this perception or notion is seldom known by the riparian community. The locals claim ownership of the ecosystems on the basis that their land parcels stretch down to the habitat. Therefore one owns a portion or section of the wetland that corresponds to one's parcel of land. In this context, it becomes extremely difficult for one member to undertake any rehabilitation activity on another person's parcel unless permitted to do so. The scenario therefore confines any rehabilitation of the ecosystem to one's own parcel. Moreover, this is only possible if one accepts to take up the task. It is worth noting that even the member who has embraced the initiative carries out the activity on his own parcel of land. Sensitization of the status of wetland

tenure systems through seminars, workshops, media and chief's *baraza* is very crucial.

4.5.2 Economic Diversification Initiatives

Economic diversification refers to the adoption of alternative sources of livelihoods or income generating activities other than the main or dominant one. The purpose of this is to ease pressure on the resource(s). The practice will therefore help to shift focus on wanton destruction or overexploitation of the resource(s). The types of alternatives or activities that may be chosen vary widely from one place to the other. Identification of the best alternatives requires collaboration between professionals, opinion leaders, entrepreneurs and community members. These experts or groups would help to establish market opportunities, ecological requirements and sustainability of the activities.

The study has revealed that craft making is the second most dominant economic activity after crop farming, accounting to about 80% of the livelihoods (Table 4.16). This implies a potential undue pressure on papyruses and reeds with a possible depletion. However, harvesting of the resources is checked by engagement in other income generating activities such as bee keeping, horticulture, cereal production, aquaculture and agro-forestry. These activities are undertaken by the members of the Okana Community Wetlands Self Help Group (OCWSHG) as ways of sustaining their livelihoods while not depending entirely on the wetland resources. As a Community Based Organization (CBO), members formed different sub-groups or committees in charge of each activity. The activities kicked off well and had good returns at the beginning. However, the group encountered several hiccups, which tampered with their common goal – environmental protection while sustaining their

livelihoods. Leadership problem emerged and mistrust within the management team cropped in where some sub- group or committee leaders personalized their projects and detached completely from the mainstream management team. Consequently, the latter ex-communicated such leaders and only worked with loyal and like minded team leaders. The hiccup can be addressed conveniently at the monitoring and evaluation stage, which is often continuous, in the proposed wetland management model (Fig. 5.1).

Another hiccup is laxity and lack of commitment on the part of the members especially resource users. At the beginning of the activities or projects, members were enthusiastic and all groups picked up. However, the vigour soon waned away and members hardly participated on regular basis. The phenomenon led to drastic decline in the production of wetland goods particularly the handicrafts. The most affected was the craft making strand. As a result, only the horticultural and cereal projects remained steady. A remedial measure for this would probably be regular visitation to centres where similar activities or projects are undertaken. Members or resource users would perhaps learn from their counterparts the virtues of commitment and hard work, and this would be awake up call for the resources users. In the proposed model, it is captured in the capacity building, which comprises seminars, workshops, field days, exhibitions and exchange programmes.

Prolonged dry spell also affected the performance of some of the projects namely fish farming, horticultural farming and agro-forestry. Contrary to the expectation, the Ombeyi-Oruba River which hardly dries up, dried at the time of research study. Since this was the only source of water for fish pond and horticultural farming, the activities had no option but to wind up. Surprisingly enough, water did not dry up completely at the site of wetland rehabilitation. Thanks to the water recharge function of

wetlands. Two lessons are learnt here. The first one concerns appropriate siting of a fish pond based on potential drying up of the river during drought. The second is to do with increased or expanded programme of wetland rehabilitation. Resource users should take up the situation as an impetus and embrace rehabilitation so as to enhance water recharge function of the wetland ecosystem.

It can be derived from the foregoing discussion that the alternative income generating activities - economic diversification - initiated by the OCWSHG, were basically experimentation and cannot be considered as viable management strategy for the wetland resources. Their sustainability and hence effectiveness still hangs in the balance. Nevertheless, they have provided a basis of reference and further implementation of similar management plans. They only provide vital lessons for the monitoring and evaluation in the implementation of a management plan for proper utilization of the wetland ecosystems for sustained livelihoods.

4.5.3 Constraints in Wetland Resource Management

According to the study findings, two management measures exist in Okana area namely, rehabilitation of the wetland ecosystem and economic diversification of livelihoods. These measures have their own weaknesses or shortcomings as have been discussed. The study further reveals a number of constraints, which impact negatively on the effective management of the ecosystems. To begin with is the transboundary nature of wetland resources. Wetland resources are diverse and are seldom confined to any particular boundary whether physiographical, ecological, political or administrative. For instance, a wetland system may extend across parts of two or more regions, communities, counties or countries.

In the context of the study area, the Okana wetlands cover several other villages, which border the sampled twelve (12) villages. All the villages therefore share the Ombeyi-Okana River basin. Besides, the migratory birds, wild game and fish which find habitat in the wetlands as well as mobilized pollutants from upstream catchments are capable of crossing territorial borders. Proper management of these resources thererfore requires involvement and cooperation between the community within the study area and other bordering regions especially those in the upstream catchment whose activities are likely to impact directly on the lower catchment in the study area. This is the essence of the proposed integrated planning and management of the wetland ecosystem. The two management initiatives have not incorporated the strategy.

The second constraint concerns land tenure system of the wetland ecosystem. Two land tenure systems exist at the study area. The wetlands are owned both communally and individually. The latter system of ownership has been shown to enhance resource management (section 4.4.1). However, customary or communal tenure system is usually complex, controversial and poses serious challenges to management of resources. Under the tenure system, every household or member has both access and use rights. A member has the right to cultivate as much land as one can manage, graze livestock anywhere except on land actually under crops, take timber for building and firewood, use water resources for various purposes, use clay, sand and stones from the communal land resources and to choose a site to build a house (Breen et al. 1997; Turner et al. 1994).

In the study area, the wetland resources are accessible to every member of the community for grazing of livestock, harvesting of wetland products such as papyruses, reeds, grasses and other macrophytes, extraction of medicinal herbs,

excavation of clay and abstraction of water. The only check and balance that regulates the use is pegged on membership. That so long as one is a member of the community either by virtue of birth or marriage, he/she qualifies for the access and use rights of the resources. Immigrants who have settled permanently in the community from other places also share these rights. This type of ownership is likely to result into conflicts between individual and communal interests. In the long run, the concept of *Tragedy of the Commons* advanced by Garrett Hardin in 1968 and further revised in 1998 is likely to emerge, where the common resources – wetland ecosystems in this case – are subject to degradation and loss. This is because every member has an incentive to maximize gains and a disincentive to conserve and manage.

The third constraint in wetland resources management in the study area is conflict of interest on the utilization of the resources. It has been shown in section 4.2.3 that the wetland resources have been invaluable in the provision of various goods and services. For instance, while some harvest wetland products for craft making, some consider the ecosystem important grazing fields especially during dry seasons. Another group may use it as rice fields. The latter two groups particularly have had long history of conflicts over conservation and wise use of the wetlands. Mitigation measure for such resource use conflicts lies in a properly designed land use plan such as the proposed one (Fig 4.9b) where each group is catered for.

The foregoing discussion on the management regimes of Okana wetlands clearly shows that there is no proper management of the wetlands in place. In fact, the existing management strategies cannot suffice in the long run given the many weaknesses and constraints outlined. It can therefore be concluded that the strategies are not effective in managing the wetland resources for sustainable livelihoods. The

findings thus answer objective four (4) that sought to assess the effectiveness of the wetland management regimes in Okana area.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

The section provides a summary of the study findings, conclusion and recommendations as well as areas for further scientific research for continuity of knowledge in wetland ecosystems.

5.1 Summary

The study has revealed the following findings namely, that Okana wetlands have been converted into agricultural farmlands and human settlements over the years. The most predominant crop is rice. Other crops are sorghum, maize and vegetables.

The residents of Okana rely on the wetland resources for their livelihoods through water supply, building and construction materials, food supply, source of energy, medicinal products as well as handicrafts, which are sold in the local market centres.

The utilization of Okana wetlands has resulted into several environmental as well as social impacts. Some of the impacts include biodiversity degradation and loss, waste generation leading to pollution of water sources, accidents and injuries including snake bites as well as creation of micro-habitats for parasites and disease vectors.

Finally, the Okana wetlands manifest mostly communal and private property regimes. Each of these regimes has its own implications in terms of management based on the incentives and disincentives associated with them. Management therefore becomes compromised in the long run.

5.2 Conclusion

The study has shown that wetland ecosystems in the study area have actually undergone serious degradation and loss due to land use changes which have taken place over the years. In fact, the resources' abundance over time has indicated a declining trend. The phenomenon is attributed to the wanton encroachment of the wetlands so as to enhance agricultural production as well as to create space for human settlement. The ever increasing human population and economic demand are thus to blame for the menace. The reality of climatic change is not an exception. The latter factor, however, was not considered since it was not within the scope of the study. The situation is exacerbated by the fact that there is no proper or effective wetland management regime.

The findings of the study have also established that wetland resources have contributed significantly to the household income of residents of the study area. This is through the socio-cultural and economic values that they provide to the residents of Okana. The community has utilized the ecosystems as sources of food, water, building and construction materials, and handicrafts, medicinal herbs as well as grazing fields for domesticated animals especially during dry seasons. They also provide important sites for rituals or ceremonies such as ash drive, worship and baptism.

The utilization of wetland resources in the study area has been shown to be associated with myriad of environmental and social problems which are likely to compromise quality of life of the residents. These range from inadequate resource base, waste generation, social conflicts over resources, and human-wildlife conflicts to accidents and injuries. All these put the lives of the residents at stake hence need to be

addressed so as to attain food security, clean and safe water, healthy or clean environment as well as social cohesion or harmonious co-existence. Sustainable use of wetland resources will therefore lead to availability of the basic needs such as food, shelter, health care, clean water and sanitation to the residents of Okana thereby achieving Vision 2030 and Agenda Four (4) as advocated for by the government.

Finally, the study has revealed that there is no specific or comprehensive wetland management regime that can be singled out in the study area. The study has shown a *laizzesfare* type of management where there is no follow up on who does what, how and why.

5.3 Recommendations

Until recently, wetland ecosystems in Kenya and elsewhere have been considered to be of little use – wastelands. Consequently, their disappearance has not captured the attention of many save for scientists and conservationists. This is attributed to wrong perception by the public or communities on the significance of wetland ecosystems. Reversal of the scenario is an imperative given the available information on the ecosystems, the current study being part. For proper planning and management of the wetland ecosystem, the study recommends the following:

1. An integrated wetland management plan for Okana wetland to be implemented by the County Government,
2. Buffering of the wetland by the community to avoid further encroachment,
3. Rehabilitation of the wetland ecosystem by the community for continued livelihood and ecological sustenance.

These recommendations have been outlined in the following sections.

Integrated Wetland Resources Management Plan

It has been established in the results in sections 4.1, 4.2, 4.3 and 4.4 that wetland ecosystems have undergone degradation and loss yet directly or indirectly support the livelihoods of Okana community through the provision of numerous goods and services. The utilization of the wetland resources has also impacted on both environmental and social issues. The wetlands have also been shown not have clear management measures in place at the time of study. That is, there is no proper management of the wetland resources due to constraints such as land tenure systems, conflicts of interests as well as lack of commitment on the part of the resource users. Nevertheless the status of the wetlands should therefore be maintained all the times if the benefits that the ecosystems provide to the community and even beyond are to be retained. The ecosystems should be safeguarded or protected against any likely alterations that may compromise their functions and values.

In order to achieve this noble goal, careful planning of specific tasks or activities tailored towards protection, restoration and wise use of the wetlands is of essence. This calls for knowledge on the land use changes over time, which might have caused or are likely to cause ecological alterations to the wetland ecosystems. Besides, identification of relevant group (s) and institution(s) apart from the inhabitants in and around the wetlands to be incorporated in the planning and management programmes is crucial.

The development of the plan is in line with the provisions of the Environmental Management and Coordination (Conservation and Management of Wetlands) Ammendment Regulations, 2017. The Regulations require that integrated wetland

management plans be developed to prevent and control further degradation of wetlands in Kenya. The details of the plan development process are outlined in the successive sections. This section therefore examines a proposed wetland management plan (Table 5.2) that can aid or help in attaining sustainable wetland resources utilization in the study area and elsewhere if adopted. It also shows a possible land use plan (Fig 4.9b), which is the major output or outcome of the study.

Wetland ecosystems comprise abiotic and biotic features namely water, soil or land, vegetation and fauna. It is the continuous interdependence and interaction of these components that regulate and sustain the functions of the wetlands. Any change in the characteristics of one or more of the components obviously lead to alteration in the status of the ecosystems. Management of the wetlands thus implies managing the specific components such as water, soil, vegetation and animals in order to maintain the functions and values of wetlands. The overall objectives of the management plan include: to involve the Okana community members in the conservation and management of the Okana wetland, to restore the natural habitat of Okana wetland in order to sustain its provision of goods and services to the residents and to promote emerging land uses such as farm forestry, apiculture, aquaculture among others for improvement of livelihoods and climate amelioration in Okana and its environs.

On the basis of the findings on land use changes, role of the wetland resources in enhancing livelihoods, impact of wetlands use in the study area over the years due to increasing human population and economic demand as well as existing management regimes of wetland resources, the research study proposes a land use plan (Fig 4.9b) and a wetland management plan (Table 5.2) for sustainable wetland resource use. The proposed land use plan will be fundamental, if implemented, to guide land uses in the

locality. This is quite essential given that currently, there is no community based institutions in place to oversee natural resource management. In fact, the Okana Community Wetland Group, under the auspices of VIRED International, is at its infancy. It is more of a demonstration or experimental organization than a management institution. What exists presently is the National Land Policy. The proposed plan will help to address the encroachment into the fragile ecosystems – wetlands. It will therefore form a localized management strategy based on the currently existing National Land Policy.

Detailed organizational design of the model is outlined in the following sub-sections. The design explicitly explains the tasks or duties and responsibilities to be undertaken by different people or agencies in the implementation, monitoring and evaluation of the management plan. Besides, the design outlines the various groups, organizations and institutions that have interacted with the community on wetland resource use. In the proposed management plan, several groups have been identified for incorporation into the planning process. The identification was based on their involvement in the wetland resource utilization and research. The groups identified included the following:

(i) Okana Wetland Self Help Group
(ii) County Government
(iii) Media Group
(iv) (VicRes)
(v) NEMA
(vi) Ministry of Water and Irrigation
(ix) World Agroforestry (ICRAF)
(viii) VIRED International
(ix) UHAI Lake Forum
(x) LVEMP
(xi) MENR
(xii) Ministry of Lands
(xiii) Academics
(xiv) Entrepreneurs

Stakeholders' analysis and Institutional Arrangements

The organizations and/or institutions identified have various roles, tasks or duties in the operationalizing/implementing the management plan. Their roles and responsibilities are outlined in the stakeholders' analysis and institutional arrangements (Table 5.1, Appendix V).

Identification of Management Tasks

In the proposed management plan, a number of specific tasks or activities have been identified to be undertaken in the course of the wetland management. These tasks are the actual actions to be carried out or implemented by the identified individuals and groups in the wetland area. The tasks include:

(i) Agro forestry
(ii) Aquaculture
(iii) Landscaping
(iv) Environmental Education and awareness
(v) Training/Seminars/Workshops
(v) Value Addition on Crafts
(vi) Formation of Surveillance Committee
(vii) Nature Reserve
(viii) Selective harvesting of wetland products
(ix) Farm forestry
(xi) Afforestation
(xii) Apiculture
(xiii) Horticulture
(xiv)Eco-tourism
(xv) Paddocking
(xvi) Field days
(xvii) Well construction
(xviii) Craft making
(xx) Documentation/Publication of booklets, posters, calendars, bulletins and brochures on wetland ecosystems and products

Capacity Building

The identified organizations, institutions and the resource users need to come together in a seminar/workshop for training in specific tasks to be carried out. Experts may be drawn from the identified organizations and institutions or other relevant sectors whether governmental or NGOs. The training is essential in order to equip the resource users (riparian community) with relevant skills required in the ecosystem management. The forum is also necessary for familiarization and networking purposes.

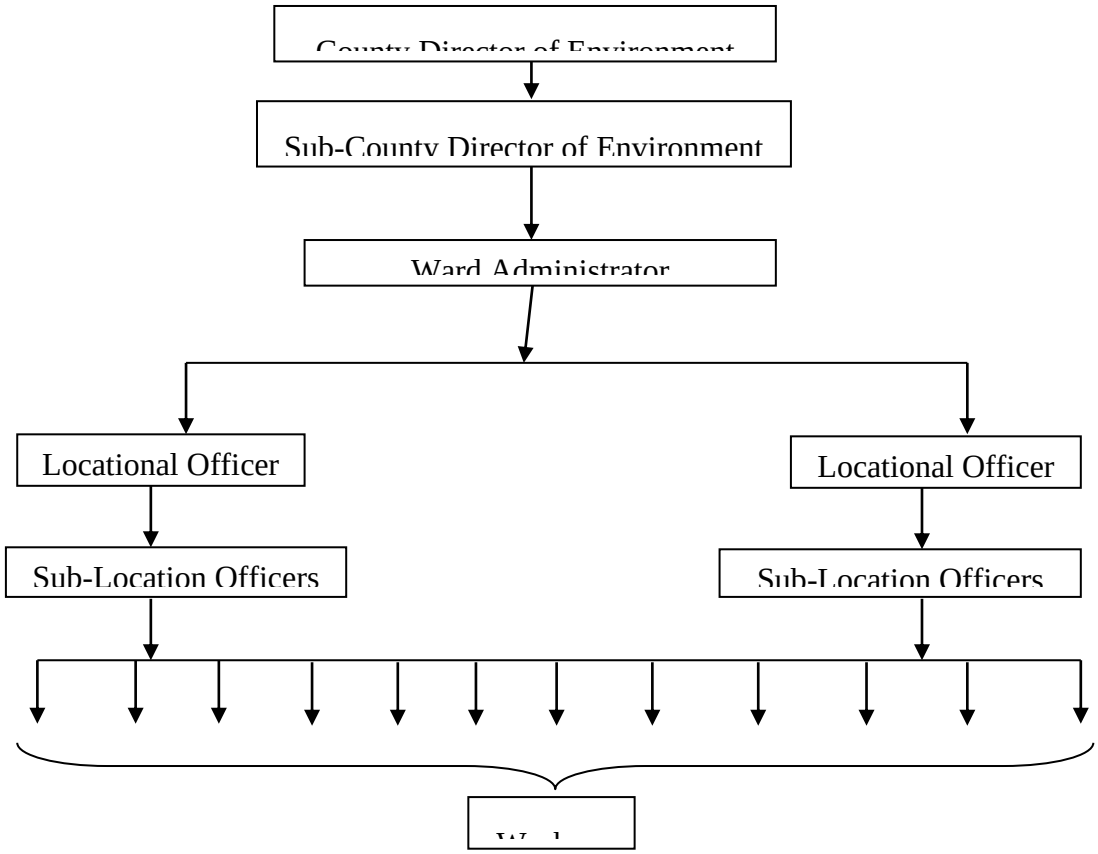
Pilot Project

Pilot exercise commences immediately after capacity building phase. This is a trial phase where the viability of individual project or task is tested. Pilot phase is important because it unravels weaknesses or shortcomings, which might have been overlooked or unforeseen at the initial phase. It therefore provides an opportunity for further improvement or incorporation of any omissions.

Operationalization of Wetland Management

The final phase of a management programme is the actual implementation of the tasks outlined. This involves the translation of the land use plan into reality. In the current study, the researcher proposes a land use plan (Fig 5.2) where each task identified and other land uses such as human settlement, market or trading centre, craft making centres among others have been designated. The riparian community or inhabitants of Okana wetlands under the auspices of OWSHG are expected to form small sub-groups or committees, where each group or committee is assigned a particular task now called project such as agro forestry project, apiculture project or aquaculture project. The criteria used in the formation of OWSHG are to be adopted in the

formation of the sub-groups or committees. Other finer details of implementation are to be referred to in the Logical Framework of Activities (Table 5.3, Appendix V) and Okana Community Wetland Management Action Plan (Table 5.4, Appendix V) developed during PRA exercise by the community facilitated by the PRA team. Figure 5.1 shows an institutional structure derived from the organizational design of the proposed wetland management plan.



Ward Administrator is in charge of several Locations while the latter also oversee several Sub-Locations hence parallel officers in the figure

Figure: 5.1 Institutional Structure of Okana Wetland Management.

(Source: Author, 2023)

In summary, the proposed management plan and accompanying organizational structure for its execution will ensure sustainable utilization of the wetland resources in the study area and even elsewhere in the country and even beyond. The plan is in tandem with environmental management plans in countries such as India where environmental issues have been seriously and effectively addressed by the government (Nag & Vizayakumar, 2012). The provincial administration namely, the Assistant County Commissioners, establish environmental offices at the Sub-County, locational and sub-locational levels to oversee environmental management issues – solid waste management – at the stated administrative levels. The officers at the lower ranks or levels report regularly to the Assistant County Commissioner on the status of garbage collection activity.

In our context (Kenya's case), the institutional structure in Fig 5.1 can be entrenched in the National Government where a uniform management of the environment, wetlands included, is ensured. Besides the institutional framework, sufficient budgetary allocation for the established departments is necessary in order to ensure that environmental matters are prioritized. If the recommendation is adopted and properly implemented, then unsustainable utilization of the wetlands would be addressed.

The plan shows a number of land uses to be adopted in the study area. The land uses include agriculture, human settlements, trade as well as forestry and public utility. All the land uses are sited strategically so as to leave a buffer zone for the riverine and flood plain wetlands in order to conserve the wetland ecosystem from a possible degradation and/or loss (Fig. 5.2).

Monitoring and Evaluation

Monitoring and evaluation of the implementation of the management plan become necessary at this stage. The processes assess whether the specific projects have kicked off as planned, problems encountered and what needs to be done to address the problems if any. Monitoring and evaluation are continuous processes and provide an opportunity for constant review from time to time as may be required.

Monitoring is important since it keeps the interest of the community high about the activities being implemented. Its absence may lower the enthusiasm with which the implementation of the action plan started. Lelo et al. (2001) observe that people are usually active and aggressive at the initial stages of an activity because they hope that their lives will be better off, but eventually give up or abandon the activity altogether as the outcomes become unclear or take too long to be realized. Besides, monitoring and evaluation will also help to know whether the activities are being carried out as planned, how to improve the effectiveness and efficiency of the activities, whether the activities are achieving the desired outcomes, whether the activities are having the anticipated negative impacts, how to convince others of the merits of other groups efforts, and influence policy makers as well as critical stakeholders and partners within the community.

The whole process of sustainable management of wetland resources can be summarized in a flow diagram as indicated in Figure 5.2. The proposed management plan is cyclic in nature and therefore conforms to any other spatial planning process which involves a cyclic activity (Koomen, 2008; WISA, 2013) for practical implementation.

The plan is cyclic in that it begins with problem identification and definition then moves to formulation of objectives, capacity building and piloting before actual implementation. Monitoring and evaluation stage or phase is where every preceding stage is interrogated for efficiency and/or effectiveness. If it is detected that desired outcome is not realized then the evaluation report reveals the phase or stage that had missing link or defect. Then the process "moves" back to that stage for correction. Once corrected, the plan proceeds to the subsequent phases through to monitoring and evaluation, hence cyclic.

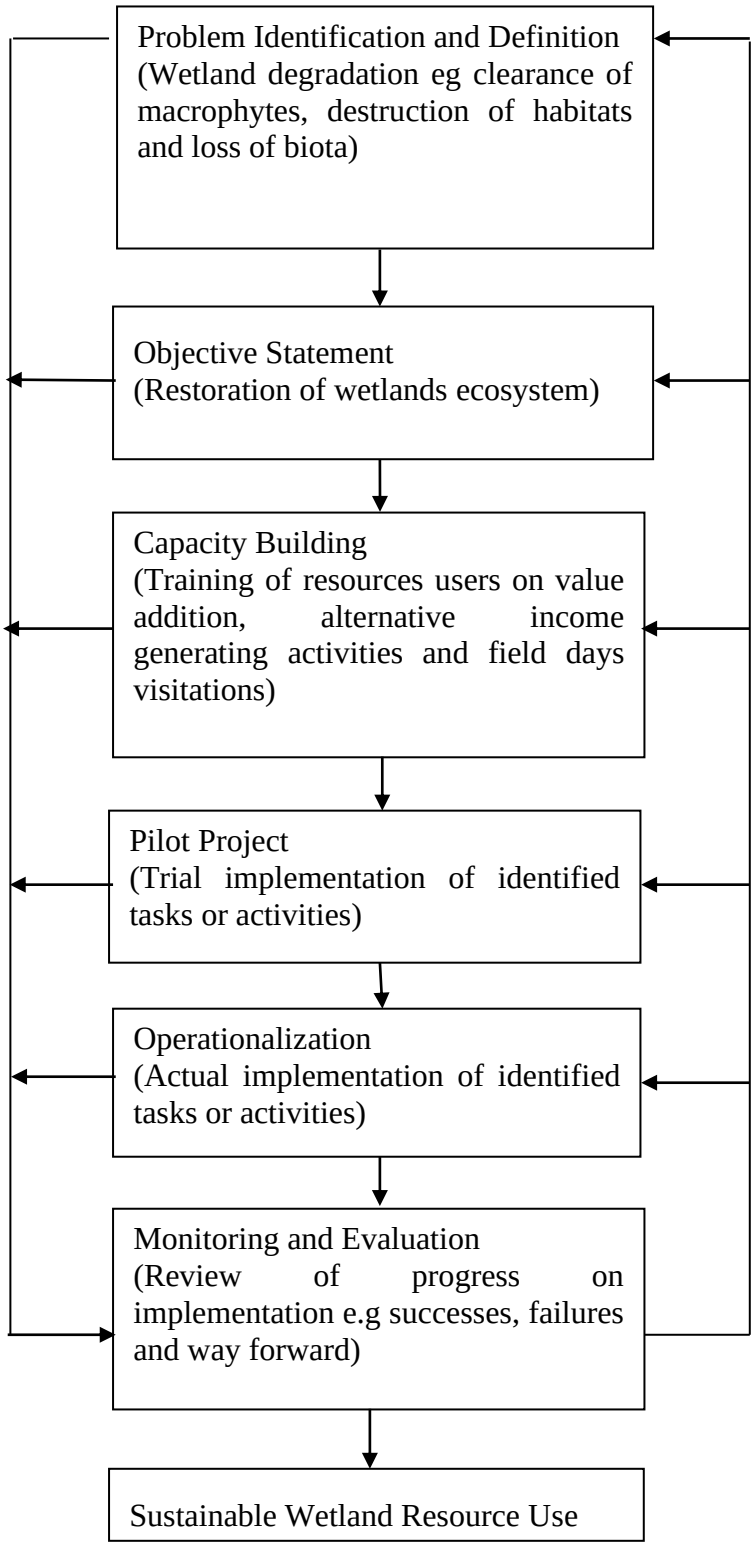


Figure: 5.2 Phases in the development of Okana Wetland Management Plan.

(Source: Author, 2023)

In conclusion, the study has established that the land use changes in Okana since 1960s point to an inevitable environmental degradation. This is evident by the vegetation cover, which has a declining trend over the years depicted by the LANDSAT satellite images for the period and confirmed by the residents of the study area during a PRA exercise (Fig 4.1). The situation is expected to become worse if not reversed. Besides, poverty index, which is already high at 60.5% (GOK, 2019a&b) is likely to rise. Immediate remedy lies in the implementation of an integrated environmental management plan, such as the proposed one where the institutional structure or framework (Fig 5.1) is established by the National Government with adequate budgetary allocation for proper implementation and prioritization of environmental matters in the country.

Buffering of the Wetland

Buffering of the wetland area is necessary in order to avoid further encroachment of the ecosystem. This is done by fencing off the wetland area based on the NEMA regulations on riparian areas. NEMA recommends a buffer zone of the riparian area of about 100 m from the water source such as stream, river or lake. In the context of the study area, the buffer zone is recommended to be about 100 m from the Landi River (Figs. 5.3a & b).

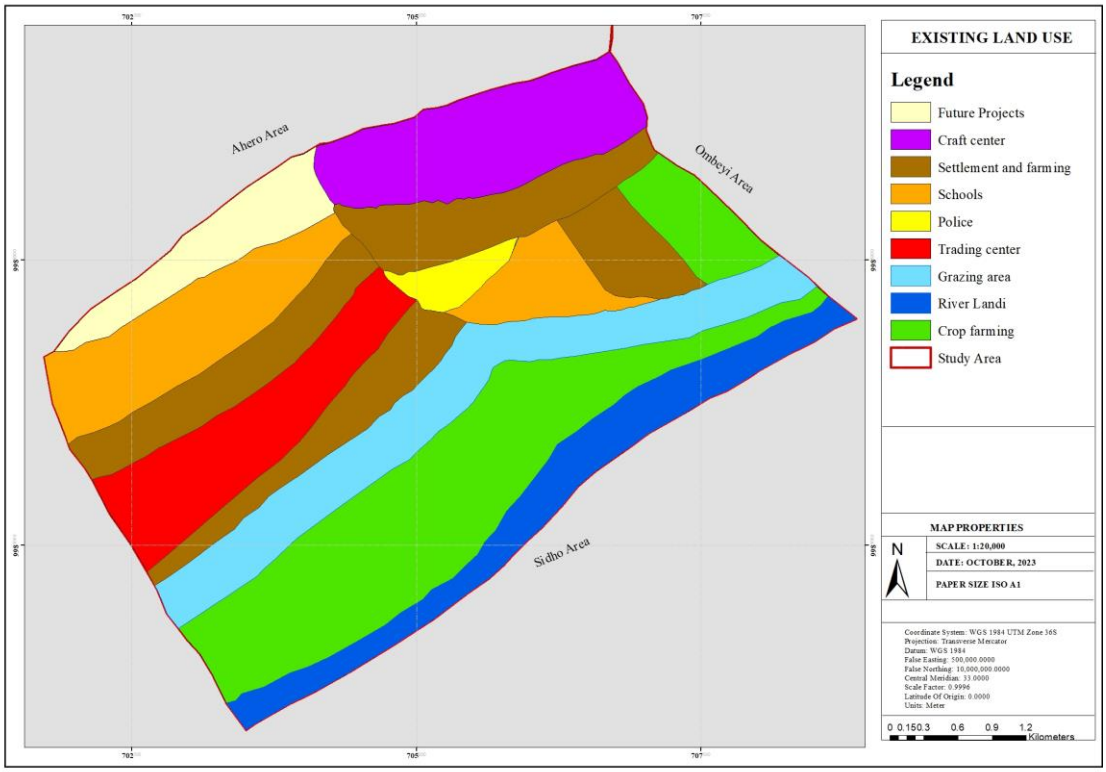
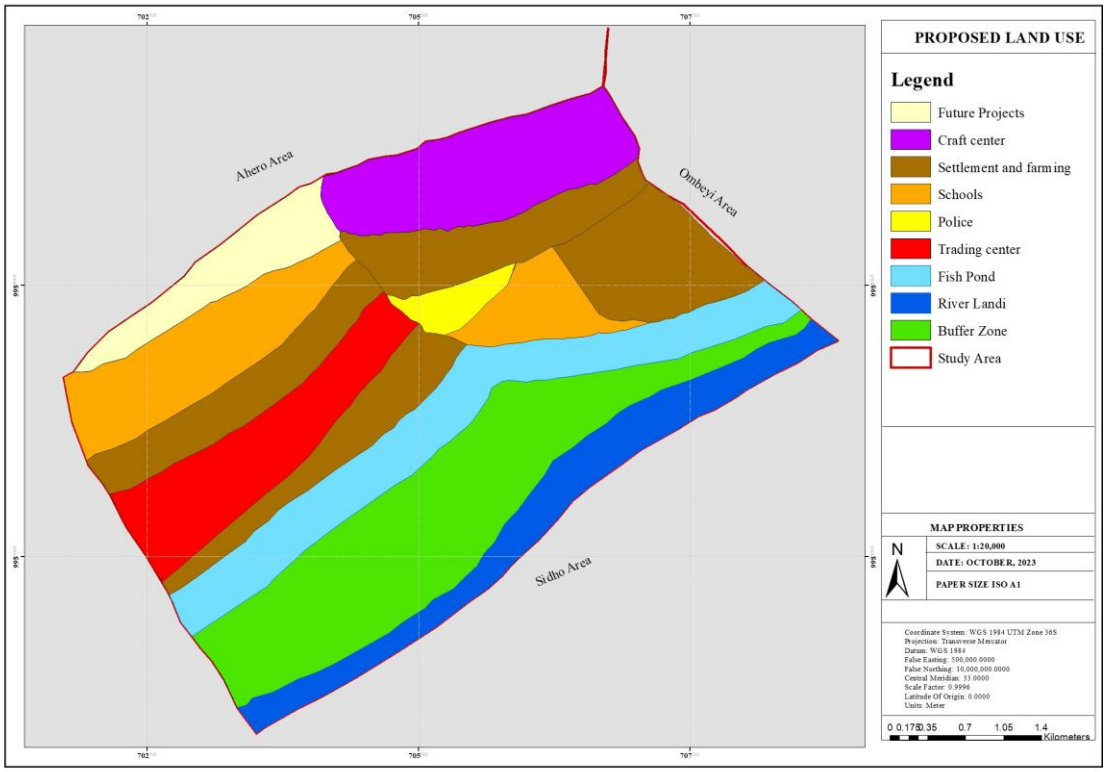


Figure: 5.3a. Current Land Use in Okana.

(Source: Author, 2023)



The buffer zone covers about 100 m from the Landi River. The coverage is as per the National Environment Management Authority (NEMA) regulations regarding riparian ecosystems.

Figure: 5.3b Proposed Land Use Plan for Okana.

(Source: Author, 2023)

Rehabilitation of Wetland Ecosystem

This strategy of wetland management is important for continued utilization of the resources for sustained livelihoods. It is achievable through adoption of the following mechanisms:

Co-management

Co-management is a management strategy that involves a partnership or collaboration between different government institutions, agencies, civil society, researchers, NGOs as well as the wetland resource users (Fig. 5.4). In the partnership arrangement, the

resources users normally take the lead in the implementation of activities and enforcement of the by-laws, policies and regulations agreed upon. This is because the resource users are direct beneficiaries if the wetland resources are used sustainably or bound to suffer severely if the resources are degraded and/or lost. Besides, the resource users are at the grass root level and know or capable of knowing the notorious violators of the regulations and can always come up with the best strategies to contain such known offenders (Borrini-Feyerabend, 1996; Kyangwa, 2003). The Co-management as a strategy thus encourages a Bottom-Up approach where the ideologies of the resource users are incorporated in the management plans. In the approach, integration between various actors implies that the stakeholders may initiate their own planning process, but co-ordinate these processes with government. However, the bulk of the implementation will be left to government, as it is custodians of the public good, with national government providing the policy framework within which decisions are taken and legislative framework and regulating the corporations, and county government delivering services to the resource users. The Co-management strategy has also emerged to be effective in resolving resource use conflicts that arise between different actors both at the local, national or regional levels (Raburu et al. 2012).

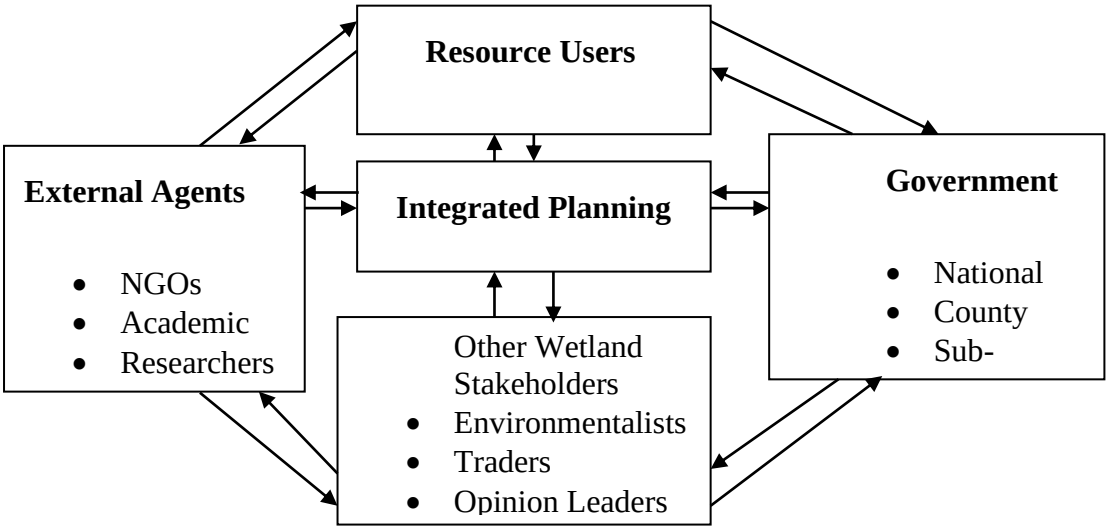


Figure: 5.4 Co-management Approach.

(Source: Modified from Pomeroy, 1995)

Incorporation of Indigenous Knowledge

Indigenous knowledge is quite essential in the management of natural resources. In the planning and management of wetland resources – subset of natural resources – it is imperative that indigenous knowledge be incorporated if sound conservation and management is to be realized. This will also result into sustainable development since such knowledge will consider the economic, social and environmental pillars in Natural Resource Use Theory as advocated for by Firey (1961) in his studies of natural resource utilization.

Environmental Economics

The various wetland-based activities are capable of sustaining the quality of the immediate environment. The sustenance lies on the returns or benefits that accrue

from the sale of wetland products (Turner et al. 1994). However, the levies on wetland products are never ploughed back into an activity that is tailored towards environmental protection. All the levies charged on the wetland products end up in the fiscal programmmes of the national and county governments. A structure should therefore be established either at the sub-county, county or national level that ensures that a given percentage of the levies on wetland products are channeled to environmental protection activities. Co-management provides mechanisms for such negotiations, where all parties are involved.

Eco-tourism

Eco-tourism is defined as responsible travel or visitation to relatively undisturbed natural areas that conserves the environment and improves the well-being of local people (Sanabria, 2001; Awange & Ong'ang'a, 2006). Eco-tourism will provide a means of avoiding environmental degradation while at the same time sharing economic benefits with local people. The activity will form yet another alternative livelihood option to the community in addition to the ones already under experimentation. It will help finance the protection of the ecologically sensitive areas such as wetland ecosystems and support the socio-economic development of the community under study and even adjacent areas.

The findings have revealed an abundance of biodiversity of flora and fauna, some of which are endangered and threatened with extinction (Table 4.30a&b). The high biodiversity index can be conserved and managed through creation or establishment of a community-based nature reserve in order to protect the endangered wildlife. The strategy will not only enhance biodiversity conservation and management, but will

also accrue income to the local people. Eco-tourism potential is based on the fact that the wetland ecosystem is communally owned. What needs to be done is an integrated impact assessment, which incorporates environmental, social, economic and ecological aspects, and a formal application to the Kenya Wildlife Service (KWS) for approval and permission. Another prerequisite is consent by all members to start the activity as proposed in the land use plan (Fig 5.2b). In the study area, some of the potential eco-tourism activities include scenic beauty, terrain view, bird watching, nature reserve, annual field days on conservation and management efforts on agro forestry, aquaculture, apiculture, forestry, horticulture and handicrafts.

Women involvement in the planning and management

Women, since time immemorial, have played a vital role in the management of natural resources. This is perhaps because of their frequent use of resources such as land, water, forests and wildlife, which constitute wetland ecosystems. However, they have been ignored by the legal and policy instruments in the new processes of natural resources management contained in the reforms for the sector plan for environment, water and sanitation whose goal is sustainable development. In Kenya, women account for about 50.7% of the national population (GOK, 2019a&b) yet they are still under represented in environmental decision making processes at all levels. In fact, the rural women majorly miss out in the scene yet they are the main managers of natural resources (GOK, 2013a&b).

The study has established that women do take active role in the wetland resources use, right from extraction of the materials from the site, transportation to making of the handicrafts as well as marketing of the products. However, they remain passive in the

use of such proceeds as well as management of the resources. The phenomenon therefore marginalizes women, their skills and experiences. The situation puts at stake sustainable management of wetland resources. The role of women as natural resource managers ought to be recognized and enhanced by incorporating them into the planning and management process right from problem identification, implementation, monitoring and evaluation stages. The recommendation has also been echoed by scholars such as Opata (2004), Iyango & Ndiyabarema (1995), Nzioki (1992), Kanogo (1992), Khasiani (1992), Khamati (1992) and Omosa (1992) in their analyses of the role of women in both resource management and development.

5.4 Areas for Further Research

The following areas or aspects have been suggested for further research:

- A comprehensive study on the economic valuation of non-consumptive uses or ecological functions of wetland ecosystems to be done.
- Monitoring and analysis of threatened wetland sites and species taking into consideration the quantitative statistics of the biological populations of flora and fauna in these ecosystems.
- A comprehensive assessment of the effect of modern agriculture especially the use of agricultural chemicals like fertilizers, herbicides and pesticides on the wetland ecology.

REFERENCES

Abila, R. (2005). *Local Adaptations, Comparative Trophic Ecology and Phylogenetic Analysis of the Haplochromine cichlids of Lake Kanyaboli, a Satellite Lake Victoria, Kenya*. Unpublished PhD Thesis, Maseno University, Kenya.

Abira, M. A. (1997). Water Resources. In: Ogola, J. S., Abira, M. A. & Awuor, V. O. (eds) *Potential Impacts of Climate Change in Kenya*. Nairobi, CAN.

AMCEN (1994). *African Common Perspectives and Position on the Convention on Biological Diversity*. Nairobi, Kenya, GPO.

Anonymous (1997). *Wetlands and Integrated River Basin Management: Experiences in Asia and Pacific*. Kuala Lumpur. UNEP/Wetlands International – Asia Pacific.

Auriacombe, C. & Ackron, J. (2015). *Integrated Development Planning*. Johannesburg, University of Johannesburg.

Awange, J. L. & Ong'ang'a, O. (2006). *Lake Victoria: Ecology, Resources and Environment*. New York, Springer.

Babbie, E. (1986). *The Practice of Social Science*. Belmont, C. A., Wadsworth.

Bakema, R. J. & Iyango, L. (2000). *Engaging Local Users in the Management of Wetland Resources: The Case of the National Wetlands Programme, Uganda*. Kampala, IUCN.

Barbier, T. (1994). *Economics of Natural Resources*. Oxford, OUP.

Beentje, H. J. (1994). *Kenya: Trees, Shrubs and Lianas*. Nairobi, National Museums of Kenya.

Bennun, L. & Njoroge, P. (1999). *Important bird watching areas in Kenya*. East Africa Natural History Society.

Blanche, T., Durrheim, M. K., & Desmond, P. (2006). *Research in Practice: Applied Methods for the Social Sciences*. Cape Town, University of Cape Town Press.

Blundel, M. (1987). *Wild flowers of East Africa*. William Collins Sons & Co. Ltd.

Borrini-Feyerabend, G. (1996). *Collaborative Management of Protected Areas: Tailoring the Approach.* Issues in Social Policy. Gland (Switzerland), IUCN.

Branch, B. (1992). *Bill Branch's field guide to the snakes and other reptiles of SouthernAfrica*. Cape Town, Struik Publishers.

Breen, C. M., Quinn, N. M. & Mander, J. J. (1997). *Wetlands Conservation and Management in southern Africa: Challenges and Opportunities*. Regional Office of Southern Africa, Harare, IUCN.

Briggs, D. & Courtney, F. (1989). *Agriculture and Environment: The Physical Geography of Temperate Agricultural Systems*. UK, Longman Scientific & Technical.

Britton, R. H. & Crivelli, A. J. (1993). Wetlands of southern Europe and North Africa: Mediterranean wetlands. In: Whigham, D., Dykyjova, D. & Hejny, S. (eds) *Wetlands of the world: Inventory, ecology and management*. London, Kluwer Academic Publishers.

Brown, L. (1979). *Grasses: An Identified guide*. New York, Houghton Mifflin Company.

Bryman, A. (2004). *Social Research Methods*. Oxford, Oxford University Press.

Burton, M. & Burton, R. (1969). *The International Wildlife Encyclopedia*. New York, Marshal Cavendish Corporation.

Corbet, G. B. & Hill, J. E. (1991). *A world list of mammalian species*. Oxford, Oxford

University Press. Natural History Museum Publications.

Crafter, S. A., Njuguna, S. G. & Howard, G. W. (1992). (eds) *Wetlands of Kenya: Proceedings of a Seminar on Wetlands of Kenya*. Nairobi, IUCN.

DFID (2001). *Sustainable Livelihoods Guidance Sheets*. UK, DFID.

DMCN (2002). *Factoring of Weather and Climate Information and Products into Disaster Management Policy: A Contribution to Strategies for Disaster Reduction in Kenya*. Nairobi, IGAD.

EASWN (2013). *Lake Victoria Climate Change Readiness Brief No. 2.: Progress and level of implementation of the East African Community Climate Change Policy commitments in the Lake Victoria Basin with respect to water and sanitation*. EASWN, Kenya.

Ellis, F. (2000). *Rural Livelihood and Diversity in Developing countries*. New York, OUP.

EMCAR (2017). Environmental Management and Coordination (Conservation and Management of Wetlands) Ammendment Regulations.

Emerton, L., Iyango, L., Luwum, P. & Malinga, A. (1999). *The Present Economic Value of Nakivubo Urban Wetland, Uganda*. Kampala, IUCN.

Emerton, L. & Kekulandala, L. D. C. B. (2003). *Assessment of the Economic Value of Muthurajawela Wetland*. Sri Lanka, Occasional Papers of IUCN. No. 4, January, 2003.

Firey, W. (1961). *Model of Natural Resource Use*. London, John Wiley & Sons.

Gichuki, J., Guebas, F. D., Mugo, J., Rabuor, C. O., Triest, L. & Dehairs, F. (2001). *Species Inventory and the Local Uses of the Plants and Fishes of the Lower Sondu-Miriu Wetland of Lake Victoria, Kenya*.

GOK (1994). *National Environment Action Plan.* Ministry of Environment and Natural Resources. Nairobi, GPO.

(2002). Nyando District Development Plan (2002-2008*) Effective Management for Sustainable Economic Growth and poverty Reduction*. Ministry of Finance and Planning. Nairobi, GPO.

(2005). *Final Draft (revised) Sessional Paper on National Wetlands Conservation and Management*. Nairobi, GPO.

(2007). *Guidelines for the wise use and conservation of wetlands*. Ministry of Lands: Physical Planning Department. Nairobi, GPO.

_____ (2009a). Kisumu East District Development Plan (2008-2012*) Kenya Vision 2030 Towards a Globally Competitive and Prosperous Kenya.* Ministry of State for Planning, National Development and Vision 2030. Nairobi, GPO.

_____(2009b). Nyando District Development Plan (2008-2012*) Kenya Vision 2030 Towards a Globally Competitive and Prosperous Kenya.* Ministry of State for Planning, National Development and Vision 2030. Nairobi, GPO.

_____ (2010). *2009 Kenya Population and Housing Census*. KNBS. Nairobi, GPO.

_____ (2013a). *Sector Plan for Environment, Water and Sanitation 2013-2017*. Ministry of Environment, Water and Natural Resources. Nairobi, GPO.

_____(2013b). *Sector Plan for Land Reforms 2013-2017*. Ministry of Lands, Housing and Urban Development. Nairobi, GPO.

_____(2013c). Kisumu County Development Profile. *Kenya Vision 2030 Towards a Globally Competitive and Prosperous Nation.* Ministry of Devolution and Planning. Nairobi, GPO.

_____ (2018). Kisumu County Integrated Development Plan 2018-2022.

_____ (2019a). *2019 Kenya Population and Housing Census*: Volume I. Kenya National Bureau of Statistics (KNBS). Nairobi,GPO.

_____ (2019b). *2019 Kenya Population and Housing Census*: Volume II. Kenya National Bureau of Statistics (KNBS). Nairobi, GPO.

Granger, T. (1989). *A Guide to Conducting Wetlands Inventories*. Washington State Department of Ecology. Washington DC, USA.

Guggisberg, C. A. W. (1986). *Birds of East Africa*. Vol. I. Mount Kenya Sundries Ltd.

Guggisberg, C. A. W. (1994). *Birds of East Africa*. Vol. II. Mount Kenya Sundries Ltd.

Hardin, G. (1998). Extentions of "The tragedy of the commons." *Science*, 280 (5364):682-683.

Harper, D. M. & Mavuti, K. M. (1996). Freshwater Wetlands and Marshes. In: MacClanahan, T. R. & T. P. (eds) *East African Ecosystems and their Conservation*. New York, OUP.

Hedges, N. G. (1983). *Reptiles and Amphibians of East Africa.* Kenya Literature Bureau.

Helliwell, D. R. (1985). *Planning for Nature Conservation*. Chichester, PackardPublishing Limited.

Howard, G. W. & Matindi, S. W. (undated). *Alien Invasive Species in Africa's Wetlands: Some threats and solutions*. Nairobi, IUCN.

Howard, R. & Moore, A. (1994). *A complete checklist of birds of the world.* London,Academic Press.

Ivens, G. W. (1967). *East African weeds and their control*. London, Oxford University Press.

Iyango, E. & Ndyabarema, J. (1995). *Assessment of Gender Participation in Craft Making in Kyojja Wetland, Masaka District, Uganda*. Kampala, IUCN.

Kamukala, G. L. & Crafter, S. A. (1993). *Wetlands of Tanzania: Proceedings of a Seminar on Wetlands of Tanzania*. Morogoro, IUCN.

Kanogo, T. (1992). Women and environment in history. In: Kameri-Mbote, P. (1992) (ed) *African Women as Environmental Managers*.Nairobi, ACTS Press.

Kapiyo, R. A., Kibwage, J. K. & Abila, R. O. (2003). *The Status of Fisheries and Fishing Activities of the Sondu-Miriu River*. Nairobi, Kenya Power Generating Company.

Kareri, R. W. (1992). The Sociological and Economic Values of Kenya's Wetlands. In: Crafter, S. A., Njuguna, S. G. & Howard, G. W. (1992) (eds) *Wetlands of Kenya: Proceedings of a Seminar on Wetlands of Kenya*. Nairobi, IUCN.

Kasoma, P. B. (2003). *Wetlands Research in the Lake Victoria Region: A Literature Review for Uganda*. Kampala, IUCEA.

Kasomo, D. (2007). *Research Methods in Humanities and Education*. Eldoret, Zapf

Chancery Research and Consultants and Publishers.

Katondo, J. M. (2005). Traditional uses of Cyperus papyrus (L) and associated problems at Simiyu fringing wetland of Lake Victoria, Mwanza region, Tanzania. In LVEMP Publication: *Knowledge and Experiences gained from managing the Lake Victoria Ecosystem*. Dar es Salaam. Regional Secretariat LVEMP Vice President's Office.

Kibwage, J. K., Onyango, P. O. and Bakamwesiga, H. (2008). Local institutions for sustaining wetland resources and community livelihoods in the Lake Victoria

Basin. *African Journal of Environmental Science and Technology*. Vol. 2(5). Pp. 97-106.

Khamati, B. (1992). Women's role in the supply of fuelwood. In: Kameri-Mbote, P. (1992) (ed) *African Women as Environmental Managers*. Nairobi, ACTSPress.

Khan, M. S., Haq, S., Rahman, A. A., Rashid, S. M. A. & Ahmed, H. (1994) (eds). *Wetlands of Bangladesh*. Dhanmondi, BCAS.

Khasiani, S. (1992). Women in soil and water conservation: an assessment. In: Kameri-Mbote, P. (1992) (ed) *African Women as Environmental Managers*. Nairobi, ACTS Press.

KLA (2005). Poverty reduction or the creation of environmental disaster: Dominion Farms (K) Limited and Yala swamp. *The Standard Newspaper*. Wednesday, December 14, 2005. Nairobi, GPO.

_____ (2008). *Wise or unwise? A survey of Some Wetlands in Kenya*. Final Report, Nairobi.

Kokwaro, J. O. (1972). *Luo-English Botanical Dictionary*. East African Publishing House.

_____ (1994). *Flowering plant families of East Africa. Introduction to plant Taxonomy*. East African Educational Publishers.

_____ (2009). Medicinal Plants of East Africa. Nairobi, University of Nairobi Press.

Koomen, E. (2008). *Spatial analysis in support of physical planning*. Netherlands, Netherlands Organization for scientific Research (NOW).

KWWG (1992). Seminar recommendations. In: Crafter, S. A. Njuguna, S .G. & Howard, G. W. (1992) (eds) *Wetlands of Kenya: Proceedings of a Seminar on Wetlands of Kenya*. Nairobi, IUCN.

Kyangwa, M. (2003). *Regulation of Uganda's Lake Victoria Fishery: A framework for the Involvement of Community-based Institutions*. Unpublished Masters Thesis, Moi University, Eldoret.

Le Bas, M. J. (1977). *Carbonatite – Nephelinite Volcanism: An African Case History*. London, John Wiley & Sons.

Lelo, F. K., Muhia, R. N. & Yobterik, A. (2001). *Manual for Facilitating Resource Management*. Nairobi, LVEMP.

Lungayia, H. B. (1994). Some Observations on the African Catfish *Clarias gariepinus* (Burchell) in the Sondu-Miriu of Lake Victoria, Kenya. In: Okemwa, E., Wakwabi, E. & Getabu, A. (eds) (1994) *Recent Trends of Research on Lake Victoria Fisheries: Proceedings of the Second EEC Regional Seminar on Recent Trends of Research on Lake Victoria Fisheries*. Nairobi, ICIPE SCIENCE PRESS.

Lutgens, F. K. & Tarbuck, E. J. (2000). *Essentials of Geology*. New Jersey, Prentice-Hall, Inc.

LVEMP (1998). *Rapid Assessment of Wetlands in Yala River Drainage Basin*. Busia, Kenya, LVEMP Wetland Management Component _____(2000a). *Rapid Assessment of Wetlands in Nyando River Drainage Basin*. Busia, Kenya, LVEMP Wetland Management Component.

_____(2000b). R*eport on Survey carried out in Okana-Ombeyi and Nyando delta Wetlands*. Busia, Kenya, LVEMP Wetlands Managenet Component.

_____ (2001). *Rapid Assessment of Wetlands in Sondu-Miriu river Drainage Basin*. Busia, Kenya, LVEMP Wetland Management Component.

_____ (2002). *An Assessment of Wetlands of the Lake Victoria Basin*. Bulletin Issue No. 3.

_____ (2014). *Ombeyi Integrated Wetland Management Plan: A Sustainably Managed Ombeyi Wetland for Improved Community Livelihoods*. Kisumu, Ministry of Environment, Water and Natural Resources.

Manyala, J. O. (1994). Floodplain Fishery of the Lower Sondu-Miriu River with

Emphasis on Nile Perch *Lates nilotica* L. In: Okemwa, E., Wakwabi, E. & Getabu, A. (eds) (1994) *Recent Trends of Research on Lake Victoria Fisheries: Proceedings of the Second EEC Regional Seminar on Recent Trends of Research on Lake Victoria Fisheries*. Nairobi, ICIPE SCIENCE PRESS.

Masese, F. O., Raburu, P. O. and Kwena, F. (2012). Threats to the Nyando Wetland. In:Raburu, P. O., Okeyo-Owuor, J. B. and Kwena, F. (2012). (eds). *Community Based Approach to the Management of Nyando Wetland, Lake Voctoria Basin, Kenya*. Nairobi, KDC-VIRED-UNDP.

Maskini, M. & Hongo, H. (2005). Impact of livestock grazing to fringing wetlands of Lake Victoria, Tanzania. In: LVEMP Publication: *Knowledge and Experiences gained from managing the Lake Victoria Ecosystem.* Dar es Salaam. Regional Secretariat LVEMP Vice President's Office.

Maundu, P. M., Ngugi, G. W. & Kabuye, C. H. S. (2000). *Traditional food plants*

of Kenya. Published by Kenya Resource Centre for Indigenous Knowledge (KENRIK). Nairobi, National Museums of Kenya.

Maynes, C. W. (1996). *Bottom-Up Foreign Policy*. Slate Group, LLC.

Medina, M. (1998). Border Scavenging: A Case Study of Aluminium Recycling in Laredo, TX and Nuevo Laredo, Mexico. *Resources, Conservation and Recycling*. Vol. 23: Philadelphia, Elsevier Science.

McClanahan, T. R. & Young, T.P. (1996) (eds). *East African Ecosystems and their Conservation*. New York, OUP.

MEA (2005). *Millenium Eacosystems Assessment, Ecosystems, and Human Well-Being: Wetlands and Water Synthesis*. Washington DC, WorldResources Institute.

Mitsch, W. J. & Gosselink, J. G. (2000). *Wetlands*. (3rd Edition). New York, Von Nostrand Reinhold.

_____(2007). *Wetlands*. (4th Edition). New York, John Wiley & Sons, Inc.

Moore, D. (1984). *Where to watch birds in Kenya*. Nairobi, Trans – Africa, Kenya.

Moss, B. (1992). Case Study: Lowland Wetland Conservation. In: Berry, R. J. (ed) *Environmental Dilemmas, Ethics and Decisions*. London, Chapman & Hall,

Mugenda, O. N. & Mugenda, A. G. (2003). *Reseach Methods: Quantitative and Qualitative Approaches*. Nairobi, ACTS Press.

Mungai, D. N. Swallow, B., Mburu, J. K., Onyango, L. & Njui, A. (2004) (eds).*Proceedings of a Workshop on Reversing Environmental and Agricultural Decline in the Nyando River Basin*. Kisusmu, World Agroforestry Centre.

Mwanuzi, F. L. (2003). *Literature Review in Wetlands of Tanzania*. Dar es Salaam, IUCEA.

Mwashote, B. M. & Shimbira, W. (1994). Some Limnological Characteristics of the Lower Sondu-Miriu River, Kenya. In: Okemwa, E., Wakwabi, E. & Getabu, A. (eds) (1994) *Recent Trends of Research on Lake Victoria Fisheries: Proceedings of the Second EEC Regional Seminar on Recent Trends of Research on Lake Victoria Fisheries*. Nairobi, ICIPE SCIENCE PRESS.

Nag, A. & Vizayakumar, K. (2012). *Evironmental Education and Solid waste Management*. New Delhi, New Age International Ltd, Pulishers.

NBI (2018). Kenya Wetlands Governance and Management Profile.

Neuman, W. L. & Robson, K. (2009). *Basics of Social Research: Quantitative and Qualitative Approaches*. Toronto, Pearson Allyn & Bacon.

Ng'eno, F. (1992). Seasonal Wetlands in Nairobi. In: Crafter, S. A., Njuguna, S.G. & Howard, G. W. (1992) (eds) *Wetlands of Kenya: Proceedings of the Kenya Wetlands Working Group Seminar on Wetlands of Kenya*. Nairobi, National Museums of Kenya.

Njagi, C. M. (2016). *Policy Review on Sustanable Management of Wetlands in*

Kenya: A Case study of the Kimana Wetland, Kajiado County.Masters Thesis, University of Nairobi.

Nyamweru, C. (1992). Origins and geomorphology of Kenya's wetlands. In: Crafter, S. A. Njuguna, S. G. & Howard, G. W. (1992) (eds) *Wetlands of Kenya Proceedings of a Seminar on Wetlands of Kenya*. Nairobi, IUCN.

Nzioki, A. (1992). Women: invisible managers of natural resources. In: Kameri-Mbote, P. (1992) (ed) *African Women as Environmental Managers*. Nairobi, ACTS Press.

Obiero, K. O., Raburu, P. O. and Masese, F. O. (2012). Manageing Nyando Wetland in the face of Climate Change. In: Raburu, P. O., Okeyo-Owuor, J. B. and

Kwena, F. (2012). (eds). *Community Based Approach to the Management of Nyando*

Wetland, Lake Victoria Basin, Kenya. Nairobi, KDC-VIRED-UNDP.

Ochumba, P. B. O. & Manyala, J. O. (1990). *Distribution of fishes in the Lower Sondu-Miriu River of Lake Victoria, Kenya with special reference to Upstream migration, biology and yield*. Kisumu, Kenya Marine and Fisheries Research Institute, Kisumu Laboratory.

Ojany, F.F. & Ogendo, R. B. (1982). *Kenya: A Study in Physical and Human Geography*. Nairobi, Longman Kenya Ltd.

Okemwa, E., Wakwabi, E. & Getabu, A. (eds) (1994). *Recent Trends of Research on Lake Victoria Fisheries: Proceedings of the Second EEC Regional Seminar on Recent Trends of Research on Lake Victoria Fisheries*. Nairobi, ICIPE SCIENCE PRESS.

Okeyo-Owuor, J. B., Raburu, P. O., Masese, F. O. and Omari, S. N. (2012). Wetlands of Lake Victoria Basin, Kenya: distribution, current status and conservation challenges. In: Raburu, P. O., Okeyo-Owuor, J. B. and Kwena, F. (2012).(eds). *Community Based Approach to Management of Nyando Wetland, Lake Victoria Basin, Kenya*. Nairobi, KDC-VIRED-UNDP.

Okidi, C. O. & Olindo, P. M. (1982). *The quality of water and its impact on the living resources of the Lake Victoria basin*. Workshop report on the Quality of Water Input to Lake Victoria held at the Tom Mboya Labour College, Kisumu, July 25 to August 7, 1982.

Okungu, J. (2004). Lake Victoria Environmental Management Programme. In: Mungai, D. N., Swallow, B., Mburu, J. K., Onyango, L. & Njui, A. (eds) *Proceedings of a Workshop on Reversing Environmental and Agricultural Decline in the Nyando River Basin*. Kisumu, World Agroforestry Centre.

Okurut, T. O. & Weggoro, C. N. (2011). *Lake Victoria Basin: A New Frontier for Development of East Africa*. Nairobi, Twaweza Communications Ltd.

Olembo, N. K., Fedha, S. S. & Ngaira, E. S. (1995). *Medicinal and Agricultural Plants of Ikolomani Division, Kakamega District*.Development Partners.

Ole Nkako, F. M. (1992). Wetland conservation in Kenya: KWS and Ramsar. In: Crafter, S. A. Njuguna, S. G. & Howard, G. W. (1992) (eds) *Wetlands of Kenya: Proceedings of a Seminar on Wetlands of Kenya.* Nairobi, IUCN.

Omondi, R. & Ogari, J. (1994). Preliminary Study on the Food anf Feeding Habits of *Schilbe mystus* in River Nyando. In: Okemwa, E., Wakwabi, E. & Getabu, A. (eds) (1994) *Recent Trends of Research on Lake Victoria Fisheries:*

Proceedings of the Second EEC Regional Seminar on Recent Trends of Research on Lake Victoria Fisheries. Nairobi, ICIPE SCIENCE PRESS.

Omosa, M. (1992). Women and the management of domestic energy. In: Kameri-Mbote, P. (1992) (ed) *African Women as Environmental Managers*. Nairobi, ACTS Press.

Onyango, J. C. O., Massawa, E. O. & Abira, M. A. (1997). Biodiversity and Climate Change. In: Ogola, J. S., Abira, M. A. & Awuor, V. O. (eds) *Potential Impacts of Climate Change in Kenya*. Nairobi, CAN.

Opata, G. P. (2004). Development Planning in Kenya: A critical review for the period 1963 – 2000. In: Achola, P. P. W., Shiundu, J. O., Mondoh, H. O. & Ng'ong'ah, B. G. (eds) *Governance, Society and Development in Kenya*. Eldoret, OSSREA/Moi University Press.

Otieno, M. N. (2004). *Spatial Distribution of Landscape Characteristics of Yala Swamp Kenya, using Multispectral Landsat TM*. Unpublished Masters Thesis, Moi University, Eldoret.

Owiti, D. O. & Kapiyo, R. A. (2003). A *General Survey on the Ecology of the Vertebrate and Higher Plant Communities of Sondu-Mirui River Basin, Kenya, East-Africa*. Unpublished Research Report.

Pomeroy, R. (1995). *Fisheries Co-Management: A Fact Sheet for Connecticut Fishermen*. Connecticut, University of Connecticut, Connecticut.

_____ (1995). *Community based and co-management institutions for sustainable coastal management in Southeast Asia*. Ocean and Coastal Management 27 (3): 143-162.

Pycroft, C. (2010). *Integrated Development Planning and Rural Local Government in South Africa*. Liverpool, Liverpool University Press.

Raburu, P. O. (2003). *Water quality and the status of aquatic micro-invertebrates and ichty of fauna in River Nyando, Kenya*. Unpublished PhD. Thesis, Moi University, Eldoret, Kenya.

Raburu, P. O., Khisa, P. and Masese, F. O. (2012). Background information on Nyando

Wetland. In: Raburu, P. O., Okeyo-Owuor, J. B. and Kwena, F. (2012).(eds). *Community Based Approach to the Management of Nyando Wetland, Lake Victoria Basin, Kenya*. Nairobi, KDC-VIRED-UNDP.

Raburu, P. O., Wa'Munga, P. O. and Okeyo-Owuor, J. B. (2012). Experiences from

Community Participation in Managing Nyando Wetland. In: Raburu, P.O., Okeyo-Owuor, J. B. and Kwena, F. (2012). (eds). *Community Based Approach to the Management of Nyando Wetland, Lake Victoria Basin, Kenya*. Nairobi, KDC-VIRED-UNDP.

Reckien, D., Creutzig, F., Fernandez, B., Lwasa, S., Tovar-Restrepo, M., Mcevoy, D. & Satterthwaite, D. (2017). Climate change, equity and theSustainable Development Goals: an urban perspective. In: IIED (2017). *Environment and Urbanization*. Vol. 29. No. 1. UK, IIED.

Richards, D. (1991). *Birds of Kenya: A celebration*. London, Hamish Hamilton.

Rongoei, P. J. K., Kipkemboi, J., Okeyo-Owuor, J. B. and van Dam, A. A. (2013).

Ecosystem services and drivers of change in Nyando floodplain wetland,

Kenya. *African Journal of Environmental Science and Technology*. Vol. 7(5). Pp 274-291, May,2013.

Ruwa, R. K. (1996). Intertidal Wetlands. In: McClanahan, T. R. & Young, T. P.

(eds) *East African Ecosystems and their Conservation*. New York, OUP.

Sanabria, R. (2001). Evolving eco-tourism alliances conserve biodiversity in the

Galapagos Islands. In: Aloisi de Larderel (ed) *Eco-tourism and sustainability*. Paris, UNEP – DTIE.

Skinner, H. A. (1994). *Snakes and Us: An Introduction to East African Herpertology*. Kenya Literature Bureau.

Swallow, B. (2004). Kenya's Nyando Basin: Problems of Poverty, Agriculture and Environment. In: Mungai, D. N., Swallow, B., Mburu, J. K., Onyango, L. & Njui, A. (eds) *Proceedings of a Workshop on Reversing Environmental and Agricultural Decline in the Nyando River Basin*. Kisusmu, World Agroforestry Centre.

Teel, W. & Hirst, T. (1984). *A pocket directory of trees and seeds in Kenya*. Kengo.

Turner, K. (1991). Sustainable Wetlands: An Economic perspective. In: Turner, K. & Jones, T. (eds) *Wetlands: Market and Intervention Failures*. London, Earthscan Publications Limited.

Turner, R. K., Pearce, D. & Bateman, I. (1994). *Environmental Economics: An Elementary Introduction*. New York, Harvester Wheatsheaf.

Williams, J. G. (1981). *A field guide to the National Parks of East Africa*. London, Collins St. Joseph's Place. _

_____ (1995). *Collins Field Guide: Birds of East Africa*. London, Harper and Collins Publishers.

WISA (2013). *Wetlands Management Planning: Methodology Manuslfor Indian Managers*. January, 2013, Version 1.0. South Asia, Wetlands International, South Asia.

Zhang, H. et al. (2017). *Monitoring urban expansion and land use/land cover changes of Shanghai metropolitan area during the transitional economy.*Shangai,China.

APPENDICES

Appendix I: Questionnaire for local community

This questionnaire is prepared for the purpose of collecting relevant data for an academic research study on the planning and management of wetland resources in Okana in the lower Nyando River basin. Please fill in the blank spaces provided below with appropriate answers.

General Information

Name of Interviewer_____

Name of respondent_____

Division_____ Location _____ Sub-location_____

Sex_____ Age _____ Period lived in the area_____

Wetland Identification

Name of wetland _____Surface Area _____ Depth/Length_____

Nature of the Wetland

1.0 How was the wetland created? _____

1.1 Since its creation, have there been any changes in it?

- o Yes
- o No

If **yes**, explain_____

1.2 What other ecosystem depends on or affected by the wetland?

- Forest
- Mountain
- Vegetation
- Others (specify)_____

Wetland Use and Gender Participation

2.0 Crop Farming

2.1 Does your household cultivate in the wetland?

- Yes
- No

If **yes,** please fill this table.

Crop	**Ha/km^2**	**Qnty Harvested**	**Purpose**	**Sale (KES)**	**Own use (KES)**
1.					
2.					
3.					
4.					
5.					
Total					

In **no**, why _____

2.2 Who actually farm in the wetland?

- Man
- Woman
- Others (specify)_____

2.3 What do other members of the household do? _____

2.4 Who sells the proceeds?

- Man
- Woman

2.5 How is the income from the proceeds used?

- Pay school fees
- Buy household items
- Buy animals
- Others (specify) _____

2.6 Who is involved in the activity in 2.5 above?

- Man
- Woman

3.0 Livestock Production

3.1 Does your household engage livestock production in the wetland?

- Yes
- No

If **yes**, please fill this table

Livestock Type	**Average no/Household**	**Purpose**	**Sale (KES)**	**Own use/wk (KES)**
1.				

2.				
3.				
4.				
5.				
6.				
Total				

If **no**, why_____

3.2 Who actually graze the livestock in the wetland?

- Man
- Woman
- Others (specify)_____

3.3 Who do other members of the household do? _____

3.4 Who sells the livestock?

- Man
- Woman

3.5 How is the income from the sales used?

- Pay school fees
- Buy household items
- Buy animals

Others (specify) _____

3.6 Who is involved in the activity in 3.5 above?

- Man

- Woman

4.0 Fishing

4.1 Does your household fish in the wetland?

- Yes
- No

If **yes**, please fill this table

Fish Caught	**Qnty/wk (kg)**	**Purpose**	**Sale/Wk (KES)**	**Own use/Wk (KES)**
1.				
2.				
3.				
4.				
5.				
6.				
Total				

If **no**, why_____

4.2 Who actually fish in the wetland?

- Man
- Woman
- Others (specify)_____

4.3 Who do other members of the household do? _____

4.4 Who sells the fish caught?

- Man
- Woman

4.5 How is the income from the sales used?

- Pay school fees
- Buy household items
- Buy animals

Others (specify) _____

4.6 Who is involved in the activity in 3.5 above?

- Man
- Woman

5.0 Craft Making

5.1 Does your household make crafts using materials from the wetland?

- Yes
- No

If yes, please fill this table

Craft made	**Qnty/wk**	**Sale/Unit (KES)**	**Sale/Wk (KES)**
1.			
2.			
3.			
4.			

5.			
Total			

If **no**, why_____

5.2 Who actually makes the craft?

- Man
- Woman
- Others (specify) _____

5.3 What do other members of the household do? _____

5.4 Who sells the craft made?

- Man
- Woman

5.5 How is the income from the sales used?

- Pay school fees
- Buy household items
- Buy animals

Others (specify) _____

5.6 Who is involved in the activity in 4.5 above?

- Man
- Woman

6.0 Sand Harvesting

6.1 Does your household excavate sand in the wetland?

- Yes
- No

If **yes**, please fill this table.

Site	**Qnty harvested/wk**	**Sale/Unit (KES)**	**Sale/Wk (KES)**
1.			
2.			
3.			
4.			
5.			
Total			

6.2 Who actually excavate sand in the wetland?

- Man
- Woman
- Others (specify)_____

6.3 What do other members of the household do?_____

6.4 Who sells the excavated sand?

- Man
- Woman

6.5 How is the income from the sales used?

- Pay school fees
- Buy household items
- Buy animals

Others (specify) _____

6.6 Who is involved in the activity in 5.5 above?

- Man
- Woman

7.0 Fuel wood Extraction

7.1 Does your household obtain fuel wood in the wetland?

- Yes
- No

If **yes**, please fill this table.

Fuel wood type	**Qnty collected/wk**	**Purpose**	**Sale/Unit (KES)**	**Sale/wk (KES)**	**Own use/wk (KES)**
1.					
2.					
3.					
4.					
5.					
Total					

If **no,** why_____

7.2 Who actually collect fuel wood in the wetland?

- Man

- Woman
- Others (specify)_____

7.3 What do other members of the household do? _____

7.4 Who sells the fuel wood collected?

- Man
- Woman
- Others (specify)_____

7.5 How is the income from the sales used?

- Pay school fees
- Buy household items
- Buy animals

Others (specify) _____

7.6 Who is involved in the activity in 7.5 above?

- Man
- Woman

8.0 Extraction of Medicinal herbs

8.1 Does your household extract medicinal herbs in the wetland?

- Yes
- No

If **yes**, please fill this table

Name of herb	**Qnty extracted/Wk**	**Purpose**	**Price/Unit (KES)**	**Sale (KES)**	**Own use/Wk (KES)**

1.					
2.					
3.					
4.					
5.					
Total					

If **no**, why_____

8.2 Who actually extract medicinal herbs in the wetland?

- Man
- Woman
- Others (specify)_____

8.3 What do other members of the household do?_____

8.4 Who sells the extracted medicinal herbs?

- Man
- Woman

8.5 How is the income from sales used?

- Pay school fees
- Buy household items
- Buy animals

Others (specify) _____

8.5 Who is involved in the activity in 8.5 above?

- Man
- Woman

9.0 Pottery

9.1 Does your household excavate clay for pottery in the wetland?

- Yes
- No

If **yes**, please fill this table

Site	**Qnty made/Wk**	**Purpose**	**Price/unit (KES)**	**Sale/wk (KES)**	**Own use (KES)**
1.					
2.					
3.					
4.					
5.					
Total					

If **no**, why_____

9.2 Who actually excavated clay in the wetland?

- Man
- Woman
- Others (specify)_____

9.3 What do other members of the household do? _____

9.4 Who sells the ceramics made?

- Man
- Woman

9.5 How is the income from the sales used?

- Pay school fees
- Buy household items
- Buy animals

Others (specify) _____

9.6 Who is involved in the activity in 9.5 above?

- Man
- Woman

10. Water Supply

10.1 Does your household obtain drinking water in the wetland?

- Yes
- No

If **yes**, please fill this table

Site	**Qnty/Wk (l)**	**Purpose**	**Price/Unit (KES)**	**Sale/Wk (KES)**	**Own use/Wk (KES)**
1.					
2.					
3.					
4.					

5.					
Total					

If **no**, why_____

10.2 Who actually draws water for drinking the wetland?

- Man
- Woman
- Others (specify)_____

10.3 What do other members of the household do? _____

10.4 Who sells the water collected?

- Man
- Woman

10.5 How is the income from the sales used?

- Pay school fees
- Buy household items
- Buy animals

Others (specify) _____

10.6 Who is involved in the activity in 10.5 above?

- Man
- Woman

11.0 Environmental Impact

11.1 Does the wetland have wildlife?

- Yes

- No

If **yes**, please fill this table

Mammals	**Amphibians**	**Reptiles**	**Birds**	**Insects**

11.2 If **yes**, does it co-exist harmoniously with the members of the community?

- Yes
- No

If **no**, describe the types of human-wildlife conflict_____

11.3 Have you encountered any environmental problem(s) associated with the following activities?

- Wetland plants harvesting
- Brick making
- Clay excavation
- Hunting and gathering
- Sand harvesting
- Grazing in the wetland

- Firewood collection
- Hyacinth harvesting
- Others (specify)_____

11.4 If **yes**, state them _____

11.5 How are you affected by these problems? _____

11.6 In your opinion, what do you suggest should be done to address these problems?_____

11.7 What do you recommend for the better use and management of the wetland?_____

12.0 Social Impact

12.1 Do you encounter any social problem(s) when utilizing the wetland resources?

- Yes
- No

12.2 If **yes**, which one(s)?

- Attacks by wild game
- Conflict between resource users
- Human-wildlife conflict
- Deaths/injuries/drowning
- Others (specify)_____

12.3 What do you suggest should be done to address the problem(s) stated above?_____

13.0 Wetland Management

13.1 Is there any threat to the wetland?

- Yes
- No

If **yes**, state them_____

13.2 Is there any management programme(s) in place to address the threats?

- Yes
- No

13.3 If **yes**, by whom?

- Government
- NGO
- CBO
- Others (specify)_____

13.4 What activities do(es) it/they actually do?_____

13.5 Is the community involved in the management programme?

- Yes
- No

13.6 If **yes**, explain the nature of involvement_____

13.7 If **no**, why?_____

13.8 In your opinion, is the management system effective?

- Yes
- No

Explain your answer_____

13.9 What do you suggest should be done to improve the management of the wetland?_____

Thank you for your participation

Appendix II: Questionnaire for key informants

This questionnaire is prepared for the purpose of collecting relevant data for an academic research study on the planning of wetland resources in Okana in the lower Nyando River basin. Please fill in the blank spaces provided below with appropriate answers. Additional sheet may be used where necessary.

General Information

Name of Interviewer_____

Name of respondent_____

Division_____ Location _____ Sub-location_____

Type of Organization/ Institution

- Governmental
- Non-Governmental Organization (NGO)
- Community Based Organization (CBO)
- Research
- Others

  (specify)_____

Wetland Identification

Name of wetland _____Surface Area _____ Depth/Length_____

1.0 Nature of the Wetland

1.1 How was the wetland formed? _____

1.2 Since its formation/ existence, have there been any changes in it?

- Yes
- No

If **yes**, explain_____

1.3 Which ecosystem (s) affects the wetland?

- Forest
- Mountain
- Vegetation
- Others

(specify)_____

1.4 Is the Wetland a Ramsar site?

- Yes
- No

2.0 Wetland Management

2.1 Does your organization / institution take part in Wetland management?

- Yes
- No

2.2 If **yes**, explain your involvement_____

2.3 What challenges do you face?_____

2.4 How do you cope with the challenges in (2.3) above?_____

2.5 What do you suggest should be done to address the challenges?_____

2.6 Do you involve the community in the Wetland management programme?

- Yes
- No

2.7 If **yes**, explain the nature of involvement_____

2.8 If **no,** why not?_____

2.9 In your opinion, is the management system effective?

- Yes
- No

Explain your answer_____

2.10 What do you suggest should be done to improve the management of the wetland?_____

Thank you for your participation

Appendix II: Pra participants

PRA TEAM

1. Daniel Odaro	Researcher/Facilitator
2. George Oduol Anyona	Facilitator
3. Jennifer Adhiambo Otieno	GIS Expert
4. Francis Aloyo	Cartographer
5. Michael Odiwuor	Rapporteur

COMMUNITY MEMBERS

1. Joseph Odhiambo Koyi	Assistant Chief
2. Andrew Obong' Okal	Chairman Okana Wetland Group
3. Joseph Abuto	Village Elder
4. Dalmas Ojwang' Omondi	
5. Kennedy Odhiambo Okoyo	
6. Petro Ong'any Rajoro	
7. John Ouru Rajoro	
8. Geoffrey Onyango Oluoch	
9. James Kisiara	

10. Mark Omondi Abuto

11. Julius Oremo

12. Catherine Akeyo Okuna

13. Plista Migan

14. Rodah Okuom

15. Gladys Kola

16. Millicent Ogindo

17. Selibia Nyandiko

18. Jane Okal

19. Dorine Amollo

20. Perez Auma Adum

21. Margaret Opande

22. Fransisca Okello

23. Patricia Ochuka

24. Siprosa Olero

25. Paulina Orianda

26. Regina Abuto

27. Margaret Gwada

28. Leocadia Atieno Juma

29. Richard Nyachar

30. Aloyce Okal

31. Leonardus Olum

32. Siprosa Auma Onguko

33. Mary Awino Okeyo

34. Carren Atieno Omondi

35. Aloyce Omondi

36. Margaret Guya

Appendix IV: Pra schedule

The Participatory Rural Appraisal was conducted in the study area and the following information was sought during the exercise.

1. Construction of the Base Map (Community Social and Resource Maps)

2. Historical Time Lines

Period	**Events (e.g. famine, deaths, outbreak of diseases, major floods, deforestation, etc)**	**Intervention in the past**	**Present impact**
1960s			
1970s			
1980s			
1990s			
2000s			

3. Seasonal Calendar of Community activities

Event	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Rainfall												
Land prep.												
Planting												

rice												
Planting other crops												
Weeding rice												
Weeding others												
Harvesting rice												
Harvesting other crops												
Human disease												
Fishing												
Animal disease												
Flooding												
Drought												

4. Historical Resource Analysis

(a) Natural assets

Product	**1960s**	**1970s**	**1980s**	**1990s**	**2000s**	**Future**	**Use**	**Remarks**
Harvest								
Land								

Livestock								
Trees (Indigenous and exotic)								
Grass								
Firewood								
Fish								
Water								
Birds								
Papyrus and Reeds								
Wild game								

(b) Financial Assets

Asset	**1960s**	**1970s**	**1980s**	**1990s**	**2000s**	**Future**	**Use**	**Remarks**
Banks								
Credit providers (micro-finance)								
Pension								
Remittance								
Earnings (formal, informal, self employment, etc)								

(c) Human Assets

Asset	1960s	1970s	1980s	1990s	2000s	Future	Use	Remarks
Educational level								
Workshops								
Training								
Field tours								
Seminars								

(d) Physical Assets

Asset	1960s	1970s	1980s	1990s	2000s	Future	Use	Remarks
Tarmac roads								
Weathered roads								
Foot paths								
Flood evacuation paths								
Telephone services(Land lines/mobiles)								
Kiosks								
Postal services								

(e)Social Assets

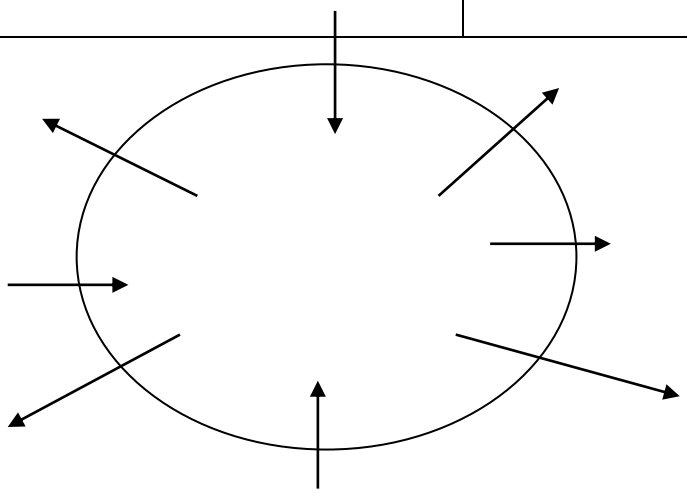
Institution	1960s	1970s	1980s	1990s	2000s	Future	Use	Remarks

Water User Association								
CBO								
NGO								
Water Service provider								
Government								

5. Farm Sketches

6. Resource flow matrix

Resources exported by the community to other regions	**Resources imported from outside the community**



← Resources from the community

→ Resources to the community

7. Livelihood mapping (Draw map after table)

Resources wholly within	**Rank**	**Resources partly within**	**Rank**	**Resources wholly outside**	**Rank**

8. Institutional and Stakeholders Analysis

(a) Institutional Analysis

Institution	**Role/Activities**	**Challenges**
Informal (i.e.		

traditions/customs/norms**)**		
Formal e.g. Schools Churches Social services Provincial administration Agriculture Fisheries Veterinary Health Local government Non-Governmental Organization Community Based Organization		

(b) Stakeholders Analysis

Stakeholder	**Activity**	**Strengths**	**Weakness**
Water users leader			
Chiefs/Assistants			
CBO leaders			
Fishermen			

Farmers			
Crafts persons			
Village elders			
Departmental reps (rice milling companies, government reps, gender, culture, agriculture etc.)			

9. Gender Analysis (Daily Calendars)

(a) Gender Daily Calendar (Men)

Time of the day	**Activity**
5-6am	
6-7am	
7-8am	
8-9am	
9-10am	
10-11am	
11-12noon	
12-1pm	
1-2pm	

2-3pm	
3-4pm	
4-5pm	
5-6pm	
6-7pm	
7-8pm	
8-9pm	
9-10pm	
10-11pm	

(b) Gender Daily Calendar (Women)

Time of the day	**Activity**
5-6am	
6-7am	
7-8am	
8-9am	
9-10am	
10-11am	
11-12noon	

12-1pm	
1-2pm	
2-3pm	
3-4pm	
4-5pm	
5-6pm	
6-7pm	
7-8pm	
8-9pm	
9-10pm	
10-11pm	

(c) Gender Daily Calendar (Youth)

Time of the day	**Activity**
5-6am	
6-7am	
7-8am	
8-9am	
9-10am	
10-11am	

11-12noon	
12-1pm	
1-2pm	
2-3pm	
3-4pm	
4-5pm	
5-6pm	
6-7pm	
7-8pm	
8-9pm	
9-10pm	
10-11pm	

10. Problem Analysis

(a) Problem Listing

Problem	**Causes**	**Coping strategies**	**Opportunities**

(b) Problem Ranking (Pair wise Ranking)

Problem	DR	FL	PI	LRM	LMG	IH	Total	Score
Drought								
Floods								
Poor Infrastructure								
Inadequate training on Resource Management								
Lack of Marketing Group								
Inadequate Harvesting								

11. Management Action Plan

Problem	Opportunities	Activities	Indicators	Time Frame	Resources /Materials /Services	Who To Provide	Who Is Responsible	When To Evaluate	Remarks

Appendix V: Tables that fit on more than two (2 pages)

Table 5.1 Stakeholders' analysis and Institutional Arrangements

Organization	**Category**	**Role**	**Responsibilities**
KFS	Primary	Legal authority for forests conservation and management	Technical support and training Forest policy guidance, Enforcement of forest Act and related regulations Conflict resolution Monitoring and evaluation
KWS	Primary	Legal authority for wetlands conservation and management Ramsar Agent in the country	Technical support and training Enforcement of wildlife conservation and management Act and related regulations Wetland protection conservation and reservation Leading in wetland restoration Conflict resolution Monitoring and evaluation
KWWG	Primary	Legal representation of the community Co-managers Rights to access and use wetland resources and	Implementation of the plan Sensitization of the community members on protection Representation and involvement of user groups Participation in decision

		customary rights Constitutional right to clean and healthy environment Participation in development	making Protection of wetlands Advocacy and awareness creation Enforcing rules and regulations Resources mobilization Sustainable use of wetlands products Training and capacity building Conflict resolution
KFWG	Primary	NGO. Constitutional right to clean and healthy environment	Advocacy and awareness creation Training and capacity building Resources mobilization
Kisumu County	Primary	Legal ownership of land on wetlands	Setting and enforcement of by-laws Provision of conducive political environment to conserve wetlands Representation of community interests Resource mobilization
Ministry of Lands and Settlement	Primary	Legal authority for land use planning and management	Setting and enforcement of by-laws in land use planning and management

KEFRI	Secondary	Legal authority for forestry research	Technical support Biodiversity assessment Monitoring Information dissemination Resource mobilization Training and capacity building.
NEMA	Secondary	Legal authority in environmental conservation and management	EIA and EA on plan implementation of activities Support to wetland rehabilitation/conservation Sensitization and awareness creation Enforcement of environmental laws and order
Sub-County Office (Agriculture)	Secondary	Legal authority on agriculture in the district	Promotion of on-farm forestry, apiculture and aquaculture Information dissemination Soil and water conservation Food security Technical support and training on farm management
Sub-County Office (Water)	Secondary	Legal authority in water issues in the district	Enforcement of Water Act and related rules and regulations Protect and development of water sources Monitoring of water quality

			and quantity periodically Building and construction of water infrastructures
Sub-County Office (Livestock Production)	Secondary	Legal authority in livestock issues	Promotion of sustainable livestock rearing activities Promotion of fodder crops Promotion of animal health Training and capacity building Law enforcement
Ministry of Youth Affairs and Sports	Secondary		Mobilization and sensitization of youths Resources mobilization Training and capacity building
Ministry of Gender, Children and Social Services	Secondary		Gender mainstreaming Training and capacity building Resources mobilization
Ministry of Planning (Sub-County Office)	Secondary		Planning and coordinating development programmes Information on socio-economics Resources mobilization

Table 5.2 Proposed Okana Integrated Wetland Management Plan

Task	**Activities**	**Resources/Materials**	**Actors**	**Indicators**	**Remarks (based on monitoring and evaluation)**
Wetland Restoration	Establish tree nurseries Planting of wetland friendly tree species Planting of papyruses and reeds Establish woodlots On-farm tree planting	Tree seedlings Land space	OCWWG Local Community VI-Agro MEWNR KFS County Government	Planted area Nursery bed Presence of increased macrophyte	
Sustainable harvesting of wetland products	Train community on selective harvesting of wetland products eg felling/cutting of mature trees and papyruses and reeds Enhance surveillance on wetland harvesting Zoning of wetlands into suitable land uses	Harvesting tools eg pangas Facilitators Surveillance team/committee	OCWG Local Community NEMA MEWNR Chiefs Ministry of Lands (Surveying Department) County Government	Zoned areas Training reports Surveillance committee Absence of bare wetland surfaces	

Improving food security	Training on organic farming Storm and rainwater harvesting for crop production Livestock upgrading Training on both crop and livestock husbandry Training on fish farming Training on greenhouse farming	Demonstration farms/fields Facilitators/Extension Officers Demonstration ponds	OCWG Local Community WARMA MOA, Fisheries and Livestock County Government	Reports on training Fish ponds Water tanks, pans and roof gutters Hybrid/Cross breeds Greenhouse	
Enhancing household income	Training on value addition on wetland products Sensitization on livelihood diversification eg apiculture Field visits or learning on wetland friendly enterprises	Experts on value addition Land space for apiary Bee hives Wetland products to be improved	OCWG Local Community MOA, Fisheries and Livestock County Government	Bee hives Initiated enterprises Training reports Reports or evidence of increased income or revenue	
Improving capacity on market research/information on wetland products	Undertake market research on wetland products Enhance research on value addition to wetland products	Research team/committee Wetland products	OCWG Local Community Research Institutions Univer	Research reports	

	Formation of marketing committee/groups Establish linkages on new market strategies/trends on wetland products		sities NGOs		
Enhancing education and awareness on wetland values to community	Organizing seminars and workshop for information on wetlands Sensitization/ awareness campaign in Chiefs *barazas* Production of documentation non wetlands eg brochures Incorporating wetland management content in school curriculum Organizing excursions during Wetland Days of Demonstrations	Wetland products Stationaries Facilitators Schools Chief's *barazas*	OCWG Local Community Ministry of Education NEMA County Government Media	Reports on seminars, workshops or excursions Documentations on wetlands eg brochures, bulletins, articles	
Enhancing awareness and compliance of policies and laws	Develop appropriate community by-laws on the Okana wetland	Facilitators Chiefs Training facilities	OCWG Local Community MEW	Existence of community based by-laws on wetlands Reports on	

on wetlands	Create awareness on wetland laws and regulation Training on community based wetland monitoring for compliance Establish community level structure for enforcement		NR NEMA Chiefs County Government	training Reports on surveillance or compliance eg offenders Existence of enforcement committee	

Table 5.3 Logical Framework of Activities

Item	Indicators of Achievement	Means of Verification	Risks and Constraints	Interventions
Goal To achieve wise use of Okana wetlands in order to sustain the livelihoods of local people	Acceptance of management programmes by the residents Active participation in the programmes	Determination of level of acceptance in percentage Marking of attendance register	Food insecurity Financial limitations Inadequate expertise	Small token as wages Capacity building Incorporation of relevant partners for support
Objectives To sensitize, mobilize and build capacity with the community To generate and document data for detailed planning To initiate a water control and management for farmers To encourage sustainable aquaculture, bee keeping, pottery, livestock rearing, raising of tree seedlings and marketing of the products To initiate waste management strategies in the community	Documentation of report and data Management structures on the ground Presence of ponds, bee hives and nursery beds Presence of marketing group or committee Presence of litter bins and dumping sites Presence of pit latrines Diversified quality and improved handicrafts Adoption of appropriate harvesting techniques Enlightened residents on wetland values	Reports for each activity or programme Diversified products in the market Litter bins in the market Number of groups involved in the management activities Number of ponds, beehives and tree nurseries Percentage of pits constructed	Misinformation Inadequate expertise Insufficient cooperation Leadership problems Lack of motivation Inadequate resources/funds	Engage opinion leaders to spearhead sensitization and mobilization campaigns Lobby for financial support through proposal writing to partners Build capacity Provide data and information and improve awareness Exchange or outreach programmes

To development and market eco-tourism opportunities To encourage sustainable harvesting and production of wetland products	and management Presence of cattle dip			
Output Environmentally sensitive and enlightened residents Documented reports of the area Ponds, beehives, cattle dip, tree seedlings Improved hygiene High quality artifacts Sustainable harvesting of macrophytes Dumping sites and litter bins Eco-tourists in the area	Reports of the area and activities Positive environmental actions e.g afforestation, agroforestry and carrying capacity Structures of various activities in place	Residents adopting the appropriate techniques Posters on particular activities Quality wetland products	Inadequate resources Conflict of interests/competing forces Inadequate expertise Poor marketing information Misinformation	Provide data and information Form marketing group Build partnership with other stakeholders Encourage participation in income generating activities
Activities/Tasks Surveys Detailed inventory of wetland resources Mapping of wetland resources and	Survey reports and documents Inventory list Community base map of the area Improved management of the wetlands	Published reports Maps Management/land use plan Active participation of members in the activities	Inadequate resources Accidents and injuries Low community response Inadequate expertise	Engage opinion leaders in the sensitization and mobilization of residents

their distribution Developing land use plan Sensitization and training workshops Field days on wetland products and related benefits to the community Formation and training of management committees on wetland management and general administrative and management skills Production of brochures and regular newsletters on successes and challenges Dredging of rivers and canals Continuing with integrated wetland management measures Formulation and adherence to guidelines and regulations Creating awareness within the community	Determine the level (%) of community participation in *barazas* and workshops Functional committees Brochures and newsletters Desilted rivers and canals Wetland management/land use plan Guidelines and regulations produced Regular community *barazas* and trainings/seminars Office Fliers, pamphlets and books Rescue team/first aiders Simple water treatment systems Artificial/constructed wetlands Dumping sites and litter/waste bins Protective gears/devices used by harvesters Harvesting programme used	Attendance register Regular meetings Application of rules by the management committee Dredged rivers and canals Presence of brochures and newsletters in nearby relevant offices Adoption of the guidelines by the community groups Office Brochures, pamphlets and fliers distributed Water points with safe drinking water Designated dumping sites and installed waste/litter bins Harvesters using gears/devices Rotational harvesting programme Increased number of products/artifacts	Misrepresentation Misinformation	Promote income generating activities (IGAs) Networking with other stakeholders and partners Lobby for finances/funding from partners Provide protective devices and snake antivenoms Provide data and information

Establishing information and eco-tourism offices Preparing information brochures, pamphlets and fliers Buying identification books Training rescue team especially first aiders Training on water treatment and waste management Acquiring protective gears/devices Training on sustainable wetland resources use Training on value addition of handicrafts Diversification of products Improving skills on artifacts Setting up a showroom Formation of marketing committee	by the community High quality products Unique artifacts Showroom with displays Marketing committee			
Inputs Facilitators/expertise Physical facilities/equip	Experts training the community and committees Equipment	Training schedules Trainees Register of		

ment Financial resources	Support from partners and stakeholders	equipment acquired Commitments by partners and stakeholders in writing		

Table shows activities/tasks to be undertaken in the implementation of the management plan

Table 5.4 Okana Community Wetland Management Action Plan

Problem	**Opportunities**	**Activities**	**Indicators**	**Time Frame**	**Resources/ Materials/ Services**	**Who To Provide**	**Who is Responsible**	**When To Evaluate**	**Remarks**
Wetland degradation and loss	Wetland restoration	Establish tree nurseries Planting of wetland friendly tree species Planting of	Planted area Nursery bed Presence of increased macrophyte	3 Months	Tree seedlings Land space Labour	OCWWG Local Community VI-Agro MEWNR KFS County Government	OCWWG Local Community VI-Agro MEWNR KFS County Government	Monthly	

		papyruses and reeds Establish woodlots On-farm tree planting							
Food Insecurity	Improving food security	Training on organic farming Storm and rain water harvesting for crop productio	Reports on training Fish ponds Water tanks, pans and roof gutters Hybrid/Cross breeds Green house	3 Months	Demonstration farms/ fields Facilitators/ Extension Officers Demonstration ponds	OCWG Local Community WARA MOA, Fisheries and Livestock County Government	OCWG Local Community WARA MOA, Fisheries and Livestock County Government	Seasonally	

		n Livestock upgrading Training on both crop and livestock husbandry Training on fish farming Training on greenhouse farming							
Inadequate trainin	Sustainable harvesti	Train co	Zoned areas	1 Month	Harvesting tools	OCWG Local	OCWG Local	Mont	

g on wetland resource management	ng of wetland products	mmunity on selective harvesting of wetland products eg felling/cutting of mature trees and papyruses and reeds Enhance surveillance on wetland	Training reports Surveillance committee Absence of bare wetland surfaces		eg *pangas* Facilitators Surveillance team/ committee	Community NEMA MEWNR Chiefs Ministry of Lands (Surveying Department) County Government	Community NEMA MEWNR Chiefs Ministry of Lands (Surveying Department) County Government	hly	

		harvesting Zoning of wetlands into suitable land uses							
	Enhancing awareness and compliance of policies and laws on wetlands	Develop appropriate community by-laws on the Okana wetland Create awareness	Existence of community based by-laws on wetlands Reports on training Reports on surveillance or compliance eg offenders Existence of enforc	1 Month	Facilitators Chiefs Training facilities	OCWG Local Community MEWNR NEMA Chiefs County Government	OCWG Local Community MEWNR NEMA Chiefs County Government	Monthly	

		on wetland laws and regulation Training on community based wetland monitoring for compliance Establish community level structure for enf	ement committee						

		orcement							
Lack of marketing Group	Train on market research on wetland products Timed production based on demands	Undertake market research on wetland products Enhance research on value addition to wetland products Formation of marketing	Research reports	1 Month	Research team/ committee Wetland products	OCWG Local Community Research Institutions Universities NGOs	OCWG Local Community Research Institutions Universities NGOs	Monthly	

		committee/groups Establish linkages on new market strategies/trends on wetland products							
Drought	Constructing water pans and shallow wells Provision of irrigation facilities Planting drought	Diggi ng wells and pans Harvestin g roof catch me	Wells and pans Tanks Tree seedlings Roof catchments	3 Months	Farm tools Seedlings Tanks Labour	OCWG Local Community WARA MOA, Fisheries and Livestock County Government	OCWG Local Community WARA MOA, Fisheries and Livestock County Government	Mont hly	

	resistant crops Planting trees to attract rainfall	nts and storm water Planting drought resistant crops Planting trees							
Floods	Building dykes Channeling of run offs to water pans Desilting rivers	Diggingdykes Channeling of run offs Desiltation of rivers	Existence of dykes Desilted rivers Channels to water pans	3 Months	Farm tools Labour	OCWG Local Community WARA MOA, Fisheries and Livestock County Government	OCWG Local Community WARA MOA, Fisheries and Livestock County Government	Monthly	
Poor Infrastructure	Repair and upgrading of rural	Gravelling of	Upgraded/Murramed roads	3 Months	Gravel Sand Hardc	OCWG Local Community	OCWG Local Community	Monthly	

	access roads Use of motor-cycles, bicycles and donkey carts/*Mkokoteni*	roads Digging of ditches Purchase/ Hiring of motor cycles, bicycles and donkey carts/ *Mkokoteni*	Motor cycles, bicycles and donkey carts/ *Mkokoteni*		ores Murram Labour	Ministry of Roads and Public Works County Government	Ministry of Roads and Public Works County Government		

Appendix VI: Similarity Report