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Analysis of Land Use Land Cover Changes of Okana Wetland Ecosystems in Lower Nyando River Basin, Kisumu County, Kenya

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Abstract: *Wetlands, like any other natural resource are exploited by the adjacent communities to sustain their livelihoods. The ecosystems have supported millions of livelihoods since time immemorial through their socio-cultural, economic and ecological values. However, the ecosystems have been steadily converted into other uses which are considered to have obvious benefits since the wetlands are perceived to be "wastelands". The phenomenon is likely to have adverse impact on the wetland ecosystems thereby compromising their sustenance. Besides, the livelihoods of the riparian communities who depend on the ecosystems will be at stake. The study aimed at establishing the land use-land cover changes that have occurred over the years in Okana area in Nyando River basin, their impact on the ecosystems and the economic values of the wetlands to the adjacent communities. The study used various techniques in data acquisition and analysis. These include remote sensing analysis using LANDSAT satellite images and Geographic Information System (GIS) analysis using ArcGIS software, field surveys, Participatory Rural Appraisal (PRA) and Barbier's tool for total economic value of resources. The study revealed that land use land cover changes were due to conversion of the wetlands into agricultural farmlands and human settlements, utilization of the resources contribute significantly to household income and also led to environmental consequences. From the study, appropriate environmental planning and management strategies were drawn, which if implemented will enhance sustainable use of the wetlands especially in the wake of the climate change phenomenon that threatens the existence of all facets of the environment.*

Keywords: Wetlands, Land use land cover, Utilization, Livelihoods, Integrated Planning and Sustainability

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1. Introduction

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 (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 and social 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 include, in the USA (Lutgens & Tarbuck, 2000), Mexico City (Mitsch & Gosselink, 2000; Mitsch & Gosselink, 2007), in Finland and in the Netherlands (Briggs & Courtney, 1989), in Japan (Anonymous, 1997), in Bangladesh, (Khan et al. 1994), in Uganda (Emerton et al. 1999; Kasoma, 2003), in Rwanda (Okurut & Weggoro, 2011) and in Kenya (Okurut & Weggoro, 2011; Masese et al. 2012; Raburu et al 2012; 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).

The study focused on the Okana wetland ecosystem in the lower Nyando River basin. Wetlands in the basin are generally riverine wetlands. It has an estimated area of about 40 km^2 (GOK, 2009). The Okana wetland system lies in West Kano in Nyando Sub-County, Kisumu County. 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).

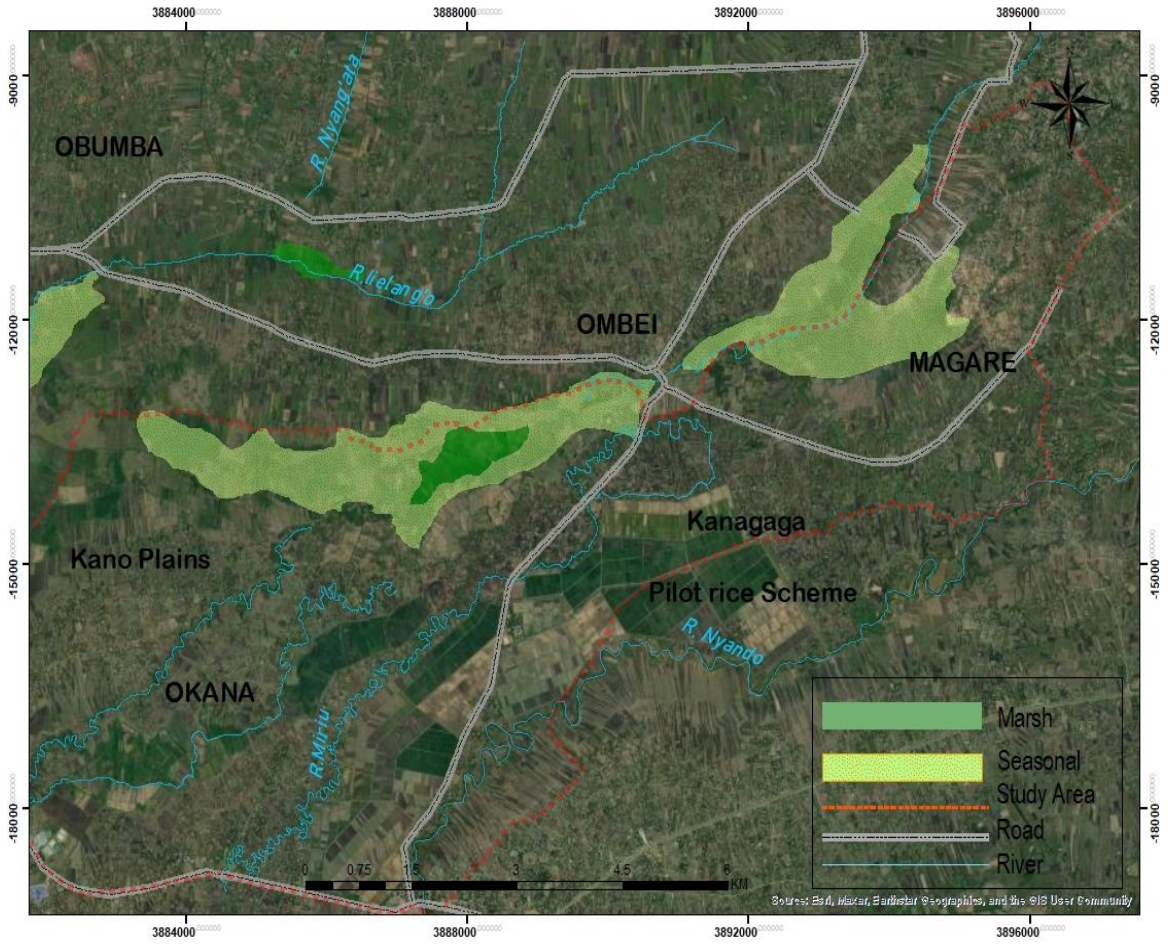

Figure 1: Okana Wetlands.

Objectives

The general objective of the study was to investigate the effects of land use-land cover changes on the Okana wetlands over time, based on the utilization of the wetland resources. The specific objectives of the study were to:

1. Determine land use changes in Okana between 1960 and 2020.
2. Determine the contribution of wetland resources to the household income in Okana.
3. Determine the environmental impacts of wetland resources utilization in Okana.

2. Literature Review

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 contribution of wetlands to 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 research 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.

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 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 (Reckien, et al. 2017; 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 (Raburu et al. 2012; NBI, 2018). The true value of the wetland ecosystems can only be achieved through comprehensive economic valuation of wetland resources.

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 was 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.

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. A comprehensive valuation of wetland products made from wetland materials such as papyrus, clay, reeds, water hyacinth, and grass among others is necessary 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, the 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.

Wetlands are often thought of as "wastelands", which have no significant economic value. 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 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, a 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.

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 revealed that there were 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 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 components. However, the ecosystems have been reclaimed for agriculture, which has led to their contraction. Besides, water hyacinth has been consistently harvested to produce 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.

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 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.

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.

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.

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). 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.

Firey's theory therefore provides a leeway for the development of a management plan 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).

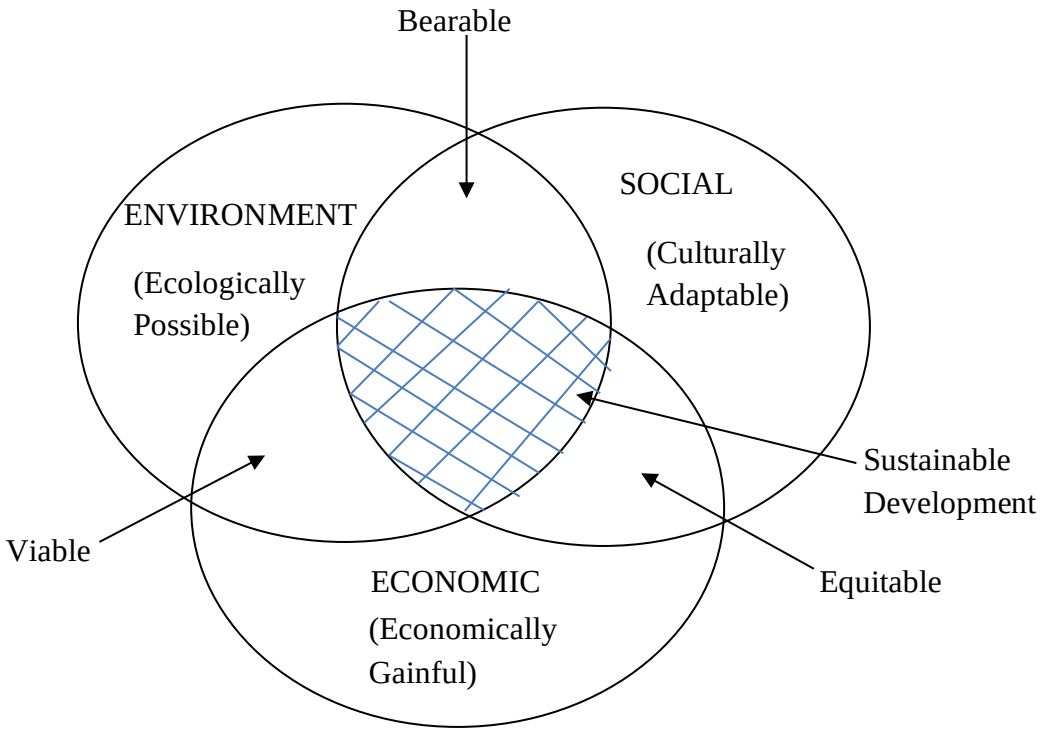

Figure 2: Sustainable Use of Wetlands.

(Source: Modified from Firey, 1961)

3. Methodology

The study used various techniques in data acquisition and analysis. These include remote sensing analysis using LANDSAT satellite images (Table 1) and Geographic Information System (GIS) analysis using ArcGIS software, field surveys, Participatory Rural Appraisal (PRA) and Barbier's tool for total economic value of 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. 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.

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.

PRA was instrumental in verifying the respondents' information during field surveys. Besides, it established the resources abundance in 1960s and 1970s that was not captured in the satellite images.

Table 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

(Source: Downloaded from USGS Website)

4. Results and Discussion

The study has established a declining trend of wetland macrophytes over the years from 1960s to 2000s. 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 (Plate 1) and PRA resource analysis (Table 2). 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.

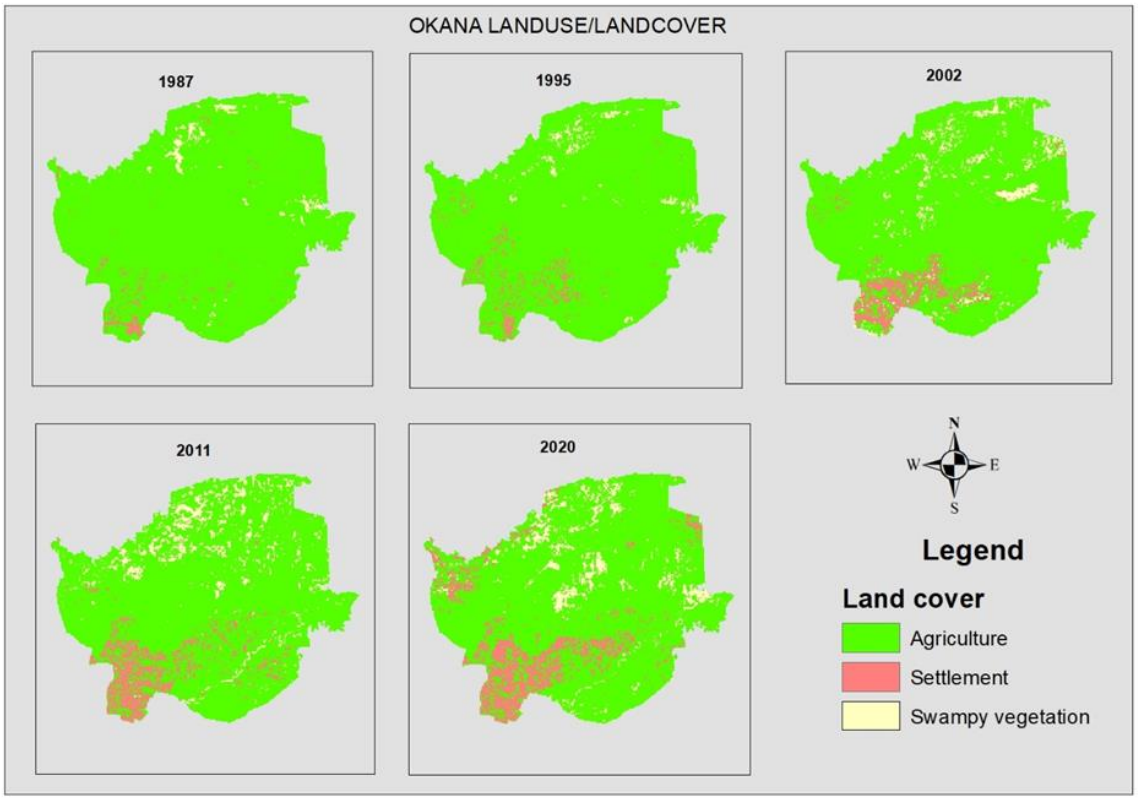

Plate 1: Satellite Images of LULC in Okana between 1980s and 2020.

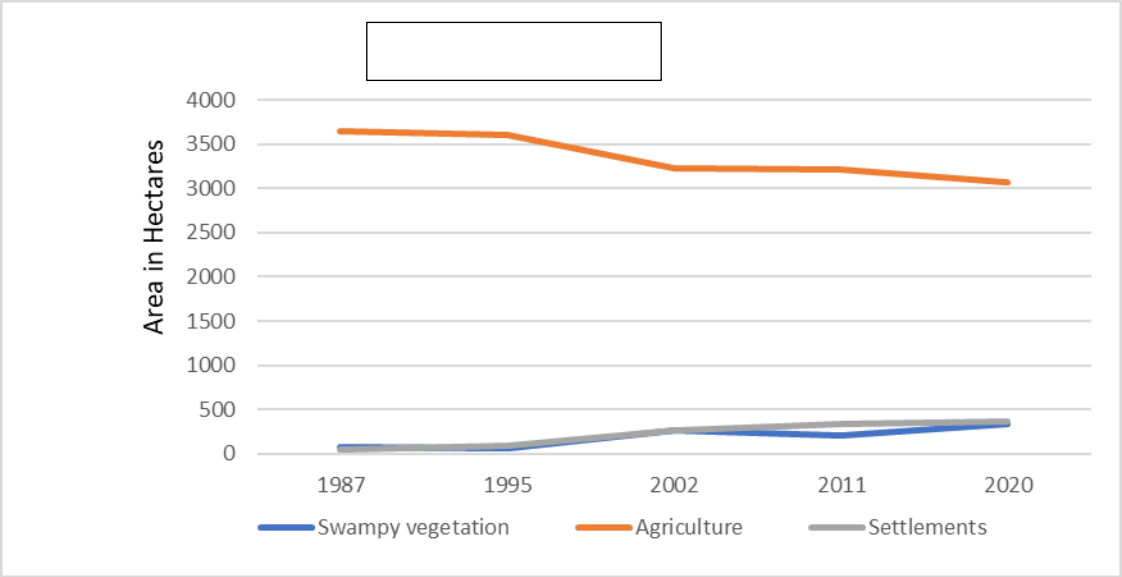

Figure 3 :Trend in LULC changes in Okana.

Table 2: 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

(Source: PRA Exercise)

KEY

5	Very Many Resources	
4	Many	"
3	Few	"
2	Very Few	"
1	No	"

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 2-3 km away from the wetland areas. The latter site was densely vegetated with macrophytes as revealed by the LANDSAT images (Plate 1) and PRA resource analysis (Table 2). The situation of the wetland area then contrasts with 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 more space for human settlement and agricultural land as indicated in the trend of LULC in Figure 3. The wetlands have therefore been cleared to provide space for the two land uses. There is a negative correlation 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 declining 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 Fig 3. The trend is likely to lead to depletion of the wetland ecosystem altogether if left unchecked. In fact, it is projected that by 2030, the wetland will diminish further if the situation is not addressed by adopting effective management strategies (Fig. 4).

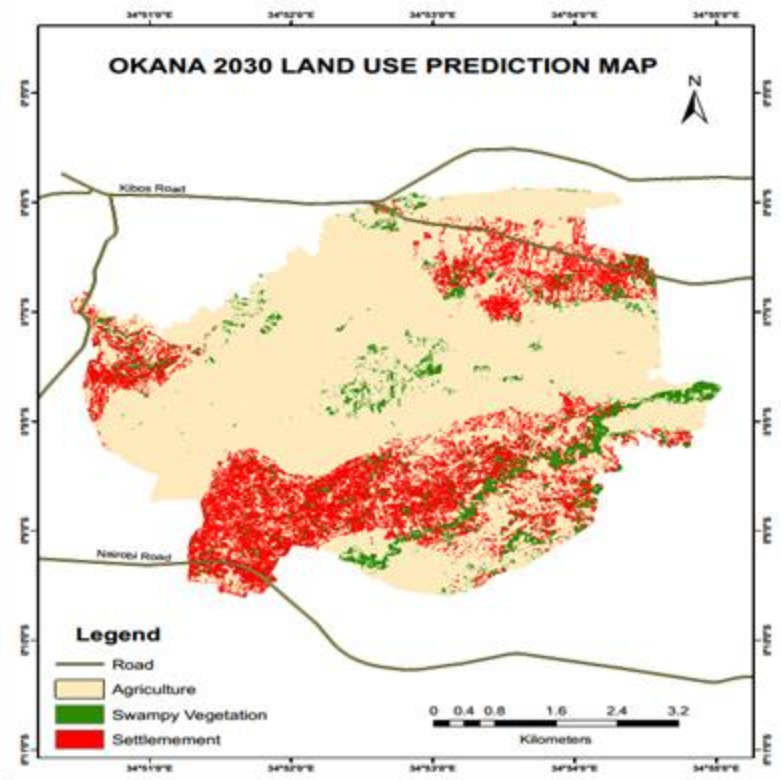

Figure:4: Land Use Projection Map in Okana by 2030.

The Okana wetlands include floodplains, riverine swamps, shallow rivers and streams, pans, wells and irrigated rice paddies. 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. 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. Besides, some resources are used as building and construction materials thereby reducing the overall household expenditure on such activities. In summary, the estimated income and/or costs from the wetland resources are contained in tables 3a and b below.

Table 3a: Estimated community income from wetland resources in Okana

Wetland Activity	Estimated Income/Season (KES)
Fishing	843,550
Crop production	3,981,000
Livestock production	91,100
Craft making	742,155

Table 3b: Estimated costs from wetland resources in Okana as at 2010

Wetland Activity	Estimated Costs (KES)
Hut (Mud/Grass thatched) construction	167,910
Livestock feed	409,640
Water use	192,031
Herbal medicine	582,250
Wood fuel	267,420

Estimates are based on Barbier's tool of economic valuation

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 resources thus have a significant contribution to household income in the study area. In fact, total estimated earnings of about KES. 7,277,056 per week 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 non-consumptive uses include regulating hydrologic, carbon sinks which reduce the greenhouse effect, biodiversity habitat, water purification through removal of nitrogen, phosphorus, heavy metals and other chemicals and pollutants from water, flood and erosion control as well as shoreline stabilization 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 and ash drive (*tero buru* conducted on the flood plains) among others. 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.

The study revealed that the utilization of wetland resources results in numerous adverse 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. These findings have been summarized in table 4 below.

Table 4: Environmental impacts of wetland resources utilization in Okana

Resource Use	Impact	Interventions/Solutions
Harvesting of macrophytes	• Waste generation • Decline and loss of biodiversity • Destruction of habitats	• Planting of wetland macrophytes and exotic trees • Buying timber for building and construction • Buying of fuel wood to supplement available ones.
Hunting and gathering	• Decline and loss of biodiversity	• Fencing of the ecosystem
Clay excavation	• Creation of micro-habitats for disease vectors	• Rehabilitation of the excavated sites
Craft making	• Waste generation	• Developing alternative uses of wastes
Agriculture	• Waste generation	• Developing alternative uses of wastes
Water abstraction	• Pollution	• Rainwater harvesting • Use of chlorine and PUR chemicals
Grazing pasture	• Slow regeneration of pasture	• Adoption of paddocking system

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 biota 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. 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 (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 (Table 5). They attribute the disappearance of the species to the clearance and burning of the wetland ecosystem to provide space for agricultural land and human settlement. Pottery is a well known wetland activity in the study area. 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 vector organisms such as mosquitoes and snails. Besides, clay excavation results in a barren land, which is completely inhabitable unless reclaimed. The scenario eventually leads to land degradation if no immediate remedial measures are undertaken.

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 on the water sources, particularly rivers.

Table 5: Species that have declined/disappeared in Okana wetlands

Local Name	Scientific Name	English/Common Name
Ondiek	*Crocuta crocuta*	Hyena
Bim	*Papio anubis*	Olive baboon
Dwe	*Tragelapus spekei*	Sitatunga
Nyang'	*Crocodilus niloticus*	Crocodile
Ng'ielo	*Python sebae*	Python
Muok	*Orycteropus afer*	Antbear
Ndemu	*Mehelya spp.*	Brown mamba
Aywer	*Francolinus spp.*	Spurfowl
Chiewo	*Hystix galeata*	Porcupine

5. Conclusion and Recommendations

5.1 Conclusion

The study showed that wetland ecosystems in the study area have actually undergone serious degradation and loss due to land use-land cover 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 populations 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 study 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, handicrafts, medicinal herbs as well as grazing fields for domesticated animals especially during dry seasons. They also provide non-consumptive uses such as sites for rituals or ceremonies like circumcision, ash drive, worship and baptism.

The utilization of wetland resources in the study area has been shown to be associated with myriad of environmental problems which are likely to compromise the quality of life of the residents. These range from inadequate resource base, waste generation, decline and/or loss of biodiversity to destruction of habitats and degeneration of pasture land. All these put the lives of the residents at stake hence need to be addressed so as to enhance sustainability of the environment and livelihoods. This will also help to achieve Vision 2030 and Agenda Four (4) as advocated for by the government.

5.2 Recommendations

From the foregoing findings and discussion, the study recommends the following in order to ensure proper planning and management of the wetland ecosystem:

1. An integrated wetland management (IWM) plan for Okana wetland. This is an arrangement where all actors including wetland resource users, government agencies, non-governmental organizations (NGOs), community-based organizations (CBOs), environmental activists, researchers and other relevant stakeholders are incorporated into the planning and implementation processes and/or activities.
2. Buffering of the wetland to avoid further encroachment. This is done by fencing off the wetland area based on the NEMA regulations on riparian areas.
3. Rehabilitation of the wetland ecosystem for continued livelihood and environmental sustenance. This includes planting of recommended plant species based on ecological impact assessments for the proposed species prior to such undertakings.

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