

Full Length Research Paper

Community perceptions on the impact of the recession of Lake Victoria waters on Nyando Wetlands

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Lake Victoria experienced drastic water level changes from October 2005 raising concerns about impact to the livelihood of the communities around the lake. The study investigated impacts of the water level decline on land use changes, wetland resource utilization, household food production, income generation, fish catches, water supply, quality and quantity and biodiversity changes within the Nyando wetlands in Western Kenya. Data was collected between August and December 2006 through in-depth household interviews of 120 randomly selected wetland resource users; key informant interviews (KII), and focused group discussions (FGD). Qualitative description and SPSS computer package Version 11.6 was used for statistical data analysis. Results of the study indicate that receding water levels led to increased availability of land for farming through reclamation and conversion of exposed wetland areas; over-exploitation of macrophytes; increased food production and income generation; and increased conflicts in the use of wetland resources. Water recession also caused shortage of domestic water supply, decrease in fish catches and biodiversity. The study recommends establishment of buffer zones to protect papyrus, formulation of national policies on wetland conservation, creation of alternative sustainable development options, and development of site specific wetland management plan to regulate the utilization of wetland resources.

Key words: Lake Victoria, water recession, Nyando wetlands, community perceptions.

INTRODUCTION

Impacts of global climatic changes in Africa have manifested themselves through shifting dry land boundaries and rise and fall of water levels in many inland lakes (Ogola et al., 1997; Juma and Bell, 2006). These long-term episodic changes involving unpredictability of climatic variability accompanied with anthropogenic activities have resulted in intermittent changes adversely affecting most habitats of the world with concomitant impacts on natural resources and global water cycles (UNDP, 2006). In East Africa, a number of water bodies

especially the Kenyan Rift Valley lakes have been affected time and again (Ogola et al., 1997; Childress et al., 2002; Aloo, 2002). The water balance of Lake Victoria has attracted more attention and concern over the past century due to its immense socio-economic and ecological benefits in the region (Okonga et al., 2005; Mngodo et al., 2005; Kull, 2006; Swenson and Wahr, 2009).

Water level recession in Lake Victoria is not a new phenomenon. Apart from events reported during the earlier expeditions by European explorers (Beadle, 1932), a number of episodic increase and decrease in water levels have been recorded between 1950 to date (Kite, 1982; Nicholson, 1998; Okonga et al., 2005; LVBC, 2006). Since attaining its historic high annual level in

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1964, the lake has not returned to the levels that characterized the first half of the 20th century (Temple, 1969; Kite, 1982; Nicholson and Yin, 2001; Swenson and Wahr, 2009). Hydrological studies over the past decades have concluded that Lake Victoria's water balance is controlled both by climatic conditions via net precipitation and catchment inflow and human management via dam outflow (Nicholson, 1998; Kull, 2006). The mean lake rainfall is 1,315 mm year⁻¹, which is 82% of the total inflow; the remaining 18% is contributed from river inflow. Of the outflow, 76% is due to evaporation from the lake and the remaining 24% (~23.5 km³ year⁻¹) is the outflow forming the White Nile River at Jinja (Nicholson and Yin, 2001; COWI, 2002). Construction of increased outlet and generation capacity at Owen Falls Phase 2 and a deviation from long observed operating rules did contribute to a rapid decline in lake level by 2.3 m from 1998 to 2005 (LVBC, 2006; Kull, 2006). The declining water levels in the entire basin impacted negatively on the socio-economic and intrinsic values of the lake's resources and contributed to losses amounting to millions of shillings¹ (LVBC, 2006).

Communities around Lake Victoria depend on the lake resources for their livelihood. Over the past few years, Lake Victoria water level has been changing thus impacting negatively on the communities that depend on its resources. Fluctuations in the lake's water level have also had profound influence on the development and status of wetlands of the Lake Victoria basin (Welcome, 1972; Ogutu et al., 2003; Kiwango and Wolanski, 2008). Wetlands are of great ecological importance and probably the most important zones that support the livelihoods and subsistence economy of the riparian communities. This is manifested through subsistence agriculture, freshwater fisheries, tourism, transport as well as being sources of water for domestic and livestock use (Gichuki et al., 2001; Ogutu et al., 2003). Recent studies show that changes in Lake Victoria levels have resulted in changes in availability of domestic water supply, fish catches, agricultural production, prevalence of water related diseases and resulted in resource use conflicts (NAPE, 2006; LVBC, 2006). The Nyando wetland is one of the largest and economically important wetland ecosystems fringing the Lake Victoria and performs important ecological, hydrological and socio-economic functions. Impacts on the wetland would be representative of the wetlands fringing Lake Victoria and is therefore used in this study as a 'microcosm' to determine the impacts of water recession on the natural resources and livelihood of the Lake Victoria communities.

Most studies on the water recession in Lake Victoria have focused on the causes of the decline *per se* (LVBC, 2006; Mngodo et al., 2005; Okonga et al., 2005; Swenson and Wahr, 2009), however, the impact of lake

water recession on fish catches, and other aquatic organisms has not been adequately addressed. It is important to note that inadequate understanding of the complexity of the ongoing ecosystem and hydrological changes may hamper full appreciation of the impact of water recession on the livelihoods of riparian communities. This information is critical in the formulation of sustainable management strategies including wise use and conservation of wetlands.

This study therefore assessed the impacts of the water level recession on the communities living around Nyando wetlands. The survey which was based on the perceptions of the riparian communities, focused on land use changes, wetland resource utilization, household food production, income generation, fish catches, water supply, quality and quantity and biodiversity changes.

METHODOLOGY

Study area

This study was conducted in the Nyando River mouth Wetlands that covers approximately 42.792 Km² and lies within the Winam Gulf of Lake Victoria between longitudes 35°25' E and 35°45' E, and latitudes 0°05' N and 0°15' S (G.O.K., 1996). The wetland traverses the Nyando, Nyakach and Kisumu East administrative districts of Western Kenya and lies within the Kano / Nyakach plains at the mouth of River Nyando. Mean annual rainfall in the Nyando basin varies from about 1000 mm near Lake Victoria to about 1600 mm in the highlands. Since the wetland is a source of livelihood to riparian communities, the intensity of several anthropogenic activities that take place increases when the lake water level recedes. The location of Nyando wetlands (Figure 1) and the approximate area affected by water recession was determined using ArcView 3.2 GIS Software and from the GIS data, Digital Elevation Model (DEM) maps were produced (Figure 3).

Data collection

Data was collected between August and December 2006 using various participatory techniques, including in-depth household interviews of direct wetland resource users (e.g. farmers, fishers, traders, hunters, herdsman, craft makers etc), Key Informants (local administrators, CBO and local NGO leaders), direct observations, Focused Group Discussions and a workshop which brought together all wetland stakeholders. The sampled population consisted of 120 randomly selected household respondents living within the lower Nyando River catchment in three locations - Kochogo, Kakola and Kawino South - found in Nyando and Kisumu East Districts. In this study, a survey design was employed with simple random sampling technique used to select households to ensure a proportionate representation of stakeholder perceptions on wetland resource utilization pattern and livelihood changes before and after the lake recession. Secondary data from published and unpublished records was used to complement primary data.

Data analysis

Data collected was entered in Excel spreadsheets and analyzed statistically using SPSS version 11.5. Qualitative description and relevant statistics were employed for data analysis. Chi-square (χ^2) test of goodness of fit and percentage distribution techniques were

¹ Currency Unit: Kenya Shillings - US\$1 = KSH 85.00 (Exchange Rates Effective, December 2011)

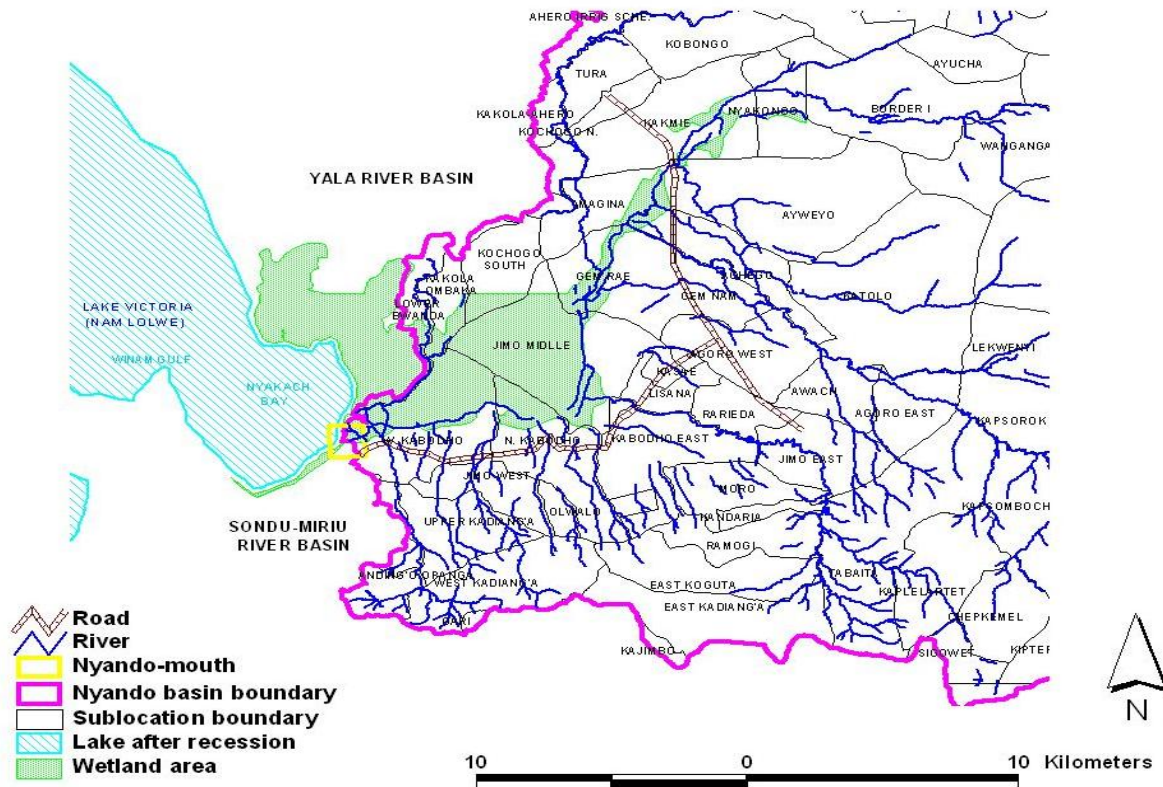


Figure 1. Map of Nyando wetland showing areas affected by Lake Victoria water recession during the study period.

used to analyze the data. Percentage rank scores were calculated for Likert-scale ranked data. For instance, changes in wetland resource use patterns were ranked and given relative scores from 1 to 3 (1 - least important; 2 - important; 3 - most important). Similarly, frequency in conflicts were also ranked and given relative scores from 1 to 3 (1 - increased; 2 - no change; 3 - decreased). Lastly, changes in food production were rated and given relative scores ranging from 1 to 5 (1 - very high; 2 - high; 3 - moderate; 4 - low; 5- no change). All the relative scores were then multiplied by the counts (no. of respondents) for each category, to produce indices for each activity, then standardized to a maximum of 100%. All data analyzed were considered significant at 95% confidence interval at 0.05 level of significance

RESULTS

Socio-economic characteristics of respondents

Among the respondents, 61.7% were males. Age distribution of the respondents ranged from 18-72 years with youth aged between 18-35 years comprising 45%, followed by adults over 50 years at 40% while the education levels were 53.3% and 27.7% for “primary school level” and “no formal education”, respectively; 17% have attained secondary education with only 2% having attained tertiary level education. The main occupation of the respondents was farming (75%), harvesting and trade in wetland goods (12%), and formal

employment (8.3%). Most of the respondents (95.5%) had inhabited the area for over 10 years, making them suitable candidates for the study.

Impact of lake recession on land use activities

Following the lake water level recession, communities living around Nyando wetlands intensified their efforts on various land use activities (Figure 2). As a source of livelihood, community around Lake Victoria cultivated the crops along the lake mainly in the wetland. Cultivating occurs in swamps and marshes either by draining wetlands or by exploiting the well-watered and rich soils from which the floods retreat during the dry seasons. There was an increase in farming land as a result of newly exposed lands hence increased crop production by farmers cultivating along the fringing-wetlands and shoreline. The study results based on percentage rank scores and acreage of land affected by water recession reveal that majority of the respondents were engaged in agricultural crop production (72%), harvesting of wetland macrophytes (10%), grazing of livestock (10%), water supply (3%), wetland fishery (2%) and human settlement (2%) within the wetland area. Other less intense land uses included cultural practices (e.g. harvesting of medicinal plants) and physical infrastructure like roads.

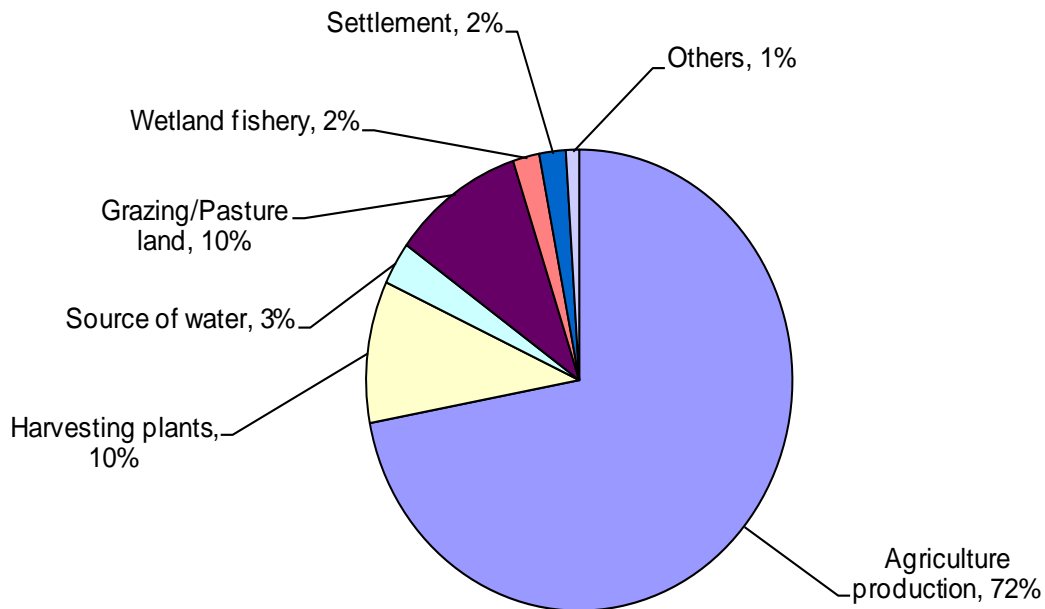


Figure 2. Percentage rating for different land use activities in Nyando wetlands.

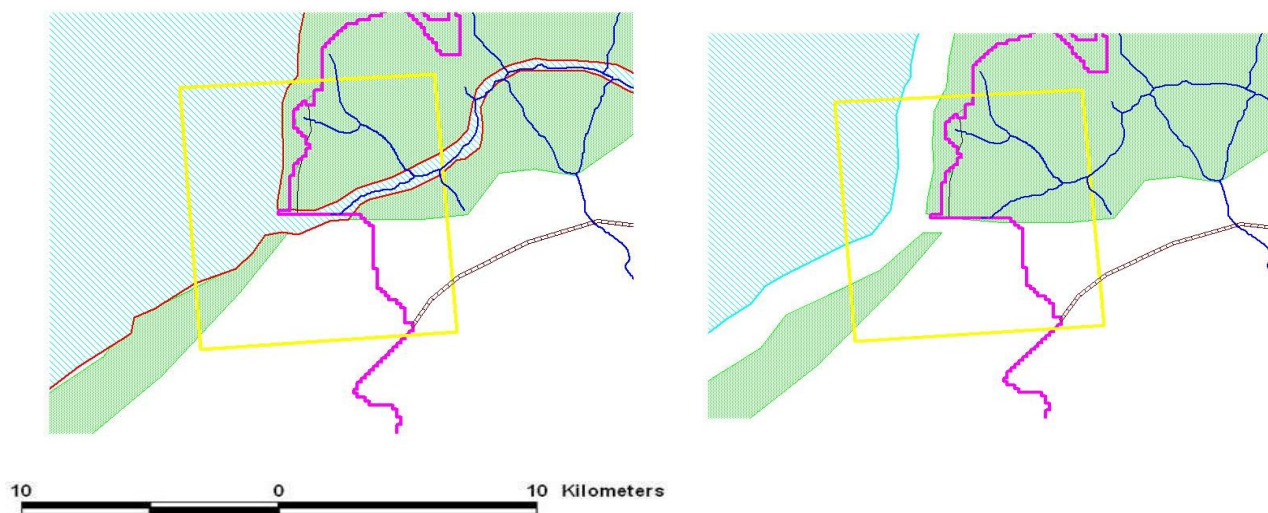


Figure 3. (a): Nyando wetlands before recession; (b) Nyando wetlands after recession.

Estimated area of wetlands areas exposed by lake recession

The estimated area of the fringing wetland before recession was 198.724 km² while the drawdown area after the recession was approximately 185.366 km². Thus, a vast area (close to 13.363 km² or 1336.3 ha) of the Nyando wetlands along the shores of Lake Victoria was exposed as a result of the lake water level recession. The DEM maps showing the estimated area of wetland area before and after lake recession are presented in Figure 3 (not drawn to scale).

Impacts of lake water recession on wetland resource utilization

The study findings indicate that the extensive Nyando wetlands are utilized by the community on both seasonal and long-term basis in their quest for livelihood benefits. Farming, fishing, livestock rearing, and wetland biomass harvesting form the main livelihood activities. Percentage rank scores of each wetland resource activity/services after the lake water receded are presented in Figure 4.

Survey results show two activities, namely crop production (92%) and harvesting of wetland macrophytes

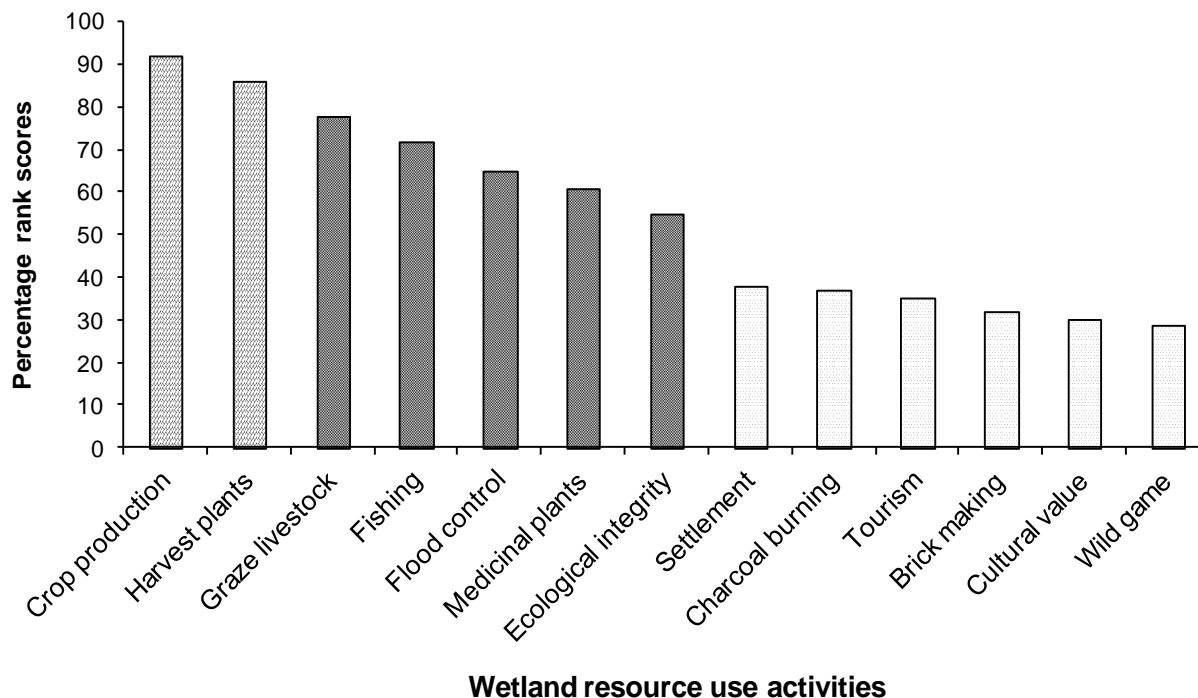


Figure 4. Ranking of importance of wetland resource use activities to household livelihood in Nyando wetlands. (Importance rating: Below 40 - Low importance; 40 - 80 = Important; 80 – 100 = Most important).

Table 1. Different types of conflicts in the Nyando wetlands before and after recession as perceived by the local communities during the study period.

Types of conflicts	% response before recession	% response after recession
Human – wildlife conflicts	87	8
Human – human conflicts	11	86
Human–conservation conflicts	2	6

(86%) obtained 'high importance' ranking scores. Five other activities namely; livestock grazing (78%), fishing (72%), flood control (65%), harvesting medicinal plants (61%), and ecological integrity roles (55%) were ranked as 'important'. The Nyando wetlands also perform important ecological services such as flood control and are also appreciated for providing filtration and purification services, especially for polluted water from agrochemical industries in addition to storage of water and offering tourism potential in the Western Kenya circuit. Moreover, the wetlands act as a source of medicinal plants, soil for brick making, timber and fuel wood, mainly at subsistence level.

Conflicts in resource use in Nyando wetlands

Unsustainable consumptive utilization activities such as increased pressure on agricultural land and over-

exploitation of wetland vegetation have been the major source of increased frequency of conflicts in the study area after lake recession. Different kinds of conflicts were reported in the study area following the lake water recession as shown in Table 1. Increased human- human conflicts resulted from invasion of the dry land created by the receding waters and the shifting river course sparking boundary disagreements among clans and individuals alike. In addition, human-wildlife conflicts increased considerably as the wildlife destroyed the agricultural crops planted in their natural habitats. Human-conservation conflicts have arisen mainly due to high poverty, lack of guidance from the relevant government authorities on issues regarding the demarcation of the buffer zones along the lakeshore and lack of national wetlands and land policies. It was noted that although the wetlands belong to the government, the boundary and access rights remain amorphous. Ownership and access to the wetlands needs to be resolved to prevent occasional

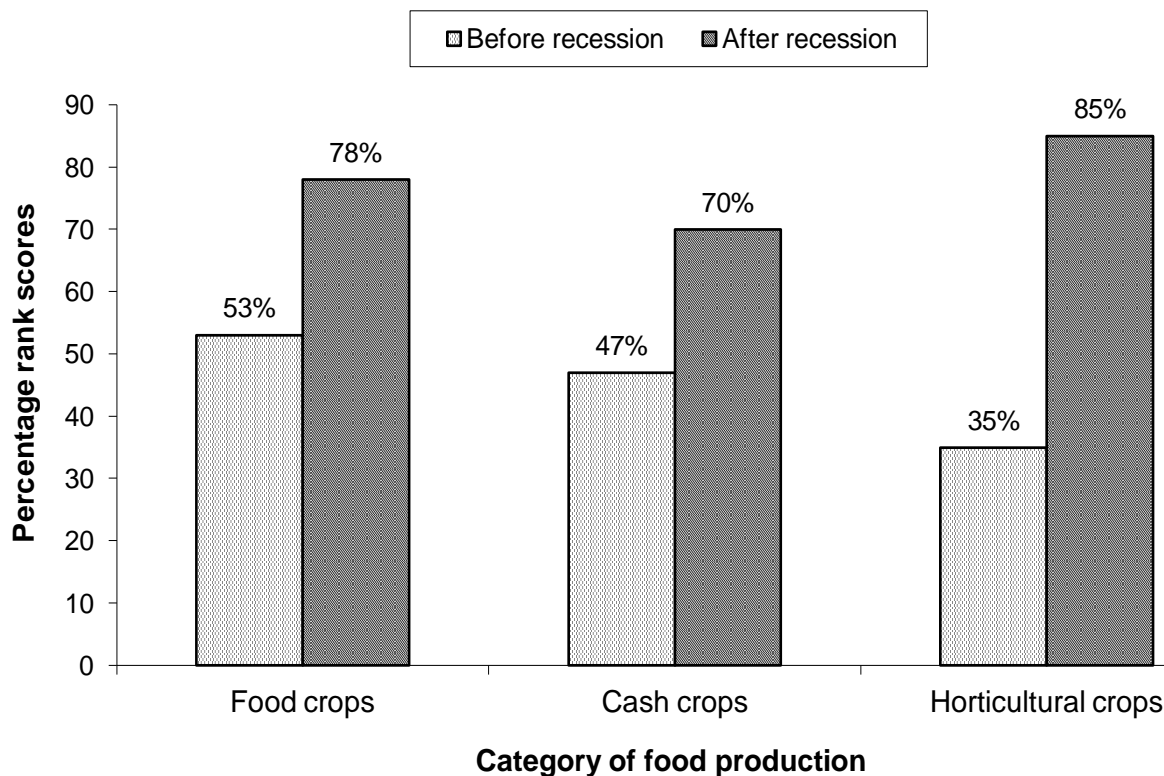


Figure 5. Changes in household food production in Nyando wetlands before and after Lake water level recession.

disputes and conflicts over resource use.

Impact of lake recession on household food production

As a source of livelihood, communities around Nyando wetlands depend on its resources for food production. How the respondents rated the changes in overall food production in the households before and after recession and results is shown in Figure 5. The major cash crops grown in the wetlands are rice, cotton and sugarcane that provide an income that is used for purchasing food from local markets. Crops that contribute directly to food consumption in the area include maize, sorghum, beans, millet, and wild vegetables (e.g. *Crotalaria* spp., black night shed, *Amaranthus* spp., cowpeas and spider flower (*Cleome gynanendra*). Results showed significant changes ($\chi^2 = 15.349$; $df = 6$; $p = 0.018$) in the perceived quantity of household food production derived from wetlands before and after recession. Though the perceived increase in food production was significant for all categories of food production (food, cash and horticultural crops), horticultural production experienced the highest increase to food contribution after recession (i.e., from 35% to 85%). The community members have initiated growing horticultural crops such as tomatoes,

onions, pepper, kales, watermelon, and other fruits to satisfy expanding rural and urban markets.

Impact of recession on economic activities and incomes

Nyando wetlands form an integral part of the rural economies of the local people. The survey findings established a significant change ($\chi^2 = 36.498$, $df = 10$, $P = 0.0001$) in income generated from lake fishery, wetland fishery and wetland farming before and after lake water recession (Figure 6).

Comparison of the sources of income shows that wetland farming (95%) became the major economic activity that fetched high income after the recession compared to only 10% before. On the other hand, two other economic activities that were important sources of income before recession, namely lake fishery and wetland fishery showed a marked decline after the lake level recession probably due to use of illegal gears and destruction of breeding areas, respectively. Income from trade in wetland products, such as papyrus and reeds experienced a slight change, owing to the overharvesting of wetland plants to clear areas for farming. Lake transport and formal employment did not play a significant role in contributing to household incomes both

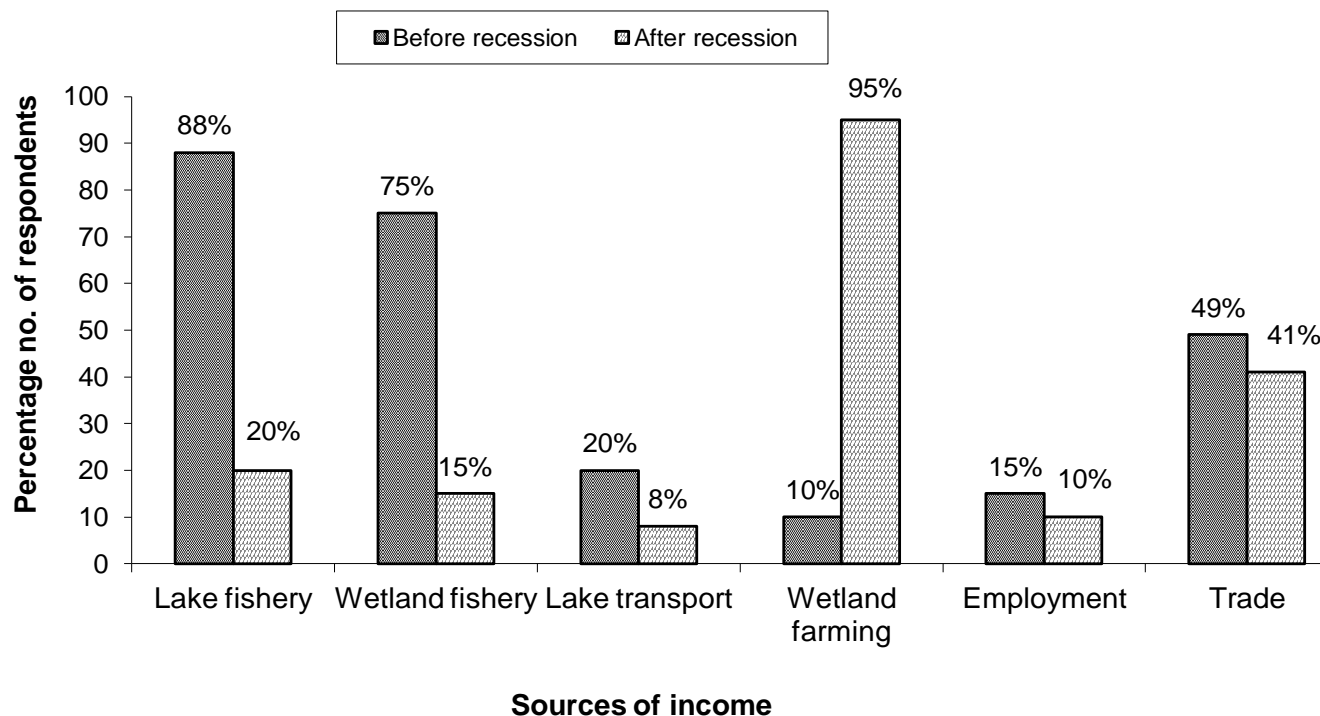


Figure 6. Changes in the local community sources of income from Nyando wetlands before and after lake water level recession.

Table 2. Common fish species found in the Nyando wetlands.

Scientific name	Common (English) name	Local (Luo) name
<i>Lates Niloticus</i>	Nile perch	Mbuta
<i>Oreochromis niloticus</i>	Nile tilapia	Nyamami
<i>Protopterus aethiopicus</i>	Lung fish	Kamongo
<i>Schilbe mystus</i>	-	Sire
<i>Rastineobola argentea</i>	Sardines	Omena
<i>Haplochromis spp.</i>	Haplochromines	Fulu
<i>Clarias gariepinus</i>	Catfish	Mumi
<i>Clarias mossambicus</i>	Mud fish	Duru
<i>Barbus altianalis</i>	-	Fuani
<i>Barbus cercops</i>	-	Adel
<i>Alestes sadleri / jacksonii</i>	-	Osoga
<i>Labeo victorinus</i>	-	Ningu
<i>Mastacembelus fretanus</i>	-	Okunga
<i>Synodontis afrofischeri</i>	-	Okoko rateng'
<i>Synodontis victoriae</i>	-	Okoko rachar
<i>Bagrus docmac</i>	-	Seu
<i>Xenoclaris spp.</i>	-	Ndhira

before and after lake water decline.

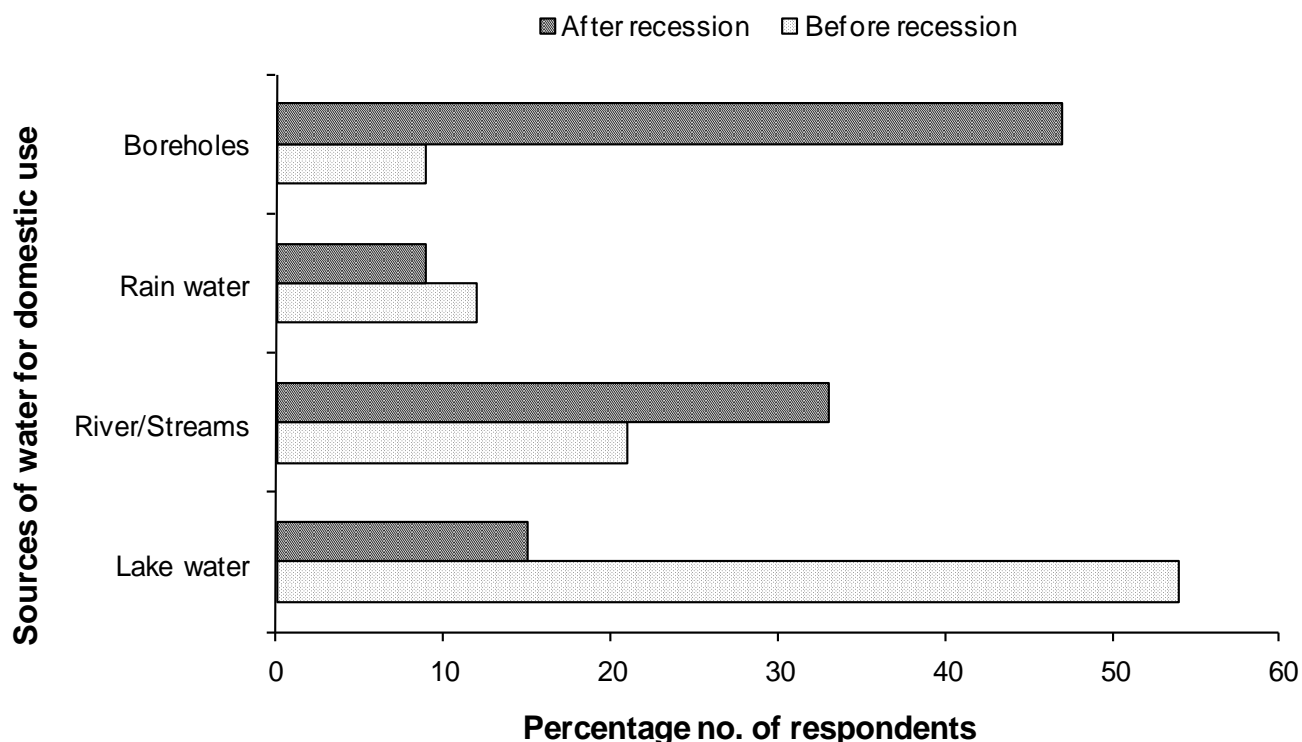
Impact of lake recession on fish catches

Fish is the most common source of protein and a wide

range of indigenous fishes are consumed by the communities living around Nyando Wetlands. Table 2 shows different fish species found in Nyando wetlands and nearby lake shores. The study findings reveal that lake fisheries and the post-wetland fishery showed a marked decline probably due to conversions and drying

Table 3. Community perception on the causes of decline in fish catches within Nyando River wetlands after the recession of the lake water level.

Causes of change in fish catches	Frequency (n = 120)	% No. of respondents
Loss of wetland habitat and refugia	52	43
Exposure of feeding and breeding areas by clearing macrophytes	48	40
Illegal and destructive fishing methods	12	10
Drying up of landing sites	5	5
Migration of fish to deep waters	3	2

**Figure 7.** Sources of domestic water supply before and after Lake water level recession in Nyando wetland.

up of beaches as result of lake recession. It was observed that those people who catch fish for food purposes did so in shallow waters. The shallow waters are the most fruitful in terms of fish catches, thus when water level is receding, fish catches also decreases. It was also observed that such areas had young regenerating grasses and macrophytes, an indication of destructive human activities that compromise the integrity of fish habitats. This threatens the food security and household economic gain of the rural communities.

Table 3 summarizes the main reasons cited for the reduction in fish catches by the local communities including loss of wetland habitat and loss of refugia; exposure of feeding and breeding areas due to clearing of wetlands; illegal fishing and destructive fishing methods; drying up of landing sites; and, migration of fish to deeper waters.

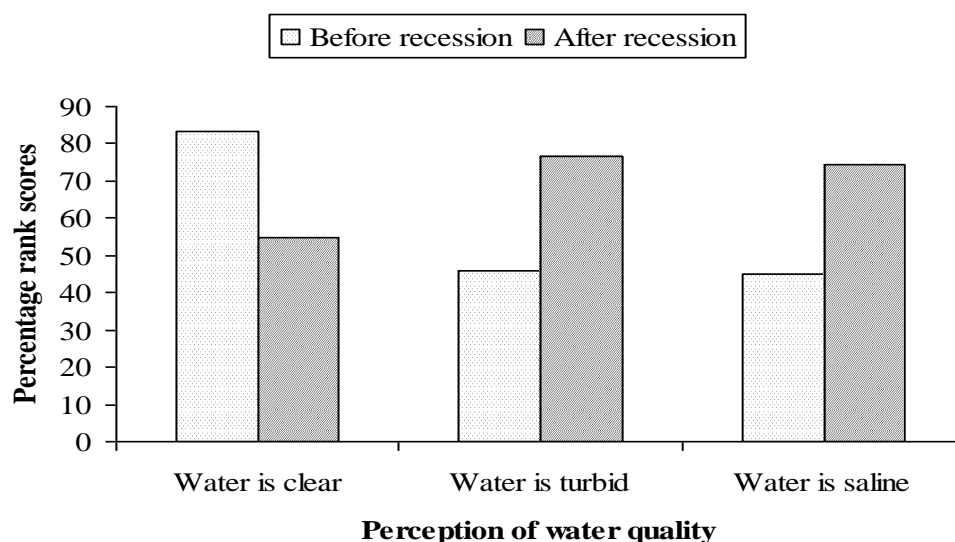
Impacts of lake recession on water supply, quantity and quality

Impacts on water supply

Figure 7 summarizes the sources of water for domestic use by the communities living around Nyando wetlands. The main source of water at household level before the lake recession was from the lake (54%), rivers/streams (21%) and rain water (12%). The people around the lake mostly depend on water from the lake for domestic purpose because lake water is fresh while water from underground wells is salty. But, the dependence on lake waters for domestic use varied with season whereby in dry season a number of households experienced water shortage. Water from protected and unprotected

Table 4. Distance and time take to water source and quantity of water used in households in Nyando Wetlands before and after lake level recession

Variables	Before recession	After recession
Average distance traveled to water source (m)	400	1200
Average time taken to water source (hrs)	1 h	2 h 30 min
Average quantity of water used daily by household (litres)	150	120

**Figure 8.** Rating of changes in selected water quality parameters in Nyando wetlands as perceived by the local communities.

boreholes was the main source after the recession according to 47% of the respondents. Only a few people continued to utilize lake waters for domestic and other purpose after the recession. This is due to increased sediment load into the lake from re-suspension of nutrients from agricultural activities.

Distance, time to the water source and average quantity of water

The proximity to respective water sources from the households is between 100 and 1200 m with the smallest percentage of households drawing water from sources that are more than 1.2 km away. Distance is a function of time. The increase in distance from water source increases time to collect water. Details of distances walked by households to draw water and time are presented in Table 4.

The households interviewed revealed that the average time taken to collect water increased from 60 min to 2 h 30 min after lake level recession due to the difficulties in accessing water points that was hitherto freely available before recession. As an adaptation it was noted that the

households reduced their water consumption from about 150 liters per household per day to about 120 litres per household per day.

Impact of lake recession on water quality

The lake water which the community uses for domestic purposes changed in its quality after the lake recession. Results of the perceived water quality changes by the community are presented in Figure 8. A significant number of respondents ($\chi^2 = 11.445$; $df = 1$; $p = 0.002$) believed that water clarity had reduced while water turbidity and salinity have increased remarkably. About 77% said that suspended solids increased remarkably after the recession making the water unsuitable for domestic purposes. A large percentage (74%) also felt that water salinity also increased.

Impacts of lake recession on biodiversity

The impacts of Lake Victoria water recession as perceived by the residents on wetland plant, animal species

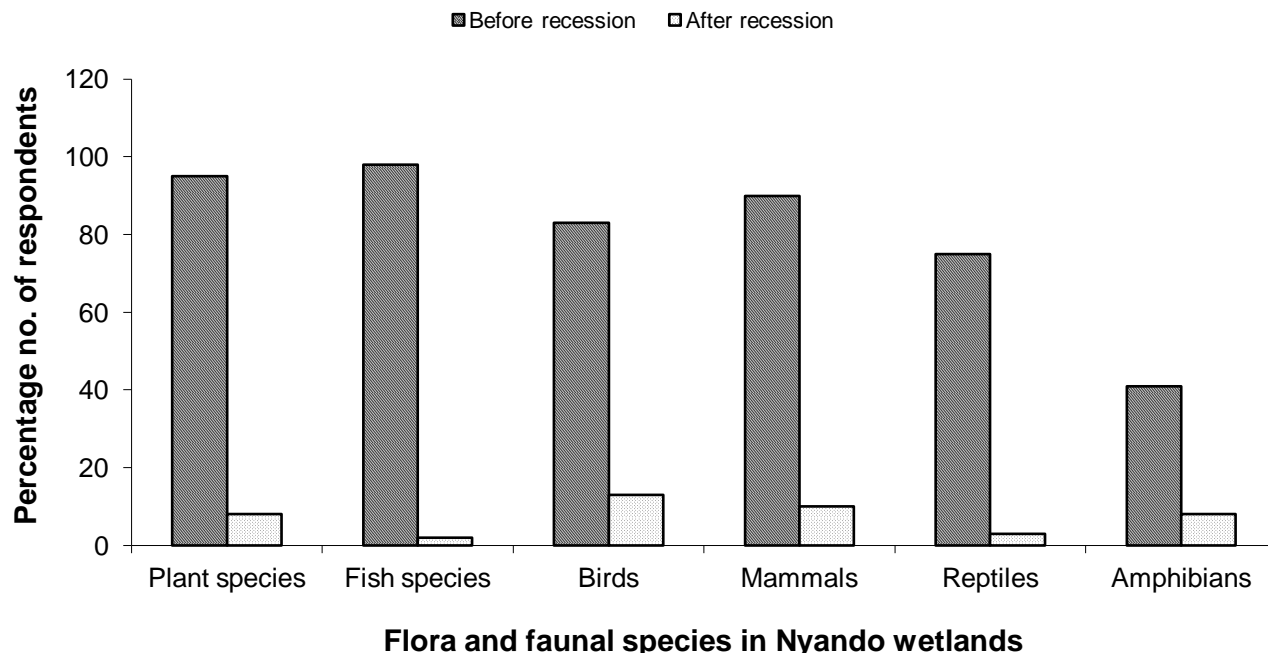


Figure 9. Perceived changes in flora and fauna before and after lake water recession in River Nyando wetlands.

is presented in Figure 9. Results show that there was significant reduction ($\chi^2 = 8.02$, $df = 5$, $P < 0.001$) in the abundance of both plants and animals species before and after recession. The declining water level exposed all the papyrus wetlands along the lake's shores. This provided an opportunity for the residents of the area to 'follow' the water leaving no vegetation and submerged macrophytes that define wetlands as they encroach on these productive areas. Study findings also indicate that the abundance per unit area of *Cyperus papyrus* in the wetland reduced from 95% before recession to 8% after recession. Similar trends were also observed for faunal species within the wetlands. Nearly all the respondents (99%) reported abundant supply of different fish species before recession of the lake water levels. In general, it appears that as the water receded, the non-aquatic animals reduced significantly in abundance while the aquatic communities move outwards back into Lake Victoria.

DISCUSSION

Socio-economic characteristics of respondents

Nyando wetlands perform both important socioeconomic and ecological functions, as indeed it is rich in natural resources on which the riparian communities depend. However, over the past few decades the wetlands have undergone severe degradation that threatens sustainable utilization of the wetland resources. Findings from this study show that the population is slightly skewed towards

the youths that normally provide labour needed for physically demanding activities like farming (CBS, 2001). Owing to the current unemployment situation in Kenya, majority of the community members increasingly rely on wetland goods and services for their livelihood thereby placing heavy pressure on the wetland resources. Additionally, unfavourable socio-economic conditions such as low literacy levels, high gender disparity, perennial floods and unskilled labour force as noted by CBS, (2004) translates into high and increasing reliance on wetlands. This entrenches the cycle of poverty, diminished economic gains from investments and increased socio-economic deprivation especially among the more vulnerable groups such as women and the youth. Many residents still live in abject poverty facing a truncated view of the future associated with inadequate housing, health facilities, supply of clean water and low levels of school enrolment, particularly at middle and tertiary level. These pressures will force the wetlands to continue shrinking if appropriate measures are not taken into consideration. The recent lake level changes are expected to exacerbate the situation, hampering the wetlands capacity to perform its role as a buffer and as a sole source of livelihood to the local communities who depend on its resources.

Impact of lake recession on land and wetland resource utilization

Wetlands are an important component of land use in the lake basin since they are among the most productive

ecosystems (Barbier et al., 1997). The main factors that make wetlands particularly attractive for agriculture are high soil humidity resulting from sediments and nutrients transported by runoff and rivers during floods that fertilize the soil and the presence of freshwater, especially during the dry season (Terer et al., 2005). The land use changes have impacted negatively on wetland ecosystems causing habitat degradation, and loss of wetland values and services (Swallow et al., 2008). The domination of the land use practices in the Lake Victoria wetlands by agricultural activities has also been reported in the past by Kairu (2001). The Nyando wetland is about 5000 ha and is characterized by high agricultural productivity. As a result of the recession and the resulting drainage of water from wetlands, approximately 1336.3 ha of new lands were created at the land/swamp interface resulting into a massive destruction of wetland ecosystem.

Linked to the lake water recession in wetland areas, was a shift in land use from subsistence to commercial economy as intensification of agricultural crop production took advantage of the newly exposed fertile agricultural land and ease of irrigation since the lands are closer to the source of water. Several studies have also reported a progressive shift of farming system enterprises from terrestrial to wetland-based production systems by households in close proximity to wetlands (Kairu, 2001; Kipkemboi, 2006). The encroachment and extensive conversion of the emergent wetland vegetation zone and its associated environmental impacts may compromise the wetlands buffering capacity which have also been observed in the past (Terer et al., 2005). Apart from changes in land use practices, other anthropogenic activities which increased in intensity include overgrazing by livestock, burning of the wetlands, and over-harvesting of macrophytes that play a synergistic role in setting inertia of degradation likely to interfere with the hydrological cycle and macroclimate regulation in the area. Over-exploitation and destruction of wetland vegetation also curtail the filter function of wetlands as pollutants and nutrients are carried directly into the lake when the vegetation of wetland macrophytes is destroyed (Odada et al., 2004; Raburu and Okeyo-Owuor, 2005). Uprooting of papyrus rhizomes by the community for use as fuel wood from the burnt and overgrazed areas may make it impossible for the papyrus to regenerate even after the water level increase in future.

Impact of recession on household food production

Nyando wetlands contribute directly to food security by providing products that people can utilize and/or sell to provide them with cash for purchasing food. The study results show that there was a strong relationship between lake water recession and increased food crop production. This increase may be attributed to availability of arable land which community members cited as one of the

greatest benefit of the recession. Increased crop production is supported by the fertile and moist soils deposited in the floodplains during previous flooding activities (Handa et al., 2002). It is important to note that is rapid proliferation of small scale horticulture activities within and along the wetlands of the lake using water from shallow hand dug wells, permanent streams and exposed lands due to lake recession. The crop harvest from the wetland areas is always ready throughout the growing season when the supply of food from the upland fields and other regions is running out for many families and the "hungry season" is starting, hence the produce from the wetland areas supplement their food security. Therefore, wetland cultivation can be seen as a critical survival mechanism (Silvius et al., 2000) and as a source of food security, (i.e. food security 'safety nets' available to impoverished people), especially for those people whose upland harvest was poor following recurrent droughts in major parts of Kenya (KFSN, 2006).

Furthermore, the riparian communities have always depended on the lake fishery for their subsistence activities, generating food for consumption and for employment (Onyango, 2005). Despite the significant role fisheries play in ensuring food security in the area, results from the present study reveal changes that have led to significant decline in fisheries food production probably due to conversion of the critical wetland habitats. The 2.5 m drop of the lake level exposed all the papyrus wetlands along the lake's shores. Since papyrus wetlands provide a refuge to tilapia juveniles, and this refuge was unavailable when the wetlands were exposed, the recruitment of tilapia juveniles in papyrus-fringed was consequently hindered. This finding agrees well with other studies that report that a decrease in water level modifies near-shore habitats and unfavorably changes the breeding area available to many fish species (Lung'aiya et al., 2001). Lake level recession also made livestock grazing areas smaller due to clearing of vegetation while the distance walked to livestock watering and grazing grounds become longer. The same was reported by Kipkemboi (2006) who observed that most farmers sold their livestock due to lack of pasture to avoid the raging conflicts that occurred in the area during dry seasons.

Impact of recession on economic activities and incomes

Commercial production from various economic activities has boosted the rural economy of most residents depending on the Nyando wetland resources. The wetlands support commercial and subsistence agriculture, fishing, as well as harvesting of macrophytes used to make marketable products (Kipkemboi, 2006). The findings of this study indicate a high degree of dependence of rural households on wetland resources for

economic benefits. For example, wetland vegetation especially papyrus, grasses and water hyacinth provide materials for making mats, baskets, furniture and other marketable products (Gichuki et al., 2001; Omollow, 2003). The results of this study confirm previous studies that wetlands resources dominate the livelihood assets and socioeconomic activities of many riparian households (Gichuki et al., 2001; Kipkemboi, 2006; Kipkemboi et al., 2007). These economic activities contribute to poverty alleviation and job creation in rural areas. This is especially true in the 100 km buffer ring around the lake as a result of wealth of natural resources and economic benefits the basin offers. The results are consistent with the findings of Schuyt (2005) in Yala swamp, who reported a similar high dependence of local riparian communities on natural wetland resources.

The receding lake water levels caused many changes in the livelihood and income generating activities of wetland communities. The most significant change was increased wetland farming in reclaimed areas. Forced by unreliable weather and frequent failure of rain-fed upland crop production, the local communities around wetlands turned the wetland margin into crop production patches (Kairu, 2001). In contrast, lake and wetland fishery showed a marked decline because a fall in lake level exposed the breeding sites making fish move to deeper waters. This makes the fish scarce whilst the prices increase leading to low affordability and reduced consumption by the local communities. However, the contribution of the wetland fishery to household economies has not been well documented to date as it is characterized by seasonal variability and is mostly at the subsistence level (Kipkemboi, 2006). Lake transport also faced a major challenge since the landing beaches dried up and most infrastructural facilities were affected (LVBC, 2006). Trade on wetland products seems not to have been affected much as a large percentage of the community utilized the papyrus cut to create way for agriculture development in the making of different papyrus products traded for income.

Impact of lake recession on fish catches

Lake Victoria fishery is the pivot of the economic activities in the basin and an important source of livelihood for majority of the riparian communities (Okeyo-Owuor, 1999; Onyango, 2005). It provides employment, protein and income to the rural community. Wetlands are of great ecological importance and are probably the most important zone for inland freshwater fisheries as they support a large invertebrate fauna; act as a breeding, nursery and feeding ground for young and growing fish; and provide refugia against predators (Balirwa, 1998; Kairu, 2001). The critical habitats for these activities have been identified as shallow (4 m deep) inshore macrophyte dominated areas, sandy and muddy-

bottomed areas in addition to riverbanks and streams (Okeyo-Owuor, 1999; Balirwa, 1998), which still provides refuge for surviving native tilapiine species that are virtually extinct in Lake Victoria (Balirwa et al., 2005).

The exposure of the littoral zones due to receding water levels have jeopardized fish spawning in wetland areas thereby hindering fish recruitment. During this study it was established that there was a significant decline in the fish species diversity of the Nyando wetlands and ecotonal lakeshore species, the majority of which are the surviving remnant endangered species. In fact, a strong relationship between lake water recession and decline in the fish species diversity and catches was established. As the lake level falls, breeding and nursery sites are exposed and left dry following the clearing of dominant macrophyte areas for crop cultivation. The shallow waters are the most fruitful in terms of fish catches, thus when water level is receding, fish catches also decreases (Kiwango and Wolanski, 2008). It was observed that those people who catch fish for food purposes caught fish in shallow waters. The same findings were recorded by Kairu (2001) who noted that the very young of several species of fish find shelter from predators, as well as food, in shallow waters. The relationship between lake water recession and decline in the fish species diversity and catches can therefore be attributed to loss of wetland habitat and loss of refugia as the water receded a position which is also shared by LVBC (2006).

Elsewhere, studies by Hickley et al. (2002) reported that changing lake water and loss of macrophytes leads to decline in fish diversity with low reported catches. The authors argued that fish catches appear to be related to trends in water level changes with a rise in lake level generally followed by increased catches and a fall in level followed by a corresponding decline in fish catches. Other factors that may contribute major threats to fish survival in the Nyando wetland include excessive fishing pressure when fish congregate to spawn, drainage of the wetlands for agriculture, massive angling for bait used in the long-line fishery of Nile perch, siltation, pollution and use of destructive fishing techniques such as beach seines and monofilament nets in wetland areas bordering the lake. The findings by Odende and Nyongesa (2004) also support this premise.

Impact of water recession on water supply, quality and quantity

The recession in water levels in Lake Victoria has had a marked negative impact on water resources and other physical infrastructure in Nyando wetland region. Boreholes, rivers, streams and trapped rainwater serve as important sources of water for domestic purposes since water collection points along the lake that used to serve the local communities before the recession dried

up. According to the LVBC (2006), water supply to riparian communities around the Lake Victoria Basin is now a challenge due to the water level recession. For instance, communities sail inside the lake to draw less muddy waters often in hired canoes. Water canals that used to supply water for rice irrigation have also been filled by silt loads while pipes supplying water are non-functional because of clogging with sand and silt (LVBC, 2006).

The conversion of wetland areas into farmlands, with a resultant destruction of macrophytes that filter sediments probably led to changes in physico-chemistry of river and lake water (Raburu and Okeyo-Owuor, 2005). It was observed that as the water receded, large areas of mud flats and very shallow turbid waters have developed close to shore and within wetland areas that used to be permanently waterlogged. Water salinity was also reported to have increased probably as a result of increased evapotranspiration, agricultural activities, drainage and low water table as the lake recedes. The residents of the area also faced water scarcity forcing them to use unsafe water for human consumption and to reduce their water consumption rate due to water transportation hitches.

Across many rural areas of Africa, domestic water use has been found to vary from some 20 litres per person per day to 40 litres per person per day (Butterworth and Soussan, 2001). In this context, the water availability for domestic use is less than the average per capita water consumption. In areas worst hit by the water stress, people have to walk greater distances to fetch water for domestic purposes. Decline in lake level impacted negatively on women who are normally charged with the responsibility of collecting water for their households. This arises from them being forced to travel long distances and hence using more time in collecting water thus compromising time to be invested in other important socio-economic activities. Similarly, time spent finding and collecting water can have a high cost in terms of lost production, income, and food gathering through reduced labour time, as well as missed education for children.

Impacts of lake recession on biodiversity changes

The study findings show that natural water lake level changes have caused dramatic changes to the biodiversity of Nyando wetlands. Low water levels have jeopardized fish spawning, reduced bird nesting areas, limited vegetation cover, exposed and promoted access to areas where reptiles use to breed and restricted amphibian spawning areas. Bennun and Nasirwa (2002) recorded that when a lake is undergoing water decline, the effect is to expose an increasing amount of the rhizome mat and associated detritus to the atmosphere, although the root systems remained continuously waterlogged. Consequently, the vegetation of the area

that defines the boundary of the wetlands and hosts many different animal species significantly reduces as a result of lake water recession, a position which we share with them in this study.

Many different species of upland and wetland birds exploit Nyando wetlands occasionally to obtain food and water as wetlands nesting grounds. As water levels receded, there was a significant reduction in the number of wetland birds that utilize these areas. This is likely to have resulted to habitat modification since large areas of the wetlands were transformed to mudflats or changed to very turbid shallow waters in the favorable feeding areas close to the lakeshore. In addition, some fish eating birds that depend on fish for food may have had restricted access to fish food due to high sediment blanketing. Several studies from elsewhere have also reported changes in wetland bird population changes in water quality and food availability (Childress et al., 2002). Bennun and Nasirwa (2002) reported that due to low water level and resulting high alkalinity, fish stocks decline or disappear followed by decline in fish eating birds. Migration of the birds to other areas is likely to take place as wetlands go dry because they are abandoned by obligate wetland species that migrate to areas with standing waters. This could be the reason why the population and diversity of avifauna declined during the recession.

Most mammals are often found around the periphery of the wetland where they forage for the emergent vegetation (van der Valk, 2006). The recession of water in Nyando wetlands may have caused massive reclamation of land for different human activities that led to increase in human-wildlife conflicts. This may explain the reduction in abundance of animals and reptiles like sitatunga (*Tragelaphus spekei*), hippos (*Hippopotamus amphibious*), crocodiles (*Crocodilus niloticus*), antelopes and hare. Decline in abundance of wetland animals as water levels recedes and the wetlands on which they depend shrink or disappear due to human encroachment has also been reported by Finlayson and Moser (1991).

Conclusions

From the study, the following conclusions can be made:

1. Lake recession increased availability of land for agriculture and crop yields. The decline in water level led people to cultivate exposed land areas so as to increase their crop yields. Pasturage and water for herding livestock also altered due to lake level changes.
2. There exist a strong relationship between lake water recession and increased food crop production. Small-scale horticulture activities along the wetland margin have exhibited rapid proliferation especially using water from shallow hand dug wells, permanent streams and exposed lands.

3. The contribution of lake and wetland fishery to food security and household income showed a marked decline. This made the fish scarce and therefore expensive, implying that fewer people were able to buy the fish after water level recession thus more vulnerability to malnutrition and food insecurity.
4. The increased utilization of wetland areas to supplement local economies led to improved economic benefits, particularly from agriculture.
5. Unsustainable utilization of the major wetlands through agricultural activities and over-exploitation of wetland vegetation has greatly compromised the buffering capacity of the wetlands. This change gave rise to poor physico-chemistry of the river and lake water hence limiting the daily consumption and a risk to human health.
6. Low water levels jeopardize fish spawning, reduced bird nesting areas, limited vegetation cover, exposed and promoted access to areas where reptiles use to breed and restricted amphibian spawning areas. As water level recedes fish catches reduce due to loss of wetland habitat and refugia by drying up critical breeding, nursery and feeding areas.

RECOMMENDATIONS

The following are some of the recommended activities that can help restore degraded papyrus swamps, as is the case with Nyando wetlands:

1. Proper buffer zones should be designed where appropriate for papyrus protection. There is need to restore, re-create and rehabilitate the destroyed papyrus swamps especially along the lake / wetland interface in Nyando basin.
2. Efforts should be made to promote the establishment of alternative sustainable development options such as aquaculture, value addition of wetland products, horticulture, recreation and ecotourism with the aim of creating employment opportunities and improving the income of people.
3. National policies on wetland conservation management which can conform with agricultural development policies are vital. Attention must be paid to the fragility of the ecological and hydrological processes of each wetland and how different types of agriculture will impact its ecosystem.
4. Alternative water sources need to be identified to cope with the declining water supply, particularly during periods of low-water levels through public private partnerships. These include: harvesting and storage of rainwater in water pans; abstraction of water during wet season from the river and lake; and construction of deep wells to circumvent water shortage for the communities around Lake Victoria.
5. Conservation and management programmes need to be implemented and developed. A Site-Specific Management Action Plan should seek to gain better formal protection for the sites, promote environmental awareness through an education programme and develop alternative forms of local land-use and employment, including developing its considerable potential as sites for bird-watching and eco-tourism.
6. Further detailed ecological studies need to be carried out to unravel the delicate balance between hydrological changes, buffering capacity and biodiversity loss resulting from recession of water levels.

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