International Journal of Advanced Research and Development
ISSN: 2455-4030; Impact Factor: RJIF 5.24
Received: 09-02-2019; Accepted: 11-03-2019
www.advancedjournal.com
Volume 4; Issue 3; May 2019; Page No. 39-43

Key wetland resources used to support community livelihoods in lake ol'bolossat catchment, Nyandarua county, Kenya

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Abstract
One of the major challenges to sustainable use of wetlands is lack of awareness by communities on the values of these ecosystems. Wetland resources are important for socio-economic, cultural and ecological supply of goods and services. Despite their importance, wetlands have remained unprotected and they are exploited beyond what they can endure. The main objective of the study was to establish the effects of natural resource-based conflicts on community livelihoods in Ol'Bolossat catchment area in Nyandarua County. The study was conducted in twenty villages, simple random sampling of 252 households and purposive sampling of key institutions such as KARI, KWS and KFS was carried out. Household questionnaires were issued to sampled households, interviews were held with conservation group leaders and FGDs with the local leaders were carried out to establish environmental issues in the study area. Transect walks, direct observation and photography revealed that there was human encroachment, crop and livestock farming in the basin. The results indicated that there was co-relation between human population increase and land use changes at Pearson product moment correlation coefficient r = 0.30, n= 252 and p= 0.01, which had led to wetland degradation and conflicts. The results also indicated that there was a significant difference in the rating of wetland uses for water, fodder, cultivation and apiary with Chi square (6.619), df (2), p (0.037) at 95% level of confidence. The people living near the lake (within 1km) depend on wetland resources more than those living further away and the former experience more conflicts. The FGDs and interviews indicated that the livelihood activities such as crop and livestock farming were based on water, land and biodiversity utilization. The study supports the conclusion that the conflicts in Ol'Bolossat catchment area are natural resource based (NRBC) and they affect the community livelihoods. The human population increase, land fragmentation, access and competition for scarce natural resources between humans, wildlife and livestock have brought about conflicts. The community livelihood is affected when wild animals destroy crops, injure and kill humans, besides transmitting zoonotic diseases to livestock with which they share the same resources. It was recommended that conservation of the natural resources ought to be enhanced through community participation and stakeholder involvement. More trees should be planted to replace those that have been cut. The farmers ought to diversify crop farming and improve on food storage in order to mitigate vulnerability to climatic conditions. The Government could as well educate the local community on methods to mitigate human-wildlife conflicts so that residents utilize the natural resources safely so that they improve their livelihoods.

Keywords: Wetland resources, community livelihoods, Kenya

1. Introduction
Lake Ol'Bolossat contributes to the livelihoods of the local community in diverse ways. It supplies goods and services to many people who compete for this same natural resource and depend on it for livelihood support. According to Wallensteen (2007) [21], there is conflict in a situation where two or more actors strive to acquire at the same moment in time an available natural resource.

The original inhabitants of the study area were Masaai pastoralists and the land belonged to the community as there was no individual land ownership. Crop farming was done on very small scale without use of chemical fertilizers. The farmers relied on human labour and dairy products were stored in pots and gourds. Cereals such as millet and sorghum were stored in ventilated baskets. The cattle were smeared with tobacco to control pests and diseases. East Coast Fever was treated by burning swollen glands with hot iron. The pastoralists killed livestock for meat and did not kill wild animals (Ruhiu, 2000) [20]. The community had their own rules and regulations controlling the use of natural resources for medicine, craft and thatching their traditional houses (manyattas).

Wetlands are important natural resources with enormous socio-economic, cultural and ecological value, which are necessary for achievement of Vision 2030. This vision emphasizes conservation of resources in a natural manner (NESC, 2006) [17]. However, environmental degradation and diminishing natural resources are linked to conflicts at international, national and local levels (Okech, 2010) [19]. This study can provide the necessary information for conservation, protection and management of the study area for livelihood support. All these strategies require an in-depth understanding of parameters that threaten conservation of Lake Ol'Bolossat.

Although Natural Resource Based Conflicts are on the increase, this remains a relatively neglected area of research (Okech, 2010) [19].

Wetland habitats include marshes, swamps, and lakes, ponds, marine and estuarine. Lakes are large while ponds are small and shallow. The main wetland resources include water, unique water-associated soils, vegetation and water animals (Ndang'ang'a, 2003) [15]. The nature of the soil

determines the type of vegetation in an area. It contains decomposed plant material and in Ol'Bolossat it has a characteristic odor of rotten eggs (Ruhiu, 2000) [20]. Some wetland soil is sandy but it is mixed with dead plant material (detritus). The plant types include cattails, bulrushes, water lilies, sphagnum moss, bald cypress, sedges and rushes. There are salt tolerant plants which include giant cord grass and bulrush. The hydrophytes have special adaptations that allow them to survive in a waterlogged environment (Kok et al., 2009) [10]. Wetlands have high primary productivity due to ability of water plants to capture large amounts of the sun's energy and store it. The grazing food chain is very productive in wetland systems (Chris, 2010) [4]. Wetland plants and animals interact with each other but some dominant species exert more pressure on the wetland as well as water and vegetation stress (Crafter et al., 2008) [6]. Mammals, Fish, amphibians and insects compete for the same natural resources. The largest herbivores in the basin are the hippopotamuses. The cattle grazing in the basin are abundant in the dry season. The hippopotamus population density is 3.6 animals per Km2, which is one of the highest in Kenya (NEMA, 2007) [16]. The grazing activities influence the structure and composition of the natural vegetation which supports a large number of herbivores and grasshoppers. Continued overgrazing maintains a low grass biomass (Ndang'ang'a, 2003) [15]. Trampling by animals affects ground-nesting birds negatively. The other water animals include waterfowls, ducks and geese and they are indicators of environmental quality. The areas with high concentration of different species of birds are also rich in diversity of other animal species as well. There are about 74 species of birds in Ol'Bolossat that have been identified (Birdlife International, 2000) [2]. Some wading birds are migrants and others are residents. Few birds of prey utilize the swamp and its grassland. The Egyptian vulture, Lanner Falcon and African Fish-Eagle inhabit the basin (Bennum and Njoroge., 2001) [1].

Lake Ol'Bolossat has been subjected to extensive degradation and this has threatened its very existence (NMK, 2006) [18]. There are conflicting interests marked with sharing of resources between livestock and water animals and this may have compromised its ability to make a meaningful contribution in supporting the local community livelihood and the country's economy (KWS, 2009). According to Laue (1993), a conflict is an escalated natural competition between two or more parties for the same scarce resources. The Natural Resource Based Conflicts (NRBCs) are manifestations of the inter-dependence (web of life) between environmental components such as animals, vegetation, soil and water. The occurrence of local conflicts highlights the need for balancing short term and long term resource needs since the destruction of one element has repercussions on other components of the environment. If degradation continued, it would take a relatively long time to rehabilitate Lake Ol'Bolossat since a lot of biodiversity would be lost. A survey by the National Museums of Kenya (NMK, 2006) revealed that farmers use agro-chemicals such as pesticides and fertilizers without standard measurements. The chemicals infiltrate into the soil and run-off to pollute the lake. Pollution from toxic chemicals kills the aquatic animals, plants and micro-organisms.

The study limited itself to Lake Ol'Bolossat catchment area. The results can only be generalized to Lake Ol'Bolossat Catchment area. Due to limitation of resources, it was not possible to study all the villages in the basin, hence the need for sampling.

2. Methodology

Lake Ol'Bolossat is bordered by Ndaragwa, Olkalou and Ol-joro-orok Divisions. It is situated in a wedge- shaped Rift Valley floor sloping eastwards and northwards. Lake Ol'Bolossat is approximately 195 km North of Nairobi. It lies between latitudes 00 09'S and longitudes 360 26'E in Nyandarua County. Most streams flow for a distance and then disappear underground (NEMA, 2007) [16].

The research design was descriptive survey in which the community members gave information to describe their behavior, perceptions and values. This design was deemed suitable for the study since through data collection from respondents, it would determine the natural resource uses, livelihood activities and the conflicts encountered there-of.

The study area has an accessible population of 16658 people, (8353) males and (8305) females. A sample size of 252 households was determined by the formula (Mugenda and Mugenda, 2003).

Water samples were collected using sterile WHIRL-PAK bags which were 10ml each. The water was taken to the laboratory and analyzed for chemicals in the water. The water quality guidelines were provided by Athi Water services. Piloting of research instruments was carried out to ascertain validity and reliability of the instruments (Kombo and Tromp, 2006). Both qualitative and quantitative data was collected using household questionnaires, interview schedule, Focus Group Discussion guide for the local leaders, photography and observation checklists.

3. Research Findings

According to the findings, (56.7%) of the respondents were males while the females were (43.3) %. According to the study, 7.8 % of the population was aged between 0-30 years, 83.4% was aged between 31-50 years while 8.8 % of the respondents were aged above 50 years.

Preliminary studies and observations indicated that the key resources which affect the community's quality of life include water, land, grassy vegetation and wildlife. Most of the respondents indicated that fresh water is the most important natural resource that affects their livelihood.

3.1 Land Use Changes

There is land contestation between 'new comers' who have stayed in the catchment area for less than ten years and long standing residents. The new comers have smaller pieces of land ranging between 0 to 3.5 hectares bought from former residents. However, most of the new comers do not depend on the wetland for grazing cattle but they practice stall feeding. The wetland is communally owned but most of the respondents said that it belongs to the government.

The wetland has been fragmented for agriculture and settlement. The existing land tenure system of inheritance has led to land subdivisions. The wetland has continued to be sub-divided to cater for the increasing population. This has resulted in continued encroachment into the wetland for various uses as farms become small (plate 1). The wetland has been used as an alternative source of grazing land. Animals are freely grazed and watered in the wetland.

Human settlement in the un-protected area

Fig 1: Encroachment in Ol'Bolossat Basin by farmers. The settlements on the right side of the row of trees are in the unprotected part of the basin. Photograph taken on 10th April, 2012.

3.2 Inter-dependence of animals in the basin

All the animals depend on wetland vegetation for food and habitation. The birds pollinate plants and disperse seeds which are fed on by animals in the ecosystem. The birds feed on ticks from the hippopotamuses bodies, thereby removing parasites that cause diseases (Ruhiu, 2000) [20]. There are strong associations among all the animals in the ecosystem and destruction of one species has negative effects on the others and conflicts ensue.

Birds such as the Yellow-billed duck, Red knobbed Coot and Glossy ibis are indicators of environmental quality and the hippopotamuses in the lake are about 200 in number. Coypu rat is an invasive species of mammals that has no natural enemies. It threatens the existence of reeds such as Cyperus ridigifolia. Buffaloes and water bucks have disappeared in a period of about ten years. Thomson's gazelles have reduced in number due to human settlement and agriculture. A few gazelles are still in existence together with hyenas and leopards.

3.3 Effects of Human Activities on Vegetation

Responses indicated that there was limited accessibility to wood sources due to the Government Policy to protect forests from destruction by the people using firewood. The fuel wood and timber had become expensive due to the policy (G.O.K. 2009). The alternatives that the community had were clearing vegetation in the wetland, intercropping trees with crops and starting woodlots.

Nevertheless, eastern side of the lake is characterized by deforestation, burning charcoal and vegetation to clear land for cultivation. The burning of vegetation poses danger of spreading fires. It leaves tracts of land bare and prone to soil erosion and loss of soil fertility. Some conservation groups have established tree nurseries but progress is hampered by lack of suitable seeds and limited space for siting the nurseries. It was noted that large areas around the lake are covered with eucalyptus trees. These are the wrong tree species to be planted in the wetland since they take up a lot of water from the water table and lose it by transpiration.

The vegetation comprises of marshland, open water vegetation, swamp and grassland. The plants in the marshes include Panicum repens, Cyperus ridigifolia, Cyperus papyrus, Cirsium vulgare and latifolia.

The open water vegetation comprises of rooted submerged, emergent and floating macrophytes. The macrophytes include Nymphae caerulene, Ludwiga stolonifera and Najas pectinatus. The invasive species include Salvinia molesta (water hyancith) and Pistia stratioles. There are dominant grasses such as Pennisetum sphacelata, Themeda triandra and sprobolus species. Other species include setaria and virgate (Ndang'ang'a, 2003) [15]. Legumes occur together with the grasses and they are used as fodder for cattle.

3.4 Uses of water

Responses indicated that water is the most important natural resource in the catchment area, which supports livelihoods (Table 1).

Table 1: Wetland used for water supply

	Frequency	Percent
Uses lake water	145	57.5
Uses other sources	107	42.5
Total	252	100

The community (57.5%) uses the lake water (Table 4.9), while (42.5%) depend on other sources of. Multiple uses of water bring about conflicts between various users. Ol'Bolossat wetland contributes to ground water recharge by holding the water until it is absorbed through the soil into the underground aquifer. The water table is high and likely to be contaminated by pit latrines during the rainy season. The community's mode of human waste disposal is through pit latrines. Apart from using water from the lake, the community members get water from boreholes for either domestic or irrigation and are likely to have colon bacteria. Unless the water is well treated it is unfit for human consumption. Water from shallow wells is unfit for domestic use as it endangers human health. The wetland removes pollutants and excess nutrients from the water that enters them. Ol'Bolossat is an avenue for recreation such as hunting, trapping, sightseeing, bird watching and photography. It is a green space where people go to relax and enjoy their picnic.

Hippopotamuses and cattle compete for water in the lake although the hippopotamuses graze at night and the cattle graze at day time. The grazing has led to continued drying up and siltation due to removal of vegetation cover. It was observed that there are flower farms such as Suera and Primarosa which extend up to the riparian grazing land and pollute the lake water. This has led to disappearance of several migratory birds whose breeding sites have been destroyed .

3.5: Human Population Pressure

The average population density is 202/km2 and has been increasing over the years just as was predicted NEMA in Ol'Bolossat Strategic Plan (NEMA 2007) [16]. Population pressure is a challenge to crop production as human settlement has taken most of the arable land. Rapid population growth leads to poverty and environmental degradation (Borgale, 2006). Land subdivisions have given rise to smaller land units, which undermined food security and community livelihoods (Table 2). The decrease in land sizes has led to less crop production.

Table 2: Changes of land sizes in Ol'Bolossat for the last 10 years

Responses	Frequency	Percent
Size not changed	33	9.5
Reduced	219	90.5
Total	252	100

High human population density has caused land fragmentation, dispersal of animal communities, habitat loss, degradation and species extinction (Ruhiu, 2000) [20]. Wetland degradation used to go on unnoticed since this ecosystem was considered unproductive and unhealthy (Irandu, 2003) [9]. It was drained to provide land for agriculture and destroy breeding sites for disease vectors such as bilharzia worms and mosquitoes. Changes in settlement have reduced mortality (G.O.K., 2009). and there is human migration from other districts in search of land (Census, 2009) [7]. The population density increased from 66 persons per square kilometer to 115 persons / km2 (NEMA, 2007) [16].

Most of the community members are low income peasant farmers who depend on the wetland for pasture. Responses indicated (17.1%) cases of people who have been attacked by wild animals. Hippopotamuses make life miserable for residents in Ol'Bolossat since they stray into farms and destroy food and cash crops which amount to big losses to the residents. The farmers accused KWS of inaction when called upon to protect the residents from animal attacks. Sometimes the farmers take the law in their hands and kill the hippopotamuses in an attempt to secure their livelihoods. High crop yields are hard to come-by since the water birds feed on wheat, which is the major cash crop in the area. The hippopotamuses feeding on maize, cabbages and beans dwindle the farmers' hopes of ever getting good harvests. KWS on its part cites lack of transport when called upon to help the farmers but when an animal is killed they find a vehicle and roam about issuing threats of arrest to the culprits. The plight of farmers is compounded by lack of compensation when the crops are destroyed. According to the District warden at Nyahururu, Conservation Management Act provides for compensation if attacks lead to human injury or death. The law does not provide for destroyed crops and property but it allows for compensation of up to Kshs 50 000 for injury and Kshs 200,000 for death. The new bill will raise the death compensation to Kshs 1.5 million.

Table 3: Occurrence of animal attacks

	Frequency	Percent	Cumulative Percent
Not Common	157	81.3	81.3
Common	33	17.1	98.4
Very Common	62	1.6	100.0
Total	252		

The community is vulnerable to attacks by wildlife but they get very little compensation from KWS. The majority of respondents (81.3%) reported that animal attacks are not common but they occur from time to time (Table 4.12) above. Only17.1% of the respondents found animal attacks on humans common while 1.6% found them very common.

3.6 Development Pressure

Development pressure or need for economic growth has led to over-exploitation of natural resources. The cost of exploiting the resources outweighs the benefits of economic growth. There is "environmental injustice (Okech, 2010) [19]." A lot of emphasis is put on economic growth at the expense of the environment. The natural resources have been subdued by the humankind since the community is more inclined to sustaining development than sustaining the environment. The Nyandarua County Council allows stone excavation in quarries and this leads to water pollution

3.7 Human Activities

The major cause of human-wildlife conflict is human interference with animal habitats. A KWS officer in Nyahururu said that human beings intrude into the animal corridors resulting in their straying into human settlement areas. The wetland is under pressure from human activities such as intensive farming in neighboring farms, charcoal burning, vegetation clearing, overgrazing, encroachment, poaching and over-fishing. The fore-mentioned activities threaten the sustainability of the ecosystem and they are not in line with conservation strategies. The activities destroy animal habitats and the aquatic animals leave the lake. The livestock grazed in the study area include, cows, goats, sheep and donkeys (Table 4).

Table 4: Livestock Population

Livestock	Population
Dairy cattle	12000
Sheep	8500
Goats	3500
Donkeys	250
Total	24250

4.4.4 Socio-economic and Environmental Status in the Study Area

The community members who are subsistence farmers depend on the wetland for pasture. Scarcity of resources in their farms has led to environmental degradation as farmers seek alternative livelihoods in the wetland. The problems are compounded by poor infrastructure and lack of revenue sharing from the proceeds of ecotourism. Poor infrastructure has ruined the marketing of farm produce to point whereby the farmers sell produce at low prices since they lack alternatives. The farmers are exploited by middle men who buy produce at low prices and sell the same at high prices in towns. Unclear policies and lack of guiding principles has guaranteed minimum returns. There are inadequate storage facilities and cooling plants for milk and horticultural products. Decrease in land sizes owing to increasing human population has led to low crop production and economic instability.

3.8 Land Tenure Systems

The majority of Ol'Bolossat residents (94.4) per cent have freehold type of land ownership. The land has been acquired through inheritance and purchase. 0.4 per cent have temporary lease of Government land beside the roads, along railway lines and near shopping centers (peri-urban). The rented farms from individual land owners comprise (5.2 %).

Ninety five per cent of the community members have freehold type of land ownership and 5 % have rented farms (Fig. 4.4).

There is patriarchal type of land ownership where sons inherit land from their fathers. The females do not inherit land but they have user rights. Women need empowerment

since they have a great impact on the environment as they carry out their daily chores of firewood collection and fetching water. Gender disparity is an issue of concern in the study area. Women support family livelihoods but do not have absolute rights of land ownership.

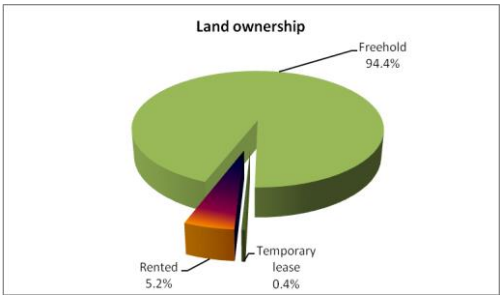

Fig 2: Type of land ownership in Ol'Bolossat Catchment area

4. Conclusions

The key resources which support community livelihoods include water, land, aquatic vegetation and wildlife; in order of their importance. The sharing and competition for the same resources leads to land, water and biodiversity related conflicts. From the data collected, it is evident that there are natural resource based conflicts which affect the local community livelihoods. The conflicts are human induced through environmental degradation and competition for scarce natural resources between humans and animals.

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