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SOCIO-ECONOMIC VALUES OF WETLAND RESOURCES AROUND LAKE MANYARA, TANZANIA: ASSESSMENT OF ENVIRONMENTAL THREATS AND LOCAL COMMUNITY AWARENESS ON ENVIRONMENTAL DEGRADATION AND THEIR EFFECTS

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ABSTRACT
Understanding local people's socio-economic values of wetlands and traditional mechanisms of managing natural resources forms the basis of conserving them. Wetlands have frequently been developed for short-term economic gains that destroy their ecological values and environmental services in the long term. A study was carried out to assess socio-economic values of the wetland resources, environmental threats around Lake Manyara and local community awareness on causes of environmental changes, degradation in the wetlands and their effects using 80 respondents. Field surveys, interviews, questionnaires and direct observation were used in data collection. It was found that local community was aware on the ecosystem services accrued from the wetlands which were unsustainably used. However, environmental degradation due to unsustainable agriculture, overgrazing, deforestation, urbanization and mining was rampant which had resulted to soil erosion, reduced water availability, wildlife mortality and frequent dry up of Lake Manyara and rivers. In order to protect the lake basin; controlled human activities, land use and water resources within the catchment are to be done in cooperation between the government departments, local authorities and the general local community around.

Key words: *Ecosystem services, rivers, Lake Manyara, wetland, agriculture*

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INTRODUCTION

Tanzania is among the developing countries in the world with the total land area of 945,000 km^2 of which 61,500 km^2 is wetlands (Bureau of Statistics 1989, NEMC/WWF/IUCN 1990). The wetland areas are important since they provide vast ecosystem services to people and support their livelihood. Their rich physical and biological resources are exploited for food, water, medicinal plants, fuel wood, materials for building and handcrafts (Terer and Githuki 2001, Thenya 2001). Because of the potentiality with wetlands, they have scenic attractions which encourage immigrations as with the case of Lake Manyara wetlands with about 4.5% immigration rate (Norconsult 2001). However, Tanzania experiences rapid human population growth with 3% annual growth rate (URTNC 2002). This remarkable population increase is accompanied by intense urbanization, agricultural, industrial and mining activities which have been found to enhance changes to water body ecosystem in particular fresh water lakes, rivers and wetlands (FAO 1994).

The negative impacts on these ecosystems result from environmental disruptions in lake basins and wetlands: rapid siltation caused by accelerated soil erosion in catchment areas; irreversible uptake of water, salinization due to irrigation; eutrophication; contamination with toxic chemicals, and acidification (UNEP 2006). In spite of the fact that freshwater bodies and wetlands are very limited and sensitive resources that need proper care and management; they are probably the most abused resources (UNEP 2006). The side effects associated with such kind of wetland interferences may include irreversible disappearance of wetland and water bodies which may be a catastrophy to humans and animals. For example, in domestic and wild animals, mortalities have been recorded because of water shortage and poisoning (Briand et al. 2003; Mtahiko et al. 2006).

Indeed, water has become competitive, scarce and of reduced quality in most of the wildlife ecosystems in Tanzania (Gereta and Wolanski 1998). For example, in the Ruaha National Park in Tanzania, water diversion for irrigation removed much of the water available for wildlife in particular during the dry seasons (Mtahiko et al. 2006). This resulted in massive disruption to wildlife, including over-population of hippos and crocodiles in the remaining small water holes in the dry season, increased mortality of fish and mammals, overgrazing and erosion of surrounding lands, and disruption to dry-season wildlife migration patterns (Mtahiko et al. 2006). Similarly in Lake Manyara water level decreases annually and is associated with hyper eutrophication which favors development of phytoplanktons in particular cyanobacteria (Lugomela et al. 2006). Permanent rivers in the basin are becoming seasonal and obvious water shortages for home use, agriculture and wildlife are nowadays realized (Ngana et al. 2003).

The survival of Lake Manyara basin as a unique wildlife conservation area and the most dependable sources of livelihood of thousands of people need proper understanding of the surrounding environment, local community land-use practices and the possible threats around. However, there has been a growing decline in the water supply into Lake Manyara and the lake and rivers around have been experiencing a frequent dry up and reduced size and depth. These problems have been caused by, or can be linked to, the increasing decline in the

frequency and amount of rainfall, rapid population growth, urbanization, industrialization and changing patterns of land use. In Tanzania, environmental conservation management decisions and projects are usually implemented by government departments and institutions with very little local community participation or involvement of which their successes have been limited (Ngana et al. 2003). For success in natural resources management, experiences show that involvements of local communities is an important endeavor but depends on people's perception, value system and use of those resources. Teter et al. (2004) reported that when implementing environmental conservation projects in rural areas, local people need to be involved in project formulation and implementation so as to create a sense of ownership, which is essential for project success and sustainability.

This paper presents findings from questionnaire surveys and direct observations made in Lake Manyara basin. The purpose of this project was to provide baseline information on the socio-economic values of the wetland resources, environmental threats around Lake Manyara, local community awareness on environmental changes and their effects. The specific objectives of the study were to assess: (a) local community awareness to ecosystem services and uses, (b) economic activities and their possible environmental effects in the basin, (c) Lake Manyara and river changes and eutrophication and, (d) community awareness on wildlife mortality and the possible causes. The findings from this study may be useful as baseline information for the conservation of fragile Lake Manyara ecosystem and environmental indicators for ecological assessment and monitoring studies.

STUDY AREA

This study was conducted in 2008 to the selected villages situated in a valley at the foot of the escarpment at the northern end of Lake Manyara which is in Arusha and Manyara regions, about 130 km from Arusha city in Tanzania. The basin lies within four administrative districts namely Mbulu, Babati, Monduli and Karatu between latitudes 03^{o}3 and 4^{o}3 south and longitudes 35^{o}51' and 36^{o}22' east covering an area of about 520 km^{2}. The lake is among the alkaline-saline lakes found within the Rift Valley of East Africa. It is a shallow (2 m max. depth) closed-basin, about 40 km long and 13 km wide. The main source of water for the lake is through precipitation and run-off from upper catchment. There are a number of rivers which drain into the lake namely Mto wa Mbu, Simba, Kirurumo, Msasa, Endabashi, Lyambi, Magara and Makuyuni which are also used for irrigation farming by the local community around (Figure 1). The climate of the area is semi-arid with two distinct rainy seasons, short rains in October to December and long rain during March to May (Rohde and Hilhorst, 2001). The mean annual rainfall is less than 700 mm. The soils vary from alkaline to non-saline-alkaline in reaction. The soil textures of the area are clay, clay-loam, loam, loamy/sand-loam and sandy-loam/sandy-clay-loam. Soils vary from fertile highly erodible volcanic material, to a variety of moderate to low fertility sedimentary and basement soil (Cohen et al. 1993).

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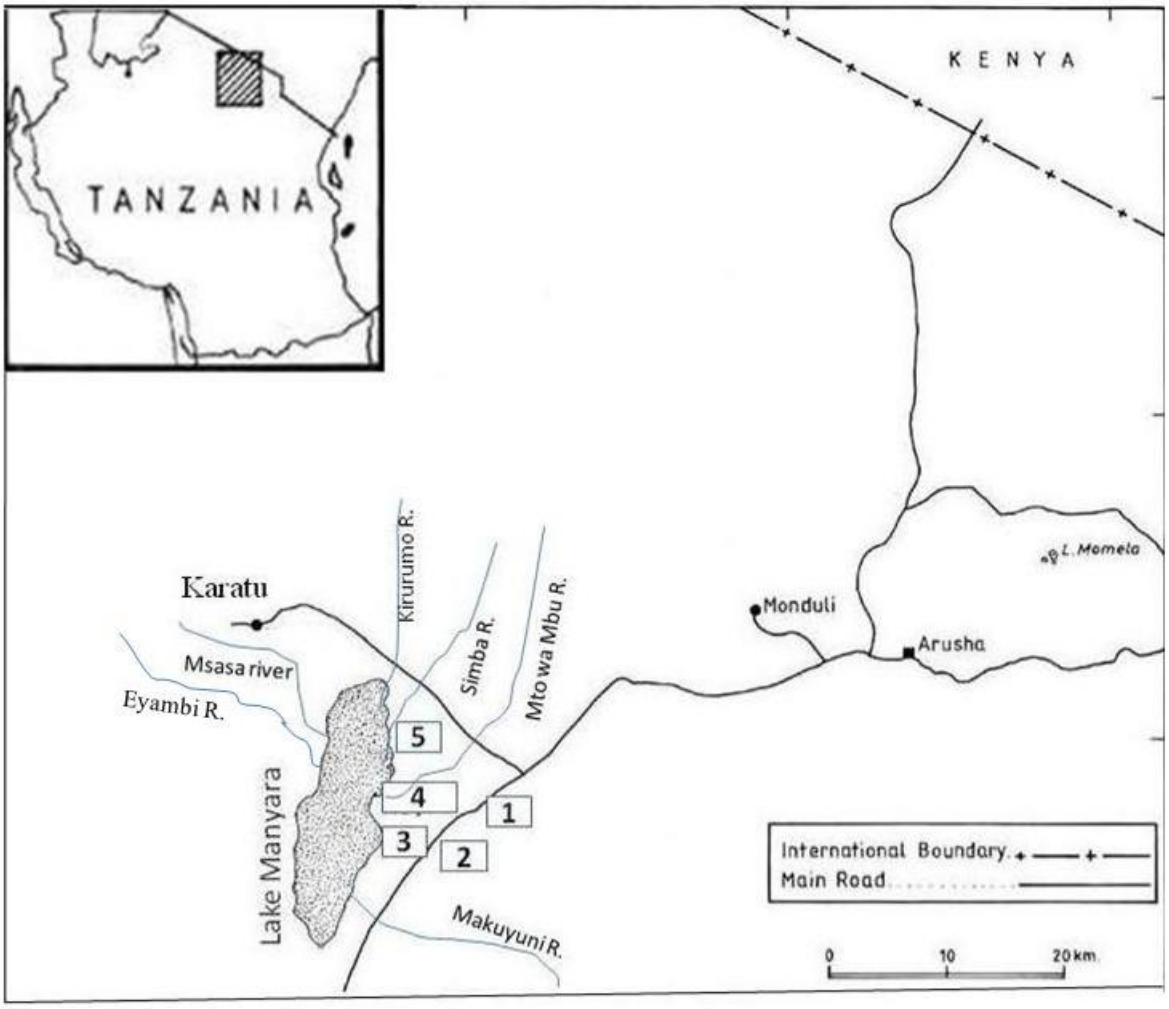

Figure 1: Map showing the study villages around Lake Manyara (*insert*: map of Tanzania with shaded region to indicate the relative location of the study area). The study villages Losilwa, Migombani, Majengo, Barabarani and Moyomayoka are numbered 1, 2, 3, 4 and 5 respectively. (Source: Lugomela et al., 2006).

The Lake Manyara basin was selected as the study area because it hosts Mto wa Mbu swamp which is a host of conflicts in resource use especially water and land because of high in migration rates to the area. The land has fertile area for agriculture, extensive pasture and water for livestock and Lake Manyara National park (LMNP) with a variety of wildlife. Hence the area is economically important and of ecological interest because of the diverse biodiversity.

The study involved five villages within Lake Manyara basin namely Barabarani, Migombani, Majengo (in Mto wa Mbu ward), Losirwa and Mayomayoka (Figure 1). The livelihood of people in the study area depended mostly on agriculture (crop production and livestock keeping), fishing and petty trades. In some villages like Barabarani, Migombani, Majengo and Losirwa there are a number of hotels, safari companies, tourist camps and souvenir markets which provide some employment and income opportunities to the residents.

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METHODOLOGY

Sociological data

Purposive sampling technique was used for selection of the study villages because were within Manyara basin, the people livelihood depends on the ecosystem services provided from Lake Manyara basin and its rivers and easy accessibility. Simple random sampling was used to get the households where respondents were recruited. Information from village leaders, agricultural extension and livestock officers were used to generate a list from which the sampling of households was used. The study household inclusion criteria were farming (crop and/or livestock production), fishing and willingness to participate in the study. A few people (< 5%) who declined to participate in the interview on different grounds were replaced by another households randomly selected from the list. A total of 80 households from the selected villages were involved in the study. The number of selected households varied between villages because of differences in populations and number of people involved in farming and fishing activities.

Both quantitative and qualitative data collection methods were used to obtain primary data. The standardized questionnaire, with structured and semi structured questions was the main instrument which involved face-to-face interviews with one respondent from each of the selected households. The household heads were chosen as respondent (father or mother) and in case of absence, another permanently resident-adults (> 18 years) in the households took part in the interview. The questionnaire was designed in English and translated into Kiswahili, the national language, which is understood by the majority of the respondents in the study area. Preliminary study survey involving 10 respondents was used to test the clarity and sequence of the questions. The information solicited included:

Respondent's socio-demographic variables (location of residence, gender, age, head of household, occupation, education, village residence duration, and type of residence i.e. born or migrated from other places).

The awareness of the local community on the importance of Lake Manyara basin, resources, uses and their values as well as their views on environmental changes was assessed. The local community activities and practices on the environment around Lake Manyara basin was explored. For the livestock keepers, information on species, number of animals kept, grazing system and availability of water for their animals was recorded. For the crop producers, information gathered on the farm size its distance from the lake, irrigation farming and water availability. Information on deforestation, mining and any other activities likely to cause environmental degradation were explored. While conducting interviews, direct observations were made on environmental destruction, overexploitation of resources from the environment and deforestation. Information on variations in rivers and Lake Manyara size, depth, water level and incidences of dry up was gathered. Community perceptions and its awareness on wildlife mortalities and their causes with much emphasis on lesser flamingos were investigated.

In-depth interviews with key informants were used to complement the questionnaire results. Information on the climatic conditions (rain season, dry season and temperature), water resource and irrigation, waste and sewage disposal and, environmental conservation were

gathered from agricultural, livestock and health officers. Moreover, information regarding wildlife and Lake Manyara ecosystem changes was obtained from LMNP ecologist.

Determination of Eutrophication in Lake Manyara

Three off-shore sampling sites, at least 200 m from the nearest Lake Manyara shoreline were established and monthly samplings was done from July 2007 to June 2008. Water parameters such as pH, salinity and conductivity were measured *in situ* using a portable water quality checker (Horiba U-10, Kyoto, Japan). Water samples for the determination of nitrate, nitrite, ammonia and soluble reactive phosphorus (phosphate) were taken at a depth of 25 centimeters below the water surface. About 100 ml water samples were immediately filtered through 0.45 µm pore sized membranes filters using a vacuum pump. The water samples were kept in acid-cleaned plastic vials and inorganic nutrient concentrations were determined as described by APHA (2005). Sampling and microalgae determination in the water samples was performed as described by Lugomela et al. (2006).

Data analysis

Quantitative data were analysed using Epi Info version 6 (Coulombier et al. 2001). Descriptive statistics of different factors that were examined were computed to obtain proportions and their 95% confidence intervals (CIs) where necessary. Differences between proportions were examined using Chi-square test at critical probability of $P < 0.05$. Bacause of similarities in farming activities and sociocultural factors, all the respondents were considered as one population during data analysis and there were no comparisons between villages. Descriptions of qualitative data were made based on their thematic contents. For the purpose of comparisons of different variables recorded, a 'rainy season' was assigned to periods from October - December and March - May and the rest of the months were regarded as a 'dry season'.

RESULTS AND DISCUSSION

Socio-demographic characteristics

A total of 80 respondents were interviewed in the selected households from the five villages within Lake Manyara basin. Their socio-demographic information is shown in Table 1. Of the respondents, 34 were from Barabarani, 15 from Mayomayoka, 13 from Migombani, nine from Majengo and nine from Losilwa villages. The age of the respondents was 48±15 (mean and standard deviation). The mean duration of respondents lived in Manyara basin was 31±14 years (range of 2 to 75 years).

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Table 1: Socio-demographic information of respondents (n=80)

Socio-demographic variable	Category	Number (%)of respondents
Gender	Male	60 (75.0)
	Female	20 (25.0)
Education	Non formal education	6 (7.5)
	Primary education	67 (83.8)
	Secondary education	2 (2.5)
	Certificate education	4 (5.0)
	Diploma	1 (1.3)
Head of household	Male	63 (78.8)
	Female	17 (21.2)
Type of residence	Born at Manyara basin	72 (90.0)
	Migrated	8 (10.0)
Occupation	Farming activities	73 (91.2)
	Crop production and livestock	40 (50. 0)
	Entire crop production	16 (20.0)
	Entire patoralists	7 (8.8)
	Farming and petty trade	5 (6.3)
	Fishing and crop production	9 (11.3)
	formal government employment and farming	7 (8.8)

Economic activities and practices in Manyara basin

Several economic activities of the local people revolved around and utilized natural resources in the basin. Crop production was the main source of food and means of income generation as it comprised a significantly (*P<0.05*) high proportion (91%) of the households investigated. The main crops produced were maize, paddy, banana, vegetables (tomatoes, spinach, egg plant, peppers, green peppers, ocra, onions, and carrots), sunflower and cotton. The median farm size was 3 hectares (range 0.25 to 100 hectres per farmer). A high (*P<0.05*) number (75%) of respondents were practicing irrigation farming particularly during dry seasons. Irrigation farming occurs in swamps, marshes and along river banks by exploiting the well-watered and rich soils from which the floods retreat during the dry seasons. The crops which were grown under irrigation were rice (78%), banana (70%), maize (50%), vegetables (48%), beans (34%), potatoes 5%, fruits (4%) and sugarcane (3%). The farm size under irrigation per household ranged from 0.25 to 3 hectares. Up to 92% (*P<0.05*) of the farmers reported that water for irrigation was not enough and conflicts among themselves on water usage was common in particular during the dry seasons. The irrigation efficiency in the area is estimated to be below 60% and is the major water consumer and yet so extravangantly done particularly due to lack of water demand management procedures and low technologies. The agricultural extension

officer reported that irrigation farming dates back in 1955 but was more expanded during 1980s by ILO project whereby up to 2500 hectares were under irrigation farming.

Other common activities included livestock keeping as it compromised 59% of all the respondents. Domestic animal kept mainly were cattle, sheep and goats. The median number of cattle per household with livestock was 12.0 (range 2 – 900) while median number of sheep and goats was 20.0 (range 2 to 880). Livestock population apart from increasing from time to time, it is also enhanced, especially during the dry season which may double due to in-migrating pastoralists with their herds. The in-migration is fueled by availability of pastures and water for livestock during the dry season which frequently causes conflicts between irrigation farmers and livestock keepers. All livestock keepers reported not to use Lake Manyara as drinking water for their animals but rather they used rivers, streams and dams which were reported to sometimes dry and cause a big water shortage. A significantly ($P<0.05$) high number (91.3%) of the livestock keepers extensively grazed their animals within Manyara basin. Fishing was another activity which constituted 11.3% of the respondents. The common fish available from Lake Manyara are catfish and Tilapia. However, fishermen reported that the fishing work has recently being unreliable since is severely affected by water shortage in particular during the dry seasons. Incidences of massive fish deaths were reported caused by increased water soda and frequent dry up of the lake.

Lake Manyara basin ecosystem services

All the respondents reported that Lake Manyara basin was important for their livelihood and supported a vast number of domestic and wildlife. As part of ecosystem services, most respondents (95%) reported several benefits they get from the lake namely: get fish, *Magadi* (soda), cool weather, good income because of tourism, horticulture, water (for irrigation and domestic animals), freshwater for domestic use, good pasture, timber, firewood, charcoal and cultural values (recreation and ecotourism, ethical values and rituals). A significantly ($P<0.05$) higher number of respondents (75%, n=60) reported more services were accrued from the rivers than Lake Manyara since it is an alkaline in nature. The rivers provided water for domestic and agricultural use. However, the lake was the sole source of *Magadi* and fish. Compared with the recent and historical past, respondents reported an increased use of the wetlands resources because of increased demand for settlements, food and grazing lands.

During this study it was observed that wetlands were also sources of problems for the local people. A significant ($P<0.05$) number of respondents (83.8%) listed down a number of problems of Lake Manyara and its basin as sources of crop destructive animals (hippos, elephants and other wildlife), noise caused by flamingo, lake salinity causes domestic animal diseases, bad smell (decaying algae and soda). Furthermore, presence of several rivers was associated with floods during rainy season which destroyed crops, properties and displaced people. Floods were said to be accompanied by many mosquitoes, frequent cases of malaria, diarrhoea and other waterborne diseases. According to the ward health officer, tropical wetlands associated diseases such as malaria, cholera, bilharzias, typhoid, eye infections and skin diseases were prevalent in the people living in Manyara basin.

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Environmental degradation related activities

In this survey, it was observed that unsustainable agricultural activities in water catchments, steep slopes of mountains, mountain ranges, near river banks and around water sources accompanied with deforestation were common practices. Indeed, obvious soil erosions which were observed in Manyara basin was partly caused by poor cultivation and extensive grazing of big herds of cattle. Many of the respondents (68%) reported to have their farms going up to the hill side with acute slopes. There were no measures to overcome the problem of soil erosion. Several rivers and streams passed through the farms of which farmers intensively used the water for irrigation. In most cases, the median distance from river banks to the farms was 0.2 km (ranged from 0.0 to 6.0 km). The natural vegetation along the river banks was cleared to get more land for cultivation. Some of the farmers had their crops like banana grown within rivers, contrary to the established bylaws at Mto wa Mbu ward that prohibit cultivation at least 4 metres on either side of the river. In some places, cultivation had gone up to the catchment areas.

A highly significant ($P<0.05$) number (97.5%) of respondents reported that deforestation in Manyara basin was a big problem and the main causes mentioned included timbering (66.3%), charcoal burning (65%), firewood (91.3%), construction (50%), logging (32.5%), 45% bush fire and clearing areas for farming (32.5%). Tree planting and other environmental conservation programmes introduced by the government were present in all the study villages but were not implemented. About 84.5% of the respondents reported that excessive agricultural, livestock and urbanization activities contributed to environmental degradation.

It was further found that unofficial small scale mining and artisanal stone breaking to quarry for construction were among the activities reported to take place nearby rivers. Active unofficial mining activities around Eyambi area just nearby Eyambi river in the northwestern part of Lake Manyara was observed. The respondents reported that the obstacles to conservation of Lake Manyara wetlands included scarcity of good agricultural land, poverty, land arbitration and land ownership problems, limited initiatives to environment conservation programmes and lack of effective government support for development.

Rivers, Lake Manyara and environmental changes

Local knowledge on trends in river and lake water level changes, size, depth and mitigation measures were also sought. All 80 respondents reported that rivers which were permanent are now becoming seasonal and there have been incidences of total river dry up. The results show that 75% of the respondents reported noticeable decline in river size and depth. On the other hand, a significant ($P<0.05$) number (90%) of respondents reported to have observed a spontaneous decrease in lake depth, size, water level and frequent dry up in the last three years (2004 to 2008). The respondents listed several effects caused by decreased water availability in rivers and lake. Evaluation of the effects indicated that 76%, 66%, 48%, 53% and 58% of the respondents highly ranked farming, domestic uses, wildlife, livestock and fishing respectively were very affected by decreased water availability in the basin (Figure 2).

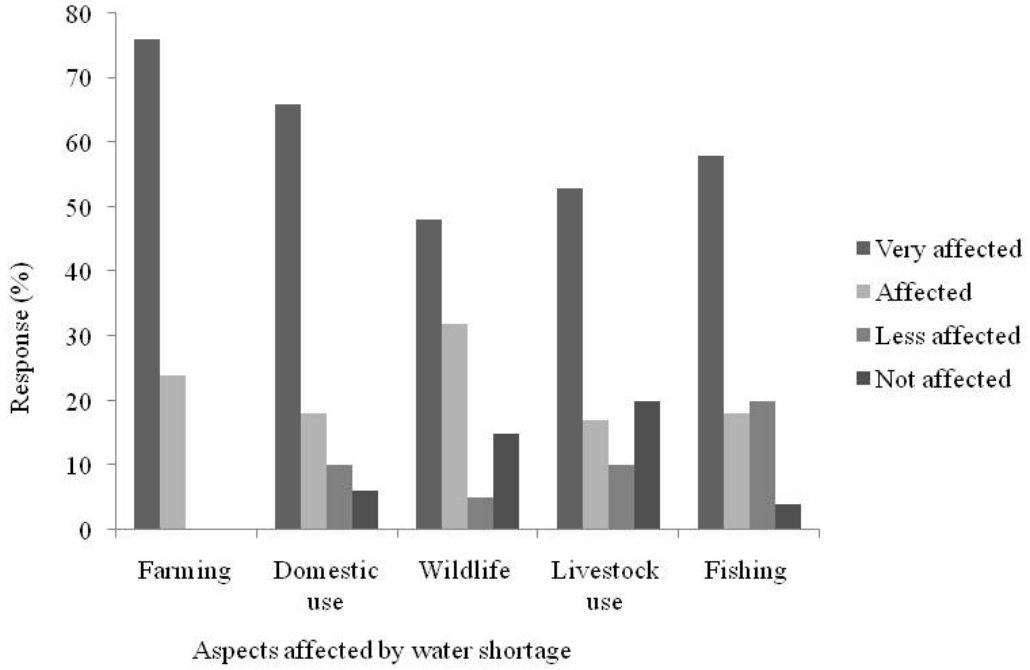

Figure 2: Ranks of effects associated with water shortage in Lake Manyara basin (*n* = 80). Ranks represent (1) very affected, (2) affected, (3) less affected and (4) not affected.

The causes of rivers and lake size, depth and water level decrease as reported by the respondents are shown in Figure 3. Up to 80%, 61% and 60% of the respondents reported increased human activities around the rivers/lake, decreased rainfall and sedimentation respectively were the most causes of decreased size, depth and water level. The shortage of rainfall was supported by the fact the short rains of October/December were becoming rare, thereby prolonging the dry season. This has had a negative effect on the wetlands because the increased grazing and farming activity on the wetlands further cause more pressure. According to the local people, the excessive floods during rainy seasons were caused by reduced river size and depth and there were limited efforts from the government to mitigate the situation.

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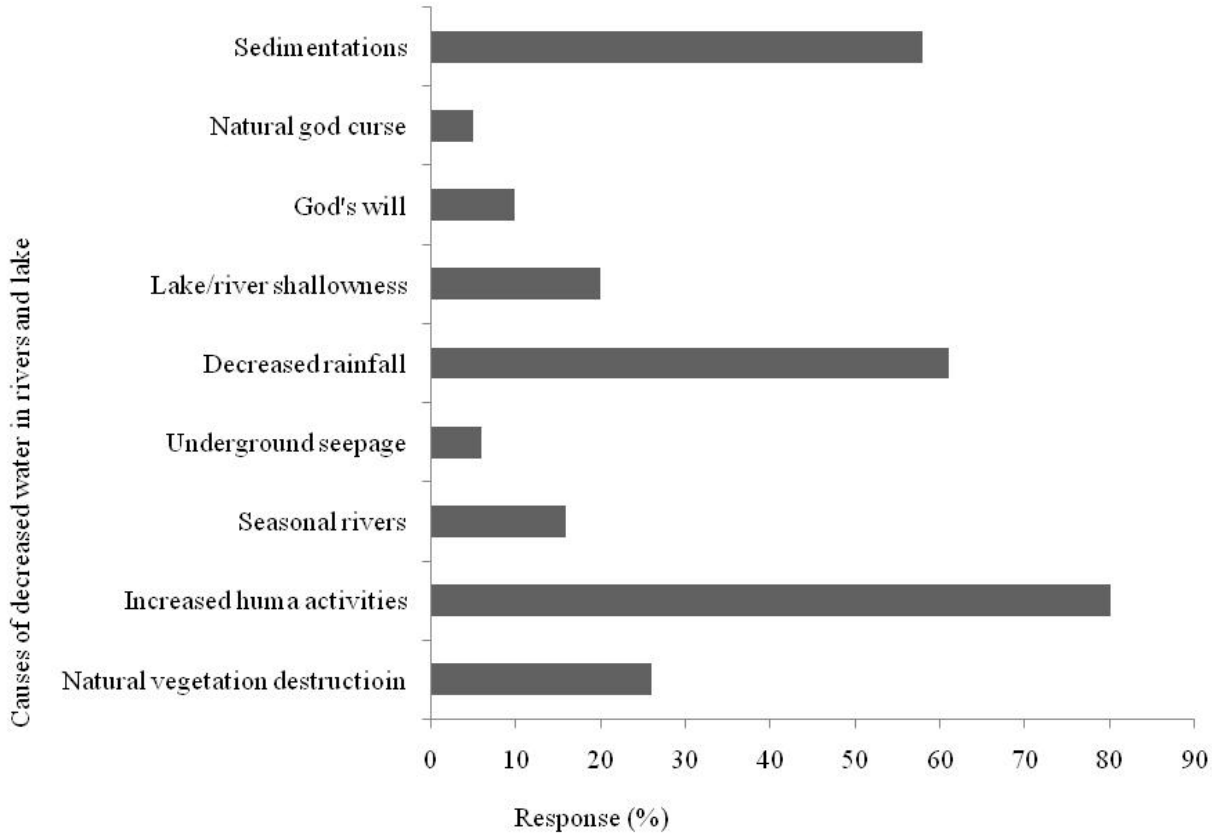

Figure 3: Respondents' views on the causes of rivers and lake size, depth and water level decrease

A number of suggestions on conservation measures were mentioned by the respondents (Table 2). Significantly (*P<0.05*), a high (85%) number of respondents were aware on the measures to overcome the problems as most of the suggested measures if implemented could rectify the effects to the rivers and Lake Manyara.

Table 2: Conservation measures of the rivers and Lake Manyara

Suggestions on rivers and L. Manyara conservation	Number of respondents (%)
Avoid grazing neaby Lake Manyara and rivers	7 (8.8)
Clean up dirty and sediments from the rivers and lake	12 (15.0)
Environmental conservation education to community	10 (12.5)
Environmental conservation activities and establish enviroment bylaws	55 (68.8)
Abide and respect to local belief rules and norms	3 (3.8)
Plant water weeds in the lake shore and trees in river banks	2 (2.5)
Not to burn trees and grasses	7 (8.8)
Not to cultivate nearby water sources, rivers and lake	16 (20.0)
Plant grass at river entries to the lake to sieve dirt and mud	4 (5.0)
Pray God for rain	4 (5.0)
Controlled use of river water for irrigation	47 (58.8)

Limnological characteristics Lake Manyara

Some of limnological characteristics for Lake Manyara which were recorded during the study period are shown in Table 3. Average low levels of ammonium (3.6±3.1 µg/l), nitrate (0.9±0.8µg/l), nitrite (0.3±0.3 µg/l) and phosphate (36.1±42.0 µg/l) were recorded in a year. Significantly ($P < 0.05$) higher phosphate concentration (53.2±52.0) was recorded during rainy season than dry season (15.7±9.3). There was no significant difference in mean nutrient concentrations for ammonium, nitrate and nitrite between the dry and rainy seasons. The mean count of microalgae was 12531±2591 cells/ml (mean ± SD). Significantly higher microalgae count ($P < 0.05$) were encountered during the dry period (mean count = 17,719±3,498 cells/ml) compared to the rain season (mean count = 7341±3,498 cells/ml).

Table 3: Nutrient characteristics for Lake Manyara during dry and rainy seasons

	Annual average	Dry season	Rainy season
Limnological parameter	Mean±SD	Mean±SD	Mean±SD
pH	9.6±0.4	9.4±0.4	9.8±0.3
Salinity (‰)	13.7±7.1	13.1±7.1	14.4±7.7
Conductivity (mS/cm)	23.7±11.2	21.0±5.9	26.5±15.0
Dissolve Oxygen	11.0±2.5	10.5±2.0	11.6±3.0
Ammonium (µg/l)	3.6±3.1	3.2±2.9	4.1±3.6
Nitrate (µg/l)	0.9±0.8	1.0±1.0	0.7±0.6
Nitrite (µg/l)	0.3±0.3	0.4±0.3	0.3±0.3
Phosphate (µg/l)	36.1±42.0	15.7±9.3	53.2±52.0
Microalgae count (cells/ml)	12531±2591	17719±3498	7341±3498

Wildlife mortality and the possible causes

Most (81.3%) of the interviewed respondents had seen or heard about wildlife mortality around Lake Manyara since 2004 to 2007. Among the wildlife massive mortalities mentioned by high (87.5%) number of respondents were lesser flamingos in 2004 to 2005. Other wildllife species mentioned to die at low rates in different years were buffaloes (13.8%), wildebeest (5.0%), hippos (5.0%), elephant (8.8%), baboons (15.0%) and fish (2.5%). Specifically, most (81.3%) of respondents reported lesser flamingo mortality occurred during dry seasons and the possible causes were food shortage, drought, poisoning and diseases which were linked up with increased human activities nearby LMNP (Figure 4).

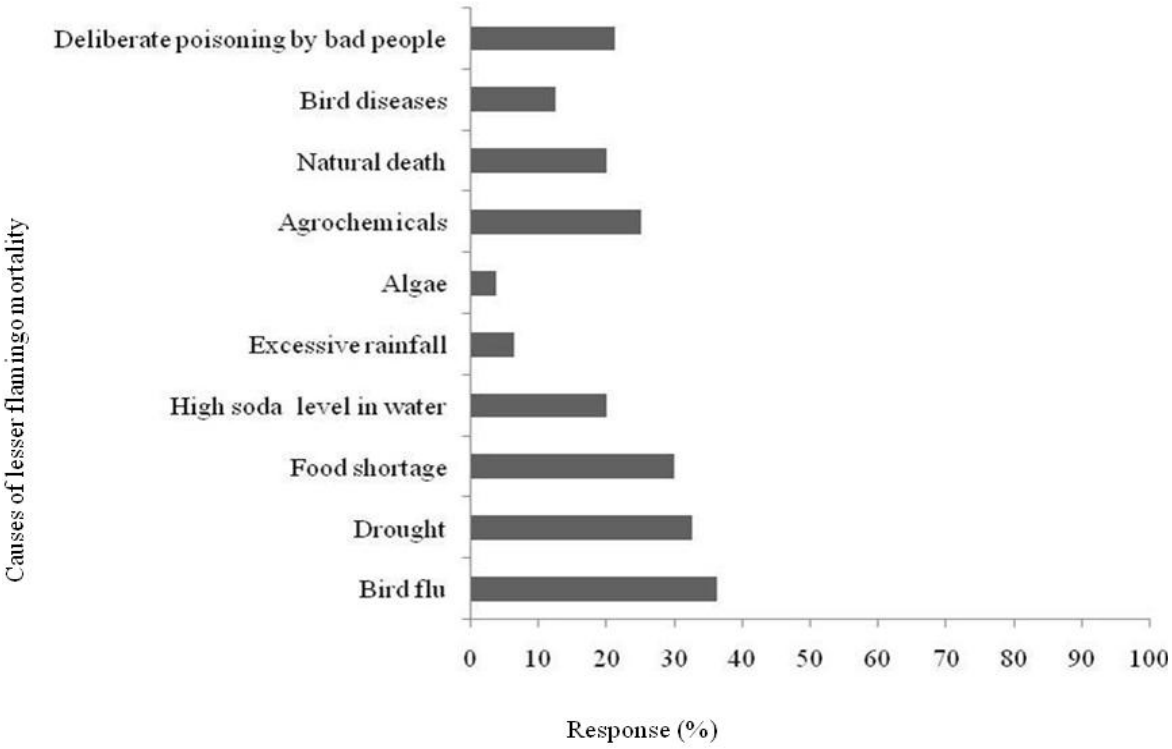

Figure 4: Possible causes of lesser flamingo mortality

Records retrieved from LMNP office revealed that flamingo mortality dated back to 2000 where more than 1000 birds died in Empakai crater. In 2002 unquantified number of flamingo died in Lake Natron, in 2004 more than 1000 birds died in Momella lakes, in 2004 and 2005 a total of 43850 and 205 birds respectively died in Lake Manyara. However, between August to November 2008 more than 10000 flamingo died in Lake Manyara. Meanwhile causes of flamingo mortality which were mentioned by the park ecologist included: water shortage, algae, agrochemicals, starvation, and drought and sometimes natural deaths as a means of population balance.

Discussion

Findings from this study show that most of the residents in Lake Manyara basin practiced subsistence farming and fishing as their major dependable livelihood. Obvious environmental destruction was observed due to unsustainable agriculture, overgrazing, deforestation, urbanization and mining which had resulted to soil erosion, reduced water availability and endangering the existence of Lake Manyara and rivers around. Frequent dry up and shrinking of the lake and rivers was also associated with severe blooming of cyanobacteria and wildlife mortality in particular lesser flamingos. Notwithstanding this situation, there were no intervention measures from the responsible authority so far despite of greater awareness of the local problem. It is important that effective systems of management can ensure that these wetland resources not only survive but, in fact, increase while they are being used, thus providing the foundation for sustainable development and for stable local people economies.

From our results, it was clear that Lake Manyara, rivers and wetlands around provided means of livelihood for the local people. The Millennium Ecosystem Assessment categorizes ecosystem services as supporting, provisional, regulatory and cultural-aesthetic (EAC 2007). As part of ecosystem services, most respondents reported several benefits they get from the lake which ranged from supporting to cultural services. Food, good income from tourism, pasture, construction materials and fuels were among the benefits. It was common for the local community to perform ritual values along the lake or main rivers (Mohammed, Personal communication 2008). The basin also supports a vast number and species of wildlife in particular lesser flamingos which attracts many tourists to visit the LMNP (Mlingwa and Baker 2006). In Tanzania, National Strategy for Growth and Reduction of Poverty (NSGRP) is the national organizing framework for poverty reduction which recognizes that most people in the country depend directly on ecosystem services for livelihood (NSGRP 2005). Land use and habitat change in simplification of the ecosystem to increase the economic value of the services such as intensive agriculture can alter ecosystems and reduce their capacity to provide a broad range of services. Although Lake Manyara ecosystem is a source of livelihoods to most communities around, degradation of ecosystem probably has increased problems. Some respondents mentioned that the ecosystem was a major source for natural disasters, tropical diseases and pandemics. Published literature by de Guenni et al. (2005) and UNEP (2006) also reported similar kind of problems to communities living in lake basins.

Findings from this study show that there are many unsustainable human activities which are likely to endanger the well-being of the Lake Manyara ecosystem. However, it is important to note that the lake and rivers also may experience some changes due to a combination of human activities and climate change, with potential serious implications for people's livelihoods and aquatic biodiversity (UNEP 2006). In tune with all these activities, environmental problems in Lake Manyara basin are diverse. Our study recorded activities which ranged from overexploitation of the natural resources in the basin to pollution discharges. Soil erosion in the basin was generally connected with cultivation, livestock and deforestations but specifically to farming methods and management. Deposition of soil in the lake and rivers lead to sedimentation. These uncontrolled human activities were rampant due to poverty, poor policy governing agriculture and land use, low level of awareness of sustainable land use, agriculture and livestock keeping as stated by Zainab (1998). At the same time, increased siltation and nutrients add up to the lake from agriculture and natural sources are thought to foster proliferations of phytoplankton and other water weeds which may ultimately lead to lake disappearance (Anderson et al. 2002). It was found that a high abundance of microalgae were recorded in the Lake Manyara particularly during the dry season.

During the survey, it was observed that most of the land was either used for agriculture or settlement being escalated by an increase in human imigration to the areas. Kiwasila (1992) reported that the human population growth that could be supported by available agricultural land in Lake Manyara basin, by 1992 was in excess by 228% and the grasslands for pastoralists was overstocked by 177% (Kiwasila 1992). During the current study, it was observed that deforestation in Manyara basin was rampant and main causes mentioned

included charcoal burning, firewood, timbering, logging, clearing areas for farming, construction, poor land practices, extensive cattle grazing and unplanned urbanization. The destruction of forests posed direct consequences for the biodiversity they support and also has significant and cumulative impacts on the catchment hydrology. Because of lack of trees and uncontrolled agriculture in steep slopes and nearby river banks; sheet and wind soil erosion was common which associated with big gullies. As the demand for water grows and abstraction rates increase, the capability of the catchment to harvest and hold rainwater appears to be diminishing. Worse still, programmes for environmental conservation existed but were not implemented; a situation further endangers the wellbeing of Lake Manyara wetland.

Regrettably, factors creating environmental problems are the same as those required for growth in agricultural production. During the survey, it was observed that agricultural intensification in the wetlands was accompanied with high uses of agrochemicals which were likely drained to the lake. In order to elucidate Lake Manyara eutrophication from agriculture; water nutrient results showed low concentrations which were comparable to the values previously reported by Lugomela et al. (2006). However, a significantly higher phosphate concentration during rainy season may be associated with high uses of fertilizers. In contrast, Ballot et al. (2009); Schagerl and Oduor (2007) reported higher values of nitrate and phosphorus in some saline lakes in Kenya which were also encroached with high agricultural activities. The low levels of nutrients recorded in Lake Manyara while all the factors for eutrophication were possible could be explained by several reasons. Big blooms of microalgae which were observed in the lake may have an influence on the uptake of nutrients. However, high salinity and conductivity may have influenced the detection and quantification of nutrients (Schagerl and Oduor 2007). Nevertheless, the availability of nutrients like nitrates, phosphorous and ammonium may sometimes be hampered by the extreme conditions, oxygen concentration and alkalinity level through pH (Jones and Grant 2000). Therefore, evidences of lake eutrophication may still rely on unsustainable agricultural practices, soil erosions, sedimentations and frequent floods.

The community was aware on the frequent mortality of wildlife in particular lesser flamingo. It was evident from the records that most of lesser flaming mortality has been common in recent years and was thought to be caused by environmental interferences. Although Lake Manyara basin is in tropical semiarid climate characterized by low mean annual rainfall (700 mm), the recent prevailing prolonged drought in the region causes stress to the birds and other wildlife due to shortage of food and water. It turn, the stressed animals when are exposed to other problems like diseases, poisoning and habitat interferences increases the possibilities for mass mortality. Ndetei et al. (2005) reported the increased flamingo mortality in East African soda lakes was caused by agro- and -industrial chemicals, diseases due to stress and cyanobacterial poisoning. Indeed, a study by Lugomela et al. (2006) reported some evidences of cyanobacteria involvement in mortality of lesser flamingo at Lake Manyara. The current study identified several species of toxic cyanobacteria like *Microcystis, Anabaena* and *Phormidium* which may also be involved in flamingo mortality.

The local people had vast knowledge on wetland ecosystems especially on their ecological changes such as decreased river and lake water level, decline in sizes and depth and frequent dry up of which water shortage consequences were already realised. Such changes were thought to be caused by anthropogenic damage of the ecosystem. It is documented that the problems of recurrent droughts, dry up of lakes and rivers in Africa are human based but when accompanied by climate change, are likely to make the situation more adverse (UNEP 2006). The greatest impact will continue to be felt by the poor, who have the most limited access to water resources (UNEP 2006). In the current study, most respondents listed the main causes of the problem to be environmental destruction due to poor land husbandry, drought, overgrazing and siltation. Excessive abstraction of river water for unguided irrigation farming over poorly managed water supplies reduced the amount of water that enters the lake which in turn reduces water level. Similar situation was expressed by Mtahiko et al. (2006) in Usangu plains in Tanzania whereby drought and scarcity of water was caused by increased human population, unsustainable agriculture and overexploitation of natural resources. These problems threaten not only the ecology and potential recreational opportunities of the wetlands, rivers and the lake, but also the lifestyle and livelihood of the local community. Experience has shown that wetlands cannot be conserved by market forces alone and that effective government intervention is required to meet the needs of society and the wetland.

Interestingly, respondents mentioned good control measures against problems of degraded rivers and lake which had caused decreased water levels. Apart from these good suggested solutions, there was no implementation in place. This could probably be due to lack of will to manage wetland resources sustainably and poor community involvement in the management of the wetland and its resources. Furthermore, most village councils have bylaws to protect wetlands and water resources but there was no enforcement. This probably could be due to lack of awareness of the link between wetland values and environmental destruction, lack of legal framework on lakes and wetlands, lack of priorities to environmental issues and insufficient policy or poor implementation of environmental policies by the governments (Mtaiko et al. 2006; UNEP 2006). However, the difficulty with managing lakes, rivers and wetlands in semi-arid areas in Tanzania is partly exacerbated by the pronounced seasonal and inter-annual variability of the water. The seasonal variability of rainfall and runoff is pronounced and the semi-arid conditions prevail in the dry season when water is scarce (Gereta and Wolanski, 1998).

CONCLUSION

It is concluded that the environmental problems are deeply rooted in complex socio-economical issues, such as the concentration of population around the basin, ambiguous and weak environmental jurisdiction and administration and underdeveloped regulatory framework. Given the scale of development and landscape modification occurring in the catchment basin areas, it would be inequitable to rely on natural processes alone to protect the rivers/lake against present and future threats arising from surrounding poor land use. In order to protect the rivers/lake and wetlads, development and human activity as well as the land and water

resources within the catchment must be managed in a way that ensures sustainability and minimizes adverse impacts. Appropriate development and education about sustainable land management practices in the catchment, delivering catchment-scale benefits but which also create a self-interest for local landowners, will help promote sustainability, maintain relatively low inputs to agricultural systems, sustain traditional techniques adapted to local conditions, and hence be closer to a truly sustainable agricultural system. However, successful management of the rivers, lake and wetlands depends on cooperation between the government departments, local authorities and the general local community around.

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