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Socio-economic Aspects of Fisheries Management in Lake Naivasha

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Abstract

A survey on Lake Naivasha identified and delineated critical breeding and nursery areas for fish which were to be protected in order to assist in the recovery of its fish stocks. Crescent Island, Oserian Bay, the river Malewa mouth and Kamere and its wetlands were identified as critical areas. A questionnaire revealed that most fishermen come from the Rift Valley and Nyanza provinces with a mean age of 36 years. Most boats operating on the lake are about 23.5 m in length and are each limited to a maximum of 10 gill nets of 112 mm (4.5 inches) mesh size. Most fishermen indicated that they know of others using illegal fishing gears. Regular patrols were identified as important (52%) and suggested that buoys be placed in the delineated areas. Respondents suggested that awareness be created to the people who depend directly on the fisheries and an all-inclusive patrol by all stakeholders including Fisheries Department and the Kenya Wildlife Services to enforce laws was recommended.

Key words: Lake Naivasha, species change, critical areas, stakeholder opinions, fishery management.

Introduction

Lake Naivasha is located in the eastern arm of the Great Rift Valley, Kenya, at about 00° 46' S; 36° 22' E and lies at an altitude of 1890 m. It is a small endorheic lake of approximately 145 km^2 and its catchment area is about 3,200 km$^{2.}$ The major inflow into the lake is the Malewa River, which supplies 90% of its water, and drains off the highest parts of the valley floor and the flanking escarpments. As a closed basin, the water level of the lake is sensitive to climatic variations and there is evidence from the elevations of ancient shorelines and sediment cores that it was once a much larger lake than it is today (Richardson and Richardson, 1972; Verschuren, 1999). Although endorheic it is a freshwater system has a unique but fragile ecosystem that was declared a Ramsar site in 1995 because of its ecological, economic, social, cultural and aesthetic functions. This has drawn the attention of environmental scientists and conservationists to the lake and its environs, especially in relation to the impacts of human activities.

Its fisheries are based on non-native species such as the blue-spotted tilapia *Oreochromis leucostictus* (Trewavas), largemouth bass *Micropterus salmoides* (Lacepédé), red-bellied tilapia *Tilapia zillii* (Gervais), common carp *Cyprinus carpio* (L.), and the crayfish *Procambarus clarkii* (Girard), These introduced species have formed the lake's fishery since 1925, except for the common carp, which is thought to have entered the lake from a fish farm in the catchment after the heavy *El Niño* rains of 1997/98. The only indigenous species in the lake are the minnow *Barbus paludinosus* Peters which invaded the lake from the rivers and the endemic *Aplochleithys antinorii* (Vinciguerra) which is now believed to be extinct, having last been reported in 1962 (Ojuok *et al*., 2007; Hickley *et al*., 2002, 2004, 2008).

As a public resource, the fishery is held in trust for society by the government, which has entrusted the lake's management to the Fisheries Department and the Kenya Marine and Fisheries Research Institute (KMFRI). The lake provides such benefits as a healthy aquatic environment, aesthetic and recreational values, scientific knowledge and economic activity as well as fish and fishing opportunities,

all of which must be utilised in harmony to avoid conflicts among the users and the resource degradation presently being witnessed (Kundu *et al,* 2010).

The lake has experienced intensive conflicts between resource-users. The fishing community blames the flower farmers, represented by the Lake Naivasha Riparian Association (LNRA), and the Kenya Electricity Generating Company (KenGEN) for the dwindling resources. This is because their abstraction of water exceeds the discharge of the only river flowing into the lake thereby causing the lake level to fall and expose shallow areas thus destroying breeding habitats (Hickley *et al* 2004). The fishermen also believe that the flower farms pump up fish eggs and fry at points of abstraction thus reducing recruitment into the fishery. Another point of conflict is between wildlife and livestock. Livestock farmers want to be allowed to use the passages set up by the Kenya Wildlife Service (KWS) to connect the parks and allow wildlife access to the lake. The graziers also want to burn the wetlands to promote the growth of grass for their livestock, which would interfere with these passages. Farmers are also encroaching into the wetlands by clearing vegetation for the crop farming.

In 2001 the lake experienced a severe drop in water level when the shoreline receded by almost 500 m and the exposed areas were invaded by terrestrial plants. The water abstraction points dried out and as the fishermen's catches declined they began to use illegal fishing methods. Local communities became gravely concerned by the imminent collapse of the fishery and the potential devastation of agricultural activities as a result of the disappearing lake. Consequently, the Kenya Marine and Fisheries Research Institute, supported by the Department of Fisheries, the Kenya Wildlife Service and the Lake Naivasha Riparian Association (LNRA), investigated the challenges facing the lake and prepared a status report with possible prescriptions for the recovery of the fish stocks and solutions for other environmental problems and conflicts (Njiru *et al* 2007).

The results were presented to major stakeholders in May 2002 at a stakeholders' workshop which recommended among other things that (1) the number of boats operating on the lake should be reduced from 140 to 40 and each boat should have only 10 gill nets with a minimum 4-inch mesh size; (2) flower firms were to ensure that contingency measures were put in place to ensure that fish eggs and fry were not sucked into their abstraction systems, and (3) the municipal council should control the discharge of sewage and solid wastes into the lake environment and recognise the economic and social values that the council derived from the lake and its environment.

The National Environment Management Authority (NEMA), one of whose core functions is to "take stock of the natural resource in Kenya and their utilisation and conservation, was not represented. It was felt, however, that this institution would play a key role in tackling issues raised by stakeholders in relation to pollution and the disposal of solid waste disposal by the Naivasha council.

The recommendations were enforced to some extent and continued monitoring of the lake revealed that there had been a sharp increase in the sizes of fish landed by fishermen. These results were shared at a stakeholders' workshop to indicate the critical roles played by each stakeholder. It was expected that their perceptions of the lake and its ecosystem were improved and this would provide the foundation for a workable management arrangement between stakeholders around the lake in order to resolve future conflicts.

It was recognised that critical fish habitats (breeding and nursery grounds) required protection and it was therefore critical these areas were identified, mapped and protected in order to revive the fishery. It was agreed that the approach should take advantage of the local communities whose experience would assist in pointing out the location of these critical areas. These communities would also be expected to be involved in the necessary management processes that would have to be established.

The main objectives of this study were to (1) identify critical fish habitats based on fishermen's knowledge; (2) assess the origins of the fishermen and types of fishing gear used by them, and (3) assess the general awareness of existing fisheries laws, environmental concerns and status of fisheries amongst fishermen.

Methods

A semi-structured questionnaire was developed to assess the origin of the fishing community and their knowledge of critical fish habitats and types of fishing gear used at various landings. The entry point for the survey was through the three Beach Management Units (BMUs) on the lake, Central, Kamere and Tarumbete, which are recognised by the Kenyan Fisheries Act for the purpose of shifting management from government institutions to a more decentralised system involving resource users in decision-making.

Using a motor boat, the team also surveyed various bays and inlets along the lakeshore that had been suggested by the fishermen, and other critical areas such as small bays and inlets. These areas were geo-referenced using a hand held GPS device and the coordinates used in a GIS application to generate a map of critical fish habitats in the lake.

Results

Critical areas

Four main areas were identified by local fishermen as critical fish habitats, namely Oserian bay in the southwest, Karongo in the northwest, an area off the Malewa and Gilgil river mouths in the north and east of Crescent Island (Figure 1). The major fish landing beaches and BMU locations (Central, Kamere and Tarambete) were located outside these areas.

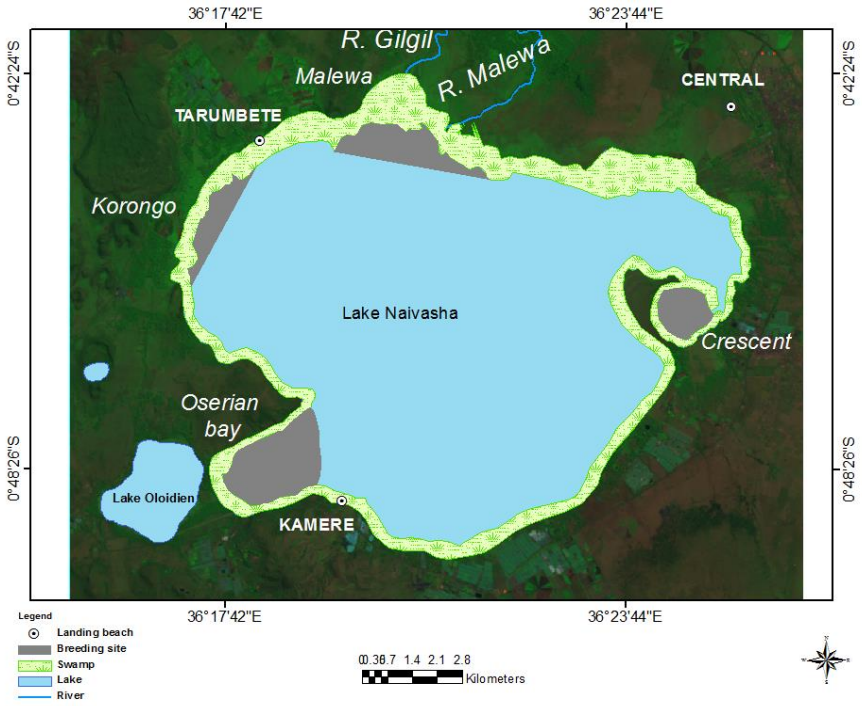

Figure 1. The location of critical breeding and nursery grounds (grey areas) for fish, and the main landing sites and BMU locations in Lake Naivasha.

Origin of fishermen

Seventy-seven fishermen were interviewed, the youngest being 18 years old and the oldest 56 years old, with a mean age of 36. Most fishermen (38%) came from the Rift Valley while 36% came from Nyanza province. The remainder were from other provinces of the country (Table 1). There was no fisherman who had come from outside Kenya.

Table 1. The origin of fishermen on Lake Naivasha, according to their province of birth.

Province	Proportion (%)
Rift Valley	38
Nyanza	36
Western	13
Central	10
Eastern	3

Fishing vessels and gear

The mean length of fishing boats was 7.1 m (23.4 feet); most were Sesse-type canoes used for setting gillnets and, according to regulations, each is required to have only 10 nets in order to control fishing effort. This requirement was hardly adhered to or enforced. Of the respondents interviewed, 26 were boat owners while 50 were crew members, while only one person operated on his own without a crew. Most (71.4%) of the boats had 3 crew members on board during fishing operations but some (18.2%) had only two people on board owing to a lack of labour. The most frequently landed fish was the common carp, caught in gillnets with a mesh size ≥ 5 inches (125 mm) and they made up 85% of the catch.

Management issues

Most fishermen set their nets at least 100 m from the shore, which is a general rule for all the inland water bodies in Kenya, and 65% of the respondents indicated that they fish far beyond this mandatory limit so that juvenile fish are not caught. Respondents were asked if they could tell whether a fellow fisherman in another boat fishing nearby was breaking the law and most of them (63%) indicated that they would know if someone was using an illegal gear. As far as critical habitats were concerned, 98% of the respondents reported that they knew where fish breed as well as the nursery grounds.

Respondents were asked to state what they think should be done to ensure that fishermen do not operate in those critical areas and 50% of them indicated that they would report illegal activities to their respective Beach Management Units. Other respondents (36%) said that they would ask their colleagues to stop if they found them fishing in the critical areas or using illegal gears while the remainder

indicated that they would report to the Department of Fisheries if they found someone disobeying the regulations.

Respondents were also asked what they thought should done to protect the breeding areas and 56% of them felt that the fisheries department should make sure that fishermen should avoid fishing in breeding areas, 24% felt that they should be allowed to fish in those areas but with recommended gears, and 5% indicated that the offenders should be arrested and prosecuted, and banned from fishing for some time (Figure 2). Other respondents suggested that fishermen should be educated to prevent the capture of juvenile fish, especially in the breeding areas and about the impacts of bad fishing practices. Some said that regular patrols by both fishers and fisheries officials should be intensified.

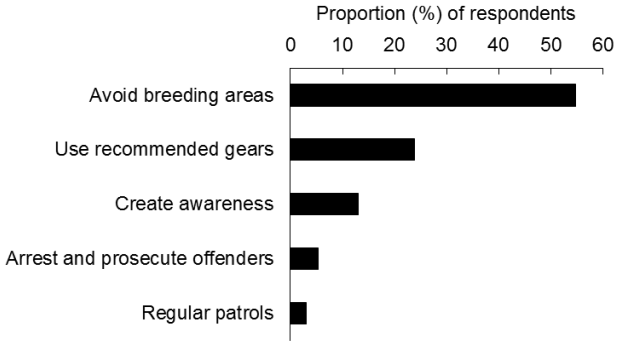

Figure 2. Suggestions from respondents on steps that should be taken to safeguard critical areas.

Environmental Factors

Most of the fishermen (85%) thought the receding water levels of Lake Naivasha was caused by the abstraction of water from the upper reaches of the Malewa River, along with excessive water abstraction from the main lake for intensively irrigated flower farms around the lake. Some respondents (7%) also thought that the 2009-10 drought was responsible for the fall in the lake level, while others attributed it to massive soil erosion in the catchment and the disposal of solid wastes by the Naivasha Municipal Council.

The changing composition of the catch

The survey also investigated changes in the composition of fish species that were being exploited 5-10 years ago as compared to what is presently landed. Most respondents were concerned that tilapias, bass and crayfish were disappearing from their catches (Figure 3). They also reported that they were catching African catfish *Clarias gariepinus* (Burchell) in their landings, a species that had never before been in this lake.

These observations are a cause for concerns amongst the fishing community who worry about the ever changing fishery on the lake. It was, however, noted that tilapia fry were present in large numbers in both open and sheltered shallow areas, which suggests that some recovery of these species may be possible. This would require a change in the behaviour of the fishermen; while the licensed fishermen mostly catch *C. carpio* illegal fishermen target tilapias in shallow areas, which they sell to unsuspecting residents of estates and slums around the Lake.

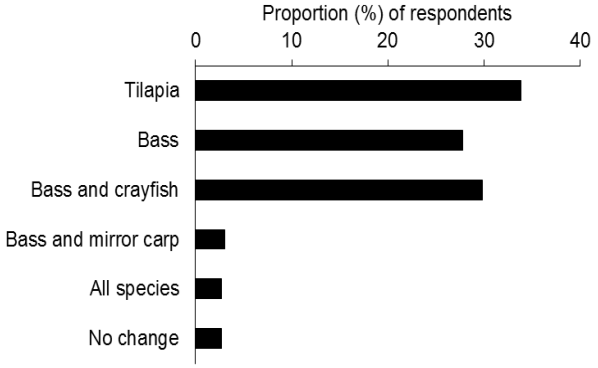

Figure 3. Species that are thought by respondents to have disappeared or declined in the catch.

The observations by the fishermen mirrors reports by several authors who have noted the considerable fluctuation in fish landings and changes in species composition. For instance, Elder *et al*. (1971) reported that the lake had originally only one endemic *A. antinorii* and that a number of species had been introduced. These included bass, tilapias and common carp, while other species were introduced but either failed or are of little importance, such as mosquitofish G*ambusia* sp., guppies *Poecilia reticulata* Peters and rainbow trout *Onchorhynchus mykiss* (Walbaum) (Elder *et al*., 1971).

The extensive fluctuation in landings is well documented with reports indicating *O. leucostictus* dominated the catches from 1987-2000, while by 2009 common carp, *C. carpio* had virtually taken over commercial landings (Hickley *et al*., 2004, 2008; Ojuok *et al*., 2007; Aloo *et al*. 2013). Recent experimental gill net surveys in the lake showed that *O. leucostictus* was the most abundant species (by numbers) followed by *T. zillii*. *Oreochromis niloticus* was the least abundant with less than 1% of the catch recorded (Mugo *et al*., 2012).

The recent appearance and increase in the number of catfish could have been facilitated by the spread of water hyacinth, which provides a favourable environment for this hardy and tolerant species. In addition, the presence of suprabranchial organs above the gills enable it to breathe ait and it can therefore live amongst the huge mats of water hyacinth that currently infest the lake and may have created anoxic conditions in the water below..

Reasons for disappearance

Respondents were asked why some species were disappearing and most (65%) attributed it to climatic factors

such as the long drought, which contributed to the falling in lake level, which was seen as a major cause of reduced cxatches and disappearing species (Figure 4). Some respondents mentioned predation as a cause of the decline and suggested that the many water birds on the lake could be feeding on fingerlings before they could be recruited into the fishery. Others suggested that water hyacinth was a cause of the problem.

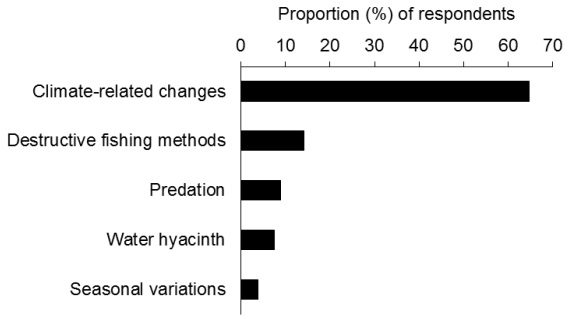

Figure 4. Reasons given by respondents for disappearance of some fish species.

Steps that should be taken for the recovery of the lake

When asked what steps could be taken to ensure the recovery of the lake, respondents suggested several actions that they believed would allow the lake to return to its original state Among the key suggestions given by respondents was that more fish should be introduced to the lake to enhance the existing stock so as to reach the previous levels of fish catches (Figure 5).

The respondents also suggested that the fishing regulations should be enforced more effectively and sport fishing controlled. It was also suggested that the lake level should be maintained by controlling water abstraction by the flower farms who should be encouraged to dig their own bore holes. A few respondents thought that catchment protection would help to improve the situation in the lake.

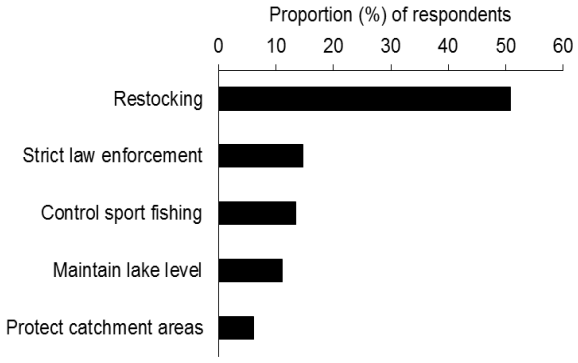

Figure 5. Suggestions made by the respondents for the recovery of species that have disappeared.

Discussion

Information from stakeholders regarding the critical habitats for fish breeding is useful for both fisheries managers and researchers to work together towards sustainable fisheries management of Lake Naivasha. The success of this survey supports the view that management by local communities can support a sustainable fishery. The respondent's knowledge should be verified by both past and present scientific to ensure that fishing activity does not take place in the protected critical areas. This approach would be in line with the conclusion that the involvement of all stakeholders in the management of Lake Naivasha is crucial for sustainable fisheries management (Njiru *et al.* 2008; Kundu *et al.* 2010). Their studies concluded that the top-down management approach adopted by the central government has failed to work for Lake Naiavsha while community involvement, through beach management units, has helped to reduce illegal fishing in Lake Victoria.

The critical habitats identified in this study (Figure 1) concur with the observations of Oyugi *et al* (2011) and Aloo *et a.l* (2013) who reported that Crescent Island was a preferred breeding site for bass, while the other species used Oserian Bay, the Malewa river mouth and shallow areas dominated by macrophytes. Almost every interviewed fisherman knew of the critical fish breeding and nursery grounds and most of them would know if someone was using illegal fishing gear. This confirms the idea that convergence between scientific information and local knowledge could be used by fisheries managers to create a self-regulating system for the fishing community.

Changes in lake level have been linked to the overall performance of the fishery in the lake (Muchiri and Hickley, 1991; Hickley *et al.*, 2002; Aloo *et al*., 2013) and most stakeholders agreed that the water resource was the most critical factor from their point of view. Over the last 5-10 years water usage in the lake basin has become main source of conflict between farmers and fishermen. The fishing community blames the farmers for excessive water abstraction and the destruction of fish eggs and fry by their pumps. The farmers around the lake do not accept these charges but there is a consensus that the level of abstraction should be controlled. It is clear that the abstraction of water from the inflowing rivers should be based on detailed hydrological information if the problem of lake level recession is to be solved.

The use of recommended fishing gear and protection of fish breeding sites were the measures preferred by fishermen for safeguarding the fishery of the lake. Many fishermen contended that introduction of more species into the lake would revive the fishery but this is a controversial view. Fisheries scientists argue that future introductions of fish species should only be carried out if thorough investigations suggest that they are justified (Muchiri *et al.*, 1994; Aloo *et al.*, 2013). In recent years, concerns have been expressed over the invasion of carp which is now the dominant species, making up > 95% of the catch (Ojuok *et al*., 2007; Britton *et*

al., 2007; Aloo *et al.*, 2013). Oyugi *et al.*, (2011) attribute the decline of *T. zillii* to the influence of carp although it does not seem to have affected *O. leucostictus*. They also point out that lake level fluctuations are the main influence on the relative abundance of tilapias in the lake and the catch is unlikely to increase, regardless of any changes in fishing effort, unless the lake level rises.

Some other measures that could address decline in the tilapia stocks in the lake have been proposed by Hickley *et al.* (2002), Kundu *et al.* (2010) and Oyugi *et al.* (2011), among others. In support of their recommendations, this survey emphasises the need to review and implement management guidelines for the lake. The fisheries management structures should incorporate KWS personnel whose function would be to enforce control and regulatory measures, especially in curbing illegal fishing on breeding grounds. The BMUs should be well equipped and supported by a legal framework to enable them execute their roles and functions to ensure the sustainability of the fishery resources. The BMUs presently lack the authority to apprehend lawbreakers on their own and bring them before the courts.

Finally, the LNRA and other stakeholders such as the Municipal Council and NEMA should work together to regulate that human activities around the lake and in its catchment to ensure that they do not threaten the lake's environment. These include water abstraction, solid waste disposal and the use of agro-chemical on the horticultural farms. These organisations should ensure that the rate of abstraction corresponds to the flow regime of the Malewa River. Abstraction points should be fitted with mechanisms to avoid sucking in fish eggs, fry or fingerlings and should be jointly inspected by the Fisheries Department and the National Environment Management Authority for compliance.

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