Potentials of Lake Kitangiri: Case study of saline lake fisheries in Tanzania.

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Abstract

Lake Kitangiri is among the saline lakes located in Iramba district of Singida region, Tanzania. The lake has pronounced fisheries, though insufficiently managed and information about the lake are scarcely documented. Attempt to conduct research and document fisheries status of the lake was commissioned to Tanzania Fisheries Research Institute (TAFIRI) by the Ministry of Livestock and Fisheries. Frame survey and catch assessment surveys were conducted along with discussion to gauge participation of the resident fishing communities. Findings shown that the lake had 358 fishers, 179 fishing crafts, gillnets of meshes "2 inches – 3.5 inches", beach seines, hooks sizes 8 – 9, traps and weirs. Main fish species encountered were *Oreochromis niloticus*, *O.amphimelas*, *Clarias gariepinus*, and *Protopterus aethiopicus*. Other fish caught occasionally were *Labeo victorianus*, *Schilbe intermedius*, and Barbus altinalis. The estimated total annual fish catch was 844.4 tons valued 463,164,853 TZS. Challenges facing the lake resources were identified to be lack of compliance to fisheries laws and regulations, conflicts between livestock keepers and fishermen all of which had policy implications on the lake fisheries management and could be resolved by licensing, strengthening of extension services and establishment of strong networking among the riparian districts.

Keywords: Fish production, Co-management, Fishing gears.

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Introduction

Lake Kitangiri has a peculiar history among many other saline lakes in the great rift valley basin passing across the corridor in central Tanzania. Other Lakes in this system include Natron, Eyasi, Manyara, Makati, Burungi, Singidani, Kindai, Basuto, Balangida, Balangidalelu, Basotu and Basoda [1,2]. Lake Kitangiri drains its water into Lake Eyasi through River Sibiti of which its water outflow intensifies during rainy seasons. Field observations revealed the lake level to be 105 km^2 [3] and had receded to 1.15 km over the past 40 years (personal observations).

Aquatic ecosystems of the lake have been greatly influenced by anthropological activities and natural processes happening in the river basins [4,5]. Whereas its hydrographic characteristics have greatly been favoured by interaction of an intricate system of seasonal rivers (Manonga, Semu and Ndirumo) and the permanent water input through Nkenkan`gombe, Yuli, Tulya and Wembere rivers.

The lake being relatively among small water bodies, it is singled out as important faunal reservoirs for the endangered species of larger reservoirs and big lakes [6,7]. For example, fish that are currently termed as rare species or to have disappeared from major water bodies are represented in such small water bodies [8]. Besides this economic value, the lakes serve as a gene bank and provide microhabitats for feeding and breeding of fishes [9,10]. The structural barriers composed of macrophytes around the lake and the apparent low oxygen regimes in the water system promotes peculiar biota in the lake [11]. Lake Kitangiri as it stands has the potential to attract scientific investigations bearing in mind the observed pronounced fish production that are found within a semi-arid environment and the associated biota. There was an extensive wetland cover, rich in macrophytic plants which seem to play an important role in regulating and controlling the biological and physico-chemical processes [2].

Recognizing the consequences of improper management of the fisheries resources and weak involvement of communities in the fisheries management, the Government of the United Republic of Tanzania adopted a participatory co-management approach to resource use which is incorporated in the National Fisheries Policy of 1997. Communities are mandated to play a vital role as partners in fisheries planning, management and development through Fisheries Act of the year 2003 and Fisheries Regulations of 2005. In the act and in its regulations, fisheries stakeholders are empowered to form community-based groups called Beach Management Units (BMUs). They are formed to manage fisheries activities in all water bodies of the mainland Tanzania.

This paper addresses the issues related to current catch and effort data provide fisheries status of the lake through frame survey, and biological aspects of the landed fish species. Others are demographic status of the fishing community and socio-economic implications of resource use as basis for management of the saline lakes.

Materials and Methods

Study area

Surveys were conducted in Lake Kitangiri (Figure 1a, 1b). Estimation of the number of active fishing crafts based on actual counting in two landing sites called Doromoni and Shauritanga. Information of the other landing sites was provided by resident fishers from the respective landing sites. Number of fishers, means of propulsion and number of fishing gear by type and size were recorded for each landing site.

Figure 1a. *A map of Lake Kitangiri.*

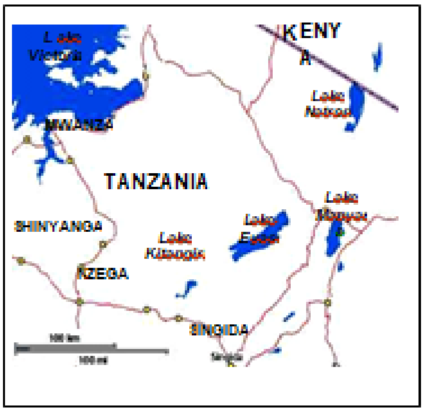

Figure 1b. *A map of Lake Kitangiri.*

Irrespective of the fishing gear details, fish catch rates by species (kg/craft/day) were determined from data collected from two landing sites of Doromoni and Shauritanga with the assumption that they remained constant across the lake. Total catch by species for the sampled month was estimated by raising the catch rates to the numbers of active fishing crafts on the lake and number of days in the month. Three phases were arbitrary assigned as peak phase covering the months of April – August (doubles factor of the lowest phase), followed by an intermediate phase from September to November (one and half factor of the lowest phase). The lowest phase (more or less closed season) extends from December to March.

Fish prices by species were recorded at Doromoni landing site. Assuming that prices remained constant across the lake and throughout the year, annual total value was estimated by raising the determined prices to the respective annual catches by species.

Fish size structures were determined by sampling fish from Doromoni and Shauritanga landing sites. Landing crafts were sampled randomly ensuring proportional representation of each craft and gear type. For each sampled craft the catch was sorted into species, where manageable the whole catch was measured for individual fish total length (TL) to the nearest millimeter below otherwise sub-sampling was done. Information on social structure, amenities and community involvement in fisheries were gathered from physical observation, interviewed resident Assistant Fisheries Officer and round table consultations with the village leaders and the fisher community.

Results

Frame survey

There were about 15,687 permanent residents on the Iramba part of the lake who depends on the fishing and fish trades. Some people earn their living also through subsistence agriculture and limited pasturing. Some social amenities like schools and dispensaries were within easy reach of the communities and there were 358 fishers operating a total of 179 crafts. Most of these crafts were dugout canoes made from B. ethiopium locally known as Mpama (31 crafts) and hardwood (148 crafts). Fishing was normally done by setting gears once and leave them to catch fish for some months. They paid visits and hauled to get fish and thereafter leaves back the nets in water. Withdrawal of the fishing gears was done at the end of the fishing season when fishers resort to agricultural activities. Fishing gears in common use comprised of gillnets (2– 3.5 inches), beach seines, hooks of size numbers 8 – 9 baited with ants and grasshoppers. Other fishing gears occasionally encountered were traps and spears. The total number of gillnets was estimated to be 5,326 nets. Numbers per mesh size are shown in Table 1.

Table 1. *Total number of gillnets per craft type.*

Craft type	Hardwood	B. ethiopium	Total
GN 2"	0	580	580
GN 2¼"	625	2176	2801
GN 2½"	310	820	1130
GN 3"	78	300	378
GN 3½"	78	360	438
Total No. GN	**1090**	**4236**	**5326**

Note: GN: Gill Nets; " indicates size in inch mesh.

Eight fish species were encountered with a pronounced semi-subsistence and commercial fisheries based on *Oreochromis niloticus* (Domo-fupi) and *Oreochromis amphimelas* (Domo-refu) [11], *Clarias gariepinus* (Kambale), *f* (Kamongo), S*hilbe intermedius* and Labeo victorianus. The species *O. amphimelas* is endemic to the rift valley salt lakes of Tanzania [12,13].

A total of 43 fishing crafts were sampled constituting 61.4% of all active fishing crafts. *Oreochromis niloticus* recorded the highest catch rate (13.1 kg/boat/day) followed by *O. amphimelas* (9.2 kg/boat/day), *C. gariepinus* (3.9 kg/boat/day) and *P. aethiopicus* (3.0 kg/boat/day). *Labeo victorianus* (0.6 kg/boat/day) and *S. intermedius* (0.5 kg/boat/day) had relatively much lower catch rates. Catch rates recorded for *O. niloticus* and *O. amphimelas* in this case were not significantly different ($p>0.05$) but the two species differed significantly ($p<0.05$) in catch rates from the rest of the other fisheries of the lake.

An estimated total catch of 45.641 tons were calculated during February sampling and the catch was dominated mainly by *O. niloticus* followed by *O. amphimelas*, *C. gariepinus* and *P. aethiopicus* (Figure 2). The least important landed species were *L. victorianus* and *S. intermedius.* Annual total catch for the year was estimated basing on the February catch to be 844.4 tons. This estimate was established bearing in mind of wide variation of intensity of fishing activities across the seasons. However, stock size estimates could not be established due to limited time and financial resources.

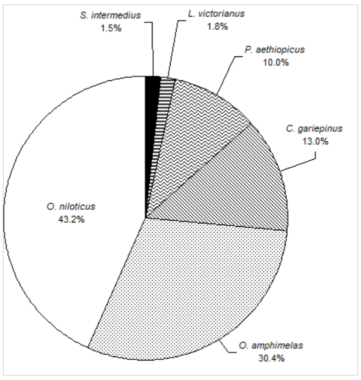

Figure 2. *Percentage fish species catch composition.*

Catch value

The value-at-beach for fish caught in February for Lake Kitangiri was estimated at 25,035,938 TZS. The value was dominated by *O. niloticus* (51.6%) and *O. amphimelas* (17.6%). *Clarias gariepinus* and *P. aethiopicus* had relatively low catches but due to their high unit prices they fetched comparable high total value to that of *O. amphimelas* whose total catch was 2 – 3 times higher (Table 2). On the basis of the value for February, an annual value was estimated at 463,164,853/= TZS. This translates to 1,293,757/= TZS earned by each fisher per annum given the number of 358 fishers operating in Lake Kitangiri. The value per fisher per day was therefore estimated at 3,542/= TZS.

Table 2. *Catch and its value-at-beach for fish caught from Lake Kitangiri.*

Species	Average price (TZS/kg)	Total catch (kg)	Total value (TZS)
O. niloticus	659	19,725	13,001,715
O. amphimelas	318	13,880	4,413,877
C. gariepinus	672	5,915	3,973,677
P. aethiopicus	688	4,574	3,148,650
L. victorianus	322	842	271,158
S. intermedius	322	704	226,861
	Total	**45,641**	**25,035,938**

Gill is an important site for the entry of copper [36]. Continuous accumulation of copper in the fish gills is due to the presence of positively charged copper ions that interact with the negatively charged gill. Similar study found that metal cautions, including Cu and Cd, bind to negative sites on fish gills [37], and metal toxicity to fish is determined by free metal ions that are bio available chemical species [38]. However, according to Schjolden et al., the copper challenge of approximately 300 µg Cu^{2+}/l was not acutely toxic (96 h LC50) to crucian carp (Carassius carassius) [39]. Reduction in respiratory surface may lead to respiratory disturbance in teleost fish. Result of different article indicated that, the level of copper in lake and river range from 0.2 µg/L to 30 µg/L, but in contaminated water, the concentrations can rise to greater than 100 µg/L. In addition to this many publication agreed on high accumulation of copper in the body of fish leads to behavioral changes like shoaling nature, swimming with their belies upwards, loss of equilibrium and irregular movement.

Fish processing and marketing

The landed catch was sold to fish mongers and traders, both men and women at landing sites. Gutting was carried out along the shore and there after parked in sacks ready for transporting to the area for processing located close to the landing sites. Fish were either sun-dried, frying or smoked providing employment opportunities across the social structure with dominance of females. Child labour was noted in low profile and could probably rise during peak fishing seasons. Fresh fish were transported to local small scale processing units and nearby fish markets in Kiomboi, Nduguti and Shelui. Most of the processed catch was transported to far markets in Singida, Manyara, Tabora, Shinyanga, Dodoma, Morogoro, Tanga, Mara (particularly P. aethiopicus) and Mtwara. The rest was exported as far as to the Democratic Republic of Congo (DRC).

According to Li et al., report reduction in Na^+ uptake was caused by inhibition of Na^+/K^+-ATPase at the Mg^{2+} binding site and also due to additional effect of competitive nature between copper and sodium at the apical side [42] as copper may be passes through Cu-specific channel or leaks through sodium channel [17,43]. Schjolden et al., found that crucian carp (Carassius carassius) did not lose ions at the same rate as other fish species exposed to Cu^{2+}. They also reported that it takes 4 times as long for crucian carp (Carassius carassius) to lose 20% of its plasma ions compared to rainbow trout(Oncorhynchus my kiss). De Boeck et al., found similar trend in ion loss occurs in gibel carp (Carassius gibelio) when exposed to sub lethal levels of copper [44,45]. According to Schjolden et al., the consequence of reduced plasma ion concentration in copper exposed crucian carp was a net movement of water from plasma to tissues [30]. Waiwood argue that increased heamatocrit in copper exposed rainbow trout was caused by movement of water from blood plasma to muscle tissue. According to Taylor et al., report rainbow trout and yellow perch (Perca flavescens) died from copper exposure (approximately 10 µg/l and 50 g/l respectively) within 96 h at the point when they had lost 60% of their whole body sodium [46,47]. In fresh water fish, copper is known to cause osmotic imbalance by reduction of brachial Na^+ uptake due to inhibiting the basso lateral Na^+/K^+-ATPase [48,49]. Reduction of brachial Na^+ uptake also decreases the uptake of Cl- which aggravates the ion regulatory disturbance, and NH_3 excretion is inhibited [50].

Size structure of fish catches

The size structures of various species landed are presented in Figure 3. *Oreochromis niloticus* had a mode at 15 cm TL and *O. amphimelas* was at 16.0 cm TL. The majority *C. gariepinus* landed fell between 32 and 33 cm TL. Whereas model lengths for *S. intermedius*, *P. aethiopicus* and *L. victorianus* were not well defined due to small sample sizes.

Seasonality in the fishery

The fishery was divided into three fishing phases determined by the dry and wet seasons. Peak and intermediate fishing phases fall within the dry season whereas the low fishing phase was restricted to the wet seasons. The peak phase (April – August) was characterized by gradual increase of catches with increasing fishing activities. Fishers moved into the fishery at full maximum number in July when agricultural activities are minimal. It was also within this phase that fish sizes indicated an increase. This was followed by an intermediate phase characterized by declining fishing activities when the water level recedes exposing macrophytes which become pastures for livestock. These activities could be destructive if no areas are specifically designated for pastoral use. This was further worsened by the recently developed habit of some fishers who clear macrophytes to extend fishing grounds. In the rainy season

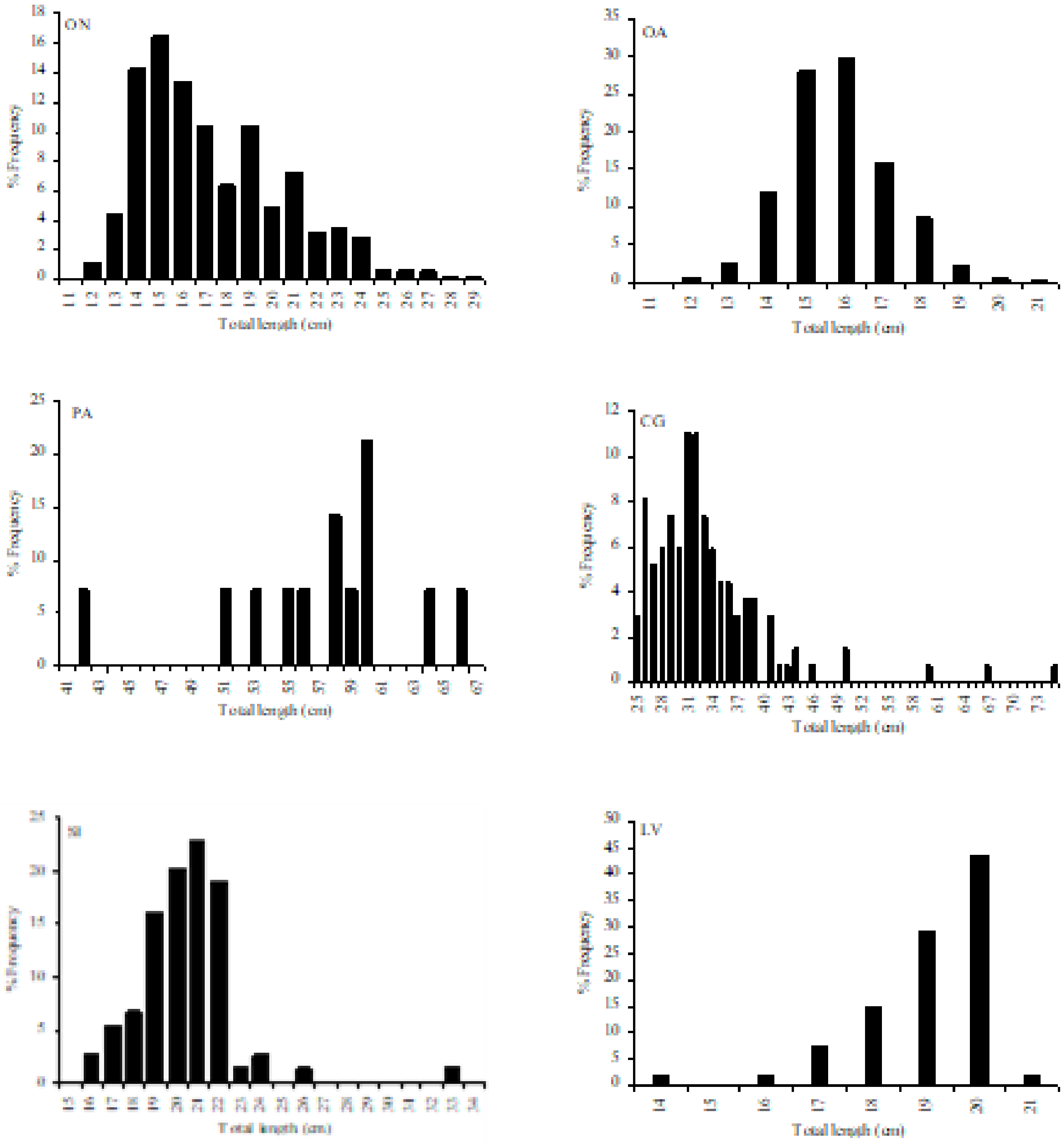

Figure 3. *Size structures of various species landed. Species names abbreviated: ON=O. niloticus, OA=O. amphimelas, PA=P.aethiopicus, CG = C. gariepinus, SI=S. intermedius, and LV=L. victorianus.*

(December to March) agricultural activities are most intensive and hence a large number of fishers leave the fishery for the reason that the stocks are low due to the preceding high fishing phases (pers.com.). Most of the surviving fish stock takes refuge in macrophyte covered areas in the lake when water recedes reducing the lake into smaller area.

Social structure and amenities

Lake Kitangiri was administratively managed by Tulya and Kidaru ward authorities of Iramba district. The two wards had a total of 3,204 families out of which 214 depends on fishing while 2,990 families were involved in farming and livestock keeping. The lake had also some fish handling and processing facilities established by the Fisheries department at Doromoni landing site in early 1970's to cater for the whole lake.

Community involvement in fisheries management

Currently there was only one resident Assistant Fisheries Officer at Doromoni and a District Fisheries Officer at Kiomboi town. Due to insufficiency of fisheries staff, effort was made to form committees like Beach Management Units (BMUs) of Lake Victoria. They were formed at Doromoni, Shauritanga, Misri, Mingela and Mdama landing sites to assist in management of the lake resources. The most active landing sites in the form of committees were Doromoni and Shauritanga whereas Mwamasonda and Usiulize landing sites had no such committees.

During round table consultation with a cross section of community members around Lake Kitangiri, revealed inadequate know how on stakeholder's role in community partnership in resource management. There was little perception on minimizing expenses on resource use, guidelines in revenue collection and no incentive to promote good governance. All these resulted in ineffective control of resource use.

Discussion

State of fisheries

Fisheries management requires among others the understanding of the status of fish stocks and accurate updated information on the exploitation to evaluate the viability and prospects of possible investments. Lake Kitangiri like many other saline lakes have their fisheries information status scantly documented [3,4,13,14]. Some available information for the lake indicated an exploitation rate of 40 tons per annum estimated in 1987, which was far below the potential yield of 1000 tons per annum estimated in 1984.

Despite its location in a semi-arid area and presence of saline waters, yet Lake Kitangiri has pronounced fisheries based on *O. niloticus, O. amphimelas, C. gariepinus, and P. aethiopicus* caught in a range of fishing gears namely gill nets, beach seines, hooks, traps and spears. The current annual fish production was estimated to be 844.4 tons per annum supporting a population of 15,687 residents in Iramba district and other people far from the district. This production is remarkable and reserves properly holistic approach management of the district sharing the waters. The lake is bordered by Iramba, Meatu, Maswa and Igunga districts although its management is solely under Iramba district. This scenario has to be reviewed so that all other partner districts to network for effective management and development of the lake fisheries resources.

Fishing crafts operated in the lake were relatively smaller in size than those used in Lake Victoria. Though the lake worthiness could not be comparable to that of Lake Victoria, it is pertinent to note that there should be compliance with the legal framework put in place by the relevant authorities to ensure security and safety of the recommended standards. Catch rates for a boat recorded estimated to be 30 kg/boat/day, the rate that surpasses catch rates of many other equivalent small water bodies around Lake Victoria [8]. However, this estimate was made during the minimum fishing level (phase) which was associated with the time when most fishers shifts towards agriculture activities. The estimated income per fisher per day was TZS 3,542/= above the estimated per capita income (1,760/= TZS) per day for Tanzania reported by the World Bank in 2013. This status is a commendable achievement which should be sustained. It is about half of what a fisher earns per day from Lake Victoria (7,095 TZS) [15].

Size structure and mode of *O. niloticus* being at 15 cm total length (TL) and for *C. gariepinus* at 16 cm TL suggests high exploitation of the fisheries. This scenario is accelerated by high demands of *O. niloticus* and *C. gariepinus* in distant Regions of Singida, Dodoma, Morogoro and even across the borders to Congo DRC. The decline was also noted from exploited fish length categories which indicated a decline and is associated with uncontrolled entry into the fishery. This may be further reduced in case there is no proper management put in place to halt the situation.

The lake has two notable fishing phases (low and high) in a year determined by fish availability. These seasonality phases were considered as opportunities for alternative livelihoods whereby fishers shifted between fishing and involving in agriculture activities. The low fishing phase was considered as a natural closed season in which most fishers go for agriculture which gives ample time for fish to breed, but the practice of clearing macrophytes obscures the impacts of this closed season. During high fishing seasons (the whole of dry seasons) fishers and farmers are actively involved in fishing because crop farming is less conducted and roads are accessible.

Compliance to fisheries laws and regulations

Majority of fishers at landing sites operated without formal licenses and those fewer with these documents were to spot for non-compliance. The number of illegal fishing gears and crafts in the lake were noted and continued to operate despite some sporadic patrols arranged by BMUs. Most of these unlawful individuals had not been sensitized and lack knowledge on the fisheries laws and regulations that could have provided by the law enforcers. The tendency to leave nets to fish day and night throughout the fishing season in the lake is among many ways that intensifies fishing capacity per fisher. There should be deliberate attempts to set and observe fishing time. Sometimes sense of ownership by the community has to be increased together with promotion of good governance in both village government and the community for effective control of the resources through patrols. It was recommended to undertake other measures such as exercising of species specific approach with respect to fish sizes to be landed, closed areas and seasons and craft size specifications. Currently there is indiscriminate fishing in the lake without taking into consideration the ecological and biological requirements of the species. This calls for specific studies aimed at identifying the appropriate gear sizes, breeding areas and seasons and reproductive biology of the fishes.

Community participation

The concept of involving stakeholders in the management of fisheries is geared towards making the fishing communities knowledgeable on the essence of cautious exploitation of the resources. The convened meeting during the study aimed at evaluating the performance of BMU leaders, members and village leaders on the importance of fisheries. It was also intended to promote discussions on the need for fisheries management, sustainable fishing, concept of resource ownership, management goals and strategies to achieve them. The outputs were to be manifested in the form of cost effective measures in management of resources, increased sense of ownership by the community, promotion of good governance through decentralization of powers and effective control of the resources.

The interview revealed a certain degree of perception of the anticipated co-management concepts through involvement in the environmental protection interventions, devising and undertaking control and surveillance measures through patrols.

Inadequate guidance on how to effect the resolutions of the convened assemblies, uncoordinated assignments on control and surveillance measures, inadequate knowledge on finances and revenue collection for executing the assigned duties need to be addressed for effective resource control. This suggests the need to provide sufficient training on the concepts of communal partnership in management and sustainable fishing.

Areas of intervention

Lake Kitangiri can be regarded as an economic growth zone for the riparian districts and distant areas such as DRC in case issues such as lack of information on the stock size, indicators arising from observations on fish size structure, fishing capacity, illegal fishing gears and practices and in situ fish processing are all handled otherwise they will lead to mismanagement of the lake resource. Still it should be noted that without concerted efforts in managing the fisheries, the lake will progressively deteriorate both in biodiversity and ecosystem health (FAO, 2002). This may lead to total collapse of the lake fisheries despite of its high productivity. For safety precaution and maintaining of sustainability of the fisheries it is recommended to streamline the process of licensing by issuing certificate of identity to registered fishers and crafts, reinforce the existing fisheries law and regulations, strengthen extension services through provision of adequate fisheries staff, establish and strengthen networking among the riparian districts, restrict livestock activities in the lake especially during the dry season, initiate the process and formation of BMU`s as per national guidelines and finally agree on the time of setting and hauling of fishing gears (e.g. nets).

Conclusion

It is recommended that another survey be arranged during the peak fishing period as a follow up study and for standardization of the catches. Extra work is also recommended on the biology of the important commercial and environmental studies including primary production.

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Conflict of Interest

There are no Conflicts of interest.

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