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Depletion of Fish Resource in Lake Kitangiri, Tanzania: Poverty - Resource Overexploitation Nexus

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Authors' contributions

This work was carried out in collaboration between all authors. Authors CR and YS designed the study, performed the statistical analysis, wrote the protocol, managed literature searches and wrote the first draft of the manuscript. Authors YS, JM and RJ managed the analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

Lake Kitangiri in Singida, Tanzania is facing enormous pressure as a result of overfishing, illegal fishing, and environmental degradation. The increase in population and climate change have caused a shift from dependency on economic activities such as crop cultivation and livestock keeping to fishing. The limited fish resources are over utilized and have been depleted due to increased fishing activities. In order to determine trends of fish production at Lake Kitangiri and the associated effects of overexploitation, a study was carriedout. Data were collected using household questionnaires, focus group discussion and key informants interviews. fish production, output of farming activities in Lake Kitangiri were found to have been decreasing over years. More importanly, fishing activities in the area have intensified due to influx of people to the area. Illegal fishing activities at the habitat for fish breeding have led to the depletion of fish in the lake. The findings suggest that the depletion of fishery resources has negative effects to the income of the

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households surrounding the Lake. The government has been trying to combat illegal fishing activities without involving the community or the community based organizations. It is therefore recommended that the government should involve the community in the conservation of the resoures. The introduction of high value crops in the area will reduce the number of people that look at fishing as the only viable livelihood activity thereby reducing pressure to the lake. It is also recommended that aquaculture be introduced to the area.

Keywords: Overfishing; livelihood; illegal fishing; Lake Ecosystem; environment.

1. INTRODUCTION

Majority of people in developing countries depend on natural resources such as forests, rivers, and lakes for their livelihood [1]. These livelihood activities, if not controlled, may lead to depletion of the resources. The relationship between environmental degradation and poverty has been clearly demonstrated [2]. Tanzania as a country developed environmental conservation measures in response to excessive exploitation of natural resources caused by an increased population pressure, which, has ultimately led to degradation of the environment and thereby increasing poverty.

There has been public concern and media attention on the depletion of fish resources as a result of the use of illegal fishing practices, high fishing pressure, environmental degradation, dumping of waste materials to the water bodies, all of which led to the reduction of fish catches and the decline of economic wellbeing of fishing communities [3]. The largest proportion of fish resources in Tanzania are currently degrading from the normal output potential, thereby threatening livelihood activities of the people surrounding the resources [4].

Most residents in the lake regions are directly dependent on fish for their survival making the resource more vulnerable to depletion [4] because these particular biological resources are finite in terms of reproduction [5]. The decreased production will eventually weaken the capacity of the lake dwellers from meeting their basic needs. Over-exploitation of water body resources is a worldwide problem [6]. In response to the over exploitation of the lake resources, different countries have passed laws against illegal harvesting of the resources.However, these laws have been less effective because the laws are not enforced properly. Fishermen have continued to use illegal fishing methods such as poisons, dynamites, and bag nets [7].

Lake Kitangiri in Tanzania is the habitat of different fish species [8] that are vital to the livelihoods of the people in Singida [9]. Different fish species found in Lake Kitangiri include *Oreochromis niloticus, Oreochromis amphimelus, Clarias gariepinus, Protopterus aethiopicus, Shilbe intermedius* and *Labeo victorianus, Oreochromis niloticus* and *Oreochromis amphimelus,* which is the dominant fish species constituting about 73.6% of the total catches per day. Fishing is one of the major economic activities in the area; therefore majority of the village communities around the lake depend on fish supplies from the lake. More people living around the lake are engaged in fishing activities, not by choice but because of climate change effects which has culminated into the decline in crop production, thereby putting more pressure on fish resources in the lake [2].

There is a plethora of literature on the depletion of fish resources in major lakes such as Lake Victoria and Lake Tanganyika [10,11,12,13] and the effects of such depletion on people's livelihood [14]. However, studies on the status of fish resources in smaller Lakes such as Lake Kitangiri in Singida are scant. This creates difficulties in analyzing the contribution of lake resources in livelihood development strategies. This situation therefore calls for an investigation that will increase our understanding on the management of fish resources and their contribution to the livelihood of the surrounding communities. Therefore, the objective of the current study was to explore the trend of fish output in Lake Kitangiri and its effects on the livelihood of the surrounding communities.

2. MATERIALS AND METHODS

2.1 Description of the Study Area

Lake Kitangiri which covers an area of 105 km^2 is found in the central part of Tanzania between Latitude 04°2' 15''S and 04°10'00"S and Longitude 34° 14'00"E (Fig. 1) and is inhabited

by 11,128 people in 6 villages [15]. This study was carriedout in three villages, which are Doromoni, Tulya and Mingela. The main economic activities of the surrounding communities include agriculture (crop cultivation), livestock keeping and fishing. The total number of households in the studied area is 374. Almost 50% of the households involve themselves in farming and livestock keeping activities. The rest 50% (187) households include a category of those who are involved in fishing activities only and those who are involved in both fishing and farming/livestock keeping activities. Out of the 187 households, only 68 involve themselves exclusively in fishing activities.

2.2 Sampling

The estimation of the sample size of fishermen in the area was carried out basing on the total number of fishing households in the studied area. Based on 5% error, the sample size was calculated from the 68 households that practice fishing (see section 2.1). Based on the sampling formula (*Slovin's formula*), $n = \frac{N}{1+N.e.e}$ where; n = sample size, N = The total polulation and e = the 5% error, the total number of sampled households was 58. The samples were selected using systematic random sampling.

2.3 Data Collection Methods

Both qualitative and quantitative methods were used in data collection. Focus group discussion involved five well informed people from fishing communities. In order to establish a variation pattern of fish production over the past years, fishermen with over 36 years of fishing experience were selected. With the help of the Fisheries Officer, five fishermen were chosen from Doromoni village landing site. A key informants interview involved different officials from the District Council such as District Fisheries Officers, District Trade Officer, Agriculture Officer, Livestock Officer and Environmental Officer. Household surveys in the villages were carried out using questionnaires. The purpose was to obtain household statistical information on the fishing activities, trend of output and the contribution of fishing activities to household economy.

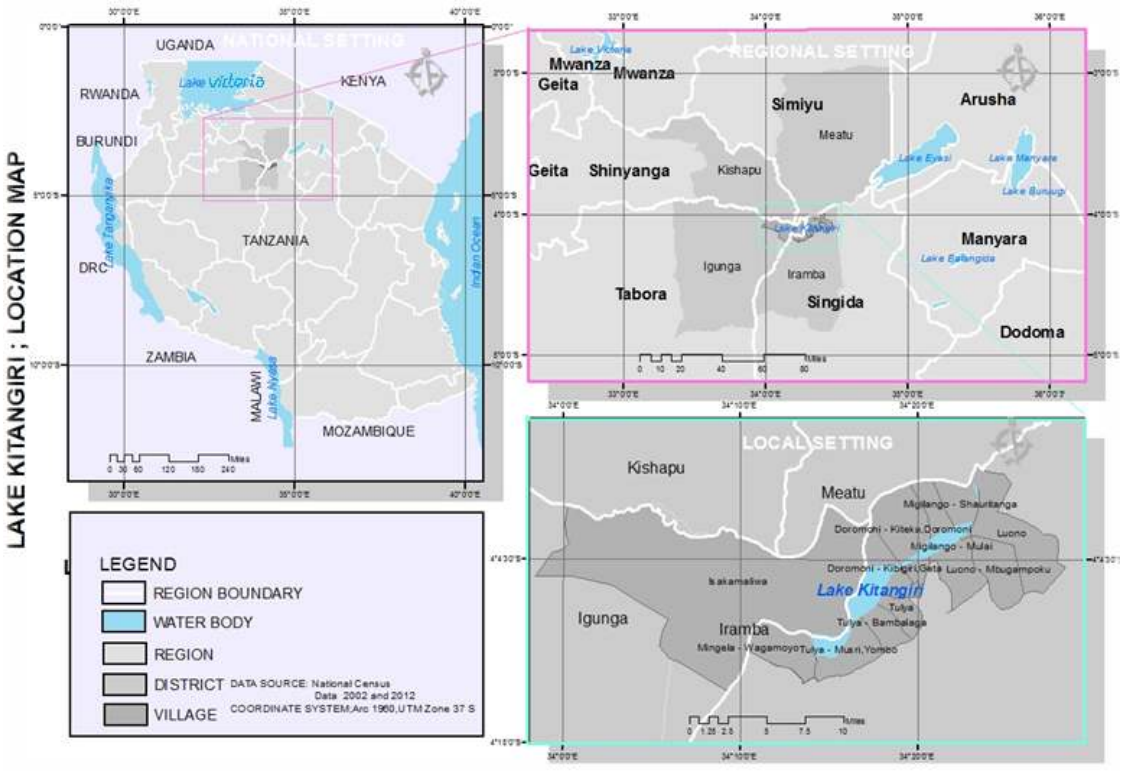

Fig. 1. Lake Kitangiri location map

3. RESULTS AND DISCUSSION

3.1 Economic Activities and the Trend of Fish Production in Lake Kitangiri

According to the survey conducted in the area, people's main economic activities are either fishing, cultivation or livestock keeping or a mixture of all (section 2.1). Fishing activities at the Lake have attracted different categories of people such as fisher-men, middlemen, fish processors, as well as sellers (vendors) from different parts of Tanzania. Division of labour in the fishing industry around the Lake is such that men are involved in fishing operations and women are invoved in the fish processing. Results from the interview with key informants show that the number of fishermen in the Lake Kitangiri in all six villages has increased from 358 in 2008 to 610 in the 2013 giving an average increase of about 67 fishermen per year, which is equivalent to 18.7%.

Despite the increased number of fishemen in Lake Kitangiri, fish production in the lake has decreased (Fig. 2). This is a testmony that the increased number of fishermen has put more pressure on the Lake resources thereby threatening the sustainability of the fishing activities in the Lake. The decrease in fish production can as well be attributed to overfishing and illegal fishing practices such as use of small size nets (as low as 1 inch), poisons and fishing on fish migratory routes, which continue unchecked in Lake Kitangiri. Consistent with the findings of the present study, [16] reported a decrease in fish caches despite the increase in fishing vessels in Pakistan and [7] reported decline in fish production as result of using poisons in fishing. Lake Kitangiri contributes 60% of the total production of fish in Singida region [9]. Experience in fish resources depletion in other lakes such as Lake Chad caused threats to food security [17]. Therefore the deterioration of Lake Kitangiri can as well be regarded as a threat to the livelihood of people in the region.

The fishery sector national wide is facing the problem of declining fish production particularly in larger Lakes such as Lake Victoria where overfishing and the use of illegal fishing methods is rampant [3,1]. As a result, lakes such as Kitangiri become a destination for fishermen from larger Lakes thereby putting more pressure on the small Lakes like Kitangiri. This has led to a decline in the number and diversity of fish species which reported to cause serious threats for the sustainable development of fishing industries, sustainable ecology and the livelihood of the communities surrounding the Lakes [7]. The abundancy of species in Lakes guarantees a sustainable ecosystem resulting to the lessening of vulnerability of such ecosystems to the chain of communities that are dependent on fish resources [18].

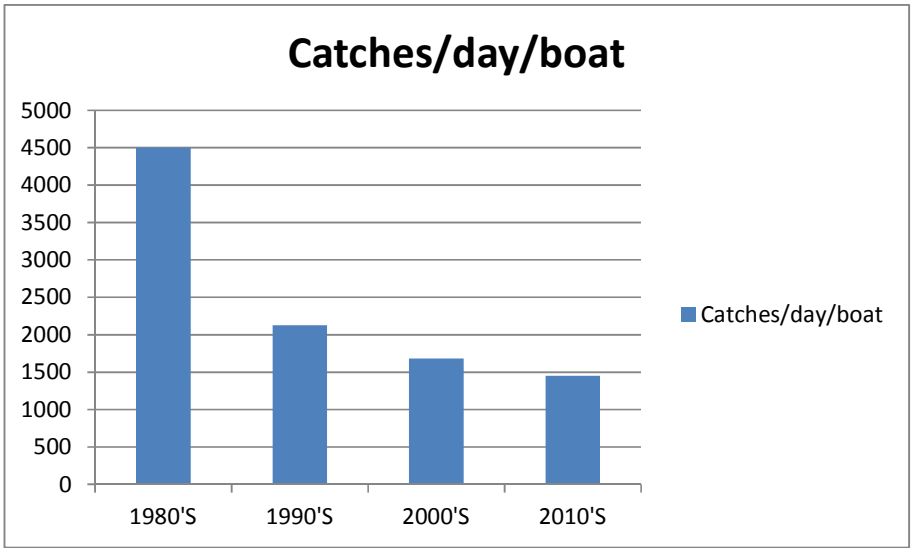

Fig. 2. The trend of fish output in Lake Kitangiri

3.2 Destruction of Fish Ecology

Results from the key informant's interview revealed that productivity of some crops such as millet in areas surrounding the Lake is decreasing (Fig. 3). As a result, farmers open more land in order to increase production. Consequently, some of the farmers extend their cultivation towards the lake shores thereby compromising the buffer zone in the lake and exacerbating soil erosion and ultimately leading to siltation that result to a decrease in the depth of the Lake. Furthermore, during the interview, it was revealed that during the dry season especially during October and November, livestock keepers extend their activities to the lake there by compromising water quality. The respondents furher pointedout that the water becomes so turbid that it becomes unusable for domestic purposes. Similar findings are reported in Lake Victoria where reduced vegetation in the fringing zones of the Lake has negatively been affecting the reproduction and survival of fish species leading to an increase of mortality rate of fish [19]. The same practice is evident in Lake Kitangiri. If this practice continues unchecked, the quality of water in the Lake may be compromised and this may lead to eutrophication [20]. According to the key informant's survey, a decrease in agricultural productivity as a result of land degradation pushes more people to fishing industry hence putting more pressure on the fish resources in Lake Kitangiri. Similarly, as a result of erratic rains and poor agricultural practices in the areas around Lake Victoria, the communities near the lake are left with fishing as the only livelihood activity, the phenomenon that leads to the overexploitation of fish resources in the lake [11]. Overexploitation of fish resources ultimately destroys the lake's ecosystem [21] with possible negative consequences to the wellbeing of the fishing and other communities surrounding the Lakes. Depletion of fish resources has been observed in Magdalena River in South America as a result of loss of nursery habitats, which were turned to farming or cattle grazing areas or agriculture land [22]. There were as well high sediment inputs to the River due to rampant deforestation, a phenomenon that is comparable to what is happening in Lake Kitangiri. This has been reported to cause extinction of some fish species in Magdalena River. Such ecosystem degradation has been reported in Amazon River, and the degradation is further worsened by Global warming [22].

If a resource on which a community relies becomes scarce, its accessibility gets reduced. Consequently people will adopt more desperate methods of exploiting the resource thereby compromising the sustainability of the resource in question [13]. If the trend continues unchecked, it may reach a point where the pursuit of livelihoods begins to undermine the ability of a resource to regenerate itself [13]. This hypothesis is consistent with the phenomenon observed in the present study. Overexploitation of fish resources in Lake Kitangiri may lead to an ecological disaster because more fishermen are coming to exploit the fish resources thereby

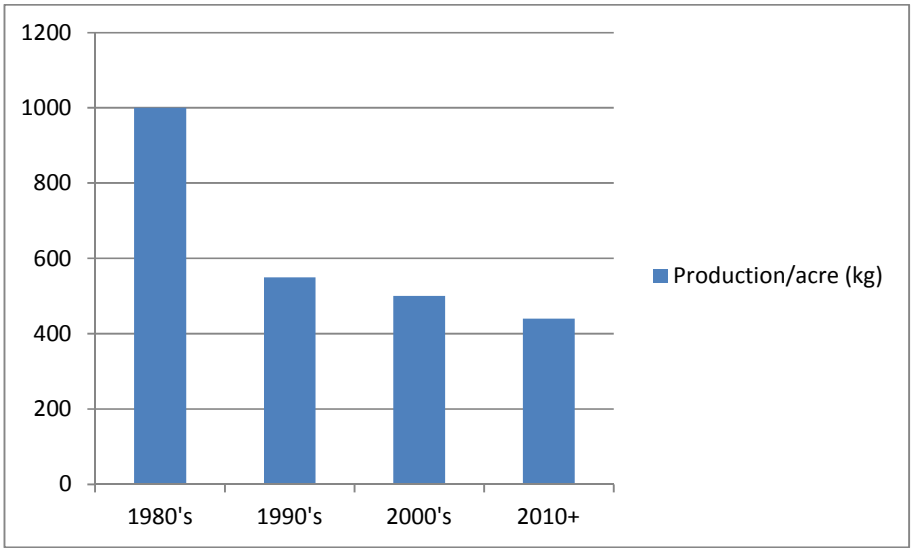

Fig. 3. Trend of millet output at Lake Kitangiri

destroying the lake ecosystem at an alarming rate through illegal fishing, as explained under section 3.1. Overexploitation of lake resources at Lake Kitangiri is coupled with poor farming practices and overgrazing where more than 7,200 livestock are kept around the lake Kitangiri valley, and the number is on the increase. This is an early sign of the phenomenon similar to the one in Aral Sea in Asia which is considered as the most serious ecological disasters making the ecosystem succumb to extinction [23] and turning to a brine reservoir [24].

Aquaculture has the pottential of increasing fish production and reducing fishing pressure on the Lakes [25]. The District Fisheries Officer in Kitangiri is campaigning for the establishment of fish ponds so as to reduce fishing pressure on the Lake. However, the response from the villagers has been low. Only one individual has responded positively. The introduction of high value crops cultivation such as horticulture can significantly help to reduce the number of people who look at the fishing industry as their promising destination. Drip irrigation in horticulture uses low water quantities for irrigation. This technique may be a plausible solution to low productivity as a result of sporadic and erratic rains.

A key informant interview revealed that farmers in the area depend on animal pastures growing close to the Lake shores particularly during the dry season (April and August). Similarly, farmers from the neighbouring regions and other nomadic pastoralists communities converge down the valley in search for pasture and water for their animals. At some points, farmers graze their animals into the acquatic plants available in the lake. This destroys the food for fish and in general distrupts the ecology of fish thereby aggravating genetic erosion of fish species. A decrease in fish reproduction is evidenced by a decrease in the number and size of fish produced and which is an indicator of ecological deterioration [7]. It was further revealed that other habitats for fish such as the acquatic vegetation within the Lake have been destroyed leading to the destruction of breeding sites, nursery grounds, and feeding for fish. These findings are consistent with those reported by [7] where the deterioration of fish resources in Old Brahmaputra in India as a result of illegal activities in the river was reported.

Similar cases of illegal fishing activities can be traced from Glencolumbkille, South West Donengal in Ireland [26]. Overfishing has also been reported in Lake Tanganyika [14] and in the South African coasts [27]. According to the key informants from TAFIRI, there is a decrease in water surface area of 1.15 km^2 over the past 40 years in Lake Kitangiri. Due to seasonal fluctuation of water levels and insuficient topographic data, it was not possible to establish the extent of the water level decrease. Nonetheless the informants strongly suggested that there is a decrease of water depth in Lake Kitangiri due to siltation. The responsible authorities are reported to have failed to combat illegal fishing and other activities due to lack of enough human resource and meagre budgets given to the local authorities to support the undertakings.

The focus group discussion which was carried-out with fishermen revealed a significant increase in the number of canoes operating in the lake between 1980's to 2015 from 179 to 360 respectively; whereas the number of people operating per canoe has increased from one to three. Despite the increase in the number of fishermen and fishing vessels, the total number of catches have been decreasing. This precipitates the escalation in the use of illegal fishing gears so as to compensate for the decline of production [16] with far reaching negative consequences on the lake ecosystem.

3.3 Contribution of Lake Kitangiri to the Family Economy

Lake Kitangiri is known to be one of the most significant resources to the local community surrounding it. According to key informants interview, the Lake has been able to support the livelihood of the people arround it, either directly or indirectly for generations. An income survey for fishermen shows an average income of 4 USD per fishermen per day which is equivalent to 119 USD per month. According to [28], in Tanzania, more than half of the population live in absolute poverty whereby 57.8% of the people survive on less than $1 a day. About 89.9% of the people live on less than $2 a day, and an average per capita income is estimated to be $340 per year. The average per capita income of fishing communities around Lake Kitangiri, and which is estimated to be 1,427 in the present survey, is considerably higher than the national per capita income by almost four fold. Furthermore, it was revealed that income levels of the houseolds practicing fishing are relatively higher than the incomes of those who practice cropping

and livestock keeping only. It is therefore concluded that higher income levels in the fishing industry compared to other sources of income attract more people to the fishing industry and hence put more pressure on the Lake resources. If the lake was well managed, fish output would go up and increase earnings of the fishing community. The higher income of fishing activities in Lake Kitangiri justfies the influx of people to the Lake. This underscores the importance of Lake Kitangiri fishing industry in alleviating poverty. A study by [7] revealed that in River Brahmaputra, the average income of fishers was as low as 1.25 USD a day in 2013. A decade ago the fishers had much better income. These are true consequences of overexploitation of fish resources. It is therefore safe to conclude that overexploitation of fish resources is a livelihood time bomb and calls for immediate measures that ensure sustainable use of the lake resources in lake Kitangiri. Lake Kitangiri provides opportunities for the expansion of other sectors of the economy. These include fish processing, which is mostly done by women, net making, and transportation. These can be regarded as significant income generating activities at the family level.

There are different effects that are associated with the depletion of the lake resources. One of them is the diminishing capacity of the lake to produce to its maximum. As a result of a decrease in fish resources, there is a reduction in the capacity of fish to breed which leads to the erosion of biodiversity thereby affecting the livelihood of the people. Secondly, the depletion of the lake resources particularly water may result into a threat of food insecurity around the area whereby the families that depend on fish from the water bodies as their source of income as well as on trade activities around the area may be seriously affected [28]. For example, the lesson learned from Lake Chad is that people around the Lake are among Africa's most chronically vulnerable to food insecurity and that further shrinking of the Lake has contributed to the collapse of fisheries activities and significant disruption of economic livelihoods [29].

3.4 Combating Illegal Fishing

The continued illegal fishing reflects failures of the government machineries to combat illegal fishing [10]. Co-management of the resources can enhance ecological and social outcomes [30] whereas community based management has proven promising in protecting fish resources and combating illegal fishing in Kenya [31]. Community based conservation can be effective if the fishers are involved through setting bylaws and in patrolling duties. This can be achieved through livelihood diversification in the areas around the Lake as a way of reducing pressure on the lake resources [32]. The creation of enabling environment for the fishing communities may lessen poverty–resource degradation nexus [16]. This can be achieved through the provision of civic education such as awareness and empowerment of the communities surrounding the Lakes. The pattern of fish exploitation in a particular area should be taken into consideration when planning for the management of fish resources because it has a correlation with the sustainability of the system [33]. This is an essential measure towards the reduction of the activities originating from ignorance by the Lake resource users [1]. Unfortunately, the conservation of Lake Kitangiri has been left in the hands of the government machineries only. In Lake Kitangiri, the community based organizations and non governmental organizations are non existent, a phenomenon that explains an accelerated overexploitation of the fish resources and the degradation of the environment in the Lake. Thus, to combat illegal fishing methods, the community should be involved in the management of the resources to ensure its sustainability. Participatory strategies should be employed as the government alone may not be able to control all the activities taking place in the resources [34]. For any conservation program to be successfull, it must get a support from the government but with the active participation of the beneficiaries of the resources [35]. In Amazon the Government has instituted conservation measures such as prohibiting fishing activities during reproductive migrations, limits on mesh size and prohibition of noxious gears such as explosives and poisons [35].

4. CONCLUSION AND RECOMMENDA-TIONS

4.1 Conclusion

Potentially, the lake resources are of great economic importance in the area due to the amount of opportunities the lake has been able to offer. Therefore, fisheries development in the region should focus on this lake due to its support to the livelihood activities in the area. As

a source of food and a means of economic survival to the households, Lake Kitangiri is a source of livelihood in the area. Incomes from fishing rank higher than the incomes from agriculture. Nevertheless an increase in fishing activities in the area has caused a gross decline in fish production due to increased human population and other economic activities that are carried out near the lake such as agriculture and sometimes within the Lake. This puts the sustainability of the Lake resources in jeopardy. Enforcing the laws in the lake is difficult due to lack of funds, equipment and community involvement and a neglet of the sector.

4.2 Recommendations

Kitangiri is potential for acquaculture. Aquaculture can reduce fishing pressure in the lake. It is therefore recommended that people living arround the Lake be assisted through extension services and pilot projects to carryout aquaculture. In line with aquaculture, high value horticultural crops can be introduced in the area so that the Lake residents may have an alternative source of economic activities that have returns as high as those of fishing activities.

Law enforcement and community involvement in the Lake are very weak. There should be law enforcement strategies that should go hand in hand with community education on the importance of sustainable use of lake resources. Approaches like conservation and good agricultural practices and formation of community based organisations to combat illegal fishing ought to be adopted to reduce pressure on the lake resources. Finally the community should be involved in the management of the resources as a way of fighting against illegal fishing methods to ensure its sustainability. As stated earlier, participatory strategies should be employed as the government alone may not be able to control all the activities taking place in the resources.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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