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Fish cage culture in Lake Victoria (Kenya): Fisher community perspectives on the impacts and benefits for better sustainable management

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Abstract
Aquaculture is the future bridging gap for the declining capture fisheries and currently the fish cage culture in Lake Victoria (Kenya) is on the increase according to the recent overview surveys of 2016-2017. To date, the majority of aquaculture practices have had few adverse effects on ecosystems. However, due to the potential positive and negative impacts, there are varied opinions on the actual social impacts and threats on the lake ecosystem. The fisher community perspectives on the nascent and growing technology on culture of Nile tilapia since it's onset in 2005 were assessed using 4 selected sites. Both structured questionnaire and socio-economic activities along the fish landing beaches on Lake Victoria, Kenya were used, based on the presence of beach management units (BMUs), fishing and potential for cage activities; to assess the respondent's perception on and attitudes towards new fish cage culture method. Few people are involved in cage culture activities, being a relatively new technology. Results from 78 randomly selected respondents from 4 sites of Ngore, Ragwe, Sindo and Nyandiwa beaches showed that fishing and fish trading were the main types of occupation. All the respondents have used and benefited from fish and fishery products for between 1 and 46 years, with a mean of 11 (±8) years. Among the notable positive impacts includes creation of employment opportunities throughout the fish value chain; and development of new and improved rural infrastructure, and road networks along the lake coastal zones. Potential impacts and advantages of cage farming over other fish culture methods are highlighted. From the preliminary socioeconomic surveys data and distribution of cages, valuable measures that management agencies should consider are outlined to support sustainable investment and development of cage culture in Lake Victoria.

Keywords: Fish cage culture, fisher community, socio-economic impacts, sustainable management

Introduction
About 200 million people and their dependents worldwide, mostly in developing countries, live by fishing and aquaculture [1]. This includes 43.5 million directly employed in fisheries and aquaculture (Of which 90% are small-scale fishers) and the rest are associated with activities generated by the supply of fish (trade, processing, transport, retail etc.) and backward linkages to supporting activities, such as boat building, net making, engine manufacture and repair; and fuel to fishing boats etc. [2]. However, capture fisheries is declining from lakes and oceans, and hence the need to develop the aquaculture sector [3].
Since the beginning of Kenyan aquaculture in the 1950's until 2006, the total annual aquaculture production has never exceeded 2,000 Mt per year [4]. Prior to the government-funded Economic Stimulus Program (ESP), about 7,500 fish farmers, mostly from the Rift Valley and central provinces, held about 7,477 production units in an estimated area of 722.4 ha [5]. Aquaculture systems in Kenya include earthen and lined ponds, dams, and tanks distributed across the country, with the most commonly farmed freshwater fish species being Nile tilapia *Oreochromis niloticus* Linnaeus 1758, which accounts for about 75% of production, followed by African catfish *Clarias gariepinus*, Burchell, 1822, which contributes about 21% of aquaculture production [6, 7]. However, there exists a huge potential in the Kenyan aquaculture industry which includes the production of live fish food, *e.g.*, *Artemia*, daphnia and rotifers, marine fish and shellfish larviculture; seaweed farming; cage culture; integrated fish farming; culture of indigenous fish species; and investment in the fish feed industry [6].

A sustainable fisheries is attainable with the participation of all stakeholders in decision making and implementation of the regulations and best management practices designed and adopted by their respective management authorities. In Lake Victoria and other inland lakes, BMU's co-arrangement approach to fisheries management has shown growth with development of harmonised guidelines. This is based on the proposition that resource-user participation in management decision-making, commonly referred to as co-management, is likely to produce legitimacy and effective regulations [8, 9]. There is a general lack of support for the BMU's, making them unable to implement their core mandates effectively. Therefore, there is a need to support technical analysis to make the provisions in community fisheries management plans more specific and easy to identify and implement.

Lake fish cage aquaculture involves the growing of fish in constructed netted cage structures which allow free exchange of water through the cages. Cage culture is a new but expanding aquaculture technology in many lakes in Africa with many other opportunities not well exploited. In Kenya it began in 2013 and has continued to attract many fishers and other stakeholders. However, concerns of the expanding cage culture are important due to the free access artisanal dominated fisheries resources, with multi-stakeholder and multi-gear fishery characteristics. To achieve sustainability in fisheries and aquaculture in line with SDG's it prudent to understand both negative and positive environmental and social impacts in order to identify appropriate adaptation and mitigation measures. Therefore to hasten sustainable co-existence of capture fisheries and cage culture there is need to implement effective environmental and social management plans as development of cage culture systems expands in the lake. An initial survey combining existing literature and cage culture survey data shows an increase in cage establishments between 2016 and 2017 [10]. However, there exists concerns on the lack of policy and regulations to guide investments [11]. The fish cage culture technology, like other developments in the lake is often subjected to environmental impact assessments to mitigate against such adverse impacts. With time, the technology will transform into a more commercial high investment from the current low - investment type, in line with the blue economy concept. To date, the majority of aquaculture practices have had few adverse effects on ecosystem. However, due to the potential positive and negative impacts, there are varied opinions on the actual social impacts and threats on the lake ecosystem. Therefore, in support of the sustainable aquaculture development; the fisher community perspectives on the nascent and growing technology on culture of Nile tilapia since it's onset in 2005 were assessed using four selected sites. The objectives were: (i) To determine the socio-economic impacts of cage culture in Lake Victoria for informed decision making. (ii) To make recommendations on the mitigation of any socio-economic impacts emanating from cage culture for the sustainable management of the lake fishery.

Materials and Methods

Study sites

The investigation was carried out in 4 sites along the southern beaches in Migori and Homa bay counties of Lake Victoria, Kenya (Fig. 1). Lake Victoria provides important ecosystem services to over 40 million inhabitants in the three riparian countries of Kenya, Tanzania and Uganda. This includes fisheries, transport, and water for domestic, agricultural and industrial uses [12]. The destination of fish markets includes towns within the Kenyan side of the catchment and other places like Nairobi and Mombasa. China fish imports are also available in the Kenyan fish markets.

Data collection

The study was conducted in (March 2018) sites S1 (Ngore), S2 (Nyandiwa), S3 (Sindo) and S4 (Ragwe) along the southern catchment beaches of Lake Victoria (Fig. 1). The study involved use of structured questionnaires and interviews at areas with developing cage culture farms. Structure questionnaires were used to assess the respondent's perception on and attitudes towards new cage culture method of farming fish in the lake. A total of 78 randomly selected respondents were involved in the study. The sites were selected based on the presence BMU's, fishing and potential for cage activities.

Statistical analysis

The information and data collected was cleaned, and stored electronically using Excel and SPSS statistical packages. The descriptive statistical tools such as data exploration using frequencies, percentages, charts and tables was conducted to understand the respondents demographic characteristics and perceptions on impacts from cage culture. Data distribution and differences of means were analysed where necessary and appropriate using T-test at a significance level of 0.05. Associations were evaluated using cross tabulation.

Results and Discussion

Demographic characteristics, utilization and main benefits from fish

The respondents (Table 1.) mean age was 37 (±11) years and there was no significant difference (df = 1, 72; $p>0.05$) in the gender age. Wild capture fish from Lake Victoria (88.3%) and cage cultured species (10.4%) were the common sources of fish to the respondents. All the respondents have used and benefited from fish and fishery products for between one and 46 years, with a mean of 11 (±8) years. *Rastrineobola argentea*, Pellegrin 1904, (Dagaa) was the fish species mostly utilized by the respondents (38.7%), followed by Nile perch (*Lates niloticus*, Linnaeus, 1758) (30.7%) and tilapia (29.3%), with Cat fish (*Clarias gariepinus*) ranked the least (1.3%). Fresh (83.8%) and dried (16.2%) fish were the main fish products utilized by the respondents, with trade (75.6%) and employment (15.4%) as the main benefits. Lake Victoria wild capture fisheries was identified as the main source of fish by the respondent's (88.3%), with the cage farms contributing minimally (10.4%). Dagaa and Nile perch fish are among the main commercial species, and based on availability, the species with a high potential in cage (*O. niloticus*), which is also the most preferred product, is more expensive in the market. The respondent's income range varied widely but those from areas with less established cage farms appeared lower than those from areas with more established cage farms nearby (Ragwe and Sindo). Other factors like non-residency in these areas could also affect income levels due to costs of housing rent and inputs in fishing activities and fish trade.

Market trends in the past ten and five years in fish and fish products from capture and cage culture

From the scale of benefits, most of the respondents perceive the benefits accrued from fish and fish products to range from minimal to moderate. The respondents perceived an

increasing demand and supply of tilapia fish from the cages indicating a gap in both demand and supply of caged tilapia fish in the past five years. In comparison, there is no clear trend in wild capture tilapia, as most of them indicated an increase in both supply and demand for the capture tilapia, with an increasing price over the past 10 years. Increasing population in those areas and increasing demands and preference of tilapia could be the reasons for its market trends. The respondent's perceptions on the average retail and wholesale prices of wild capture and caged fish, shows a generally higher price for the wild capture tilapia than the cage fish, which could also be due to the current low tilapia production and availability from the cages in those areas. According to the latest market information around the lake basin counties and Nairobi county, tilapia prices at the major markets shows a daily price range of 201 Ksh/Kg (minimum) and 500 Ksh /Kg) maximum during April 2019, with a mean of 370 Ksh/Kg [13]. Dagaa and Nile perch fetched lower prices (mean of 214 Ksh/Kg) of 156 Ksh/Kg (lowest) and 277 Ksh/Kg (highest), with Nile perch attracting a mean price of 281 Ksh/Kg with the lowest and highest price of 238 Ksh/Kg and 331 Ksh/Kg respectively [13]. The initiative benefits the fisher community (who formed the highest proportion of respondents), fish processing and export industry and fish consumers. Therefore information from cage farms can easily be incorporated in the electronic fish market system, for the benefits of all the actors in the fish value chain in the EFMIS model [14].

Cage culture impacts

Reasons for approval of cage culture

The study revealed that most of the respondents were aware of cage farming activities (very aware - 39%; aware - 31.2%; less aware - 24.75% and not aware - 5.2%) and cages are present in each of the study sites. Areas with notable presence of cage activities included Ngore beach, Mbita, Mfangano, Sindo, Ragwe beach, Roo beach, Kameta beach, Nyandiwa, Gwasi and Kithebunga areas. However not many of the people were involved in cage culture activities since it is a relatively new fish culture method. A large proportion of the respondents were workers in cages or cage farms (workers in cages/cage farms - 52.6%; cage owners - 15.8%; boat transporters and traders - 10.5% each; feed transporters and cage makers - 5.3% each). Ninety percent of them were only involved in cage culture activities for up to 2.4 years (less than 0.6 yrs. - 35%; 0.6 to 1.2 yrs. - 15%; 1.2 to 1.8 yrs. - 5% and over 2.4 yrs. - 10%). The earned incomes ranged from less than 180 to 720 Ksh/day for the majority of the respondents (less than 180 Ksh/day - 11.1%; 180 to 360 Ksh/day - 44.4%; 360 to 540 Ksh/day - 27.8%; 540 to 720 Ksh/day - 0% and >720 Ksh/day - 16.7%). Respondents perceived creation of employment or income opportunities and fish availability (i.e. over 35%) as the main reasons for approval of cage culture. Only less than 10% perceived reduced risks and fishing pressure on the capture fisheries, and cage culture as alternative source of fish as reasons for cage approval. Past socio-economic changes in the lake fishery include the development of the export Nile perch fishery and use of the dagga in fish meal industry. The artisanal fishery was originally for domestic consumption by the riparian communities around the lake. This could have resulted in lack of new opportunities in the fish value chain, and investment initiatives to the historical artisanal fishing activities and as a result of a decline in catches. The continued presence of water hyacinth also impacted more of the artisanal activities (destruction of fishing nets, blockage of boat transport and fishing vessels) and blockage of landing sites. The wild tilapia fish was the most preferred choice by the respondents (>70%) compared to cultured tilapia, and was perceived as the most profitable. In both the retail and wholesale trade, wild capture tilapia fisheries were perceived to fetch much higher prices per piece than tilapia from culture systems. However, the prospects of the tilapia fishery are still good as both cage and wild fisheries will end up maximizing on the same water resource if best management practices (BMP's) are implemented and other negative threats are addressed.

Many developing countries' fish suppliers are supplying seasoned fish species to the markets and which could change the consumer base time to time [15]. Fish species have seasonal cycles in the life histories. Nile tilapia are more tolerant fish species, and sexual maturity is a function of age, size and environmental conditions. Life history traits (fecundity, sex ratio, reproduction, mortality, size, and age at maturity) of Tilapia from L. Victoria [16] showed that *O. niloticus* spawned throughout the year, but with a peak between December and June (the breeding period). There was little seasonal variation in relative condition between males and females. When results of the growth and population parameters were compared to previous results, increase in growth curvature, natural and total mortality and decrease in growth performance index, fishing mortality, exploitation rate and length at first capture was attributed to existing high fishing capacity and changing lake conditions [17]. Again increased use of illegal fishing methods and gears (e.g. under sized gillnets of less than five inches mesh size) and beach seines are a concern to the promotion of sustainable fisheries as a whole. However, it is easy to sustain demands for tilapia from the planned production from cage farming than capture fishery. Therefore, for the capture fisheries fish products availability and supply to can be limited, when compared to the cultured species. Also, fish value addition helps to bring the different forms of fish products to the market place, while reducing fish post - harvest losses.

From a survey of cage establishment, a relatively higher number of cage culture investment was found in Siaya County [11]. This may explain the respondent's lack of information in the study area as compared to the northern side. However, there is a general acceptance of the technology, as approval for cage culture was high (87%). Although studies could be limited in scope, several challenges facing implementation of fishery co-management for Lake Victoria indicate BMU's are involved in activities that have high potential for social sustainability, but have been either unable or unwilling to undertake their core functions related to enforcement and compliance with fishing rules [18].

According to the existing number of BMUs, they are well placed to provide easy access to various sources of information to the lakeshore community engaged in fishing. In this study, cage culture was perceived as a new technology, with majority of the respondents benefiting from employment, as opposed to ownership of the cages, although in some of the sites the number of existing cages were very few or just recently initiated. With the growing number of investments in cage farming in the different counties, since the initiation of the first mapping survey of 2018, this study can be replicated in other areas, to extract more additional information. Communities living along Kenya's lakes and coastline benefit

further in terms of food security, as small-scale fishing is essential to their overall household wellbeing, providing both income and nutrient-rich food [19]. Many of the respondents (81%) foresee a future in the cage culture technology, and are not well aware of the potential undesirable impacts (71%). Supplementary feeding is the main source of uneaten feeds and additional nutrients in the ambient aqueous media and lake ecosystem under fish cage farming. Envisaged changes in the lake water quality appear to be the concern of many of the regulatory organs, but to date there has not been a serious impact reported, as most potential operators are guided by the environmental assessment report. Price and Morris [20] highlighted some chemical contaminants associated with marine aquaculture. Negative impacts on the water quality are considered the common problems emanating from lack of implementation of the BMP's. Cage culture experimental studies from Uganda and Tanzanian side of L. Victoria found no consistent environmental changes using water quality parameters, phytoplankton and macro-invertebrates [21, 22]. Effect of nutrient discharge on DO was not pronounced. Nevertheless, some cases of environmental degradation in coastal areas have occurred due to, for example, intensive cage culture operations in Europe and shrimp farming practices in South-East Asia and Latin America [23, 24].

Socio-economic contribution of the fisheries sector to the national economy (Trade, food security employment, rural community's development)

The fishery resources of Kenya contribute to the national economy through foreign exchange earnings, employment generation, food security support and rural development. Of Kenya's 2014 estimated population of 44.9 million, the fisheries sector provides employment to 2 million and livelihood for at least 2.3 million people. The sector also brings in valuable foreign exchange to the government, earning some 0.5% of the Gross Domestic Product per annum [19]. Nile perch and tilapia are important commercial species. International fish trade started in the early 1980s with the establishment of the Nile perch processing industry. Kenya's total fish export for 2007, 2008 and 2009 were 31 376 tonnes, 29 575 tonnes and 18 506 tonnes respectively, representing 13.4%, 13.3% and 7.8% of total annual catch, leaving between 70% and over 90% for local consumption within these periods [19]. The contribution of fish to overall protein intake is low at 7.6% and this is attributable to the fact that many Kenyans do not regularly consume fish for historical or cultural reasons. However, Kenya's fishing communities depend heavily on fish as a rich source of protein. Engaging largely in subsistence fishing, fishers usually take part of their catch to their families, friends and relatives for food. This proportion of the catch is locally known as *kitoweo*. However, the prevailing decline of Lake Victoria's natural fish stocks directly threatens food security and income for livelihoods of lakeside communities [19].

The free and open access nature of many fisheries leads to overexploitation. It raises therefore questions of defining ownership and property and use rights [25]. The Kenyan portion of Lake Victoria traditionally has the largest fishery in the country, with a 2006 total fish production of 143 900 tonnes. This catch quantity declined to 111 370 tonnes in 2008, and further to 108 900 tonnes in 2009. The lake's 44 263 fishers operating light and small-scale gear and craft constitute the largest fishing community in Kenya [19].

The respondent's perception of fish products availability, labour movement and involvement of middlemen in capture and cage fisheries showed that, cage culture fish products (42.1%) are less available than capture fisheries (26.9%). The results showed there was more middlemen involvement (63.8%) and labour movement to capture fisheries (59.6%), than in cage culture activities. Also there were more fish and fishery products availability from capture fisheries (42.1%) than cage culture (26.9%). This is attributed to the current low investments in cage culture. With a high fish species diversity, Lake Victoria hosts between 170 to 350 fish species, the three of most commercial importance of which are the Nile perch (*Lates niloticus*), the silver cyprinid 'dagaa' or 'omena' (*Rastineobola argentea*) and the Nile tilapia ('ngege'), all of which have universal occurrence in the lake. In the past few years, these three have constituted about 58 percent, 30 percent and 10 percent respectively of the total fish landed on the lake [19], and hence the presence of tilapia from the cages may not be significant at this particular stage in the commercialization of fish cage culture. Market information is a key factor influencing sellers and buyers' decisions and choices in the market, such as; what, how much, what price and when to sell or buy. However, such information is not readily available for most small scale producers in agriculture and fisheries, thus giving undue advantage to those with access to information. For example, players higher up the fish value chain tend to have greater access to market information, consequently take advantage of producers at the lower end [26].

All ecosystem-based approaches to management of economic activities "rely on similar precepts: the need for sound science, adaptation to changing conditions, partnerships with diverse stakeholders and organizations, and a long-term commitment to the welfare of both ecosystem and human societies" [27]. Fishing has traditionally been a free access activity and the small scale fisheries are often associated with the poor. However, developments in commercial fisheries and new technologies attracts investment s in the sector. Assessing the scale of fisheries effects relative to other impacts can be difficult, because of confounding and interacting combinations with other anthropogenic effects (e.g. pollution, habitat degradation, climate change) and natural variability of environmental factors. In the early 1970s, pollution and habitat degradation originating from land-based activities were considered to be the main factors of fisheries degradation [28]. More recent publications hold that excessive fishing has become the main destabilizing factor of ecosystems, directly, through removals and associated impacts, as well as indirectly, through the aggravation of eutrophication and subsequent oxygen depletion [29].

Socio-economic impacts from cage culture activities

Positive impacts

Small-scale fisheries can be broadly characterized as a dynamic and evolving sector employing labour intensive harvesting, processing and distribution technologies to exploit marine and inland water fisheries resources [30]. The activities of this sub-sector, conducted full-time or part-time or just seasonally, are often targeted on supplying fish and fisheries products to local and domestic markets, and for subsistence consumption [30, 31]. Market value of fish is also an important determinant of fish consumption patterns of the poor, as low income households have limited purchasing power [31]. Around the LVB, the small dried fish, dagaa/omena/mukene (*Rastrineobola argentea)*, is one relatively cheap fish and it is

commonly consumed among poor people in the lake shore communities. Fresh large fish, such as tilapia and Nile perch (*Lates niloticus*), are not always affordable even for the middle class population due to their high market value [32]. Affordability of fish is determined by availability of staple foods, seasonality, and the market value of fish [31]. Therefore, interventions which promote poverty alleviation should be designed to promote more benefits from fish for the poor. Lack of inputs (seed and feed) are the common constraints among all tilapia pioneer cage operations. We feel the respondent's perception demonstrated the lack of information and credit for investments, and model production units for adoption by community members, with a clear establishment of a clear carrying capacity, for a sustainable development of aquaculture.

According to aquaculture production by species in 2009 [33], Nile tilapia constitutes about 70% of the fish culture in the earthen and liner ponds. However, current information shows a huge gap in availability of the fish for trade and limited value addition along the tilapia value chain, which is mostly traded in fresh form. Therefore, the successful development of sustainable aquaculture lies in the promotion of aquaculture as a viable investment, create linkages and collaboration among all stakeholders (research institutions, universities, fish farmers, nongovernmental organizations (NGOs), civil society, government officials, and policy makers) by creating a strong forum for exchange of information [6]. Mechanisms must also be developed to link small farmers to local, urban, regional, and global markets and rural schools are needed to educate farmers and strengthen their capacities to adopt new aquaculture technologies [6]. Therefore some of the key positive impacts of cage culture includes:-

(i) Employment opportunities throughout the fish value chain (ii) Improved and sustainable fish production, incomes and livelihoods, and nutritional and social well-being. (iii) Efficient utilization of water resources as waterways, for artisanal fishing and cage culture activity. (iv) Improved contribution to the national economy. (v) Capacity building targeting local communities in water related expertise, fisheries and aquaculture, especially in engineering, commercial feed production, hatcheries, value addition and farm management. (vi) Development of new and improved rural infrastructure and road networks along the lake coastal zones and (vii) Improved food and nutritional security in the country.

Negative impacts includes: (i) Increased potential degradation and destruction of designated critical fish habitats (as defined by BMPs and national fisheries regulations); (ii) Increased exposure of workers at cage sites to waterborne diseases (malaria and bilharzia) and algal toxins; (iii) Reduction of social benefits as a result of a lowered lake water quality; (iv) potential emergence of resource user conflicts by sharing of the fishing grounds with cage farmers as a result of low awareness and stakeholder involvement. Low awareness could be a reflection of the lack of information and support to the resource - poor fisher community in investments in the new fish culture technology.

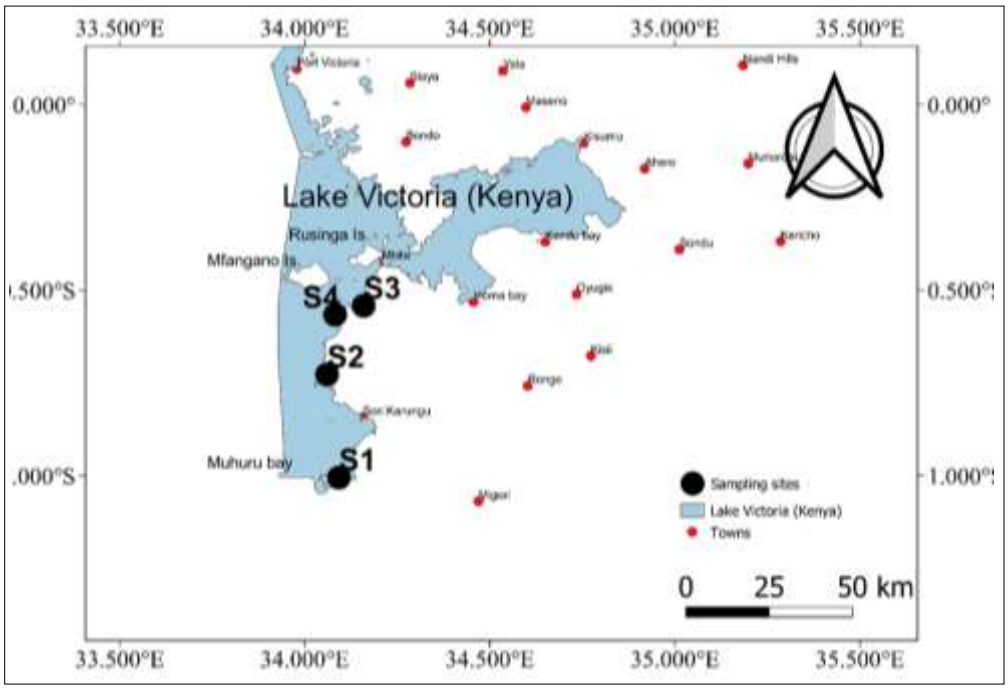

Fig 1: A map showing the sampling sites along the beaches of Lake Victoria (Kenya)

Table 1: Demographic characteristics (Number and percentage) of the respondents

		Study sites				
		Ng'ore beach	**Nyandiwa beach**	**Ragwe beach**	**Sindo beach**	**All sites**
Respondents	N	20 (25.6%)	24 (30.8)	22 (28.2)	12 (15.4)	78 (100%)
Gender	Males	19 (95%)	20 (83.3%)	12 (54.5%)	11 (91.7%)	62 (79.5%)
	Females	1 (5%)	4 (16.7%)	10 (45.5%)	1 (8.3%)	16 (20.5%)
Age (Years)	18-31	8 (40%)	7 (29.2%)	3 (13.6%)	4 (33.3%)	22 (28.2%)
	31-44	4 (20%)	14 (58.3%)	10 (45.5%)	4 (33.3%)	32 (41.0%)
	44-57	2 (10%)	3 (12.5%)	8 (36.4%)	4 (33.3%)	17 (21.8)
	57-70	1 (5%)	0 (%)	1 (4.5%)	0 (0%)	2 (2.6%)

	>70	1 (5%)	0 (0%)	0 (0%)	0 (0%)	1 (1.3%)
Education level	None	0 (0%)	6 (25%)	0 (0%)	0 (0%)	6 (7.7%)
	Primary	12 (60%)	6 (25%)	15 (68.2%)	5 (41.7%)	38 (48.7%)
	Secondary	7 (35%)	12 (50%)	7 (31.8%)	6 (50%)	32 (41.0%)
	College	1 (5%)	0 (0%)	0 (0%)	0 (0%)	1 (1.3%)
	University	0 (0%)	0 (0%)	0 (0%)	1 (8.3%)	1 (1.3%)
Occupation	Fisher	16 (80%)	14 (58.3%)	9 (40.9%)	10 (83.3)	49 (62.8%)
	Fish trader	2 (10%)	5 (20.8%)	13 (59.1%)	1 (8.3%)	21 (26.9%)
	Transporter	0 (0%)	0 (0%)	0 (0%)	1 (8.3%)	1 (1.3%)
	Cage farmer	1 (5%)	1 (4.2%)	0 (0%)	0 (0%)	2 (2.6%)
Income (Kshs/day)	<100	1 (5%)	0 (0%)	1 (4.5%)	0 (0%)	2 (2.6%)
	101-350	3 (15%)	5 (20.8%)	9 (40.9%)	0 (0%)	17 (21.8%)
	351-500	8 (40%)	9 (37.5%)	2 (9.1%)	1 (8.3%)	20 (25.6%)
	501-1000	2 (10%)	5 (20.8%)	5 (22.7%)	3 (25%)	15 (19.2%)
	1001-2000	5 (25%)	1 (4.2%)	3 (13.6%)	4 (33.3%)	13 (16.7%)
	>2000	1 (5%)	0 (0%)	0 (0%)	4 (33.3%)	5 (6.4%)
Residence	Resident	16 (80%)	8 (33.3%)	0 (0%)	6 (50%)	30 (100%)

Conclusions

Majority of the respondents were involved in fish trade and fishing, and were aware of the new fish culture technology, However, they felt that there was a low involvement in cage culture activities. All the respondents have used and benefited from fish and fishery products, hence their well-being was linked to the fisheries. Among the notable positive impacts of fish cage culture includes creation of employment opportunities in the fish value chain; and development of new and improved rural infrastructure and road networks along the lake coastal zones.

Overall, *O. niloticus* is a delicacy, and the high preference ranks it highly among the fish species utilized for food, but concerns on availability of the fish from wild capture fisheries and new opportunities in employment, could be attributed to the high proportion of respondents approving the cage culture. This is a preliminary socio-economic survey, but to support this investment avenue, sound regulatory and management measures are required with effective monitoring to lessen resource user conflicts and ensure more effective involvement of the fisher community so as to take advantage of the investment opportunity juxtaposition with the capture fisheries.

Recommendations

(i) There is need for more sensitization and awareness on the protection of fish critical habitats as cage culture expands in the lake. (ii) Stakeholders and fish cage farmers are required to fully implement effective monitoring and BMPs to reduce risks from investment losses and other potential disease outbreaks (iii) Effective community participation fisheries resource management as water and fisheries resources attract multiple uses and can attract resource use conflicts which can impact negatively on the community and economy at large as well as the integrity and sustainability of the lake environment. (iv) Ensure that all stakeholders are aware of the investment opportunities, proper regulations and aquaculture BMPs (v) Establish effective networks with extension services to cage investors so as to manage risks from fish diseases (vi) Implement measures to reduce increasing lake eutrophication and exposure to risks from persistent cyanobacterial blooms (vii) Strengthen the capacity of BMU's to enhance monitoring, surveillance and control (MCS) activities and promote alternative livelihood options for fisher communities (viii) Support for improved security in cage operations and zoning of suitable cage areas to reduce costs of environmental impact assessments, and resource user conflicts (ix) Support development of affordable and low cost feed, materials and quality seed as inputs for reduced environmental and ecological impacts and for the sustainability of the lake ecosystem; (x) Recommend use of floating feeds to avoid excessive accumulation of uneaten feeds; (xi) Cage culture can be designed through research information on how best they can boost the production of some of the species considered threatened and rare in catches (*O. esculentus* and *O. variabilis*) at a time when the lake ecological conditions have changed compared to conditions prior to the introduction of the exotic species (xii) Create a form of insurance of the investments against potential perceived risks and losses; (xiii) Improvement of infrastructure and facilities in fisheries should be supported to spur economic activities along the lakeshore landing beaches and towns and thus reduce poverty.

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