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Full Length Research Paper

Cage fish culture in the lake victoria region: Adoption determinants, challenges and opportunities

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Fish cage farming was first introduced in Lake Victoria in 2005, however, its adoption and production has not met expectations. It is a promising venture that can help solve the problems of food insecurity, unemployment and alleviate poverty if, a conducive investment environment is put in place. This study sought to explore the adoption determinants, challenges and opportunities of this technology within the Lake Victoria shoreline. Using a cross-sectional survey, a questionnaire was administered to 100 respondents along the Lake Victoria beaches in Bondo Sub County of western Kenya. Data were analyzed using a Probit model. Gender, credit access, training, were major determinants of cage adoption while market, quality seed and feed, high investment cost, policy framework, insecurity were found to be major challenges. Nevertheless, dwindling wild capture, growing market and changing lifestyle, government initiatives such as Big Four Agenda and Blue Economy were the emerging opportunities identified in the region. Conclusively, solving the challenges would help prospective investors take advantage of the opportunities thus enhancing adoption.

Key Words: Aquaculture, food security, livelihood

INTRODUCTION

Sustainable use of ocean, seas and marine resources is one of the key global Sustainable Development Goals (FAO, 2018). Under the fourteenth Sustainable Development Goal, target 14.4, countries pledged to use sustainable scientific management strategies to replenish the dwindling fish stocks for improved safe and diversified healthy diets, environmental, social and economic developments (FAO, 2018). The world wild fish capture has been declining due to overfishing (Aura et al., 2018) use of illegal equipment (Limuwa et al., 2018), pollution among others (Chan et al., 2019) amid increasing world population (FAO, 2018) which has necessitated the

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development of aquaculture (Lynch et al., 2020).

Aquaculture, the practice of rearing, breeding and harvesting of aquatic fishes, plants and micro-organisms, under different aquatic environments, has been growing steadily (Obiero et al., 2019) and was a major contributor of fish stock globally (Ombwa et al., 2018). In 2016, aquaculture contributed the 47 (80 million tonnes of food fish) of the 53% of global fish production (Obiero et al., 2019), translating to USD 232 billion in revenue (FAO, 2018). Although aquaculture in Africa has experienced some growth over the last decades, its production only contributed 2.5% towards global production (Chan et al., 2019).

In Kenya, aquaculture has seen steady growth, stimulated by national government support through various frameworks and programs, such as the Economic Stimulus Programme (Orina et al., 2018). Kenya's Vision 2030, Big Four Agenda and other policy frameworks identify aquaculture as one of the pathways to rural poverty reduction, food and nutrition security and creation of more job opportunities, especially for the youth (Kenya Marine and Fisheries Research Institute (KMFRI), 2017). Due to this steady growth, Kenya has been the fourth largest aquaculture producer in Africa after Egypt, Nigeria and South Africa (KMFRI, 2017). Over the last decade, this sector has contributed between 0.5 and 0.8% of the country's Gross Domestic Product (Otieno, 2019), thus leaving ample scope for growth.

Freshwater fish account for close to 95 of Kenya's reported aquaculture production, of which 90% are from Lake Victoria (Maina et al., 2014). Nevertheless, this production has been on a downward trend due to overfishing, pollution, climate change and ecosystem degradation and has been unable to meet the growing demand (Njiru et al., 2019) spurred by a change in lifestyle towards a healthier source of protein, which fish has the potential to offer (Munguti et al., 2014). The decline in wild capture from the lake has prompted the introduction of cage farming to meet the fish deficit and further provide livelihood source to the fisher folks around the lake (Njiru et al., 2019). In fact, this deficit has prompted fish imports from China and further, attracting the interests of both domestic and foreign investors (Wangui et al., 2018).

While there have been reported cases of success in cage culture in America, Europe and Asia, this technology is still struggling in Africa since its introduction in the 1980s (Orina et al., 2018). Cage farming was first introduced in Kenya in 2005 in Siaya County (Njiru et al., 2019). Since then, there has been sporadic cage farming within the beaches along the Lake Victoria's shoreline (Aura et al., 2018). Despite the efforts from Kenya Marine and Fisheries Research Institute, Ministry of Fisheries and other interested stakeholders, the uptake of this technology and fish production is still wanting.

This study, therefore, sought to find out the adoption determinants, challenges and opportunities of this technology within the Lake Victoria shoreline (Bondo sub-county) of Kenya. Results of this investigation will be of value to policy makers and relevant fish stakeholders.

MATERIALS AND METHODS

Study area

This study was conducted between March to July, 2019 along the beaches in Bondo sub-county of Siaya County, Kenya (Figure 1). It lies between 0'26' and 0'90' south of the Equator and from longitude 33'58'E and 34'35'W. The choice of the area was informed by the fact that this sub-county has the highest number of fish cages within the Lake Victoria shoreline in Kenya (Orina et al., 2018), having received support from Ministry of Devolution towards Western Kenya Community Driven Development and Flood Mitigation Project, which prioritized cage farming as one of the pathways to poverty alleviation (Ombwa et al., 2018), in addition to support from Jaramogi Oginga Odinga, University of Science and Technology (JOOUST) towards cage culture within the sub-county. The major economic activity is fishing, though crop and livestock farming is equally practiced on a smaller scale (Government of Kenya, 2007).

Study design and data collection

The study used primary data which were collected using questionnaires administered to the 100 sampled respondents. During sampling process, a two-stage sampling procedure was used to select respondents to be included in the study. In the first stage, out of the five counties along the shores of Lake Victoria, Siaya county was purposively sampled because it has a high number of cages in the lake. In the second stage, the county was stratified into sub counties and Bondo was purposively sampled because of the high concentration of fish cage farming compared to the other 5 sub counties. A total of 100 respondents were then randomly selected from twelve beaches within the sub county. Data were collected from the selected farmers through a semi-structured questionnaire. The questionnaire sought information on adoption determinants, challenges and opportunities of fish farming at Lake Victoria.

Data analysis

Descriptive statistics involving mean, percentage and standard deviations were used to assess the household characteristics and institutional factors affecting fish farmers' responses to the adoption of fish cage technology. Both Chi-square analysis and Student t-test were used to compare the qualitative determinants affecting the decision of both non-adopters and adopters. These analyses were performed using R version 4.02 software.

Empirical approach and model specification

In this study, both descriptive statistics and econometric model were used to assess the relationship between explanatory and dependent variables. For the econometric model, Probit model was used to assess the factors influencing adoption of fish cage farming. It included various variables such as household characteristics, institutional characteristics and marketing

Figure 1. Location of the study area.

characteristics. It is hypothesized that the farmers' behavior is driven by the need to derive maximum benefit associated with the practice. Depending on the farmers' perception on the benefit, choice is made, either to adopt or not. Since the farmers' benefit maximization behavior cannot be observed, the choice made by the farmer is assumed to represent the farmers' perceived maximum benefit. The decision to adopt or not to adopt was assessed using the Probit model. The choice of this model is based on the fact that the decision to adopt is discrete; that is, either one adopts or does not. Furthermore, the study assumes that the error term is normally distributed hence the choice of the Probit model. The Probit model used is specified in Equation (i) below:

$$Prob\left(Y_i = 1 \middle| X = \int_{-\infty}^{x'\beta} \varphi(t)dt = \varphi(X'\beta)\right) \quad \text{(i)}$$

where Y_i is an indicator variable equal to unity of households that adopt fish cage farming, φ is the standard normal distribution function, βs are the parameters to be estimated and Xs are the determinants of the choice. When the benefit that household *i* derives from fish cage is greater than 0, Y_i takes a value equal to 1 and 0 otherwise. It follows therefore, that:

$$Y_i = \beta_i X_i + V_i \quad \text{(ii)}$$

where Y_i^* is the latent level of benefit the household gets from fish cage farming and $V_i \sim N(0,1)$. Given this assumption, it follows that:

$$Y_i = 1 \text{ if } Y_i^* > 0 \text{ and } Y_i = 0 \text{ if } Y_i^* \leq 0 \quad \text{(iii)}$$

Empirically, the model can be represented as follows:

$$Y = \beta_i X_i + \varepsilon_i \quad \text{(iv)}$$

Where, Y is the probability of a household adopting fish cage farming given socio economic, market and institutional characteristics X_i and the error term ε_i.

RESULTS

Socio-economic characteristics of both adopters and non-adopters

Sampled households were heterogeneous in various attributes. The average household sizes showed a mean household size for adopters being 5.92 compared with 6.35 for the non-adopters (Table 1). Although these values are higher than the national average family size of 3.9, the differences were not statistically significant ($P \geq 0.05$) at 95% confidence level. Differences in amount borrowed and frequency of advice between the two groups were also not significantly different between the adopters and non-adopters. The mean market distance where adopters who sold their fish were 0.94km, while for non-adopters were 32.89km. On the other hand, the average years' experience in fishing activities was significantly different between adopters (2.18 years) and non-adopters (0.10 years) as expressed by a significant P-value ($P<0.01$) at 5% level of significance.

A paltry 3.13% of females adopted fish cage farming as compared to 96.87% of males. Similar trend was observed amongst the non-adopters (Table 2). Education level was significantly different between adopters and non-adopters with the latter possessing only primary (73.53%) and secondary (26.47%) education. Interestingly, majority of the respondents, adopters (82.81 %) and non-adopters (79.41%) were involved in other income generating activities. At least two fifths (40.62%) of the adopters were found to be members of farmer groups unlike the over 10% (14.71%) of non-adopters.

Credit access and training are both critical in adoption of technology and have proved significant in adoption of fish cage technology in the Lake Victoria region. Significance is the low number of respondents (adopters 15.62% and non-adopters 35.29%) accessing credit services, nevertheless, majority of the respondents (adopters 54.69% and non-adopters 70.59%) had attended training with topics related to fish farming.

Gender, credit access and extension services ($P\leq 0.05$) were found to be significantly influencing fish cage adoption (Table 2) while age, market distance, education level, and group membership displayed non-significant effect on adoption of the technology at 5% level of significance.

Training and credit access both influenced adoption of fish cage farming (Table 3). Further analysis on the reasons behind the acquisition of the credit and amount used in fish cage activities revealed that majority of the respondents acquired credit for other reasons such as for emergency (12%), school fees (12%), buying inputs for crop farming (52%), boosting other businesses (20%) and only 4% percent had the intention of investing in fish cage farming. On the other hand, respondents reported having attended trainings from both public and private institutions such as Department of Fisheries and FARM-AFRICA on various topics traversing from fish cage farming (6.93%), aquaponics (4.95%), fishing sector policies (35.64%), fish pond technology (22.77%), fish value addition (14.85%), fingerling production (0.99%) marketing and entrepreneurship (11.88%) to book keeping (1.98%).

Challenges facing fish cage farming in Lake Victoria region

Challenges to sustainable cage investment in Lake Victoria included resource use conflicts and insecurity problems (24.24%), high initial investment costs combined with difficult access to necessary materials for cage construction (21.72%), natural calamities (21.72%), unavailability of cost-effective high-quality feeds and seeds/fingerlings (13.64%), challenges in marketing of cage fish (9.6%), lack of technical knowhow (5.56%) and diseases and predators (3.54%) (Figure 2).

Opportunities of fish cage farming in Lake Victoria

The opportunities highlighted by the respondents were dwindling wild capture (41%), growing markets and changing lifestyle (29%), government initiatives such as the Big Four Agenda (19%) and Blue Economy initiative (11%) (Figure 3).

DISCUSSION

Socio-economic characteristics of both adopters and non-adopters

Fish cage farming around Lake Victoria is a male dominated enterprise operated by a relatively young age group (38.24 years) as compared to the overall national mean age (60 years) of fish farmers (Obiero et al., 2019). This is also in agreement with the findings of Njiru et al. (2019) on the engagement of middle-aged male farmers in cage farming in the lake. This could be explained by the fact that fishing is one of the major economic activities within the region and hence one of the major sources of employment for this young group. Contrastingly, there was high engagement (adopters 82.81%; non-adopters 79.41%) of the respondents in other non-fish activities, an indication of diversification of sources of income. This diversification might mean that the respondents would dedicate their time and other resources in activities that bring stable incomes than fish cage farming. It was further speculated that young people along the lake being used to fishing, view it as a menial job thus would rather seek white collar jobs.

Table 1. T- test of socio-economic characteristics of both adopters and non-adopters.

Characteristic	Adopters		Non-adopters		t-test of difference in mean	P-value	Remarks
	Mean	SD	Mean	SD	T		
Age (years)	38.24	10.52	38.55	12.26	0.127	0.899	NS
Household size (numbers)	5.92	2.78	6.35	2.99	0.695	0.489	NS
Experience (years)	2.18	1.02	0.10	0.02	-15.847	-0.000	S
Distance to market (Km)	0.94	2.51	32.89	9.45	-2.855	0.006	S
Amount borrowed	35156.25	141264.05	20088.24	43498.8	-0.79	0.434	NS
Frequency of advice	0.70	0.85	0.41	0.89	-1.57	0.122	NS

*** Significant at 0.1, ** significant at 0.05 and * significant at 0.01, NS-Not Significant, S-Significant.
Source: Survey data, 2019.

Table 2. Chi square test results of socio-economic characteristics of both adopters and non-adopters.

Characteristic	Adopters (%)	Non adopters (%)	Chi square	P-value	Remarks
Gender					
Female	3.13	29.41			
Male	96.87	70.59	11.937	0.0005*	S
Marital status					
Single	6.25	8.82			
Married	92 .19	91.18	0.739	0.691	NS
Widowed	1.56	0.00			
Education level					
None	1.56	0.00			
Primary	40.63	73.53	13.558	0.0035*	S
Secondary	34.38	26.47			
College/tertiary	23.44	0.00			
Involvement in off-fish activity					
Yes	82.81	79.41			
No	17.18	20.59	0.472	0.789	NS
Group membership					
Yes	40.62	14.71			
No	59.38	85.29	5.751	0.0165**	S
Credit access					
Yes	15.62	35.29			
No	84.38	64.71	3.869	0.0492**	S
Training					
Yes	54.69	70.59			
No	45.31	29.41	4.739	0.029**	S

*** Significant at 0.1, ** significant at 0.05 and * significant at 0.01, NS-Not Significant, S –Significant.
Source: Survey data, 2019

Mean household size for both adopters (5.92) and non-adopters (6.35) was higher than the overall national mean household size of 3.9 persons (KNBS, 2019) though they were not statistically significant. Larger households are always associated with sources of cheap labor especially for agricultural related enterprises in

Table 3. Factors influencing adoption of fish cage farming.

Characteristic	Coefficients	Std error	Z	P- value	Remarks
Age (Years)	-0.003	0.193	0.134	0.893	NS
Gender (Male/Female)	2.559	0.811	3.155	0.002*	S
Distance (Km)	0.054	0.047	1.147	0.252	NS
Education level					
Primary	0.185	0.007	-0.003	0.998	NS
Secondary	0.177	0.007	-0.003	0.998	NS
Tertiary	-0.001	0.007	0.000	1.000	NS
Credit access (Yes/No)	-1.080	0.497	-2.172	0.029**	S
Group membership (Yes/No)	1.378	0.547	2.520	0.107	NS
Training (Yes/No)	1.064	0.453	2.351	0.019**	S

*** Significant at 0.1, ** significant at 0.05 and * significant at 0.01, NS – Not Significant, S-Significant.
Source: Survey data, 2019

Africa thus encouraging higher rates of adoption of a new technology.

Education level presented a heterogeneous result with non-adopters tending to possess only primary (73.53%) and secondary (26.47%) level of education unlike adopters that was comparable across education levels (Table 1). Education enables farmers to acquire and synthesize information and as such well-educated farmers would be expected to adopt a new technology as they are more informed while at the same time it can be factor against adoption since this elitist group would prefer white collar jobs as opposed to fish cage farming**.** Education increases the ability of farmers to obtain, process, and use relevant information leading to greater use of new technologies. This might explain the comparable adoption by the elitist group (23.44%) who possessed post- secondary level of education. Notably, 1.56% of the adopters who had no education were experienced fishers now turning to cage farming due to dwindling wild capture.

This category of people has extensive experience knowledge on fishing operations irrespective of their educational background. However, there has been no consensus among researchers on influence of education on technology adoption (Obiero et al., 2019).

The mean market distance where adopters sold their fish was 0.94Km reflecting ease of market access. This scenario lends credence to why the respondents opted to adopt the fish cage technology. On the other hand, mean distance of market outlets for non-adopters was 32.89Km which might be a deterring factor to adoption. It is, therefore, apparent that market proximity may be a motivating factor to engage in fish cage farming.

Adopters (40.62%) were found to be members of farmer groups, unlike the 14.71% of non-adopters. Group membership has been associated with information asymmetry reduction and pooling of resources amongst members thus aiding in adoption of new technologies. The high number of respondents not organized into groups or farmer groups (adopters 59.38%; non-adopters 85.29%) might be a contributing factor to non-adoption since acting alone increases transaction costs thus dissuading respondents from adopting the technology (Orinda et al., 2017). Furthermore, lack of association or groups might prevent these fish farmers from enjoying the benefits of high bargaining power in bulk buying of inputs, marketing of their outputs thus being susceptible to exploitation by middlemen. Members in a group influence each other thus leading to adoption, in fact, higher interactions among members of a group increase chances of widening understanding of new technologies and associated advantages.

Factors influencing adoption of fish cage farming

3.13% of the sampled respondents, of the adopters were female against 96.87% males. Consequently, being a male greatly increased the chances of a respondent adopting the technology. This huge gender disparity is alarming calling for efforts to rectify the situation for a pro-gender approach to fish cage farming within the Lake Victoria region. In the African rural set up, males are the main owners of productive assets and also control the utilization of these assets (World Bank, 2009) even though women carry out the majority of work related to agricultural activities (Sexsmith, 2017).

However, it was observed that women were mainly engaged in the downstream segment of the fish value chain. This calls for development of women friendly aquaculture and value addition technologies which they can engage in.

Farmers who had attended one form of training or another had a higher chance of engaging in cage farming

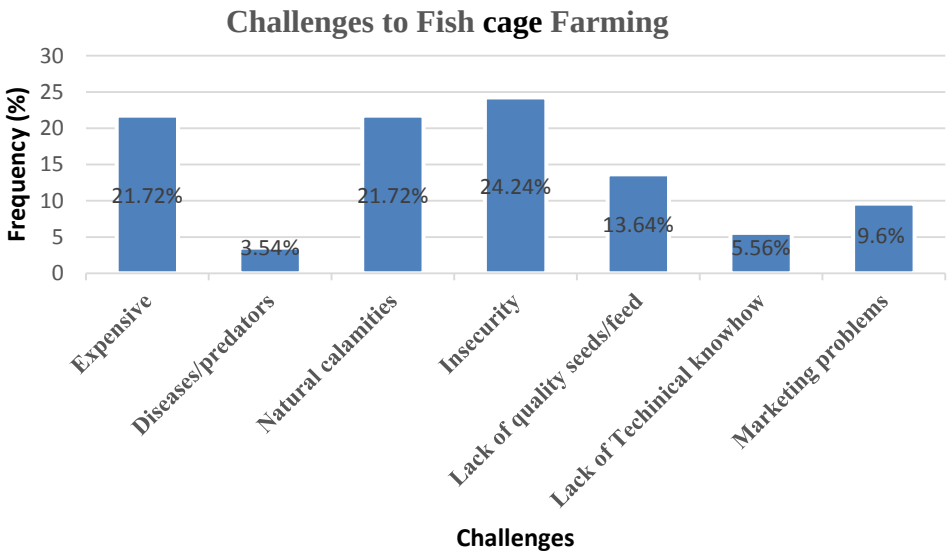

Figure 2. Challenges of fish cage farming by percentage.

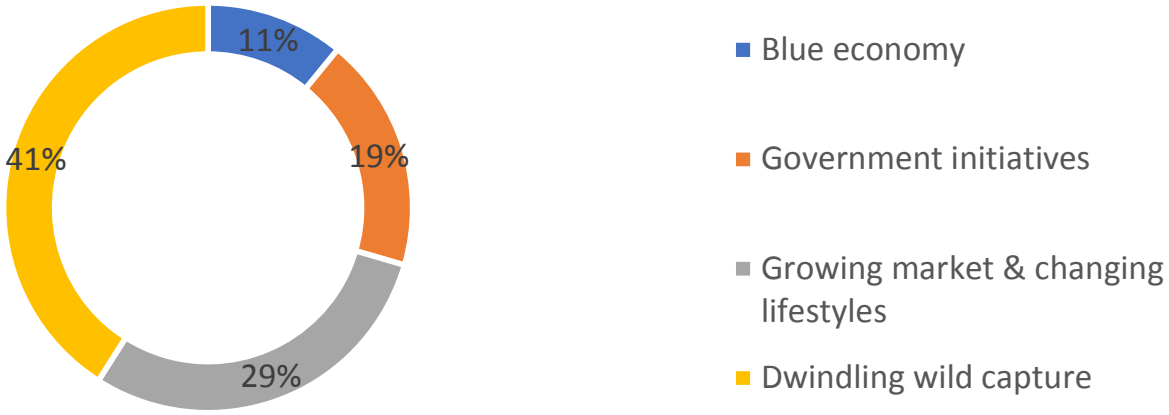

Figure 3. Opportunities of fish cage farming.

than those who had not. In this study, 54.69% of adopters and 70.59% of non-adopters had attended training on fish related issues. Further analysis revealed that only 6.93% of the respondents had been trained specifically on fish cage farming.

This small percentage calls for more incentives towards training to enable the interested fisher folks to overcome the production challenges such as stocking rates, siting of cages, feeding rates amongst others. This was also reported by Shitote et al. (2013) as a constraint to fish development in western Kenya. Training is always associated with high rates of adoption as it bequeaths the targeted recipient with the knowledge and characteristics of the new technology. This does not only enable farmers to assess the benefits but also the risks associated with new technology under promotion.

Availability and access to information reduces the risk associated with the new technology thereby providing incentives to farmers to embrace the new technology (Orinda et al., 2017). Frequent training will not only bequeath the farmers with information about the technology but will also help change their perception and attitude towards the new technology. Furthermore, it will equip farmers with information on availability and properties of the new technology and technical skills for using it.

Credit access negatively influenced adoption. In fact, increase in credit access, reduced the chances of respondents engaging in fish cage farming. Further analysis indicated that only 15.62% of adopters and 35.29% of non- adopters accessed credit during the study period, of which only 4% were invested in fish cage venture. The low access to credit services could be a disincentive to adoption of fish cage farming since this venture requires high initial investment.

Farmers with better access to credit are significantly more likely to be adopters of the technology since they are able to overcome their financial constraints and thereby buy required inputs. Wangui et al. (2018) noted that credit access was one of the constraining inputs in aquaculture development in Kenya and further recommended development of conducive financial environment to enable farmers, access loans for aquaculture development.

Challenges facing fish cage farming in Lake Victoria

Marketing challenges

Survey results indicated that most of the fish produced are sold to individual consumers (39.29%) and middlemen (30.71%) while the rest are sold to retailers (18.57%), wholesalers (5.71%), trader groups (4.29%) and hotels (1.43%), respectively.

Further analysis of buyers' preference reveals the availability of proximate buyer at 45.72% because of either better price (27.14%) or consistency in paying cash (25.71%). Only a mere 1.43% was under contract. This is an indication of one-time-only buyer-seller interactions which forces the fish farmers to sell their produce at the given price thus constraining commercialization. For market expansion and longer-term business operations, fish farmers need to explore value chain upgrading operations and options such as vertical coordination and functional upgrading. Vertical coordination such as contract farming will not only give price and income surety but also ensure production of specified quality of fish thus building consumers' confidence and trust. The fish cage farmers can also explore functional upgrading along the fish value chain by performing different chain tasks through value addition. This will ensure improved economic rent and shelf life thus preventing dumping off to the nearest or available buyer at a lower price. However, this option requires technical know-how and substantial capital requirements.

Another marketing challenge is the perception of cultured fish viz-a viz the wild captured among many consumers, which has been majorly attributed to lack of information (Githukia et al., 2014). Most consumers perceive cage fish as of lower quality and full of pollutants such as heavy metals, pesticides and hormones due to industrial and agricultural activities. Due to this negative perception, it is important that more market responsive and awareness strategies are put in place to appeal to the consumers. Fish farmers additionally face stiff competition from fish imports from China and Uganda which are cheaper. This has prevented the fish cage farmers from competing favorably in the market.

Technical know-how and policy framework

Although 5.56% of respondents reported lack of technical know-how and policy framework as one of the challenges faced by cage farmers, survey results indicated that majority (46.5%) had been trained on fish farming related practices along the fish value chain. Further analysis however, revealed that only 6.93% of the trainings were specific to cage farming. Evidently, specific training and information on cage farming is still lacking as demonstrated by trial and error stocking rates and feeding rates practiced by farmers. Occasionally, this leads to overstocking and or underfeeding thus affecting growth rates and yields. Furthermore, poor siting on the shallow part of the lake is a testament that technical skills, is critical in the success of this novel technology. Gaps in technical skills have been reported to hinder adoption of best management practices and novel technologies (Kumar et al., 2018), and as such, there should be strong linkage between research, extension and farmers on the ground to help with dissemination of right and timely information to farmers. Aquaculture being an important sub sector for development has been operating without comprehensive policy framework in Kenya. This has created a lot of uncertainties in the investment environment due to undefined legalities.

Policies concerning fish cage farming should therefore be enforced to enable success of the technology.

Insecurity

24.24% of the respondents reported insecurity and conflicts as one of the challenges faced by fish cage farmers in the Lake Victoria waters. These are majorly between fishermen, transporters and cage farmers over the siting of the cages since there are no regulations and zoning of the lake. Conflicts are exacerbated by lack of ownership and common access to the water body. This sometimes leads to stealing and or vandalization of cages. Informal reports record of a complete dis-adoption of cage farming in some beaches such as *Wichlum* as a result of conflict. The capacity to ensure a secure return on an investment is one of the motivating factors for any investor however presence of insecurity may deter as well as demotivate interested fish cage farmers. For this technology to pick up, the government should come up

with policy on how Lake Victoria resources should be shared by all the stakeholders, in addition to involving the local community and relevant stakeholders in early stages of implementation of cage business planning and use of Beach Management Units (BMUs) in allocating resources.

Natural calamities

Natural calamities accounted for 21.72% of the challenges faced by fish cage farmers in Lake Victoria region. There have been reports of farmers losing their stocks due to mixing of hypoxic water in the lake. This is hazardous since fish cannot tolerate the low dissolved oxygen (KMFRI, 2016). This is worsened by the shallow siting of the cages in the gulfs and clogging of the cage nets by the unconsumed feed. Bostock et al. (2010) also observed that nutrient enrichment sometimes leads to eutrophication or increased algae growth which increases the risk of hypoxia leading to death of fish as was reported by some of the respondents.

High initial cost of investment (Expensive)

21.72% of the respondents decried the high initial cost of fish cage investment which is majorly incurred during cage design and construction. This high initial and operational cost of this investment has not only deterred the new interested farmers but has also demotivated the already practicing farmers especially when initial investment is not recouped back.

Additionally, the requirement that interested cage farmers adopt environmentally friendly galvanized metal and High Density Poly Ethylene (HDPE) cages, which are more costly, has worsened the situation (Orina et al., 2018). Farmers now are using locally available materials and adapting their designs to local conditions to cut down on cost, however, these are not durable (Charo-Karisa, 2009). The drive for low cost must be balanced with the need for reliability.

Inadequate access to credit and insurances services has also worsened the situation as most farmers either lack collateral, fear defaulting on loans or are not well informed on the sources of agricultural loans. This calls for targeted and subsidized tailor-made loan packages for this niche sector to stimulate fish cage development in the area.

Diseases and predators

In this study, 3.54% of the respondents reported the presence of diseases and predators such as rotting fin, birds, snakes, crabs and frogs respectively. With the intensification of fish cage farming, the possibility of disease outbreak cannot be ruled out as well as possibilities of disease exchange between farmed and wild fish. Disease is a major risk in cage aquaculture and fish health management is an important aspect of business planning (FAO, 2018). This calls for good farm husbandry and management practices promotion to help prevent any possible outbreak. Although predators can be prevented, key and relevant stakeholders in this sector should be prepared for possible disease outbreaks.

Lack of quality inputs-seeds and feed

Feed and seed quality, availability and affordability accounted for 13.64% of the reported challenges. Notably, feed cost mostly accounts for between 40-60% of production cost. Farmers either have to rely on costly imports or contend with locally available low-quality feeds (Ombwa et al., 2018). There has been limited access to quality fingerlings as most farmers relied on Dominion Farms which has since closed down and the remaining sources, Jewlet and Pioneer Farms, are not only able to meet the rising demand, but also to ensure supply of quality fingerlings. In worst case scenarios, farmers resort to sourcing of wild fingerlings which are of low quality thus affecting production yields (Njiru et al., 2019). To make aquaculture more profitable and sustainable there is need for a reliable access to the best quality and affordable feeds. Government agencies like Kenya Bureau of Standards (KEBS) should strengthen their quality checks on feed and seed to safeguard farmers from exploitation from quacks and conmen.

Opportunities of fish cage farming in Lake Victoria

Dwindling wild capture

The declining wild fish capture accounted for the 41% of the reported opportunities within the lake region. Njiru and Aura (2019) reported of a decline of Nile perch stocks and catches from 340,000 tonnes in 1990 to 251,000 tonnes in 2014 and 99,000 tonnes in 2019. This has necessitated the government and policy makers to come up with novel ways and ideas on how to meet the ever -increasing fish demand. Several technologies such as pond and cage fish farming, hydroponics, and aquaponics among others have been put forward to help increase fish production. This decreasing supply from catch fisheries provides an opportunity for fish farmers willing to invest in aquaculture technologies to capitalize on fish prices that are likely to increase in the short to medium term. This is an opportunity for fish cage farmers along the Lake Victoria shorelines to increase their

production and meet the market demand both locally and internationally.

Growing market and changing lifestyle

29% of the respondents felt that a growing middle class who are more health conscious is an emerging opportunity for the interested fish cage farmers. Most people are now shifting from consuming meat to fish as a source of protein due to perceived health benefits of fish (Githukia et al., 2014). This has created demand for fish hence market opportunity for the fish producers especially the fish cage farmers. Globally, it is projected that fish consumption will be approximately 98.6 million tonnes in 2020, which is an increase of 57% (Njiru et al., 2019). This has been brought about by a favorable economic climate and the growing strength of domestic markets due to a rising demand for fish from a rapidly growing population and emerging middle class. Furthermore, absorption of excess fish imports from Uganda and China is a testament of the growing market in Kenya.

Government initiatives-big four agenda on food and nutritional security

The government initiatives like the Big Four Agenda under which Food and Nutritional Security falls, accounted for the 19% of the emerging opportunities for the fish cage farmers as was reported by the respondents. Fish is a critical source of quality protein thus its production contributes to food security and subsequently source of livelihood. Through these initiatives, the government intends to increase fish production by 10% and per capita fish consumption from 4.75 - 10/Kg/capita/year by the year 2030. This has come with both production and market opportunities which cage farmers should strategically target.

Blue economy

In this study, 11% of the respondents felt that Blue Economy initiative was one of the opportunities that can spur uptake of the fish cage technology in the region. It is postulated that this might have been spurred by the just concluded sustainable Blue Economy Conference held in Kenya in 2018. The government through the Kenya's Blue Economy Framework, is promoting the exploitation of blue economy resources as a means of diversifying livelihood opportunities to ease pressure on capture fisheries. Cage culture is one of the lucrative and unexploited prospects for sustainable and ecological fish production. As capture fisheries stocks dwindle in Lake Victoria, new opportunities for investment as stipulated in the Kenya's Blue Economy concept and the potential yield of cage culture promises to supplement capture production and boost food security in the East African region (Wenhai et al., 2019).

Conclusion

Cage fish farming is a promising venture that can help alleviate poverty, unemployment and reduce food insecurity and as such the government needs to improve environment for the investors and fish farmers by ensuring that there is provision of farmer and female friendly loans by the banking sector, high quality and affordable seeds and feed, of importance is the supporting policy framework on fish cage farming that can spur growth of the sector. There is also need to ensure that extension services are effective and efficient. The Government has a role in ensuring the type/quality of extension material/information that is given to farmers. On the other hand, farmers should be encouraged to form strategic farmer associations to strengthen their market bargaining power, reduce information asymmetry and help in pooling of resources thereby taking advantage of the emerging opportunities.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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