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# Socioeconomic dynamics and characterization of land-based aquaculture in Western Kenya

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*With the global decline in capture fisheries, aquaculture remains alternative in bridging the gap and meeting the demand for fisheries products. Currently, aquaculture contributes approximately 50% of world total fishery production, hence becoming an important intervention in promoting food and nutritional security, and employment creation. Western Kenya is suitable for aquaculture production due to favorable climate and good soil as well as high demand for fish. The present survey purposed to assess the Socio-demographic characteristics of fish farmers, fish feed and seed producers in 9 Counties within Western Kenya. The information obtained included socio economic dynamics and challenges to fish farming. Fish farming mainly occur in rural areas in Western Kenya where the most dominant system is earthen ponds, measuring 300 m². Aquaculture in the region is male dominated and majority of players practice individual enterprises. The majority of the hatcheries are authenticated and the lack of credit facility was mentioned as the most important challenge. However, for feed producers lack of adequate raw materials was the most important bottle neck. From this study, both environmental and social factors in the region must be synergized to achieve aquaculture sustainability. There is need for empowerment of farmers through capacity building and availability of credit facilities whereas hatcheries and feed producers must be empowered with adequate skills and infrastructure in order to adhere to good standards.*

*Keywords: fish, Blue Economy, sustainability*

## Introduction

Aquaculture is considered among the fastest growing sectors of food production in the world and currently contributes approximately 50% of fish production (FAO, 2018). Although in developing countries it is considered a potential sector which can enhance food security and create wealth and employment to the rural and urban poor populations, the commercial level is yet to be reached (World Fish Center, 2011). One of the reasons is the lack of proper understanding of how socio-demographic characteristics of fish farmers influence fish farming. Often, socio-demographic factors have a direct and indirect influence on decisions and level of investment in aquaculture. Factors such as age, level of education, occupation, level of income, among others, are key drivers in



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enhancing sustainable fish farming. Such factors are also thought to influence investment and production levels in any aquaculture enterprise (Shitote et al., 2013).

Feed typically account for between 40 and 60% of production cost (Jabir, 2012) for semi intensive and intensive systems of aquaculture. Currently, one of the most pressing challenges in fish farm operation is the lack of efficient and low cost farm made feeds for different stages of fish development. Single ingredients (brans) are not adequate in essential macro and micro nutrients while digestibility is also compromised due to high level of fiber in these feed stuff leading to low fish yields (Liti et al., 2006). Compounded feeds are used to supplement natural food to maximize yield. For enhanced and substantial aquaculture growth, there is a need to optimize feed production and employ best on-farm feed management practices to sustain aquaculture growth for small holder fish farmers (Munguti et al., 2014). Through Fish Farming Enterprise Productivity Program (FFEPP), fish feed standards were created to ensure high quality fish feed in the market. The government however, needs to conduct regular checks to ascertain whether the feeds meet the set specifications. The survey set out to assess the fish feed production capacity and conformity to the feed standards in Western Kenya.

Lack of quality fish fingerlings is another bottleneck for aquaculture development in Kenya, since 1920 when the activity was initiated (Bowman, 2007). Upscaling aquaculture productivity requires availability of quality seeds. The demand for fish

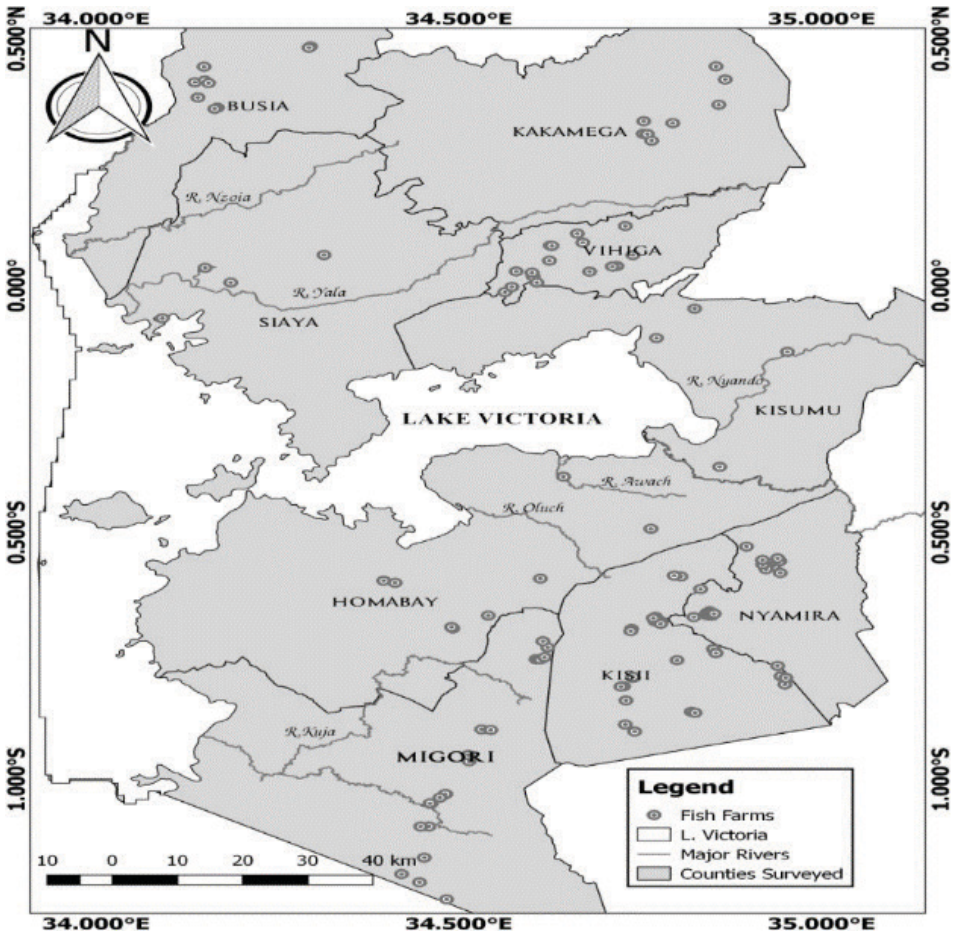


**Figure 1.** Map showing counties in Western Kenya where the status survey was conducted.

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seed is expected to rise as more farmers adopt aquaculture as an economic activity in Western Kenya. The information derived from the study will be important in formulation and enforcement of government policies to support aquaculture development.

## Purpose and objectives of the survey

Western Kenya comprises of nine counties riparian to Lake Victoria (Figure 1). These counties are characterized by increasing population growth and hence increased demand for fish protein (FAO, 2018). It has been over ten years since the inception of the FFEPP but no systematic evaluation was done to date on the state of fish farming in Western Kenya. In particular, there is limited information on fish farmers' management practices, culture species, type and sources of feed used, opportunities and challenges faced by fish farmers. There is also no adequate and updated information on the quality of water and feeds used in fish farming. Such information is useful for farmers to improve their practices for policy makers to design programs which address the challenges faced by the farmers and exploit the opportunities available.The present survey purposed to find out the Socio-demographic characteristics of fish farmers, fish feed and seed producers in 9 Counties within Western Kenya. The objective of the study was to evaluate the socio- economic dynamics and characterize fish farming management practices in the Counties in Western Kenya in order to bring out the challenges and opportunities in the sector.

## Material and methods

### Study area

The survey was conducted in nine counties of Western Kenya, namely: Busia, Kakamega, Vihiga, Siaya, Kisumu, Homa Bay, Migori, Kisii and Nyamira counties (Fig. 1) in the month of November 2018. With the exception of Kisii and Nyamira, all the other counties are riparian to Lake Victoria. The study in the counties was influenced by socio economic dynamics, increased fish farming and the proximity to the Lake which could have a greater influence on aquaculture production in this region.

### Data collection and analysis

Data was collected using structured questionnaires where grow-out farmers, hatcheries, feed producers and County Directors of Fisheries were interviewed. Survey teams targeted to interview 50% of pond culture farmers who were either in a group or at individual levels. Individual farms, hatcheries and feed production sites coordinates were marked by Global Positioning System (GPS). Primary data were recorded in Microsoft Excel computer package (2010), coded and transferred into Statistical Package for Social Sciences (IBM-SPSS Inc. version 20.0 IBM Corp. Released 2011, Armonk, NY: USA). Descriptive and inferential statistics, mainly mean and frequencies, were computed to determine key characteristics of farmers' aquaculture production status while correlation analysis were used to compare the relationship between age and level of income for fish farmers in Western Kenya.

## Results and Discussion

### Socio economic characteristics of farmers in Western Kenya

The socio economic characteristics of fish farmers in Western Kenya are illustrated in Table 1. Majority (n=111, 88.8%) of these farmers were aged 40 years and above whereas only about 11.2% were less than 40 years. Fish farming in Western Kenya is dominated by farmers aged between 50-59 years. This scenario was observed in all the 9 counties. This observation is in line with earlier findings which reported a similar trend, where retirees or those about to retire settled in fish farming (Oseni and Winters, 2009). This could imply that younger people have low levels of income and may be facing limitations in getting starting capital to establish fish farming enterprises. Similarly, majority (n=14, 88%) of hatchery owners were over 40 years.

However, the relationship between age and level of income for fish farmers, revealed that there was no significant ($R = 0.307$, $p = 0.468$) relationship between age and level of income for

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fish farmers in Western Kenya. This result perhaps can be attributed to inaccurate information or lack of openness in giving of income estimates by respondents. In addition, the low number of youths owning aquaculture enterprises could be associated with involvement in alcohol, drug abuse and touting by some of the youths (Shitote et al., 2013). However, these findings differ with those reported for Kiambu and Machakos counties, where majority of fish farming enterprises were owned by individuals below 50 years (Ngwili et al., 2015).Fish farming in Western Kenya is dominated by men just like in capture fisheries (FARM AFRICA, 2016). Majority (n = 133, 87%) of males were involved in fish farming in Western Kenya as opposed to only (n= 15; 13%), females (Table 1). This is in agreement with findings of studies by Manyung-Pasani et al., (2017) who indicated that traditional African setup limits women from owning property hence limiting their involvement in fish farming and other related activities. Women face challenges accessing land, control of production, decision making on the use of assets and control over household income. Evidence has shown that in as much as there is cultural and economic diversity in many developing economies, the position and perception of women regarding the fisheries sector is the same (Geheb et al., 2008).

Overall educational status of fish farmers in the 9 Counties surveyed in Western Kenya is presented in Table 1. About 40% of respondents (n=53) had secondary education with just a few having post-graduate education (n=3; 2%). The present study confirms the earlier findings by Finegold, (2010). Further, the findings reveal that even those with degree and postgraduate levels of education are actively engaged in aquaculture, though in relatively smaller numbers. This indicates recognition of aquaculture and the great potential in job and wealth creation for improved livelihoods. Majority (n=9, 56%) of hatchery owners were degree holders followed by those with a secondary level of education (n=4, 25%). Seed production, is a new enterprise which requires individuals who have the skills and ability to understand and adopt appropriate technologies (Ngwili et al., 2015). The paradigm shift where elites take up aquaculture activities, a venture which for long was a preserve of the poor and the illiterate in society (Kundu et al,. 2016), is a signal of a better future for aquaculture in the region. With such trends, aquaculture is no longer at subsistence level but is evolving into a serious commercial activity in this part of the country. Education is important in aquaculture sustainability by equipping farmers with better skills and training, resulting to better management and high production. often elites who have attained tertiary education demean fish farming and go for formal employment leaving aquaculture in the hands of illiterate poor smallholders (Dickson et al., 2016).

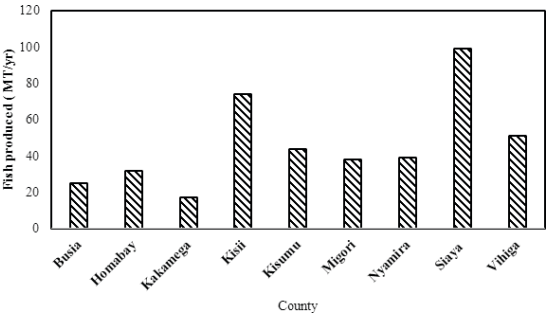


**Figure 2**. Annual fish production per count.

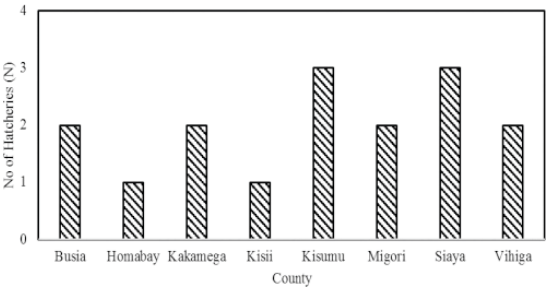


**Figure 3**. Number of hatcheries per county in Western Kenya.

Aquaculture systems in Western Kenya (n=125; 94%), were individually owned while a small portion was owned by institutions and groups (n= 8; 6%). Thus, the sector appeared to attract individual investment more than groups. Group ownership somehow suffer from intrigues of group dynamics, time and again characterized with poor management and low productivity due to lack of cooperation among group members and neglect of enterprises (Mucai et al., 2016).

Monthly income for 36.4% of the fish farmers (n=45) was between Kshs 10,000-20,000 (with 1 United States Dollar exchanging for 108 Kenya Shillings) whereas fish farmers with an income less than Kshs 5000 were the least (n=18, 14.5%). The fish farmer's monthly income trend reported

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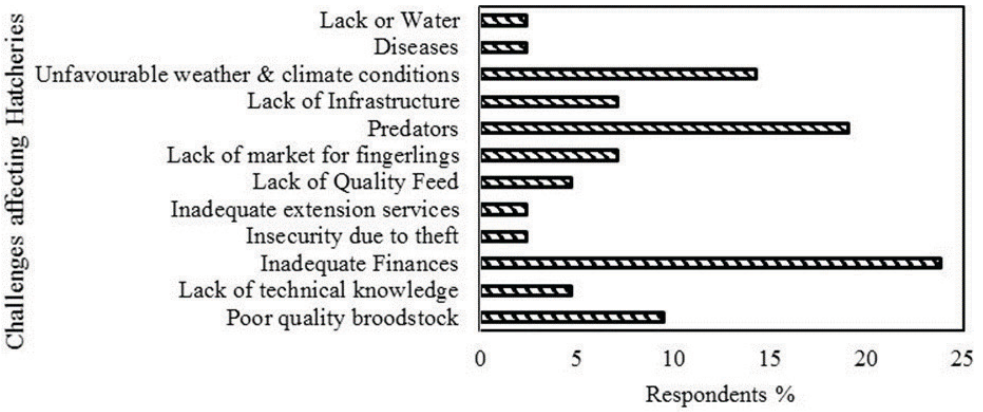


**Figure 4.** Challenges facing fingerling production in Kenya.

in this study differs with the one reported earlier for Siaya County. According to Pant et al. (2014), it was shown that majority (n=176, 91.7%) of fish farmers in Siaya County had an income of less than Kshs 10,000. The variation between the earlier report and the present findings may be because, the earlier findings reported income specifically from fish farming whereas the present study records total household monthly income from all sources. The findings show that majority (n=123, 94.6%) of fish farmers were married whereas those that were single were the least (n=2, 1.5%). This is because marital responsibilities require more income and can compel married people to invest in aquaculture and other enterprises to diversify sources of income. Farmers in Western Kenya ventured into fish farming as a means of extra income to support their families (Nguka, 2017).

## Aquaculture production characteristics in Western Kenya

From the survey, the majority of the fish farmers (n=129, 98%) practiced semi intensive system of aquaculture. In pond systems, 97% (n=127) of farmers cultured fish in earthen ponds. Earthen pond system is more dominant because of the low cost of establishment and management. However, there was no farmer practicing extensive culture system, due to low productivity and less returns associated with the same. The survey also revealed only 2%, (n=2) engaging in intensive aquaculture practice. This is perhaps attributed to high start-up cost, operational costs and the risk associated with such systems. They are mainly suited for high value fish like the Rainbow trout (Opiyo et al., 2018). However, production reduced drastically in the past 3 years, with 14,952 metric tonnes.

The survey findings in the study area reveal that majority of fish farms, (n= 106, 81%), were within the rural areas whereas urban settings had the least number of ponds, (n=5, 4%) (Fig. 4). The high number of ponds in rural areas could be because of availability of space, water and the type of soils ideal for pond construction. In most African countries aquaculture is done at subsistence level and whatever surplus is then sold in rural markets (Rajee et al., 2017).

Spring is the most common source of water in this survey (Figure 5). Famers consider the need to site farms in areas with permanent sources of water (Nguka, 2017). Few Farmers have adopted modern rain harvesting technologies for fish farming hence only 2% (n= 2) were involved in the same.

Most farmers, (n=88, 72%) had ponds ranging between 201-300 $m^2$ while farmers having small sized ponds, 50-100 $m^2$, were the minority (n=5, 4%). This scenario is attributed to the government intervention through FFEPP that encouraged farmers to construct fish ponds measuring 300 $m^2$.It was around the time that fish farming became more popular in Kenya (Kariuki, 2013, Musa et al, 2012).

Most ponds in Western Kenya, about (n=270, 68 %), are stocked at a density of 3 fish $m^{-2}$. Ponds stocked at a density below 3 fish $m^{-2}$ were the least, (6%), whereas those stocked above 3 fish $m^{-2}$ were about 26%. This was due to the semi intensive aquaculture system being practiced by a majority of fish farmers in the study area. Semi-intensive

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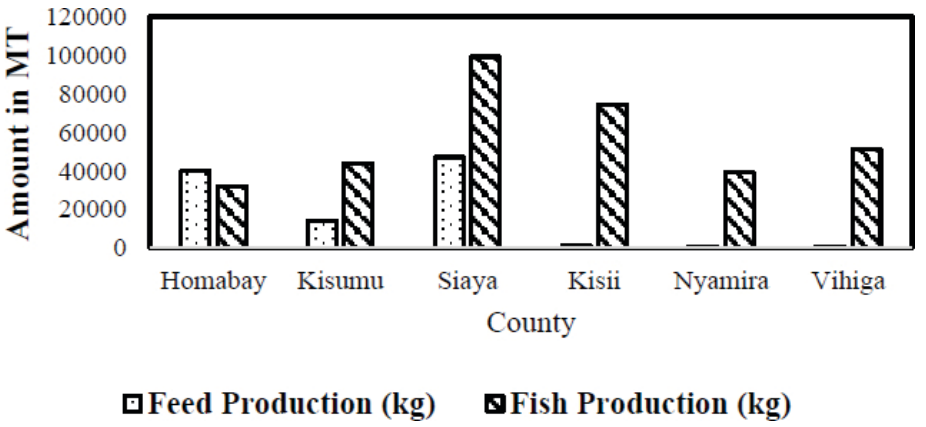


**Figure 5**. Comparison for feed and fish production in Western Kenya.

pond system involves cheap feed supplements and fertilizers for aquaculture production in Kenya (Liti et al., 2005).

From this survey it was observed that Tilapia was the most popular species for culture in Western Kenya (n=130, 83%). The ability to feed low in the food chain and consume a wide variety of food items is one of the reasons why Nile Tilapia *(Oreochromis niloticus*) is very popular and one of the most farmed species in tropical countries (Fitzsimmons, 2019). Catfish was the second most preferred culture species (n=27; 17%). This finding concurs with a review by Munguti et al., (2014) the mariculture sector has yet to be fully exploited. The Kenyan aquaculture industry has seen slow growth for decades until recently, when the government-funded Economic Stimulus Program increased fish farming nationwide. Thus far, the program has facilitated the alleviation of poverty, spurred regional development, and led to increased commercial thinking among Kenyan fish farmers. Indeed, national aquaculture production grew from 1,000 MT/y in 2000 (equivalent to 1% of national fish production , where the most cultured species in Kenya were Tilapia (70%) followed by Catfish at 21%. As illustrated in Figure 2, the total aquaculture production status per county is in Western Kenya. Siaya County exhibits the highest aquaculture production in this study.

## Hatcheries in Western Kenya

As opposed to grow out fish farmers and fish feed producers, majority (n=12, 75%) of hatcheries were group owned. It is inevitable for individuals to join hands and pool resources together in order to manage seed production. Comparatively, Siaya and Kisumu Counties had the highest number of hatcheries while Kisii and Homa Bay had one hatchery each (Figure 3). This could be because of high market demand for fingerlings due to the proximity of Siaya and Kisumu to Lake Victoria where there is high adoption and uptake of cage culture as an investment alternative.

About (24%, n=10) cited inadequate finances as the bottleneck towards their aquaculture development (Figure 4). This was followed by predator menace and unfavorable weather conditions (19%, n=8 and 14%, n=6), respectively. Poor quality brood stock and poor infrastructure also emerged. Studies by Yongo et al. (2011), reported that a majority of the respondents (30%) recommended availing credit facility as the best way of improving aquaculture, this concurs with the present results.

## Types of feed and production infrastructure

There were at least four main types of fish feed that the manufacturers produced, these were categorized as floating, slowly sinking, sinking and mash. With exception of Kisii County, all the other counties were producing floating pellets. In regard to infrastructural capacity, Siaya, Vihiga and Homa-Bay Counties were having extruder machines, an indication that the farmers in such counties were able to access floating pellets. Floating pellets are

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often recommended for feeding fish due to their stability in water and they are easy for the fish to consume while the sinking ones often end up as waste and pollute the environment (Holmer, 2010). However, some farmers were still using sinking pellets with low water stability. Some were stored in poor conditions (on the floor) with no uniform size of pellets and with molds. Molds produce a chemical known as aflatoxin. When fish are fed with feed contaminated with aflatoxin, it may result to Aflatoxicosis, a disease that can wipe out the entire stock due to carcinogen (Bartholomew and Olubunmi, 2014).

## The dynamics of feed production variables in Western Kenya

The amount of feed produced per county had a strong influence on fish production as shown in Figure 5. Siaya County had the highest fish feed production and a similar trend was noted for fish production. There was no significant relationship ($R = 0.463$, $p = 0.17708$) between the crude protein for the starter diet and the price charged. Notably, the crude protein level for the grow out diet did not correlate ($R = 0.287$, $p = 0.42$) with the prices charged. This could imply that protein content was not the main determining factor in price of feed in Western Kenya. The finding of the current study contradicts previous research which have reported protein as the most expensive nutrient and its quality and quantity determine the cost of fish feeds (Mohanta, 2012). This could imply that there could have been progressive replacement of fresh water shrimp meal by cheaper animal protein feedstuffs that could have contributed to reduced cost of fish feeds. There was no significant relationship ($R = 0.187$, $p = 0.43$) between the number of staff and feed produced. This could imply that number of staff does not translate to direct energy for production.

## Challenges in feed production in Western Kenya

Feed producers face various challenges that compromise their activity. In this study, lack of raw material was the main challenge facing fish feed production in Western Kenya (n=195; 32%). High cost of production was the second major challenge for the sector (n=117; 20%). Oftenly, unavailability, competition and fluctuating prices of fishmeal and fresh water shrimp are affecting aquaculture feed production and consequently the profitability. Most fish feeds contain a proportion of animal protein, which is considered to be more digestible and palatable than plant based sources. In Kenya fresh water shrimp which is a by-product of Omena (*Rastrineobola argentea*) fishery is used mostly as the animal protein source in aquafeed production, however, it becomes increasingly scarce and expensive due to frequent closures of the Omena (*R. argentea*) fishery (Munguti et al., 2014). These challenges make commercial production of feeds more expensive and the cost of the feed expensive for most farmers to afford (Wakhungu, 2012).

**Table 1.** Socio demographic characteristics of fish farmers in Western Kenyan.

| Characteristic | n | Proportion |
|---|---|---|
| **Age** | | |
| 20-29 | 4 | 3.2 |
| 30-39 | 10 | 8 |
| 40-49 | 38 | 30.4 |
| 50-59 | 44 | 35.2 |
| > 60 | 29 | 23.2 |
| **Gender** | | |
| Male | 133 | 87 |
| Female | 12 | 13 |
| **Education** | | |
| Primary | 47 | 36 |
| Secondary | 53 | 41 |
| Diploma | 14 | 11 |
| Degree | 13 | 10 |
| Post Graduate | 3 | 2 |
| **Monthly income** | | |
| <5000 | 18 | 14.5 |
| 5000-10000 | 38 | 30.6 |
| 10000-20000 | 45 | 36.4 |
| >20000 | 23 | 18.5 |
| **Pond ownership** | | |
| Individual | 125 | 94 |
| Group | 4 | 3 |
| Institutional | 4 | 3 |

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## Conclusions

Farmers in Western Kenya embrace fish farming as an economic venture, however, most of them practice semi intensive aquaculture system. The climatic conditions of Western Kenya are conducive for fish farming with Nile Tilapia being the most cultured species. Therefore, there is a great potentiality of this region in embracing and taking up fish farming as an economic activity for food security and poverty alleviation. Results in this study demonstrate that environmental and social factors in the region must be synergized to achieve aquaculture sustainability.

The availability of high quality fish seed and feed is important for a successful aquaculture fish production enterprise. Aquaculture is being developed in Western Kenya today, offers an alternative source of fish supply hence bridges the gap between fish demand and its supply. Fish seed production and aquaculture development in Western Kenya is dependent both on technical, infrastructure development and government interventions in policy formulation and implementation.

## Recommendations

In order to address the food security problem, both elites and the poorer small holder aquaculture farmers ought to be empowered with information in order to venture into commercialized aquaculture. There is need to provide credit and other incentives to the vibrant youths and women who are interested in fish farming but lack starting capital.

The government should consider subsidizing equipment meant for fish feed and seed production in order to enable women and young people with low levels of income to afford. There is need for improved breeding techniques and procedures in feed production to ensure production of quality seeds, thus, it is important that fish seed hatchery operators conduct regular training and capacity building programmes that will improve their skills. This may necessitate government and other relevant agencies intervention in organizing regular and training workshops and seminars for hatchery operators. For feed production that enhances more fish production; there is need to find alternative replacement to fishmeal in the diet of fish, probably from locally available plant based ingredients so as to lower the price of processed feeds.

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