Adoption of Aquaculture Technologies and Management Practices, Challenges and Productivity of Fish-Ponds in Kakamega County, Kenya

ABSTRACT

There is increasing demand for fish products worldwide. To meet the growing demand there has been increased shift from wild-caught fish to farm-based production. The adoption of best practices in aquaculture is imperative in meeting this natural demand. This study investigated the adoption of best technological and management practices, challenges and productivity of fish-ponds among smallholder aquaculture farmers in Kakemega County, Kenya. Purposive and stratified sampling techniques were used to select 27 aquaculture farmers in 3 out of 12 Sub counties in the area, for interviews. Nine recommended technologies and management practices were used to develop an adoption index for each interviewee. Fish pond productivity was significantly lower for adopters below the median index; t (24) = -3.088, P = .005, with a mean of 196.3 g/m^2 for lower index adopters and 449.5 g/m^2 for the higher index. Variances in productivity were high. The study finds that the major on-farm challenges included; fish predators, poor quality feeds, insecurity and lack of quality fingerlings. Wilcoxon signed-rank test was used to test the deviation of views from neutral; score of 3 on a 5-point scale. Market unavailability was not a significant constraint. There was high demand for fish products. Access to technical information was above 3 (median =4). Risk rating significantly deviated from neutral; there was a view that aquaculture was a risky venture. There were no extreme views on its profitability. In conclusion, the adoption of the technologies aided the productivity. The fish-pond productivity was relatively low and faced major challenges that need to be addressed to enhance the adoption of best practices and increase output from the ponds. Actions by stakeholders to address the challenges both at farm level and at policy level are recommended. Training on risk management strategies for the aquaculture farmers is recommended.

Keywords: Adoption; aquaculture; technologies; best practices.

1. INTRODUCTION

Modern fish production is increasingly getting more farm-based as opposed to catching from the wild. The shift towards farm-based production is largely in response to the increasing demand for fish products worldwide [1]. Capture fisheries production has levelled off and is no longer capable of supplying sustainably the demand for fisheries products [2]. The Per Capita fish consumption has increased consistently from 9 kg in 1961 to 20.5 kg in 2018 [3]. Africa accounts for approximately 2.7% of the global aquaculture production. The Fish farming is increasing throughout the world in response not only to the increasing demand but also to the dwindling landings from capture fisheries [4]. Aquaculture is thought to have great potential as a source of high value proteins particularly for the less developed countries [5]. Africa has a high biophysical potential for aquaculture and has the fastest growing aquaculture sub-sector, but it is yet to contribute significantly to sustainable food supplies [6]. Kenya is one of the fastest-growing producers of fresh water aquaculture in Africa, but the overall volumes produced are low. Farmed fish production was estimated at 21,856 tons in 2013, having risen by more than four times the production of 2009 [7]. This fast growth was attributed to the availability of seed and other government support towards smallholder producers through an Economic stimulus program initiated by the government in 2009 [6]. Producers received the support in form of farm inputs subsidy and capacity building through training on appropriate aquaculture technologies and management practices as a food security strategy. The rapid growth in aquaculture has been attributed to the availability of seeds and financial investments. The strategy in turn has stimulated a need for technical information in fish farming. Fisheries extension-staff have been deployed in all regions of Kenya to deliver information inputs to smallholder producers. Reports indicate that the fish stocks in Kenya are dwindling in lakes and water bodies [8], suggesting a need to continue investing more in aquaculture systems.

Through the economic stimulus program, the government of Kenya constructed 3000 fish ponds between 2009 and 2013, but the ponds performed dismally across the country [8].The reasons for the dismal performance have not been adequately documented. Some reports suggest that the initial investments on areas such as fingerling production and access to pond liners and quality feeds among others diminished soon after the Economic Stimulus Program came to an end [9]. The Government of Kenya implemented the Economic Stimulus Program (ESP) that provided subsidies between 2009 and 2013. The program focussed on fish feed, construction of ponds and supply of fingerlings, but came to an end in 2013. The argument of the decline in investments post ESP is plausible in light of the decline in fresh water fish production from the year 2015 to 2018 [7] as illustrated in Fig. 1. Low productivity from aquaculture sub sector in Kenya persists.

Farm Africa (FA) reported a low output from ponds at 0.31 kg/ m^2 from small scale Tilapia (*Oreochromis niloticus*) fish farmers, 0.82 kg/m^2 for catfish (*Clarias gariepinus*) farmers in a survey conducted in 2016 in their counties of operation [10]. A total of 14 counties, Kakamega included, participated in the program. The yields reported compares poorly with a potential of 0.8 kg/m^2 for tilapia under simple semi-intensive system with regular manure application and some supplemental feeding. Higher yields can be achieved by stocking mono-sex fish and using nutritionally complete feeds. The current study

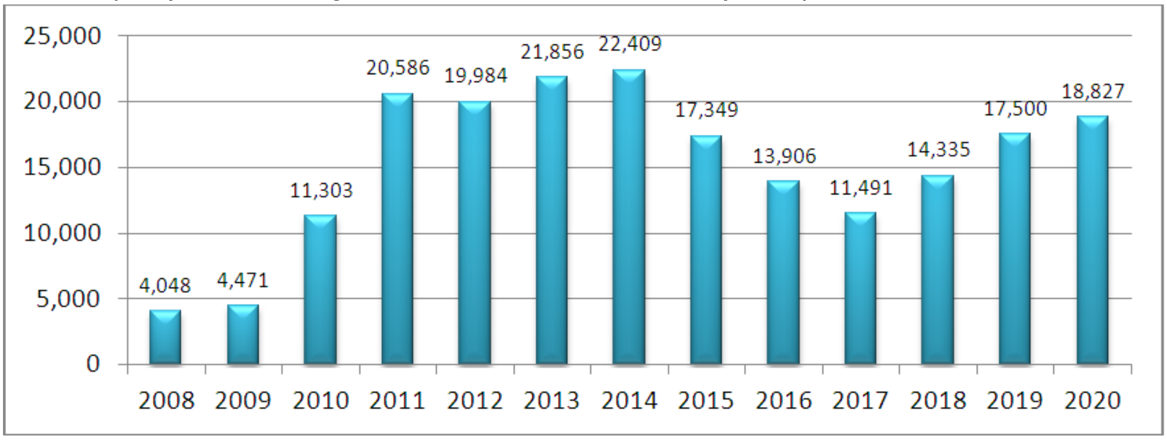

Fig. 1. Live weight of fresh water fish (Tons), Kenya: 2008-2020
Source: FAO (2021) Fisheries Statistics (https://www.fao.org/fishery/statistics)

investigated whether the low productivity levels have improved in the light of the presence of programs that have supported the delivery of technical information inputs to the smallholder fish farmers. The Kenya Aquaculture Market-led Program operated in the area between 2016 and 2019. The Government of Kenya, through the department of fisheries had been involved in capacity building of small scale fish farmers since the days of the economic stimulus package in 2009 [6]. Has the adoption of best practices, as delivered through the programmes, improved the outputs from the small-holder fish-farms in Kakamega County? This is the broad question the current study sought to investigate.

Kakamega County is the second most populous county in Kenya with the highest rural population among the counties in Kenya [11]. The county's' demand for proteins are met mostly through the work of smallholder farmers involved in chicken rearing, fish farming and cattle rearing. Fish farming is an efficient way to produce farm protein; according to [1], fish has the ability to convert 100kg of fish feed to produce up to 15 times more protein than cows fed an equivalent amount of feeds. Fish farming has the natural advantage of being less prone to seasonal production cycles, suggesting that it can be viewed as a climate-smart production system. With a population density of about 648 persons per km^2 in Kakamega county as in 2018 [11], land is increasingly getting scarce and the need for intensification on the use of natural resources (including in aquaculture) getting increasingly urgent. The increasing population amid competition for land and water resources means that the demand for food will continue to increase. Aquaculture has an important role to play in the household food and income systems, particularly for vulnerable households [12].The adoption of best practices is imperative in meeting this natural demand for a better utilisation of natural resources. The delivery of quality technical information inputs to smallholder fish producers and its subsequent adoption is expected to lead to intensification on the use of natural resources and ultimately result in higher outputs. This study investigates:

i) The adoption of selected best technological and management practices among the aquaculture farmers
ii) The productivity of the smallholder aquaculture and
iii) The challenges experienced by the smallholder aquaculture farmers in Kakamega county

2. METHODOLOGY

2.1 Study Site

Kakamega County is located in the Western parts of Kenya and neighbours' Siaya and Vihiga counties to the west, Nandi and Uasin Gishu to the East and Bungoma and Transzoia to the North (Fig. 2). The county covers an area of 3051.3 Km^2 with a population density estimated at about 753 persons per Km^2 in 2022 [11]. Annual rainfall ranges from 1280 to 2214mm per annum with temperature ranges of 18^0 C to 29^0 C. The relatively warm climate, high rainfall and high population density have implications on aquaculture production.

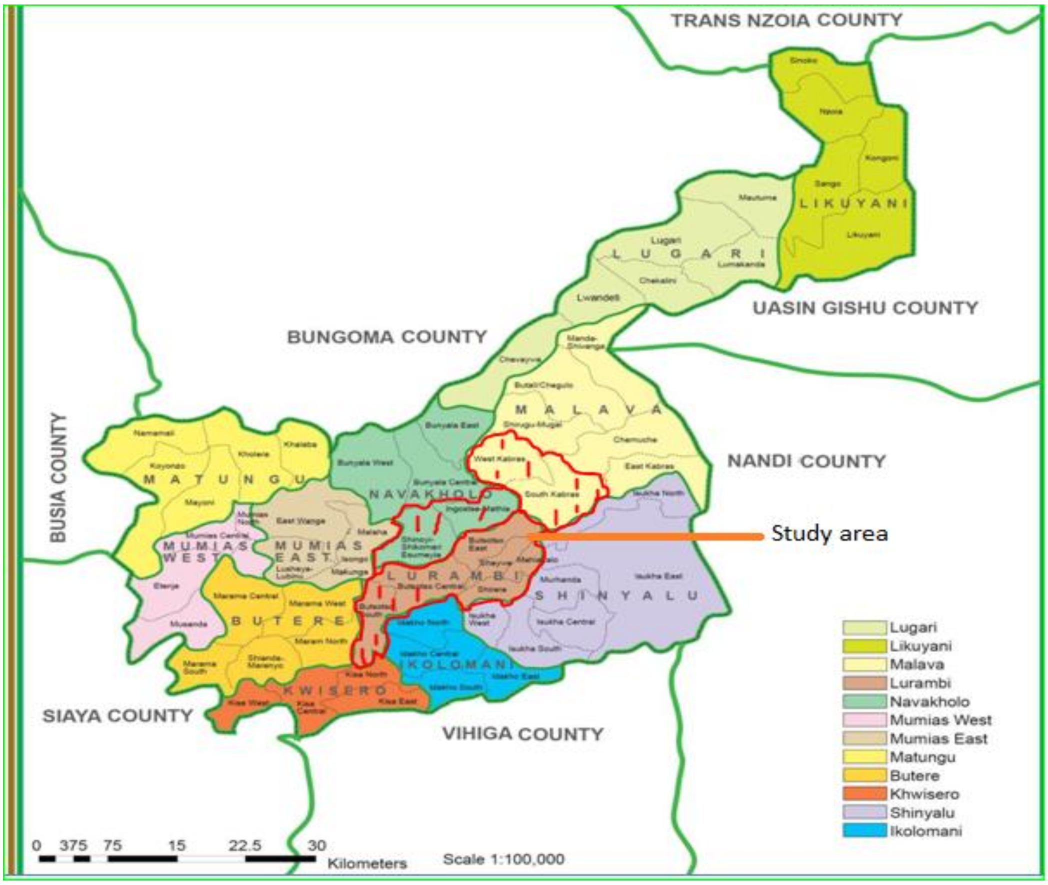

Fig. 2. Map of Kakamega County, Kenya, showing the study location

Source: County Government of Kakamega (2018)

2.2 Target Population

Estimates by the County Government of Kakamega indicate that there were 7,845 fish farmers with 8,336 fish ponds in the county. The county produced about 1,627,500kgs of fish in 2017 [11]. The fish was mostly produced from earthen fish ponds. There were six fish hatcheries in Kakamega County that served as a source of fish fingerlings for tilapia *(Oreochromis niloticus)* and catfish (*Clarias gariepinus)*. The fish farming has an important economic role; it earned the smallholder farmers about 450 million Kenya shillings in 2017. It has crucial roles in food security and employment creation [11].

2.3 Data Collection

Purposive and stratified sampling techniques were used to select fish farmers to participate in the study. Three sub counties, from the 12 in the county, were selected on the basis of intensity of fish-farming activities. At least one farmer was interviewed from each of the administrative Locations where aquaculture farmers were in active production. Although interviewing is time-consuming and expensive, it has the advantage of deploying observation and probing, alongside the interviews, for in-depth information. To achieve this, purposive sampling was used to identify the aquaculture farmers who could provide information for the study objectives. Aquaculture farmers in three sub-counties were deliberately selected to provide qualitative and some quantitative information. Although sample size for qualitative data collection is an area of conceptual debate, it is generally agreed that the determining criteria should be data adequacy; a level at which further data collection is not generating any new information [13]. As suggested by [13]; when utilizing information-rich cases, sample sizes tend to be small in order to support depth of the case-focused analysis. In total, data were collected from 27 farmers spread across the three Sub Counties (Table 1).

Table 1. Distribution of farmers interviewed

	Sub-county	No. of participants
1	Lurambi	10
2	Malava	4
3	Navakholo	13
	Total	27

2.4 Data Analysis

Descriptive and non-parametric inferential statistics were used to analyse the data. The descriptive statistics used in the analysis were frequencies, means and medians. In view of the small sample size inherent in qualitative interview studies, the non-parametric inferential statistical tools were deemed appropriate. The farmers' opinions were captured at an ordinal level. For the ordinal data that was obtained from the interviewees, the non-parametric one-sample Wilcoxon signed-rank test was used to test a null hypothesis that the views were not extreme: H_0: $m = m_{0,}$ that the population median (m) on the views did not differ significantly from the hypothesized median (m_o). The hypothesized median in this study is that it would be neutral (no extreme views). The views were measured on a Likert scale of 1 to 5; it was thus hypothesized that the median would be near neutral (a value of 3). The Wilcoxon signed-rank test was deemed appropriate as it is a non-parametric test that is not based on the assumptions of large samples and normality of data distribution [14]. This test was computed by SPSS version 20 for Windows.

Nine recommended best practices in aquaculture were used to compute a best practice index for each interviewee, depending on whether they had adopted the practice (scored 1) or not (scored 0). The scores from the 9 variables were summed up and divided by 9 to obtain an index for each interviewee. The highest possible index was 1.00 where the interviewee had adopted all the 9 practices. A median value for the sampled farmers was worked out. An interviewee with median equal to or less than the median was treated as 'low' best practice index farmer, a value higher than median as 'high' best practice index. The Best Practice Index (BPI) was worked out, thus:

$$B\text{PI} = \frac{\text{Sum of the Scores from all Variables}}{\text{Number of Variables Assesse}}$$

hence; BPI = $\sum_{i=1}^{n} Si \frac{1}{Vn}$,

where BPI is the best practice index, S_i is the score for each variable (1 if the practice has been adopted, 0 – otherwise) and Vn is the number of best practice variables assessed. Differences in aquaculture productivity between the two categories of farmers (low and high BPI) were analyzed by t-test.

3. RESULTS AND DISCUSSION

3.1 Socio- Demographics

From the total of 27 aquaculture farmers interviewed, 1 (one) did not have any formal education, 9 primary level, 13 secondary and 4 had tertiary education, farm sizes ranged from 1 to 10 acres with a median of 3 acres. A median household size of 8 and age distribution from 25 years to 73 years with a median of 53 was observed. There were 21 males and 6 females among the interviewees. 19 of the interviewees were married, 6 were single and 2 were widowed. One of the interviewees had 19 fish ponds, others had between 1 and 4 with a median of 2. The dominant pond type was flow through (23); others were static (2), Refill (1) and a mix (1). The dominant water source for the ponds was the stream, reported by 15 households, other sources were springs (8), well (3) and river (1). The ponds were mostly sited on gentle slopes (22) and few on flat ground (5). Clay soils were dominant in the fish ponds (13), others had loam soils (7), sandy (4) and silty (3). 15 of the respondents raised fish for sale, 12 largely for home consumption. The farmers experience in aquaculture ranged from 1 year to 5 years with a median of 3 (Table 2).

The observed socio-demographics suggest that most of the aquaculture farmers in the study area have basic education (primary and secondary level), are mostly males and majority married, though some are single and others widowed. The singles and widow headed households are often regarded vulnerable as they have no partners in raising income for their households. The median age of 53 years indicates that the majority of the farmers are elderly. Some of the aquaculture producers were highly commercial as indicated by the number of fish ponds they operated; one interviewee had 19 fish ponds and 15 of them indicated that they raised the fish for commercial reasons rather than home consumption. The observation means that smallholder aquaculture producers are increasingly producing for the markets. The pond-types were predominantly flow-through. The flow-through type of fish-ponds tends to maintain water quality, particularly when the water in-flows nearly equal the water out-flows [15]. Soil types within the pond areas largely ranged from clay to loam (20 out of 27); a few had ponds dominated by sandy and silty soils (Table 2). Clay covered ponds tend to require less water for its maintenance as it is less prone to losses through seepage [15]. This suggests that some farmers require more water to maintain their water quantity and quality.

3.2 Adoption of Technologies, Management Practices and Productivity

Pre-establishment soil testing and post-harvest cooling were the least adopted management practices (Table 2). Farmers appear to generally ignore the practice of soil testing before pond construction. A similar observation was made in a study conducted in Nigeria where only 42% of fish farmers adopted the practice despite receiving a package from the local government extension service [5]. Majority had adopted pond liming and installed inlets/outlets in their fish ponds. This observation was similar to that reported by [5] where 80% of participants in a study had adopted the practice.

The practice of securing ponds was adopted by only 7 of the 27 participants in the study. Paradoxically the same farmers complained that predators were a major source of challenge in fish farming. According to [15], construction of low barriers around ponds and use of nets helps keep small animals and birds from predating on the fish. Less than half of the farmers had adopted the practice of cleaning the fish ponds daily, processing fish before sale and keeping of records. A high proportion of the respondents had adopted the use of improved fish feeds; 22 out of 27 (Table 3). The high rate of adoption may have been due to the farm inputs subsidy program operated by the county government. Elsewhere, [16] reported a 51.5% adoption of improved feeds.

Table 2. Socio-demographics of the participants (N = 27)

Variable	Frequencies

Education	No Formal	Primary	Secondary	Tertiary
	1	9	13	4
Farm size(acres)	Range	Median		
	1-10	3		
Household size	Range	Median		
		8		
Gender	Males	Females		
	21	6		
Age (years)	Range	Median		
	25-73	53		
Marital status	Married	Single	Widowed	
	19	6	2	
No. of ponds	Range	Median		
	1-19	2		
Pond type	Flow-through	Static	Refill	Mix
	23	2	1	1
Water Source	Stream	Springs	Well	River
	15	8	3	1
Pond site	Gentle slope	Flat ground		
	22	5		
Soil type	Clay	Loam	Sandy	Silty
	13	7	4	3
Main Purpose	Sale	Home use		
	15	12		
Experience(years)	Range	Median		
	1-5	3		

Table 3. Adoption of best practices (N = 27)

		Adopted?	
		Yes	**No**
i.	Pre establishment soil testing	4	23
ii.	Pond liming	19	8
iii.	Pond inlets/outlets	21	6
iv.	Pond securing	7	20
v.	Daily cleaning	10	17
vi.	Record keeping	12	15
vii.	Post harvest cooling	4	23
viii.	Prior-sale processing	11	16
ix.	Feed supplementation/ Improved fish feed	22	5

Table 4. Adoption of best practices based on calculated best-practice index

	N	Mean yield (g/m²)	Std Deviation
Low BPI	12	196.3	162.4
High BPI	14	449.5	240.6
Total	26	332.7	241.4

3.3 Best Practice Index and Yield

The best practice index was calculated based on the recommended smallholder aquaculture practices as explained by [15]. The practices included; soil testing before establishment of pond, liming, inlet/outlet for pond, securing pond, daily cleaning, record- keeping, refrigeration/cooling after harvest, processing prior to marketing and feed supplementation [15]. The practice was scored 1 if fully or partially done and 0 otherwise. Each interviewee' total was divided by a maximum possible score of 9 to generate an index for the individual farmers. An index equal or less than the median value of 0.333, was treated as low, an index higher than 0.333 as high for purposes of comparative analysis. Based on this categorization, twelve (12) of the interviewees had a 'low' best practice index, fourteen (14) had a 'high' index, and one interviewee had a missing score and was excluded from analysis. The overall mean pond yields for all the 26 farmers were 332.7 grams per metre square of pond (Fig. 3). A comparison of yields between low adoption of best practices and high is as illustrated in Table 4.

The fish pond productivity as measured by fish harvested per square metre was significantly higher for farmers with best practice index greater than 0.333 compared to lower; $t(24) = -3.088$, $P = .005$. The mean for low best practice index was 196.3±162.4, while the mean yield for the high best practice index was 449.5 ±240.6. The variances in yields within each category were quite high, as illustrated in Fig. 3, suggesting that apart from adherence to best practice there were many other factors at play. The high variations are probably due to the challenges cited by the farmers.

The higher productivity associated with 'high' best practice index is consistent with the argument by [17] that the adoption of technologies can aid in the growth of an aquaculture sector through greater farm productivity. The mean fish production per m^2 of pond was 0.332 ± 0.241kg. This finding is similar to the 0.31kg/m^2 reported by Farm Africa (2019) from a survey conducted in the same region. According to [10], tilapia can produce 1.2kg/m^2 pond under medium management practices. The current finding indicates that there is a huge gap between the current achieved yields and the existing potential.

3.4 Challenges Experienced by the Aquaculture Farmers

3.4.1 On-farm challenges

The data collection process had sought to establish at most three major challenges faced by each interviewee in aquaculture farming. The unstructured responses were analyzed to obtain broad categories on the challenges. Fish predators and fish-feeds related challenges had a high prevalence of 27% and 23 % respectively. The fish predators and feeds related challenges appeared to account for 50% of the challenges encountered by the farmers. The other challenges included insecurity/ theft, lack of fingerlings/ poor quality of the fingerlings, lack of marketing, siltation/ flooding challenges and lack of capital (Fig. 4).

The high prevalence of fish predators as reported by the respondents presents a similar scenario to that reported by [18]. According to the author, predation was a serious threat to fish farming; and in their study about 88% of the fish farms surveyed were affected by predators. The predators identified in their study were birds, crabs, snakes and frogs. Authors [15] recommended the use of low barriers around ponds and nets above the ponds to keep most predators away. The current study reveals that most farmers are yet to adopt this practice (Table 2).

The high cost of fish feed and associated poor quality was the second most prevalent constrain at 23%. This observation indicates that feed related challenges are a major constraint to fish farming in the area. High cost of feeds, its unavailability and low quality were similarly cited as major challenges in a study conducted by Shitote et al. [18] in western Kenya. Lack of fingerlings for breeding was also cited in their report, an observation with a prevalence of 11% in this study. Poor security was a factor too. Farmers reported a prevalence of theft/insecurity at 17%. Elsewhere in West Africa, high cost of recommended inputs featured in studies conducted by [19] and [20].The other challenge cited by the farmers was siltation and flooding of the ponds. It appeared in 7% of the comments. Siltation and floods affects the water quality [18] thus adversely affecting productivity of the fish ponds. Lack of capital had a prevalence of 4%, suggesting that some farmers were unable to access financial capital for the maintenance of the fish ponds.

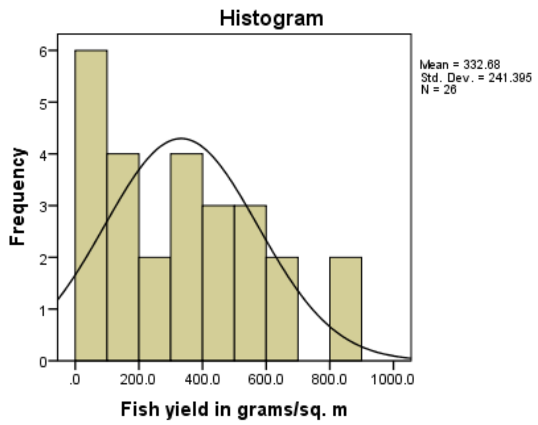

Fig. 3. Distribution of fish yields/m^2 of pond area

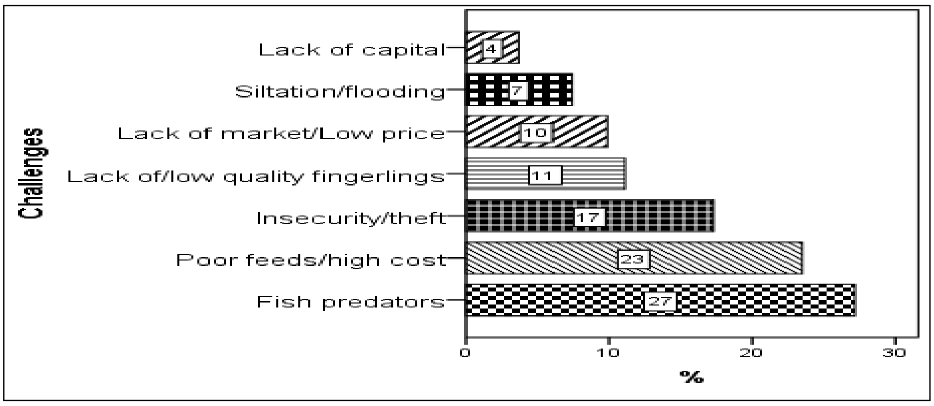

Fig. 4. Challenges as expressed by the producers

3.4.2 Off-farm challenges

Farmers' opinions were sought in regard to support factors such as market access, local demand for fish, access to technical information, quality feeds, profitability and external risks. The factors were tested against a hypothesis that there were no extreme opinions; that the median views were near neutral.

Market availability: The farmers' perception on market availability was measured on a 5-point Likert scale; from strongly disagree to strongly agree on a statement to the effect that market availability was a constraint to fish-farming. The hypothesized mean was 3 (neutral). A one-sample Wilcoxon Signed-rank test with a null hypothesized value as the cut point of 3 was run to test whether the observed values differed significantly from neutral. The observed median was not significantly different from the hypothesized (P > .05), suggesting that market availability was not a significant constraint in aquaculture (Table 5). It suggests that the farmers' responses were near neutral, neither strongly disagreeing nor strongly agreeing that market availability was a constraint. This observation suggests that markets were not a constraint to fish farming in the area. Similar findings were reported by [21], where 90% of participants in a study had ready access to markets.

Local demand for fish: The recorded perceptions of the farmers in regard to demand for fish in the locality was tested by Wilcoxon Signed-rank test against a hypothesized median of neutral (3). The Null hypothesis was rejected; the observed median was significantly greater than 3 (Z = 2.332, P = .020) as captured in Table 5. This suggests that the participants were in agreement that there was high demand for fish. This observation is consistent with the observation made earlier in this study that market availability was not a constraining factor in fish production. The observation is similar to that reported by [22] in a study conducted in Kibwezi, Kenya, where 81% of the fish was sold to local markets due to the prevailing high demand; a paltry 19% was sold outside the locality.

Access to technical information: On a five-scale rank of very poor to very good with a cut-point 3; meaning neutral, a one-sample Wilcoxon Signed-rank test, with a null hypothesis of a median of 3, the null was rejected (*P* = .005). The observed median was significantly higher than the hypothesized (*Z* = 2.830, *P* = .005), the observed median score was 4, indicating that overall aquaculture farmers had good access to technical information required for their routine practices. Studies elsewhere suggest that lack of knowledge and skills is widespread among fish farmers. Access to technical information was ranked first among problems faced by fish farmers in Papua New Guinea [20] and in Kibwezi, Kenya, a study by [22] found that farmers lacked the relevant know-how for their fish farm management practices.

Fish feed quality: Was fish feed quality a major constraint? To answer the question, the interviewees were requested to rate the quality of fish feed they used from 1 – very poor to 5 – very good, with a neutral value of 3. A one sample Wilcoxon Signed-rank test on the null hypothesis that the median of quality rating equals to 3, retained the null (*P* > .05). This indicates that there were no widespread extreme strong perceptions in regard to fish-feed quality. However, on the basis of the comments made by the farmers, as solicited through unstructured questions, the problem was experienced by some fish producers. Authors [18] reported that fish feed quality was a major challenge to fish farmers in the region. Elsewhere, author [3] reports that fish feed supply in Africa is generally erratic and unreliable; farmers are often unable to access the required quantity and quality when needed.

Aquaculture profitability: A one sample Wilcoxon Signed-rank test with a null hypothesis that the median opinion was neutral (3) failed to reject the null at 95% confidence interval. This observation suggests that there were no extreme views in regard to profitability of aquaculture. It suggests that in the view of the farmers, the profitability is neither low nor high. Indeed looking at the descriptive data, the profitability rating had a mean of 3.22, a median of 3.00 and a mode of 3. The implications of this are that aquaculture farming in the study area is viewed as neither profitable nor loss-making. From the 27 farmers interviewed, however, one farmer rated the profitability of the enterprise as very high, suggesting that there is potential for the enterprise to record high profits where constraints have been addressed.

Table 5. Significance of off-farm challenges

Variable measured (N=27)	Standardized test statistic (Z)	***P*-value**
Market availability	-1.051	NS
Local demand for fish	2.332*	.020
Access to technical information	2.830*	.005
Fish feed quality aquaculture	0.258	NS
Profitability	1.897	.058
Risk rating	3.255**	.001

NS – Not significant
** Significant at 5% significance level*
*** Significant at 12% significance level*

Risks in fish farming: On a scale of 1 to 5 the risks in fish farming as perceived by the farmers had a median of 4. This median was significantly higher than the hypothesized median of 3 (neutral) as tested by Wilcoxon Signed-rank test, suggesting that there was a widespread view of aquaculture as a risky venture. A descriptive statistical analysis showed that the distribution of the data did not show any Skewness or Kurtosis (>1.00) (*Skewness* = -.144, *Kurtosis* = - 0.377) and could therefore be subjected to a t-test. A one sample t-test with a hypothesized test value of 3, showed that the mean value was highly significantly higher than the hypothesized chance value of 3 (t (26) = 4.163, *P* = 0.000). Since risk is the subjective evaluation of a negative outcome [23], it can be viewed to adversely affect the implementation of technologies in aquaculture. Farmers who are risk averse generally lack the risk-taking behaviour. In the absence of risk-taking behaviour, adoption of technologies would be adversely affected [24]. The current study suggests that the fish farmers view the fish farming as risky. According to [25], risks in agricultural production systems can be classified into productivity risks and business risks. Whereas the former relate to weather and external factors that affect productivity, the latter relate to uncertainty due to variability in market prices, supply and demand. In light of the challenges cited by the farmers which include fish predators, insecurity/theft and low quality feeds and fingerlings, it can be argued that the farmers' major source of concern relates to productivity risks.

4. CONCLUSION

The study investigated the adoption of best practices among the aquaculture farmers and its implications on output and the challenges faced by aquaculture farmers in Kakamega County. The study concludes that the smallholder fish farmers are at diverse levels of adoption of technologies and management practices and continue to experience low yields from pond fish, with an observed average of 0.332 kgs per M^2 against a potential of 0.8 kgs per M^2. The challenges that adversely affect the productivity of aquaculture include the prevalence of fish predators, high cost of feeds; insecurity & theft and the lack of fingerlings or low quality of fingerlings accessed by the farmers. The study recommends concerted efforts by stakeholders to address the challenges both at farm level and at policy level. Training on risk management strategies for the small scale aquaculture farmers is recommended.

CONSENT

Consent for participation in the study was sought from each of the participants before commencement of the data collection. Each interviewee was assured that no individual names would be published.

TERMS

Adoption: In this article the term adoption refers to putting a recommended management practice or technology or an innovation into use.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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