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Aquaculture adoption among small scale fish farmers in Meru County, Kenya

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ABSTRACT

Information on level of adoption and factors influencing adoption of aquaculture among fish farmers is important as it indicates level of acceptability of the technologies and projects. Eleven parameters were investigated through a research survey in Meru County Kenya, over a period of three months (between August 2015 and November 2015). The aim of the study was to assess the level and the factors influencing the adoption of aquaculture technologies in the study area. Ninety (90) fish farmers and Ninety (90), who were not practicing fish farming were interviewed through a structured questionnaire in the study area. Descriptive and inferential statistical methods were used to analyze data. Binary logistic regression analysis revealed that, out of the eleven factors assessed, market availability, quality extension services, credit facilities and annual farm income significantly ($p<0.05$) influences the adoption of fish farming technologies in Meru County. The study concludes that the level of adoption of aquaculture technologies is high among the fish farmers in the study area. Finally, the study recommends that during planning process of projects, socioeconomic characteristics of a community are key for higher success rate.

Keywords: Adoption, aquaculture, extension services, aquaculture technologies, variables

INTRODUCTION

Globally, fish provides more than one billion people with a cheap source of daily animal protein (Bush *et al.* 2019). More than 250 million people globally depend directly on fisheries and aquaculture for their livelihoods and millions are employed in the sector in roles such as processing or marketing. Fish is the primary source of nutrition being an affordable animal source of protein in some of the poorest countries, creating growing demand for this staple. However, fish supplies are failing to meet demand and there are major shortages in some developing countries where they are needed most (Eric, 2015: Bush *et al.* 2019).

Generally, fish is food, controls diseases, is a source of income and employment (Jose, 2018). Fish is an important source of essential nutrients and micro - nutrients, omega - 3s fatty acids, cognitive to physical and mental health development in human beings (Jennifer 2018: Eric, 2015). According to (Shutter, 2018) fish consumption is associated with a lower risk of fatal and coronary heart diseases, reduces risk of Alzheimer's brain disease, decreases symptoms of depression, improves quality of brain, vision and eye health among others .

The amount of fish being captured in the wild globally leveled out from the 1990s and the State of World Fisheries and Aquaculture reports that 90.9 million tonnes of fish was captured globally in the wild in 2016 — a reduction of 2 million tonnes from the year before. In Africa, aquaculture production has stagnated at about 430,000 tonnes same period (Helga, 2010).

Oreochromis niloticus has for many decades been responsible for the global tilapia production from freshwater aquaculture and it accounts for about 83 % of total tilapia produced worldwide (Jose, 2018). It is the most preferred strain of tilapia due to its high feed conversion ratio (FCR), superior taste, big size for filleting, high demand and therefore is the widely grown farmed fish (Christopher *et al*. 2014) compared to other species. However, aquaculture's growth has slowed leveling out to 5.8 percent annual growth between 2010 and 2016, down from 10 percent in the 1980s and 1990s (Jose, 2018).

Despite the government of Kenya promoting aquaculture (fish farming) especially from 2009 to 2013 through the introduction of the famous Economic Stimulus Fish Farming Enterprise Programme, fish production still remains low in the country (Mary *et al.* 2014). Fish catch from Lake Victoria has been declining over time due to overfishing, ineffective management practices, hyacinth invasion, industrial and agricultural pollution (Jose, 2018).

A sustainable approach to aquaculture will help to protect our natural resources and ensure that fish stocks are available for future generations. Currently Aquaculture, in particular, has tremendous potential to enhance food security and be environmentally sustainable. Small-scale aquaculture is especially important for meeting the world's growing demand for fish. As fish farming require a smaller environmental footprint than other enterprises, aquaculture is a more environmentally sustainable option for meeting the world's food needs than other animal source foods (Jose, 2018).

The study therefore sought to fill the knowledge gaps by analyzing the level and factors that influence aquaculture adoption in the county. Investigation of the parameters is significant since it will lead to increase in fish production, incomes, food security, improving nutrition status of the residents..

MATERIALS AND METHODS

Determination of the sample size

The factors that influence the adoption of fish farming technologies were determined using interviews. From 2040 fish farmers who were supported through ESP (Economic Stimulus Project) in the study area, 180 respondents i.e (90 fish farmers who adopted and 90 fish farmers who did not adopt) the technology were interviewed. The sample size of 180 respondents was calculated using (Charan and Biswas, 2013) formula where,

$$\text{Sample size} = Z^2 P (1 - P)/d^2$$

Z^2 - Is standard normal variate (at 5 % type one error). In several studies, P values are considered significant below 0.05 hence 1.96 is used in the formula.

P = Proportion of the population in the study area engaged in active aquaculture = 2040 or 0.136 % of 1.5m

D – Absolute error or precision – 0.05

Substituting $1.96 \times 1.96 \times 0.136(1 - 0.136)/.05^2$

=180 Farmers

Selection of the respondents

Meru County has 9 Subcounties and the distribution of the fish farmers is as shown in (table, 1). Selection of the respondents was purely random (Mugenda and Mugenda, 1999). The number of farmers in each subcounty was coded according to the total number per subcounty. Pieces of paper were numbered according to the number of farmers and the desired number of farmers per subcounty drawn randomly from the list of farmers. Selection of the farmers who had not adopted fish farming was also done randomly in each sub-county.

Table 1: Population and sampling frame for the study

Subcounty	Population	Sample
Imenti South	318	14
Imenti Central	210	9
Imenti North	282	13
Buuri	117	5
Tigania West	293	13
Tigania East	296	13
Igembe Central	165	7
Igembe North	110	5
Igembe South	249	11
Total	2040	90

Data collection procedure

County deputy fisheries officer, 9 subcounty fisheries officers and 9 clerks were trained on how to fill the questionnaire after which each subcounty fisheries officer was issued with the desired number of semi – structured questionnaires to distribute to identified respondents in the field. Field visits to distribute and interview the respondents in the field was conducted using motorbikes by the officers and clerks. The interview was precluded by introduction and then answering of the questions by interviewees asked by the interviewer who recorded answers on the questionnaire in the field. A total of 180 questionnaires were used.

Level of adoption and factors influencing adoption

Logistic regression model by (Hardwick *et al.* 2015) was used to examine the factors influencing adoption of fish farming technologies in the study area. Primary and secondary information was used in the study. A survey was conducted in Meru County Kenya from August to November 2015 using a structured questionnaire. A total of 90 fish farmers who had adopted aquaculture and 90 who had not adopted were interviewed. Factors influencing adoption of fish farming were assessed using a logistic regression model. The dependent variable, adoption of fish farming was dichotomized with a value of 1 if a farmer was an adopter of fish farming and 0 otherwise as used by (Thangata and Alavalapati, 2003) to examine similar issues for various technologies in different areas.

The independent variables included, age of household head, gender of household head, marital status of household head, years of education, size of household, land size, annual farm income, market availability, credit availability, labour availability and quality extension services availability. Age of household head (AGH) was included in the model as a continuous variable measured in years. Age was hypothesized to be positively related to adoption of fish farming. Gender of household head (GHH) was recorded in the model as a dummy variable with 1 for male and 0 for female. It was expected that the majority of adopters of fish farming would be males perhaps because men mostly carry out construction of ponds while women do other tasks such as pond management. It was therefore hypothesized that gender would have a positive relationship to the adoption of fish farming technologies.

Marital status (MS) of the household head was included in the model as a dummy variable with 1 for those people who were married and 0 representing those who were not married. It was hypothesized that adoption of fish farming was positively related to marital status of the household head.

Years of educational (YOE) was categorized as a continuous variable with primary level, secondary level, college, university level and others captured as the highest level of education in years attained. Farmers with some education are able to process information and are open to new ideas. Educational status was therefore considered to have positive influence on adoption decisions. Number of dependants in a household, family size (SOH) was recorded as a continuous variable. Adoption of fish farming is expected to be positively related to family size. Farmers with large family are likely to adopt fish farming. They are expected to have enough labour compared to those with small family size.

Land size (LS) was recorded in hectares. It included all land available to the household. The larger the size of the land, the higher the chances that one would adopt fish farming. Land size was therefore hypothesized to have a positive relationship to adoption of fish farming. Annual farm income (AFARMI) was included as a continuous variable measured in Ksh per year. Availability of farm income (capital) increases the financial capacity of the farmer to venture into various capital intensive projects. Availability of farm income was therefore hypothesized to have a positive relationship with adoption of fish farming technologies in the study area.

Availability of a fish market (MAV) was recorded in the model as a dummy variable with 1 for availability of a fish market and 0 otherwise. Availability of a fish market was expected to influence adoption of fish farming technologies greatly as it acts as catalyst to fish farming. It was therefore hypothesized that availability of a fish market would have a positive relationship to adoption of fish farming in the study area.

Availability of credit facilities (CREA) was included as a dummy variable with 1 for availability of credit facilities and 0 otherwise. Provision of credit facilities was expected to enhance financial capacity of fish farmers. Availability of credit facilities was therefore hypothesized to have a positive relationship to adoption of fish farming technologies.

Labour availability (LA) was included in the model as a continuous variable measured in the number of labourers in a household. Labour availability eases the farmer's burden especially during fish pond construction, stocking, fish pond management, harvesting and marketing. Labour availability was thus hypothesized to have a positive relationship with adoption of aquaculture technologies in the study area. Quality extension services (QES) was recorded as a dummy variable with I if farmer has access to quality extension contact and 0 if the farmer has no extension contact. Uptake of new technologies is influenced by contact between extension staff and farmers due to information flow. It was hypothesized that quality extension contact is positively related to adoption of fish farming. The parameters in the model were estimated using the following equation (Hardwick *et al*. 2015)

$E(Yi) = \alpha + \beta_1 AGH + \beta_2 GHH + \beta_3 MS + \beta_4 YOE + \beta_5 SOH + \beta_6 LS +$
$B_7 AFARMI + \beta_8 MAV + B_9 CREA + \beta_{10} LA + \beta_{11} QES + \mathcal{E}_i$

Where Yi = dependent variable (adoption); α = constant; β_i = coefficients of each of the independent variables; $\mathcal{E}_i$ - error term.

Computation of the level of adoption resulting from every unit change in the value of each of the independent variables considered was conducted by computing the marginal effects of the logistic regression model using the formula margins, dydx(*)atmeans (Richard, 2017). Ranking of the factors was then carried out according to their importance.

Data analysis

Descriptive (mean, percentage) and inferential statistical methods were used to analyze data using STATA software package. Logistic regression analysis was used to examine the factors influencing level of adoption of fish farming technologies in the study area. Data was presented in form of tables and graphs.

RESULTS AND DISCUSSION:

Socioeconomic characteristics of the respondents

Socio-economic characteristics of the respondents showed marked variations after descriptive statistics of the variables were computed (Table 2). Average age of the household heads in the study area was 42 years. This average age compares well with other similar studies in aquaculture (e.g., Rozana, 2015; Ng *et al*. 2013; Ahmed, 2009; Omar *et al*. 2006). The Kenya National Bureau of Statistics (KNBS, 2010) gives an estimate of the proportion of population in 15 – 64 age group as 54.9 percent, which is higher than the computed figure in the current study.

The male headed households was 59 percent in the selected sample. This presents an averagely equal gender representation in the collected data. Other similar studies in the region used varied gender proportions (Ayandiji and Oke, 2016) 71.8 percent males and 28.2 percent females in a similar study in Nigeria. Gender is an important factor in aquaculture production (Obisesan, 2014). About 83 percent of the respondents were married in the study (Table 2). According to Olaoye, (2016), Ayandiji and Oke, (2016) marriage places family responsibilities on those who are married and for these responsibilities to be continually met, diversification of income generation activities are inevitable.

Most of the respondents in the study area had attained secondary education mean (10.30 years). Over 70 percent of respondents had gone past primary and secondary education. The Kenya National Bureau of Statistics, KNBS, (2012) gives a literacy rate of 53 percent in Meru County. Education influences respondents' attitudes and thoughts (Waller *et al*. 2008; Namara and Weligamage, 2013). Mean size of household in the study area was about 3 people. Kenya National Bureau of Statistics, KNBS, (2012) reports a labour force of about one person working for a household. Similar findings were reported by Okoruwa and Ogundele, (2006), Suleiman, (2013) in Nigeria.

Mean land size in the area of study was 2.38 acres (Table 2). Kenya National Bureau of Statistics reports a land holding size per household of 1.8 Ha for small scale and 18.25 Ha for large scale land owners (KNBS, 2012). Scarcity of land and increased population pressure result in intensification of production practices to increase land productivity of investments if intensifications are profitable (Margaret, 2015) and (Rozana, 2015).

The average recorded annual farm income in the study area was about Ksh. 20,077 (Table 2). Kenya National Bureau of Statistics (KNBS, 2012) reports that, about 20 percent of the household income in the county comes from self-employment mainly from the agricultural sector and wage employment. This figure compares well with the Ksh 20,077 recorded in the study area. Annual farm income acts as an important strategy for overcoming credit constraints faced by the rural households in many developing countries (FAD, 2013; Reardon, 2007). Annual farm income is reported to act as a substitute for borrowed capital in rural economies where credit markets are either missing or dysfunctional (Ellis and Freeman, 2004; Diiro, 2013). Employment and annual farm income are the twin decisive factors mostly used for determining the living standard of any community or region (Singha, 2012: Tapashi and Mithra, 2014).

About (90 percent) of the respondents had access to market in the study area (Table 2). Availability of market is crucial for any value chain or enterprise to thrive and stimulates production of any commodity since farmers produce with surety of selling their commodity to improve their livelihoods (Lowenberg, 2011; Peter, 2014).

About 46 percent of the respondents in the study area had access to credit facilities (Table 2). Access to credit promotes relaxation of the liquidity constraint as well as boosting of household's-risk bearing ability and startup capital is no longer a constraint (Mohamed and Temu, 2008).

Labour availability in the study area was about 22 percent (Table 2). Kenya National Bureau of Statistics (KNBS, 2012) reports that only 10 percent of the total population (about 135,630) are engaged for wage labour mainly in the agricultural sector in Meru County. High cost of hired labour, inputs, unavailability of demanded packages and untimely delivery are some of the main constraints facing most farmers in developing countries (Makokha *et al.* 2001; Ouma, 2006).

Table 2: Descriptive statistics of the variables

Variable	Mean	S.D.	Minimum	Maximum
Age of household head	41.46	10.93	19	61
Gender of household head	0.59	0.49	0	1
Marital status	0.83	0.38	0	1
Years of education	10.30	4.28	0	16
Size of household	2.80	1.67	0	7
Land size	2.38	2.12	0.5	12
Annual farm income	20077.78	21310.54	0	65000
Market availability	0.90	0.30	0	1
Credit availability	0.46	0.49	0	1
Labour availability	0.22	0.48	0	2
Quality extension service	0.50	0.50	0	1

About 50 percent of the respondents were accessing quality extension services in the study area (Table 2). Availability of extension information and dissemination is key to the success of any agricultural enterprise (Foster and Rosenzweig, 2010; Rab, 2011). Development programs should focus more on information dissemination, training and monitoring visits (Pillay, 2006).

Fish farming technologies adopted by farmers in the study area

The study revealed Six (6) types of aquaculture technologies are practiced in the study area (Table 3). The use of liner technology was popular (22.55 %) while extensive was the least adopted technology (6.82 %) (Table 3). In order of importance, Liner technology was therefore the most popular technology followed by monosex or all male Tilapia, then earthen, intensive, concrete and extensive was the least adopted technology (Table 3). Pond liners are applied where soils tend to be sandy and are not able to hold water for long. The preferred type of liners are those which are environmentally friendly, Ultra-Violet treated inorder to shield pond water from dangerous radiations. However in swampy and wetlands areas, liners are not applied.

Extensive culture technology was the least popular in the study area (Table 3), possibly due to the fact that, most fish farmers have abandoned the technology, embracing modern technologies which result in high yield of fish. In extensive culture technology, there is fertilization of pond water and fish are not fed. Fish production from such systems is very low.

Compared to other studies, (Emmanuel, 2013; Waidbacher *et al*. 2007: San, 2008) report that fertilization of pond water and supplemental feeding of fish in a pond increases fish production immensely compared to extensive culture technology where fish is not fed but pond water is fertilized. While Namara and Weligamage, (2013) add that, lining fish ponds using liners greatly conserves the water in ponds since there is no water loss through percolation and also water quality and cleanliness are improved. Black liners are preferred since they are good conductors and absorbers of heat and they also conceal fish from predators.

Table 3: Proportion of aquaculture technologies in the study area

Type of Technology	Percentage	Ranking
Intensive	14.25	4
Extensive	6.82	6
Liner	22.55	1
Concrete	13.24	5
Earthen	21.08	3
All Male Tilapia	22.06	2

Table 4: Determinants of adoption of fish farming technologies in the study area

Variable	Coefficients	S.E.	t-Test	p Values
Age of household head	0.074	0.062	1.200	0.232
Gender of household head	1.523	1.280	1.190	0.234
Marital status	0.655	1.145	0.570	0.567
Years of education	0.229	0.135	1.700	0.089
Size of household	0.344	0.368	0.930	0.350
Land size	0.027	0.186	0.140	0.885
Annual farm income	0.001	0.000	2.480	0.013***
Market availability	4.273	1.614	2.650	0.008***
Credit availability	3.327	1.173	2.840	0.005***
Labour availability	0.218	0.424	0.520	0.606
Quality extension service	3.425	1.344	2.550	0.011***
Constant	17.727	6.131	2.890	0.004

Note: ***Significance at 5 %

Table 5: Marginal effects of the Logistic Regression model

Variable	dy/dx	S.E.	t-Test	p -Values
Age of household head	0.019	0.015	1.200	0.231
Gender of household head	0.380	0.320	1.190	0.235
Marital status	0.163	0.286	0.570	0.567
Years of education	0.057	0.034	1.700	0.089
Size of household	0.086	0.092	0.930	0.351
Land size	0.007	0.046	0.140	0.885
Annual farm income	0.001	0.001	2.460	0.014***
Market availability	1.066	0.406	2.620	0.009***
Credit availability	0.830	0.294	2.820	0.005***
Labour availability	0.054	0.106	0.520	0.606
Quality extension service	0.854	0.328	2.600	0.009***

Note: ***Significance at 5 %

Determinants of adoption of fish farming technologies in the study area

Variables influencing adoption of fish farming technologies in the study area showed marked variations after analysis of the eleven socioeconomic characteristics of the respondents using logit regression analysis (Table 4). The Marginal effects (Table 4) shows that annual farm income, market availability, credit availability, quality extension services significantly (*$p < 0.001$*) influence the adoption of fish farming technologies in the study area. In order of importance, market availability had the strongest influence with a marginal effect of (1.066) followed by quality extension services (0.854), credit availability (0.830) and least was annual farm income (0.001).

Various authors have advanced different factors that influence adoption of aquaculture technologies in different parts of the world (Feder and Zilberman, 2008; Rab, 2011: Margaret *et al*. 2014) reported that extension services provide farmers with adequate and appropriate information in order to make better decisions and that helps them to optimize their use of limited resources. Fasikim, (2008) reported that extension services act as a major source for disseminating information to respondents especially the modern fish farming technologies and that poor extension service delivery is a serious constraint to aquaculture production.

Salau *et al*. (2014) reported that availability of credit facilities enables a farmer to invest more in farm production and hence improves his/her ability to procure improved technologies. Credit facilities can also transform small scale fish farmers to commercial farmers because startup capital is no longer a constraint to the small-scale farmers (Eze and Akpa, 2010). Access to credit has been reported to stimulate technology adoption (Mohamed and Temu, 2008).

The marginal effect of market availability indicates that farmers are more likely ($p < 0.009$, Table 5) to adopt fish farming with an increase in accessibility of market for fish and fish products. This may be attributed to surety of farmers of selling the harvested fish to earn income and consequently enhance the household welfare.

Compared to other studies, (Wetengere, 2008; Stanley *et al*. 2010) reported that fish farming technologies are acceptable if profitability arising from them is high compared to the existing practice. Provision of markets and cooperative societies or marketing groups can greatly influence the adoption of fish farming technologies (Ike and Roseline, 2007; Njankouawandji *et al*. 2012).

Provision of quality extension services marginal effect (*$p<0.009$*) indicate that with increased provision of quality extension services, fish farmers adopt aquaculture technologies more (Table 5). This could be attributed to the fact that, extension services quickly equip the fish farmers with new effective ways of increasing fish production. Provision of extension services possibly also increases fish farmer's confidence and trust in fish farming due to the close guidance and instruction by qualified extension agents. Farmers therefore identify easily with the extension agents increasing adoption rate of the fish farming technologies.

Compared to other studies, Pillay, (2006) and Rab, (2011) reported that development programs should focus more on information dissemination, training and monitoring visits as means of transferring technologies on fish farming. According to Ohajianya *et al*. (2007), factors such as extension educational contacts with fishermen, regularity of the contacts and provision of needed fisheries input are the main determinants for fishermen's adoption of technologies. Provision of credit facility ($p<0.005$) influence adoption of fish farming technologies (Table 5). Fish farmers are more likely to adopt fish farming technologies with increase in provision of credit facilities. This may be attributed to the fact that, provision of credit facilities greatly enhances the farmers' financial capacity to procure expensive inputs like liners and quality fingerlings. Most farmers' dilemma is the source of adequate capital for initiating meaningful enterprises. Empowering them financially raises their morale to produce and readily adopt to new technologies.

Compared to other studies, Margaret, (2015) reported that availability of credit facility strongly and significantly influenced the adoption of technologies in Kiambu, Kenya. Access to credit promotes the adoption of risky technologies through relaxation of the liquidity constraint as well as through the boosting of household's-risk bearing ability (Tapashi and Mithra, 2014). There is therefore need for policy makers to improve current smallholder credit systems to ensure that a wider spectrum of smallholders are able to have access to credit, more especially female-headed households (Koppel, 2008). This may, in certain cases, necessitate designing credit packages that are tailored to meet the needs of specific target groups (Muzari *et al*. 2013).

Kenyan government has started a program that offers free interest loans to youths and women (UWEZO fund) which has gone a long way in empowering women and enabling them to adopt agricultural technologies hence enhancing economic growth (Margaret, 2015). Truong and Yamada, (2008), El-Sayed, (2006) and Itejika, (2007) while investigating the factors that influence the adoption of fish farming technologies in Malaysia, reported credit facility availability as one of the main factors playing a key role in adoption of fish farming technologies.

The marginal effect of annual farm income also indicates that with increase in annual farm income ($p<0.014$), fish farmers are more likely to adopt fish farming (Table 5). This may be attributed to the fact that, availability of annual income increases a farmer's financial capacity for investing in the farm enterprises, land preparation and procurement of inputs. Annual farm income availability also empowers the farmers financially and reduces their over reliance on borrowed loans or credits from financial institutions. Due to the increased financial capacity and empowerment, the farmers are thus more willing and capable of adopting fish farming technologies in the study area.

Compared to other studies, Reardon *et al*. (2007) reported that farm income acts as an important strategy for overcoming credit constraints faced by the rural households in many developing countries. Farm income is reported to act as a substitute for borrowed capital in rural economies where credit markets are either missing or dysfunctional (Singha, 2012; Diiro, 2013).

CONCLUSION

1. Liner ponds, intensive culture, faster growing species, monosex (all male tilapia technology), were the most preferred modern aquaculture technologies in the study with liner ponds culture being the best preferred fish farming technology in all the subcounties.

2. Assessment of the level of adoption of aquaculture technologies and the factors influencing adoption showed marked variations. In order of importance, market availability, quality extension services, credit availability, and annual income were identified as the most important factors influencing the adoption of fish farming technologies in the study area with market availability being the most significant. Level of adoption of aquaculture technologies in the study area was thus high.

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Conflict of Interest

The author declares that there is no conflict of interest.

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