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Determinants of Aquaculture Productivity Among Small Holder Farmers in Bungoma County, Kenya

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Abstract

The world fish demand is steadily rising as result of low supply thus the need to intensively promote aquaculture. Concerted efforts by the Kenyan government and stakeholders have been in place to promote commercial aquaculture. However, despite the effort there is still a big gap between supply and demand. This was an explanatory study that sought to investigate the determinants of aquaculture productivity among small holder farmers in Bungoma County, Kenya. The study targeted a population of 428 households with ponds in the study area. Using Yamane formular, 207 households were sampled for the study. Sampling of respondents was through purposive, multistage and simple random techniques. A Cobb-Douglas production function was fitted into a stochastic frontier model and analyzed by means of Maximum Likelihood Estimation to determine the efficiency of aquaculture enterprise. Descriptive statistics on the other hand was analyzed through tables and graphs using SPSS. Generally, the study found out that aquaculture in Bungoma is largely semi-intensive in nature. Access to credit, scale of operations, resource support and availability of other sources of household income were found to be significant ($p<0.05$) predictors of aquaculture farming. Therefore, there is need to increase credit access for farmers as a way of mitigating for the lack of financial resources for investment.

Keywords: Aquaculture, farming, production, fisheries, productivity, driver

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Introduction

The world's population is on the rise, as is the demand for aquatic food products. At the same time, production from capture fisheries at the global level is leveling off most of the main fishing areas having reached their maximum potential (FAO 2000e). Kenya is endowed with large natural water resources: springs, wetlands, water reservoirs, temporary water bodies, lakes, rivers and coastal and marine waters (including the Exclusive Economic Zone, EEZ) providing a huge potential for not only the wild fisheries but also aquaculture development (GoK, 2009). Kenya's vast water resources favor the culture of a wide variety of aquatic species which include; tilapia, catfish, common carp, trout and ornamental fish (GoK, 2010). Kenya's fishing industry contributes about 0.5% of the national GDP and about 2% of the national export earnings (Kimani et al 2020). This is further validated by (KNBS, 2018) that fisheries sector contributed a modest 0.5% of Kenya's GDP in 2018. This is an unfortunate circumstance given the large water resources. This is partly due to the

inability of the country to exploit the marine resources, the fledgling of L. Victoria fisheries and the small scale and limited aquaculture development (FAO, 2012).

Aquaculture in Kenya is currently practiced at subsistence level with only a few commercial fish farm enterprises. In the past decade, aquaculture has been recognized as one of the flagship projects in Kenya capable of stirring the country's economy (Nyonje et al., 2018). This has contributed to the increase in aquaculture production in Kenya, which currently stands at about 18,000 tons annually (KNBS, 2020). While the contribution to fish supply from aquaculture remains low in comparison to that of fisheries, it has grown exponentially in the last decade (FAO, 2020). This increase in supply is due to the rapidly expanding tilapia farming industry, with countries such as Kenya leading the cage culture revolution on some of Africa's largest lakes (Kaminski et al., 2018; Njiru et al., 2018).

According to INNOROV 2023, Kenya's overall fish production was predicted to be 163.6 thousand metric tons in 2021, with aquaculture accounting for 2.7% of this total (Kenya Fisheries and Aquaculture Sector, 2021). Kenyan fish exports totaled USD 121.6 million in the same year, while imports totaled USD 203.9 million (Kenya Fisheries and Aquaculture Sector, 2021). The growing demand for fish and fish products in Kenya has contributed to a gradual shift from extensive to semi-intensive and moderately intensive aquaculture production systems (FAO, 2018). According to KNBS 2020, the production has gradually increased from 12,356 MT in 2017 to 18,542 MT in 2019 showing a significant advancement in promotion and adoption of strategies in the aquaculture value chain in Kenya. However, Kenya's vast water network favours the culture of a wide variety of cultured fish species and can be used for large scale production. Western Kenya, Coastal region, parts of Rift Valley, Eastern and Central Kenya regions have very high potential for aquaculture development (GoK, 2009). The regions are endowed with a lot of water resources that include springs, wetlands, oceanic waters, rivers, water reservoirs and the temporary water bodies.

Western Kenya has high potential in both fish production through aquaculture and ready market. This potential can be tapped to increase fish production through fish farming. According to Fish Farming Enterprise Productivity Programme ((FFEPP 2009-2014)), there has been a lot of effort both by the public and the private sectors to promote aquaculture as a means of ensuring food security through produce supply, employment creation and income generation among smallholder aquaculture farmers (FAO, 2021), Fish farming promotion has been based on suitability mapping report of 2009 which showed Bungoma County having a very high potential for aquaculture farming (GoK, 2010; FAO, 2021 in), Besides, farmers own initiative of constructing 103 private ponds other than the 325 ponds constructed in Bungoma Central and West Sub-Counties under the economic stimulus Programme attests to the potential of the enterprise. FFEPP document stipulates that the beneficiary farmers commit to construct at least one additional pond for sustainability and profitability. The achievement of this is yet to be assessed in detail.

Print and electronic media is full of information on aquaculture success stories yet very little are about western Kenya especially Bungoma. In regions such as Central Kenya, there are stories of commercialization, replication and export of aquaculture products yet aquaculture promotion began in western Kenya and has taken considerable time in the region before up scaling. It is paradoxical to hear of very little success stories from the region. The numerous interventions notwithstanding, there is still clear evidence that fish supply in Bungoma County is still low. This research was informed by the lack of such critical information with regard to the County and the need for sustainability of the interventions. This research work therefore had the intention to investigate the determinants of aquaculture practices among small holder farmers in Bungoma County, Kenya.

Methodology

The study was carried out in Kabuchai and Sirisia Sub-Counties currently known as Sirisia and Kabuchai Sub-Counties are among the 9 Sub-Counties that currently constitute Bungoma County. The choice of study area was deliberate given the convenience offered the study given its collective operations in extension services, operations as a single unit in the implementation of the Fish Farming Enterprise Productivity Program in phases, I & II. It has a total of 428 fish ponds.

A cross-sectional survey was carried out and a sample size of interest chosen based on the formula by Yamane (1967) from the population. Out of the total population 428 households undertaking aquacuturwe farming, 207 were sampled out for the study. The sample population for this study consisted aquaculture farmers in the two Sub-Counties (Kabuchai and Sirisia). which were purposively selected due to the convenience they provide based on their working together as a single administrative unit under the Economic Stimulus Programme as well as their coordination from a central point and the availability of consolidated data on the subject of interest.

Purposive sampling was used to target only aquaculture farmers in the study area. A list of farmer groups and individual farm households was generated and there after systematic random sampling used to select groups and individual households considered in the sample size. With regard to the choice of individual farmers or households, multi-stage sampling was done by use of area sampling starting with the choice of Ward, Location, Sub-Location and Village. Households included in the sample population were chosen by use of simple random sampling. A combination of semi-structured questionnaires and focus group discussions (FGDs) were used to collect data from the study participants. Data collected were checked for completeness and entries were fitted into computer for analysis.

Descriptive statistics was used to analyze the socio-economic characteristics of the farmers in the sample area which include age, incomes, education levels, farming/agronomic patterns/systems & practices as well as belonging to organized farmer groups. Input and output variables and the distribution of efficiency levels was also analyzed by use of descriptive statistics. The study employed use of percentages and frequencies. Regression analysis was done to identify predictors for aquaculture production at 95% confidence level.

Ethical approval to conduct the study was obtained from the university ethics committee and from Bungoma County Department of Agriculture, Livestock, Fisheries, Irrigation and Cooperatives Development. Consent was sought from the study participants who were also informed about the nature and purpose of the study.

Results

Socio-economic characteristics of aquaculture farmers

Table 1 socio-economic characteristics of aquaculture farmers. The characteristics analysed include: gender, household leadership, age, level of education, total land size, number of adults I households, number of ponds owned and sources of income.

More men than women are involved in aquaculture value chain. This is partly explained by the unwritten laws on land tenure within the community. Fish ponds are owned as assets of the household even though men largely carry the owner's tag. Women play a vital role in achieving sustainable development as reaffirmed by Agenda 2030 and the sustainable development goals, which makes commitments to ensuring women's equal rights and opportunities. Ramachandran et al, (2010) asserts that when an activity becomes commercially profitable, very often women doing the work are displaced meanwhile the solutions are piecemeal, and bigger issues involving property rights, advocacy and male-dominated monopolization of profit have not been given much attention. On household leadership, 82% of the aquaculture farming households are led by men which is in agreement with the gender findings. Families are men led and even where its women participating in an enterprise, it's men that are visible as household heads. Therefore, the dominance of men in household head position doesn't necessarily imply that they are the aquaculture farmers.

Among the farmers, 61% of the farmers are in the productive age range of between 36 and 55 years. The youth are either reluctant to involve in aquaculture farming or their access to natural resources including land is limited. The findings indicates that a majority (92%) of the fish farmers have formal education at different levels with only 23% having post-secondary education. Study notes that highly educated farmers are able to make efficient adoption decision and record a high adoption rate. The study suggests that most decision-makers have acceptable levels of formal education and have come forward to participate in fish-culture activities. The average land size among the aquaculture farmers is two acres which has to be allocated between competing enterprises

thereby limiting enterprise expansion. This has led to a majority (55%) of farmers having only one pond as the numbers continue reducing towards four ponds. The farmers have to supplement farming income with income from formal employment, businesses and non-formal employment.

Table 1: Socio-economic characteristics of aquaculture farmers (n=207)

Social -economic characteristic		Frequency	Percentage
Gender	Male	139	67.1
	Female	68	32.9
Household leadership	Respondents as household heads	169	81.6
	Respondents not household heads	38	18.4
Age	18-35 years	35	16.9
	36-45 years	62	30.0
	46-55 years	64	30.9
	>55 years	46	22.2
Level of education	No formal education	16	7.7
	Primary school	55	26.6
	Secondary school	89	43.0
	Post-secondary school	47	22.7
Total land size	<1 acre	108	52.2
	1-3 acres	68	32.9
	>3 acres	31	15.0
Number of adults	1 adult	55	26.6
	2 adults	93	44.9
	3 adults	54	26.1
	4 & above adults	5	2.4
Number of ponds	1 pond	113	54.6
	2 ponds	52	25.1
	3 ponds	23	11.1
	4 ponds & above	19	9.2
Other sources of income	Salary	38	18.4
	Business	88	42.5
	No formal income	81	42.5

Source: Researchers data 2021

Extension services and resource support for aquaculture farmers

Consistency in extension service provision and/or support given to farmers boost aquaculture farming. Table 2 shows findings on extension services as well as support with regard to aquaculture farming.

A majority of the farmers have access to extension services mostly from government institutions and supplemented by farmers to farmer extension as the extension messages are cascaded through learning. The findings also indicate that 66% of the farmers rely on their own resources to support the enterprise while 34% established the enterprise through resource support. The support given mostly by the government and development partners was in terms of pond construction and inputs such as pond liners and feeds. The findings also determined that only 29% of the aquaculture farmers have access to formal financing which is an indicator of the economic performance of the value chain or lack of tailored credit services in support of the enterprise.

Table 2: Extension services and resource support for aquaculture farmers (n=207)

Variable	Frequency	Percent
Access to extension services		
Accessing	182	87.9
Not accessing	25	12.1
Sources of extension service provision		
Government of Kenya (GoK)	66	31.9
Farmer to farmer	39	18.8
GoK & farmer to farmer	81	39.1
No extension	21	10.1
Resource support to agriculture		
Supported	70	34.0
Not supported	137	66.0
Type of support		
Input	21	10.1
Input & pond construction	166	80.2
No support	20	9.7
Aquaculture famers' access to credit		
Accessing	60	29.0
Not accessing	147	71.0

Source: Research data 2021

Factors affecting aquaculture production

Factors deemed to determine technical efficiency namely: fingerlings, feeds, fertilisers, labour, security, maintenance and cost of capital are shown in figure 1.

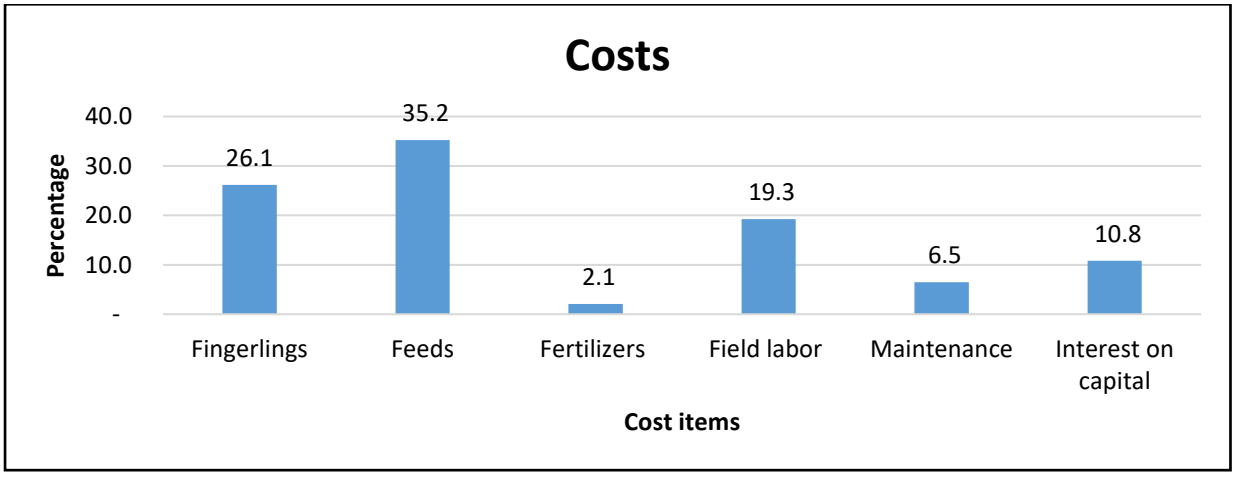

Figure 1: Analysis of costs of production
Source: Research data 2021

The study determined that feeds constitute the greatest cost in aquaculture farming and that economic viability lies in innovation around the feeding cost. The other costs include acquisition of fingerlings, field labor, on capital, pond maintenance and pond fertilization. To realize profits, the farmers have to innovate around the costs to increase efficiency while seeking cheaper sources of capital and labor.

Regression analysis was done to check on whether farm income, household leadership, level of education, resource support, gender, land size, access to extension services, access to credit, number of ponds, number of adults in household are predictors of aquaculture production (table 3).

Table 3: Factors affecting aquaculture production (n=207)

Predictor	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	64.174	9.454		6.788	.000
Level of education	-22.823	23.048	-.206	-.990	.323
Gender	-9.184	7.359	-.060	-1.248	.214
Access to credit	-26.611	8.164	-.169	-3.260	.001**
Access to Extension services	-8.166	10.700	-.037	-.763	.446
Number of ponds	18.813	7.555	.199	2.490	.014**
Land size	-2.046	9.099	-.018	-.225	.822
Household leadership	.343	8.909	.002	.039	.969
Resource support	-19.386	7.017	-.129	-2.763	.006**
Number of adults in household	39.566	24.667	.337	1.604	.110
Farm Income	6.946	.763	.494	9.103	.000**

**Significant at 95% significance level

Source: Research data, 2021

From the analysis, access to credit, number of ponds, resource support and other sources of farm income were found to be significant at 95% degree of confidence level. These corroborated with findings from focus group discussions. The respondents in the discussions agreed that the various forms of resource support were necessary for the enterprise. This support included pond construction, stocking and feeding. Most resource poor farmers were able to pick up the enterprise or opportunity due to the support. After economic stimulus, the County government of Bungoma has continued supporting fish farmers with inputs and this has put them afloat. In addition, farmers with more ponds were found to be more ready to adopt technology in pond management especially with regard to fingerling purchase and feed type. The discussions indicated that the number of ponds were a precursor to business acumen and risk attitude which are prerequisites for business development.

On the other hand, level of education, gender, access to extension, size of land, household leadership, number of adults in the household were found not to significantly ($p>0.05$) affect aquaculture production. From the discussions, the respondents' perception was that educated youth leave in search of better prospects while those remaining around were not keen on farming. Additionally, the methodologies and technologies in aquaculture were the same among the educated and the other members of the society thus no significant difference in output between the two categories. Gender of the farmers was also found not to significantly affect aquaculture output. During focus group discussions, the farmers observed that ponds are household assets and all household members are involved in the operations. The men own the land and have a say in enterprise selection, establishment or adoption but it is the women and youth who were involved in the farm operations.

Access to extension was thought to be of significant influence in aquaculture farming which was found not to be the case. The respondents emphasized, during the discussions, that there has been extension overtime and most farmers are knowledgeable in aquaculture practice. The farmers were aware of what needs to be done and even in the absence of government and private extension, they were able to consult with each other even in on a limited extent. Additionally, they elucidated that with a majority of farmers having a fair level of education, they were accessible to some resources from books, articles and internet that fill the vacuum of physical meeting with extension agents. On land size, the respondents in the discussions alluded to the fact that pond productivity remained the same for both small-scale and large-scale aquaculture farmers.

From the study findings, household leadership was found insignificant in relation to the

output. Many households were led by men. In the discussions, the respondents said that men were very active in the initiation stages of the enterprise adoption but later on adopted family ownership and management of the enterprises. Similarly, the number of adults in the household according to this study was found to be insignificant. The respondents observed that aquaculture is neither labour intensive nor a full-time business for the farmers thus the number of adults in the household does not affect output.

Discussion

In characterizing the production systems in the County, a number of parameters were looked at. The study established that the predominant system is semi-intensive owing to the management practice especially in feeding. Aquaculture in Bungoma was found to be a family venture although to a larger extent it's mostly men who are visible. This result compares favorably with Kimathi *et al.* (2013) who obtained a near similar gender spread for fish farmers in Kenya (72.7% males and 27.3% females). The findings are also in agreement with (KMAP, 2016) which found out that there are no cultural or traditional barriers to women's participation in aquaculture. However, women's participation is not at the same level as that of men. Fish ponds are owned as assets of the household even though men largely carry the owner's tag.

Women play a vital role in achieving sustainable development as reaffirmed by Agenda 2030 and the sustainable development goals, which makes commitments to ensuring women's equal rights and opportunities. Ramachandran *et al* (2010) assert that when an activity becomes commercially profitable, very often women doing the work are displaced meanwhile the solutions are piecemeal, and bigger issues involving property rights, advocacy and male-dominated monopolization of profit have not been given much attention. Moreover, many households were headed by men. This is in tandem with the community social structure in relation to access and use of resources. In as much as ponds are regarded as household assets, men tend to have an upper hand in decision making part of which may be attributed to land tenure system that is skewed towards men. Families are men led and even where it is women participating in an enterprise, it's men that are visible as household heads. Therefore, the dominance of men in household head position doesn't necessarily imply that they are the aquaculture farmers.

The study findings indicate that a majority (82%) of the fish farmers have formal education. The enterprise is dominated by the better educated in the society. Aquaculture may not be a new concept in Kenya, but in the study area, this statistic is in line with the stages of innovations adoption in extension informed by better or ease of understanding of extension messages, required resources for investment and the risk attitude necessary for the undertaking coupled with the ESP promotion. This is consistent with Rahm & Huffman (1984); Saha *et al* (1994) who established that highly educated farmers are able to make efficient adoption decision and record a high adoption rate. According to Ali *et al* (2010), education has an impact on aquaculture by assisting farmers to obtain and understand information about a technology. Osondu (2014) concurs that education enhances the acquisition and utilization of information on improved technology by farmers which tend to positively influence productivity.

According to study findings, over a half (54.6%) of the farmers own and manage single ponds, 25% own 2 ponds, 11% own 3 ponds and 9% have four ponds or more. The need to balance land use for the various enterprises given limited land access is reflected in the number of ponds per household in the study. The 52.2% of those with less than an acre nearly corresponds to the 54.6% who own single ponds. This trend indicates that those with more land tend to have a higher number of ponds as a trade-off between enterprises in relation to food security, income and nutrition.

Among the aquaculture farmers in Bungoma, 39% had no formal employment (were involved exclusively in farming of crops and livestock), 18% had formal employment where they drew salaries and 43% were engaged in business. This is supported by the findings of (Alam, 2009) that aquaculture enterprise in developing countries is majorly subsistent and is supported by other sources of income. Kwamena *et al* (2009) treatises that while some farmers operate fish farms as an independent enterprise, others incorporate fish farming as part of the portfolio of agriculture enterprises they operate such as crop and livestock production.

The study found out that the major costs in aquaculture in Bungoma are feeds (35.2%) and cost of fingerlings (26.1%). These total to 61.3% of operations cost or the cost of production. Thus, although aquaculture farming is technically efficient, there is room for improvement. The bottleneck for the desired status is in addressing input prices by availing quality inputs at a competitive price.

To improve on the production system, four factors were arrived at as having major impact on aquaculture production. These were: access to credit, number of ponds, resource support and other sources of income to the farm household. Access to credit is very vital in the success of the enterprise. This was in the line of acquisition of inputs and fingerlings being some of the major costs' components of production. Acquisition and proper utilization of credit for any agricultural purpose enhances the production capacity of a farmer. According to study findings, over two-thirds (71%) of famers had no access to financial services and this contrasts Kwamena *et al* (2009) who postulates that Kenyan fish farmers located in the Western province have a strong likelihood of using credit facilities for their fish farming activities. Furthermore, the government of Kenya encourages aquaculture development by offering credit facilities through the government agricultural finance institution, Agriculture Finance Corporation (AFC). Nevertheless, the level of credit use in fish farming is very low (Kaliba *et al.*, 2007).

However, inadequacy in extension services provision has been cited as a major challenge to development of fish farming in Western Kenya (Shitote *et al*, 2012). Also, Shitote *et al* (2012) reckons that inadequate outreach programmes and inefficiency in dissemination of technology transfer to farmers as well as a number of other challenges have contributed to the slow pace of fish farming in Western Kenya.

Conclusion and recommendations

From the study findings, access to credit, number of ponds, resource support and increased family income sources as the drivers for the desired production system and efficiency in the farm operations. Therefore, there is need to increase credit access for farmers as a way of mitigating for the lack of financial resources for investment. This can be done through encouraging community resource mobilization, grants to youth and women, increasing bank facilities for aquaculture farmers and government investment through donors, development partners and Programmes. Both the County and National Governments can introduce a subsidy option along the value chain nodes that would steer interest and adoption of the enterprise with efficiency considerations in focus.

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