

Original Research Article

Profitability and Viability Analysis of Aquaculture production in Central Uganda: a case of Urban and Peri-Urban Areas

ABSTRACT

Aquaculture sector if fully exploited has great potential of boosting foreign exchange, household nutritional and incomes levels. However, not much has been done in terms of economic analysis of aquaculture production to attract and guide investment. This study was carried out to assess the profitability and viability of the aquaculture enterprises in the central Uganda. The study focused was on the socioeconomic and production characteristics, profitability indices and major challenges experienced by fish farmers. The fish farmers were selected using simple random and purposive method from the farmer lists provided by Aquaculture Research Centre. A quantitative approach was adopted and in-depth interviews were conducted with individual fish farmers using structured questionnaires. A total of 53 individuals were interviewed. Interviews were carried out in Kampala, Mukono and Wakiso districts between the months of July and August 2015 using well structured questionnaire complemented with interview schedule. Data were analyzed using descriptive and inferential statistics based on equations of Gross margins (GM), Net farm incomes (NFI), Benefit Cost Ratios (BCR) and Return on investment (ROI). The results indicated that majority (86.8%) of the farms were owned by male aquaculturists. On the average, majority (84.9%) of the respondents' cultured tilapia as the major species. The farmers spent an average of US \$473 to construct a pond production area of 1108m². Operational costs accounted for 52.5% of the total production cost. The Tilapia and African Catfish culture periods lasted for 8 and, 9 months to attain an average body weight of 0.5kg and 1kg, respectively. A kilogram of tilapia and catfish were sold at an average of \$3.7 and \$2.6, respectively. The positive Gross margins (GM) of US \$1186 and \$1316 were recorded for attained among tilapia and Catfish enterprises, respectively. The Benefit Cost Ratio of 1 was realized by the fish farmers, with a payback period of 4 years and 5 months to recover money invested. The fish farmers are still faced challenges of expensive fish feeds and, water turbidity at sources (34%) due to increasing urbanization. The study recommended the need for farmers to re-organize themselves into cooperatives to collectively purchase inputs, train farmers in business management skills to run aquaculture as sole business entities, stocking of monosex tilapia for easy control of tilapia populations and efficient feed utilization to reduce on the current FCRs.

Keywords: Socioeconomic characteristics; Profitability; viability; indices; Aquaculture production; urban; peri-urban; Uganda

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1. INTRODUCTION

The fisheries sector that includes both capture and Aquaculture together contributes 1.2 % to the Uganda's Gross Domestic Product and 5% [11] to the agricultural gross domestic product. The sector generating revenue of about \$134.8 from fish and fish products [11], the sector employs about 1.2 million directly and 1.4 million people indirectly along the fish value chain (reference). Despite the fact that natural stocks of fish and shell fish are renewable, they have a limited carrying capacity which cannot be exceeded even under the best management practices, a situation that provides aquaculture with a privilege of being harnessed explored to bridge the current gap in fish supply [19]. The aquaculture production in Uganda has improved from a tune of 24382.5 in 1995 to 98,063 metric tonnes in 2013 [18] via from small scale producers, commercial farms and community stocked dams. The current increase in fish production has accelerated the country's contribution from 0.07 percent in 1995 to 0.33 percent 2014 within the Sub-Saharan Africa [11]. The rise in demand for fish protein sources is attributed to the rise in global population and consistently busier society that demand for healthier animal protein source. Previously the sector was dominated by traditional extensive culture systems, it is worth to note should be noted that pond production areas have improved and there is also increased investment in cage culture [15]. Aquaculture production volumes are expected to increase with the rise in fish prices, stagnating supply from capture fisheries, increased investment in cage culture and the current growing demand for food fish [10]. Uganda currently supplies fish and fish products in the country and to the neighboring countries particularly Congo, Rwanda and Kenya in form of technical expertise, feed, fingerlings and other aquaculture inputs, which calls for increased investment within the sector. Nile tilapia (*Oreochromis niloticus*) and African catfish (*Clarias gariepinus*) are the commonly cultured fish species. Nile tilapia is the predominant farmed species among fish farmers in Uganda due its prolific nature and good taste. However its growth and development has been somehow hampered by uncontrolled reproduction of mixed tilapia in culture system that has resulted into stunting that affects final sizes harvested. African Catfish (*Clarias gariepinus*) production is on the rise and popular among farmers especially in the Eastern region due to perfection in catfish breeding technology even among small scale hatchery operators [13]. The species has got great potential of addressing nutritional security and household incomes, based on the fact that the African Catfish is fast growing, has the ability to thrive on house hold organic waste for its growth [7]. The African catfish has been adopted at different levels of production that include hatchery level for seed production, grow out for table size and some fingerlings sold as baits for exploiting Nile Perch Fishery industry [8]. This particular species is also tolerant to harsh environmental conditions with ability to survive under low dissolved oxygen [7]. The adoption of the use of commercial quality feeds and, increase in stocking rates have seen relatively significant trend in aquaculture production. The above development aspects point to the need for profitability analysis of aquaculture enterprises was carried out with the purpose of establishing the feasibility and viability of aquaculture enterprises in Uganda. Economic analysis of aquaculture enterprises has not been explored apart from a few studies that include [5, 9] to guide aquaculture investment. The inadequacy lack of information on the economic performance of fish farming in Uganda hampers progress and development of the sector. As a contribution to the decision making during enterprise selection for investment and attracting potential investors within the sector, this study focused on 3 objectives namely; socioeconomic characterization of aquaculture enterprises, analysis of profitability indices and major challenges experienced by fish farmers in the peri-urban and urban area of Central Uganda.

2. MATERIALS AND METHODS

The study was conducted in the central Uganda. Permission to carry out the study was obtained from the relevant authorities at different levels of district local governments with guidance from fisheries officers) of the selected districts. A sample of 53 fish farmers were purposively selected from the three districts of (Kampala (6), Wakiso (20) and Mukono (27)) being the most populated districts in the country [21]. In Kampala district, the study covered 3 out of the 5 division areas namely Kawempe, Central and Rubaga). In Mukono district, the study covered the sub-counties of Naama, Goma, Kyampisi, Nakisunga and Ntenjeru Sub-counties. In Wakiso district, Sub counties covered included Wakiso Town Council, Budo, Nsangi, Nabweru and Kakiri. Identified the technique(s) used in drawing the sample size from the sampling frame.

Present the sampling frame showing the selected districts, sub-counties, sampling frame in each sub-counties and the sample size for each sub-counties.

A structured questionnaire complemented with interview schedule was used to interview respondents and obtain quantitative and qualitative data needed to explain the phenomena in the way they existed. Consent to conduct the interviews was obtained from farmers through telephone calls before the actual visit to their farms for data collection. Data collection involved face to face interview with farmer groups and individual farmers (farm owners, farm managers, spouses and chair persons of fish farmers 'groups). The collected data were as coded and entered into the excel sheet package 2010, and validated using the dropdown list to ensure consistency and check for errors. An equivalent exchange rate of 3400 Uganda shilling to an equivalent of \$ 1 US [22] was adopted for inputs and output costs involved in fish production in the Central Uganda. Results were calculated based on average production area of 1108m² of both Catfish and Tilapia enterprises. The collected data were as analyzed using descriptive statistic and pseudo-profit function, statistics and results presented as averages and frequencies depicting socioeconomic, production characteristics and major challenges affecting aquaculture production. Inferential statistics were analyzed using costs and return analysis equations [16, 4] presented below.

Model specification

$$\text{Profitability } (\pi) = TR - TC \quad (1)$$

Where: TR=Total Revenue (US\$); TC=Total cost (US\$); and.

The And Total Revenue (TR) was calculated using price (P) multiply by the *qQuantity of fish harvested (Q)

$$\text{Gross margin } (GM) = TR - TVC \quad (2)$$

Where: TVC=Total variable costs

$$\text{Net Farm Incomes } (NFI) = GM - TFC \quad (3)$$

Net farm incomes refer to a measure of return to operator's equity that can be distributed among 4 principal factors of production that include land, Labor, capital and management

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Comment [S2]: This technique is unscientific. It should be calculated on the basis of cost of production i.e either kilogram, quintal or ton.

Comment [S3]: NFI = GM-TFC

[4]. Where TDC= Total depreciated costs. Where fixed costs of the farm assets (ponds, seine nets, predator nets and water pump) were depreciated using the straight-line method over equipment economic life [3].

$$\text{Depreciation of fixed cost} = \frac{\text{cost of equipments}}{\text{salvage life}}$$

Benefit Cost Ratio of the aquaculture enterprises was adopted in this study to determine economic viability of aquaculture enterprises in the long run, and an interest rate of 23% levied on loan attained by individual borrowers from commercial banks [12] was adopted for calculation of a discount factor, used to discount both the benefits and costs. Benefit Cost Ratio analysis enables us determine the financial worthiness of investment in the aquaculture sector via vise other sectors?? Benefit cost ratio is not meant for cross-sectional data both rather time series data. Read more on the application of B/C ratio. The interest charged on loan if for operational item should be captured under TVC while the one charged for capital items should be captured under TFC.

Discount factor (DF) = $\sum_{t=1}^n \frac{1}{(1+r)^t}$, Where DF is the discount factor, R = interest rate and n is the time lag.

$$\text{Discount factor} = \frac{1}{(1+r)^t} = \frac{1}{(1+0.23)^1} = \frac{1}{1.23} = 0.81$$

Benefit Cost Ratio (BCR) equation

$$BCR = \frac{\sum_{t=1}^n \frac{B_t}{(1+r)^t}}{\sum_{t=1}^n \frac{C_t}{(1+r)^t}} \quad (4)$$

Where BCR is the Benefit Cost Ratio, B_t is the sum of the discounted benefits, C_t is the sum of the discounted costs

Return on dollar Investment (ROI)

$$ROI = \frac{GM + TVC}{\text{Investment}} \quad (?)$$

GM = gross margin, TVC = total variable cost

Rate of Return on Capital Invested (RORCI)

$$\text{Return on Investment (ROI)} = \frac{NFI}{TPC} \quad (5)$$

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Where NFI=Net farm incomes, TPC=total production costs

2.3 Study Area

The study covered a total of 53 fish farmers from the Victoria basin (table 1) located in the central region, with focus on urban and peri urban areas of Kampala, Wakiso and Mukono districts. The selection of these districts was based on the fact that central region has the highest recorded number of fish farmers and rapid population growth National wide [15, 22]. The study targeted farmers actively engaged in fish farming. In Kampala district, the study covered 3 out of the 5 division areas namely Kawempe, Central and Rubaga). In Mukono district, the study covered the sub-counties of Naama, Goma, Kyampisi, Nakisunga and Ntenjeru Sub-counties. In Wakiso district, Sub counties covered included Wakiso Town Council, Budo, Nsangi, Nabweru and Kakiri.

3. RESULTS AND DISCUSSION

3.1 Results

3.1.1 Socio-economic characteristics of fish farmers

Of the respondents interviewed, 47.2% were farm owners while 43.4% were farm managers. In addition, were 4 fish farmer group leaders (7.5%) and 2% who were female spouses to farm owners. The study observed that Mukono and Wakiso districts had the biggest numbers of fish farmers (47%) due to accessibility to water sources and relatively adequate land for expansion, compared to Kampala where farmers are limited by increased urbanization rates that directly affects production. On average 83% of the farms were functional, the nonfunctional farms as indicated in (table 1) were also taken into consideration to provide insights on the challenges that had pushed the farmers out of business. The study established that 86.8% of the farms visited were owned by men. However, the study revealed that both genders (males and females) involved in aquaculture business were still struggling with poor profit margins due to high costs of production. the low levels of women participation in aquaculture production was attributed to limited access to land, high interest rates on agriculture loans that has affected the up scaling of aquaculture production in the central Region. However if men and women are organized under cooperatives under the fish value chain, they can collectively purchase inputs to cut on production costs. About 46% percent of the farmers had attained tertiary level of education. These farmers had more than 10 years' experience in aquaculture production, showcasing the importance of aquaculture sector in providing livelihood options to both rural and urban population. 50% of the respondents of age group 40-60 actively engaged in aquaculture production.

Comment [S5]: These results did not tally with the results presented in Table 1. Cross-check.

Table.1: Socio-economic characteristics of respondents

Gender	Percentages	Educational level	Percentages
Male	86.8	Primary	13

Female	13.2	Certificate	46
Age		Diploma	4
≤39	33.3	Degree	35
40-60	52.1	None	2
61-80	12.5	Farm status	
≥81	2.1	Functional	89
Farm ownership		Non Functional	9
Group	8	Under Renovation	2
Family	38		
Sole proprietors	55		

These are characteristics that define fish farmers in the central region

3.1.2 Production characteristics of aquaculture enterprises

Farmers practiced monoculture that included the raising of a single species in the production systems, and those who practiced polyculture included catfish and tilapia as the main cultured species. Tilapia (*Oreochromis Niloticus*) emerged as the most cultured species among the fish farmers. This particular species is a delicacy among Ugandan households as influenced by predominance of supply from capture fisheries. However with the decline in wild stocks this fish has been widely adopted among fish farmers due to its ready market within Uganda and her neighbors particularly Congo, Rwanda and Kenya. **Seed supply is still limited to the main research Centre in the country and the few hatchery operators.** 48% of the farmers sourced their seed from Aquaculture Research Centre, 36% from fellow farmers, 4% from farmers' own hatcheries and 12% farmers that got their seed supply from the wild. There is need to satisfy all the seed suppliers in the country and ensure that the regional fry Centre are operational to ensure that farmers are in position to get quality seed to sustain production. **These results are not in tandem with the results presented in Table 2. Cross-check!**

Fish farmers utilized available water sources that included springs (40.4%) were the major source of water for aquaculture production, followed by underground water 23.1% while 36.5% accounted for streams, swamps and public National water. Majority of the farmers (60%) had clear water at source while 34% farmers reported turbid water at source particularly in major towns of Mukono and Kampala. Respondents attributed the poor water quality to rise in construction of commercial and residential areas which render the land open and without sufficient vegetation cover to check run-off from rain. **??????????????????** **Cross-check Table 2!**

Fish feeding, 50% of the respondents fed their fish on commercial complete diets that included floating, sinking and powdered feeds purchased from local companies like Ugachic, Aquaculture Centre, and other small feed mixers like Nsava Feeds in Mukono district (table 2). Besides using commercial diet, 48% of the farmers practiced on farm feed mixing which included a combination of ingredients with nutrients required for optimum fish growth. Other farmers improvised with plain maize bran (by-products) and green vegetables which had

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negative effects on the final body weight gain due to lack of adequate nutrients. In extreme instances of trying to avoid cost of feeding fish, the study found that 3% of the farmers were not feeding their fish. [Cross-check Table 2!](#)

Table 2: Production characteristics of Aquaculture enterprises

Culture Systems	Percentage	Culture practices	Percentage
Ponds	84.9	Monoculture	57.1
Tanks	7.5	Polyculture	42.9
Reservoirs	7.6		
Culture species		Feed utilization	
Tilapia	77.4	Commercial feeds	49
Catfish	18.9	On farm mixing	48
Others	3.7	Not feeding	3
Water sources		Feed sources	
Under ground	49		
Rivers	48	Ugachic	65.4
Swamps	12	Kajjansi center	13.5
Others	9	Small feed mixers	19

3.2: Production costs for tilapia and catfish enterprises in Central Uganda

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Operational costs accounted for 52% of the total production costs. The costs included seed, feed, labor, organic fertilizers, and lime as a disinfectant among others (table 3). Among the fish farmers interviewed, average stocking densities ranged between 3081 for tilapia fingerlings and 2456 fingerlings for catfish for an average production area of 1108m² fish farmers used an average of 210.1 kg of commercial feeds to feed their fish up to table size. Farmers also fertilized ponds in order to induce growth of natural food for fish while cutting costs of money spent on purchasing complete diet feeds. Tilapia took an average of 270 days culture period to attain 0.5kg average body weight, African Catfish took an average of 240 days culture period to attain average body weight of 1.5kg. On average of 130.2kg of organic manure was used for pond fertilization. Lime is applied in a pond before stocking to improve the quality of water and to eliminate eggs of wild fish that can contaminate the preferred stock for rearing these farmers also used an average of 107.5kgs of lime.

Depending on the size of the pond area, farmers employed an average of 2 workers responsible for production and 1 casual laborer responsible for general management of the farm at a cost of US \$59 per month. Additional labor of 4 people was hired during harvesting and general farm maintenance and paid an average wage of US\$10 per day per person depending on the work load (table 3). For general maintenance of the fish farm, assorted tools used included wheel barrows, slashers, spade and hoes, fixed costs included pond construction, seine nets, predator nets and water pump for the farmers whose ponds could

not drain by gravity or easily receive water. These costs accounted for 47.5% of the total production costs. Majority of these ponds were constructed between 1994 and early 2014. Fish farmers in Kampala and Mukono districts owned an average of 4 ponds, while those in Wakiso district had an average of 3 ponds for fish production. Farmers spent an average of US \$472 to construct a pond of an average size of 1108m² (Table 2). These construction costs varied depending on the site location and the technology used. The application of excavators for pond construction was considered faster and efficient although relatively expensive compared to manual labor. Farmers who utilized tanks for fish production adopted circular concrete and plastic tanks. Concrete tanks were widely adopted for seed production. Only 2 farmers were utilizing plastic tanks of 1000 liters for grow out fish in Kampala district. , farmers owned 4 tanks with an individual tank costing US\$100 for table size fish production especially in Kampala, however, it should be noted that this particular system comes with a number of water quality management challenges that affected fish growth and therefore farmers should seek more knowledge before investing in this type of technology. Farmers owned an average of 5 predator nets valued at US\$713 for controlling predators such as birds, otters and snakes. Depending on the pond area to be shielded predator nets the cost can be high. As a measure of cutting costs, some farmers were using strings which they tied across the ponds to keep away predator birds. The respondents owned at least one seine net valued at US\$399, and 1 water pump costed at \$ US391. Pond construction, seine nets, predator nets and water pumps costs were depreciated using their salvage life of 5, 2, 4 and 2 years respectively.

Table 3 Investment costs for Tilapia and catfish farms crop yr.2015

Variable costs	Unit cost	Average costs(US \$)	Percentage cost
Tilapia (price)	0.06	205	10.9
Catfish(price)	0.09	235	12.5
Feed (kg)	1	211	11.3
Regular labor	5958.9	177	9.4
Fertilizers (kg)	0.064	8	0.4
Lime (kg)	0.25	27	1.5
Additional labor	9.5	38	2.0
Assorted tools	55	55	3.0
Transport (Feed + seed)	27	27	1.4
Total variable costs (TVC)		984	52.5
Depreciated capital			
Pond construction (m ²)		94	5.0
Seine Nets (pcs)		199	10.6
Water pump		98	5.2
Predator Nets		356	19.0

Maintenance costs	142	7.6
Total depreciated Capital	890	47.5
Total Production costs (TVC+TDC)	1874	100.0

All the fixed costs in this table were depreciated using asset value and salvage life. Official exchange rate used: 1US\$ = US\$3400

The costs and returns estimates should be on per unit area or per unit of output and not the average taken since farmers endowment differs. Therefore, this result is unscientific.

3.2.1 Profitability analysis of tilapia and catfish production

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A comparative analysis was done for Catfish and tilapia production using 15 fish farms that provided comprehensive input and output data. These farmers harvested an average of 706.1kgs of tilapia and 869kg catfish from monoculture pond production size of 1108m² (table.2). Operation costs of fingerlings, fish feeds and labor constituted the largest share of the total costs production. And the fixed costs included pond construction costs, seine nets and predator nets which accounted for 48% of the total production costs. Harvest were smaller as compared to total production areas as indicated in (table 3). An average of 41% of the respondents sold their fish at farm gate level targeting both individual consumers and regional traders who picked fish from the fish farms using their own trucks, 3% of respondents sold their fish at trading centers. Fixed costs were depreciated spread over a period of time depending on asset value and average salvage life. Positive gross margins of US \$1186 among tilapia and US \$1521 among catfish producers for average production area of 1108m². A positive gross margins and net farm incomes were highly influenced by quantities of fish marketed and fish prices (table 3). A BCR of 1 was realized among catfish and tilapia farms which was influenced by farmer commitment to fish farming and better management skills in terms of stocking quality seed and giving fish quality feed. Although the return on investment were miger for every shilling invested (table 4). Farmers were expected to produce 533.2kgs of Tilapia and 630kgs of catfish for their enterprises to recover production costs without making profits neither losses. And at low quantities of fish (tilapia) produced farmers were expected to sale their fish at relatively higher prices to break even. Payback period of aquaculture enterprises were calculated based on initial investment capital /estimated annual net cash flows. A Payback period of 5.1 years and 4.4 years was expected for tilapia and catfish recover the initial capital invested as indicated in (table 4), and it should be noted that a short payback period is the most desirable.

Table-4 Profitability analysis of tilapia and Catfish enterprises crop year 2015

Parameters	Tilapia(Ushs)	US \$*	Catfish(Shs)	US \$*
Yield (kg)	706.1	706.1	869	869
Price (Ushs)	10450	3	9000	2.6
Total Revenues (sales)	7378745	2170	7821000	2300
Total variable costs (TVC)	2547231	984	2648161	779

Depreciated capital (TFC)	3,025,574	890	3,025,574	890
Total costs (TPC)	5,572,805	1,874	5,673,735	1,669
Gross Margins (TR-TVC)	4831514	1186	5172839	1521
Net farm Incomes (GM/DFC)	1805940	531	2,147,265	632
Discount factor (DF)	0.81	0.81	0.81	0.81
Discounted total costs (DTC)	6,880,006.2	2313	7004611.1	2060
Discounted Benefits (DGM)	5964832	1465	6386221	1878
Benefit Cost Ratio (DB/DC)	1	1	0.9	0.9
Payback period(I.I cost /Net cash flow)	5.1		4.4	
Return on investment (NFI/TPC)	0.32	-	0.4	0.0001
Break even yield (TPC/PX)	533.2	533.2	630.4	630.4
Break even price (TPC/Yield)	7892.3	2.3	6529	1.9

299 All the fixed costs in this table were depreciated using asset value and salvage life exchange
300 rate of 3400 (Ushs) = \$ US 1 was adopted (Bank of Uganda 2016).Initial investment cost
301 (IIC) used to calculate payback period. [????????????? Unscientific results.](#)

302 3.3 Major challenges

303 Various challenges were experienced by famers during fish production and mainly included
304 high cost of feed, predators and lack of technical advice as indicated (figure 1). Expensive
305 fish feeds and lack of satisfaction about the quality of feed on market forced farmers to mix
306 their own feed, a common practice borrowed from poultry producers. However with the
307 establishment of other feed processing companies farmers were optimistic that feed prices
308 can go down without compromising the quality. Predators like oaters, snakes, birds, monitor
309 lizards' ae still a major challenge to fish farmers contributing to economic losses especially
310 fry level. Based on the fact that the level of adoption of use of predator nets is still low
311 among fish farmers attributed to high costs involved.as most of the farms were located in
312 urban and peri urban areas, 5.7% farmers experienced seasonal drying of ponds. Although a
313 few of the farmers had constructed water holding reservoirs for desilting and holding water
314 during dry season. It should be noted that Water quality management challenges resulting
315 from increased urbanization rates, rise in temperature puts the sector at threat. Lack of
316 technical advice especially during pond construction and actual production was one of the
317 challenges experienced by the farmers. Some of the ponds were wrongly sited within
318 swamps, and in places with limited access to water. These ponds could neither access water
319 or drain by gravity which led extra water pumping costs, some of the ponds were too wide
320 and very deep which made fish harvesting and predator control very difficult, and some were
321 more prone to floods that results into fish losses. Other challenges included expensive labor,
322 small sized fish at harvest especially among small holder farmers that affected marketing
323 and also competition from the fish from the wild which can be overcome through value
324 addition. [This is not how to report research article. Report what are in your results and not](#)
325 [story telling](#) .

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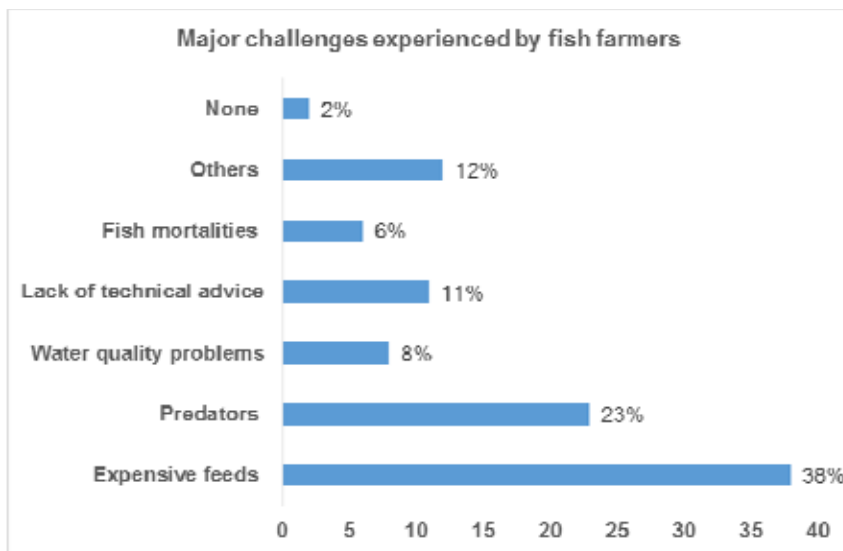


Figure 1. Challenges experienced by fish farmers

4.0 Discussion

Majority of Aquaculture farmers had attained some level of education certificates (table 2), which is advantageous to the sector in terms of quick information dissemination, technology uptake and record keeping. Trailing very close to the The farmers with certificate were farmers who under this study had tertiary level of education which compares with fish farmers in countries like Nigeria?? [1, 16] implying that fish farming is increasingly attracting farmers above basic level of formal education. Farmers' high level of education puts them at an advantage of understanding and correctly interpreting agriculture information, share business ideals and network. A few women were actively engaged in aquaculture production (table 2) and much more involved in feeding and harvesting. These disparities could be attributed to the gender roles assigned by our cultures where women have no land own ship right to set up long-term investment [1]. Such disparities have implications on household income, food security because women are major determinants of daily household food consumption. The women's role in aquaculture value chain must be fully recognized to streamline their financial independence, empowerment and equality.

Pond based culture model has been widely adopted for fish culture in the central region since majority of the fish farms were constructed between 1994 and 2014. The study observed increase in pond production area to averages of 1108m² in the Central Region as compared to the 200m² pond sizes reported in 2001 [15]. Tilapia was the most cultured species influenced by the local demand and consumer preferences for this particular species. Commercial culture of African Catfish in the central region is affected by cultural, religious beliefs and morphological makeup of this species that makes consumers shy away from catfish consumption. However it should be noted that this particular species is fast

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growing, has the ability to forage on any household organic waste and thrive under harsh environmental conditions [7]. Therefore there is need for training farmers on product development and value addition of the African catfish in form of smoked ready to eat products, fish fillets to increase its consumption. The study noted variations in stocking densities among fish farmers which seemed undefined, this calls increased information dissemination for farmers on appropriate stocking densities. Inappropriate stocking densities affects proper fish growth, prolongs culture period which affects returns on investment in form of extra feeding costs with no significant weight gain [12, 6]. Furthermore, the long culture periods tie up working capital that could be invested in a more productive way. This also calls for farmer's willingness to switch to faster growing fish strains to obtain better growth within shorter culture period [3] in combination with feeding fish on a quality diet. Operation costs of feed, fingerlings and labor accounted for the biggest percentage of the total production costs as indicated in (table 4) which are similar to the findings reported by [8,16].

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Whereas aquaculture enterprises can be profitable, their economic viability may not be sustained in the long run. An understanding of input and output indices is therefore important in guiding enterprise selection during investment decision making. A positive gross margin and net income was observed among the tilapia and catfish farmers although there were meagre returns depending on the initial investment costs and the payback period required to recover money invested (table 4). A Benefit Cost Ratio equal to 1 was observed among Catfish and tilapia producers implying that the present value of benefits were equal to the total present value of costs [20]. Farmers do not only need to breakeven in any agriculture business for that particular period of time but also sustainably manage enterprises to recoup all money invested [3]. Farmer profits in this study were affected by the high operation costs that included expensive feeds (table 3) which is in agreement with the findings of [5,23]. High cost of feed is a persistent challenge for fish farmers especially in sub-Saharan Africa as highlighted by various studies in Uganda [5,25], Kenya [27] and Nigeria [24,26 and 24] and can be addressed through research into cheap alternative plant protein sources to replace expensive fish meal. The poor returns on investment observed were a result of small yields due to underutilization of total pond production areas. None the less, appropriate stocking densities, water fertilization and efficient feed utilization are vital for increased fish production. The results that suppose to yield these discussion are faulty/unscientific

4. CONCLUSION

Aquaculture enterprises in the central region are predominately owned by males, with some level of education training. Catfish and tilapia production was profitable and economically viable based on the sample of (15) farmers who provided sufficient data. Challenges experienced by the farmers included expensive fish feeds, water management challenges attributed to rise in urbanization rates, and lack of technical advice required for general farm management. Therefore as the industry grows, the study recommends the need to avail a cheap but efficient feed to the farmers through continuous research on cheap alternative protein sources, dissemination of information on specific fish feed management that can result into better Feed Conversion Ratios (FCRs) to cut on the current production costs per unit fish produced. There is need for government to certify all seed suppliers and extension service providers to deal with the problem of quacks within the industry, this will guarantee quality and protection of fish farmers. Training of farmers in business management skills and record keeping to efficiently manage their portfolios and their enterprises. As the

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temperatures rise and population continuously grow, there is need to invest into research of different effluent re-use technologies that are water and land saving to sustain the existence of the industry. [??](#)

COMPETING INTERESTS

Authors have declared no competing interests.

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