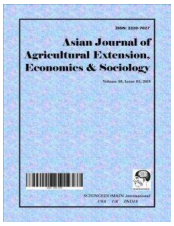

Asian Journal of Agricultural Extension, Economics & Sociology

22(4): 1-11, 2018; Article no.AJAEES.37721
ISSN: 2320-7027

Profitability and Viability Analysis of Aquaculture Production in Central Uganda: A Case of Urban and Peri-Urban Areas

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Authors' contributions

This work was carried out in collaboration between all authors. Authors NS, AG, OL, WR, CA, OS and AAI designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors NS, AG and BM managed the analyses of the study. Authors NS and AG managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJAEES/2018/37721
Editor(s):
(1) Mehmood Ali Noor, Chinese Academy of Agricultural Sciences, Institute of Crop Science, Key Laboratory of Crop Physiology and Ecology, Ministry of Agriculture, China.
Reviewers:
(1) M. S. Sadiq, Swami Keshwanand Rajasthan Agricultural University, India.
(2) Doaa Mohamed Atia, Electronics Research Institute, Egypt.
(3) A. A. Girei, Nasarawa State University, Nigeria.
(4) Borislav Kolaric, Serbia.
Complete Peer review History: http://www.sciencedomain.org/review-history/23391

Original Research Article

Received 26th October 2017
Accepted 9th February 2018
Published 3rd March 2018

ABSTRACT

Aquaculture sector if fully exploited has great potential of boosting foreign exchange, household nutritional and income levels. However, not much has been done regarding 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 central Uganda. The study focused on the socioeconomic and production characteristics, profitability indices and significant challenges experienced by the fish farmers. The fish farmers were selected using simple random and purposive

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method from the farmers' lists provided by the Aquaculture Research Centre. The study was carried out in Kampala, Mukono and Wakiso districts between July and August 2015 using well structured questionnaire complemented with interview schedule. The collected data were analysed using descriptive statistics and pseudo-profit function. The results indicated that male aquaculturists owned the majority (86.8%) of the farms. On the average, a majority (77.4%) of the respondents' cultured tilapia as the primary species. 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. The operational costs accounted for 2736000 and 2865960 Uganda shillings of the total tilapia and catfish production cost. A kilogram of tilapia and catfish were sold at 10800, and 9360 Uganda shillings, respectively and positive gross margins were reported for both species. The fish farmers still faced challenges of expensive fish feeds, predators and water quality problems due to increasing urbanisation. The study recommended the need for farmers to re-organise 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 the current feed conservation ratios.

Keywords: Profitability; viability; aquaculture production; urban; peri-urban; Uganda.

1. INTRODUCTION

The fisheries sector that includes both capture and Aquaculture together contributes 1.2% to Uganda's Gross Domestic Product (GDP) and 5% to the agricultural gross domestic product. The sector generate revenue of about $134.8 employs about 1.2 million people directly and 1.4 million people indirectly along the fish value chain [1,2]. Despite the fact that natural stocks of fish and shellfish are renewable, they have limited carrying capacity which cannot be exceeded even under the best management practices, a situation that provides aquaculture with a privilege of being harnessed to bridge the current gap in fish supply [3]. The aquaculture production in Uganda has improved from a tune of 24,382.5 in 1995 to 98,063 metric tonnes 2013 [4] via 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 in 2014 within Sub-Saharan Africa [2]. The rise in demand for fish protein sources is attributed to the increase in global population and consistently busier society that demand for a healthier animal protein source. Previously, the sector was dominated by traditional extensive culture systems, it is worth to note that pond production areas have improved and there is also increased investment in cage culture [4,5]. Aquaculture production volumes are expected to increase with the rise in fish prices, stagnating fish supply from capture fisheries, increased investment in cage culture and the current growing demand for food fish [6]. Uganda currently supplies fish and fish products to the neighbouring countries particularly Congo, Rwanda and Kenya in the 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 cultivated species among the fish farmers in Uganda due to its prolific nature and good taste. However, its growth and development has been somehow hampered by uncontrolled reproduction of mixed tilapia in culture systems 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 [7]. The species has got great potential of addressing nutritional security and household incomes, based on the fact that the African Catfish is fast growing, can thrive on house hold organic waste for its growth [8]. 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 [7]. This particular species is also tolerant to harsh environmental conditions with the ability to survive under low dissolved oxygen [8]. The adoption of the commercial quality feeds and increase in stocking rates have seen a relatively significant increase in aquaculture production. The above development aspects point to the need for profitability analysis of aquaculture enterprises with the purpose of establishing the feasibility and viability of aquaculture enterprise in Uganda. However only a few studies have been carried

out to determine the profitability of aquaculture production in Uganda, such studies include studies done on profitability analysis in 2011 and socioeconomic analysis of aquaculture production in West Nile region 2014 [9,10]. Economic analysis of fish farming or any other business is imperative in guiding informed decision-making process by policymakers and attracting direct investment by potential investors. Therefore the lack of empirical economics data about a given sector does not only negatively affects direct investment but also limits credit access from commercial banks and microfinance institutions which hampers the progress and development of the aquaculture sector. As a contribution to a facilitation of quick decision-making process during enterprise selection for investment, this study focused on 3 objectives namely: socioeconomic characteristics of aquaculture entrepreneurs, profitability estimates of the enterprise and the 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. A multi-stage sampling technique was adopted to draw a sample from the data base list of fish farmers provided by aquaculture research and development center. A total of 53 fish farmers were selected using purposive and snow balling sampling techniques from the three districts of Kampala (6), Wakiso (20) and Mukono (27). These are the districts with a representative number of fish farmers in the central region. In Kampala district, the study covered 3 divisions of Kawempe (3), Central (1) and Rubaga (2). In Mukono district, the study covered the sub-counties of Nama (4), Goma (9), Kyampisi (3), Nakisunga (4) and Ntenjeru (4) and municipality (3). In Wakiso district, sub counties covered included Wakiso Town Council (5), Nsangi (8), Nabweru (3) and Kakiri (4) fish farmers from all the sub counties and municipalities.

A structured questionnaire complemented with interview schedule was used to obtain quantitative and qualitative data needed to explain the phenomena in the way they existed. The collected data were validated using the dropdown list to ensure consistency and check for errors. The collected data were analyzed using descriptive statistic and pseudo-profit function. At the time of the study the exchange rate stood at 3,400 Uganda shilling for an equivalent of $ 1 US [11,12,13]. Profitability estimate was done based on quantity of fish produced in kilograms per production area of 1108m^2, stated below are the profitability index:

Fig. 1. Map of Uganda showing study districts

2.1 Pseudo Profit Function

The profit functions include all parameters of Gross margin and Net farm incomes that reveals the principle goal and costings of all business ventures. Return on investment and Rate of Return on capital invested were calculated to justify investment decisions. All the fixed costs were depreciated to calculate Net incomes. Gross margin ratio was taken into consideration to measure efficiency of resource utilization during the production process, compares the tilapia and catfish business entities against their profit margins generated. And the other parameters included operating Ratio, Fixed Ratio, per unit marginal ratio and break even yield.

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

Where; TR =Total Revenue (US$); TC=Total cost for both the fixed and variable costs. Total Revenues of tilapia and catfish enterprises were calculated using price of fish (P) multiplied by the quantity (Q) of fish harvested in kilograms

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

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 [14]. Where TFC = Total fixed costs. Where fixed costs of ponds construction costs, seine nets, predator nets and water pump were depreciated using the straight-line method over equipment salvage life [15,16].

$$\text{Depreciation of fixed cost} = \frac{\text{cost of equipments}}{\text{salvage life}} \quad (4)$$

Return on investment (ROI)

$$\text{Return On Investment } (ROI) = GM \div TVC \quad (5)$$

Where GM =

Gross margin, TVC = Total variable cost

Rate of Return on Capital Invested (RORCI)

$$RORCI = \frac{\text{Net profits before taxes}}{\text{Total production costs}} * 100 \quad (6)$$

Gross margin ratio is calculated by dividing gross margins by net sales

$$\text{Gross margin ratio } (GMR) = \frac{\text{Gross margin } (GM)}{\text{Net sales } (NS)} \quad (7)$$

Operating ratio (OR)

$$\text{Operating ratio} = \frac{\text{Total variable costs}}{\text{Gross incomes}} \quad (8)$$

Fixed ratio (FR)

$$\text{Fixed ratio} = \frac{\text{Total fixed costs}}{\text{Gross incomes}} \quad (9)$$

3. RESULTS AND DISCUSSION

3.1 Socio-economic and Production Characteristics of Aquaculture

This section consists of socio economic characteristics and production characteristics of aquaculture enterprises, and estimated production using enterprises budget, profitability analysis and the discussion section as stated below.

3.1.1 Socio-economic characteristics of fish farmers

The study observed that Mukono and Wakiso districts had the highest numbers of fish farmers (51%) due to accessibility to reliable water sources and relatively adequate land for expansion, compared to Kampala where farmers are limited by increased urbanization rates that has led to destruction of water supply sources that is limiting aquaculture expansion in urban areas. On the average 88% of the farms were functional, the nonfunctional farms as indicated by the results were 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-down 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. It is also revealed that 50% of the respondents of age group 40-60 actively engaged in aquaculture production.

3.1.2 Production characteristics of aquaculture enterprises

Pond based culture model accounted for 84.9% of aquaculture production in central region. Fish farmers in Kampala and Mukono districts owned 4 ponds each, while farmers in Wakiso district owned 3 pounds each. For tank technology, 7.6% of the fish farmers adopted concrete tanks for catfish fingerling production and these farmers owned an average of 4 tanks with a carrying capacity of 1000 liters of water for grow out fish in Kampala. 57.1% of the farmers practiced monoculture that include the raising of a single species in the production systems, while 42.9% of the farmers cultured fish under polyculture system that included catfish and tilapia. Tilapia (*Orechromis Niloticus*) emerged as the most cultured species among fish farmers in the central region due to the species prolific nature as indicated in Table 2. 48% of the farmers sourced their fingerlings from Aquaculture Research Centre, 36% from fellow farmers, 4% from farmers' own hatcheries and 12% farmers got their seed from the wild. However, there is need to certify all the fingerling suppliers in the country and also operationalize regional fry centers to ensure that farmers are in position to access quality seed to sustain aquaculture production.

Spring water (40.4%) is the major source of water for aquaculture production in the three districts, followed by underground water 24.9%, streams accounted for 21.2% and other water sources that included, swamps, rain water supplemented with public National water accounted for the remaining percentage. The results showed that 49% of the fish farmers fed their fish on commercial complete diets that included floating, sinking and powdered feeds purchased from local companies like Ugachic, Aquaculture Research and development Centre and other small feed mixers like Nsava Feeds in Mukono district .Due to high feed costs, 48% of the farmers mixed their own feeds using a combination of locally available feed ingredients like maize bran, cotton seed cake, soya bean, mukene among others to cut-down the production cost. 11.6% of the farmers fed their fish on plain maize bran supplemented with green. In extreme instances of trying to minimize cost of fish feeding, the study found that 7.5% of the farmers did not adequately fed their fish.

3.2 Production Cost Analysis for Tilapia and Catfish Enterprises

Tilapia and catfish operational costs included seed, feed, labor, organic fertilizers, and lime required to cover a single production cycle (Table 3). Stocking densities ranged between 3081 Tilapia and 2456 Catfish fingerlings in a production area of 1108m^2. Farmers applied lime in ponds to neutralize acidity before stocking and 210.1 kg of commercial feeds was used to feed fish up to table size. Farmers fertilized their ponds using organic manure to enhance growth of phytoplankton to cut on the feed costs.

Table 1. Socio-economic characteristics of fish farmers

Districts	Percentages	Educational level	Percentages
Mukono	51	Primary	13
Wakiso	38	Certificate	46
Kampala	11	Diploma	4
		Degree	35
		None	2
Gender		**Farm status**	
male	86.8	Functional	88
Female	13.2	Non functional	10
		under renovation	2
Age		**Ownership**	
≤39	33.3	Group ownership	8
40-60	52.1	Family	38
61-80	12.5	Sole proprietors	55
≥81	2.1		

Source: Field survey 2015

Table 2. Production characteristics of Aquaculture enterprises

Seed sources	Percentage	Culture practices	Percentage
ARDC-Kajjansi	48	Monoculture	57.1
Own farm	4	Polyculture	42.9
Fellow farmers	36		
Others	12		
Culture system		**Culture species**	
Ponds	84.9	Tilapia	77.4
Tanks	7.5	Catfish	18.9
Reservoirs	7.6	Others	3.7
Feed utilization		**Feeds suppliers**	
Commercial feeds	49	Ugachic	65.4
On farm mixing	31.9	ARDC-Kajjansi	13.5
Maize bran +Vegetables	11.6	Small feed mixers	19
None	7.5		
Water sources			
Springs	40.4		
Under ground	24.9		
Streams	21.2		
Others	13.5		

Source: Field survey 2015

Regular labor of 1 worker responsible for production and general management of the farm at a cost of 99960 Uganda shillings per month. Additional labor of 4 people was hired during harvesting and general farm maintenance. The additional laborers are paid a daily wage of 32300 shillings per individual depending on the work load (Table 3) for the general maintenance of the fish farms. 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 1.5 kg. Fixed costs included pond construction, seine nets, predator nets and water pump used by fish farmers whose ponds could not drain by gravity or easily access water. Farmers spent 1,604800 shillings to construct a pond size of 1,108m^2 (Table 3), However pond construction costs are highly influenced by the site location and the type of technology used. Farmers owned an average of 5 predator nets valued at 89080 shillings for predator control such as birds, otters and snakes responsible for economic losses in aquaculture. And other farmers were improvising with strings tied around ponds to control predators. The respondents owned one seine net and 1 water pump valued at 1356600 and 1210400 shillings respectively. Total fixed costs of pond construction, seine nets, predator nets and water pumps were valued at 5325760 shillings, these costs were depreciated using equipment salvage life of 5, 2, 4 and 2 years respectively as indicated in (Table 3).

3.2.1 Profitability analysis of tilapia and catfish production

A comparative analysis of profitability was drawn among 15 fish farming enterprises that provided comprehensive input and output data. Operation costs included fingerlings, fish feeds, organic manure, lime and labor constituted a total of 2584000 and 2706740 Ugandan shillings for tilapia and catfish enterprises. And the fixed costs included pond construction costs, seine nets and predator nets, assorted tools were depreciated using the equipment salvage value that totaled to US 2174300 Uganda shilling as indicated in (Table 4). These farmers made sales of 706.1kgs of tilapia and 869kg catfish from monoculture pond production area of 1108m^2. Revenues generated are based on farm gate prices of 10200 for tilapia and 8840 shillings for catfish sold to regional traders and individual consumers within the communities. Positive gross margins were observed for both catfish and tilapia producers (Table 4) from unit production area of 1108m^2 reflecting greater efficiency in turning fish sales into income. A positive gross margins and net farm incomes were highly influenced by quantities of fish marketed and fish prices (Table 3). Gross margin ratios were calculated using gross margins divide by the revenues generated with the aim of comparing marginal contribution of tilapia and Catfish sales towards the revenues generated. Gross margin ratio stood at 64.1 percent and 64.8 percent for Tilapia and Catfish respectively,

Table 3. Estimated average production costs for aquaculture enterprises crop year 2015

Variable costs	Quantities	Unit cost (US	Total costs	
Fingerlings (Pieces)				
Tilapia	3081	204	628660	
Catfish	2455.6	306	751400	
Feed (kilogram)	210.1	3400	714340	
Regular labor	1	99960	901000	
Fertilizers (kilogram)	125.2	217.6	27200	
Lime (kilogram)	107.5	850	91800	
Additional Labor	4	32300	129200	
Transport costs (feed +seed)		91800	91800	
Fixed costs	**Quantities**	**Unit cost**	**Total cost**	**Depreciated capital**
Pond construction (M^2)	1108	7820	1604800	319600
Seine Nets	1	1356600	1356600	676600
Predator Nets	5.4	89080	482800	333200
Pump	1	1210400	1210400	300900
Assorted tools	19		188360	61200
Maintenance costs			482800	482800
Total fixed costs (TFC)			5325760	2174300

Source: Field survey 2015

Table 4. Profitability Analysis of Tilapia and Catfish enterprises

Parameters	Tilapia (Ushs)	Catfish (Ushs)
Yield (kg)	706.1	869
Price/kg	10200	8840
Total Revenues (sales)	7202220	7681960
Total Variable costs (TVC)	2584000	2706740
Total Fixed costs (TFC)	5325760	5325760
Depreciated Capital (TFC)	2174300	2174300
Total production costs (TVC+TFC)	7909760	8032500
Gross Margins (TR-TVC)	4618220	4975220
Net farm Incomes (GM- DFC)	2443920	2800920
Return on Investment (GM/TVC)	1.8	1.8
Gross Margin Ratio (GM/Revenue*100)	64.1	64.8
Per unit marginal Ratios (GM/No of units produced)	6540.5	5725.2
Breakeven yield (Fixed costs/per unit production)	814.3	930.2
Operating Ratio (TVC/GM)	0.6	0.5
Fixed Ratio (TFC/GM)	1.2	1.1
Rate of Return on capital (Net profits/TPC*100)	30.8	34.8

Source: Field survey 2015

indicating that aquaculture enterprises were in position to pay for the operational costs. Per unit contribution margin ratio of fish sales towards the total margins generated stood at 6062.0 and 6925.2 Uganda shillings for Tilapia and Catfish enterprises respectively. Fish farmers were expected to produce 814.3kgs of Tilapia and 930.2kg of Catfish to breakeven at a given market price. Operating ratios of 0.6 for tilapia farmers and 0.5 for catfish production were observed, indicating how much farmers remained with after paying off the variable production costs. These ratios enable aquaculture enterprises determine their level of efficiency in controlling operational production costs. The fixed ratio for both tilapia and catfish enterprises stood at 1, an indication that these businesses were operating at breakeven. However it is important for farmers to improve the fixed ratio above 1 to increase cash flows which will significantly improve aquaculture profit margins.

3.3 Major Challenges

Expensive fish feeds emerged as the pressing challenge affecting fish farmers in the central region as indicated in Fig. 2. Fish farmers (23%) reported predators like oaters, snakes and birds

to be the major challenge accounting for economic losses on the aquaculture farms. 11 % of the respondents identified inadequate technical advice during pond construction and general farm management due to limited extension service provision at district and sub county level. Water quality problems (8%) are one of the emerging problems in the urban and Peri-urban areas of Kampala, Mukono. Other challenges included expensive labor, and market competition from wild fish and 2% of the fish farmers did not experience any of those problems.

4. DISCUSSION

Majority of Aquaculture farmers had attained tertiary level of education as indicated in (Table 2) which is advantageous to the sector in terms of quick information dissemination, technology uptake and record keeping [15,17] implying that fish farming is increasingly attracting famers 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 of fish. These disparities could be attributed to the gender roles assigned by our cultures where women have no land ownership right to set up long-term investment [17]. Such disparities have implications on household income, food security because women are the 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 1,108 m^2 in the Central Region as compared to the 200 m^2 pond sizes reported in 2001 [18,5]. 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 growing, has the ability to forage on any household organic waste and thrive under harsh environmental conditions [8]. Therefore there is need to train fish farmers on product development and value addition of the African Catfish in form of smoked ready to eat products, and fish fillets to increase its consumption. The study noted variations in stocking densities among fish farmers which seemed undefined, and this calls for increased information dissemination for farmers on appropriate stocking densities. Inappropriate stocking densities affected proper fish growth, which prolongs culture period affecting returns on investment in form of extra feeding costs with no significant weight gain [19,16]. Furthermore, the long culture periods tie-down working capital that could be invested in a more productive way. This also call for farmers' willingness to switch to faster growing fish strains to obtain better growth within shorter culture period [15,20] in combination with feeding fish on a quality diet.

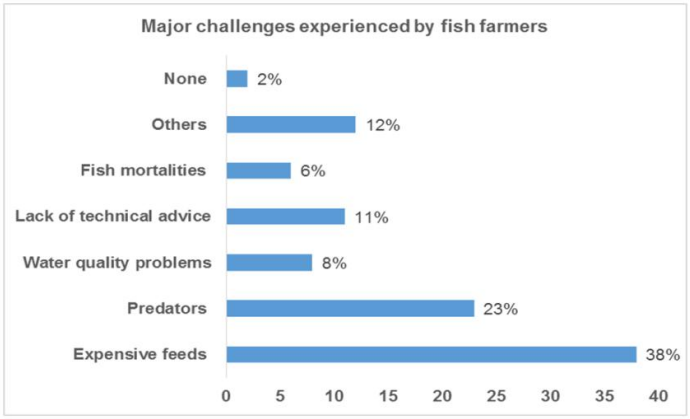

Fig. 2. Challenges experienced by fish farmers

Production costs were categorized into two components of fixed and variable costs as indicated in (Table 3). Both the fixed and variable costs were used to determine profit levels of tilapia and catfish enterprise which is paramount in guiding viable enterprise selection and investment [21]. The study revealed that fingerlings, feeds and labor costs accounted for the biggest percentage of the production costs which is similar to the findings [22,23] in the different regions of the country. Positive gross margins were observed indicating that both tilapia and catfish production of the 15 fish farmers was profitable, which is consistent with the findings of [24] who assessed profitability of aquaculture production in 2010. Positive returns on investment and rate of return observed for both enterprises indicated that aquaculture production was profitable since for every money invested the fish farmers were in position to recoup a few cents as indicated in (Table 4), although the rate of return was migre. The smaller rate of return is attributed to high production costs Vis vie small fish yield harvested resulting from understocking of pond production areas. The study observed differences in the per unit marginal ratios contribution to the yield harvested and marketed among tilapia and catfish farmers. Breakeven analysis revealed that Catfish enterprises had to produce slightly higher kilograms of fish to recoup the money invested without making loses as compared to Tilapia farmers. However it should be noted that farmers do not only need to breakeven in any agriculture business for that particular period of time but should sustainably manage their aquaculture enterprises to recoup all money invested [15,21]. Farm level profits were minimal as indicated in (Table 4), this is attributed to the high operational costs that included expensive feeds (Table 3) which is in agreement with the findings of [9,23]. High cost of feed is a persistent challenge affecting fish production as highlighted by various studies in Uganda [5,9,22], Nigeria [17,23,24] and Kenya [25]. However this problem can be addressed through research into cheap alternative plant protein sources to replace expensive fish meal. None the less, appropriate stocking densities, water fertilization and efficient feed utilization are vital for increased fish production in Uganda.

5. CONCLUSION

Aquaculture production in Central Uganda is predominately owned by males, who have attained 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, lack of technical advice and water quality management problems that are on the rise in the region, which calls for research on effluent re-use and land saving technologies to sustain aquaculture production in urban and peri urban areas. As the aquaculture industry intensifies, there is need to avail a cheap but efficient feed to the farmers to cut on the current production costs through research on alternative protein sources to replace expensive fish meal, effective information dissemination on specific fish feed management practices to better the current Feed Conversion Ratios (FCRs) per unit fish produced. There is need for government to certify all fingerling suppliers and extension service providers to deal with the problem of quacks with in the industry, to guarantee quality and protection of fish farmers. Training of farmers in business management skills and record keeping to ensure efficient management of aquaculture enterprises and their portfolios

ACKNOWLEDGEMENT

This work was funded by Africa-Brazil, grant number 411 under ‘Utilizing sustainable energy for water management in semi-intensive aquaculture project. We also appreciate the anonymous reviewers for the comments made to improve the quality of the manuscript. Special thanks to the District fisheries officers and fish farmers who willingly participated in this study.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history/23391