VIABILITY OF AQUACULTURE IN UGANDA

Simon Peter Kigongo Sserwambala
Department of Zoology, Entomology and Fisheries Sciences
Makerere University
P. O. Box, 7062, Kampala, Uganda
sserspek@gmail.com

Supervisors:
Professor Helgi Thorarensen
Department of Aquaculture and Fish Biology
Holar University College
helgi@mail.holar.is

and
Þorgeir Pálsson
Smáratún 2, 225 Garðabæ
thorp@simnet.is

ABSTRACT

This study was conducted in Uganda to examine the viability of small and medium scale pond aquaculture. Data from 38 fish farms was collected through a questionnaire and telephone interviews. Additional data was obtained from input suppliers and service providers in the aquaculture industry. The start-up costs for an average pond of 1000 m^2 were computed and compared with results of analysis of primary data from the questionnaire. Data were also analyzed for correlations between production and total feed used per cycle, average pond size, total pond area used, total seed stocked and labour. Results indicated significant relationships between fish production and the number of seed stocked and average pond size. A significant relationship was found between average pond size and cost of construction. The relationship between fish production and total pond area at the farms, stocking density, and farm labour, were not significant. The cost of production is very high compared to the average market prices and hence many farmers sell at a loss. The average cost of feed is still high and greatly influences the cost of production. The study did not assess labour costs due to lack of reliable data. The fish farms were found to be constrained by poor management, feed (cost, quality, and access), poor extension services, poor infrastructure, and markets.

This paper should be cited as:
Sserwambala, S. 2018. *Viability of aquaculture in Uganda.* United Nations University Fisheries Training Programme, Iceland. Final project. http://www.unuftp.is/static/fellows/document/Simon17prf.pdf

TABLE OF CONTENTS

List of Figures

List of Tables

1 INTRODUCTION AND BACKGROUND

1.1 Background

Natural conditions in Uganda are very favourable for aquaculture. Lakes and rivers cover 18% of the country's 241,550.7 km² area. There are two long rainy seasons each year with a mean annual rainfall of 1000-1606 mm and mean temperature of 14-31 °C (UBOS, 2015). These are conditions particularly suitable for fish production. In addition, the government, through the Directorate of Fisheries Resources, has put in place policies and laws for promoting the growth of aquaculture and, as a result, a number of fish farms have been established. The aquaculture industry is regulated by the National Fisheries Policy 2004 and the Fish (Aquaculture) rules 2003. These are supplemented by the various government programmes aimed at aquaculture development like the operation wealth creation (OWC) and the national agricultural advisory services (NAADS) under which support is given to fish farmers in form of seed and feed. The fish and aquaculture rules (2003) provide for guidelines for investment, management, and marketing of aquaculture products. Under section 25 (1 and 2), the rules outline the need for proper record keeping and reporting the same to relevant authorities (GoU, 2003). Applications for aquaculture permits fees are also provided for in the same rules, which also provide for waivers for fish size restrictions for aquaculture fish in markets.

There are currently about 14,000 fish farmers in the country with a total of over 30,000 ponds and about 2,135 cages in Lake Victoria alone (Kubiriza, 2017 and Mbowa, *et al*, 2017). The main species grown are African catfish (*Clarias gariepinus*) (50% of production volume) and Nile tilapia (*Oreochromis niloticus*) (48% of the production volume) while the Common carp (*Cyprinus carpio*) contributes less than 1%. Currently, aquaculture contributes about 20% of the total fish production in Uganda, the rest comes from fisheries. Aquaculture production is reported to have increased from 31 MT to 117,590 MT from 1984 to 2015 (Figure 1) (Kasozi, *et al*, 2017 and FAO, 2017). However, this may be an overestimate and the actual production may be considerably lower (Ssebisubi, 2011). Kubiriza Kawooya (2017) estimated the aquaculture production to be about 30,000 MT in 2013 based on reports from the Ministry of Agriculture Animal Industry and Fisheries (MAAIF). He justified this estimate by relating it to the feed supply and aquaculture infrastructure in the country at the time. He concluded that although there may be growth in aquaculture in Uganda, it may not be as high as indicated by FAO numbers.

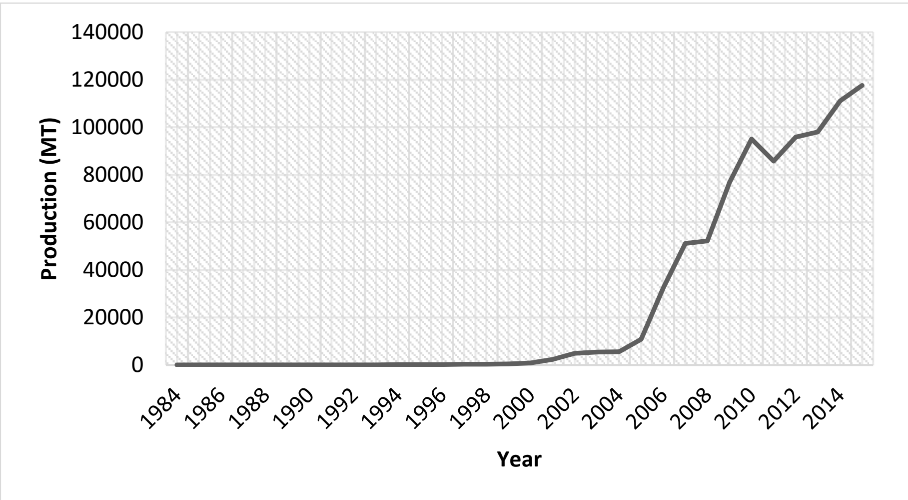

Figure 1. Aquaculture production in Uganda (1984-2015) (FAO stat database 2017)

Landed catches from capture fisheries are decreasing although demand is increasing with population growth. There was a 26.5% and 2.4% decline in catches from two major water bodies, Lake Kyoga and Lake Albert respectively, while catches from Lake Wamala decreased by 18% between 2010 and 2014 (MAAIF 2016).

There is an urgent need to increase fish production in Uganda to meet the growing demand. Uganda's population reached 37.7 million in 2017, with a growth rate of 3% per year (National Population Council, 2017). There were reports of increased demand as the fish supplies reduced in the past year although no quantities were specified (Abdallah, 2017). Developing aquaculture to increase production is the key to achieve this target.

1.2 Issues in Uganda's aquaculture

Several factors may limit the growth of aquaculture in Uganda, both social and economic in nature. The major issues constraining aquaculture in Uganda are outlined below.

The costs involved in starting up aquaculture farms are high and, therefore, limit investment. It is estimated that a farmer needs over US$2,500 to open a 1000 m^2 fish pond and to cover costs until the first production is sold (Ssebisubi, 2011). This is a large amount given that most farms are established on farmers' personal savings. The risks involved in starting a fish farm are significant. Farmers stand a risk of getting poor quality feed and seed from some of the local suppliers. Farmers could also fail to access feed at a certain stage given the unreliable supply (Dalsgaard, *et al*, 2012). Even with large-scale producers, farmers are not guaranteed access to feed all the time. All these reduce the chances of farmers starting and operating economically viable enterprises.

Uganda's aquaculture value chain is rudimentary regarding production practices, markets and feed and supply chains (ILRI, 2011). The value chain is constrained by poor support services, small-scale enterprises with low production and targeting local markets. Lack of quality broodstock, poor hatchery performance and lack of affordable quality feed, which meet the nutritional demands of the fish, further limit farm production. The structure of the aquaculture value chain in Uganda (Figure 2) gives fish traders higher bargaining power than farmers (Ssebisubi, 2011). Farmers have low bargaining power due to the low and inconsistent volumes produced and competition from capture fisheries. A study conducted by FAO on value chains and the small-scale sector found that relative to other players in the value chain, small-scale fishermen and fish farmers were receiving the smallest economic benefits for their products (FAO, 2014). The study found processors and retail markets recieve more of the distributional benefits of the value chain owing to their stronger bargaining power. At the input stage, the value chain is constrained by weak markets for quality seed and feed, poor distribution networks for feeds which lead to feed spoilage and limited value addition for farmed fish (ILRI, 2011). A combination of all these factors results in low farm productivity and marginal profits making the industry less viable.

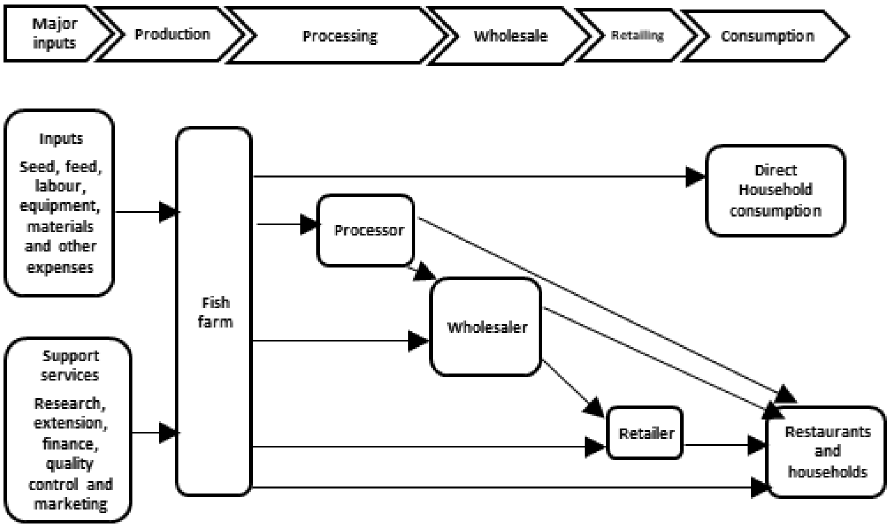

Figure 2. Schematic presentation of the aquaculture value chain in Uganda

A study conducted in central Uganda by Hyuha, *et al*, (2011), found that farmers had no access to extension services to help them address technical aspects of fish farming. It has been observed that even where such services are available, the quality is not satisfactory. As a result, the few good quality service providers charge high fees for their time (Isyagi, *et al*, 2009)

Many fish farms are owned by either retired public servants or active businesspersons and civil servants (Ssebisubi, 2011). Due to their other professional engagements or places of residence, they employ mostly family members and then supervise them from afar. Unqualified staff and remote control or "telephone supervision" are factors that contribute to the failure of fish farms (Isyagi, *et al*, 2009). Other management failures include poor record keeping, irregular and improper feeding, overstocking and lack of requisite management equipment (Isyagi, *et al*, 2009, Hyuha, *et al*, 2011).

Other factors limiting the development of aquaculture in Uganda include lack of market development, absent or weak business development services e.g. advice, technology, and capital; misguided/misinformed producers and new entrants expecting a quick return on investments (Dalsgaard, *et al*, 2012). These challenges, in addition to other social and environmental issues, have limited the expansion of aquaculture in Uganda. It is, however, important to determine alternative strategies for operating viable aquaculture enterprises. This study attempts to put into context viability of aquaculture enterprises in Uganda. The analysis includes the cost of investment, production methods, production cost and market prices of aquaculture fish in Uganda.

1.3 Objective of the study

This study examines the viability of pond aquaculture investments in Uganda based on the status and performance over the past five years.

The specific objectives of the study are:

i. To determine the start-up cost in pond aquaculture in Uganda

ii. To conduct a questionnaire to assess the performance of fish farms.

iii. To identify constraints to growth of aquaculture farms in the study area

1.4 Rationale

Studies have been conducted to analyze the profitability of aquaculture in Uganda and some have indicated the industry as profitable and worthy of investment (Hyuha, *et al*, 2011). Some researchers have presented promising results, indicating the industry is viable (Mbowa, *et al*, 2017). However, the industry has not taken off despite the potential for growth. The government’s target to increase aquaculture production to 300,000 MT by 2016, through the establishment of aquaculture parks has not been achieved (Mbowa, *et al*, 2017). This study could provide key insights into the economic viability of aquaculture and could help current and potential investors to plan their enterprises better.

The outcome could also help enhance the achievement of strategic objective (ii) of the proposed national investment policy of aquaculture parks 2012 (NIPAP). The National Investment Policy of Aquaculture Parks 2012 (NIPAP) was proposed with the following objectives; “(i) identification and demarcation of areas suitable for AP establishment, (ii) mobilization of aquaculture producers to access and utilize the established APs, iii) provision of support extension services to the APs together with marketing and market linkages; and (iv) institutional support and coordination, among others” (Mbowa, *et al*, 2017). Successful implementation of NIPAPs (2012) is partly aimed at creating over 86,000 jobs along the aquaculture value chain. This could provide a new source of livelihood for women pushed out of the traditional fisheries by regulations and development (FAO, 2017). Its implementation has fallen behind schedule with only objective (i): partly achieved (Mbowa, *et al*, 2017).

2 REVIEW OF LITERATURE

2.1 Aquaculture farming systems

There are three common aquaculture systems used by Ugandan fish farmers: monoculture, polyculture and integrated farming systems. In monoculture, farmers stock a single species in a pond, tank or cage. Farmers can practice mixed monocultures if they maintain a single species of fish per culture unit, even when the farm grows several species of fish. In polyculture, farmers mix more than one species of fish in a culture unit. Common polycultures include tilapia and catfish or tilapia and the common carp (*C. carpio*). Farmers normally select polyculture species to maximize production space and increase fish output per unit area of the farm used (Rakocy & McGinty, 1989). Integrated farming involves sequential linkage between two or more farm activities, of which at least one is aquaculture. These may occur directly on-site, or indirectly through off-site needs and opportunities, or both (Little & Edwards, 2003). Integrated fish farms may choose either monoculture or polyculture of different fish species for their enterprises. Tilapia and catfish can be grown alongside other enterprises like poultry and swine farming, either in monoculture or polyculture (Rakocy & McGinty, 1989).

2.2 Aquaculture farming practices

Aquaculture production is largely dependent on the level of intervention in management that a farmer undertakes. A fish farm may be described based on the level of management. There are three common levels of intervention in fish farming used by fish farms: extensive, semi-intensive, and intensive farming. Extensive fish farming uses large stagnant ponds that allow only a low stocking density and relies on natural production to feed the animals (i.e. there is no supplemental feeding) (Rural Fisheries Programme, 2010). Semi-intensive farming involves more intervention either through feeding and/or improvement of water quality through aeration and partial water exchange. This allows for an increase in the production when compared to extensive systems. Intensive fish farms are maintained at high stocking densities and feeding comes solely from introduced formulated feeds. The culture systems tend to be highly technical and rely on electricity to operate. The space required is relatively small and the system is designed to optimize water use and quality. Management and skills input is also high (Rural Fisheries Programme, 2010). Farmers choose farming practices and systems based largely on their economic abilities to finance the enterprise. Other factors influencing choice include target markets, technology, and experience.

2.3 Aquaculture production cycle

The production cycle in aquaculture is the period between stocking and harvesting of fish for sale. It varies between species and enterprises depending on the purpose; being shorter for hatcheries and baitfish farms than for grow-out systems. In Uganda, the two major aquaculture species; tilapia and catfish, have production cycles ranging between six months and one year depending on management and target market. Markets in Uganda accept catfish from as low as 500g as table size fish while tilapia as low as 250g can be sold as well (Isyagi, *et al*, 2009). For such markets, well-managed farms can afford short production cycles while cycles are generally longer where the market requires larger fish.

2.4 The economics of aquaculture in Uganda

The economics of aquaculture production is a function of different costs that interact through investment to production and marketing. These costs include seed, feed, labor (production and harvesting), rental costs, transportation and net purchases (Hyuha, *et al*, 2011). The sum of all costs and minus the revenue from the sales of aquaculture products gives the profit of the farm (Tisdell, 2001). The magnitude of the profit determines the financial health of the investment and encourages continuity. Two studies have independently attempted to analyze the proportionate contribution of the various costs to total costs in Uganda and Kenya (Table 1).

Table 1. Comparison between aquaculture production costs in Uganda and Kenya (Hyuha, *et al*, 2011and Okechi, 2004)

Running costs	Uganda	Kenya
Seeds	29.8%	33%
Feeds	24.8%	28%
Labour (production)	29.8%	15%
Labour (harvesting)	0.8%	1%
Fertilising	-	6%
Net purchase	6.9%	18%
Net rental	0.3%	
Transportation	0.4%	
Total variable costs (TVC)	92.8%	
Total fixed costs (TFC)	7.3%	
Total costs (TVC+TFC)	100%	100%

The cost of investment varies greatly depending on the culture units or system selected. Overall, it is generally cheaper to invest in aquaculture in cages established in natural waters bodies than it is for land-based systems (Satia, 2017).

The cost of setting up land-based aquaculture, which is the predominant form in Uganda, includes costs of land and construction of ponds and tanks before production starts (Kubiriza, 2017). These costs are generally treated as fixed for every farm and account for less than 10% of total farm costs (Hyuha, *et al*, 2011). This may, however, vary across farms depending on farming enclosures selected. An increasing number of farmers in Uganda are using larger ponds at least 1000 m^2. The costs of constructing such ponds are relatively high depending on the methods of construction and nature of the site. Such a pond would produce up to 2 MT of fish per year (Ssebisubi, 2011).

2.5 The viability concepts

Viability implies a situation where different components and functions of a dynamic system and their future existence at any time is guaranteed with sufficiently high probability (Baumgärtner & Quaas, 2007). In economics and finance, an enterprise or management action is considered viable if it continually generates a cash flow higher than a certain predefined level. For this study, a viable fish farm is one that can continue to generate economic benefits above the running costs for each production cycle.

2.6 Aquaculture sustainability in Uganda

Like all other enterprises, the sustainability of aquaculture developments hinges on their ability to provide economic, social and environmental benefits to the operators and community. The main driving factor for investment in aquaculture is economic benefits in the form of profits. In a study conducted on 200 farms in central Uganda, only 45% of the farmers had made a profit (Hyuha, *et al*, 2011). In 2012, Uganda's aquaculture industry was reported as struggling, with many producers failing to make a profit or break-even on their investments (Dalsgaard, *et al*, 2012). The report cited poorly developed markets, highly priced and poor-quality feeds with a volatile supply and absent business development services. The interventions by government and development partners in providing free extension services and inputs (seed and feed) has not improved the situation. Farmers have reported that the inputs provided are of low quality and often delayed.

2.7 Managing for profit in aquaculture

Small and medium scale aquaculture can be complex to manage profitably. As noted, the profit margin is very small and hence only attainable through good management (Hyuha *et al.*, 2011). A key strategy is to avoid over capitalization of the investment especially by building expensive structures in a low market area (Isyagi *et al.*, 2009). Although fish prices are reported to be increasing over time, it is possible that the costs of production are also increasing (Ssebisubi, 2011). This implies, that farmers ought to evaluate their potential markets and invest accordingly, avoiding certain costs that could eat into their profits. It pays off to convert more of the fixed costs into variable costs to break even in a shorter time for instance by working with rented spaces, and facilities or using seasonal labour.

2.8 Fish growth and farm economics

Fish growth is a function of management (feed quality and quantity, stocking rates, water quality) and genetics. The quality and quantity of feed given to the fish is an important factor in determining growth rates (Aquatic community, 2018). Other important factors include water quality, water temperature, the health of the fish, stocking density and oxygen levels. Using a good quality feed in poor quality water, poorly supplied water or poorly managing the feed during storage and use will result in low production.

2.8.1 Tilapia

For tilapia, the lower stocking density of (1 fish/m^2) results in faster growth rates of approximately 2.5 g per day when appropriate culture conditions are maintained in ponds. Higher stocking densities at 2 fish/m^2 result in higher yields per acre, slower growth rates (1.5-2.0 g/day) but also additional costs in aeration of pond water to maintain quality. The added cost of production can be compensated by the additional benefits in added yield per square meter (Tilapia fish, 2018). Tilapia can grow to a body weight of over 400g in 5-6 months and 700 g in 8-9 months, with appropriate culture conditions (Towers, 2018). Since the market in Uganda accepts Tilapia at 250 g, it is economically feasible for farmers to plan farm cycles of eight months. Shorter rearing cycles ensure higher returns through reduced expenditure on farm running costs. Different strains of tilapia grow at different rates in different environments, hence a strain that is fast growing in one location can be slower in others. It is therefore important that suitability to local conditions is checked before farmers pick on any strain for aquaculture (Tilapia fish, 2018).

2.8.2 Catfish

Catfish can grow up to 800 g body weight in one year. Stocking rates of 5 juveniles per square meter are recommended for monocultures while polycultures with tilapia are recommended to stock at 0.5-1 catfish juvenile for every 2 tilapia juveniles. At this stocking rate, low input ponds stocked with catfish and tilapia juveniles are able to produce 3-4 $MT \cdot ha^{-1} \cdot year^{-1}$ while higher input ponds with follow-up management could increase production up to 10-25 $MT \cdot ha^{-1} \cdot year^{-1}$ (FAO, 2010).

2.9 Fish mortalities and their effect on farm performance

The final harvest quantity of a fish farm per stocked pond is a function of the number/total biomass stocked minus total mortalities across the production season. The lower the percentage mortality, the higher the harvest volume and hence the sales volume. According to the tilapia aquaculture guide produced for Kenyan farmers in 2014, a minimum of 10% will be lost as mortality for various reasons in a six-month rearing cycle. Fish mortalities in aquaculture can be caused by disease, toxic conditions in water, predation or escape from culture units as the case in flooded ponds.

2.10 Farm productivity

Pond aquaculture is reported to be the least productive as compared to tanks and cages. Data from the aquaculture research and development center (ARDC) in Uganda shows that ponds on average yielded 0.2 kg/m^3 as compared to 100 kg/m^3 and 150 kg/m^3 for tanks and cages respectively (Rutaisire, *et al*, 2009). This translates into a yield of 2,000 kg per hectare of ponds. However, with good management using farm-made feed and/or offal for catfish yields were reported to have improved to about 7,000 to10,000 kg/ha/crop (Isyagi, et al., 2009).

3 RESEARCH METHODOLOGY

3.1 Data collection

Data for this study were collected between August and December 2017 from 38 farms that were growing fish in ponds in Uganda. Respondents were asked to answer a questionnaire comprising of both closed and open-ended questions (Appendix I) by a team of three research assistants. Additional data were captured from input suppliers and key informants through telephone interviews.

The major target group for the study was the small and medium scale fish farmers. The study group included farmers, farm managers, and key informants, especially from the input and service sector.

The farms were selected through a combination of purposive sampling and snowball methods where farms that had been in operation for at least five years were mostly targeted. This category of farms was targeted specifically to enable the researcher to record production and marketing data for the past five years in fish farming. In total, 97% farms had been in operation for five years or more while one farm was two years old. These farms were selected from 11 districts across the eastern, central and mid-western regions of Uganda.

3.2 Data analysis

Data were analysed for descriptive statistics using MS Excel 2016. The results are presented in the next chapter as descriptive statistics and relationships between variables measured. Inferential statistics were used to determine the correlation between variables.

3.3 The aquaculture start-up costs

Information was collected to estimate the actual cost of setting up a fishpond of 1000 m^2 in Uganda. The costs were estimated for setting up a typical pond in a medium-sized farm where pond construction is accomplished by machines together with human labour. A 1000 m^2 pond was selected for the study based on of the analysis of primary data from the studied farms. The most common pond size for the farms studied was 1000 m^2. The overall cost of construction included the excavation fees per day (working 8 hours a day), consultancy fees, fittings, human labour for finishing captured in man hours. The cost of land was not included due to its highly variable nature of in the study area.

In the central Uganda where the study was conducted, the cost of land changes rapidly with time due to growing urbanisation of the area. It also varies greatly between places in short distances apart. There are high chances of wrongly estimating the start-up cost if included.

3.4 Assumptions made

The assumptions in Table 2 were made for the study. Some of the figures were obtained from the analysis of primary data from the survey while others were obtained from key informants and literature.

Table 2. Assumptions made during the study

Description	**Quantity**	**Unit**	**Remarks**
Exchange rate	1USD:3633	Ug. shs	(Bank of Uganda, 2018)
Pond area (grow out)	1000	m^2	
Average depth is	1.2	m	
Total pond volume	12000	m^3	
Construction cost/m^2	53,000	Ug, shs	

4 RESULTS

4.1 Farm sizes

The farms sampled had a total pond area of 149,400 m^2 (14.9 ha) and an average of 4 ponds/farm. The largest farm had a total pond area of over 20,000 m^2 while the smallest had only 100 m^2 (Figure 3). Some farms have ponds larger than 1,000 m^2 while most of the farms used ponds less than 1000 m^2. The most common pond size was 1000 m^2, while the average pond size was 1580 m^2. The average production per farm was 370 kg while the average yield was 0.84 tonnes.

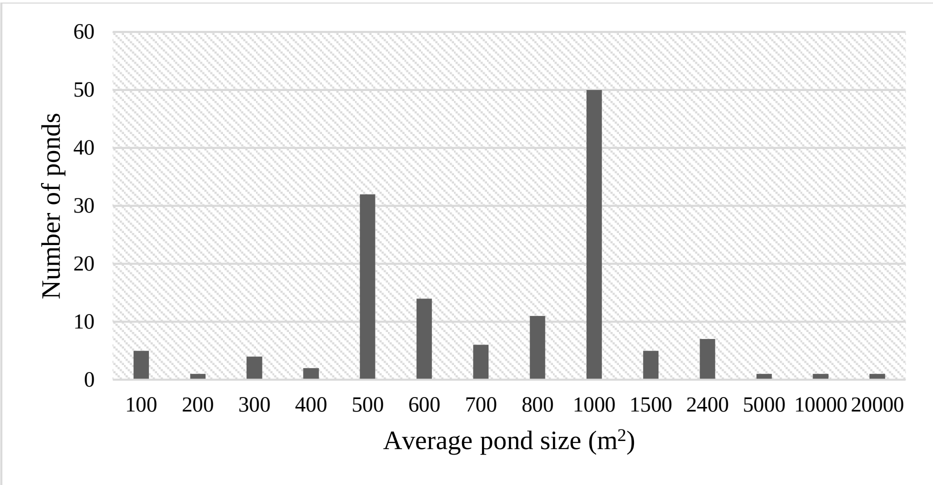

Figure 3. Number of ponds of various sizes

The study targeted mostly farms that had been in operation for at least five years. The oldest farm in the study was also the largest, opened in 2004. Most of the farms began operation between 2010 and 2012 while only one farm was opened in 2015 (Figure 4).

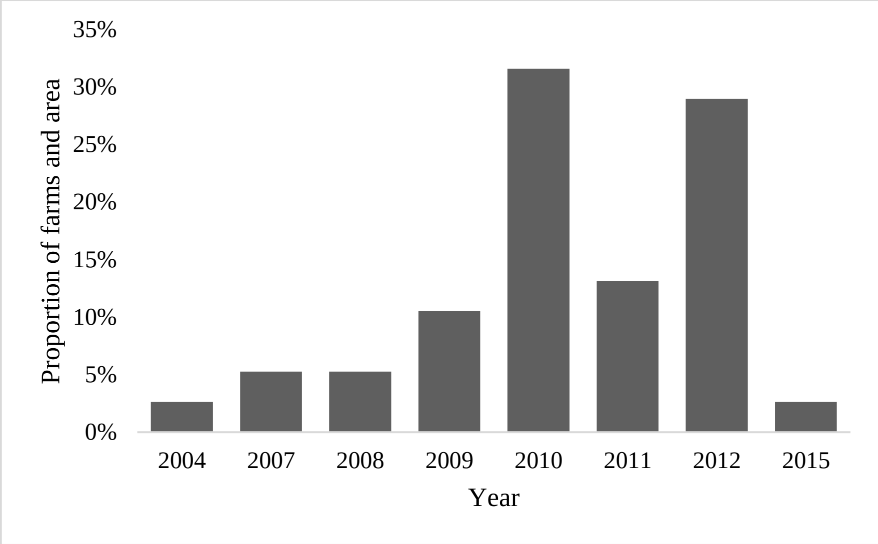

Figure 4. The year the farms were founded and total pond area depending on age.

The farms used mainly three farming systems to raise fish. Monocultures of tilapia (and one farm with catfish), polyculture of tilapia and catfish and integrated farms. The largest proportion (65%) of the farms grow catfish and tilapia as polyculture while 28% farmed tilapia as monocultures and 5% cultured catfish in monoculture (**Error! Reference source not found.**5). Integrated farms practiced both monoculture and polyculture. Polyculture farms contributed over 70% of total fish production from the farms (Figure 5).

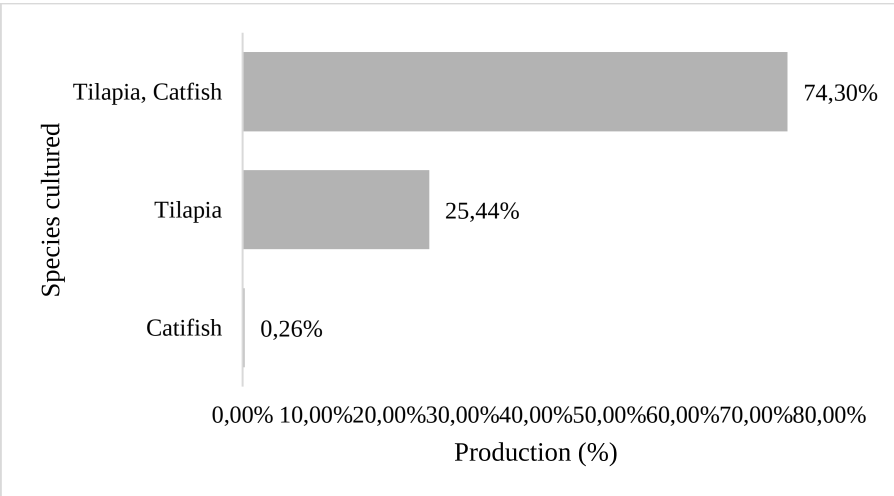

Figure 5. Species cultured and total production (2016)

Over 70% of the farms were not licensed nor did they have aquaculture permits from any designated government department for their operations. Only 26% (10 farms) held aquaculture permits from either local government departments or from the ministry of agriculture, animal industry and fisheries (MAAIF).

The major source of water for the farms studied were natural streams, followed by underground springs and surface run-off collected in reservoirs. Over 50% of the farms sourced water from natural streams to fill the ponds. Other farms had more controlled access to water from underground springs while 13% of the farms relied mostly on reservoirs collecting surface runoff and then supplying to the ponds for farming (Figure 6).

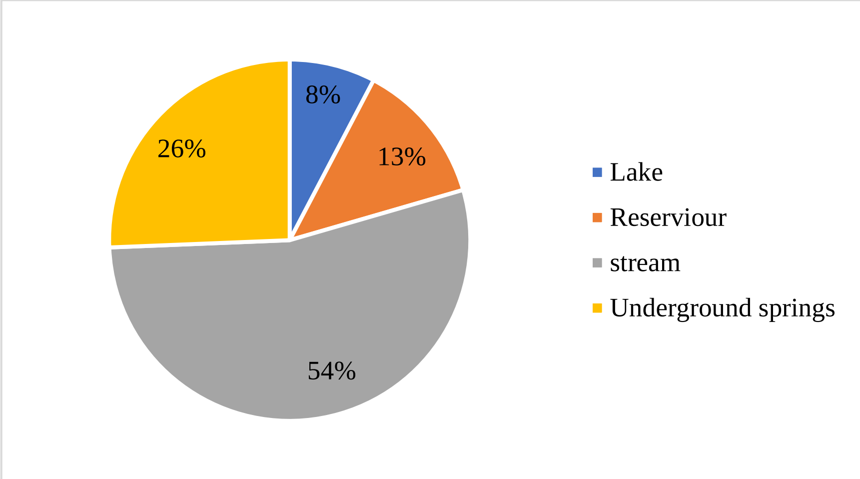

Figure 6. Sources of farm water

Of the 38 farms sampled, 26 (66%) farms had at least one permanent staff. The farm staff was 75% male and 25% female. Five of the farms (19%) employed over 47% of the total staff reported. The farms that did not report any staff relied on family labour to accomplish the various farm activities.

The farm managers were the most educated category of the respondents with the lowest educated farm manager having attained secondary education. Over 60% of the farm managers had attained tertiary education. The farmers, on the other hand, were distributed across all categories with 21% of them having no education at all (**Error! Reference source not found.**3).

Table 3. Education of the respondents

Respondent education level	Caretaker	Farm manager	Farmer	Total
No-education	0%	0%	21%	13%
Primary	50%	0%	9%	10%
Secondary	25%	34%	35%	33%
Tertiary	25%	66%	34%	44%
Total	**100**	**100**	**100**	**100**

4.2 Farm production and management

The relationship between total pond area and production was not significant (*p*>0.05, n=34) (Figure 7). The yield range was 0.06 – 3.5 MT·ha^{-1}, With an average of 0.84 MT·ha^{-1}. Over 68% of the farms had yield ≤ 1.0 MT·ha^{-1}, while 31.6% of the farms had yields between 1.1 to 3.5 MT·ha^{-1}.

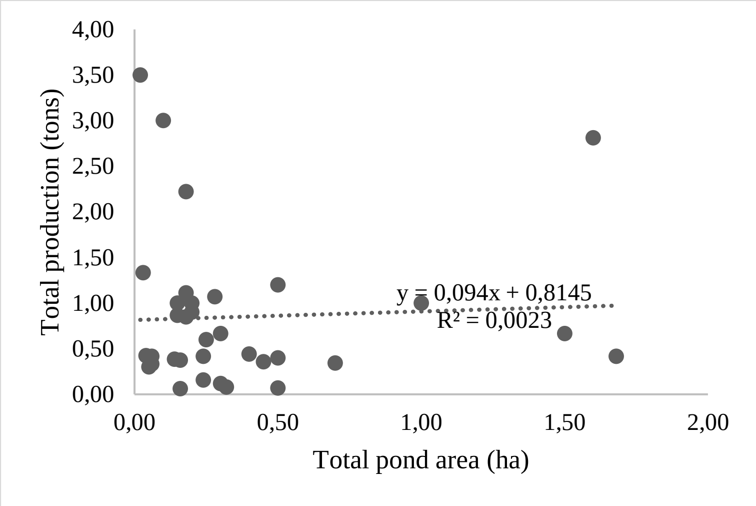

Figure 7. Fish production and total pond area

The analysis revealed a significant relationship between average pond area and total annual production even when the large ponds were excluded from the analysis (p<0.00001, n=34). Furthermore, farms using small ponds had lower fish production than farms with large ponds (**Error! Reference source not found.**8).

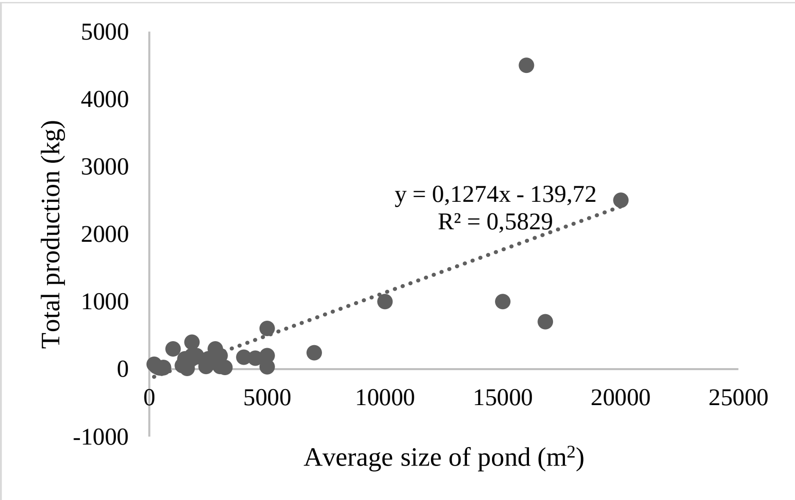

Figure 8. Fish production and average size of ponds

The number of catfish in the total fish stocked was less than half that of tilapia (Figure 9). Generally, the overall number of fish stocked per square meter of the pond was lower than the recommended stocking rate for semi-intensive farms. Farms reported stocking rates between 1 and 7 juvenile·m^{-2}. The average stocking rates for both tilapia and catfish were lower than 1 juvenile·m^{-2} based on the number reported during the survey. There was a significant correlation between the total fish stocked and fish production (p= 0.00003, n=34).

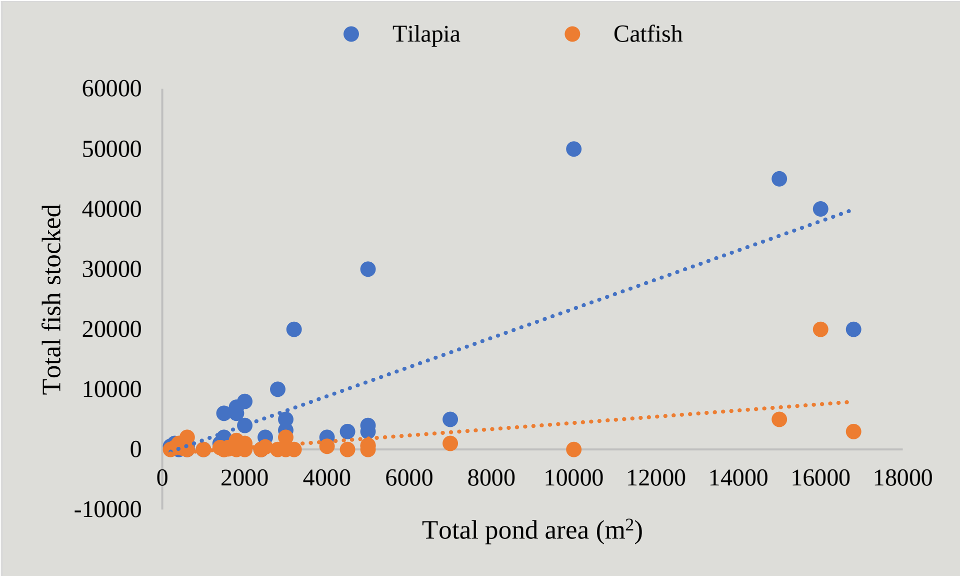

Figure 9. Relationship between fish stocked and total pond area of the farms

The farmers reported several sources of feed used for their farms. These included the aquaculture research and development station at (Kajjansi), Ugachick poultry breeders, source of the Nile (SoN) fish farm, Sabra industries, local stores (other sources) and feeds formulated on the farms (On-farm feeds). The feeds from Ugachick poultry breeders and Sabra Industries are floating pellets, Kajjansi feed and SoN are sinking pellets while the rest of the stores supply powder feeds.

The number of farms that reported feed use was 80% of all farms studied. Over 60% of these farms formulated their own feed while 17% used Kajjansi feed. About 15% used Ugachick feed while others relied on feeds from small-scale suppliers close to their farms (Figure 1010).

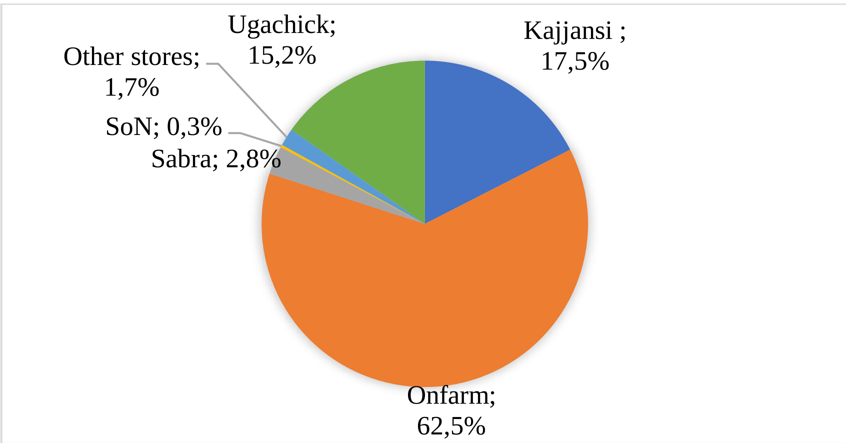

Figure 10. Feed sources

The study shows that there is no significant relationship between the duration of the production cycle and the average size at harvest (*p*>0.05, n=33). The farm that reported the shortest rearing cycle grows fish in 9 months to 400 g body weight. The farm that reported the longest rearing cycle grows fish in 14 months to 420 g. Long rearing cycles were not associated with increased size at harvest.

There was a significant relationship between the amount of feed used and fish production from the farms that reported the quantity of feed used per cycle (p<0.0001, n=30). This, however, changed when the largest farm was excluded from the analysis, then the relationship was no longer significant (p>0.05, n=29).

Over 80% of the farms used less than 5 tonnes of feed per cycle and produced less than a tone of fish (Figure 51). There were farms that used large quantities of feed however but produced less fish. There was one exception among all the farms that had a relatively high production far above the average of the other farms (Figure 511). The FCR for all the ranged between 0.4 to 600, with an average of 39.5. A selection of farms (13%) that had their FCR below 3 was filtered out and these had their average FCR at 2.1. These farms had an average production per farm higher than the overall average at 629 kg, with a range of 25 - 2500 kg. All calculations relating to feed costs were based on this FCR and average farm production (section 5.5).

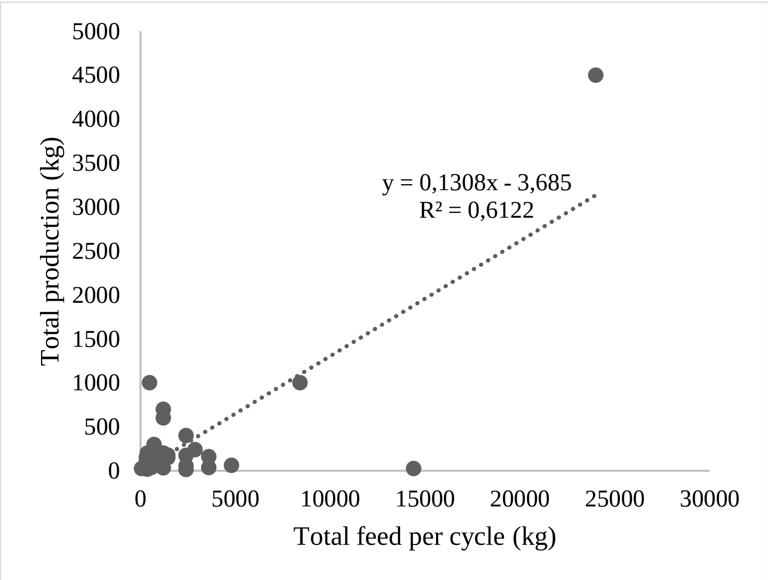

Figure 5. Relationship between total production and feed uses per cycle

The relationship between production and number of staff was not significant (P>0.05, n = 26). The total fish production was not dependent on the number of staff at the farms since some farms had low production even with higher staff numbers (Figure 12). The number of staff employed by the farmers does not necessarily indicate the amount of work at the farms. The farm that reported the highest production per staff produced 1000 kg of fish with one hired staff while the farm that reported the lowest production per staff produced 10 kg with a total staff number of six (06).

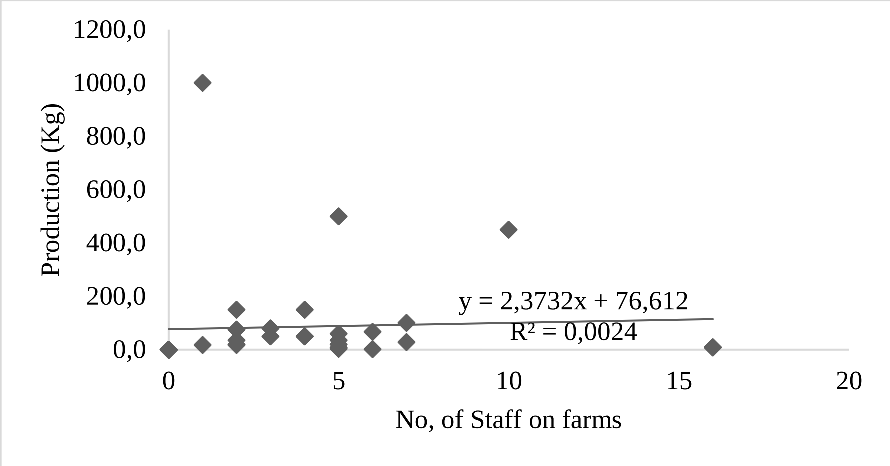

Figure 6. Farm production and number of staff

Farms reported their market size of fish at harvest ranging from 200 - 850 g. The average size at harvest was found to be 381 g. The study revealed a direct relationship between market size at harvest and the total fish production (*p*=0.003, n=24). Farms that targeted larger average body weight of fish had higher production as compared to those that sold fish at lower body sizes (Figure 7).

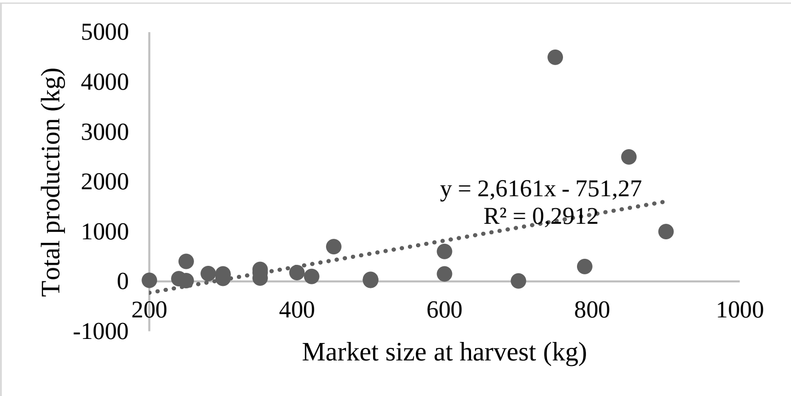

Figure 7. Relationship between total fish production and market size at harvest

The total fish production had no significant relationship with the seed and stocking density of the farms (*p*=0.12, n=34). Some farms with low stocking densities had higher production per square meter, while there were other farms with equally low stocking densities and low production.

The average seed requirement for each kilogram of fish produced was 24 juveniles for a farm targeting average fish weight of 380 g at harvest. Some farms, however, reported that they required over 100 juveniles for every kg of fish produced. The farm that reported the lowest number of juveniles per kg of fish produced used 2 juveniles for every kg of fish produced. Only 11% of the farms were able to use <10 juveniles for every kg of fish produced.

4.3 Farm costs

Small and medium scale pond culture investments according to the Directorate of Fisheries Resources (DFR) at the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF), are exempt from the mandatory feasibility studies and Environment Impact Assessment (EIA). The potential farmer is only required to apply for authorisation from the directorate of fisheries resources and the aquaculture permit is issued as provided for under the fish and aquaculture rules 2003 (GoU, 2003). A farmer would require a total of USD 1500 to set up a 1000 m^2 pond ready for stocking with fish (**Error! Reference source not found.**4). This translates into Ug. shs 5,300 m^{-2} of the pond.

Table 4. Farm start-up costs

Description	Quantity	Unit cost	Ug. shs	Total cost USD
Aquaculture establishment approval permit			20000	6
Application fees			1000	1
Excavation (8 hours per day)	2	1,200,000	2,400,000	661
Finishing labour (man days)	40	20000	800,000	220
Fittings	Variable		400,000	110
Miscellaneous			800,000	220
Total			**4,420,000**	**1218**
Professional fees			884,000	243
Grand total			**5,305,000**	**1,461**

The data used to generate costs in table 5, above, were obtained from key informant sources and input suppliers and service providers.

From the data obtained from farms, however, small ponds appeared to be costlier to set up as compared to large ponds. Farms reported construction costs ranging from 0.08 to 1.65 USD·m^{-2}. The farmers with large ponds (more than 2000 m^2) reported lower construction costs as compared to farms using small ponds where construction costs per square meter were above USD 0.55 m^{-2} (**Error! Reference source not found.**4). The average cost of construction for ponds was found to be 0.69 USD·m^{-2} of the pond. The relationship between the cost of construction of a pond and the total average area of the pond was significant (*p*=0.03, n=38).

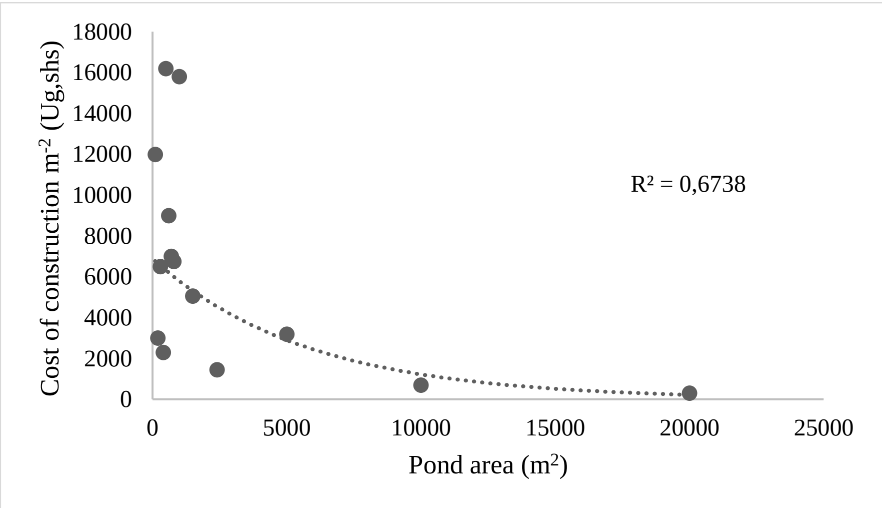

Figure 8. Pond construction costs per square meter

The running costs for the farms studied were analysed and presented as costs per kg of fish produced by the farms (Table 6). It was not possible to estimate the cost of labour since only part of the farms reported the use of hired labour while the rest of the farms relied on family labour. Attempts to estimate the cost of labour based on primary data resulted in a total cost per kg, higher than the highest market price paid to farms at farm gate (Table 65).

When the cost was estimated without the cost of labour, the resulting cost of production was USD 2.13 kg^{-1}. This cost was lower than the highest price paid to farmers in 2016. The costs in table 5 are based only on farms that had consistent data indicating good feed management and maintaining FCR below three (3). These farms were less than 15% of all the farms studied. Other costs were estimated to be 15% of the highest cost (feed) for the farms.

Table 5. Farm running costs

Description	**Unit cost (Ug. shs)**	**Cost per kg of fish produced**	**Percentage share**
Seed (per piece)	0.08	0.20	9.1%
Feed (per kg):	0.77	1.68	79.0%
Other costs	-	0.25	11.9%
Total		2.13	100.0%

4.4 Markets and market access

Over 50% of the farms rely on markets that are very close to the points of production (Figure 15). Neighbourhood markets are those located close to farms' geographical locations while all markets within the country in major urban centers are considered national markets.

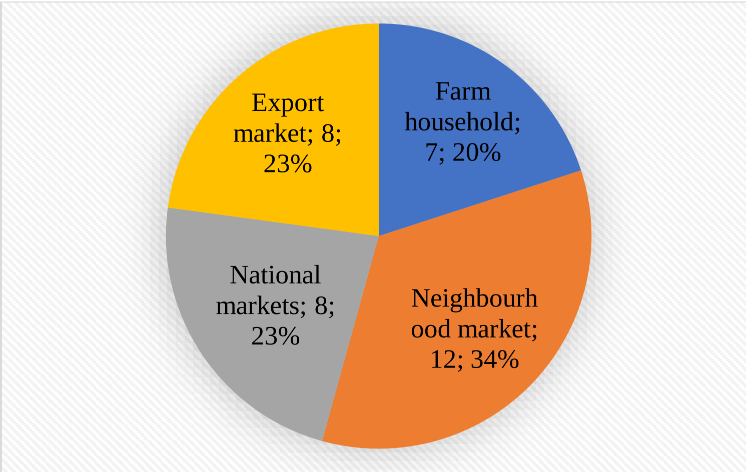

Figure 15. Target market for fish farms

4.5 Market prices

The farm gate prices stated the by farmers appeared to be increasing over the last three years between 2014 and 2016 (Table 66). Some farms enjoyed high prices per kg of fish produced while other farms sold at low prices. The average price per kg of fish at farm gate was USD 1.46 kg^{-1}.

Table 6. Farm gate fish prices per Kg 2014-2016

Prices in the year:	**Lowest price (USD)**	**Highest price (USD)**	**Average price (USD)**
2016	0.83	3.30	1.46
2015	0.83	2.20	1.43
2014	1.10	1.93	1.43

4.6 Wastewater management

Only three farms were found to have structures for management of wastewater from ponds before it was discharged into the surrounding systems. These structures were lagoons and settlement ponds where wastewater is collected from production ponds. The rest of the farms relied on natural systems like swamps and streams to discharge wastewater from ponds.

5 DISCUSSION

The study was conducted to examine the viability of small and medium scale fish farms in Uganda. These farms are the major target beneficiaries of government programmes like operation wealth creation (OWC) and the national agricultural advisory services (NAADS). Through these programmes, the farms receive free inputs in seed and feed and have access to free extension services from local government staff. Their performance goes a long way in underlining the impact of government programmes geared towards aquaculture development. All the farms studied qualify for government support although the study did not establish whether there were any beneficiaries at the time.

The quality of the primary data obtained from farms on the key inputs; seed, feed and labour, and the total annual fish production had significant gaps. Many farmers were not able to provide accurate data regarding total feed and seed used, total fish production and total number and status of staff on the farms. Using this data, it was hard to determine correct FCR, seed requirement per unit of fish produced and the cost of labour. The FCR average of 39.7 was too high to be believed. Equally, the number of seed per kg of fish produced was too high. Although farms may not be properly managed, extreme figures could not be believed or used to describe the status of farms. Many farms still sell fish in pieces and could only estimate their total sales based on the total number of fish sold. An average fish farm harvesting fish at 380 g would then require three fishes to make a kilogram. In some cases, farms report fish prices basing on the largest fish and not the average size.

5.1 Pond farms in Uganda

The results of the study show that most of the fish farms in Uganda are relatively small, with few larger farms. The average pond area per farm is 1580 m^2. The farms use a range of pond sizes from as small as 100 m^2 to as large as 20,000 m^2. The average yield was estimated at 0.84 $MT\cdot ha^{-1}$ based on 2016 production records from primary data. The lowest yield was 0.06 $MT\cdot ha^{-1}$ while the highest reported yield was 3.5 $MT\cdot ha^{-1}$. The average yield is much lower than yields estimated by Rutaisire, *et al*, (2009) and Isyagi, et al, (2009) at 2 $MT\cdot ha^{-1}$ and 10 $MT\cdot ha^{-1}$ respectively. The yield data reported by Rutaisire, *et al*, (2009) were the results of an experiment carried out at the aquaculture research and development center in Kampala, to compare the performance of fish ponds, fish tanks, and cages. The data reported by Isyagi is contained in a review of aquaculture policies and programmes in sub-saharan Africa.

The Nile tilapia was the dominant species in the farms studied followed by the catfish. The dominance of tilapia against the catfish is not in agreement with the FAO numbers that have consistently ranked catfish above tilapia in total annual volumes (FAO, 2010). It could, however, be explained by the dependence of commercial large-scale farms on catfish as opposed to small and medium scale farms.

The average stocking density was less than 1 juvenile/m^2 for both tilapia and catfish. This was lower than the number reported by Towers (2018) at 2 juveniles/m^2. Farms reported stocking rates ranging between 1 and 7 juveniles$\cdot m^{-2}$. Low stocking rates below the recommended imply that farms do not maximize production space and reduce yield per farm.

The average size of fish at harvest was 380 g after a 12-month rearing period. Farms produced sizes ranging between 200-850 g. The average size at harvest is lower than the numbers reported by Towers (2018), who reported that tilapia up to over 400 g in 5-6 months and 700 g in 8-9 months, with appropriate culture conditions. This could indicate that the farms are poorly managed and that production could be increased with better management practices. Given the low volumes produced by each farm, it is also possible that they do not give due consideration to managing the farms.

There was a significant relationship between average pond size and total fish production. These results are comparable to the findings of Hyuha *et al*, (2011) who found pond size to be significantly related to farm profitability.

The relationship between total pond area and fish production was not significant. This could be due to a possibility that the entire pond area reported is not used for farming at all times. Several factors could explain lack of maximum utilisation of pond area; lack of seed, a failed season in the past or lack of funds.

Based on available literature, and the average farm production of 370 kg per farm per year (primary data), the total estimated aquaculture production from ponds is about 5,180 MT of fish. This estimate is lower than the estimates made by Kubiriza (2017), probably because it is only based on small and medium scale farms. When the total production from cages is added, the total production from aquaculture then comes to 8,180 metric tonnes. This is however much lower than the FAO numbers at 110,000 MT (Figure 1, section 1.1).

Over 60% of the farms formulated their own feed while the rest used commercial feeds. The study was not able to establish the quality of on-farm formulated feeds but given the low production volumes reported, the feeds may not be of good quality. The main reason given for using on-farm formulations is the high cost and the low quality of commercial feeds. The average price for feeds is equivalent to 50% of average farm gate price for fish. There was no significant relationship between fish production from farms and the total amount of feed used. The average FCR for the farms was very high at 39.7. This could be a result of farmers not keeping records properly for both feed and seed and hence reporting the abnormally high amount of total feed per cycle. It is also possible that they do not use the feeds consistently and what they reported were projections or feed quantities used only intermittently. Keeping proper farm records were found to be significant in determining fish farm profitability (Hyuha, *et al*, 2011). A selection of 15% of the farms that had consistent data on seed and feed were able to produce fish at FCR below 3. The average FCR for these selected farms was 2.1, and this is the FCR used in computing the farm costs (section 4.5). Such an FCR value is acceptable where the quality of feed is good and farms are able to manage feeds properly during storage and feeding.

Most of the farms reported hired staff while the rest of the farms reported no staff. Over 45% of the total workers reported were employed by only 5 farms. The production per staff for the farms that reported staff was found to reduce with increase in the number of staff. This implies that increasing staff numbers alone may not necessarily result in improved performance of farms. It is also possible that these workers are not full-time employees of the farms. These findings are comparable to those of Hyuha, *et al*, (2011) who found that farms studied to rely on seasonal labour at the peak of activities like during harvest.

The largest proportion of farms (over 70%) were not legally registered as required by the laws governing the industry in the fish and aquaculture rules (2003). This implies that these farms are not being monitored by either the ministry concerned or the local governments where they are located. It also implies that data about their activities including production is also not being reported to the relevant authorities. The local government extension officers are charged with supervision of fish farms, advising on legal procedures and mobilizing farmers to follow laws and regulations. The fact that the farms are not registered, as required by law, could reflect the limited extension and advisory services provided by the government through local governments.

Farmers access aquaculture advisory services and information through various channels including the local government officers, private consultants, and the media. These sources, however, tend to send out mixed information on techniques, methods, sources, and markets for fish. Whereas government officials are reliable in terms of information quality and validity, the lack of facilities to reach all farmers constrains their operations. The media and the private consultants, on the other hand, give conflicting information for unknown reasons. Unfortunately, due to the challenges of accessing public extension systems, farmers find it easy to resort to the media and the private consultants. Isyagi (2009) cautioned farmers against trusting private consultants, but farmers have limited choices. This is encouraged by among other factors, the lack of a common reference for aquaculture at the national level where data on performance and potential can be accessed.

The difficulty of getting reliable data on farm costs like seed, feed, and labour made it hard for the researcher to make plausible estimates of the farm performance. This affects the entire industry as farms cannot fully determine their viability positions and hence plan for improvement.

5.2 Start-up cost

A farmer requires on average USD 1.38 m^{-2} to construct a fish pond. The cost of construction reduces with increase in the size of the pond. Larger ponds were found to be cheaper to construct at less than USD 0.55 m^{-2}. The figures obtained from the farmers are not much different although they are slightly lower at USD 0.69 m^{-2}. The reduction in pond construction costs with an increase in pond size is explained by the technology used in construction. Unlike in the past years when pond construction was accomplished with human labour, the use of earth moving equipment like excavators now allows for shorter construction time and reduces the costs greatly. Human labour is only used at the finishing point to perfect dykes, walls and fix fittings. This also explains the increased use of large ponds above 1000 m^2.

5.3 Cost of production and market price

The cost of production was computed from the cost of seed, feed, labour and other costs. The cost of labour was not estimated due to significant gaps in the data provided and because a considerable number of farms did not report labour.

The feed cost was the highest accounting for over 80% of total running costs contributing USD 1.68 kg^{-1} of fish produced. This was probably partly due to the high FCR (2.1) and partly due to the high cost of feed.

The average seed cost per kg of fish produced was estimated at USD 0.2 contributing 9.1% of total production costs.

Other costs were estimated at 15% of the highest costs (feed cost) and contributed 12% the total cost of running costs at USD 0.25. The total cost of production was USD 2.13/kg.

The farm gate prices reported by farms ranged between USD 0.83 to USD 3.3 with an average of USD 1.46/kg. This implies, therefore, that if farms were able to sell at USD 3.3/kg of fish, they would have a gross profit margin of 35.6% without considering the cost of labour. The average farm-gate price would result in a loss of 46% without the cost of labour. The data indicate that only 32% of the farms were able to sell at prices above the farm average. Only two farms (5%) had managed prices above the cost of production and therefore had registered profits. The net profit margin could not be estimated correctly without the estimate for labour costs. For the farms to remain viable, they must start targeting higher prices through market research and development. The fish and aquaculture rules (2003) provide for waivers for farm-raised fish in markets for size restrictions which allow farmed fish freely in all markets despite the fact that sometimes average size is small. This would however only apply where farms are fully registered and hold aquaculture permits to prove the source of fish. As stated earlier, the largest proportion of the farms were not registered as required by law and hence hold no such permits. As a result, fish of a particular average size from these farms cannot be sold in open regulated markets which offer higher prices. This could partly explain the reliance of these farms on markets close to areas of production. The low volumes produced by these farms also do not facilitate access to larger national and regional markets.

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Based on the outcomes of the analysis of the data collected from the study, the following conclusions have been drawn on the small and medium scale aquaculture industry in Uganda.

The introduction of improved pond construction technology reduces the cost of pond construction. The use of machines, in addition to human labour, is faster, more efficient and cheaper construction method than human labour alone. This is likely to reduce the start-up costs and increase total pond area in fish farms and if followed with proper farm management, production is likely to increase.

Judging by the low productivity and lack of correlation between inputs and outputs, small and medium-size fish farms are poorly managed. The farms appear to use large quantities of feed and produce very small quantities of fish which cannot recover the costs invested. Records of inputs and production are not reliable.

The cost of feed is high when compared to the farm gate prices offered to fish farmers. At the current prices, many farms appear to be producing fish at a cost higher than the prices offered. These farms may continue operating for some time under these conditions but will not grow and many will eventually be abandoned.

It is possible that these findings reflect the image of the industry as a whole. Although the study targeted small and medium-scale aquaculture, the situation may not be very different with commercial aquaculture.

6.2 Recommendations

Based on the conclusions above, the following recommendations are made to all stakeholders for consideration in order to facilitate the potential of the industry into actual growth.

The government should regulate the seed and feed sectors to allow farmers access them at an affordable cost. The government aquaculture Development and Hatchery Centres should be rejuvenated to ensure that farmers have access to seed of reliable quality and at affordable costs.

Improve the quality of public extension services to avail farmers with reliable technical advice whenever needed. It is important that farmers understand the importance of registering their farms and reporting their data on farm performance to the government. This data can easily be collected, organized and reported by local government extension workers to the ministry for compilation into the national database. In order to accomplish the task, extension workers should be able to access farms easily and keep in constant communication with farmers to motivate them into reporting performance.

There is a need to conduct a similar study at a national level focusing on aquaculture at three different levels: small-scale aquaculture, medium-scale aquaculture and “commercial” aquaculture. The assessment also ought to consider cage aquaculture separately from pond aquaculture given the efforts invested in promoting its adoption by potential farmers.

The difficulty of farms keeping updated farm records reflects the management abilities and skills that farmers have. It is important that these farmers are helped and supported by existing extension structures to improve their management skills. This will improve the performance of farms.

Farmers ought to be sensitized on the importance of keeping proper farm records for their farms and the entire industry. They need to be educated on how and why to always be willing to provide appropriate data for such studies to help the aquaculture industry progress.

Data collection could be improved by engaging farmers prior to the planned study and helping them understand their role and how they stand to benefit from the activity. Templates of desired records need to be handed out to farmers after training them on how to capture the details. This could help improve the quality of data obtained in future studies.

ACKNOWLEDGEMENTS

I would like to extent my sincere thanks to everyone that contributed to the success of this project.

To Dr. Tumi Tomasson, the UNU-FTP Director, thank you for accepting me into the programme and offering me all the support I needed to the end.

To the entire staff at the UNU-FTP; Mr. Thor H. Asgeirsson, Ms. Mary Frances Davidson, Mr. Stefan Ulfarsson, and Ms. Julie Ingham, I say thank you so much for everything.

To my supervisors, Professor Helgi Thorarensen and Þorgeir Pálsson, thank you for your patience and support all through the project period.

To the staff and students at Verið: Associate Prof, Olafur Sigurgeisson, and the entire team of Holar University, thank you so much.

To my friends and colleagues at Makerere University, the Head of department Zoology, Entomology and Fisheries Sciences, thank you so much for all the support.

To my colleagues, thank you for all the support offered right from the time we met.

Lastly to my family, thank you all for standing with me to the end.

REFERENCES

Abdallah, H. (2017, March 13). EAC states now act on overfishing to save stocks in Lake Victoria . *The East African*.

Aquatic community. (2018, February 16). Retrieved from Tilapia growth rate: http://www.aquaticcommunity.com/tilapia/growthrate.php

Bank of Uganda. (2018, January 02). *Bank of Uganda*. Retrieved from Bank of Uganda: https://www.bou.or.ug/bou/home.html

Baumgärtner, S., & Quaas , M. F. (2007). *Ecological-economic viability as a criterion of strong sustainability under uncertainty.* Lu¨neburg,: University of Lüneburg Working Paper Series in Economics .

Dalsgaard, J., Malcolm , D., Jagwe, J., & Longley, C. (2012). *Uganda Aquaculture Value Chains: Strategic Planning Mission Report* . WorldFish CGIAR Research Program 3.7 - Livestock & Fish .

Dickson, M., Nasri-Allah, A., Kenawy, D., & Kruijssen, F. (2016). Increasing fish farm profitability through aquaculture best management practice training in Egypt. *Aquaculture*, 172-178.

FAO. (2010). *Cultured Aquatic Species Information Programme. Clarias gariepinus. Cultured Aquatic Species Information Programme* . Rome: FAO-UN.

FAO. (2014). *Value chain dynamics and the small-scale sector: Policy recommendations for small-scale fisheries and aquaculture trade.* Rome: FAO-UN, Fisheries and Aquaculture Technical Paper 581.

FAO. (2016). *State of the World Fisheries and Aquaculture: Contributing to food security and nutrition for all.* Rome. 200 pp.: FAO.

FAO. (2017). *FAO Global Fisheries and Aquaculture Production Statistics.* Rome: FAO.

FAO. (2017). *Towards gender-equitable small-scale fisheries governance and development.* Rome: FAO.

GoU. (2003). *Statutory Instruments 2003, No. 81: Fish and aquaculture rules (2003).* Kampala: Governement of Uganda.

Hyuha, T., Bukenya, O. J., Twinamasiko, J., & Molnar, J. (2011). Profitability analysis of small scale aquaculture enterprises in Central Uganda . *International Journal of Fisheries and Aquaculture* , 271-278.

ILRI. (2011). *Fish value chains in Uganda and Egypt: Background proposals for the CGIAR Research Program on Livestock and Fish.* Nairobi, Kenya: International Livestock Research Institute.

Isyagi, N., Atukunda, G., Aliguma, L., Ssebisubi, M., Walakira , J., Kubiriza , G., & Mbula, E. (2009). *Assessment of National Aquaculture Policies and Programmes in Uganda.* SARNISSA.

Isyagi, N., Karen , L. V., Rashid , A., & William, H. D. (2009). *Manual for the Commercial Pond Production of the African Catfish in Uganda.* Kampala: WAFICOS.

Kasozi, N., Rutaisire, J., Nandi, S., & Sundaray, J. (2017). A review of Uganda and India’s freshwater aquaculture: Key practices and experience from each country. *Journal of Ecology and the Natural Environment*, 15-29.

Kofi, E., Asamoah , E. A., & Osei-Asare, Y. B. (2014,). Economics of aquaculture production: a case study of pond and pen culture in southern Ghana. *Aquaculture Research*, 675–688.

Kubiriza, K. G. (2017). *The effects of dietary lipid oxidation on farmed fish: PhD dissertation.* Reykjavik: Faculty of Life and Environmental Sciences, University of Iceland, 107pp.

Little, D., & Edwards, P. (2003). *Integrated livestock-fish farming systems.* FAO , Fisheries and Aquaculture Department [online]. . Rome: FAO-UN. . Retrieved February 1, 2018

MAAIF. (2015). *Joint Agricultural Sector Annual Review (JASAR) (Performance Review).* Entebbe Uganda: MAAIF.

MAAIF. (2016). *Agriculture Sector Strategic Plan 2015/16-2019/20* . Entebbe: Ministry of Agriculture Animal Industry and Fisheries.

Marriott, A., Dillon, M., & Shaun, H. (2004). *Impacts of Globalisation on Fish Utilisation and Marketing systems in Uganda: DFID Project R8112.* Grimsby: Manufacturing Improvement International.

Mbowa, S., Odokonyero, T., & Munyaho, A. T. (2017). *Harnessing Floating Cage Technology to Increase Fish Production in Uganda.* Kampala: Economic Policy Research Centre.

Mugabira, M., Borel, P., Mwanja, W., Rutaisire, J., Balirwa, J., Wadanya, J., . . . Kivunike, G. (2013). *National Investment Policy for Aquaculture Parks in Uganda.* Kampala: Trust Africa. .

Muke, C., Mukooli, L., & Wambede, F. (2018, January Tuesday 23). Government abandons fish project. *Daily Monitor*.

National Population Council. (2017). *State of Uganda Population 2017.* Kampala: Governement of Uganda.

Okechi, J. (2004). *Profitability Assessment: A Case Study of African Catfish (Clarias Gariepinus) Farming in the Lake Victoria Basin, Kenya.* Reykjavik: UNU-FTP.

Rakocy, J. E., & McGinty, A. S. (1989). *Pond Culture of Tilapia.* Texas: SRAC Publication 280.

Rural Fisheries Programme. (2010). *A Manual for Rural Freshwater Aquaculture.* Rhodes University, Department of Ichthyology and Fisheries Science . Pretoria, South Africa: Water Research Commission.

Rutaisire, J., Charo-Karisa , H., Shoko, A. P., & Nyandat, B. (2009). Aquaculture for increased fish production in East Africa. *African Journal of Tropical Hydrobiology and Fisheries*, 12: 74-77 .

Sanusi, S. (2014). Profitability of Small Scale Fish Farming in Minna Agricultural Zone of Niger State in Nigeria. *Indian Journal of Economics and Development*, 382-386.

Satia, B. (2017). *Regional Review on Status and Trends in Aquaculture Development in Sub-Saharan Africa – 2015* . Rome: FAO.

Ssebisubi, M. (2011). *Analysis of small-scale fisheries' value*-*chains in Uganda.* Kampala: Aquaculture Management Consultants Limited,.

Tilapia fish. (2018, February 25). *Growth rate in tilapia*. Retrieved from Tilapia fish: http://www.tilapia.ws/growthrate.php

Tisdell, C. (2001). Aquaculture Economics and Marketing: An Overview. *Research Gate*.

Towers, L. (2018, February 15). *Fish species, diseases*. Retrieved from The Fish site: https://thefishsite.com/articles/tilapia-life-history-and-biology

UBOS. (2015). *Statistical Astract.* Kampala: Uganda Bureau of Statistics.

7 APPENDIX I: DATA COLLECTION QUESTIONNAIRE

My names are Simon Peter Sserwambala Kigongo, a UNU-FTP Fellow 2017/2018. As part of my fellowship program, am conducting a study in Uganda titled "**A situational analysis of aquaculture viability in Uganda"**. This questionnaire is designed to capture the Economic, and other relevant data for the study. I request you to accept and provide a genuine response to the success of the study.

All responses will be treated with due confidentiality and used solely and exclusively for purposes of completing this study. I thank you in advance.

Date ………………………………………………

	Name of the farm	District	Subcounty	Village	Year of opening
	Name of the farmer	Gender (tick) Male Female	Age	Tel. contact	
	Name of the respondent (if different from farmer)	Gender (tick) Male Female	Age	Position Qualification	
	Fish Species raised at the farm (tick all applicable) Tilapia Catfish Carp Others (specify)				
	Why this species?				
	Fish Species currently stocked and number Tilapia ……………... Catfish …………………. Carp………………...Others (specify)………………				
	Farming system used (tick) Monoculture (single species of fish in a pond/tank)				

<table>
<tr><td></td><td>Polyculture (mixed fish species in same pond/tank)

Integrated system (practiced alongside other agro-enterprises in a mutual arrangement)</td></tr>
<tr><td></td><td>Farming methods used (tick)

Extensive (no feeding, only fertilizers)

Semi-intensive (partly feeding, and fertilizing)

Intensive (fully dependent on formulated feeds)</td></tr>
<tr><td></td><td>State your average rearing cycle/period in months</td></tr>
</table>

<table>
<tr><td rowspan="6">m</td><td>Farming enclosures used</td><td>Number</td><td>Average Size

(m2)</td><td>Unit cost of construction (Ug. Shs)</td><td>Number of units stocked currently and total number of fish stocked</td></tr>
<tr><td>Earthen Pond</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Concrete Ponds</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Lined ponds</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Tanks</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Others(specify)</td><td></td><td></td><td></td><td></td></tr>
</table>

<table>
<tr><td rowspan="6"></td><td colspan="4">Feed Information</td></tr>
<tr><td>Type</td><td>Source/Manufacturer</td><td>Quantity (Kg) per month</td><td>Unit cost (Ug. Shs)</td></tr>
<tr><td>Powder</td><td></td><td></td><td></td></tr>
<tr><td>Sinking Pellet</td><td></td><td></td><td></td></tr>
<tr><td>Floating pellet</td><td></td><td></td><td></td></tr>
<tr><td>others</td><td></td><td></td><td></td></tr>
</table>

	Chemicals used on the farm

	Type	Name	Frequency of use
	Disinfectants		
	Hormones		
	Antibiotics		
	Others		

	Legal status of the farm (tick appropriately)	Yes	No	Not sure
	Licensed by NEMA			
	EIA conducted			
	Periodic environmental audits conducted			
	Other licenses (specify)			

	Describe any farm structures in place to manage wastewater before discharge
	How often do you change the water in ponds/tanks, how much do you exchange?
	Describe the source of water for the farm
	Describe any previous management challenges related to water e.g pond flooding, ponds drying, water changes, etc

Fish Production records for the last five years(Kg), state average weight of the fish?				
2016	2015	2014	2013	2012

State the Farm-gate Price trends for the last five years (Ug. Shs)				
2016	2015	2014	2013	2012

State the proportion of the farm’s total annual harvested fish (%) that is sold to or consumed by:			
Farm household	Neighbourhood market	National market	Export market: Specify ……………………………………

For export markets, name destination and reason.

Why that market distribution	

State your cost breakdown as follows;		
Investment costs	Operation costs for a year	Others

Give a breakdown of your farm labour as follows in percentage of total			
Degree holders	Diploma holders	Certificate holders	Others

	Provide a gender breakdown of your farm workers (%)	Males	Females	Total number of workers
	Reasons			
	Name two immediate projects in the neighbourhood that share water with farm Upstream Downstream			
	How do these projects affect farm operations?			
	How does farm operations affect these projects?			

Thank you once again.