Assessing the Profitability of Small -Scale Aquaculture Fish Production in Zambia

by

Thelma Namonje-Kapembwa and Paul Samboko

Working Paper 123

September 2017

Indaba Agricultural Policy Research Institute (IAPRI)
Lusaka, Zambia
Downloadable at: http://www.iapri.org.zm/

Assessing the Profitability of Small -Scale Aquaculture Fish Production in Zambia

by

Thelma Namonje-Kapembwa and Paul Samboko

Working Paper No. 123

September 2017

Indaba Agricultural Policy Research Institute (IAPRI)
26a Middleway, Kabulonga,
Lusaka, Zambia

Namonje-Kapembwa and Samboko are Research Associates with Indaba Agricultural Policy Research Institute.

ACKNOWLEDGMENTS

The Indaba Agricultural Policy Research Institute is a non-profit company limited by guarantee and collaboratively works with public and private stakeholders. IAPRI exists to carry out agricultural policy research and outreach, serving the agricultural sector in Zambia so as to contribute to sustainable pro-poor agricultural development.

We wish to acknowledge the financial and substantive support of the Swedish International Development Agency and the United States Agency for International Development (USAID) in Lusaka. We further would like to acknowledge the technical and capacity building support from Michigan State University and its researchers and Patricia Jonnes for formatting and editorial assistance.

Any views expressed or remaining errors are solely the responsibility of the authors.

Comments and questions should be directed to:

The Executive Director
Indaba Agricultural Policy Research Institute,
26A Middleway, Kabulonga,
Lusaka.
Telephone +260 211 261194
Telefax +260 211 261199
Email: kabaghec@iconnect.zm

INDABA AGRICULTURAL POLICY RESEARCH INSTITUTE TEAM MEMBERS

The Zambia-based IAPRI research team comprises of Antony Chapoto, Brian Chisanga, Munguzwe Hichaambwa, Chance Kabaghe, Mulako Kabisa, Stephen Kabwe, Auckland Kuteya, Henry Machina, Rhoda Mofya-Mukuka, Olipa Zulu-Mbata, Thelma Namonje-Kapembwa, Hambulo Ngoma, Paul Samboko, Mitelo Subakanya, and Ballard Zulu. Michigan State University-based researchers associated with IAPRI are Eric Crawford, Steven Haggblade, Thomas S. Jayne, Nicole Mason, Melinda Smale, and David Tschirley.

EXECUTIVE SUMMARY

The fisheries industry in Zambia has gained recognition as an important sector in terms of its contribution to food, nutritional security, and employment creation. The sector is comprised of both the capture and aquaculture fisheries with the former contributing approximately 80% of the total fish produced. Evidence shows that as income rises people tend to move away from consumption of starchy foods towards animal proteins. In addition, a study by Musumali et al. (2009) show that fish and fish products account for more than 20% of animal protein intake and provide essential micronutrients to the majority of Zambia's population[1]. Further, in the low-income countries with water and fisheries resources, fish is an important source of livelihood, income and food for the rural poor and by far the most frequently consumed animal-source protein (Thilsted et al. 2014).

Aquaculture is one sector that can contribute to reducing food insecurity and it is the world's fastest growing source of animal protein (Hishamunda and Ridler 2006). Aquaculture production not only increases food supply but also provides employment income that can be used to purchase other necessities for home consumption. Hence, its potential as a source of livelihood among smallholder farmers is key but evidence on the profitability of the enterprise to this group remains absent. Though the sector is relatively small in Zambia, it can have substantial local impacts and its growing importance, therefore, merits study.

The overall objective of the study was to assess the profitability of small-scale aquaculture production in selected areas in Zambia. To achieve this objective, the study addressed the following research questions:

i) What is total investment cost in aquaculture production at a small-scale level?
ii) What is the profitability of small-Scale aquaculture investment in Zambia?
iii) What are some of the constraints faced by aquaculture fish farmer?

The data used in this study was collected through a structured questionnaire that was administered to a sample of 100 small-scale fish farmers in Kitwe, Luanshya, Kalulushi, Mkushi, Kabwe, and Chongwe districts. Data collected through the formal the questionnaire was supplemented with focus group discussions from the selected districts. The analysis combined descriptive statistics, enterprise budgets, and financial analysis tools. The profitability of the aquaculture venture was determined using the indicators of investment returns including, net present value (NPV), internal rate of return (IRR) and benefit-cost ratio (BCR).

The following were the key findings:

1. Over 80% of the ponds owned by small-scale fish farmers are earthen type with less than 5% made of concrete. The average size of the ponds is 502m^2 with an average production of 475 kilograms (kgs) per cycle.
2. The estimated initial start-up cost for 500m^2 (0.05ha) pond for fish farming is approximately 24,750 ZMW, this is inclusive of the cost of constructing the pond, setting up the water supply, stocking of fingerlings, feed and other operational costs.
3. Over the useful life of the ponds (approximately 10 years), the estimated NPV was 17,524.13 ZMW and the IRR was 42.38% measured at the discount rate of 15%. The positive NPV implies that the aquaculture enterprise is feasible and profitable for small-scale fish farmers.

[1] At global level, fish accounts for 17% of the animal protein intake and in some countries, it exceeds 50% (FAO 2014).

4. The projected cash flow is sufficient to repay the invested capital and provide returns on the capital. The BCR was estimated to be **1.2** at the 15% discount rate and since BCR is greater than one it further confirms that fish farming is a profitable and viable enterprise.
5. The results also show that aquaculture production was very sensitive to changes in the price of fish. For instance, a 10% reduction in the price of fish resulted in a 59% decrease in the estimated NPV holding other factors constant. While a 20% increase in the loan interest rate only showed a 4% decline in the NPV *ceteris paribus.*
6. The main constraints identified by the farmers included animal and bird predators, high cost of feed, lack of capital (finances), non-availability of fingerlings, the inconsistent supply of water as well as limited access to extension services.

Studies have shown that Zambia has potential to increase its aquaculture production levels, however, small-scale farmers are faced with many constraints and based on the study findings the following are some of the recommendations:

i) Increasing farmer's access to credit from micro-finance banks and commercial banks is necessary to ensure aquaculture development in Zambia. Hence, there is need for public-private partnership agreements to establish credit schemes for small-scale fish farmers.

ii) Farmers need to be encouraged to adopt the integrated Livestock-Crop-Fisheries production system as a way of reducing costs associated with fish feed. The animal droppings, maize, and soybean can be used in formulating feed for fish. This, however, requires training the farmers in best farm practices that ensure sustainable growth of the aquaculture sector.

iii) There is need for government to invest more in the extension services especially for the fisheries and livestock sector. More funds should be allocated to the ministry for operational purposes as well as for improving staffing at district levels.

iv) In addition, it was observed that the facilities for fingerling production in various districts are available but not operational due to lack of funds. There is need to increase production of fingerlings for the fish farmers within the districts to help minimize the cost of sourcing fingerlings outside the provinces where they are located. Lastly, there is need to fast track the operationalization of the aquaculture and fisheries fund in order to stimulate fish production especially for aquaculture that requires a significant amount of resources to be invested in.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS

BCR	Benefit Cost Ratio
CSO	Central Statistics Office
DOF	Department of Fisheries
DR	Discount Rates
FAO	Food and Agricultural Organization
FGDs	Focus Group Discussions
GM	Gross Margins
ha	hectare
IAPRI	Indaba Agricultural Policy Research Institute
IRR	Internal Rate of Return
kg	Kilograms
NPV	Net Present Value
ZMW	Zambian Kwacha

1. INTRODUCTION

Rapid urbanization, growing population coupled with sustained income growth has led to changes in the consumption patterns in most developing countries. Evidence shows that as income increases people tend to move away from consumption of starchy foods towards animal proteins. A recent issue on the state of world fisheries and aquaculture by the Food and Agricultural Organization (FAO), show that fish accounts for about 17% of the global population's intake of animal protein and in some countries, it exceeds 50% (FAO 2014). In Zambia for instance, fish and fish products account for more than 20% of animal protein intake and provide essential micronutrients to the majority of the population (Musumali et al. 2009). Further, in low-income countries with water and fisheries resources, fish is an important source of livelihood, income and food for the rural poor and by far the most frequently consumed animal-source protein (Thilsted et al. 2014). And as the human population continues to grow worldwide, the demand for fish and fish products is expected to increase. However, in the recent years, capture[2] fisheries production has leveled off while aquaculture[3] has continued to show sustained growth (FAO 2006, 2010, 2014). Therefore, the growing demand for fish can be met by increased production from aquaculture.

The Department of Fisheries (DoF) in Zambia estimates the average annual fish production to be at 75,000 mt and 20,000 mt for capture and aquaculture fisheries respectively. It is also estimated that the fisheries sector contributes about 0.4% to the GDP (CSO 2010). This relatively small contribution at a macro level often masks the significant contributions of fish production in the rural economy and the nutrition security of the Zambian population. The sector provides income for 1,000,000 people who earn their income directly as fishers or fish farmers or indirectly as traders, processors and other service providers along the value chain (Musumali et al. 2009). However, the current fish consumption per capita in Zambia is still low compared to the global consumption (10.3 kg per capita compared to 19.2 kg per capita). At the current consumption[4] and production levels, there is a deficit of 35,000 mt, which is often met through importation of fish from various countries. Zambia's fish imports have since increased from 25% to 35% over the years (DOF 2016).

However, despite the well-known benefits of fish production, there are no empirical studies that have been conducted in Zambia to evaluate the profitability of the aquaculture production, especially for the small-scale fish farmers. This study determined the profitabiilty of small-scale investment in aquaculture production by addressing the following research questions:

i) What is the total investment cost in aquaculture production at a small-scale level?
ii) Is it profitable to invest in aquaculture production at a small-Scale level?
iii) What are some of the constraints faced by aquaculture fish farmer?

By increasing production from aquaculture, it will also drive demand for feed thereby increasing more opportunities in other segments of the value chain. The government of Zambia has shown keen interest in improving the fisheries industry and the key findings from this study present evidence-based information to the policy makers, key stakeholders such as the Department of fisheries, world fish, aquaculture association, and individual firms. The

[2]Capture fisheries involves the harvesting of fish from naturally occurring water bodies such as rivers and lakes.
[3] Aquaculture fisheries refers to the fish farming.
[4] 130,000 mt vs 95,000 mt

rest of the paper is organized as follows: Section 2 gives an overview of the fisheries sector in Zambia; Section 3 shows the data and methods used in this study, section 4 and 5 presents the results both from the descriptive statistics and profitability analysis. Section 6 highlights the constraints in fish farming. Lastly, section 7 presents the conclusion and recommendations based on the study findings.

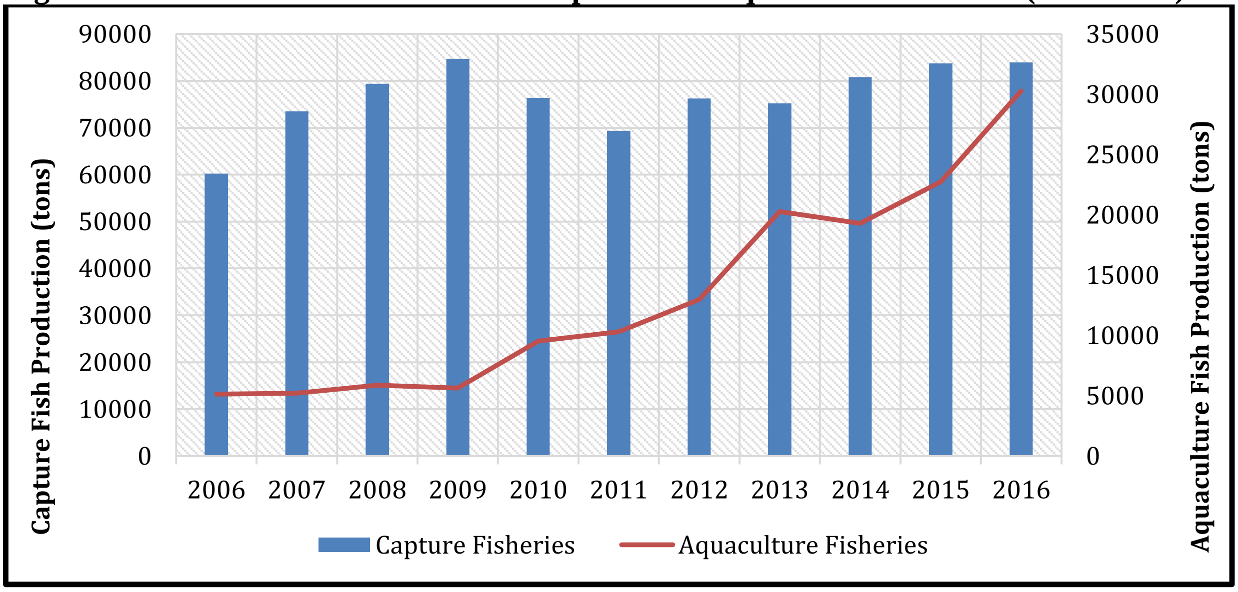
2. OVERVIEW OF FISHERIES SECTOR IN ZAMBIA

The Zambia's fishing industry is slowly gaining recognition as an important sector in the contribution to food and nutritional security as well as employment creation. The sector is comprised of both the capture and aquaculture fisheries with the former contributing most of the total fish produced. Fish production from capture fisheries like other countries has been fluctuating over years while for the aquaculture fisheries there has been an increase in the production levels since 2004. Figure 1 shows the production trend for both aquaculture and capture fisheries from 2006 to 2016.

It has been observed that the estimated annual production from capture fisheries is unlikely to increase from the current average of 75,000 mt due to the use of destructive methods coupled with increased number of fishers (Shula and Mofya-Mukuka 2015). With the rapidly increasing consumption of high-value protein foods derived from livestock and fish, the fish supply deficit is bound to increase unless the production from aquaculture or imports can be increased to offset the deficit. This shortfall, therefore, presents a host of new development opportunities for the small- and medium-scale farmers in the suitable areas to invest in the aquaculture production to significantly contribute to fish consumption, reducing rural poverty and unemployment. In Zambia, tilapia and catfish are the main types of fish that have been adapted to grow in the cage or pond system and there has been an increase in the awareness of the potential for aquaculture to contribute to domestic fish production.

There is need for the both the public and private sector to invest in aquaculture production to address the growing demand for fish and create employment. Evidence from various studies indicate that a pragmatic business approach focusing on small and medium-scale private enterprises would produce more benefits for more people than centrally planned and government-led development projects.

Figure 1. Fish Production Trend from Capture and Aquaculture Fisheries (2006-2016)



Source: Department of Fisheries 2017.

3. DATA AND METHODS

3.1. DATA

This study used both quantitative and qualitative data resources. The quantitative data were collected using a structured questionnaire from selected fish farming households in three provinces namely, Lusaka, Central, and Copperbelt Provinces. In these provinces, selected districts included; Chongwe in Lusaka Province; Mkushi, and Kabwe in Central Province; Kitwe, Kalulushi and Luanshya in Copperbelt Province. One hundred fish farmers were interviewed and Table 1 shows the distribution of the sampled households by province and district. The districts were selected based on the aquaculture activities that are currently going on and the suitability of the aquaculture production in these areas. The farmers were randomly selected from the farmer's registers at district fisheries offices. However, it was observed that not all the registered fish farmers were currently producing fish. A number of the fish farmers especially in Central Province had abandoned fish farming due to inadequate supply of water. We, therefore, selected only farmers that were actively involved in fish farming. The active members included those who recently stocked their ponds or recently harvested and those who produced in 2016 but did not have stock in 2017. From the survey conducted, it was observed that most of the active farmers were found in the Copperbelt Province compared to the other provinces that were selected hence a high proportion of the sampled households are from Copperbelt Province.

In addition, the quantitative data collected was supplemented with five focus group discussions (FGDs) which were conducted in five districts. The main purpose of qualitative data collection through the FGDs was to gain a better understanding of small-scale aquaculture production especially with regard to the constraints faced by the farmers as they engage in fish farming business. Thirty fish farmers participated in the FGDs of which 23 were male and seven were female.

3.2. METHODS

This study addressed three research questions as highlighted in Section 1. Firstly, the information collected from the household survey included socio-economic characteristics of the farmers, type and sizes of ponds, production cycles, costs of constructing the ponds, the cost of feed and fingerlings, and other operational costs. This information helped to determine the initial cost of investing in aquaculture production at a small-scale level.

Secondly, to estimate the profitability of an investment, two measures of profitability are commonly used in literature: net present value (NPV) and internal rate of return (IRR). According to Correia da Silva et al. (2003), IRR and NPV are conceptually the correct methods for measuring profitability. This is because these measures take into account the cash inflows and outflows of a business activity (rather than accounting revenues and costs,

Table 1. Distribution of the Sampled Households

	Copperbelt Province			Central Province		Lusaka Province
District	Kitwe	Kalulushi	Luanshya	Mkushi	Kabwe	Chongwe
Number Selected	14	12	30	10	14	20
Total			56		24	20

Source: Authors field notes.

which include accruals and non-cash items). These measures apply discounting to the cash flows and incorporates the economic concept of the time value of money. Profitability was be analyzed using Excel financial analysis tools.

Other studies that have looked at the profitability of fish farming have also estimated NPV and IRR though using other tools. For instance, Okechi (2004) and Salia and Jensson (2008) estimated NPV and IRR using a profitability model which is simply a simulation model of initial investment and subsequent operation (Jensson 2006). IRR is also referred to as the discount rate that causes the net present value of future cash flows from the investment to equal zero. To determine the NPV and IRR of a small-scale aquaculture investment, the following assumptions were made for this study.

3.2.1. Basic Production Assumptions

- One homestead Earthen Pond to be constructed (500m^2)
- Fish survival rate 90% for a complete cycle
- Harvest size of fish 200g
- Stocking rate 5 fish/m^2
- Production period 6 months (one cycle)
- Price of fish K23/kg
- Initial Financing of investment
  - Commercial Loan 70% of total Investment cost
  - Working Capital 30% of total Investment cost
  - Loan repayment period 4 years
  - Bank Interest Rate 12.5%
- Depreciation of the ponds estimated using the straight-line method
- Salvage value of the pond taken to be zero
- Expected life span of the homestead earthen ponds taken to be 10 years
- Cost of fingerlings used average price as reported by the farmers
- Cost of constructing the ponds used average price as reported by the farmer (see Appendix)
- Constant annual production and cash flow assumed
- Estimated period 10 years.

Given the above assumptions, the equations of estimating NPV and IRR are as follows:

$$NPV = \sum_{t=0}^{n} \frac{CF_t}{(1+i)^t} \quad (1)$$

CF_t = Cash flow in year t and
i = Discounting Factor

IRR is derived by extrapolating two net present values that have been calculated using two random Discount Rates (DR) as shown in the equation below.

$$\text{IRR} = \text{Lower DR} + \text{Difference between two DR} * (\text{NPV at lower DR}) / (\text{Absolute Difference between the NPV}) \quad (2)$$

In addition to estimating NPV and IRR, the study also estimated Benefit Cost Ratio (BCR), which measures the viability of a business venture. BCR is estimated as shown in equation 3

$$\mathrm{BCR} = \frac{\sum_{i=1}^{n} \frac{\mathrm{Bn}}{(1+\mathrm{r})^{\mathrm{n}}}}{\sum_{i=1}^{n} \frac{\mathrm{Cn}}{(1+\mathrm{r})^{\mathrm{n}}}} = \frac{\text{Discounted Revenues}}{\text{Discounted Costs}} \qquad (3)$$

Further, it should be noted that when estimating the cash flows for an investment there are fixed costs are associated with the long-term operation of the fish farming business such as depreciation of the ponds. In this study, depreciation was estimated using a straight-line method that involves allocation of an even rate of depreciation every year over the useful life of an asset. The formula for straight-line depreciation is given as:

$$\text{Pond Depreciation} = \left(\frac{\text{Asset Cost} - \text{Salvage Value (Residual Value)}}{\text{Expected useful life}}\right) \qquad (4)$$

Where asset cost here represent the cost of constructing the pond, salvage value is the value of a fixed asset post the useful life and in this study, we assume the salvage value of the pond is zero. Useful life, on the other hand, is the period over which the fixed asset is considered to be productive and in this study, the expected useful life is 10 years.

Thirdly, the study estimated the expected gross margins from the aquaculture business venture. Gross margin analysis has been used frequently in studies to determine the profitability of aquaculture production enterprise (Hyuha et al. 2011; Issa et al. 2014; Akegbejo-Samsons and Adeoye 2012). Using the primary data collected, we created enterprise budgets for each pond category based on the size. The enterprise budgets provide estimates of specific inputs and outflows associated with aquaculture production system. The estimated margins are based on an already established fish farming business. The estimated gross margins takes the form

$$\text{Gross Margin (GM)} = \text{Total Revenue} - \text{Total variable Costs} \qquad (5)$$

4. RESULTS

4.1. Social-Economic Characteristics of Fish Farmers

Table 2 shows the socio-economic characteristics of the fish farmers in the three provinces.

4.1.1. Individual Characteristics

The individual characteristics evaluated include age, gender, and education level of the fish farmers. Results in Table 2 shows that the average age and education level of the fish farmers is 53 years old and 12 years of formal education respectively. The results are similar in the three provinces and the test of difference in means shows no significance for the two variables. Similar findings were reported for the aquaculture baseline study that the average age of the fish farmers in Copperbelt and Northwestern Province was 52 years and the study also indicated that most of the fish farmers had attained senior secondary school education (Mwango et al. 2016). The implications of this finding is that majority of the people engaged in fish farming are over the age of 40 years and this to some extent shows the limited participation of youths in fish farming.

Further, results show that majority of the fish farming households are headed by men with very few households been headed by women. This, however, does not imply low participation of women in fish farming. Findings from the focus group discussions reveal that women are actively involved in fish farming. For instance, some farmer cooperatives indicated that women are actively involved in the construction of ponds and marketing of fish.

Table 2. Characteristics of Aquaculture Fish Farmers

Variables	Mean	Copperbelt Province	Central Province	Lusaka Province	Level of Significance
Number of Observations	100	56	24	20	
Age of farmer (yr.)	53	53	54	51	
Education level (yr.)	12	11	13	13	
Gender of farmer (Male=1)%	92%	89%	100%	89%	
Household Size (number)	5	6	6	5	*
Use of Hired Labor (%)	56%	60%	46%	58%	
Value of Assets for Fishing (ZMW)	10,105	7,319	11,238	16,329	
Production Cycle (#Months)	6.18	6.07	6.28	5.9	
Number of Ponds Owned	3	2	3	2	
Quantity of fish produced in cycle (Kg)	475	725	359	342	**
Income from Fish (ZMW)	17,663.14	21,226.34	10,489.12	15,940.56	**
Income from other activities (ZMW)	61,836.73	21,880.54	77,351.74	160,821.10	***

Source: Authors calculations from IAPRI 2017.

Note; T-test between provinces *, **, *** shows significant differences at 10%, 5% and 1%

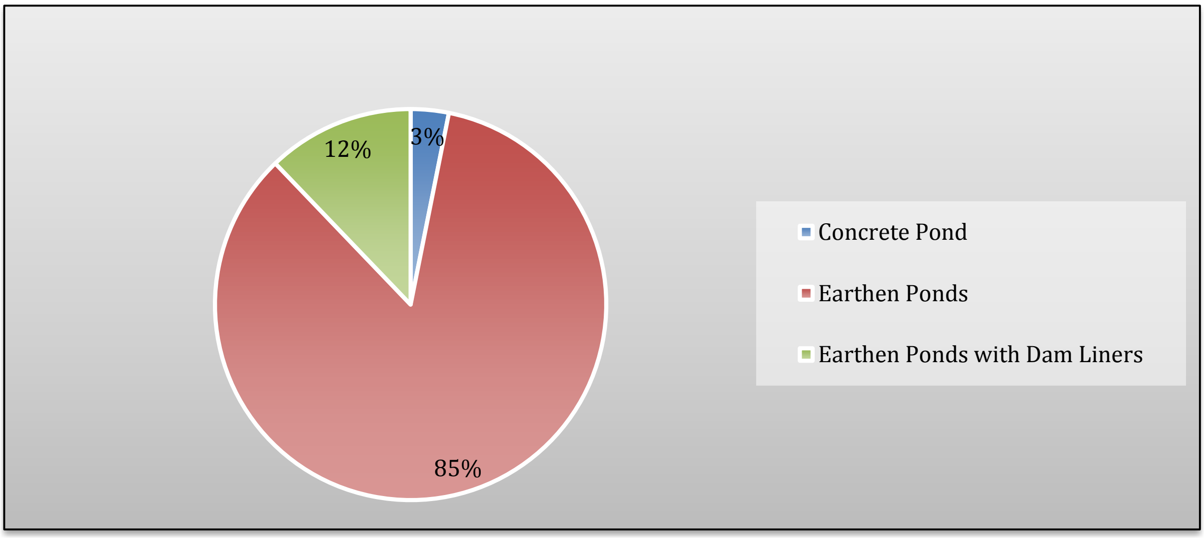
In Chongwe district for example, the aquaculture program for the youths comprises of 18 females out of the 30 members participating in the program. The participants in the FGDs noted that they engage youths and women so that they take care of the business especially marketing of fish is entrusted to women in most of the areas visited.

4.1.2. Economic Indicators

There are some key things to note from the results presented in Table 2 that give general economic characteristics of fish farmers. Firstly, the average length of the production cycle (from stocking to harvesting) is six months for most of the farms surveyed in all the provinces. This implies that farmers can produce fish twice in a year provided they have the resources to do so. Secondly, the average quantity produced by the farmers is 475 kg per cycle with Copperbelt recording the highest (725 kgs) while Lusaka had the least average quantity produced (342 kgs). Thirdly, the income earned from fish farming also varied across the three provinces with the average of 17,663.14 Zambian Kwacha (ZMW) and Copperbelt recording the highest amount earned. The test of difference in means for both the quantity of fish produced and income earned shows that the results are statistically significant at 5%. Fourth, with regard to labor, on average 56% of the fish farmers use hired labor with Copperbelt and Lusaka Province recording the highest percentage of fish farmers that use hired labor. Lastly, the results indicate that fish farmers are also actively involved in other economic activities to generate household income. The economic activities included crop production, formal wage employment as well as other off-farm activities in a year. Comparing the three provinces, fish farmers in Lusaka had the highest average income earned from other economic activities and the results are statistically significant at 1%.

Figure 2 shows the type of aquaculture facilities that are used by the fish farmers and results indicate that majority of the farmers utilize earthen ponds (85%)About 12% of ponds were earthen ponds with dam liners and less than 5% were concrete ponds. Similarly, the baseline study by Mwango et al. (2016) show that over 90% of the farmers utilize earthen ponds compared concrete ponds. However, the aquaculture studies in Nigeria show that a majority

Figure 2. Aquaculture Facilities Used by Farmers



Source: Authors compilation from IAPRI 2017.

of the small-scale fish farmers utilize concrete ponds compared to earthen ones (Issa et al. 2014; Akegbejo-Samsons and Adeoye 2012). The choice of the type of facility to use by the fish farmers is dependant on a number of factors such as water availability and soil type, as well as costs associated with constructing and maintaining the ponds.

Further, results in Table 3 show the different sizes of ponds that farmers own by the facility type. The result indicates that the average size of ponds is about 502m^2 and most of the ponds are between 150m^2 and 500m^2 followed by those that are less than 150m^2. The third highest category of pond sizes is between 500m^2 and 700m^2 and only 19 out of the 255 ponds were more than 1000m^2.

Table 3. Size of Ponds by Facility Type

Pond Size Category	All types of Ponds (Count total)	Type of Ponds			
		Concrete Pond	Earthen Ponds	Earthen with Plastics	Average Size of Ponds
		Count	Count	Count	
<150 m^2	(64)	2	57	5	109m^2
150 to 500 m^2	(85)	4	57	24	327m^2
500 to 700 m^2	(62)	0	60	2	590m^2
700 to 1000 m^2	(25)	2	23	0	860m^2
>1000 m^2	(19)	0	19	0	1932m^2
Total	255	8	216	31	502m^2

Source: Authors compilation from IAPRI 2017.

5. PROFITABILITY ANALYSIS

5.1. Cost of Investing in Aquaculture Farming

In order for a farmer to venture into fish farming business, one needs to know the costs associated with starting up fish farming and the required capital (money) to invest. The investment may include obtaining land, buildings, ponds and other start-up costs. In this study, however, we assume the farmer already has land available at his/her homestead hence our study does not include the cost of obtaining land. Other studies that have looked at the profitability of aquaculture production have included the cost of buying land and building other farm structures besides the fish ponds (Okechi 2004; Salia and Jensson 2008). The initial investment costs for constructing a 500m^2 earthen pond are presented in Table 4. The costs include setting up the ponds, cost of water pump and pipes, and other fishing equipment. In the initial investment cost, we include a 4% contingency. Financing of the investment is assumed to be paid by equity, which is approximately 30% of the total capital and a one-time loan accounting for 70% of the total investment costs and other start-up costs. In this study, we also assume the repayment period of the loan is four years with a one-year grace period in the first year of setting up the business and an interest rate of 12.5%. The total investment cost and other start-up cost is estimated to be 24,000 ZMW of which 12,500 ZMW is for constructing the pond, setting up the water supply and other fishing equipment.

5.2. Is Aquaculture Investment Profitable?

5.2.1. NPV and IRR

To answer this research question we estimated the profitability and viability of aquaculture production using net present value, benefit-cost ratio as well as the internal rate of return. Based on the data collected for this study and other past studies on aquaculture production in Zambia (Mwango et al. 2016; Shula and Mofya-Mukuka 2015), we made production assumptions as presented in Section 3.2.1. to estimate the profitability of aquaculture production. Table 8 in the Appendix shows the projected 10-year operational costs and cash inflows. It should be noted that the total costs (cash outflow) in the first year include the

Table 4. Initial Investment Costs and Financing

Initial Investment	ZMW
Construction of Pond (500m^2)	3,500.00
Water Pump and Pipes	7,000.00
All other Fishing Equipment	1,500.00
Contingencies (4%)	504.00
Total Investment	12,504.00
Other start-up costs*	11,894.00
Total Costs in Year 1	24,398.00
Financing	
1. Loan Drawn	17,000.00
2. Equity	7,400.00
Total Financing	24,400.00

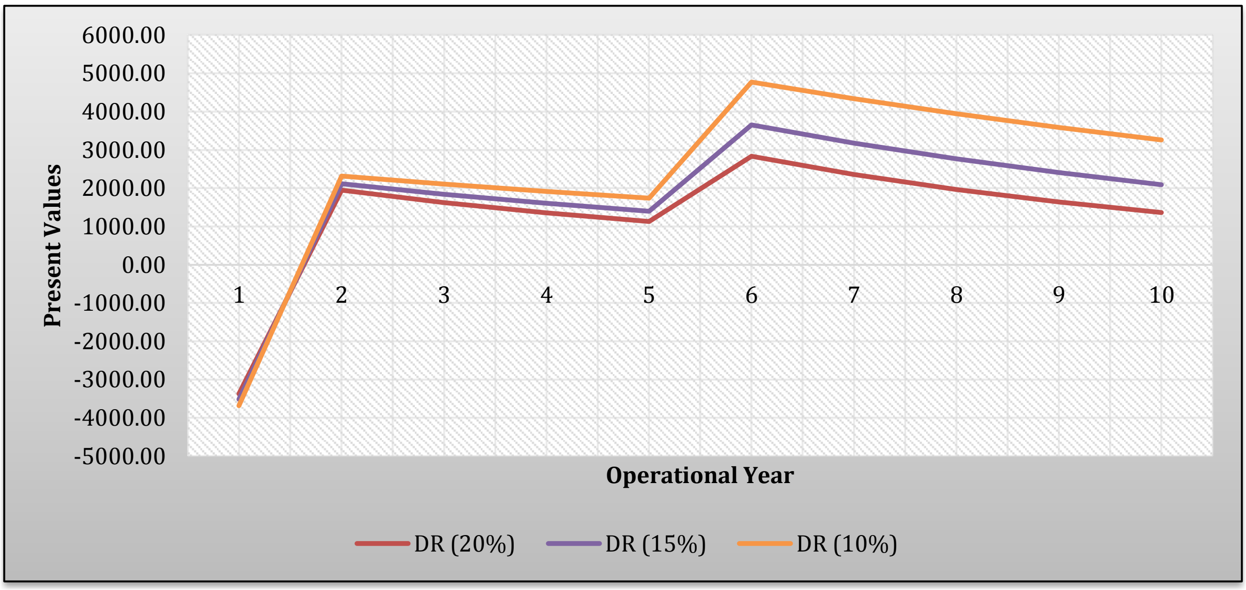
Source: Authors Calculations using aquaculture survey data from DOF 2017.
* Note; Refer to Table 5 on the operation costs.

initial investment costs. Further, in estimating the operational costs we include fixed costs and variable costs. Fixed costs are associated with the long-term operation of the fish farming business such as repayment of borrowed money and depreciation.[5]

NPV is the most commonly used measure for evaluating the profitability of an investment and it indicates how much value an investment adds to the business. Results in Table 9 in the appendix show that the estimated net present values (NPV) at 20%, 15%, and 10% discount rates and results show that NPV is positive. For the purposes of this study, the discount rate used is 15%. Using this rate NPV at the end of 10 years of business operation was found to be 17,524.136 ZMW. A positive NPV implies that the aquaculture business venture is feasible and profitable. Figure 4 shows the estimated NPVs over the 10-year period and the results show that NPV is sensitive to the choice of discount rate used.

Evaluating costs and benefits of an investment involves an important step of choosing a discount rate. According to Kossova and Sheluntcova (2015), the discount rate allows for comparison of social benefit and costs that might arise at different time points and the value of the discount rate has a significant impact on the present value of a project/investment. For instance at 20% discount rate the estimated NPV is 12,829.98 ZMW compared to 17,524.136 ZMW and 24,292.31 ZMW at 15% and 10% respectively. The decision to accept or reject an investment can be affected by the discount rate used. For example, an overestimated rate might lead to the rejection of a worthwhile project/investment and conversely, an underestimated rate might cause acceptance of a long-term investment/projects with distant benefits (Kossova and Sheluntcova 2015). Though there is no clear guide on the choice of the discount rate to use, Treasury Guidance (2003) suggests that for very long-term investments/projects (over 30 years) a lower discount rate should be used.

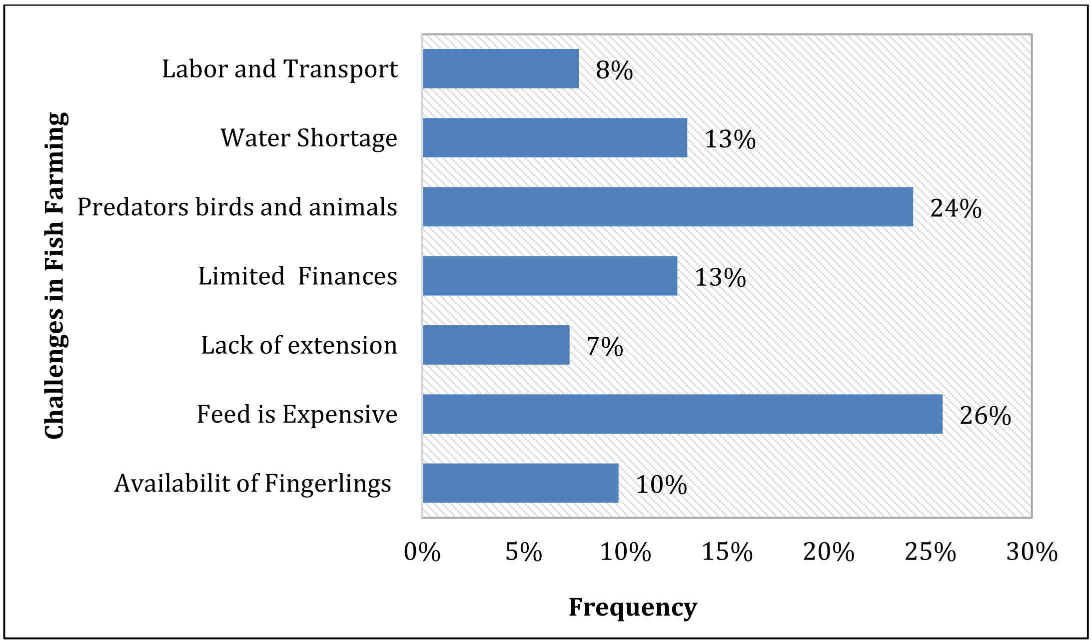
Figure 3. Estimated Present Values at Various Discount Factors



Source: Authors Calculations using aquaculture survey data from DOF 2017.

[5] Depreciation of the pond = $\frac{3{,}500}{10} = 350$

Figure 4. Constraints to Fish Farming



Source: Authors Calculations using aquaculture survey data from DOF 2017.

After estimating the NPV, we estimated the IRR, which is simply the rate of return that is expected to be derived from an investment considering the amount and timing of the associated cash flows. For this study, we use 10% and 20% as the discount rates for estimating IRR and the estimated IRR[6] is 42.38%. The IRR of 42.38% suggests that the proposed investment in aquaculture production will generate an average annual rate of return equal to 42.48% over the life of the project. Since the estimated IRR is positive and above 0, it implies that the investment in aquaculture production is profitable and is a worthwhile investment.

5.2.2. Benefit-Cost Ratio (BCR)

In addition to the NPV and IRR, another measure used to determine if the investment is profitable and viable is the Benefit Cost Ratio (BCR). BCR has been used in past studies to evaluate the viability of fish farming (Emokaro 2010; Olaoye et al. 2012; Akegbejo-Samsons and Adeoye 2012). The benefit-cost ratio measures how effective the revenues cover the cost of an enterprise. Using the 15% discount rate (DR), Table 5 shows the discounted benefits (revenues) and costs.

$$\text{BCR} = \frac{\text{Discounted Revenues}}{\text{Discounted Costs}} = \frac{103{,}888.51}{86{,}364.37} = 1.2 \qquad (6)$$

The estimated benefit-cost ratio is 1.2, which is greater than 1, and this indicates profitability of small-scale fish farming in the study areas. The estimate of 1.2 indicates that at 15% discount rate, the gross revenue covers the total cost 1.2 times. Fish farming is, therefore, a viable business in the study areas.

[6] IRR=10+10*(24,292.31/11,462.34)=42.38%

Table 5. Calculation of Benefit-Cost Ratio (BCR)

Year	Total Revenue	Total Costs	DR (15%)	Discounted Revenues	Discounted Costs
1	20,700.00	24,748.00	0.870	18,000.00	21,520.00
2	20,700.00	17,900.00	0.756	15,652.17	13,534.97
3	20,700.00	17,900.00	0.658	13,610.59	11,769.54
4	20,700.00	17,900.00	0.572	11,835.29	10,234.38
5	20,700.00	17,900.00	0.497	10,291.56	8,899.46
6	20,700.00	12,244.00	0.432	8,949.18	5,293.42
7	20,700.00	12,244.00	0.376	7,781.90	4,602.97
8	20,700.00	12,244.00	0.327	6,766.87	4,002.59
9	20,700.00	12,244.00	0.284	5,884.23	3,480.51
10	20,700.00	12,244.00	0.247	5,116.72	3,026.53
				103,888.51	86,364.37

Source: Authors.

Table 6. Gross Margins for Fish by Pond Size

	Average Size Pond (544m2)	<150 m2	150-500m2	500-700	700-1000
Production Cycle (Months)	6	6	6	6	6
Variable Costs					
Average Fingerlings Stocked	2,348	1,144.00	2,094.00	3,066.00	4,006.00
Cost per Fingerlings	0.58	0.62	0.57	0.53	0.4
Cost of Fingerlings	1,361.84	709.28	1,193.58	1,624.98	1,602.40
Cost of Feed	1,521.00	1,258.63	1,670.00	1,843.00	2,000.00
Labour Cost	1,800.00	1,800.00	1,800.00	1,800.00	1,800.00
Cost of Manure	202	247.57	125.99	294.54	341.3
Transport Cost	185	158	181	202	204
Total Cost	*5,069.84*	*4,173.48*	*4,970.57*	*5,764.52*	*5,947.70*
Fish Sold in one Cycle (Kg)	981	637.2	587.83	1,207.29	1,226.28
Price per kg	22	20	22	23	22
Revenue	*21,582.00*	*12,744.00*	*12,932.26*	*27,767.67*	*26,978.16*
Gross Margins (GM)	*16,512.16*	*8,570.52*	*7,961.69*	*22,003.15*	*21,030.46*
Net Profit Margin (%)	*77%*	*67%*	*62%*	*79%*	*78%*

Source: Authors Calculations using aquaculture survey data from DOF 2017.

5.2.3. Gross Margins Estimations

This section presents the estimated gross margins based on the costs and revenue information collected from 100 farmers in the districts surveyed. The gross margins are estimated based on the pond size categories as well as on the overall average size ponds. Table 6 shows the variables used to estimate the gross margins, which include the cost of fingerlings, cost of feed, labor, and transportation costs. The production cycle is estimated at six months based on the responses from the farmers.

The analysis of gross margins presented in Table 6 is positive indicating that fish farming enterprise is profitable and can contribute to household incomes. The gross margins, however vary across the different sizes of the ponds from 7,961.60 ZMW to 22,003.15 ZMW. The averagely sized ponds of 544m^2 generate approximately 21,582 ZMW per production cycle and the estimated gross margin is 16,512 ZMW**.** For the purposes of gross margins calculations, we used the average cost of hired labor for all the fish farmers interviewed in this study. The number of hired workers ranged from zero to four persons per farm and the average labor cost is per production cycle estimated to be six months. Table 6 reveals that the cost of labor, feed, and fingerlings accounted for the large proportion of the cost of fish farming in the study area. The high cost of feed was cited by the farmers that participated in the focus group discussions as one of the challenges faced by fish farmers. Similarly, studies that have looked at profitability of aquaculture production in Kenya, Nigeria, and Uganda have also indicated that the cost of feed and fingerlings are important factors that affect the economic potential of fish farming (Hyuha et al. 2011; Issa et al. 2014; Okechi 2004; Olaoye et al. 2012; Akegbejo-Samsons and Adeoye 2012). Further, the net profit margin percentages for all the categories of ponds show that fish farming in the selected areas is a profitable business venture.

5.3. Sensitivity Analysis

Since prices of commodities are constantly changing, a sensitivity analysis was performed to this study to analyze the risk of establishing an aquaculture business in the selected areas. The sensitive analysis will not only help to check the robustness of our findings that aquaculture production has positive returns but will also help to highlight some potential interventions in case of the changes. Table 7 shows the sensitivity analysis by computing the NPV, IRR, and BCR with the best and worst case scenarios. The pessimistic scenarios show the effect of a decrease in the price of fish by 10% and an increase in the loan interest rate by 20%. The optimistic scenario, on the other hand, shows the effect of an increase in the price of fish by 10% and a decrease in the loan interest rate by 20%. The four scenarios are performed separately to see the effect in changing one variable at a time. The results highlighted in Table 7 shows that the profitability of aquaculture production is more sensitive to changes in the price of fish compared to the changes in the loan interest rate. For instance, a 10% decrease in the price of fish reduces NPV from 17,524.136 ZMW to 7,135.28 ZMW while IRR reduces from 42.38% to 31.19%.

Table 7. Sensitivity Analysis

Profitability Variable	Pessimistic Price of fish reduces by 10% (20.3ZMW/Kg)	Optimistic Price of fish increases by 10% (25.3 ZMW/Kg)	Pessimistic Interest rate increases by 20% (to 15%)	Optimistic Interest rate reduces by 20% (to 10%)
NPV	7,135.28	27,912.99	16,783.06	18,251.53
IRR	31.19	47.75	41.67	43.06
BCR	1.08	1.32	1.19	1.21

Source: Authors Calculations using aquaculture survey data from DOF 2017.

6. CONSTRAINTS IN FISH FARMING

The third objective of this study was to identify the constraints to fish farming among the small-scale fish farmers in Zambia. Both in the structured questionnaire and the focus group discussions, the participants (respondents) were asked to highlight the three main constraints they face in fish farming. From the results presented in Figure 4, predators (this includes birds, snakes, and wild animals) and the high cost of feed were identified to be the most serious constraints to fish farming.

6.1. Fish Predators and Cost of Feed

During the FGDs, participants mentioned that commercial feed for fish is expensive hence, some of the farmers resort to using alternative feed that has very little effect on the growth of fish. In some cases, farmers mentioned that they use maize bran and vegetables such as cabbage to feed their fish.

The issue of predators was mentioned to have a negative impact on the quantity of fish that farmers eventually harvest thereby reducing the income that can be generated from fish. The issues of high cost of feed and predators have also been highlighted in other studies as factors affecting the profitability of fish farming (Hyuha et al. 2011; Olaoye et al. 2012; Ugwumba and Chukwuji 2010; Ume et al. 2016). Further, Ume et al. (2016) indicate that due to high costs and often unavailability of fish feed, it makes fish farming unproductive as resource poor farmers tend to stop feeding their fish when the prices of feed are high and resume only when they can afford the cost.

6.2. Limited Supply of Water and Lack of Capital

The other constraints include shortage of water and limited capital to finance the aquaculture business venture. The majority of the farmers visited depend on ground water for their fishing; this poses a challenge to fish production especially in the hot season as well as during drought years or when the rainfall is very low. One participant indicated that she was forced to construct a pond on a colleague’s farm that is very far from her place due to shortage of water. In Central Province, the situation on the ground is that most fish farmers have abandoned the practice due to water shortage as most ponds have dried up. One way to address this is investing in water pumps that can continuously pump water into the ponds. Investment in aquaculture production can be capital intensive especially for the resource-poor farmers and participants from the FGDs indicated that the cost of constructing the ponds and initial costs of feed, setting up water is usually high. However, they also indicated that once they started harvesting they were able to generate enough revenue to cover the cost. Therefore, access to credit for the small-scale farmers is vital in purchasing productive inputs and hiring labor to increase their productivity. The level of productivity by small-scale farmers is dependent on their access to productive resources, which is often determined by the availability of finances (credit).

6.3. Availability of Fingerlings

Further, some farmers especially those in Central Province indicated that availability of good quality fingerlings was another challenge they faced in their fish farming business. They bemoaned that they have to travel either to Copperbelt or Lusaka Province to purchase fingerlings. This was contributing to the high cost of doing business due to high transport costs.

6.4. Lack of Management and Technical Skill

It was also noted that most of the fish farmers only had one-time training in fish farming. They indicated that lack of management skills and technical knowledge of fish farming was prevalent among the fish farmers. Lack of site selection and design skills was also a challenge. One respondent gave an example of his colleague that built a pond only to stop afterward as the walls of the pond started cracking due to constructing the ponds near the trees. The participants during the FGDs indicated that they were only visited by extension officers from the fisheries department when they started the cooperatives and there have never been follow-ups on how they are performing in fish farming.

6.5. Transport and Labor Cost

Lastly, some farmers indicated that non-availability of transport and high cost of labor was a challenge that they faced in fish farming. In some areas, farmers indicated that due to non-availability of transport they end up selling their fish within the community, which usually fetches low prices. For households that are using hired labor, the farmers highlighted that labor was expensive and also as presented in the gross margins and profitability analysis in the earlier sections, labor costs are higher. However, the issue of the high cost of labor did not come out very strong from the participants this may be due to the composition of participants in the FGDs as some farmers may be depending on family labor as opposed to hired labor. Recall that Table 2 shows that about 44% of the fish farmers only depend on family labor hence the high cost of labor is coming from the 56% that are using hired labor for their fish operations.

7. CONCLUSION AND RECOMMENDATIONS

The objective of this study was to assess the probability of small-scale investment in aquaculture production and to identify the constraints faced by the small-scale fish farmers in the study areas. The study utilized primary data collected through a structured questionnaire that was supplemented with focus group discussions with individual fish farmers and members of cooperatives. To address these objectives, the study utilized both descriptive analysis and financial analysis tools using the data collected through the field survey that was administered to 100 farmers, as well as the qualitative information from the FGDs.

The following were the findings that emerged from the study:

Firstly, in terms of social-economic characteristics, the average age of the fish farmers from the surveyed areas was 53 years old with 12 years of formal education. It was observed that over 80% of the ponds owned by the fish farmers are earthen type of ponds with less than 5% concrete type of ponds. The average size of ponds is 502m2 and the average quantity of fish produced in one cycle is 475 kgs. The production cycle for the majority of the farmers is 6 months. The descriptive results further revealed that about 56% of the fish farmers used hired labor with Copperbelt Province recording the highest percentage of farmers that utilize hired labor.

Secondly, this study estimated that a farmer would require approximately 24,750 ZMW as start-up capital for constructing the pond, setting up the water supply, stocking up fingerlings, and purchasing other inputs. The operation costs, however, tend to reduce in the following year. An insight into the economic feasibility of the fish farm operations was gained using the financial analysis tools and it was useful in determining the feasibility of the enterprise. The indicators of investment returns estimated include Gross Margins, NPV, IRR, and BCR. The results from the profitability analysis show positive net revenue, Net Present Value and Internal Rate of Return. The Benefit Cost Ratio is also greater than one implying that investment in aquaculture production is profitable and viable business venture. The profitability analysis is based on the assumption that one 500m^2 (0.05ha) pond for a small-scale fish farm can produce at least 900 kgs of fish per year. The assumption of the production figures is based on the survey findings. The results reveal that over the useful life of the ponds, which is assumed to be 10 years, the estimated NPV is 17,524.13 ZMW and the IRR is 42.38% measured at the discount rate of 15%. The positive NPV implies that the aquaculture enterprise is feasible and profitable. The projected cash flow is sufficient to repay the invested capital and provide returns on the capital.

The BCR was estimated to be 1.2 at the 15% discount rate and since BCR is greater than one it further confirms that fish farming is a profitable and viable enterprise. The profitability analysis was further subjected to a sensitivity analysis and the results show that aquaculture production was very sensitive to changes in the price of fish. For instance, a 10% reduction in the price of fish resulted in a 59% decrease in the estimated NPV holding other factors constant. While a 20% increase in the loan interest rate only showed a 4% decline in the NPV ceteris paribus. The findings of this study compare favorably with other studies that have shown that fish farming is viable and profitable even at a small-scale.

Thirdly, the study identified some of the constraints and challenges that fish farmers face. The main constraints include the animal and bird predators, high cost of feed, lack of capital (finances), non-availability of fingerlings, and the inconsistent supply of water as well as limited access to extension services. These factors have negative implications on the profitability of the fish farming enterprise. For instance, farmers complained of limited knowledge in the management of their fish and this has resulted in the low production levels. The limited knowledge in fish management often results in underfeeding/overfeeding the fish and poor water management. Consequently, this affects the size of fish harvested, which ultimately determines the price of fish.

Based on the study findings, investment in aquaculture production is very profitable and viable for the small-scale farmers to generate income besides crop production. Studies have shown that Zambia has potential to increase its aquaculture production levels; however, small-scale farmers are faced with many constraints of which access to credit is among the top challenges. This study, therefore, recommends that the government in partnership with private companies (financial lending institutions) should establish credit schemes for fish farmers. Increasing farmer's access to credit from microfinance banks and commercial banks is necessary to ensure aquaculture development in Zambia.

To address the issue of high cost of feed, farmers should learn how to formulate quality feeds from the own grown crops that that can be used as feed ingredients. Farmers can adopt the integrated Livestock-Crop-Fisheries production system as a way of reducing costs associated with the fish feed. The animal droppings, maize, and soybean can be used in formulating feed for fish. This, however, requires training the farmers in best farm practices that ensure sustainable growth of the aquaculture sector. Hence, there is need for government to invest more in the extension services especially for the fisheries and livestock sector.

Lastly, to address the issue of non-availability of fingerlings in selected areas, the government through the department of fisheries should operationalize the existing aquaculture facilities in various provinces. It was observed that the facilities for fingerling production in various districts are available but not operational due to lack of funds. There is need to increase production of fingerlings for the fish farmers within the districts to help minimize the cost of sourcing fingerlings outside the provinces where they are located. There is need to operationalize the aquaculture and fisheries fund in order to stimulate fish production especially for aquaculture that requires a significant amount of resources to be invested in.

APPENDIX

APPENDIX 1

Table A.1. Projected 10-Year Operational Expenses and Cash Inflows

Year	1	2	3	4	5	6	7	8	9	10
Cash Inflow										
Sales (kg/year)	900.00	900.00	900.00	900.00	900.00	900.00	900.00	900.00	900.00	900.00
Price (ZMW/Kg)	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00
Revenue	20,700.00	20,700.00	20,700.00	20,700.00	20,700.00	20,700.00	20,700.00	20,700.00	20,700.00	20,700.00
Annual Operating Costs										
Variable Costs										
Cost of Fingerlings	1,600.00	1,600.00	1,600.00	1,600.00	1,600.00	1,600.00	1,600.00	1,600.00	1,600.00	1,600.00
Feed Cost	3,700.00	3,700.00	3,700.00	3,700.00	3,700.00	3,700.00	3,700.00	3,700.00	3,700.00	3,700.00
Transport Cost	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00
Cost of Manure	404.00	404.00	404.00	404.00	404.00	404.00	404.00	404.00	404.00	404.00
Maintenance works	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00
Labor Cost	5,190.00	5,190.00	5,190.00	5,190.00	5,190.00	5,190.00	5,190.00	5,190.00	5,190.00	5,190.00
Total Operational Costs	11,894.00	11,894.00	11,894.00	11,894.00	11,894.00	11,894.00	11,894.00	11,894.00	11,894.00	11,894.00
Fixed Costs										
Pond Depreciation	350	350	350	350	350	350	350	350	350	350
Loan Repayment	0	5,656.00	5,656.00	5,656.00	5,656.00					
Total Cash Outflow	24,748.00	17,900.00	17,900.00	17,900.00	17,900.00	12,244.00	12,244.00	12,244.00	12,244.00	12,244.00

Source: Authors Calculations using aquaculture survey data from DOF 2017.

APPENDIX 2

Table A 2. Calculation of NPV and Economic Rate of Return by Interpolation

Year	Total Revenue	Total Costs	Incremental benefit	Discount Factor at 20%	Present Value at 20%	Discount Factor at 15%	Present Value at 15%	Discount Factor at 10%	Present Value at 10%
1	20,700.00	24,748.00	(4,048.00)	0.83	(3,373.33)	0.870	(3,520.000)	0.91	(3,680.00)
2	20,700.00	17,900.00	2,800.00	0.69	1,944.44	0.756	2,117.202	0.83	2,314.05
3	20,700.00	17,900.00	2,800.00	0.58	1,620.37	0.658	1,841.045	0.75	2,103.68
4	20,700.00	17,900.00	2,800.00	0.48	1,350.31	0.572	1,600.909	0.68	1,912.44
5	20,700.00	17,900.00	2,800.00	0.40	1,125.26	0.497	1,392.095	0.62	1,738.58
6	20,700.00	12,244.00	8,456.00	0.33	2,831.90	0.432	3,655.762	0.56	4,773.19
7	20,700.00	12,244.00	8,456.00	0.28	2,359.91	0.376	3,178.924	0.51	4,339.27
8	20,700.00	12,244.00	8,456.00	0.23	1,966.60	0.327	2,764.281	0.47	3,944.79
9	20,700.00	12,244.00	8,456.00	0.19	1,638.83	0.284	2,403.723	0.42	3,586.17
10	20,700.00	12,244.00	8,456.00	0.16	1,365.69	0.247	2,090.194	0.39	3,260.15
NPVs					12,829.98		17,524.136		24,292.31

Source: Authors Calculations using aquaculture survey data from DOF 2017.

APPENDIX 3

Table A.3. Cost of Constructing the Ponds by Size and Type

Size of Pond	Type of Ponds		
	Concrete Pond	Earthen Ponds	Earthen with plastics
	Cost of Construction (ZMK)?	Cost of Construction (ZMK)?	Cost of Construction (ZMK)?
	Mean	Mean	Mean
<150	13,750	2,239	2,824
150 to 500	7,375	2,181	3,646
500 to 700	*	4,317	7,500
700 to 1000	10,500	4,913	*
>1000	*	7,447	*

Source: Authors.

REFERENCES

Akegbejo-Samsons, Y. and D. Adeoye. 2012. Measuring Profitability in Small Scale Aquaculture Enterprises in South West Nigeria. Presented at the 16th IIFET Conference, July 16-20, 2012. Dar es Salaam, Tanzania.

Correia da Silva, Luis, Gunnar Niels, Swee Chua, Leonie Bell … and Rupert Booth. 2003. *Assessing Profitability in Competition Policy Analysis*. Economic Discussion Paper No. 6. Prepared for the Office of Fair Trading by OXERA. London, UK. Retrieved from http://www.oxera.com/Oxera/media/Oxera/downloads/reports/OFT-Assessing-profitability.pdf?ext=.pdf.

CSO. 2010. Central Statistical Office Summary Report Gross Domestic Product 2010 Benchmark Estimates. Lusaka: CSO.

Department of Fisheries (DOF). 2017. Department of Fisheries 2016 Annual Report. Chilanga, Zambia: Government of Zambia, Department of Fisheries.

Emokaro, C., P. Enkunwe, and A. Achile. 2010. Profitability and Viability of Catfish Farming in Kogi State, Nigeria. *Research Journal of Agriculture and Biological Sciences* 6.3: 215–219. Retrieved June 20, 2017 from https://www.aensiweb.net/AENSIWEB/rjabs/rjabs/2010/215-219.pdf.

FAO. 2006. The State of World Fisheries and Aquaculture. Aquaculture. http://www.fao.org/docrep/013/i1820e/i1820e.pdf.

FAO. 2010. The State of World Fisheries and Aquaculture. Food and Agriculture Organization of the United Nations (Vol. 2010). Rome, Italy: FAO. http://www.fao.org/docrep/013/i1820e/i1820e.pdf

FAO. 2014. *The State of World Fisheries and Aquaculture*. Food and Agriculture Oraganization of the United Nations (Vol. 2014). Rome, Italy: FAO. Retrieved on September 10, 2017 from http://41.77.4.165:6510/www.fao.org/3/a-i3720e.pdf.

Hishamunda, N. and N.B. Ridler. 2006. Farming Fish for Profits: A Small Step Towards Food Security in Sub-Saharan Africa. *Food Policy* 31.5: 401–414. http://doi.org/10.1016/j.foodpol.2005.12.004.

Hyuha, T.S., J.O. Bukenya, J. Twinamasiko, and J. Molnar. 2011. Profitability Analysis of Small Scale Aquaculture Enterprises in Central Uganda. *International Journal of Fisheries and Aquaculture* 3.15: 271–278. http://doi.org/10.5897/IJFA11.069.

Indaba Agricultural Policy Research Institute (IAPRI). 2017. Aquaculture Fisheries Survey Data. Lusaka, Zambia: IAPRI.

Issa, F.O., M.O. Abdulazeez, D.M. Kezi, J.S. Dare, and R. Umar. 2014. Profitability Analysis of Small-scale Catfish Farming in Kaduna State, Nigeria. *Journal of Agricultural Extension and Rural Development* 6.8: 267–273. http://doi.org/10.5897/JAERD2013.0570

Jensson, P. 2006. Profitability Assessment Model. Reykjavik, Iceland. Retrieved on May 3, 2017 from www.hi.is/~pall/verkefni/UNU/Profitability-Paper.doc.

Kossova, T. and M. Sheluntcova. 2015. Evaluating Performance of Public Sector Projects in Russia: The Choice of a Social Discount Rate. *International Journal of Project Management* 34.3: 403–411. http://doi.org/10.1016/j.ijproman.2015.11.005

Musumali, M., S. Heck, S. Husken, and M. Wishart. 2009. *Fisheries in Zambia: An Undervalued Contributor to Poverty Reduction.* World Bank Policy Brief 1913. Washington, DC: The WorldFish Center/The World Bank. https://www.worldfishcenter.org/content/fisheries-zambia-undervalued-contributor-poverty-reduction

Mwango, J., A.S. Kefi, E.C. Manda, M. Chijoka, and N. Chimba. 2016. Status of Aquaculture in the Copperbelt and North-Western Provinces of Zambia. Chilanga, Zambia: Department of Fisheries.

Okechi, J.K. 2004. Profitability Assessment: A Case Study of African Catfish (Clarias Gariepinus) Farming in the Lae Victoria Basin, Kenya. Final Project. Kisumu, Kenya: Kisumu Research Centre. http://innri.unuftp.is/Proj04/OkechiPRF04.pdf.

Olaoye, O., F.O. George, W. Abdul, O. Adelaja, S. Ashley-Dejo, and A. Salako. 2012. Profitability and Viability of Fish Farming Enterprises Using Government Credit Agency Loan in Ogun State of Nigeria. *Nigeria Journal of Fisheries* 9.1: 460-463.

Salia, A.M.J. and P. Jensson. 2008. Economic Analysis of Small-Scale Tilapia Aquaculture in Mozambique. Final Project. Maputo: Institute Nacional de Desenvolvimento de Aquacultura (INAQUA).

Shula, A.K. and R. Mofya-Mukuka. 2015. *The Fisheries Sector in Zambia: Status, Management, and Challenges.* Indaba Agricultural Policy Research Institute Technical Paper No. 3. Lusaka, Zambia: IAPRI. Retrieved on September 9, 2017 from http://www.iapri.org.zm/images/TechnicalPapers/TP_3.pdf.

Thilsted, S.H., D. James, J. Toppe, K. Iddya, and R. Subasinghe. 2014. Maximizing the Contribution of Fish to Human Nutrition. Second International Conference on Nutrition: Better Nutrition Better Lives, 19-21 November. Rome, Italy. http://41.77.4.165:6510/www.fao.org/3/a-i3963e.pdf

Treasury Guidance. 2003. The Green Book: Appraisal and Evaluation in Central Government. Evaluation. London: Government of the United Kingdom. https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-governent

Ugwumba, C.O. and C. Chukwuji. 2010. The Economics of Catfish Production in Anambra State, Nigeria: A Profit Function Approach. *Agriculture and Social Sciences* 6.4: 105–109. Retrieved on June 21, 2017 from http://www.fspublishers.org/published_papers/71507_..pdf.

Ume, S.I., L.A. Ebeniro, C.D. Ochiaka, and F.O. Uche. 2016. Economics Analysis of Catfish Production in Anambra State, Nigeria. *International Journal of Environment, Agriculture and Biotechnology* 1.3: 476–481. Retrieved on June 21, 2017 from http://dx.doi.org/10.22161/ijaers/3.10.25.