ECONOMICS OF COMMERCIAL TILAPIA CAGE AQUACULTURE IN UGANDA: HOW ECONOMIES OF SCALE AFFECT PROFITABILITY

Catherine Nazziwa
National Agricultural Research Organisation, Uganda
info@muzardi.go

Supervisors:

Arnþór Gústavsson: arntorgustavs@gmail.com
Ólafur Sigurgeirsson: olisig@holar.is

ABSTRACT

A major constraint to cage fish farming in Uganda is related to finance resulting in many farmers abandoning cage fish farming along the production pathway. This research designed a production and profitability tool of three different scales of producing tilapia in cages in Uganda at a commercial level. The objectives included drawing production and enterprise budgets, formulating 5-year production schedules, and structuring a 5-year cash flow analysis for these scales of production. Production and cost data from Pearl Aquatics fish farm was used to draw assumptions for small and largescale production scenarios. The investment budgets for cage aquaculture in Uganda were USD 47,236, 94,393 and 163,373 for small-scale, medium-scale and large-scale operations consecutively. The 5-year cash-flow analysis indicated costs for small-scale, medium-scale and large-scale to be USD 636,264, 1,706,955 and 3,750,284 respectively. All financial parameters, including Net Cash Flow, Net Present Value, Percentage Profitability, Internal Rate of Return, indicated financial viability from the three scales. Break-even prices and the cost needed to produce 1kg were USD 2.12, 1.93, 1.90 and USD 2.29, 2.0 and 1.82 for small-scale, medium-scale and large-scale respectively.

Key words: Tilapia, cage aquaculture, profitability, economies of scale, Uganda.

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Acronyms

ABW:	Average Body Weight
BEP:	Break-Even Price
BH:	Biomass Harvested
CV:	Cage Volume
DRC:	Democratic Republic of Congo
FAO:	Food and Agricultural Organisation
FCR:	Feed Conversion Ratio
FHN:	Final Harvested Number
FN:	Fish Number
FNH:	Fish Number Harvested
G:	Grams
H:	Height
HDPE:	High Density Polyethylene
IC:	Investment Costs
IRR:	Internal Rate of Return
Kg:	Kilogram
L:	Length
MAAIF:	Ministry of Agriculture Animal Industry and Fisheries
NFI:	Net Farm Income
NPV:	Net Present Value
OC:	Operation Costs
PV:	Present Value
TC:	Total Costs
TFC:	Total Fixed Costs
TVC:	Total Variable Costs
UBOS:	Uganda Bureau of Statistics
UGX:	Ugandan Shillings
US $:	United States Dollar
VC:	Variable Costs
W:	Weight

1 INTRODUCTION

1.1 Background

The global population is growing at a rate of 1.6% and by 2030, an increase to 8.5 billion people is anticipated (United Nations, 2015). To feed these people, food production will need to double (Aanyu, Opio, Aruho, & Getrude, 2020). Fish is one of the fundamental products under white meat highest in-demand globally. The average annual growth rate of total edible fish consumption was 2.1 per cent in 2020 (FAO, 2020). Aquaculture is among the fastest-growing food production methods and is the only viable alternative for boosting fish output. It has continued to be the main source of fish available for human consumption with a logged outstanding performance (Figure 2). Its share shifted from 4% in 1950 to 52% in 2018 and is expected to increase to about 59% by 2030. With production from capture fisheries continuing to drop, Food and Agricultural Organisation (FAO) projections show a continued decrease in global food fish consumption from capture fisheries. As regards per-capita consumption (Figure 1), 9.8kg and 10.7kg of fish are available from capture fisheries and aquaculture respectively. The increased consumption of fish from aquaculture is attributed to the increased production as well as the advancements in processing cold chains, rising incomes and increased awareness of the health benefits of fish. From the above background, the relevance and support of aquaculture are inevitable.

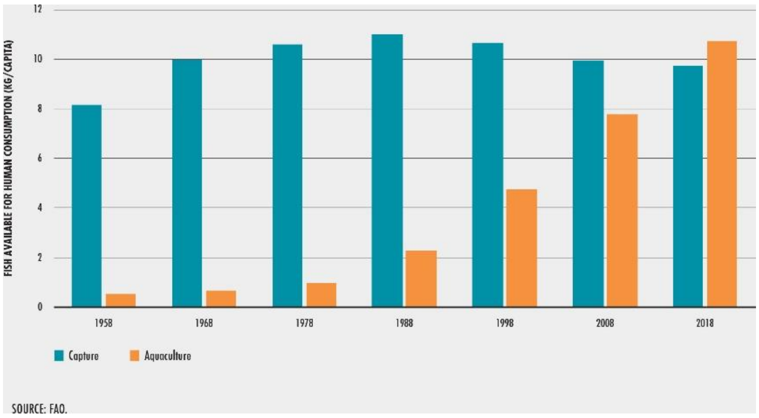

Figure 2: Trend of the Global Fish Available for Human Consumption, FAO 2020

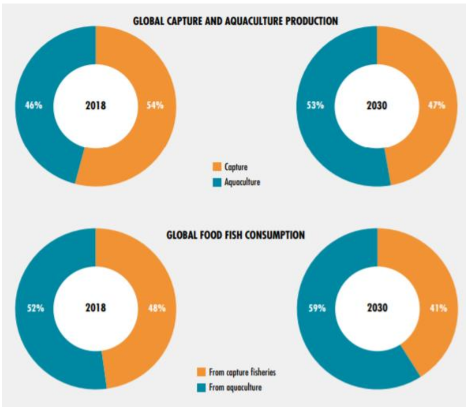

Figure 1: Global Capture and Aquaculture Production with Global Food Fish Consumption Projections, FAO 2020

1.2 Aquaculture in Uganda

Aquaculture was introduced by the colonial authorities in 1941 in western Uganda. It started with the culture of common carp from Israel as a subsistence practice to provide rural households with low-cost animal protein (MAAIF, 2020). In the 1990s, the FAO promoted aquaculture growth through rural development projects and comparative evaluation initiatives between common carp and tilapia. This development picked up momentum in 2000 with financial support from development partners like the German government and promotion primarily by the Ugandan government through strategic initiatives (Hyuha, Ekere, Egna, & Molnar, 2017).

As a result of the above development, commercial aquaculture was promoted. Commercial aquaculture is the cultivation of aquatic animals (fish) under controlled or semi-controlled settings purposely for sale. Since the shift from solely subsistence production to commercial aquaculture, production in Uganda has increased from 5,000 metric tons in 2004 to over 100,000 metric tons in 2014. Uganda is now the third-largest aquaculture producer in Africa after Egypt and Nigeria, with an average growth rate of 15% per annum, producing 120,000 metric tons in 2018 (Aanyu, Opio, Aruho, & Getrude, 2020). Figure 3 shows the trend of aquaculture production in Uganda over time. The production of farmed fish in Uganda comprises 20,000 farmers owning close to 25,000 ponds and over 3,000 cages (MAAIF, 2020). Most of these producers are small scale farmers practising extensive and semi-intensive aquaculture. A few mega farms run intensive aquaculture with production mainly from cages. In 2016, these contributed 20% to the country's total fish production however, currently, its undoubtedly more with the increase in cage aquaculture. The government of Uganda recognises the potential of aquaculture to contribute significantly to national food security, economic growth and the livelihood of its people. Uganda's population is currently 45 million growing at an annual rate of 3% and projected to reach about 100 million by 2050 (World Bank, 2020). This increasing population has created a rising demand for fish and fish products. Regional and internal markets have increased as well, and aquaculture provides an opportunity to bridge the supply gap from the dwindling capture fisheries. The country supplies fish and fishery products including fish seed, aquaculture inputs and technical expertise to its neighbouring states, primarily Kenya, Congo, and Rwanda.

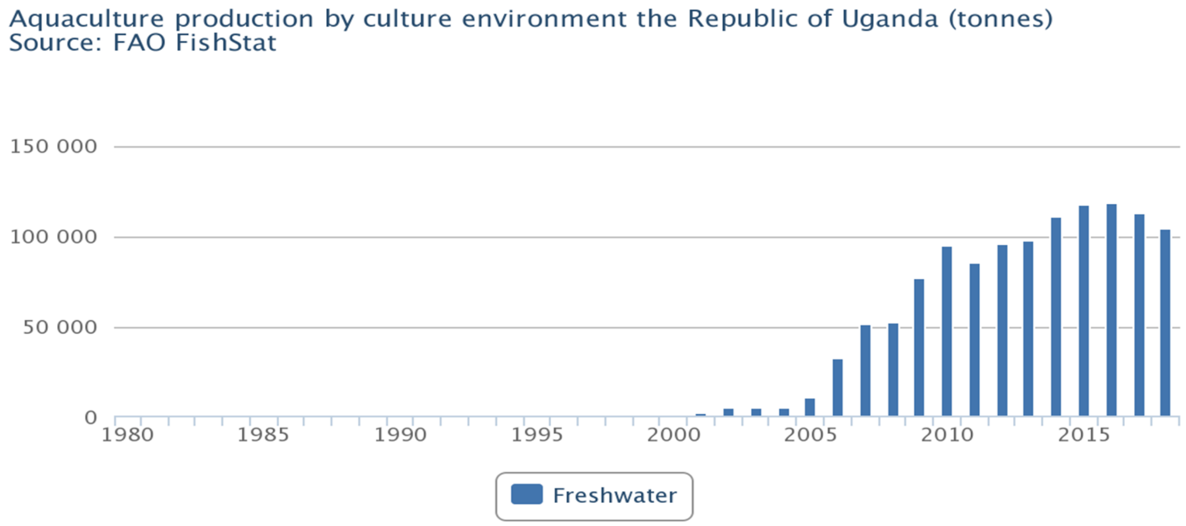

Figure 3:Trend of aquaculture production in Uganda over time

1.3 Cage Production System in Uganda

Cage aquaculture is a farming system where net enclosures are used to raise fish in open waters (Schmittou, Jian, & Creamer, 1998). The mesh materials secure fish as well as allow for water exchange with the surrounding environment. In Uganda, the commercialisation of aquaculture led to the introduction of cage aquaculture because of its potential to boost aquaculture production when compared to other production units like ponds and tanks (Musinguzi, et al., 2019). Both high-density polyethylene cages and low-density cages are utilised. Commercial HDPE cages used are approximately 200 cubic meters by volume with stocking densities ranging from 80 to 100 fish/m^3 and a production output ranging between 40 and 50 kg/m^3. These are adopted by large scale commercial farms. Cage materials including cage frames and nets are imported from China and assembled in Uganda. They are made in circular and square shapes depending on the owner's preference. On the other hand, small cages have cage frames that are made from materials obtained from within Uganda. They are made from polystyrene floats and wooden walkaways and the nets are made from nylon produced in the country (Mbowa, Ondokonyero, & Munyaho, 2017). They are on average 16 m^3 with slightly higher stocking densities of 150 to 250 fish/m^3 and production output of 80 to 150kg/m3. They have a cheaper capital outlay compared to the former, however their overall production output is low because of the low volume. In Uganda there are 47 cage installations with a total of 3,612 cages. Lake Victoria holds the biggest share of the cages with 3,338 of these in 29 installations. Most of these cages are installed at lengths greater or equal to 5 meters deep in the lake (Musinguzi, et al., 2019).

1.4 Potential of Cage Aquaculture in Uganda

The annual per capita fish consumption in Uganda is about 10 kg (FAO, 2018), lower than the recommended average consumption of 20-30 kg. Uganda's population is growing at a fast rate of 3% per annum and is estimated to reach 55 million people by 2025. The increase in population will need an increase in food and fish consumption. The projected demand for fish consumption and trade is at 1,700,000 tons per year (MAAIF, 2016). Current capture and aquaculture production is at 570,000 MT, with 450,000 MT from capture fisheries and 120,000 MT from aquaculture. There is currently a deficit in fisheries production of over 300,000 MT if the recommended per capita consumption is to be met (Musinguzi, et al., 2019). Of the projected 1,700,000 MT, the Ministry of Agriculture Animal Industry and Fisheries (MAAIF) set to obtain 700,000MT from capture fisheries and the 1,000,000 MT from aquaculture (MAAIF, 2017). The biggest share of production is expected to be obtained from aquaculture given the potential of cage fish farming in the country. Uganda is enriched with natural freshwater: 21% (42,383Km^2) of its surface area is underwater providing room for cage aquaculture production (UBOS, 2018). The suitable native culture species in the country offer a high potential for massive production. Additionally, cage aquaculture has advantages over alternative culture systems, particularly pond-based fish farming, including simpler regular farm management techniques, higher fish productivity per unit volume, and easier and faster setup (Beveridge, 1984).

1.5 Problem Statement

The potential for economic returns is one of the factors to consider when choosing an appropriate production system (Isyagi, 2007). Cage aquaculture in high-density low volume cages has been rendered profitable and highly productive in previous studies on Lake Victoria (Musa, Mulanda, & Okechi, 2021; Nazziwa, 2021). However, its profitability and high productivity are accompanied by high investment costs. The largest constraint to cage aquaculture in Uganda is the unavailability of funds which renders the financial investments unsustainable (Kwikiriza, et al., 2018). There is a lack of information to understand the economics of cage aquaculture in Uganda despite its potential in the country. Comparative studies of neighbouring countries have been used by potential investors, but this creates room for error due to non-similarity in some cost margins. The lack of economic indicators greatly contributes to the hesitation of potential investors towards spending money because of the low economic feasibility. With the financial needs and outcomes not streamlined, existing cage aquaculture farms may find it difficult to secure business loans and this is a barrier towards enterprise insurance (Aura, et al., 2018). With cage aquaculture on the rise, venture capitalists will need to make rational decisions through an evaluation of investment possibilities.

1.6 Justification

The economics of commercial cage aquaculture will provide valuable information to producers and owners/investors of cage fish farms in and outside the country. This information when utilised will contribute to the understanding of the day-to-day operation and financial needs of commercial tilapia cage aquaculture. It will be beneficial in knowledge-based decision making for running enterprises and in making initial investments. As a result, economic sustainability will be achieved, and this will improve cage aquaculture business profitability and productivity. The project will result in the development of a production and profitability tool in excel. The model will be beneficial for projecting costs and returns of commercial cage aquaculture. Use of the tool to analyse will provide farmers and investors with information that may be applied to their enterprises for analysis. Assistance in planning and preparation through proper production schedule formulations and financial resource allocation will be realised. Information from the production and financial tool will aid farmers and investors to understand more about resource allocation thus decreasing chance of error, reducing bottlenecks and provide more efficient use of inputs. Knowledge on how much money is needed for the investment, the major cost items, start-up costs, operational costs will easily be obtained and adjusted from one place. As a result, budgeting, financial management and appraisal of these enterprises will be simplified. Proper budgeting and financial management are crucial in enterprise evaluation and sustainability once established. With this information in hand, investors and entrepreneurs would have access to additional economic understanding of cage aquaculture enterprises leading to information-based decisions. All the above is prudent in the effective financial management of cage production facilities and overall sustained farm business profitability. In the end, general economic sustainability will be promoted, a major objective for commercial aquaculture ventures.

1.7 Project Goal

The goal of this project is ‘to design an Excel tool that will provide information on the day-to-day operations and finances, leading to a detailed understanding of the economics of tilapia cage aquaculture.’ It may then be used by farmers and potential investors as a decision-making tool in tilapia cage enterprises.

1.8 Objectives

1.8.1 General Objective

Create an Excel functional tool encompassing growth and profitability models to be used as a decision-making tool in tilapia cage aquaculture.

1.8.2 Specific objectives

i. Develop investment and production enterprise budgets for three production scenarios in commercial tilapia cage aquaculture.
ii. Formulate a 5-year production schedule for the three production scenarios.
iii. Carry out a 5-year cash flow analysis for the three production scenarios.

2 LITERATURE REVIEW

2.1 Tilapia Culture

With a global production of approximately 7 million tonnes, tilapia (*Oreochromis niloticus*) is the second most significant cultured finfish species after cyprinids (FAO, 2020). Its adaptability to harsh environments, good growth qualities, ease of seed production and firm and flavoured flesh are all grounds for its widespread production (Daudpota, et al., 2016). With a production of 74,924 tons, Uganda was among the top ten producers in the world in 2017, ranked ninth (El-Sayed A.-F. M., 2020). In Uganda, tilapia is cultured in all production systems that are currently in use: ponds, tanks, and cages. However, it is the most appropriate, preferred, and only cultured species in cages because, among all available cultured species in the country, it has a ready market both locally and regionally. In addition, tilapia is not an aggressive fish species, and is capable of living in a cultured environment without causing physical material damage. The ease of culture is also related to ease of propagation, good growth characteristics from both natural and supplemented feeds, highly marketable, palatable and highly nutritious, ability to produce in captivity with a short generation time, and feeding on low trophic levels with acceptance of artificial supplemental feeds (Chhorn & Carl, 2006; El-Sayed A.-F. M., 2020). Tilapia is cultured at high densities and the breeding disadvantage that usually triggers in other production units is disrupted even when mixed sex fish are cultured. All male tilapia fry, which are readily available due to the current boost in production by private and government farms, are nonetheless promoted for use in tilapia production. The average price of tilapia fry is about USD 0.012, and the average selling price of table size fish (400-500g) is USD 2.26. Table size fish of 500 grams and over is commonly raised and preferred by the market because it fits competitively with the market size of captured tilapia. The production cycle is about 9 months in ponds and is reduced to 7 months in cages with good management conditions. Good quality feed (dietary nutrients: Proteins, lipids, carbohydrates, vitamins, and minerals) with the best administration, the right stocking density and good water quality are some of the conditions for faster growth and better productivity (Nazziwa, 2021).

2.2 Tilapia farm business management

Efficient management of fish in cage aquaculture makes a noticeable difference between making profits and losses. It involves more than just attending to the biological aspects of the operation; decisions in farm management need to be beyond merely producing the greatest weight of fish with the lowest food conversion ratio. They must also include paying attention to the farm’s economic and financial metrics (Carole & Ivano, 2005). To be successful, a farmer who decides to raise and sell fish for profit must run the farm like a company paying close attention to the farm’s capital position and cash flow. Enterprise budget, balance sheet, income statement and cash flows budgets are the most basic forms of financial records and analysis that all fish farmers should have. Each of them offers a viewpoint on the farm's performance. The balance sheet indicates the capital position and solvency of the business; the enterprise budget gives an estimate of the overall profitability of the business; the income statement shows annual profits or losses of the business; and the cash flow budgets show whether the farm will be able to make payments when they are due. It is crucial to spend time keeping updated farms records including financial statements that can be prepared once a year. The best time is usually established by the farmer and a routine for financial analysis is maintained. During this time, the farmer can think through and make financial adjustments that will benefit the enterprise (Carole & Ivano, 2005).

2.3 Business Planning in Aquaculture

Most modern aquaculture enterprises require a significant amount of cash for capital and operations. The size of the capital resources required to build, equip, and operate an aquaculture enterprise necessitates meticulous management that begins with a comprehensive business plan. A thorough business plan serves as a road map for the enterprise, indicating its strengths, where and when challenges are expected to arise, and analysing different tactics for resolving them. A documented business plan, updated annually, provides a framework for ongoing business analysis, and may include, but not be limited to the following (Carole E. R., 2010).

a) An executive summary
b) Background information detailing the history of the farm, analysis of the industry and analysis of the enterprise’s position in the industry for the country, if any.
c) Enterprise strategic goals and objectives include a description of the short-term and long-term goals and objectives of the enterprise, its internal opportunities, and threats, as well as the external opportunities and threats.
d) General description of the enterprise includes the characterisation of the enterprise with a description of the production system and the resources available to the farmer.
e) A production and marketing plan showing the products of the enterprise, technology to be used in the production, the target size of stocking and harvest, and the expected selling price of the product.
f) The financial plan estimates the costs and returns of the enterprise, the required financing estimation, the farm’s appraisal at that time, a balance sheet for already operating business, a cash flow and income statement.
g) Staffing or human resources management plan
h) Owner’s financial statement

2.4 Aquaculture Enterprise Profitability

Just like any other business, the purpose of cage aquaculture is to make money, or in other words, generate profits. Economic measures quickly guide investors and operators of existing farms on whether, or not, the farm is profitable in a general sense. The margin between total revenue and total expense is considered profitability (Carole E. R., 2012).

2.4.1 Enterprise Budgeting

Enterprise budget analysis is one of the fast measures of financial performance at the initial stage of production. It is a broad overview of the company’s costs and profits; it gives an estimate of the overall profitability of the enterprise. Profitability can as well be obtained by assessing whether the revenues to be generated from the sales of the fish are more than the production costs (Carole & Ivano, 2005). During enterprise budgeting in commercial cage aquaculture, it is important to consider a common budgetary unit that can vary from one cage. It needs to be specified in terms of size and production period; this is usually one production cycle. The key headings of an enterprise budget contain, but are not limited to, item, description, unit, quantity, unit price and total cost. Costs are categorised into investment costs, variable costs, and fixed costs. Investment costs are those incurred at the initial start of the business during the set-up of the enterprise and are independent of the actual production costs of the venture. Variable costs in aquaculture are costs that vary with the farm's production volume like fingerling costs and feed costs; fixed costs include management costs that are incurred at a fixed rate regardless of the level of production. During cost stipulation of these costs, it is important to describe the input because costs usually vary with the product like the size of fingerlings bought and protein percentage of the feed bought. Profits are determined by the difference between the generated revenue and the total costs to be incurred in the enterprise, or by simply examining if the revenues are greater than the total cost spent to produce the fish. Table 1 shows an example of a well-managed enterprise budget for a 1-hectare tilapia farm in Kenya fed with pelleted extruded feeds stocked at 3fish/m³ and adjusted by converting Kenyan shillings to dollars.

Table 1: Enterprise budget for a 1-Hectare tilapia farm in Kenya fed with pelleted feed stocked at 3 fish/m³.

Item	Description	Unit	Quantity	Price/Unit	Total Cost
Gross Receipts					
Tilapia	Live	Kg	10,464	0.88	9,179
Total gross receipts					9,179
Variable Costs					
Tilapia fingerlings	Hatchery raised	#	36,000	0.03	947
Pelleted diet	15% crude protein	Kg	34,992	0.11	3,683
Fertilizer	Urea	Kg	528	0.18	93
	Diamond phosphate	Kg	256	0.19	49
Agricultural lime	Lime	Kg	2,500	0.03	76
Field labour	Stock, feed, fertilise, harvest	days	365	1.05	384
labour construction		days	152	1.32	200
Security personnel	Day and night guard	days	365	1.32	480
Total Variable costs		$			5,913
Net returns above TVC		$			3,266
Fixed costs					
Equipment		$			79
Ponds		$			158
Interest on investment		$			250
Total Fixed costs (TFC)		$			487
Total Costs		$			6,400
Net returns above TC		$			2,779
Net returns per hectare		$			2,779
Break-even price	Above TC	$/Kg			0.61
	above TVC	$/Kg			0.31

Adjusted from (Carole & Ivano, 2005)

2.4.2 Income statement

For existing enterprises, an income statement is one of the best ways to measure the economic status of cage aquaculture farm enterprises. The income statement evaluates and measures profits on an annual basis. Unlike the enterprise budget that uses assumed values, an income statement uses actual farm revenues and expenses from the farm's enterprise. For a business running on profit, the generated revenues must exceed the incurred expenses (Carole & Ivano, 2005).

Cash flow analysis

A cash flow analysis involves the estimation of how money circulates in and out of the business. It is estimated usually on a yearly schedule based on a thorough business plan over the lifetime of the enterprise (Jensson, 2006). Figure 4 shows an example of a cash flow with total and net for investors capital and equity cash flow series from the profitability assessment model paper by Pall Jenson.

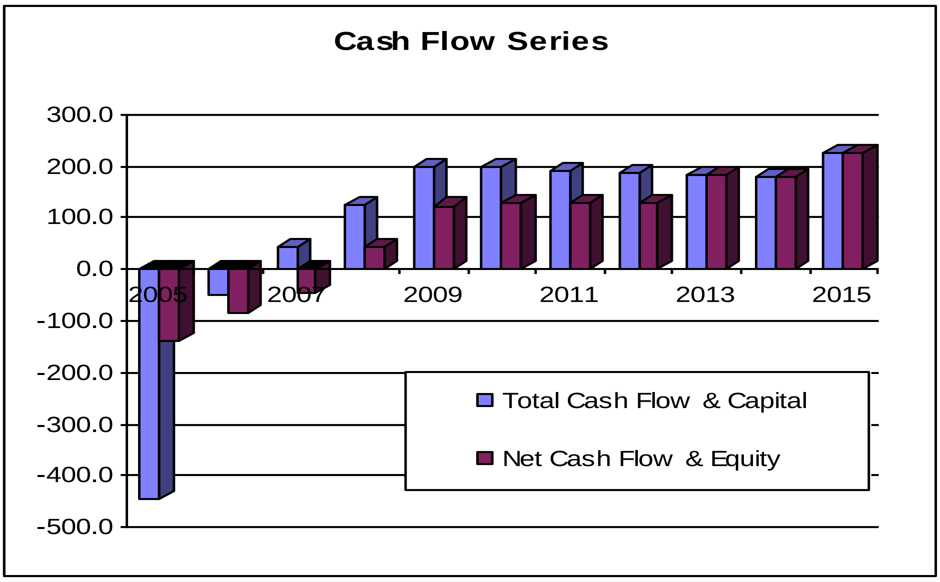

Figure 4: An example of a cash flow analysis from total and net cash flows of an aquaculture enterprise (Jensson, 2006).

2.4.3 Sensitivity Analysis

Aquaculture is a highly risky business venture but at the same time very profitable. Just like other projects that involve investing effort, time and money, there is a level of uncertainty that may occur in its lifetime. The uncertainties may come in the form of variations in production inputs, changes in market prices and even output quantities (Cobbina, 2010). In this regard, a farmer and investors must consider how varying the costs or quantities of production factors affect the profitability of cage culture farms. Sensitivity analysis is highly beneficial in identifying the most sensitive inputs whose increase or decrease have a great effect on profitability. In aquaculture, the market price of the product and the costs incurred on the purchase of feeds have been identified as the most sensitive inputs in cage aquaculture around Lake Victoria (Nazziwa, 2021; Musa, Mulanda, & Okechi, 2021).

2.5 Financial Analysis Measures

2.5.1 Net Farm Income

The primary measure of farm profitability is net farm income (NFI). It measures the return to the operator's equity, capital, unpaid labour, and management and is determined from the income statement (Carole E. R., 2010). NFI is the amount of money that the project earns from its management ability minus costs of capital, labour, and other operational costs. It represents the value of the farm's produce in the year not inclusive of the total costs of production showing the profit or loss from the farm's operations (Edwards, 2022). It is a measure of the project's profitability specifically providing money that is available to the owner of the business by the business (Kantrovich, 2022). NFI indicates project viability where a negative NFI indicates an operation under loss and a positive NFI shows an operation under profit.

2.5.2 Net Present Value

To determine the project's financial performance, the Net Present Value (NPV) discounting investment appraisal technique is used. This method takes into consideration the time value of money, employs the correct opportunity cost, selects mutually exclusive projects consistently, and follows the value additivity principle (Lumby & Jones, 2000). NPV assumes that money gained now can gain interest or dividends or be used in profit yielding venture, and that enjoying resources now is more certain than the uncertain future. Important determining factors of NPV are present value, time of the cash flow, the total time (number of years) of the enterprise, the discount rate, and the net returns, where the discount rate represents the cost of capital. Net returns are obtained by the difference of total costs on total revenue and the present values are usually calculated from the product of the net cash flow and the discount factor (Sooper, 2004). A positive NPV symbolises the profitability of the venture and the higher it gets the more worth the business is to take on.

2.5.3 Pay Back Period

The payback period is the length of time required for an investment to recover the original cost of the investment from the net cash flow (Cobbina, 2010). The payback period is estimated by dividing the investment cost of the project by the project's annual cash flow and it is expressed in years. In aquaculture projects, the payback period can be used to determine the amount of time in which the investment is to be paid back. The enterprise payback time is highly dependent on the margin between the initial costs of production and the returns. Biggers margins lead to a longer payback period. The shorter the payback period, the more sustainable it is for the investors and producers. Most cage aquaculture producers prefer a shorter payback period for continued sustainability. Depending on the nature of the business, some yield more returns at the start of the business and others yield more in the later years of production.

2.5.4 Internal Rate of Return

Internal rate of return (IRR) is a rate of interest that equates the present worth of a cash flow stream to zero. IRR is the expected compound annual growth rate of an enterprise that is used to estimate the profitability of potential investments. It provides useful information regarding the return on investment and is frequently used as a measure of efficiency (Hatman & Schafrick, 2004), (Sooper, 2004). IRR is calculated directly from the Excel spreadsheet using the formula; = IRR (net returns year 0: onto net returns of last year of project life, discount rate) or a guess of the discount rate. It can be used by decision-makers in enterprise financing by comparing it to the discount rate, if it is greater than the discount rate then the project is feasible, and the reverse is true. The higher a project's internal rate of return than the cost of capital, the more desirable it is to undertake. IRR can also be used to rank multiple prospective projects. It provides a projected return on investments and allows comparison of projects which are then ranked based on their projected return/yield, the investment with the highest internal rate of return is selected (Hatman & Schafrick, 2004).

3 MATERIALS AND METHODS

Qualitative data was collected for this study through interviews, extraction from a farm's production data sets, monthly costs and sales reports, literature reviews, and the author's experience was used in the assumptions.

3.1 Study Area-Pearl Aquatics fish farm

Pearl Aquatics Limited is a professional farm that provides a cooperative investment platform for commercial cage fish farming as well as professional management services in Uganda. Tende Bay on Lake Victoria, with coordinates 0.052481N, 32.557693E, is where the farm's cage operations have been enlarged. Cage fish farming at Pearl Aquatics fish farm commenced in 2015 with a joint business operation between Gerenge Tropical Fisheries Aquapark and Industrial Inputs Ltd. The farm specializes in the production of tilapia (*Oreochromis niloticus*) worth approximately USD 240,000 (Namuswe, 2016). The range of production entities of Pearl Aquatics include (Namuswe, 2016):

- Grow-out of single-sex Nile tilapia to an average body weight of 420g for the Rwanda and DRC markets, and average body weight of 550g for the Nairobi, Kenya market.
- Production cycle in three separate phases of raising fish including (i) nursing 0.1g fry to 2.0g in land-based raceways (ii) raising 2g fry to 15g juveniles in lake-based juvenile cages and (iii) raising juveniles to table-sized fish in lake-based low-density high-volume production cages.
- A production cycle covering a period of 7 and 8 months for the Rwanda/DRC markets and Nairobi, Kenya markets, respectively.
- Cages framed using imported pipes and accessories made from HDPE raw materials especially suited for continuous use in harsh environments and fitted with nets made from PE netting with global cutting-edge technology and treated with the anti-UV process, which guarantee the nets of high intensity, good security, and long service life.
- Production cages of 6x6x6m in size, stocked with 80fish/m^3 with an average production output of 32kg/m^3.
- A production plan that allows a monthly market output of approximately 14 tons, where 2 production cages are stocked monthly.
- Professional management of the entire cycle including planning, market sourcing of supplies, market sourcing of fish products and routine management.
- Utilisation of high-quality fish feeds with an FCR of 1.5 and unit cost of feed at USD 1.03/kg.

3.2 Data collection

Production and financial data from Pearl Aquatics fish farm were utilised. This was obtained from the farm's data sets from previously completed production cycles accessed through interviews with the farm's production manager and director. In addition, monthly production reports were utilised. Data on production cage size used, feed type used, current cage numbers at the farm and any other relevant information that could arise were obtained from phone/email interviews. From the farm's monthly production data sets, the following information was collected: stock-in dates; stocking densities; numbers stocked; survival rate; daily feed dosages and feed types; monthly sampling average body weights and sampling dates; monthly mortalities; harvest quantities; and the selling price. The cost data collected includes fry costs, feed costs, management costs, operation costs, and investment costs.

All obtained data was entered and organised into Windows 10 Excel 2016 software for analysis.

3.3 Research methods and analysis

Excel 2016 was used to perform the adjustments, calculations and to draw visual plots in the study.

3.3.1 Production characteristics

Direct production characteristics were drawn from the farm's data. Cage volume (CV), fish number (FN), cost of fingerlings per cage, initial biomass (IB), feed per cage, feed cost per cage, final numbers at harvest (FNH), harvest output (HO), Production Yield (PY) were calculated using the formulas below.

a. *CV=L*W*H*
b. *FN=Stocking density*CV*
c. *IB=Initial ABW*FN*
d. *Feed per cage=FCR*(Final Biomass-Initial biomass)*
e. *Feed cost per cage=Feed per cage*unit cost of feed*
f. *FNH= (Survival rate÷100) *Initial stock-in numbers*
g. *HO= (FNH*ABWH) ÷1000*
h. *PY= (BH÷CV)*

3.3.2 Scale scenario assumptions

Three scales of commercial aquaculture were assumed for this project with guiding data from Pearl Aquatics, the model farm. As per the country's current production scale, Pearl Aquatics is considered a medium-scale commercial company. The farm is currently running on 15 production cages. Two other scenarios were assumed for this project: a small-scale production scenario operating 5 cages, and a large scale production scenario operating 30 cages. These were obtained by dividing the medium operation by two for small scale and multiplying the medium by 2 for large scale. However, 5 cages were considered due to the author's preference for reality.

3.3.3 Production enterprise budgets

Production quantities and volumes needed for the different inputs in the respective scales were obtained by multiplying the cage number in the respective scale by the corresponding production characteristic of a single cage. Unit costs for the production inputs are indicated in Table 2. The total cost for each input was then calculated from the product of the unit cost of the specific input and the quantities. Seven months was the assumed production time. Varying costs like fingerlings and feed were obtained from the production characteristics by first obtaining volumes as a product of single cage characteristics with the cage number. Then the product of the assumed unit (Table 2) and the volumes for a single cycle were obtained.

The following parameters were calculated: total production costs (TPC) from the sum of all costs incurred in the full production cycle, total revenue (R), profit (P) and production cost for 1kg. Where FP is fish price and BH is harvested biomass, the methods below were applied to calculate the parameters above:

a. $R = FP \times BH$
b. $P = R - TC$

c. *Production costs for 1kg = TPC÷BH*

Table 2: Assumptions during adjustment of the production enterprise budget for tilapia cage aquaculture in Uganda

Input	Small-scale	Large-scale
Fingerlings number	Number of fingerlings in one cage*5	Number of fingerlings in one cage *30
Fingerlings cost	2% added on the farm unit cost of fingerlings	5% reduced on the farm unit cost of fingerlings
Feed quantities	Quantity needed for a single cage *5	Quantity needed for one cage*30
Feed cost	2% added on the farm's unit cost of feed	5% reduced on the farm's unit cost of fingerlings
Wedges	Workers reduced from 6 (farm's number of workers) to 4 to cater for 2 feeders, a security guard, and a farm manager	Workers increased from 6 to 10 to cater for additional labour on feeders and management.
Petty Cash	Farm's unit cost maintained	Farms unit cost *2
Monthly repairs on boats, nets, engine, and minor repairs on farm equipment	Farm unit cost maintained	Farm unit cost *2

3.3.4 Investment budgets

The underlying assumptions that were applied to attain the unit costs of the various inputs under the different scales are shown in Table 3. These unit costs were multiplied by the cage number in each of the scales to achieve the total amount of money spent on each item. A discount of 10% was applied to the large-scale scenario to cater for bulk purchase discounts. For the small-scale scenario, 5% of the unit cost was added to cater for a 5% discount on medium scale purchases. Land purchase and heater machine costs were maintained throughout all three production scenarios.

Table 3: Assumptions employed while adjusting the investment budgets for tilapia cage aquaculture in Uganda.

Input cost	Small-scale	Large-scale
Land	Farm unit cost maintained	Farm unit cost maintained
Housing	Farm unit cost maintained +Floating security platform costs from the farm maintained)	Farm unit cost *2+Floating security platform cost of farm maintained
Cage frames	5% added on-farm unit cost*5	10% reduced on the farm unit cost *30
Nets	5% added on the farm unit cost*5	10% reduced from the unit cost obtained from the farm*30
Installation Services	5% added on the farm unit cost*5	10% reduced on the farm's unit cost*30
Cage Equipment	5% added on the farm's unit cost for each equipment cost	10% reduced on the farm's unit cost for each equipment
Customs, Licences, and other charges	Farm costs maintained	Farm costs *2
Operation nets (Sampling and harvest nets)	Unit cost from the farm maintained	Unit cost from the farm was maintained but the number of nets increased from 2 to 4

3.3.5 Cash flow Analysis

The financial analysis for the three investments was obtained using the following steps:

i. Tilapia growth model for a single cage was determined using the farm's production characteristics. A power equation (*Y=14.697X^-0.459*) was obtained from the Zemach growth rate in the Zemach feeding and growth table (Zemach feed mill; https://zmf.co.il/english-pages/). The Zemach food conversion ratio together with this power equation was then used to predict the growth weights for this project (where x is the initial weight in the previous month).
ii. A monthly operation plan running for five years was then designed for the three scales of production. In this project year, 0 was assumed to be the construction and preparation time. One cage was stocked per month for the small-scale operation, three cages for five months for the medium-scale, and six cages for five months for the large-scale production. Figure 6 shows the operation schedule assumed in this study for the three production scenarios. Yellow for the stocking month, blue for the harvesting month and a mixture of the two colours to imply both stocking and harvesting within the same month.
iii. Other variables per month for the investments (feed, mortalities, number of fish and biomass) was obtained by summing up the cage cumulative figures for the stocked cages monthly until all harvests in all cages were completed.
iv. The above trend was followed maintaining a production cycle of seven months per cage for five years with a resting interval of one month before the next production cycle is started. This was to assume a preparation time for the same cages to be used again.
v. Using the operation schedule, a cash flow for costs per month was then drafted using unit costs obtained earlier in the enterprise budgets.
vi. The financial analysis involved arranging the yearly costs and output. Investment costs (IC) were obtained from the investment budgets, variable costs included costs on fingerlings, transport for the fingerlings from purchase farm to the enterprise, feed for fish, transport for feeds and hired labour during stocking and harvesting of cages. Overhead costs (OC) included repair and maintenance, petty cash, small farm equipment, fuel and oil, and management costs earlier referred to as operation costs. Total costs (TC), variable costs (VC), farm income (FI), net farm income (NFI), present value (PV), net present value (NPV), internal rate of return (IRR), percentage profitability (PP) and break-even price (BEP) were calculated, and the formulas below were applied:

a. *TC=(IC+VC+OC)*
b. *NCF= (R_t-TCT)*
c. *FI= sum (R year0: R year 5)*
d. *NFI = TR – TC*
e. $PV=\frac{X_t}{(1+r)^t}$
f. $NPV=\sum_{t=0}^{T}\frac{X_t}{(1+r)^t}$
g. *IRR= Excel software formula*
h. *PP = NFI÷TC×100*
i. *BEP=(VC+OC) ÷HO*
j. *Cost per Kg of fish produced=TC÷HO*

**HO*	*Harvest output*
X_t	*Annual net return*
t	*The time of the cash flow*
T	*The lifetime of the investment*
r	*Discount rate (cost of capital)*

(Musa, Mulanda, & Okechi, 2021)

The chart below (Figure 5) shows the flow of methods incorporated during the development of the production and profitability analysis tool for tilapia cage aquaculture in Uganda.

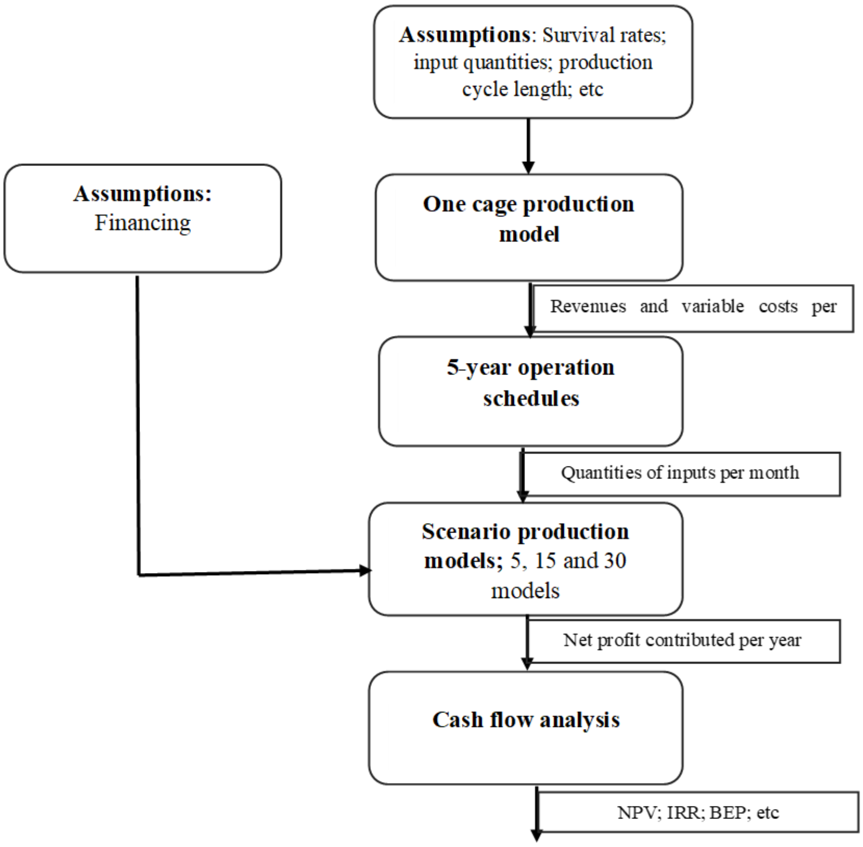

Figure 5: Flow of methods applied in the development of the production and profitability analysis tool.

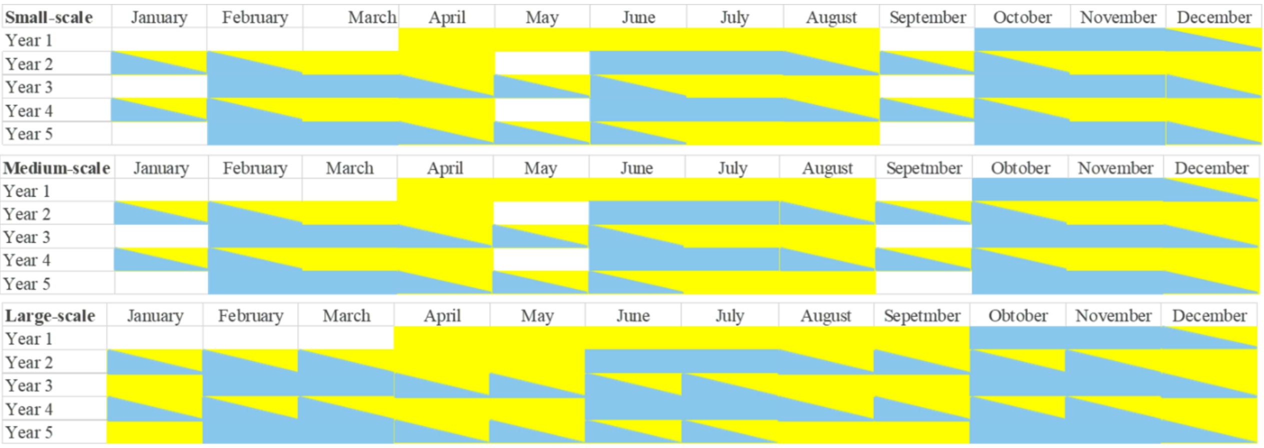

Figure 6: Assumed operation schedule for tilapia cage aquaculture in Uganda.

4 RESULTS

This project was a preliminary study to set a working guideline for cage aquaculture investments and production economics in Uganda. The decision-making tool is an Excel software tool with production budgets, investment budgets and operations plan for the three scale scenarios defined in the study. The operation plan constitutes of 5-year production schedules, detailed 5-year cost estimates and cash-flow analysis for small-scale, medium-scale and large-scale scenarios. It is presented as an attachment to this project and the results from the various sections are indicated in the results chapter below.

4.1 Production characteristics

The production characteristics for commercial cage aquaculture in Uganda discovered at Pearl aquatics fish farm are indicated in Table 4 below. High-density polyethene square cages of 6*6*6 length, width and height respectively were found to be used by this model farm.

Table 4: General production characteristics for commercial cage aquaculture in Uganda producing grow-out tilapia using the extruded pelleted feed.

Production Characteristics	Unit	Value
Volume of cage	m³	216
Production cycle	Months	7
Stocking density	no./m³	80
Stock in numbers	#	17,280
ABW at stocking	g	15
Initial biomass	kg	260
Survival Rate	%	93
FCR	#	1.5
Feed per cage	kgs	10,459
Final tilapia number at harvest	#	16,070
Average Body Weight at harvest	g	450
Harvest output per cage	kgs	7,232
Production Yield-live tilapia	kg/m³	32
1 U.S $	UGX	3,600
Weighted Average cost of Capital	%	10
Selling price of fish product	$/kg	2.4
Tilapia fingerlings cost	$/piece	0.08
Pelleted diet cost	$/kg	1.08
Feed cost per batch/cage	$	11,295

4.2 Enterprise budgets for the three production scenarios

4.2.1 Production enterprise budgets

The production costs for all three scenarios included: costs incurred on purchases of feeds, fingerlings, monthly wedges, operation costs and small farm equipment. A detailed description of the production inputs is shown in Annex 1. The quantities and amounts are stipulated below in Tables 5, 6 and 7. The production costs needed to operate small-scale, medium-scale and large-scale cage aquaculture enterprises producing table-sized tilapia in Uganda are USD 76,437, 208,987 and 393,867 respectively for single production of seven months. The harvest output, revenue and returns for all increase as the scale is increased. Harvest output for a small-scale operation is about 36,000 kg, 108,000 kg from the 15 cages of a medium-scale operation and about 210,000 kg from a large-scale operation. These production costs yield returns of USD 86,780, 260,340 and 520,681 for small-scale, medium-scale and large-scale respectively.

Table 5: Production enterprise budget of tilapia cage aquaculture on Lake Victoria in Uganda under small-scale production.

Item Description	**Unit cost ($)**	**Quantity**	**Cost/monthly ($)**	**Cost/cycle ($)**
Fingerlings (Pcs)	0.082	86,400		7,050
Feed (kgs)	1.102	52,294		57,607
Transport (Fingerlings and Feed)			129	903
Fuel & Oil (monthly)	1.51	24.5	37	259
Repairs(monthly)	55.56	7	56	389
wedges (4workers)	313.40	7	1,254	8,775
Small Farm equipment	100	7	100	700
Harvest Allowance/cage	112	5		560
Petty Cash	27.78	7	27.8	194
Total production costs				**76,437**
Harvest output	**36,158**			
Revenue	**86,780**			
Returns	**10,343**			

*Harvest output (kg); 36,158

Table 6: Production enterprise budget of tilapia cage aquaculture on Lake Victoria in Uganda under medium-scale production.

Item Description	**Unit cost ($)**	**Quantity**	**Cost/monthly ($)**	**Cost/cycle ($)**
Fry (Pcs)	0.080	259,200		20,736
Feed (kgs)	1.080	156,881		169,431
Transport (Fingerlings and feed)				2,084
Fuel & Oil/monthly	1.51	25	37	260
Repairs/monthly	55.56	7	56	389
wedges (6 workers)	313.40	7	1,880	13,163
Small Farm equipment/monthly	150	7	150	1,050
Harvest Allowance	112	15		1,680
Petty Cash	27.8	7	28	194
Total production costs				**208,987**
Harvest output/kgs	**108,475**			
Revenue	**260,340**			
Net returns	**51,354**			

*Harvest output (kgs); 108,475

Table 7: Production enterprise budget of tilapia cage aquaculture on Lake Victoria in Uganda under large-scale production.

Item Description	Unit cost ($)	Quantity	Cost/monthly ($)	Cost/cycle ($)
Fingerlings (Pcs)	0.076	518,400		39,398
Feed (kgs)	1.026	313,762		321,919
Transport (Fingerlings and Feed)				4,167
Fuel & Oil/monthly	1.51	49	74	518
Repairs/monthly	111.12	7	111.1	778
wedges (10 workers)	313.40	7	3,134.0	21,938
Small Farm equipment/monthly	200	7	200	1,400
Harvest Allowance	112	30		3,360
Petty Cash	55.56	7	55.6	389
Total production costs				**393,867**
Harvest output/kgs	216,950			
Revenue	**520,681**			
Returns	**126,813**			

*Harvest output (kgs); 216,950

Percentage shares of the various production costs for all three scenarios are indicated in Figure 7. For all the three production scenarios, feed cost showed the biggest share at 76%, 81% and 82% in small-scale, medium-scale and large-scale respectively. In both medium-scale and large-scale, fry costs had a percentage share of 10% and 11% in a small-scale production scenario. Monthly wedges in the small-scale production scenario had a percentage share of 9%, 6% in medium and 6% in large-scale production. Operation costs and funds for small farm equipment had the least percentage share of the total cost for all three production scenarios.

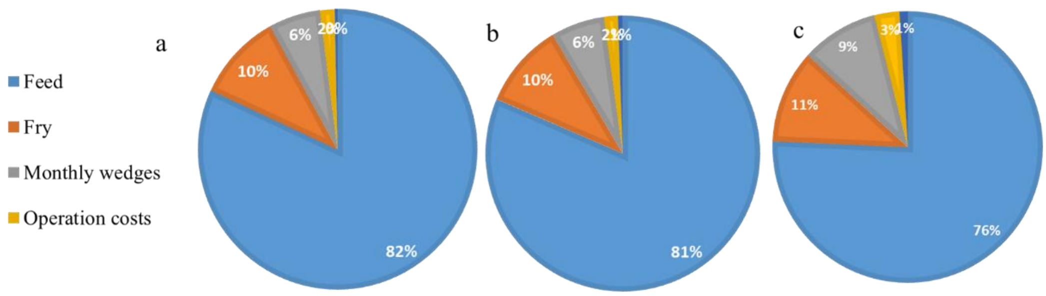

Figure 7: Percentage share of inputs under the production budget of tilapia cage aquaculture on Lake Victoria for a) large-scale b) medium-scale and c) small-scale.

The costs incurred during the start-up of commercial cage aquaculture in Uganda include purchases of cage frames, nets, farmland, operation equipment, installation equipment, and housing materials. Nets include grow-out nets, juvenile nets, outer covers, and predator nets. In addition, hired labour for housing construction and installation services are requirements. Installation services combine installation labour, shipment service costs, clearance costs, and operation costs. The amounts needed for the three scales are indicated in Tables 8, 9 and 10. Investing in cage aquaculture in Uganda rearing tilapia to table size for a small-scale operation of five cages needs USD 47,236, 94,393 and 163,373 for an operation of 15 and 30 cages respectively.

Table 8: Investment budget of a small-scale tilapia cage aquaculture enterprise on Lake Victoria in Uganda.

Item	**Useful Life (Years)**	**Unit Cost ($)**	**Quantity**	**Total Cost ($)**
Farmland		8333	1	8,333
Housing		2843	1	2,843
Cages Frames	10	2,625	5	13,125
Grow-out Cage Nets	10	1,412	5	7,061
Other Nets-Juv; cover; alnets	5	1,913		1,913
Heater Machine	10	2,500	1	2,500
Installation Services-hired labour		210	5	1,050
Cage Equipment; anchor ropes; mooring				800
Customs, Licences, and other charges				5,133
Operation equipm; wheelbarrows; boat etc.				3,619
Operation nets-harvesting & sampling		429	2	858
Total				**47,236**

Table 9: Investment budget of a medium-scale tilapia cage aquaculture enterprise on Lake Victoria in Uganda.

Item	**Useful Life (Years)**	**Unit Cost ($)**	**Quantity**	**Total Cost ($)**
Farmland			1	8,333
Housing			1	2,843
Cages Frames	10	2,500	15	37,500
Grow-out Cage Nets	10	1,345	15	20,175
Other Nets-Juv, Cover, Predator etc.	5			6,910
Heater Machine	5	2,500	1	2,500
Installation Services- Hired labour		200	15	3,000
Cage Equipment- Anchor rope; mooring	5	300	4	2,700
Customs, Licences, and other charges				5,132
Operation Equipment-Weighing scales, harvest accessories, boat etc.				4,443
Operation nets- Sampling and Harvesting nets				857
Total				**94,393**

Table 10: Investment budget of a large-scale tilapia cage aquaculture enterprise in Uganda.

Item	**Useful Life (Years)**	**Unit Cost ($)**	**Quantity**	**Total Cost ($)**
Farmland			1	8,333
Housing			1	5,114
Cages Frames	10	2,250	30	67,500
Grow-out Cage Nets	10	1,211	30	36,315
Other Nets-Juv; cover; predator etc.				12,438
Heater Machine	5	2,500	1	2,500
Installation Services-Hired labour		180	30	5,400
Cage Equipment-Anchor rope; mooring	5			5,400
Customs, Licences, and other charges		8,000	1	10,264
Operation Equipment; weighing scales, harvest accessories, boat etc.				8,394
Operation nets-Sampling and harvest nets				1,714
Total				**163,373**

The percentage shares of the investment items for small-scale, medium-scale and large-scale operations are indicated in Figure 8. Cage frames and all nets have the largest share of the total investment costs for all production scales in tilapia cage aquaculture in Uganda.

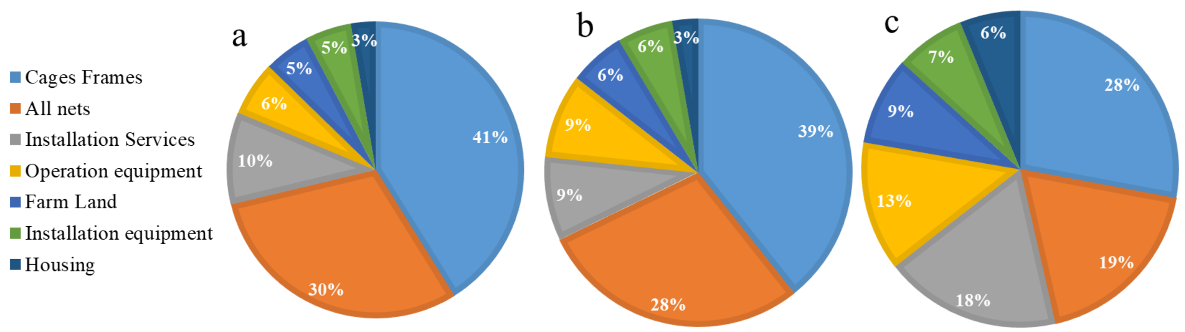

Figure 8: Percentage share of investment inputs for tilapia cage aquaculture for a) large-scale, b) medium-scale and c) small-scale enterprises.

4.3 Cash-flow Analysis

The financial analysis of the three scales of production indicated positive gains. Details for each financial parameter are indicated in Tables 11, 12 and 13 for small-scale, medium-scale and large-scale respectively. Operating five cages in Uganda has a net present value of USD 3,787 an internal rate of return of 12%, percentage profitability of 5, the breakeven price of USD 2.12 and its costs average USD 2.29 to produce one kilogram of fish. The total costs used in investment and production is USD 636,264 yielding a revenue of about USD 666,736.

A medium-scale tilapia farm operating cages on Lake Victoria over five years needs an estimate of a total of USD 1,706,955 yielding a revenue of about USD 2,000,207. Its present value is

174,575, 45% IRR, 17 percentage profitability, USD 1.93 BEP and it costs on average USD 2.0 to produce one kilogram of fish.

A 30-cage operation here referred to as the large-scale total investment and production over time for the five years is about USD 3,750,284. with a farm income of USD 4,727,763. The NPV is USD 1,065,686, IRR 73%, percentage profitability 26%, BEP USD 1.82 and on average USD 1.82 is incurred to produce 1 kilogram of live tilapia.

Table 11: Cash-flow analysis of a small-scale cage aquaculture enterprise producing 520g tilapia over five years.

Small-scale	**Year 0**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Investment costs	47,236					
Variable costs						
Fingerlings ($)	-	8,460	12,690	8,460	12,690	8,460
Transport-fingerlings ($)	-	833	1,250	833	1,250	833
Feed ($)	-	60,472	87,067	104,501	87,067	104,501
Transport-feed ($)	-	278	278	347	278	347
Hired labour-Harvesting ($)	-	336	784	896	784	896
Overhead costs						
Repair & maintenance ($)	-	500	667	667	667	667
Petty cash ($)	83	250	334	334	334	334
Small farm equipment ($)	300	900	1,200	1,200	1,200	1,200
Fuel and oil ($)	37	333	444	444	444	444
Management costs wedges ($)	-	11,282	15,043	15,043	15,043	15,043
Total Costs	**47,656**	**83,645**	**119,756**	**132,725**	**119,756**	**132,725**
Revenue ($)	-	60,612	141,429	161,633	141,429	161,633
Net Cash flow ($)	**- 47,656**	**- 23,032**	**21,672**	**28,908**	**21,672**	**28,908**
Total costs ($)	**636,264**					
Farm Income	**666,736**					
Net Farm Income	**30,472**					
Present Value	- 47,656	- 20,939	17,911	21,719	14,803	17,950
Net Present Value	**3,787**					
IRR	**12%**					
Percentage Profitability (%)	**5**					
Breakeven price	**2.12**					
Cost needed to produce 1kg of fish	**2.29**					

A 30-cage operation here referred to as the large-scale total investment and production over time for the five years is about USD 3,750,284. with a farm income of USD 4,727,763. The NPV is USD 1,065,686, IRR 73%, percentage profitability 26%, BEP USD 1.82 and on average USD 1.82 is incurred to produce 1 kilogram of live tilapia.

Table 12: Financial analysis of a medium-scale cage aquaculture enterprise producing 520g tilapia over five years.

Medium-scale	**Year 0**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Investment costs	94,393					
Variable costs						
Fingerlings ($)	-	25,920	38,880	25,920	38,880	25,920
Transport for fingerlings ($)	-	2,500	3,750	2,500	3,750	2,500
Feed ($)	-	177,859	256,079	307,355	256,079	307,355
Transport for feed ($)	-	556	556	694	556	694

Hired labour (Harvesting) ($)	-	1,008	2,352	2,688	2,352	2,688
Overhead costs						
Repair and maintenance ($)	-	500	667	667	667	667
Petty cash ($)	83.40	250	334	334	334	334
Small farm equipment ($)	450.00	1,350	1,800	1,800	1,800	1,800
Fuel and oil ($)	37.10	334	445	445	445	445
Management costs (wedges) ($)	-	16,924	22,565	22,565	22,565	22,565
Total Costs	**94,964**	**227,200**	**327,427**	**364,968**	**327,427**	**364,968**
Revenue ($)	**-**	**181,837**	**424,286**	**484,899**	**424,286**	**484,899**
Net Cash flow ($)	**- 94,964**	**- 45,363**	**96,859**	**119,931**	**96,859**	**119,931**
Total costs	**1,706,955**					
Farm Income	**2,000,207**					
Net Farm Income	**293,253**					
Present Value	- 94,964	- 41,239	80,049	90,106	66,156	74,467
Net Present Value	**174,575**					
IRR	**45%**					
Percentage Profitability (%)	**17**					
Breakeven price ($)	**1.93**					
Cost needed to produce 1kg ($)	**2.0**					

Table 13: Financial analysis of a large-scale cage aquaculture enterprise producing 520g tilapia over five years.

Large-scale	**Year 0**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Investment costs	**163,373**	-	-	-	-	-
Variable costs						
Fingerlings ($)		55,158	78,797	63,037	78,797	63,037
Transport for fingerlings ($)		5,834	8,334	6,667	8,334	6,667
Feed ($)		370,344	596,874	687,755	596,874	687,755
Transport for feed ($)		1,111	1,111	1,389	1,111	1,389
Hired labour (Harvesting) ($)		2,016	6,048	6,048	6,048	6,048
Overhead costs						
Repair and maintenance ($)		1,000	1,333	1,333	1,333	1,333
Petty cash ($)	166.80	500	667	667	667	667
Small farm equipment ($)	600.00	1,800	2,400	2,400	2,400	2,400
Fuel and oil ($)	73.99	666	888	888	888	888
Management costs (wedges) ($)		33,847	45,130	45,130	45,130	45,130
Total Costs	**164,214**	**472,276**	**741,582**	**815,315**	**741,582**	**815,315**
Revenue ($)	**-**	**363,674**	**1,091,022**	**1,091,022**	**1,091,022**	**1,091,022**
Net Cash flow ($)	**-164,214**	**- 108,602**	**349,440**	**275,707**	**349,440**	**275,707**
Total costs	**3,750,284**					
Farm Income	**4,727,763**					
Net Farm Income	**977,479**					
Present Value	- 82,107	- 98,729	345,980	275,432	349,405	275,705
Net Present Value	**1,065,686**					
IRR	**73%**					
Percentage Profitability (%)	**26**					
Cost needed to produce 1 kg	**1.90**					
Breakeven price	**1.82**					

The aquaculture of tilapia in cages for the three scales of production yields positive returns only after the first year of operation. This is demonstrated in Figures 9 and 10. Figure 9 shows the cash flow by year and Figure 10 shows the flow of total revenue and total costs by year with the emphasis on the break-even points for the small-scale, medium-scale and large-scale operations.

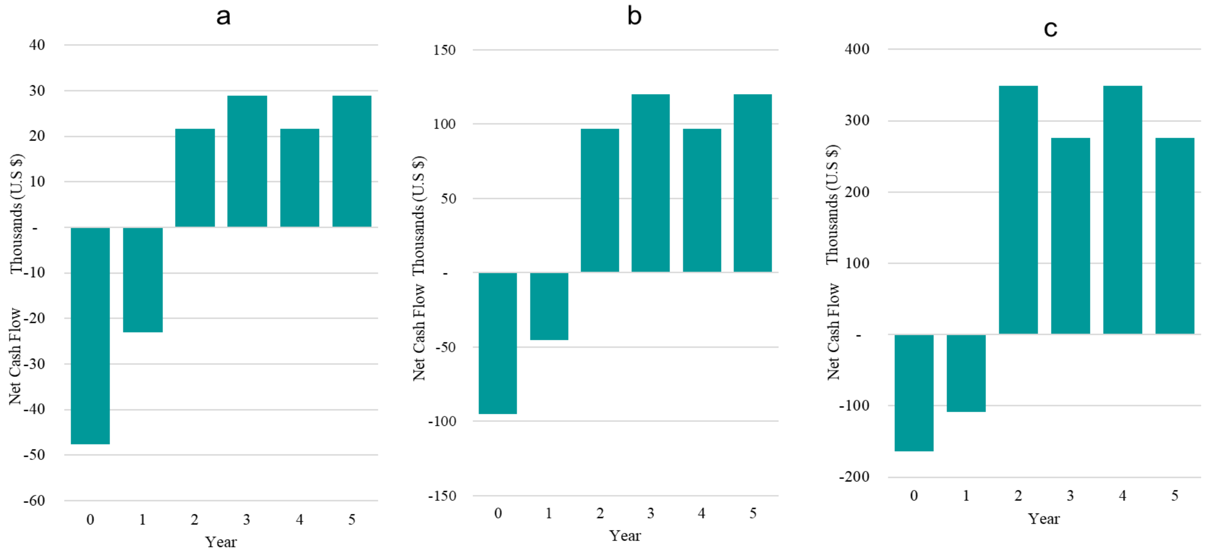

Figure 9: Net cash flow by year for the three commercial scales of production for tilapia in cages in Uganda a) small-scale, b) medium-scale c) large-scale enterprises for tilapia in cages in Uganda.

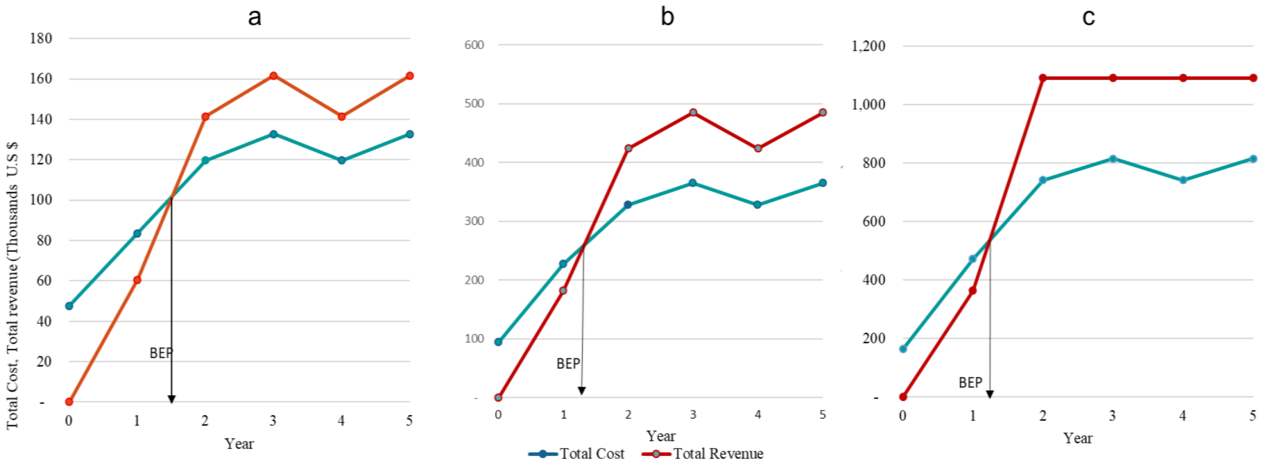

Figure 10: Relationship between total costs and total revenue by year with emphasis on the break-even point for a) small-scale, b) medium-scale and c) large-scale enterprises for tilapia in cages in Uganda.

5 DISCUSSION

5.1 Enterprise budgets

Enterprise budgeting is a form of assessing the cost structure of an enterprise. It is important to assess the weight of a single input for both the production and investment costs. This cost structure analysis is essential for the identification of areas where investors need to adjust costs to maximise profits from the enterprise. In this study, both production and investment costs increased with the increase in the scale of production. This is because the economic needs of the enterprises increase with the increase in production volumes. Production costs largely constitute feed costs; above 75% of the total costs. Feed costs have been reported to account for more than 50% of the production costs in aquaculture (Musa, Mulanda, & Okechi, 2021; Nazziwa, 2021; Bezerra & Dominique, 2015; Bolivar, Jimenez, & Brown, 2006; El-Sayed A.-F. M., 2006). Aquaculture feeding accounts for a significant portion of the cost of commercial fish production, and the expense distinguishes lucrative from unprofitable culture operations (Bolivar, Jimenez, & Brown, 2006). It is therefore important to pay close attention to the feed and feeding management to minimise any forms of waste that may arise. In Uganda feed costs are high partly because good quality feeds with the substantial amount of protein required for optimal growth of the fish is imported, the farm in question uses imported feed from Israel. Importing feed adds freight, taxes, and transportation charges to the initial cost of feed making the price higher compared to the locally available feeds. The increase in feed costs; 76%, 81% and 82% with the increase in production scale is related to the difference in the stock biomass that greatly affects feed requirement in the farm. The decrease in the portion of other costs of production as the scale increases is because bigger investments gain more from operating costs. This could also arise from the discounting factor applied to these inputs for the medium and large-scale operations.

Farming tilapia in commercial cages requires a high investment (Musa, Mulanda, & Okechi, 2021). The costs arise from the high cost of imported HDPE cage materials and associated equipment that have a high purchase price. Costs incurred on import transport and duties also increase the margin on the total cost of these cages. In most cases, expertise on installation is internationally sourced. This raises the capital outlay by increasing installation costs unlike other production systems like pond aquaculture where local expertise is used during preparation. Large scale operations have the benefit of gaining more from land and housing costs thus a reduction in the percentage share of these as the production scale increases. There is also a benefit of discounts for medium and large-scale enterprises on operation equipment as a result of buying in bulk. This is demonstrated by the decrease in the unit cost of the installation equipment, cages and nets as the production scale is increased.

5.2 Cash flow analysis

Operating cage aquaculture in Uganda using cages of 216 m³ under the operation of 5 cages, 15 and 30 is economically viable. The positive NFI ($ 30,472, $ 293,253, $ 977,479) under small-scale, medium-scale and large-scale production indicates enterprise profitability. NFI increase with an increase in farm scale. This is because of the increase in production volumes with increasing production scale. Studies in aquaculture concur with the link between high profitability and bigger investments because of high production volumes as production intensifies. Big farms are observed to be more profitable than smaller farms with similar characteristics (Adebayo & Daramola, 2013; Musa, Mulanda, & Okechi, 2021). The large returns in the medium and large-scale production enterprises make them more attractive to investors and are thereby considered lucrative. The cash flow from all scales of production indicated negative cash flow in year zero and year one. This implies that investors have to be well prepared financially with available funds to sustain the enterprises throughout this period.

The NPV for all was negative for year zero and year one of production and thereafter it became positive. This means that cage tilapia cage aquaculture in Uganda is feasible after an initial two-year period for all scales of production. It is only in the second year of production that tilapia cage aquaculture can generate more cash to cater for all the invested capital and be able to return cash to investors. Shorter periods between initial investment and when investment costs are equal to the net returns attract financial institutions and more investments in the aquaculture business (Brigham & Houston, 2004). In the five years of operation assumed, the highest NPV is observed in the large-scale operation USD 1,065,686, then USD 174,575 for the medium-scale operation and the least was USD 3,787 from the small-scale operation. Enterprises with a higher NPV are preferred to those with a smaller NPV (Carole & Ivano, 2005). Therefore, for commercial purposes, it would be more beneficial to operate a medium-scale and large-scale production than a small-scale enterprise in Uganda. A high IRR of 73% was observed in large-scale productions then 45% for medium scale production and 12 % in small-scale production, this can be linked to the difference in production volume. All the obtained IRR were above the discount rate on the cost of capital implying that the expected compound annual growth rate of operating tilapia cage aquaculture at a commercial level in Uganda is higher than the cost of capital. The decision to rule with IRR is that it should be higher than the discount rate for a viable business (Nazziwa, 2021).

All operations are only profitable after the first year of operation including year zero as the preparation time. This implies that the break-even point of tilapia cage aquaculture in Uganda is about one year and a half. No returns are expected to be obtained until this time is surpassed therefore investors should be able to sustain the business expecting no profits during this time. The analysis in this study revealed that the BEP for tilapia cage operations under small, medium, and large scale is $\$2.12kg^{-1}$, $\$1.93kg^{-1}$ and $\$1.90kg^{-1}$ slightly below the farm gate price of $ 2.4 for farmed Nile tilapia in Uganda. This means that small-scale, medium-scale and large-scale operations can only recover the invested finances when they sell fish at $\$2.12kg^{-1}$, $\$1.90kg^{-1}$ and $\$1.90kg^{-1}$ respectively. The reduction in BEP as the scale increases gives an advantage to investors to operate medium and large-scale operations because they can obtain returns at a lower cost per kg of fish, an element preferred by the market. The unit costs of production were also decreasing with an increase in the scale of production ($\$2.29kg^{-1}$, $\$2.0kg^{-1}$, $\$1.82kg^{-1}$ for small-scale, medium-scale and large-scale respectively). The decrease demonstrated an effect of economies of scale through gaining more in the fixed inputs. This arises from the decrease in unit cost of inputs through discounts applied as a result of bulk purchases for medium and large-scale operations. Economies of scales are demonstrated in other research showing that an increase in cage production size leads to a reduction in the unit cost of the product (Blow & Leonard, 2007).

The operation schedule used in this study affected the costs and returns obtained in a year. It was set in a way that cages were evenly stocked each month for five months for the small and medium-scale operations, and 6 months for the large-scale operation. Stocking cages in a continuous schedule allows for continuous production. Farmers can however adjust the number of cages they would wish to stock per month depending on the market and production needs.

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusion

Cage aquaculture is seen as a way to bridge the growing gap between demand and availability of fish in Uganda. It allows investments under the blue economy label with potential returns. Tilapia cage fish farming needs both intense management and financial management for it to thrive. Commercial aquaculture of tilapia is practised using 216 m^3 cages, a stocking density of 80 fish m^{-3} with a harvest output of 32 kgm^{-3} using extruded feeds. Investments in tilapia cage aquaculture in Uganda varies from USD 47,236 for a small-scale operation running 5 cages to USD 94,393 for the medium-scale farm of 15 cages and USD 163,373 for a 30-cage operation. Adjustments to the fitting size of operation by the farmer or investors can now be made using the single unit production characteristics provided in this study or otherwise. Feed costs cover over 75% of all variable costs during production therefore efforts need to be made to reduce feed costs without hindering the quality and quantity administered to the fish. The FCR influences return, production time and harvest size in the business as observed in the growth model therefore good quality feeds need to be utilised for optimum returns. The positive returns above both variable and total expenses, based on the assumptions and production parameters with data from Pearl Aquatics fish farm show the feasibility of these enterprises. Small-scale businesses have the lowest NFI, NPV, and IRR, offering investors in medium and large-scale operations a considerable margin of safety. It is more cost-effective to operate over five 216m^3 cages for Nile tilapia culture in Uganda, but the returns produced with five cages are also noteworthy. The Excel tool from the study can now be used as a guiding tool for financial planning and management and farmers to better understand the economics of cage aquaculture. Extending this financial management knowledge to potential investors and farmers already practising fish farming as a business delivers an opportunity for financial sustainability. The end goal of more investments, more returns gained and more production of fish in the country will be realised. It should be noted and emphasised that the figures in this study are adjusted estimates that could be affected by the dollar rate and input prices at the time of enterprise set-up and operations.

6.2 Recommendations

6.2.1 Further study

We recommend conducting a detailed study on tilapia cage aquaculture that links production, costs, and returns, including a full sensitivity analysis, under an experimental setup to give practical results. This study relied on feed tables from a feed company to determine the growth rates and growth weights during modelling.

6.2.2 Government and Research Institutes

Training of government officials, extension workers, farmers, and other stakeholders, in financial analysis management of tilapia cage aquaculture. Current training in aquaculture is focused on production techniques and economics is not dealt with in detail.

The government should strengthen its policies on tilapia imports to prevent incidences of dumbing fish, especially from China. This will protect the current market prices of the fresh live tilapia in Uganda which seem to be profitable over both the total and variable costs combined.

Policymakers in Uganda should direct more investment and research towards the development of high quality locally available feed made from locally sourced ingredients to reduce the total cost of good quality feed in the country.

6.2.3 Farmers

The best production management practices should be applied hand-in-hand with financial management for cage fish farmers to realise the return goals of their enterprises.

Farmers should establish more direct fish trade with consumers and add value by processing the live tilapia offering more products whose shelf life is longer and sells at a higher price than the wholesale farm gate price offered by wholesale buyers.

Record keeping is emphasised as a crucial element in tilapia cage aquaculture. Records are the basis of the financial analysis of the enterprises. Without proper detailed records, economic analysis cannot be achieved.

6.2.4 Potential Investors

Potential investors need to be aware of the total amount of money needed to invest in tilapia cage aquaculture, especially during the first 2 years of production. It is recommended that investors are advised to have sufficient money to take them through the initial period when the farm is not making positive returns. This will minimise enterprise failures due to poor financial preparation and allocation.

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9 APPENDICES

Appendix 1: Description for the production Inputs Utilised in Tilapia Cage Aquaculture in Uganda

Cost Category	**Cost particular**	**Unit of measure**
Operation Costs	Fingerlings -monosex tilapia 15g	Pcs
	Feed-extruded commercially manufactured feeds ranging between 1mm 42% and 6mm 30%	kgs
	Fuel	Ltrs
	Fry transportation-car hire, packaging materials, transport fuel	Rounds
	Feed transportation-car hire, transport	Rounds
	2T oil/month	Ltrs
	Engine service/month	Service
	Repairs (Boat)/month	Service
	Petty cash/month	
	Harvest allowance/cage	Hired labour
Management costs	Salaries	
	Transport allowance to workers	
	Food for worker	
	National Social Security Fund (NSSF) for the workers	
Small Farm equipment	Including twines, wheelbarrows, stationary among others	

Appendix 2: Production Schedule of Small-scale Enterprise for Tilapia Cage Aquaculture in Uganda

Small-scale	Stocking month		Harvest Month		Fingerlings per year		Harvest output per year						
Year 1	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**	**Total**
Fingerlings stocked (Pieces)	0	0	0	17,280	17,280	17,280	17,280	17,280				17,280	103,680
Feed (kgs)	0	0	0	392	1,260.77	2,951.02	5,265	8,130	11,201	10,333	8,642	6720	
Mortalities (Pieces)	0	0	0	585	910	1,028	1,128	1,220	635	310	192	677	
Number of fish (Pieces)	0	0	0	17,280	33,975	50,345	66,597	82,749	97,589	80,894	64,524	65,552	
Biomass (Kgs)	0	0	0	259	1,171	2,998	6,033	10,560	16,607	24,113	22,286	19,511	
Harvest output (Kg)	0	0	0	0	0	0	0	0	0	8,418	8,418	8,418	25,255
Year 2	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**	**Total**
Fingerlings stocked (Pieces)	17,280	17,280	17,280	17,280	0	0	0	17,280	17,280	17,280	17,280	17,280	155,520
Feed (kgs)	4,724	2,951	5,265	8,130	11,201	10,333	8,642	6,720	4,724	2,951	5,265	8,130	
Mortalities (Pieces)	910	1,028	1,128	1,220	635	310	192	677	910	1,028	1,128	1,220	
Numbers at end of month (Pieces)	66,095	66,405	66,597	82,749	97,589	80,894	64,524	65,552	66,095	66,405	66,597	82,749	
Biomass (Kgs)	15,896	11,417	6,033	10,560	16,607	24,113	22,286	19,511	15,896	11,417	6,033	10,560	
Harvest output (Kg)	8,418	8,418	0	0	0	8,418	8,418	8,418	8,418	8,418	-	-	58,929
Year 3	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**	**Total**
Fingerlings stocked (Pieces)	0	0	0	17,280	17,280	17,280	17,280	17,280	-	-	-	17,280	103,680
Feed (kgs)	11,201	10,333	8,642	6,720	4,724	2,951	5,265	8,130	11,201	10,333	8,642	6,720	
Cumulative mortalities (Pieces)	635	310	192	677	910	1,028	1,128	1,220	635	310	192	677	
Numbers at end of month (Pieces)	97,589	80,894	64,524	65552	66,095	66,405	66,597	82,749	97,589	80,894	64,524	65,552	
Biomass (Kgs)	16,607	24,113	22,286	19511	15,896	11,417	6,033	10,560	16,607	24,113	22,286	19,511	
Harvest output (Kg)	0	8,418	8,418	8,418	8,418	8,418	-	-	-	8,418	8,418	8,418	67,347
Year 4	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**	**Total**
Fingerlings stocked (Pieces)	17,280	17,280.00	17,280.00	17,280	-	-	-	17,280	17,280	17,280	17,280	17,280	155,520
Feed (kgs)	4,724	2,951	5,265	8,130	11,201	10,333	8,642	6,720	4,724	2,951	5,265	8,130	-
Mortalities (Pieces)	910	1,028	1,128	1,220	635	310	192	677	910	1,028	1,128	1,220	-
Numbers at end of month (Pieces)	66,095	66,405	66,597	82,749	97,589	80,894	64,524	65,552	66,095	66,405	66,597	82,749	-
Biomass (Kgs)	15,896	11,417	6,033	10,560	16,607	24,113	22,286	19,511	15,896	11,417	6,033	10,560	-
Harvest output (Kg)	8,418.38	8,418.38	-	-	-	8,418	8,418	8,418	8,418	8,418	-	-	58,929
Year 5	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**	**Total**
Fingerlings stocked (Pieces)	-	-	-	17,280	17,280	17,280	17,280	17,280	-	-	-	17,280	103,680
Feed (kgs)	11,201	10,333	8,642	6,720	4,724	2,951	5,265	8,130	11,201	10,333	8,642	6,720	-
Cumulative mortalities (Pieces)	635	310	192	677	910	1,028	1,128	1,220	635	310	192	677	-
Numbers at end of month (Pieces)	97,589	80,894	64,524	65,552	66,095	66,405	66,597	82,749	97,589	80,894	64,524	65,552	-
Biomass (Kgs)	16,607	24,113	22,286	19,511	15,896	11,417	6,033	10,560	16,607	24,113	22,286	19,511	-
Harvest output (Kg)	-	8,418	8,418	8,418	8,418	8,418	-	-	-	8,418	8,418	8,418	67,347

Appendix 3: Production Schedule of Medium-scale Enterprise for Tilapia Cage Aquaculture in Uganda

Medium-scale	Stocking month		Harvest Month		Fingerlings per year		Harvest output per year						
Year 1	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**	**Total**
Fingerlings stocked (Pieces)	-	-	-	51,840	51,840	51,840	51,840	51,840	-	-	-	51,840	311,040
Feed (kgs)	-	-	-	1,175	3,782.30	8,853.05	15,795	24,389	33,604	30,998	25,927	20,160	164,684
Mortalities (Pieces)	-	-	-	1,755	2,730	3,084	3,384	3,660	1,905	930	576	2,031	20,055
Number of fish	-	-	-	51,840	101,925	151,035	199,791	248,247	292,767	242,682	193,572	196,656	
Biomass (Kgs)	-	-	-	778	3,514	8,995	18,098	31,679	49,821	72,340	66,859	58,534	
Harvest output (Kg)	-	-	-	-	-	-	-	-	-	25,255	25,255	25,255	75,765
Year 2	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**	**Total**
Fingerlings stocked (Pieces)	51,840	51,840	51,840	51,840	-	-	-	51,840	51,840	51,840	51,840	51,840	466,560
Feed (kgs)	14,173	8,853	15,795	24,389	33,604	30,998	25,927	20,160	14,173	8,853	15,795	24,389	237,110
Mortalities (Pieces)	2,730	3,084	3,384	3,660	1,905	930	576	2,031	2,730	3,084	3,384	3,660	
Number of fish	101,925	151,035	199,791	248,247	292,767	242,682	193,572	196,656	101,925	151,035	199,791	248,247	
Biomass (Kgs)	47,689	34,250	18,098	31,679	49,821	72,340	66,859	58,534	47,689	34,250	18,098	31,679	
Harvest output (Kg)	25,255	25,255	-	-	-	25,255	25,255	25,255	25,255	25,255	-	-	176,786
Year 3	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**	**Total**
Fingerlings stocked (Pieces)	-	-	-	51,840	51,840	51,840	51,840	51,840	-	-	-	51,840	311,040
Feed (kgs)	33,604	30,998	25,927	20,160	14,173	8,853	15,795	24,389	33,604	30,998	25,927	20,160	284,588
Mortalities (Pieces)	1,905	930	576	2,031	2,730	3,084	3,384	3,660	1,905	930	576	2,031	
Number of fish	292,767	242,682	193,572	196,656	101,925	151,035	199,791	248,247	292,767	242,682	193,572	196,656	
Biomass (Kgs)	49,821	72,340	66,859	58,534	47,689	34,250	18,098	31,679	49,821	72,340	66,859	58,534	
Harvest output (Kg)	0	25,255	25,255	25,255	25,255	25,255	-	-	-	25,255	25,255	25,255	202,041
Year 4	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**	**Total**
Fingerlings stocked (Pieces)	51,840	51,840	51,840	51,840	-	-	-	51,840	51,840	51,840	51,840	51,840	466,560
Feed (kgs)	14,173	8,853	15,795	24,389	33,604	30,998	25,927	20,160	14,173	8,853	15,795	24,389	237,110
Mortalities (Pieces)	2,730	3,084	3,384	3,660	1,905	930	576	2,031	2,730	3,084	3,384	3,660	
Number of fish	101,925	151,035	199,791	248,247	292,767	242,682	193,572	196,656	101,925	151,035	199,791	248,247	
Biomass (Kgs)	47,689	34,250	18,098	31,679	49,821	72,340	66,859	58,534	47,689	34,250	18,098	31,679	
Harvest output (Kg)	25,255	25,255	-	-	-	25,255	25,255	25,255	25,255	25,255	-	-	176,786
Year 5	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**	**Total**
Fingerlings stocked (Pieces)	-	-	-	51,840	51,840	51,840	51,840	51,840	-	-	-	51,840	311,040
Feed (kgs)	33,604	30,998	25,927	20,160	14,173	8,853	15,795	24,389	33,604	30,998	25,927	20,160	284,588
Mortalities (Pieces)	1,905	930	576	2,031	2,730	3,084	3,384	3,660	1,905	930	576	2,031	-
Number of fish	292,767	242,682	193,572	196,656	101,925	151,035	199,791	248,247	292,767	242,682	193,572	196,656	-
Biomass (Kgs)	49,821	72,340	66,859	58,534	47,689	34,250	18,098	31,679	49,821	72,340	66,859	58,534	-
Harvest output (Kg)	-	25,255	25,255	25,255	25,255	25,255	-	-	-	25,255	25,255	25,255	202,041

Appendix 4: Production Schedule of Large-scale Enterprise for Tilapia Cage Aquaculture in Uganda

Large-scale	Stocking month		Harvest Month		Fingerlings per year		Harvest output per year						
Year 1	January	February	March	April	May	June	July	August	September	October	November	December	Total
Fingerlings stocked (Pieces)	-	-	-	103,680	103,680	103,680	103,680	103,680	103,680	-	-	103,680	725,760
Feed (kgs)	-	-	-	2,351	7,564.60	17,706.09	31,591	48,779	69,560	67,209	61,995	54,204	360,959
Mortalities (Pieces)	-	-	-	3,510	5,460	6,168	6,768	7,320	7,320	3,810	1,860	4,662	
Number of fish	-	-	-	103,680	203,850	198,446	399,582	496,494	592,854	585,534	485,364	490,824	
Biomass (Kgs)	-	-	-	1,555	7,028	17,990	36,195	63,358	101,197	150,152	144,679	135,273	
Harvest output (Kg)	-	-	-	-	-	-	-	-	-	50,510	50,510	50,510	151,531
Year 2	January	February	March	April	May	June	July	August	September	October	November	December	Total
Fingerlings stocked (Pieces)	103,680	103,680	103,680	103,680	103,680	-	-	103,680	103,680	103,680	103,680	103,680	1,036,800
Feed (kgs)	45,534	38,487	31,591	48,779	69,560	67,209	61,995	54,204	45,534	38,487	31,591	48,779	581,749
Mortalities (Pieces)	6,012	6,168	6,768	7,320	7,320	3,810	1,860	4,662	6,012	6,168	6,768	7,320	
Number of fish	493,482	494,790	495,942	496,494	592,854	585,534	485,364	490,824	493,482	494,790	495,942	496,494	
Biomass (Kgs)	122,541	106,339	86,705	63,358	101,197	150,152	144,679	135,273	122,541	106,339	86,705	63,358	
Harvest output (Kg)	50,510	50,510	50,510	-	-	50,510	50,510	50,510	50,510	50,510	50,510	-	454,593
Yea 3	January	February	March	April	May	June	July	August	September	October	November	December	Total
Fingerlings stocked (Pieces)	103,680			103,680	103,680	103,680	103,680	103,680	103,680			103,680	829,440
Feed (kgs)	69,560	67,209	61,995	54,204	45,534	38,487	31,591	48,779	69,560	67,209	61,995	54,204	670,327
Mortalities (Pieces)	7,320	3,810	1,860	4,662	6,012	6,168	6,768	7,320	7,320	3,810	1,860	4,662	
Number of fish	592,854	585,534	485,364	490,824	493,482	494,790	495,942	496,494	592,854	585,534	485,364	490,824	
Biomass (Kgs)	101,197	150,152	144,679	135,273	122,541	106,339	86,705	63,358	101,197	150,152	144,679	135,273	
Harvest output (Kg)	-	50,510	50,510	50,510	50,510	50,510	50,510			50,510	50,510	50,510	454,593
Year 4	January	February	March	April	May	June	July	August	September	October	November	Dcember	Total
Fingerlings stocked (Pieces)	103,680	103,680	103,680	103,680	103,680	-	-	103,680	103,680	103,680	103,680	103,680	1,036,800
Feed (kgs)	45,534	38,487	31,591	48,779	69,560	67,209	61,995	54,204	45,534	38,487	31,591	48,779	581,749
Mortalities (Pieces)	6,012	6,168	6,768	7,320	7,320	3,810	1,860	4,662	6,012	6,168	6,768	7,320	-
Number of fish	493,482	494,790	495,942	496,494	592,854	585,534	485,364	490,824	493,482	494,790	495,942	496,494	-
Biomass (Kgs)	122,541	106,339	86,705	63,358	101,197	150,152	144,679	135,273	122,541	106,339	86,705	63,358	-
Harvest output (Kg)	50,510	50,510	50,510	-	-	50,510	50,510	50,510	50,510	50,510	50,510	-	454,593
Year 5	January	February	March	April	May	June	July	August	September	October	November	December	Total
Fingerlings stocked (Pieces)	103,680	-	-	103,680	103,680	103,680	103,680	103,680	103,680	-	-	103,680	829,440
Feed (kgs)	69,560	67,209	61,995	54,204	45,534	38,487	31,591	48,779	69,560	67,209	61,995	54,204	670,327
Mortalities (Pieces)	7,320	3,810	1,860	4,662	6,012	6,168	6,768	7,320	7,320	3,810	1,860	4,662	-
Number of fish	592,854	585,534	485,364	490,824	493,482	494,790	495,942	496,494	592,854	585,534	485,364	490,824	-
Biomass (Kgs)	101,197	150,152	144,679	135,273	122,541	106,339	86,705	63,358	101,197	150,152	144,679	135,273	-
Harvest output (Kg)	-	50,510	50,510	50,510	50,510	50,510	50,510	-	-	50,510	50,510	50,510	454,593