

Examining Determinants of Fish Farming Business Performance. A Case of Zambia National Service Chanyanya

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ARTICLE INFORMATION	ABSTRACT
<p>Article history: Published: October 2026</p> <p>Keywords: Examining determinants Aquaculture Capture Performance Ministry of Livestock and Fisheries</p>	<p>This study aimed to examine the determinants of fish business performance in Zambia particularly at Zambia National Service Chanyanya fish farm. Employing a descriptive research design, data was collected through questionnaires from a stratified sample of 60 participants. Data analysis was conducted using Excel, with findings presented through frequency tables and pie charts. The study's primary objectives were to ascertain the determinants of fish farming business performance in Zambia, analyse how profitable fish farming business is in Zambia and determine fish farming business constraints in Zambia. Findings revealed the following as the determinants of fish business performance: The majority of 14% respondents indicated Sound policy formulation and appropriate implementation of political will and agenda and the rest were Government support through financial and technical services, production systems that suit local environment conditions, improved technical support, different fish production system and models to better utilize water and land resources and strive for better economic and environment efforts, opportunities to improve existing technologies and introduce new ones, creation of environment that promote private investment holder, species improvement, creation of environment that promote private investment holder, water quality, PH levels, frequency of feeding and dissolved oxygen, fish density and demand of fish. The methods used to measure fish business profitability were: Net present value, Benefit-Cost Ratio (BCR), Internal Rate of Return (IRR) Gross margin and Net return. The majority of 40% respondents preferred (NPV) method. The constraints faced by fish business farmers were: predators, high cost of feed, limited supply of water, lack of capital, access to credit facilities, availability of fingerlings, lack of manpower and technical skills, transport cost, labour cost, seed supply hatcheries, farmer-to-farmer networking and suitable environment and climate. The majority of 20% respondents indicated predators as main constraints. The recommendations made were as follows: In addressing the issue of high cost of feed, farmers should learn how to formulate quality feeds from their own grown crops that that can be used as feed ingredients, farmers should adopt the 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 the need for government to invest more in the extension services especially for the fisheries and livestock sector, 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 and operationalize the aquaculture and fisheries fund in order to stimulate fish production especially for aquaculture that requires a significant number of resources to be invested. Lastly, 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.</p>

1. Introduction

1.1 Background

According to Fisheries Act No. 22 (2011), aquaculture is the production, propagation, or farming of fish, aquatic vegetation, or other living aquatic resources, whether from eggs, spawn, spat, or seed, or by rearing fish that have been legally taken from the wild or imported into the nation. The first attempts to cultivate native members of the Cichlidae family, primarily tilapias, in dams and

earthen fish ponds in Zambia date back to the 1950s. An empirical study done in China on factors determining fish production performance, can help Zambian aquaculture increase its production by applying flexible Chinese lessons (Cavallo et al., 2023). About 35% of the world's fish and seafood output volume in 2020 came from China, making it the world's greatest producer of aquatic products (FAO: Rome, Italy, 2022). In 2023, China produced 68 million tons of aquatic products overall (Fisheries Administration Bureau: Beijing, China, 2023), compared to just 4.65 million tons in 1978 (Li et al., 2011). With the implementation of multifaceted policies, particularly from the mid-1980s, China's aquaculture industry grew significantly, making it the first nation in the world to produce more aquaculture than capture. When comparing China's aquaculture development path to Zambia's current circumstances, there are many parallels that can be found. As a result, Zambia could learn from China's experience and improve its aquaculture production by utilizing current opportunities and avoiding some potential pitfalls. Thus, the examination of determinants of fish business production performance are highlighted in this study. Instead of comparing, Zambia might learn some lessons from China's aquaculture sector development experiences that could readily boost domestic fish production and assist identify the factors influencing fish farming in the nation. Furthermore, Kimani et al. (2020) observed that the fishing sector in Kenya accounts for around 2% of the country's export revenue and 0.5% of its GDP. This is further supported by the fact that, in 2018, the fishing industry made up a meager 0.5% of Kenya's GDP (KNBS, 2018). Although aquaculture's share of the fish supply is still small compared to fisheries, it has increased dramatically over the past ten years due to the Government and technical support (FAO, 2020). The fast-growing tilapia farming sector is the cause of this rise in supply; Kenya is spearheading the cage culture revolution on some of Africa's greatest lakes (Kaminski et al., 2018; Njiru et al., 2018). Aquaculture was estimated to make up 2.7% of Kenya's total fish production in 2021, which was expected to reach 163.6 thousand metric tons, according to INNOROV 2023 (Kenya Fisheries and Aquaculture Sector, 2021). In the same year, Kenyan fish imports came to USD 203.9 million, while exports came to USD 121.6 million (Kenya Fisheries and Aquaculture Sector, 2021). The 53.4% of Zambians' animal protein intake comes from fish, making it a significant source of protein for the country's population (IAPRI, 2017). Aquaculture and capture fisheries are its two main sources. Zambia has 8 million hectares of wetlands and 12 million hectares of water in the form of lakes, rivers, and swamps (ADP 2009).

1.2 Statement of the problem

With capture and aquaculture fishery output stagnating and the national population continuously growing (IAPRI, 2017), the country is faced with a large gap of fish production and demand, resulting in a large number of fish imports every year while also threatening national food and nutrition security. As earlier alluded, the national fish deficit for Zambia stands at 40,000 metric tons per year (IAPRI, 2017). One significant problem is the limited understanding of the determinants of fish farming performance in Zambia. Despite the potential benefits, there is a lack of comprehensive research on examining the determinants of fish production performance which can contribute to improved fish productivity. This lack of understanding hampers informed decision-making in the Ministry of Livestock and may hinder the effective allocation of resources and planning efforts to increase fish productivity and bridge the gap of fish deficit in the country. Additionally, there are concerns regarding on how to measure fish business profitability and be sure of the payback periods if the venture was funded through credit facilities. Without addressing these concerns, there is a risk that fish production performance may not improve in Zambia. Furthermore, constraints in fish production may include cost of feed, inadequate infrastructure, predators, limited human resources, transport cost, mortality and limited hatcheries for fingerlings production. There is limited knowledge on constraints inherent in fish farming business and how to address them systematically. Conducting research to address these gaps is essential for improved fish productivity, reduce the gap of fish deficit in the country and create employment for the citizens. The study would also help the Government to reduce expenditure on imported fish from other countries and increase the opportunity of raising revenue through fish exports.

1.3 Research Objectives

- To ascertain the determinants of fish farming business performance in Zambia.
- To analyse how profitable fish farming business is in Zambia.
- To determine fish farming business constraints in Zambia.

1.4 Theoretical Framework

The highest theoretical equilibrium yield that can be consistently extracted (on average) from a stock under current environmental conditions without substantially impacting the reproduction process is known as the maximum equilibrium yield theory. The Schaefer model and other models of surplus output are used to estimate it (Indicators for Sustainable Development of Marine Capture Fisheries, 1999). It is anticipated that the mass of a given fish stock will decrease compared to its normal level as the amount of fishing that it is subjected to rises. Consequently, the more fishing done, the less can be harvested with a given amount of labor, other things being equal. The degree of saturation of the range that sustains the fish should decrease as fishing reduces the stock's density. Under simple ideal conditions, if a given modest harvest were to be repeated year after year, the stock should eventually reach a new equilibrium at a mass lower than that of the virgin stock, declining less quickly each time. Therefore, decreased abundance can simply indicate that the resource is being used. There must be a limit, or a degree of decline, to a fish stock's capacity to achieve equilibrium with a fishery. It would be anticipated that fishing would increase the catch with which the stock could reach the threshold of equilibrium and beyond. To prevent overfishing, pond, tank and cage fish farming should be used for additional continuous effort beyond the critical level of fish stock. One definition of "overfishing" would be an increase in fishing effort that leads to a decrease (in comparison to what would have been attained otherwise) in both the density of stock and the total weight of catch. To preserve fish equilibrium for human consumption and bridge the gap of nation's fish deficit, farmers must be encouraged to raise fish in ponds, tanks and cages. The government can encourage the growth of fish in ponds, tanks, and cages on water bodies to augment native fish if there is a substantial demand for them. Furthermore, when the resource has been depleted beyond its level for maximum equilibrium yield, the price that society would pay for it may increase enough due to scarcity and to discourage the

fishing effort to continue. The unguided interaction of social factors can lead to a waste of effort that management could have prevented because the same equilibrium poundage might have been generated with less work prior to the stock being lowered below the critical point. Although it is unlikely that extermination for profit could affect most marine fishes and invertebrates, a commercial fishery could cause extermination if fishing continued to be profitable until the stock is reduced below the level at which it could maintain equilibrium. This is the case for whales and anadromous fishes. Therefore, the results of lowering a stock below the level for maximum equilibrium yield may be clearly defined in terms of wasted effort. Since overfishing is a result of dietary discrimination, it is difficult to prove the societal advantages of management's efforts to save this endeavor. For example, Zambia's capital fisheries, which are the best-documented example of a marine fish stock primarily imported from China, can also feed nutrient-dense fish of other types (like tilapia) raised in the nation's cage and fish ponds to keep fish stock levels in balance. Thus, the high nutritional value attributed to the fish types that allow overfishing seems to be the consequence of a culturally conditioned desire that can only be described as logical in a very narrow sense. These preferences aren't always set in stone.

2. Literature Review

2.1 How to ascertain the determinants of fish farming business performance in Zambia.

According to a Chinese empirical study, aquaculture policy and regulation are significantly influenced by sound policy formulation and the appropriate application of political will and agenda (Cavallo et al., 2023). Along with a number of goal-oriented policies and strategies to encourage, direct, and support the sector's rapid development, China has long established the "aquaculture-prioritized" principle for the development of its fisheries. Additionally, China grows the sector sustainably and uses a distinctive experimental method to public policy development (Kritzer et al., 2023).

Moreover, pilot projects at the provincial and local levels in Zambia provide an opportunity to experience new methods in controlled, small-scale environments (Namonje-Kapembwa, T.; Samboko, P., 2017). Effective and successful strategies in various settings are then expanded into new national policies for expansion and replication (Battista et al., 2017). In order to combat hunger and malnutrition, overcome the country's estimated 40,000-ton annual fish shortage, and address current and emerging issues impacting fish output to generate economic growth, Zambia implemented the NFAP in 2023. Additionally, this strategy is viewed as a way to ensure that the nation's plentiful natural resources are used sustainably. Promoting sustainable fish production and productivity, bolstering the provision of extension services, research, and development, expanding the market for fish products, preserving and enhancing aquatic animal health, safeguarding the environment, and mainstreaming cross-cutting issues in fisheries and aquaculture are just a few of the actions listed in the NFAP.

2.2 How to analyse profitability of fish farming business in Zambia.

The field of fisheries has seen a large number of studies. The most relevant recent research that has been conducted in connection with the study is covered in the part that follows: Ahmed (2003) conducted a study whose main goals were to assess the different cultural practices and determine the relative profitability of fish farming in the Mymensingh district. He discovered that the average carp fingerling stocking density per year ranged from 9537 to 10445 per hectare. The average cost of producing fish was estimated to be between Tk. 23210 and Tk. 24790 per hectare, while the net return was found to be between Tk. 59119 and Tk. 56484 per hectare annually. "Carp polyculture is profitable," he declared.

The investment is anticipated to be financed by stock, or roughly 30% of the total capital, with a one-time loan covering 70% of the total investment expenditures and associated start-up costs. We also assume a 12.5% interest rate, a one-year grace period in the first year of the firm's incorporation, and a four-year loan repayment duration in this research. Pond building, water supply setup, and other fishing equipment will cost 12,500 ZMW of the anticipated 24,000 ZMW total investment and associated start-up expenses. Is investing in aquaculture profitable? To answer this research issue, they calculated the profitability and viability of aquaculture production using Net Present Value (NPV), Benefit-Cost Ratio (BCR), Internal Rate of Return (IRR), Gross Margin, and Net Return. Based on the information acquired for this study and other earlier research on aquaculture production in Zambia (Mwango et al. 2016; Shula and Mofya-Mukuka 2015), they developed the production projections in order to evaluate the profitability of aquaculture production.

2.3 How to determine fish farming business constraints in Zambia.

An empirical study conducted in Bangladesh reviewed that though aquaculture is frequently seen as a component of Bangladesh's cultural heritage, fish farmers face quite a number of constraints such as lack of initial capital, predators, theft, cost of fertilizers, transport cost, shortage of high-quality fingerlings, excessive feed and other input prices, a lack of economic expertise, and inadequate financing options (Chowdhury and Maharajan 2001). With so many rivers, the nation offers a wealth of freshwater resources that are perfect for aquaculture. To satisfy their needs for animal protein and minerals, most Bangladeshis depend on fish and aquatic products. Over 60% of the animal protein supply comes from fish (DoF, 2014). The country's abundant water resources include ponds, canals, rivers, estuaries, oxbow lakes, low-lying natural depressions known as haors and beels, and marine water areas. Many of Bangladesh's commercially important fish species are found in these areas. Since they provide food, nutrition, livelihoods, incomes, and export money, these fish have long been considered a vital part of the nation (Alam 2005; Nasir Uddin et al., 2003; Dey et al., 2010; Jahan et al., 2010 and Belton et al., 2011). The marine and inland fishing sectors, which generate 2.01% of export earnings, 23.37% of agricultural output, and 4.37% of GDP, are vital to the country's economy (DoF 2014). Bangladesh was the world's fourth-largest aquaculture producer in 2012, behind China, India, Vietnam, and Indonesia (FAO 2014).

3. Research Methodology

3.1 Research Design

In the study Examining determinants of fish farming business performance: A Case Study of Zambia National Service, Chanyanya fish farm, a descriptive design was employed to systematically explore and describe how determinants of fish production can be

utilized in Zambia to increase fish productivity. The descriptive design aimed to provide a detailed account of the existing farming practices, determinants of fish farming, profitability ratios in fish farming and constraints inherent in fish business. By using this design, the study sought to gather comprehensive information about the current state of fish farming at Zambia National Service fish farm. The descriptive approach allowed the researchers to collect data through various methods such as questionnaires, interviews, surveys, and document analysis, thereby offering a holistic understanding of determinants of fish production in Zambia National Service. The case study format further enabled an in-depth exploration of the specific context of the Zambia National Service fish farm, making it possible to identify key determinants of fish production. Additionally, the descriptive design facilitated the identification of gaps and areas for improvement in fish production, providing valuable insights that could inform future enhancements in fish productivity.

3.2 Target Population

According to Meadowcroft, J. (2004), the target population includes all participants of interest to the researcher and selecting participants is one of the most important aspects of planning and designing a research study. Individuals with valuable information was targeted. Thus, the target population for the study included 60 personnel at Zambia National Service Chanyanya fish farm. The respondents were selected from different departments.

3.3 Sample design

The sampling plan describes the sampling unit, sampling frame, sampling procedures, and sample size for the study. The sampling frame describes the list of all population units from which the sample was selected Meadowcroft, J. (2004) observes that sampling involves selecting a given number of subjects from a defined population so as to represent the entire population. A stratified sampling technique will be used in this study. From each category, representative samples will be drawn through simple random methods. In this case, the researcher will choose the respondents at random, remembering that each item in the strata had an equal chance of being chosen for the sample. This method ensured that all the individuals in the target population had an equal chance of being included in the sample. This helped to eliminate the bias. To obtain the desired sample size for the study with a population of 60, the Nassiuma (2000) formula was used since it's more precise than other formulas. Sixty (60) Zambia National Service Personnel were randomly selected for research at ZNS Chanyanya of which (30) were female and the other thirty (30) male.

3.4 Sampling Technique

Longwe, D. (2016) stated that sample size in research refers to the number of items to be selected from the universe to constitute a sample. A sample is a subset of the population to be studied. The study employed purposive sampling in coming up with a sample size for the purpose of examining determinants of fish farming business performance at ZNS Chanyanya fish farm. Purposive sampling was used to select the 60 participants from the lists of ZNS Chanyanya fish farm personnel.

3.5 Data Collection Methods

The two types of data that were used are primary and secondary sources; the primary sources of information for this research were mainly obtained from questionnaires, interviews, focus group discussions and observations. On the other hand, secondary data was collected from articles, previous research findings, books, journals, the internet, and other documentation with relevant information. The data collection tools were as follows: (a) questionnaires are simply a "tool" for collecting and recording information about a particular issue of interest. This research used questionnaires to obtain data from Zambia National Service Chanyanya fish farm. The list of questions was identified and written in such a way that the objectives of the research was be attained. Respondents were made aware of the purpose of the research and told when they would receive feedback on the findings. This research used questionnaires to obtain data from Zambia National Service Chanyanya fish farm.

3.6 Analysis

The researcher analyzed the collected data manually using descriptive statistics tools, tables, and percentages. Since the study was descriptive in nature the researcher utilized both qualitative and quantitative research approach in analyzing the data and summarized it using narrations. Analyzing data is a process of evaluating data using analytical and logical reasoning to examine each component of the data provided in order to form some sort of findings or conclusions. The researcher also used quantitative approach in data analysis because quantitative data analysis enabled the researcher to organize data, summarise data and analyse exploratory data in order to communicate the meaning to others by presenting data in tables or graphical displays. The responses from the questionnaire were tallied, computed, analyzed, and recorded. Recorded data was entered into a spreadsheet created using Microsoft Excel and column charts representing responses were created using Microsoft Excel charts.

Furthermore, the first step the researcher took was to familiarize with the data collected; the aim of familiarization was to understand information in detail in order to make sense of the raw data collected. Thereafter, coded, quantified, and analyzed data based on evidence and the recurrent themes that emerged in the data collected from the questionnaires in order to establish the patterns and relationships (Mouton 2001). The data was also carefully edited, systematically classified and tabulated, scientifically analyzed and interpreted rationally (Sidhu, 2006). In the final data analysis, all the materials from the questionnaires that spoke to one theme or concept were grouped together and compared (Rakotsoane, 2006). Consequently, the data was reduced to the manageable level and recorded under each major theme. Finally, the collected data was related to the present situation and the study resulted in a conclusion and recommendation in chapter five and six of this research papers (Smith, 2008).

3.7 Triangulation

Triangulation is a technique used for analyzing the results from multiple-method research designs. It is most often used as a form of cross-checking to validate the results from different kinds of methods, such as the collection of demographics and other information.

This study involved the use of the survey method, the use of a structured questionnaire or interview guide in an interview, the use of a sample, and the use of probability sampling techniques to arrive at the sample. The data was coded and thematically analyzed. The collection of data by the researcher identified the complexities related to the context of the study. The surveys were supplemented by interviews and focus groups. Each research method exposed one aspect of reality. This multimethod, multidisciplinary, collaborative research was insightful.

3.8 Limitation of the study.

The researcher encountered problems like respondents having difficulties in understanding the questionnaire's format, financial support needed to enable the researcher to go around collecting data, and some important information was not disclosed by the respondents due to issues of confidentiality. Additionally, the sample size was not adequate enough because the study was purely for academic purposes and limited in both time and resources. Furthermore, not all respondents were willing to participate in the research.

3.9 Ethical consideration

The study was approved by the Information Communication University. As the research involved primary research, research ethics was applied extensively to ensure that the research results were robust and relevant. The research ethics principles that were utilized included informed consent, anonymity, and confidentiality. According to Christensen et al. (2011), informed consent entailed providing primary research respondents with an understanding of the research objectives and allowing potential respondents to opt in or out of participating in the primary research. For reasons of anonymity, the details of the participants in the primary research were not included and are not linked to any of the primary research results (Blumberg et al., 2008). Finally, for reasons of confidentiality, the research results are only shared with those who have a stake in the results and are part of the research in a specific capacity.

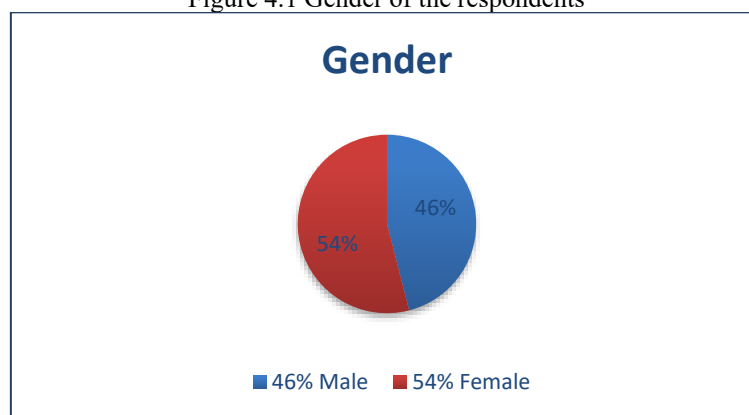
4. Presentation Of Findings

4.1 Demographic data.

The researcher distributed 60 questionnaires to respondents at Zambia National Service Chanyanya fish farm but only 50 questionnaires were answered as follows:

4.1.1 Gender

Figure 4.1 Gender of the respondents

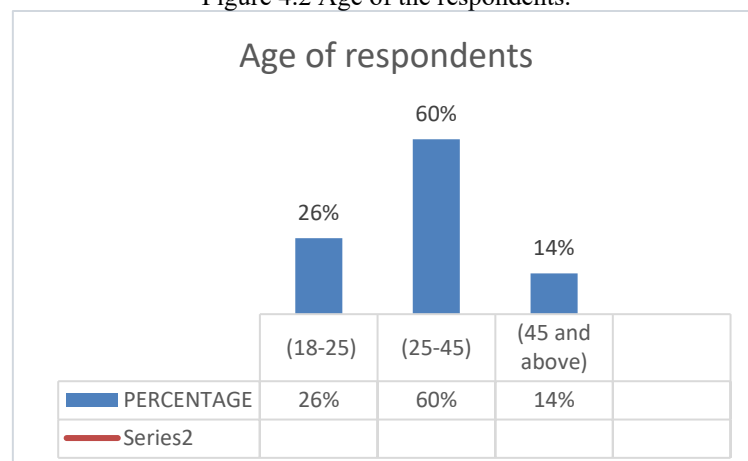


Source: Primary research data (2024)

Table 4.1 and figure 4.1 illustrates the gender of respondents in the study at ZNS Chanyanya fish farm in answering the question "What is the sex of the respondents?". 54% respondents were females and 46% were males.

4.1.2 Age of respondents.

Figure 4.2 Age of the respondents.

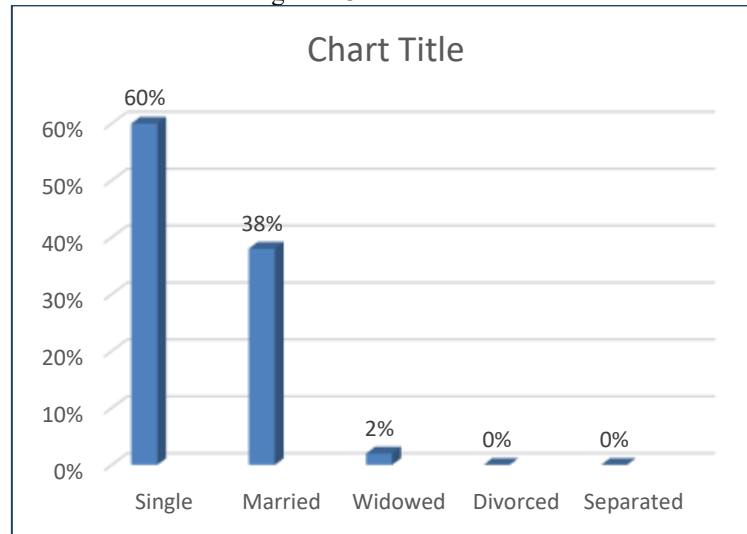


Source: Primary research data (2024)

Table 4.2 and figure 4.2 illustrates the age of respondents in the study at ZNS Chanyanya fish farm in answering the question “how old was the respondent?”. It is clear that the majority of respondents were between 25 and 45 years of age.

4.1.3 Marital Status.

Figure 4.3 Marital Status.

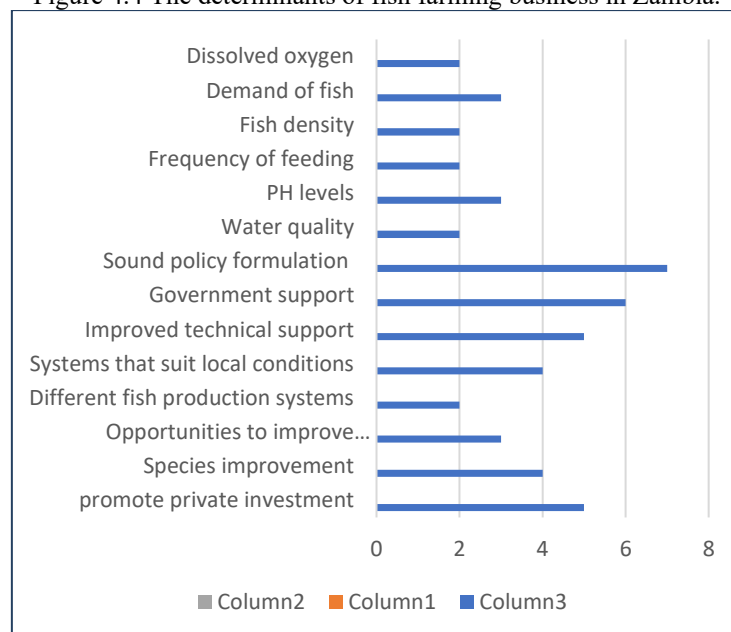


Source: Primary research data (2024)

Table 4.3 and figure 4.3 illustrates the age of respondents in the study at ZNS Chanyanya that the majority of respondents were single. The illustration answered the question on the marriage status of the respondent.

4.2 The determinants of fish farming business in Zambia.

Figure 4.4 The determinants of fish farming business in Zambia.

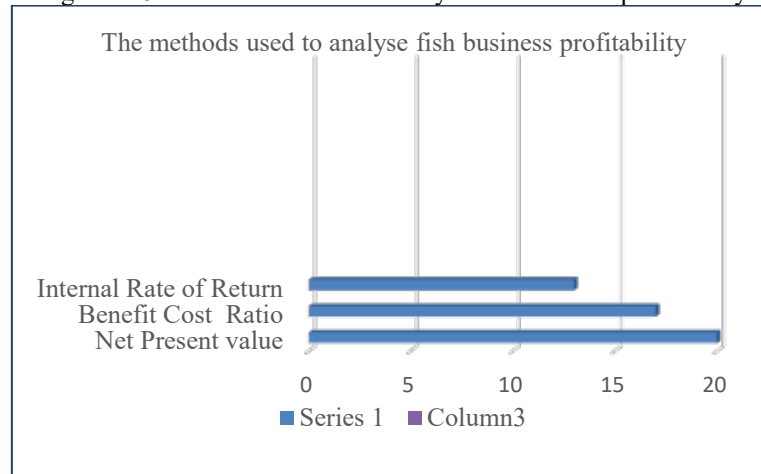


Source: Primary research data (2024)

The responses were given in form of qualitative nature and they were compiled together and were as follows; fifty (50) participants indicate the determinants of fish farming business performance that included; Seven (07) said sound policy formulation and appropriate implementation of political will and agenda. Six (06) said step-to-step goals Government support through financial and technical services. Five (05) said to improve technical support through the extension of service delivery, four (04) respondents said the production system that suit local conditions. Two (02) respondents said different fish production system and models to better utilize water and land resources and strive for better economic and environment efforts. Further, three (03) respondents said opportunities to improve existing technologies and introduce new ones. Four (04) said species improvement through traditional selective breeding and molecular approach. Five (05) respondents said creation of environment that promote private investment The quality of water used in aquaculture influences feeding, growth, disease burden, and survival of small holder. Two (02) respondents said water quality parameter such as temperature. Three (03) respondents said water PH levels. Two (02) respondents said frequency of feeding. Two (02) said the dissolved oxygen. Two (02) respondents said fish density and four (03) respondents said demand of fish. Table below summarizes the answer to the following question: What are the determinants of fish farming business performance in Zambia National Service?

4.3. Methods to analyse profitability of fish farming business in Zambia.

Figure :4.5 The methods used to analyse fish business profitability

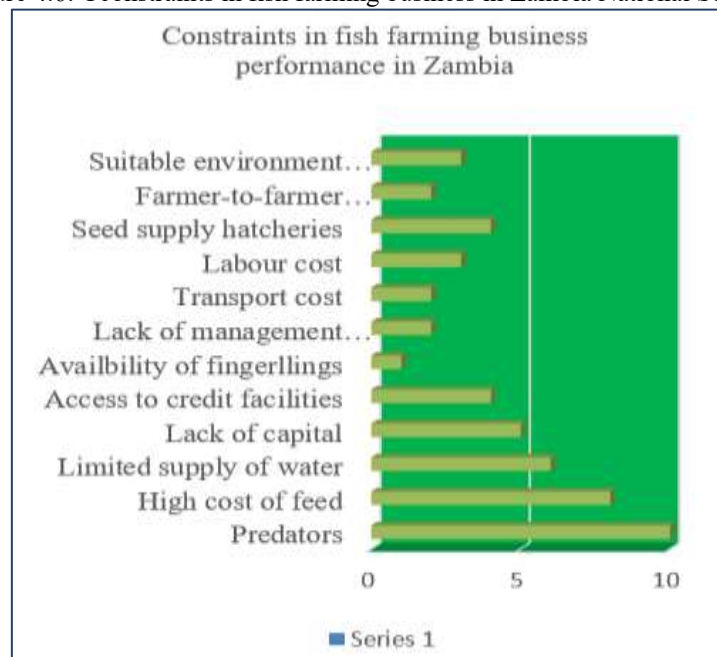


Source: Primary research data (2024)

The methods used to analyse fish business profitability in Zambia stated by the participants were okay concern not be ignored in the undertaking of this study, as they have a bearing on the outcome of the findings of the study. The following were some of the responses out of 50 participants on the questionnaire. Twenty (20) participants indicated Internal Rate of Return (IRR); ten (17) participants indicated Benefit Cost Ratio (BCR) (13) participants indicated Net Present Value (NPV).

4.4 The constraints in fish farming business in Zambia.

Figure 4.6: Constraints in fish farming business in Zambia National Service.



Source: Primary research data (2024)

The question of what are constraints in fish farming business in Zambia was answered as follows: Ten (10) said predators. Eight (08) said high cost of feed. Six (06) said limited supply of water. Five (05) said lack of capital. Four (04) said access to credit features. One (01) said availability of fingerlings. Two (02) manpower and technical skills. Two (02) said transport cost. Three (03) labour cost. Four (04) said seed supply hatcheries. Two (02) farmer -to- farmer networking. Three (03) suitable environment and climate.

5. Discussion Of Findings

5.1 Ascertaining the determinants of fish farming business performance in Zambia.

The study delved into examining determinants of fish farming performance's essential components of increasing fish productivity at Ministry of Livestock and Fisheries and Zambia National Service Chanyanya fish farm. The findings offered subtly understanding of the respondents' perspectives on determinants of fish farming performance. When respondents were asked to indicate the key determinants of fish farming business performance, the results highlighted fourteen major areas of focus. Firstly, 14% of the respondents emphasized the importance of sound policy formulation and appropriate implementation of political will and agenda. Another 12% of respondents identified Government support through financial and technical service as the critical components in increasing fish productivity at the fish farm. This response underscores the government-sponsored demonstrations,

farmer-level training, and education are required to guarantee a greater comprehension of the aquaculture industry (Kaminski A.M et al., 2022). To help current and prospective farmers expand or launch aquaculture enterprises and spur development, more scientific but adaptable licensing and regulatory frameworks, as well as concrete assistance like government subsidies, may be made available for access to production inputs, similar to those in agriculture. 10% of the respondents indicated that improved technical support is important in enhancing fish productivity at Zambia National Service fish farm. Empirical studies support this observation, promoting sustainable fish production and productivity, bolstering the provision of extension services, research, and development, expanding the market for fish products, preserving and enhancing aquatic animal health, safeguarding the environment, and mainstreaming cross-cutting issues in fisheries and aquaculture are just a few of the actions listed in the (NFAP, 2005). Additionally, financial and technical services is one of the main drivers of increasing aquaculture output in China. The establishment of important national research projects that receive sufficient government funding to create new technologies and enhance current ones forms the basis of China's aquaculture advancements. Without robust government backing for the industry, Zambia's NFAP initiatives to advance sustainable fish output and productivity might not be successful. For instance, China's significant input into fishery S&T is demonstrated by the estimated 63% contribution rate to the development of the fishery sector during the 13th five-year plan (2016–2020) and is expected to reach 67% during the 14th five-year plan (2021–2025). 8% respondents indicated that production systems that suit local environment conditions are cardinal for proper fish production. This implies that local environment conditions such as temperature and type of soils play an important role in fish production. The most effective technique for local conditions China's diverse production systems, which are based on various local variables such as climate, terrain, economic level, and consumer tastes, greatly contribute to the country's rapid aquaculture development. Numerous aquaculture models, including monoculture, polyculture-like-integrated multi-trophic aquaculture (IMTA), and integrated farming systems, are employed, as are production techniques such pond farming, cage and pen culture, and recirculating systems. While Zambia's aquaculture industry is still relatively new, opportunities to utilize different production systems and models exist (Hasimuna, 2023). 4% of respondents indicated that different fish production systems and models to better utilize water and land resources and strive for better economic and environment efforts are necessary for fish production. 6% of the respondents mentioned that opportunities to improve existing technologies and introduce new ones. This implies that new technologies to be utilized in the production process of fish is of paramount importance in order for fish farmers to bridge the gap of fish deficit. 8% of respondents indicated that there was need for species improvement. Moreover, only about eight fish species—mostly from the Tilapia genus—are apparently employed in aquaculture in Zambia at the moment, and only one species is still undergoing strain improvement (Maulu, S., 2019). With approximately 450 fish species recorded in the fisheries sector (Fish Base) and at least three species outside the tilapia genus demonstrating potential for use in aquaculture, there is a great deal of opportunity to bring new species into aquaculture (Maulu, S., 2019). Therefore, expanding Zambia's aquaculture species diversity is essential to attaining higher productivity and sustainability. Enhancing research on current cultivation species and investigating the potential economic and scientific benefits of cultivating other species is necessary to accomplish this. Additionally, this might strengthen the industry's resistance to new illnesses and climate change (Maulu, 2019). 10% of the respondents answered that creation of conducive environment that promote private investment holder was of cardinal importance. Battista et al. (2017) acknowledged the importance of establishing an atmosphere that encourages private investments and help smallholders' advancement. The value chain of the fisheries industry must be extended in order to support the sector's growth by increasing employment and revenue, enhancing food and nutrition security, and generating greater economic and social benefits. In many nations, the private sector plays a significant role in the growth of fisheries and aquaculture, and it has been shown to be essential in assisting governmental initiatives to support sustainable development. Their degree of involvement, however, typically hinges on the availability of a conducive atmosphere for private investment as well as a well-defined plan or "policy" to direct these initiatives. For example, in China, private companies in feed manufacturing (such as the Tongwei group) and genome-sequencing companies (such as BGI in Shenzhen, China) were established to support government efforts in providing technical solutions to promote a sustainable and profitable aquaculture industry (Wang, P. et al., 2020). Although Zambia has managed to attract private investments in cage aquaculture such as (Yalelo Ltd., Lusaka, Zambia) and feed manufacturing companies (Aller Aqua Ltd, Lusaka Zambia), upgrading and commercialization in aquaculture chains are found to be taking place in various forms, there is still substantial potential to attract more private investments into the sector, such as offering tax preferences, simplifying registration procedures, improving infrastructures, and helping to dock with farmers or state-owned bases. Smallholders, on the other hand, have been largely excluded from commercialization processes and have benefited less from industry upgrading; for this reason, it is important to seek synergies between larger enterprises and small-scale producers in order to best benefit impoverished rural and urban households. For example, this could involve investing in better technical and financial services in terms of employment or corporate leadership, as well as better organization of smaller producers (Subasinghe, R.P., 2010). Small farmers' increased organizational levels could give them greater influence and a stronger voice in the value chain than they could have on their own. 4% of the respondents answered that water quality plays an important role in the production of fish. 6% of respondents indicated that pH level parameters need to be monitored for they are important in the aquaculture. Moreover, easy stock management for fish farmers and extensive environmental control on variables like water, DO, pH, and waste that can be altered are made possible by the flow-through system (To maximize *O. niloticus* productivity International Journal of Biometeorology, 2022). Yakubu et al. (2014) observed that a density of 100 m⁻³ fish, data analysis revealed noticeably greater weight growth, indicating that circular net cages with modest stocking densities are better for producing Nile tilapia. According to Bwanika et al. (2007), males of *O. niloticus* grow significantly faster, larger, and more uniformly than females, indicating notable sex-specific growth differences. 4% of the correspondents indicated that frequency of feed fish at fish farm was a factor. Short feeding intervals reduce the efficiency of certain fish species. There is evidence that tilapia that are fed too often use their meal less effectively. The ideal time frequency of feeding will depend on the appetite returning. Feed frequency's effect on feedings of farmed Nile tilapia. Fish consume the food that is available to them at times determined by how long it takes for their stomachs to empty.

Temperature, fish weight, meal size, feed mix, and feeding frequency all affect how quickly the stomach empties. 4% of correspondents answered that dissolved oxygen a significant role fish production. Furthermore, fish cannot use the food they eat when dissolved oxygen (DO) is low (Nehemia et al. 2012). Fish are sensitive to water quality, so low water quality can affect them. Feeding should be reduced or stopped when water quality falls below certain thresholds. DO levels fall shortly after feeding, and it is best to keep DO levels above 5 ppm to ensure good growth. At 3–5 ppm, feeding should be reduced and discontinued at 3 ppm or lower (Riche and Garling 2003). De Long et al. (2009) stated that dissolved oxygen should be in the range for tilapia tanks at levels between 5 and 7 mg/L. DO concentrations of less than 3.5 mg/L will reduce growth and feed conversion. Short-term exposure (less than 10 min) to DO concentrations as low as 0.8 mg/L is possible with survival and recovery. Sriyasa et al. (2015) advised using aeration and mechanical mixing interventions when DO concentrations are low, which helps minimize stress on fish and prevent fish death from the accumulation of DO. 4% correspondents answered that fish density in the ponds matters in the production of fish and 6% of correspondents indicated that demand of fish also plays an important role in fish production. The more the demand for fish the higher the production to meet the deficit.

5.2 Constraints inherent in fish farming business in Zambia National Service.

The study delved into examining determinants of fish farming performance's essential components of increasing fish productivity at Ministry of Livestock and Fisheries and Zambia National Service Chanyanya fish farm. The findings offered subtlety understanding of the respondents' perspectives on constraints of fish farming performance. When respondents were asked to indicate the key constraints of fish farming business performance, the results highlighted fourteen major areas of focus. Firstly, 20 % of the correspondents indicated that predators are some of the constraints in fish production, fish predators are living things that feed on fish. When such living things have access to your fish pond, they attack and eat or feed on the fish. Fish predators are very worrying to farmers because they cause a lot of fish loss to the farmers. As a fish farmer, you need to be aware of such living things. 16% of correspondents mentioned that high cost of feed is hinderers to fish production. Thus, it is crucial to take into account the variables that affect tilapia fish culture production, including feed type, ration size, different feeding frequency, and their potential effects on feed utilization and growth. For cultured organisms to attain the maximum food conversion and weight, feeding frequency (FF) is crucial (Ferdous et al. 2014).

6. Conclusion

The study revealed that the determinants of fish farming performance play a crucial role in the production of fish. As regards to the determinants of fish farming performance business; it was found out that the following were the determinants: Sound policy formulation and appropriate implementation of political will and agenda, government support through financial and technical services, production systems that suit local environment conditions, improved technical support, different fish production system and models to better utilize water and land resources and strive for better economic and environment efforts, opportunities to improve existing technologies and introduce new ones, creation of environment that promote private investment holder, species improvement, creation of environment that promote private investment holder, water quality, pH levels, frequency of feeding, dissolved oxygen, fish density and demand of fish. The methods used to measure fish business profitability were: Net present value, Benefit-Cost Ratio (BCR), Internal Rate of Return (IRR) Gross margin and Net return. The constraints faced by fish business farmers were as follows: predators, high cost of feed, limited supply of water, lack of capital, access to credit facilities, availability of fingerlings, lack of manpower and technical skills, transport cost, labour cost, seed supply hatcheries, farmer-to-farmer networking and limited suitable environment and climate.

Despite some constraints observed in fish farming, there is now a huge chance for aquaculture to boost productivity and close the gap in the supply of fish for human consumption because capture fisheries are unable to maintain the supply of fisheries products required to meet the rising domestic demand for fish (FAO, 2014). The government of Zambia has pushed aquaculture as a crucial weapon in the battle against poverty, hunger, and food insecurity. Furthermore, aquaculture offers a promising chance for the agricultural industry to diversify. The National Aquaculture Strategy and the Development Plan have prioritized the growth of smallholder aquaculture farming (DoF 2015). Cages, ponds, circulation tanks, and dams are all part of Zambia's aquaculture production methods (Nsonga and Simbotwe 2014). There are two categories of aquaculture producers in Zambia: smallholder and commercial. Commercial fish farming requires a significant amount of labor and capital, uses ponds, tanks, and cages, has high stocking densities of monosex fish species, and depends on supplemental feeding with agricultural wastes including mill sweepings, sunflower cake, maize bran, and chicken litter. It also entails applying chemical fertilizer or compost organic manure to increase control over the environmental pond conditions. Small ponds and minimal input systems, particularly the use of chicken manure for pond fertilization, are used in smallholder farming to raise fish, mostly tilapia (Nsonga and Simbotwe, 2014). For many years, Zambia's primary fish supply came from capture fisheries. But for a long time, the number of fish produced by capture fisheries has remained constant at 75,000 tons annually, and the rise of aquaculture has been the primary driver of the nation's recent increase in fish production. Aquaculture output has grown significantly over the last two decades, with large-scale commercial fish farms accounting for the majority of the nation's overall fish production, while small-scale farmers have contributed just a minor amount. According to Fisheries Act No. 22 (2011), aquaculture is the production, propagation, or farming of fish, aquatic vegetation, or other living aquatic resources, whether from eggs, spawn, spat, or seed, or by rearing fish that have been legally taken from the wild or imported into the nation. The first attempts to cultivate native members of the Cichlidae family, primarily tilapias, in dams and earthen fish ponds in Zambia date back to the 1950s. Zambia has 8 million hectares of wetlands and 12 million hectares of water in the form of lakes, rivers, and swamps (ADP 2009). The Congo, Luapula, and Zambezi catchments are the three main water basins that make up this endowment, which is a vast fisheries and aquaculture resource. Lake Tanganyika is a symbol of the Congo basin, which is the smallest. The Chambeshi River, the Bangweulu Lakes and Swamps Complex, the Luapula River, Mweru-wa Ntipa, and Lake Mweru make up the Luapula Basin. The greatest catchment area is the Zambezi, which includes the Lower Zambezi, the Middle Zambezi (today dominated by Lake Kariba), the Kafue River, the Luangwa River, and the Lukanga marshes. Fish culture

operations have significantly improved as a result of government extension services. Currently, the country is home to about 13,000 fish ponds and over 6,000 small-scale fish farmers, mostly in the provinces of Luapula, the eastern, northwestern, and northern regions. In the Copperbelt, Lusaka, and Southern provinces, where favorable business conditions prevail, there are also fifteen operational huge commercial fish farms dispersed along the railroad line. Aquaculture has spread throughout all nine provinces of Zambia thanks to government and private sector extension efforts. With an estimated production of over 8,500 tonnes in 2000, valued at US\$19 million, Zambia is now one of the largest aquaculture producers in Sub-Saharan Africa (ibid). Systems of fish farming vary from multi-species to mono-species culture, and from extensive to intensive. Fish farmers can be classified as small-scale, smallholder, or commercial. Family-run small-scale farmers work long hours, use extensive culture, and produce one to two tons per hectare annually. The smallholders raise fish alongside crops and cattle. In addition to ensuring food security, they also apply inputs, make money, and are gaining investment through the employment of hired labor for a variety of jobs. The annual production ranges from 2 to 2.5 tonnes/ha. The vision and mission statements, environmental scanning, and robust data management practices, such as collection, storage, and analysis. 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 500m² (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.

7. Recommendations

The researcher was prompted to make the following recommendations as stated below:

- To address the issue of high cost of feed, farmers should learn how to formulate quality feeds from the own grown crops that can be used as feed ingredients.
- Farmers should 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.
- 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. Operationalize the aquaculture and fisheries fund in order to stimulate fish production especially for aquaculture that requires a significant number of resources to be invested.
- 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.

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References

- [1] A review of inclusive business models and their application in aquaculture development. Reviews in Aquaculture, 12(3), 1881-1902. Kenya National Bureau of Statistics (KNBS), 2018.
- [2] Abban, E. K., J. Moehl, L. K. Awity, M. Kalende, J. K. Ofori, and A. Tetebo. 2006. Aquaculture Strategic Framework. Ministry of Fisheries. 33p.

- [3] Abbas, I.I and Ukoje J.A. 2009. Rural water utilization: Factors affecting aquaculture in Owo local government area of Ondo State, Nigeria. *Journal of Geography and Regional Planning* Vol. 2(8), pp. 190–197, August, 2009 <http://www.academicjournals.org/JGRP> ISSN 2070-1845
- [4] 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.
- [5] Akenbor, A. S. Ike, P.C. 2015. Analysis of Technical Efficiency of Catfish Farming in Edo State, Nigeria *Journal of Biology, Agriculture and Healthcare* Vol.5, No.2, 2015, p.96-99
- [6] Alagawany M, Abd El-Hack ME, Farag MR, Shaheen HM, Abdel-Latif MA, Noreldin AE, Khafaga AF (2020) The applications of and its derivatives in human, ruminant and fish nutrition—a review. *Ann Anim Sci* 20(2):389–407.
- [7] Alam A. (2009). Production, accessibility and consumption patterns of aquaculture products in Bangladesh.
- [8] Alamin HMd, Hasan MdS, Mondal S, Hossain MdM (2017) Fish culture in indoor-tank using green water technology. *J Entomol Zool Stud* 5(6):2498–2502.
- [9] Alemayehu TA, Getahun A (2017) Effect of feeding frequency on growth performance and survival of Nile tilapia in a cage culture system in Lake Hora-Arsedi, Ethiopia. *J Aquacult Res Dev* 8:479. <https://doi.org/10.4172/2155-9546.1000479>. Viewed on 10.10.2024
- [10] Ali MS, Stead M, Houlihan DF (2006) Effects of stocking density on ammonia excretion and the growth of *O. niloticus*. *Bangladesh Fish Res* 10(1):13–24.