

# Assessment of Production Practices in Fish Farms in Nsukka Local Government Area, Enugu State

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**Abstract-** *This study assessment of production practices in fish farms in Nsukka local government area, Enugu state. The study adopted a descriptive survey design and multistage sampling techniques was used. The study locations were from the three zones of Nsukka Local Government namely; Nsukka East, Nsukka Central and Nsukka West. Eighteen fish farms across the three zones of Nsukka local government area were used a sample of the study. A well-structured questionnaire was used titled: Evaluation Production Practices in the Fish Farms (EPPFF). The questionnaire was validated by the experts from the Department of Zoology and Environmental Biology as well as the Department of Agricultural Education of the University of Nigeria, Nsukka. Data were analyzed using descriptive statistics (t-test, ANOVA, Duncan's New Multiple Range Test and Inferential statistics (Pearson Correlation) using SPSS version 27. A Cronbach's alpha value of 0.5 and above was considered acceptable for reliability. Results showed that there were Furunculosis is the most predominant across the three locations. The frequency of pond water change correlated positively to parameters of the pond tested, the fish number months of rearing and the size of fish. The level of hydrogen in water (pH) significantly associated negatively with level of parameters tested in pond. The study highlighted the crucial role of maintaining optimal water quality global best practices in fish farms to enhance fish optimal yields. The researcher recommended that the local government should promote sustainable aquaculture practices which will help to reduce waste and improve production efficiency. Regular training and workshops for fish farmers should be organized to enhance their knowledge and skills in aquacultural activities.*

**Index Terms-** *Fish Farming, Stock Density, Feeding Management, Disease Management*

## I. INTRODUCTION

Fish farming plays important roles in global efforts towards eliminating hunger and malnutrition by

supplying fish and other aquatic products rich in protein, essential fatty acids, vitamins and minerals. According to Mahmoud, *et al.* (2020), fish contains those essential amino acids lacking in plant protein sources such as methionine, tryptophan and lysine; vitamins such as A and D, minerals such as phosphorous, calcium and sulphur and also contains low levels of cholesterol, which are essential for human healthy growth. Fish has higher feed conversion efficiency than most of the farm animals transforming 70 percent of their feed into flesh, and when compared with livestock farming, it requires less space, time and money (FAO, 2020).

According to FAO (2021), aquaculture activities such as fishing contribute to the National economies of Africa; such as 0.48 percentage in Nigeria, 1.1 percentage in Tunisia and 5.3 percentage in Gambia. Also, aquaculture directly creates 12 million full time jobs which significantly contributes to the national Gross Domestic Product (GDPs) in many developing countries with appropriate management, the sector stands to be ready to meet up with the expected short fall in fish supply for the coming decades and to improve global food security. Nigeria has a fish demand of about 2.1 million tons per annum and the domestic fish production was estimated at about 800,000 metric tons with a difference of about 1.3 million metric tons (Ahmed, 2015). Relevant figures indicated that the value of fish imports keeps increasing which has been attributed to the increasing growth rate of the Nigerian population (Edafe and Zehra, 2022). According to FAO (2020), aquaculture the farming of aquatic organisms such as fish, mollusks, crustaceans, and aquatic plants, has become increasingly important worldwide as a means to meet the growing demand for animal protein. Aquaculture continues to play a crucial role in global food security, providing a significant source of

protein for millions of people worldwide. Over the past few decades, the aquaculture industry has experienced remarkable growth, with production levels increasing steadily to meet the rising demand for seafood. Efforts are being made to improve aquaculture sustainability which included the development of eco-friendly farming techniques, better waste management practices, and the promotion of responsible aquaculture certification schemes (Troell, 2014). The government has recognized the importance of the aquaculture sector in addressing food security concerns and reducing the nation's dependence on imported fish, leading to the implementation of various policies and programs to support the industry (Ovie, 2020).

Ikuerowo, *et al.* (2020) noted that the aforementioned attributes of fish farming notwithstanding, the sector faces some challenges such as inadequate infrastructures, limited access to finance, disease outbreaks, poor fish health management, environmental degradation and pollution. Water serves as the physical support for every fish in which they carry out their function such as feeding, swimming, breeding, digestion and excretion. Water quality is determined by various physico-chemical and biological factors that directly or indirectly affect its quality and consequently its suitability for the distribution and production of fish and other aquatic animals. Suitability of any water for fish farming depends on the extent of which the water is influenced by pollution and many other production and anthropogenic factors. Physico-chemical parameters influencing the aquatic environment are: temperature, pH, salinity, dissolved oxygen, turbidity, hardness amongst others. These parameters influence the growth and survival of organisms (Adeboyejo, *et al.*, 2024). In fish pond the characteristics of aquatic physical and chemical parameters have straight impact on primary and subsequently secondary production operations. Efforts to address these challenges are underway, with initiatives focusing on improving access to finance and technical support for small-scale farmers, enhancing infrastructure development, and promoting sustainable aquaculture practices (Ovie, 2020).

Catfish is a diverse group of freshwater fish belonging to the order Siluriformes. They are widely cultivated around the world due to their fast growth

rate, adaptability to various environmental conditions, and high market demand. Among the most commonly farmed species are the African catfish (*Clarias gariepinus*) and the channel catfish (*Ictalurus punctatus*), both prized for their mild flavor and versatile culinary applications. Catfish farming typically involves the intensive or semi-intensive production of juveniles in hatcheries followed by grow-out in ponds, tanks, or cages, with feed comprising a combination of natural and formulated diets tailored to meet the nutritional requirements of the fish (Tacon and Metian, 2015). Disease management strategies, such as regular health monitoring, vaccination, and the use of probiotics, are essential for minimizing losses and maintaining the productivity of catfish farms. Furthermore, sustainable aquaculture practices, such as efficient water and waste management, are important for mitigating the environmental impact of catfish farming and ensuring the long-term viability of the industry (Jayalekshmi, *et al.*, 2021).

Catfish farming within Nsukka Local Government Area, has emerged as the dominant farmed species due to its suitability to local conditions and high market demand. The popularity of catfish farming in Nsukka can be attributed to several factors, including the ease of breeding and management, rapid growth rate, and adaptability to varying environmental conditions (Onyekuru, *et al.*, 2019). One of the key advantages of catfish farming is its ability to thrive in a wide range of aquatic environments, including ponds, rivers, and reservoirs, making it accessible to small-scale farmers in developing countries (Tacon and Metian, 2015).

The sustainability and productivity of fish farms in Nsukka local government area are depending upon various factors, including physicochemical conditions and production practices within the farms. The rapid expansion of fish farming activities in Nsukka local government area may exacerbate existing environmental pressures, water quality issues and farm productivity challenges if not properly managed (Bostock, 2010). Rearing of fish in pond is rapidly developing in Nigeria, however many interested fish farmers who lack basic knowledge of rearing fish in pond are facing problem in the area of managing good water quality in their ponds (Ajayi, 2004).

Sustainable aquaculture development requires a holistic approach that considers both environmental sustainability and socio-economic viability (FAO, 2020).

Investigating the production practices in fish farms would help provides a valuable insight into the sustainability and efficiency of aquaculture operations in the Local Government Area. By assessing factors such as stocking density, feeding practices, water exchange rates, and waste management techniques, researchers can determine the overall productivity and environmental impact of fish farming activities in the Local Government Area. The study therefore evaluated the physicochemical parameters and production practices of fish farms in Nsukka local government area of Enugu state with a view to gather insights that will enable process optimization among fish farmers in the area.

Cultural practices surrounding fish reflect the intricate relationship between human societies and aquatic ecosystems, encompassing a diverse array of traditions, knowledge systems, and livelihood strategies. Indigenous and traditional fishing methods have long been shaped by local environmental conditions, cultural beliefs, and social norms. Recent research has emphasized the importance of recognizing and preserving indigenous knowledge systems in fisheries management and conservation efforts (Bennett, *et al.*, 2019). Traditional fishing and aquaculture have emerged as significant aspects of cultural practices related to fish. Small-scale fish farming operations, particularly in developing countries, often integrate local knowledge and cultural values into production systems (Belton and Little, 2020). These practices did not only contribute to the food security and economic development but also play a vital role in preserving cultural heritage and identity. However, the expansion of industrial aquaculture has raised concerns about its potential social and environmental impacts, highlighting the need for sustainable aquaculture practices that respect cultural diversity and promote community resilience (Gentry, 2019). The cultural practices surrounding fish extend beyond production and harvesting to include food traditions, rituals, and folklore. Fish often hold symbolic significance in many cultures, representing abundance, fertility, and spiritual

connections to the natural world (Neis, 2018). Traditional fish-based dishes and cooking techniques are passed down through generations, serving as expressions of cultural identity and community bonding.

However, changing dietary preferences, globalization, and environmental pressures have led to shifts in consumption patterns and culinary traditions, underscoring the dynamic nature of cultural practices related to fish (Johnson, 2020). Cultural practices of fish are deeply intertwined with human societies' historical, social, and ecological contexts. Recognizing and supporting diverse cultural perspectives and knowledge systems are essential for promoting sustainable fisheries management and aquaculture development. Integrating traditional wisdom with modern science and technology, it is possible to foster resilient, inclusive, and culturally sensitive approaches to fishery conservation and food production in a rapidly changing world (Neis, 2018). The estimated annual average per capital per fish consumption for Nigeria is 13 kg (Edefe, *et al.*, 2020; FAO, 2021), although the Directorate of Agriculture and Rural Development-ECOWAS Commission, (2020) reported a lower estimate of 8.33kg. Fish remains an important dietary element for Nigeria, especially in the southern part of the country where fish is highly valued and one of the cheapest sources of animal protein available to many Nigerians (FAO, 2021). The fishery sector is 1.09% of the national GDP in 2020 and 0.97% in 2021 (NBS, 2021).

Stocking density in fish farming refers to the number of fish placed within a given area of a fish culture system, such as a pond, tank, or cage. It is a crucial factor influencing the growth, health, and welfare of farmed fish, as well as the overall efficiency and sustainability of aquaculture operations. Optimal stocking density depends on various factors, including species, size, water quality, feeding regime, and management practices. Research suggests that stocking density would significantly impacts fish behavior, physiology, and stress levels, with both understocking and overstocking having negative consequences on production outcomes (Shafaq, *et al.*, 2020). Maintaining appropriate stocking densities is essential for minimizing competition for resources, such as food, oxygen, and space, among fish within a

culture system. Overcrowding can lead to increased stress, disease susceptibility, reduced growth rates, and poor water quality, ultimately compromising the welfare and productivity of farmed fish (Kumar, 2021).

Feeding management is a critical aspect of fish farming that directly influences the growth, health, and efficiency of aquaculture operations. Proper feeding practices involve supplying fish with nutritionally balanced diets in appropriate quantities and frequencies to meet their metabolic needs and optimize production outcomes. The selection of feed ingredients, feeding strategies, and feeding frequency depends on factors such as species, life stage, environmental conditions, and production goals. Research in aquaculture nutrition continues to advance, providing insights into the dietary requirements of various fish species and improving feed formulations to enhance growth performance and feed conversion efficiency (Glencross, 2023).

Aquafeed formulation plays an importance role in feeding management, as it determines the nutritional composition and digestibility of feeds. Recent developments in feed technology have led to the production of specialized feeds tailored to the specific dietary needs of different fish species and production systems. These feeds often incorporate alternative protein sources, such as plant proteins and single-cell proteins, to reduce reliance on fishmeal and fish oil derived from wild-caught fish stocks (Kaiser, 2021). The inclusion of functional additives, such as probiotics, prebiotics, and immunostimulants, in aquafeeds has been shown to improve gut health, disease resistance, and overall performance of farmed fish (Fazle, *et al.*, 2022).

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Intensive fish culture involves a high or heavy stocking of water inclusion and the use of artificial feeds to improve production. Fish feeds provide nutrients for optimal growth and this rapid growth achieved implies that fish feeds are essential for the economic use of time. Through shortened grow-out periods, a fish farmer can affect two cropping within a year. The increased amount of cropping of table-sized fish imply that more profit can be generated by the fish farmer. Therefore, feed of adequate nutritional value is the foundation on which fish farming is built. Good and high-quality feeds improve the quality of the edible portion of fish, enhances high protein retention and gives the fish flesh a firm consistency and delicate flavor (Omoniyi, *et al.*, 2019).

Water exchange rates plays an important role in the health and well-being of fish populations in aquaculture systems. Water exchange refers to the process of replacing water within a fish culture system to maintain optimal water quality parameters, including dissolved oxygen levels, temperature, pH, and ammonia concentration. The frequency and volume of water exchange are influenced by various factors, such as stocking density, feeding rate, waste production, and system design. Proper water exchange management is essential for promoting fish

growth, minimizing stress, and reducing the risk of disease outbreaks in aquaculture facilities (Boyd, 2017).

Disease management is a critical aspect of fish farming that aims to prevent, control and mitigate the spread of diseases within aquaculture systems. Fish are susceptible to a wide range of infectious and non-infectious diseases caused by bacteria, viruses, parasites, and environmental stressors. Effective disease management strategies encompass various measures, including biosecurity protocols, vaccination, water quality management, and treatment interventions. Continuous monitoring of fish health, early detection of diseases, and prompt response to outbreaks are essential for minimizing economic losses and maintaining the sustainability of aquaculture operations (Gozlan, *et al.*, 2024). Biosecurity measures also play an important role in disease prevention and control by minimizing the introduction and spread of pathogens within aquaculture facilities. These measures include strict quarantine protocols for new fish stocks, disinfection of equipment and facilities, controlling the movement of personnel and vehicles, and implementing barrier systems to prevent contact with wild fish populations. Waste management is a crucial aspect of sustainable fish farming, aiming to minimize environmental pollution and maximize resource utilization within aquaculture systems. Fish farming generates various types of wastes, including uneaten feed, faeces, and metabolic byproducts, which can accumulate in water bodies and degrade water quality if not properly managed. Effective waste management strategies involve the implementation of measures to reduce waste production, improve waste treatment efficiency, and promote waste recycling and reuse (Martins, 2020). Optimization is one of the key approaches to waste management in aquaculture that concerns with the feeding practices in other to minimize feeding wastage and nutrient excretion by farmed fish.

## II. METHODOLOGY

Nsukka local government area is one of the seventeen local government areas that make up Enugu state, South-East Nigeria. Nsukka local government area

lies approximately between Latitude 6.86°N, and 7.39°E with an area of 1,820 km<sup>2</sup>. Towns and villages that make up Nsukka local government area include; Ede-Oballa, Nsukka (Nkpunanor, Ihe-owerre, Nru, Echara, Umakashi, Nguru, Isi-Akpu), Lejja, Opi, Eha –Alumona, Alor Uno, Obukpa, Ibagwa Ani, Okpuje, Okutu and Anuka. The study adopted a descriptive survey design. Multistage sampling techniques was used. A structured questionnaire was used; titled: Evaluation of Production Practices in the Fish Farms (EPPFF). The questionnaire was validated and reviewed by the experts from the Department of Zoology and Environmental Biology as well as the Department of Agricultural Education of the University of Nigeria, Nsukka. The reliability of the questionnaire was tested through a pilot study conducted with 3 fish pond one each from the three Zones. The data from the pilot study was analyzed using the Cronbach's alpha coefficient to determine the internal consistency of the instrument. A Cronbach's alpha value of 0.5 and above was considered acceptable for reliability. Data was analyzed using descriptive statistics (t-test, one-way Analysis of Variance (ANOVA), Duncan's New Multiple Range Test (DNMRT) and inferential statistics (Pearson correlation) were used to perform the statistical analysis. The analysis was done at 95% confidence interval with the result considered significant at  $p < 0.05$ .

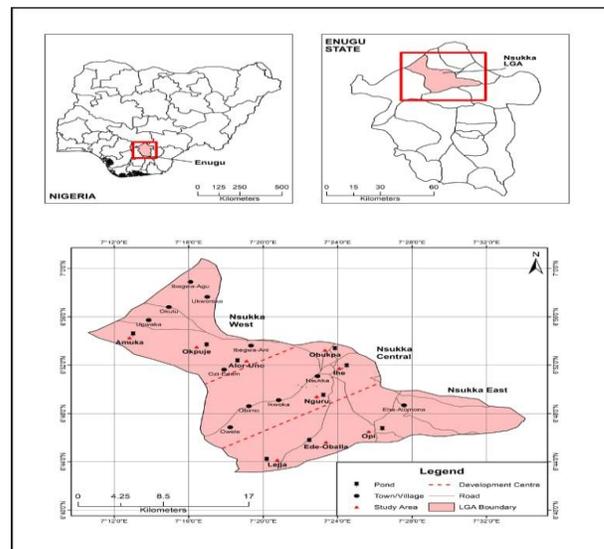


Fig. 1.1: Map of Nsukka Local Government Area showing the Sample Communities

Production Practices of Fish Farms in Nsukka Local Government Area

50-51	2 (30.0%)	0 (0.0%)	3 (50.0%)
52-70	4 (56.0%)	0 (0.0%)	1 (25.0%)
Total	7 (100.0%)	6 (100.0%)	5 (100.0%)

Table 1: Gender of farmers

Sex	Nsukka	Nsukka	Nsukka
	Central	East	West
Male	6 (86.0%)	6 (100.0%)	3 (60.0%)
Female	1 (14.0%)	0 (0.0%)	2 (40.0%)
Total	7 (100.0%)	6 (100.0%)	5 (100.0%)

The result in table 1 shows that, in the sex variable, Nsukka Central has 86% males while female is 14%, Nsukka East has 100% for male with 0% female and Nsukka West has 60% male and 40% female. The distribution of male and females varies across different locations within Nsukka indicating potential differences in gender and demographic. Nsukka West exhibits a relatively more balanced sex distribution with males comprising 60% and females making up 40% of the population.

Table 2: Educational level of farmers

Location	Nsukka	Nsukka	Nsukka
	Central	East	West
None	0 (0.0%)	0 (0.0%)	0 (0.0%)
Primary Education	0 (0.0%)	0 (0.0%)	0 (0.0%)
Secondary Education	0 (0.0%)	0 (0.0%)	0 (0.0%)
Higher Education	7 (100.0%)	6 (100.0%)	5 (100.0%)
Total	7 (100.0%)	6 (100.0%)	5 (100.0%)

Table 2 shows the educational level of the populations in three locations: Nsukka Central, Nsukka East and Nsukka West. In Educational qualification all are higher degrees across the three locations. Also, this indicated that, the entire population in the areas has pursued education beyond secondary school which could be attributed to the factors such as access to quality education, cultural emphasis on education and economic opportunities.

Table 3: Age of farmers

Age (years)	Nsukka	Nsukka	Nsukka
	Central	East	West
35-49	1 (14.0%)	6 (100.0%)	1 (25.0%)

Table 3 shows the age distribution of the populations in three locations: Nsukka Central, Nsukka East and Nsukka West. The farmers were within the age bracket of 35 – 70 years in Nsukka central age 35 – 49 years (14%), 50 – 51 years (30%), 52 – 70 years (56%) average. While within Nsukka East within the age bracket of 35 – 49 years. While Nsukka West is 35 – 49 years (25%), 50 – 51 years (50%) and 62 – 70 years (25%). The uniform age distribution in Nsukka east may indicate a planned community or a specific age trend. Also, the data highlights the need for tailored approaches to address the unique age characteristics of each location.

Table 4: Farm experience of farmers

Farm Experience	Nsukka	Nsukka	Nsukka
	Central	East	West
2-4 years	2 (29.0%)	1 (16.67%)	4 (75.0%)
5-7 years	3 (42.0%)	4 (66.66%)	0 (0.0%)
8-10 years	2 (29.0%)	1 (16.67%)	1 (25.0%)
Total	7 (100.0%)	6 (100.0%)	5 (100.0%)

Table 4 shows the farmer farm experience distribution of the populations in three locations: Nsukka Central, Nsukka East and Nsukka West. Their farm experience is between the range of 2 years and 10 years. The data reveals significant variations in farm experience across Nsukka Central, Nsukka East and Nsukka West. Nsukka Central has a relatively even distribution of farm experience with 29% of farmers having 2 – 4 years of experience, 42% having 5 – 7 years and 29% having 8 – 10 years of farming experience. Nsukka East is dominated by farmers with 5 – 7 years of experience accounting for 66.67% of the total. Nsukka West has a unique with 75% of farmers having 2 – 4 years if experience and 25% having 8 – 10 years of experience. The results suggested that, Nsukka East has more experienced farming community while Nsukka West has a

relatively few farmers. The variation in farm experience across the three locations may have implications for agricultural productivity, technology adoption and extension services. The differences in the farm experience may also reflect underlying factors such as access to training, credit and markets.

Table 5: Administration of medications

Period		Nsukka Central	Nsukka East	Nsukka West
Once week	a	4 (57.1%)	2 (33.3%)	3 (60.0%)
Twice week	a	3 (42.9%)	4 (66.7%)	1 (20.0%)
Less than twice week	a	0 (0.0%)	0 (0.0%)	1 (20.0%)
Total		7 (100.0%)	6 (100.0%)	5 (100.0%)

Table 5 shows the administration of medications in Nsukka Central, Nsukka East and Nsukka West. Nsukka central has 57.1% and Nsukka West has 60% that receives medications once in a week. Majority of the respondents in Nsukka East has 66.7% that received medications twice a week and Nsukka west has a proportion of 20% of respondents receiving medications less than twice a week. The data suggest variations in healthcare practices and medication administration across the three locations. These differences may be influenced by factors such as access to healthcare services, medication availability and healthcare provider practices. Also, the data highlights the need for standardized healthcare guidelines to ensure consistent care across the different locations.

Table 6: Diseases affecting fishes

Diseases	Nsukka Central	Nsukka East	Nsukka West
Ich	1 (14.3%)	0 (0.0%)	0 (0.0%)
Furunculosis	3 (42.8%)	5 (83.3%)	4 (80.0%)
Ich and Furunculosis	3 (42.9%)	1 (16.7%)	1 (20.0%)
Total	7 (100.0%)	6 (100.0%)	5 (100.0%)

Table 6 shows the disease affecting fishes. Disease affecting the fishes of the farmers which includes Ich, Furunculosis and Ich and Furunculosis affect the farmers across the locations. The results show that, Furunculosis is the most predominant across the three locations (Nsukka Central, Nsukka East and Nsukka West) and frequency of outbreak is moderately rare. The results highlight the importance of monitoring and addressing fish diseases to ensure the sustainability of aquaculture practices.

Table 7: Frequency of disease outbreak

Frequency of outbreak	Nsukka Central	Nsukka East	Nsukka West
Rare	0 (0.0%)	2 (33.3%)	0 (0.0%)
Moderately rare	7 (100.0%)	4 (66.7%)	4 (80.0%)
Frequent	0 (0.0%)	0 (0.0%)	1 (20.0%)
Total	7 (100.0%)	6 (100.0%)	5 (100.0%)

Table 7 shows the frequency of disease outbreaks in Nsukka Central, Nsukka East and Nsukka West. Nsukka central reported a moderately rarity of disease outbreaks with 100% of respondents indicating that outbreaks are moderately rare. In contrast, Nsukka East has a mix of rare of 33.3% and moderately rare of 66.7% disease outbreaks. Nsukka West has a higher frequency of disease outbreaks with 20% respondents reported frequent outbreaks and 80% reported moderately rare of outbreaks. The results suggested, disease outbreaks are under control in Nsukka Central and Nsukka East but may be a more significant concern in Nsukka West. The data highlights the need for continued disease surveillance and management efforts to prevent outbreaks.

Table 8: Disease management

Diseases management	Nsukka Central	Nsukka East	Nsukka West
Treatment	7 (100.0%)	6 (100.0%)	5 (100.0%)
Prevention	0 (0.0%)	0 (0.0%)	0 (0.0%)
Others	0 (0.0%)	0 (0.0%)	0 (0.0%)
Total	7 (100.0%)	6 (100.0%)	5 (100.0%)

Table 8 shows the disease management of the fish. Their disease management measuredly involved 100% treatments while their preventive measures were more using water quality management by Nsukka Central fish farmers and 50% quality management by Nsukka East. While farmers in Nsukka West had no preventive measures such as feeding, monitoring and water quality management. The results highlight the need for a more holistic disease management strategy that incorporates both treatment and prevention.

Table 9: Disease preventive measures

Disease preventive measures	Nsukka Central	Nsukka East	Nsukka West
Feeding	0 (0.0%)	1 (16.7%)	0 (0.0%)
Monitoring	0 (0.0%)	1 (16.7%)	0 (0.0%)
Pond management	0 (0.0%)	1 (16.7%)	0 (0.0%)
Water quality management	7 (100.0%)	3 (50.0%)	0 (0.0%)
Total	7 (100.0%)	6 (100.0%)	0 (0.0%)

Table 9 shows the use of preventive measures in disease management in Nsukka Central, Nsukka East and Nsukka West. Nsukka Central relies solely on water quality management is 100% as its preventive measure indicating a focus on maintaining optimal water conditions to prevent disease outbreaks. Nsukka East employs a combination of preventive measures including water quality management was 50%, feeding was 16.7%, monitoring was 16.7, and pond management was 16.7%. Nsukka West does report using any of the listed preventive measures. The results highlight the importance of water quality management in preventing disease outbreaks particularly in Nsukka Central.

Table 10: Number of fishes

Number of Fishes	Nsukka Central	Nsukka East	Nsukka West
100-350	3 (42.0%)	1 (16.67%)	5 (100.0%)
400-500	2 (29.0%)	1 (16.67%)	0 (0.0%)
1000	0 (0.0%)	2	0 (0.0%)

			2 (33.33%)	0 (0.0%)
2000	0 (0.0%)	2 (33.33%)	0 (0.0%)	0 (0.0%)
3000	2 (29.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Total	7 (100.0%)	6 (100.0%)	5 (100.0%)	5 (100.0%)

Table 10 shows the number of fishes by farmers in the study areas. The results revealed that the number of fishes found among the farmers are between 100-3000. Nsukka central were more of 100-350 (42%), Nsukka west were more into 1000-2000 fishes (33.3%) while farmers in Nsukka East dwell more on 100-350 fishes. The results suggested Nsukka East has a more commercial-scale fish farming operation while Nsukka Central and Nsukka West have a smaller scale operation.

Table 11: Average income per year from each source

Average Income per year	Nsukka Central	Nsukka East	Nsukka West
100-300	1 (14.0%)	1 (16.67%)	4 (75.0%)
400-700	3 (43.0%)	0 (0.0%)	1 (25.0%)
1m and above	3 (43.0%)	5 (83.33%)	0 (0.0%)
Total	7 (100.0%)	6 (100.0%)	5 (100.0%)

The average income across the three locations as showed in the table 11 revealed that the average income of the farmers in a range of ₦100,000 – ₦300,000, ₦400,000 – ₦700,000 and ₦1,000,000 and above. Farmers within Nsukka central were more in the range of ₦400,000 and ₦1,000,000 and above, ₦400,000–₦700,000 (43%) and ₦1,000,000 and above is (43%). While the average income of fish farmers in Nsukka east are more of the higher income level of ₦1,000,000 and above (83.3%). But those farmers in Nsukka west were in ₦100,000–₦300,000 range (75%). The results show that Nsukka East has a stronger economy while Nsukka West may face economic challenges. The variations may be as a result of occupation, education and access to resources.

Table 12: Farm size (number of ponds)

Farm Size	Nsukka Central	Nsukka East	Nsukka West
2	4 (57.0%)	1 (16.67%)	5 (100.0%)
4	1 (14.4%)	3 (50.0%)	0 (0.0%)
5	1 (14.3%)	1 (16.66%)	0 (0.0%)
10	0 (0.0%)	1 (16.67%)	0 (0.0%)
15	1 (14.3%)	0 (0.0%)	0 (0.0%)
Total	7 (100.0%)	6 (100.0%)	5 (100.0%)

Table 12 shows the number of ponds per farmer in the study areas. The results revealed that, number of ponds per farmers indicating the farm size, is in the range of 2 ponds – 15 ponds. Farmers of Nsukka Central were more in 2 ponds range (57%) likewise, farmers of Nsukka West were more of 2 ponds (100%). However, the farmers of Nsukka East, cut across the range of 2 ponds to 10 fish ponds per farmer, but measuredly, 4 ponds (50%). The results suggested that Nsukka West was characterized by small-scale farming while Nsukka East has a mix of small and medium scale farming operations. The variations in the farm size were as a result of land availability, capital and market demand.

Table 13: Challenges to fish farming

Challenges	Nsukka Central	Nsukka East	Nsukka West
Inadequate water supply to the farm	1 (14.0%)	1 (17.0%)	0 (0.0%)
Management Issue and Inadequate water supply to the farm	3 (43.0%)	0 (0.0%)	2 (40.0%)
Management issues and pond caused challenges	1 (14.0%)	0 (0.0%)	0 (0.0%)
Nil	2 (29.0%)	5 (83.0%)	3 (60.0%)
Total	7 (100.0%)	6 (100.0%)	5 (100.0%)

Table 13 shows the challenges of the farmers in the study areas. The results revealed that the challenges of the farmers are inadequate water supply to the farm, management issues and inadequate water

supply and management issues and pond caused challenges. Farmers of Nsukka Central management issues and inadequate supply of water 43% was the most prominent challenges of the farmers. While farmers of Nsukka East and Nsukka West felt indifference to those three challenges since they were 100% nil and 80% by Nsukka West. The results show that Nsukka East has a more stable and supportive farming environment while Nsukka Central and Nsukka West require interventions to address water supply and management issues.

Table 14: Business of fish farming

Item	Nsukka Central	Nsukka East	Nsukka West
No	7 (100.0%)	6 (100.0%)	4 (80.0%)
Yes	0 (0.0%)	0 (0.0%)	1 (20.0%)
Total	7 (100.0%)	6 (100.0%)	5 (100.0%)

Table 14 shows the business of fish farming in Nsukka Central, Nsukka East and Nsukka West. In Nsukka Central and Nsukka West, 100% respondents were of the opinion that fish farming is a non-business activity, suggested that fish farming is primary practiced for subsistence or personal consumption. In Nsukka West 80% of respondents viewed fish farming as a non-business and 20% agreed that it is a business. The results suggested that fish farming is not widely regarded as a commercial venture in all the zones. Also, the results highlight the need for training and support services to promote fish farming as a viable business.

Table 15: Species of fish

Species	Nsukka Central	Nsukka East	Nsukka West
Cat Fish	7 (100.0%)	6 (100.0%)	4 (80.0%)
Tilapia	0 (0.0%)	0 (0.0%)	0 (0.0%)
Mud Catfish	0 (0.0%)	0 (0.0%)	1 (20.0%)
Total	7 (100.0%)	6 (100.0%)	5 (100.0%)

Table 15 shows that, in Nsukka Central and Nsukka East, 100% of respondents are farming Cat fish indicating a high demand for the species. In Nsukka West, 80% of respondents selected that they are farming Cat Fish. In Nsukka West 20% respondents

are farming Mud cat fish species. The absence of Tilapia farming in all the three zones is because they may not be well-suited for the local environment or market demands.

Table 16: Types of ponds

Type of ponds	Nsukka Central	Nsukka East	Nsukka West
Tarpaulin	5 (71.0%)	3 (50.0%)	2 (40.0%)
Concrete	2 (29.0%)	3 (50.0%)	2 (40.0%)
Earthen Ponds	0 (0.0%)	0 (0.0%)	1 (20.0%)
Total	7 (100.0%)	6 (100.0%)	5 (100.0%)

Table 16 shows a varied landscape of pond infrastructure. Tarpaulin ponds are the most type of fish pond use in Nsukka Central with 71% and Nsukka West with 40%. While Concrete ponds are equally use in Nsukka East with 50% responses which indicate a greater investment in more durable and long-lasting pond structure. Nsukka West and Nsukka East also have an equal proportion of concrete ponds with 50% and 40% respectively. Nsukka West reported that 20% of respondents are using Earthen Ponds types of ponds. The results show that, fish farmers in across the three zones are adapting to their local environment and resources to construct ponds that meet their needs.

Table 17: Size of fish pond

Size	Nsukka Central	Nsukka East	Nsukka West
10 × 13 m	1 (14.0%)	0 (0.0%)	0 (0.0%)
10 × 7 m	6 (86.0%)	6 (100.0%)	5 (100.0%)
Total	7 (100.0%)	6 (100.0%)	5 (100.0%)

Table 17 shows the size of the fish pond across the three zones; Nsukka Central, Nsukka East and Nsukka West. Nsukka Central has a more varied pond size with 14% of respondents having 10 × 13m ponds and 86% having 10 × 7 m ponds. In Nsukka East and Nsukka West have a uniform pond size with 100% of respondents in both zones having 10 × 7 m ponds. The dominance of the 10 × 7m ponds size in Nsukka East and Nsukka west suggested the

standardized approach to pond construction which led to the factors such as land availability water supply and market demands. The results highlight the differences in fish pond size and construction practices across the three zones.

Table 18: Farming more than one species of fish in a pond

Item	Nsukka Central	Nsukka East	Nsukka West
No	7 (100.0%)	6 (100.0%)	1 (20.0%)
Yes	0 (0.0%)	0 (0.0%)	4 (80.0%)
Total	7 (100.0%)	6 (100.0%)	5 (100.0%)

Table 18 shows that, Nsukka Central and Nsukka East was 100% of respondents do nor farm multiple species of fish in a single pond suggested a focus on monoculture fish farming. Nsukka West exhibits a divergent practice with 80% of respondents farming multiple species of fish in a single pond which indicates a polyculture approach. This differences in farming practices may be influenced but the factors such as market demand, water quality and disease management. The polyculture approach in Nsukka West may provide benefits such as increase in biodiversity and reduced disease.

Table 19: Types of fish faming

Number	Nsukka Central	Nsukka East	Nsukka West
One type	7 (100.0%)	6 (100.0%)	5 (100.0%)
More than one	0 (0.0%)	0 (0.0%)	0 (0.0%)
Total	7 (100.0%)	6 (100.0%)	5 (100.0%)

Table 19 shows the number of the types of fish farming in a pond. In all the three zones, Nsukka Central, Nsukka East and Nsukka West was 100% of respondents which practice only one type of fish farming. The uniformity of the fish farming is as a result of market demands, water quality and farmer expertise.

Table 20: Sources of water supply

Sources of water supply	Nsukka Central	Nsukka East	Nsukka West
Borehole	6 (86.0%)	4 (67.0%)	2 (40.0%)

Bore hole and well	1 (14.0%)	0 (0.0%)	0 (0.0%)
Tank	0 (0.0%)	0 (0.0%)	3 (60.0%)
Well	0 (0.0%)	2 (33.0%)	0 (0.0%)
Total	7 (100.0%)	6 (100.0%)	5 (100.0%)

Table 20 shows the sources of water as follows: Nsukka Central borehole 86%, Nsukka East borehole 67% and Nsukka West tank 60%. Bore hole is the dominant source of water supply in Nsukka central followed by Nsukka East which rely on groundwater. Nsukka West has a more diversified water supply with 60% of respondents using tanks, 40% are using boreholes, the use of tanks in Nsukka West suggested a reliance on harvested rainwater or any other external sources of water. The absence of wells as a source of water supply in Nsukka Central and a low usage in Nsukka East and Nsukka West may be as a result of lack of access to or reliability of well water

Table 21: Change of water in the pond

Number of changes	Nsukka Central	Nsukka East	Nsukka West
1 week – 10 days	0 (0.0%)	1 (17.0%)	1 (20.0%)
2 days	1 (14.0%)	1 (17.0%)	1 (20.0%)
3 days	4 (57.0%)	3 (50.0%)	3 (60.0%)
5 days	2 (29.0%)	0 (0.0%)	0 (0.0%)
Once in two weeks	0 (0.0%)	1 (16.0%)	0 (0.0%)
Total	7 (100.0%)	6 (100.0%)	5 (100.0%)

Table 21 revealed that most farmers change water of the pond every three days as Nsukka Central 57%, Nsukka West 50% and Nsukka East 60%. This suggested that most farmers frequent water changes to maintain optimal water quality. Also, there are differences in water frequencies across the three zones with Nsukka Central having a proportion of respondents changing water every 5 days with 29%. Nsukka East and Nsukka West have a more uniform distribution of water change frequencies. The results show the importance of water quality management in fish farming and suggested that farmers are adopting different strategies to achieve optimal water quality.

Table 22: Do you test your pond water parameters?

Response	Nsukka Central	Nsukka East	Nsukka West
No	7 (100.0%)	5 (83.0%)	5 (100.0%)
Yes	0 (0.0%)	1 (17.0%)	0 (0.0%)
Total	7 (100.0%)	6 (100.0%)	5 (100.0%)

Table 22 revealed that the farmers do not test their water against physicochemical parameters (nitrite, nitrate, temperature, ammonia, turbidity, pH, DO) as the results revealed 100% no to test of pond water by farmers of Nsukka central, 83% no to test of pond water to Nsukka east and 100% no to test of pond water by the farmers of Nsukka west.

Table 23: Usual water level of the pond

Response	Nsukka Central	Nsukka East	Nsukka West
No	7 (100.0%)	5 (83.0%)	4 (80.0%)
Yes	0 (0.0%)	1 (17.0%)	1 (20.0%)
Total	7 (100.0%)	6 (100.0%)	5 (100.0%)

Table 23 revealed that in all the three zones, majority of respondents reported that the water level in their ponds was usually consistent with 100% of respondents in Nsukka Central 83% in Nsukka East and 80% in Nsukka West which shows the consistent water level. This result shows that, the farmers are maintaining a stable water environment for their fish. While in Nsukka East and Nsukka West with 17% and 20% respectively reported that their ponds do not usually have a consistent water level. The result shows that, farmers are able to maintain consistent water level.

Table 24: What parameters do you test in the pond?

Response	Nsukka Central	Nsukka East	Nsukka West
Nil	7 (100.0%)	5 (83.0%)	4 (80.0%)
Others	0 (0.0%)	1 (17.0%)	1 (20.0%)
Total	7 (100.0%)	6 (100.0%)	5 (100.0%)

Table 24 indicated that there were indifferences to the parameters testing as the result revealed 100% nil by the Nsukka Central, 83% nil by the Nsukka East and 80% nil by the Nsukka West.

Table 25: Does water quality test influence the farm management practice?

Response	Nsukka Central	Nsukka East	Nsukka West
No	7 (100.0%)	5 (83.0%)	4 (80.0%)
Yes	0 (0.0%)	1 (17.0%)	1 (20.0%)
Total	7 (100.0%)	6 (100.0%)	5 (100.0%)

In table 25, the three zones which are Nsukka Central, Nsukka East and Nsukka West majority of the respondents reported that water quality testing does not influence their farm management practices with 100% of the respondents in Nsukka Central, 83% in Nsukka East and 80% in Nsukka West which indicated that there is no influence. In Nsukka East and Nsukka West have a proportion of 17% and 20% respondents respectively which indicated that, water quality testing does influence their farm management practices.

Table 26: Do you fertilize your farm before stocking?

Response	Nsukka Central	Nsukka East	Nsukka West
No	6 (86.0%)	3 (50.0%)	4 (80.0%)
Yes	1 (14.0%)	3 (50.0%)	1 (20.0%)
Total	7 (100.0%)	6 (100.0%)	5 (100.0%)

Table 26 showed 86% no to pond fertilization by farmers of Nsukka central and 80% no by farmers of Nsukka east. However, farmers of Nsukka east were 50% no and 50% yes to pond fertilization before stocking.

Table 27: How many times do you feed your fish in a day?

Response	Nsukka Central	Nsukka East	Nsukka West
1 time	0 (0.0%)	0 (0.0%)	0 (0.0%)
2 times	7 (100.0%)	6 (100.0%)	5 (100.0%)
3 times	0 (0.0%)	0 (0.0%)	0 (0.0%)
4 times	0 (0.0%)	0 (0.0%)	0 (0.0%)
Total	7 (100.0%)	6 (100.0%)	5 (100.0%)

In table 27, Nsukka Central, Nsukka East and Nsukka West both have 100% of the respondents which indicated that farmers across the three zones are feeding their fish twice a day this would help in the

providing optimal nutrition to their fish which is essential for growth, health and productivity.

Table 28: Could you describe the feeding method you do employ in your fish farm?

Response	Nsukka Central	Nsukka East	Nsukka West
Broadcast feeding	1 (14.0%)	1 (14.0%)	1 (20.0%)
Hand Feeding	6 (86.0%)	4 (72.0%)	4 (80.0%)
Point feeding	0 (0.0%)	1 (14.0%)	0 (0.0%)
Total	7 (100.0%)	6 (100.0%)	5 (100.0%)

Table 28 shows that feeding method employed by the farmers involved broadcast feeding, hand feeding and point feeding. But they were more into hand feeding since farmers in Nsukka Central 86%, Nsukka East 72% and Nsukka West 80%. The result shows that diversity of feeding methods employed by the fish farmers in the three zones. This is as a result of differences in farmers experience, training and access to resources as well as the specific needs and characteristics of their fish stocks.

Table 29: What quantity of feed do you give to your fish per day?

Response	Nsukka Central	Nsukka East	Nsukka West
1 kg	1 (14.0%)	1 (14.0%)	3 (60.0%)
2 kg	1 (14.0%)	0 (0.0%)	0 (0.0%)
3 kg	0 (0.0%)	1 (14.0%)	0 (0.0%)
Above 3 kg	5 (72.0%)	4 (72.0%)	2 (40.0%)
Total	7 (100.0%)	6 (100.0%)	5 (100.0%)

Table 29 shows the quantity of feed given to fish per day in Nsukka Central, Nsukka East and Nsukka West. In Nsukka Central and Nsukka East was 72% which reported that, the farmers feed their fish with above 3 kg per day. While in Nsukka West has a moderate feeding with 60% of respondents feeding their fish 1 kg per day. The result shows the difference in feeding practices between Nsukka West and the other two zones with Nsukka West having a

lower proportion respondent feeding above 3 kg per day. This is as a result of differences in fish size, growth stage, farmers experience and access to resources.

Table 30: What is the average stocking capacity per cycle of production?

Stocking	Nsukka Central	Nsukka East	Nsukka West
100-300	3 (43.0%)	1 (17.0%)	4 (75.0%)
400-1500	1 (14.0%)	2 (28.0%)	1 (25.0%)
2000	0 (0.0%)	3 (55.0%)	0 (0.0%)
3000	3 (43.0%)	0 (0.0%)	0 (0.0%)
Total	7 (100.0%)	6 (100.0%)	5 (100.0%)

Table 30 show that Nsukka Central has 43% of respondents stocking of 100-300 fish and 43% stocking 3000 fish. Nsukka East has a higher proportion of 55% responses with stocking of 2000 fish per pond which indicated a more production system. Nsukka West has a more moderate approach with 75% of respondents stocking 100-300 fishes. The results suggested that farmers in the three zones adopted different stocking strategies which may lead to fish growth, health and productivity.

Table 31: How many months do you rear your fish before harvesting/sales?

Duration	Nsukka Central	Nsukka East	Nsukka West
3 months	0 (0.0%)	0 (0.0%)	0 (0.0%)
4 months	0 (0.0%)	0 (0.0%)	0 (0.0%)
5 months	0 (0.0%)	0 (0.0%)	2 (40.0%)
6 months	0 (0.0%)	0 (0.0%)	0 (0.0%)
Above 6 months	7 (100.0%)	6 (100.0%)	3 (60.0%)
Total	7 (100.0%)	6 (100.0%)	5 (100.0%)

Table 31 shows that most of the farmers harvest their fishes after 6 months of rearing and they usually use antibiotics during the incidence of disease outbreak. Nsukka Central and Nsukka East has 100% respondents which indicated that, the farmers rear their fish for more than 6 months before harvesting as a result of growing rate. Nsukka west has 40% of respondents rearing their fish for 5 months and 60%

for more than 6 months. The longer rearing periods in the three zones was due to market demands and higher value of fish.

Table 32: How many months do you rear your fish before harvesting?

Medication	Nsukka Central	Nsukka East	Nsukka West
Antibiotic	7 (100.0%)	6 (100.0%)	4 (80.0%)
Sulfonamide	0 (0.0%)	0 (0.0%)	1 (20.0%)
Anti-parasites	0 (0.0%)	0 (0.0%)	0 (0.0%)
Antifungals	0 (0.0%)	0 (0.0%)	0 (0.0%)
Total	7 (100.0%)	6 (100.0%)	5 (100.0%)

Table 32 revealed that Nsukka Central fish farmers (100%), Nsukka East (100%), Nsukka West (80%) uses antibiotics while 20% of respondents in Nsukka West reported using Sulfonamide. The results show some diversity in the use of the medication such as antibiotics. The result shows that there is widespread use of antibiotics in fish farming across the three zones.

Table 33: How frequent do you administer medications in you fish farming operations?

Number of times	Nsukka Central	Nsukka East	Nsukka West
Once time per week	4 (57.0%)	2 (33.0%)	3 (60.0%)
Twice times per week	3 (43.0%)	4 (67.0%)	1 (20.0%)
Three times per week	0 (0.0%)	0 (0.0%)	1 (20.0%)
Total	7 (100.0%)	6 (100.0%)	5 (100.0%)

Table 33 above shows that they usually administered their drugs some once per week, some twice per week and others. Nsukka central fish farmers adopted once per week 57%, Nsukka east twice per week 67% and Nsukka west once per week 60%. The result shows that, fish farmers in the three zones are administering medications frequently which may indicate a high reliance on medications to manage disease.

Table 34: How do you manage disease outbreak?

Measures	Nsukka Central	Nsukka East	Nsukka West
Monitor	0 (0.0%)	0 (0.0%)	1 (20.0%)
Diagnosis	0 (0.0%)	0 (0.0%)	0 (0.0%)
Treatment	7 (100.0%)	6 (100.0%)	4 (80.0%)
Prophylactic measures	0 (0.0%)	0 (0.0%)	0 (0.0%)
Total	7 (100.0%)	6 (100.0%)	5 (100.0%)

Table 34 shows the measures taken by the fish farmers in Nsukka Central, Nsukka East and Nsukka West that can manage disease outbreaks. Nsukka Central and Nsukka East has 100% and Nsukka West has 80% relying on treatment to manage disease outbreaks. While in Nsukka West reported 20% using monitoring measures to manage disease outbreak. The result show that treatment is the primary measures used by the farmers across the three zones. This is as a result of disease management strategies.

Table 35: What is the typical frequency of disease outbreak within your fish farm?

Medication	Nsukka Central	Nsukka East	Nsukka West
Very often	0 (0.0%)	0 (0.0%)	0 (0.0%)
Moderately	7 (100.0%)	4 (67.0%)	4 (80.0%)
Rare	0 (0.0%)	2 (33.0%)	1 (20.0%)
Total	7 (100.0%)	6 (100.0%)	5 (100.0%)

Table 35 shows that disease outbreaks are commonly found in the three zones where Nsukka Central has 100%, Nsukka East has 67% and Nsukka West has 80% moderately frequency of disease outbreak. 33% of respondents in Nsukka East and 20% in Nsukka West reported rare in disease outbreak. The moderately frequency of disease outbreaks reported by the majority of the respondents suggested that disease management is an ongoing challenge for fish farmers in the three zones.

Table 36: What preventive measures do you take to minimize the occurrence of the disease in you farm?

Preventive Measures	Nsukka Central	Nsukka East	Nsukka West
Water Quality Management	0 (0.0%)	2 (34.0%)	1 (20.0%)
Biosecurity	0 (0.0%)	0 (0.0%)	0 (0.0%)
Monitoring	0 (0.0%)	2 (34.0%)	0 (0.0%)
Feeding	0 (0.0%)	1 (17.0%)	0 (0.0%)
Pond Management	7 (100.0%)	1 (17.0%)	4 (80.0%)
Total	7 (100.0%)	6 (100.0%)	5 (100.0%)

Table 36 shows that pond management is the most widely used preventive measures with 100% respondents in Nsukka Central and 80% in Nsukka West. While in Nsukka East has 17% of the respondents. Water quality management and monitoring are used by 34% and 17% for feeding. The dominance of pond management use by the farmers in the three zones is as a result of environmental management to prevent disease.

### III. DISCUSSION

#### Production of fish farms and pond characteristics

The fish farmers of the three locations; Nsukka Central, Nsukka East and Nsukka West were long involved in fish farming, and it was indicated that most individuals of the locations preferred rearing catfish in the concrete and tarpaulin pond. This is because catfish farming has become a lucrative venture in Nigeria due to the increasing demand for this delicious and protein-rich fish. The fish is usually having a fast-growing performance and well appreciated by fish farmers (Isiwanto, *et al.*, 2015). Because of this, most farmers in the locations rear only one type of the fish (*Clarias gariepinus*). In line with this study, a previous study indicated that most farmers prefer rearing of catfish in concrete ponds (Ugwumba, 2010).

#### Feeding number and water management of the ponds across zones

The farmers fed a higher number of fish in their ponds and this is attributed to their financial capacity or the knowledge to thrive more in fish rearing (Kresic, *et al.*, 2022). The farmers change water

regularly and understand the consequences. As such, the farmers suggested that ammonia and turbidity are the two factors that make them change the pond water regularly.

#### Disease management and control

Disease affecting the fishes of the farmers which includes Ich, Furunculosis and Ich and Furunculosis affect the farmers across the locations. The results show that, Furunculosis is most predominant across the three locations (Nsukka Central, Nsukka East and Nsukka West). The previous study by Plumb (1999) supported that Furunculosis is a significant disease affecting fish farms worldwide. The frequency of outbreak is moderately rare. Their disease management measuredly involved 100% treatments using antibiotic while their preventive measures were more using water quality management. It indicated that a poorly managed aquatic ponds often face greater risks of fish disease (Mohan, *et al.*, 2021). Also, when a pond harbors infection there is a high possibility of poorer productivity due to poor growth of aquatic organisms (Hennig and Jain, 2018). Farmers relied heavily on antibiotic treatments while preventive measures focused primarily on water quality management (Adeogun *et al.*, 2017).

#### Interrelation between production practices of fish farms

This study found that the type of pond only correlated positively with the years of experience. A study indicated that the type of pond ensures confidence in keeping fingerlings (Iruo, *et al.*, 2018). Therefore, there is a possibility that the most experienced farmers have come to realize the need for the best type of pond to keep more fish which is Tarpaulin and Concrete. However, the negative relationship between type of pond and pond size, including the parameters used in testing the health of the pond, number of fish farmed, months of rearing to harvesting and the size of fish during harvest. According to Kumar, *et al.* (2018) the type and size of pond can significantly impact the health and productivity of fish farms and inexperienced farmers may not be aware of the optimal pond design and management practices.

Suggest that some of the farmers do not inexperienced or are not well informed about the negative consequences attributed to the type pond and size of pond to be built. Conversely, the pond size correlated significantly to the tested parameters of the pond, the quantity of feed fed per day, the fish number months of rearing and the size of fish. The frequency of pond water change correlated positively to parameters of the pond tested and fish seedling sources. These findings are consistent with a previous study of Lawal, *et al.* (2023) that indicated that the monitoring of physical and chemical parameters of a pond could result in higher productivity. A parameter such as ammonia correlated positively with seedling sources, meanwhile, it correlated negatively to number of fish raised in the pond. Suggesting the sources seedling may variability feed them before arriving at a customer's fish pond. As such, some seedling might have been fed with feed containing a higher concentration protein that could be converting into ammonia (Ogbonna and Chinomso, 2010). The quantity of feed given per day correlated positively to the number of months' duration before harvest, this indicated that consumption increased with rearing duration. This is possible because the more the fish grow the more the feed the fish could consume (Aderolu, *et al.*, 2010).

#### IV. CONCLUSION

The study highlighted the crucial role of maintaining optimal water quality global best practices in fish farms to enhance fish optimal yields. Therefore, regular monitoring, training and control measures should be embarked upon by environmental protection agencies in order to protect the study area, enhance fish production and environmental sustainability. The supply of safe water has a significant impact on fish. The abundance of organic compounds, radionuclides, toxic chemicals, nitrites and nitrates in water may cause unfavorable effects on the fish. The study highlighted the crucial role of maintaining optimal water quality in fish farms to enhance fish yields. Therefore, Regular monitoring and control measures should be embarked upon by environmental protection agencies in order to protect the study area, enhance fish production and environmental sustainability.

## V. RECOMMENDATIONS

Based on the findings of this study, the following recommendations were made:

1. The Local government the farmers should promote sustainable aquaculture practices which will help to reduce waste and improve production efficiency.
2. Modern fish farming infrastructure should be incorporated in other to increase fish production and improve productivity in the study area.
3. Regular training and workshops for fish farmers should be organized to enhance their knowledge and skills in aquacultural activities.

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