COMPARATIVE ECONOMIC ANALYSIS OF EARTHEN POND AND CONCRETE TANK PRODUCTION SYSTEMS AMONG FISH FARMERS IN LAGOS STATE, NIGERIA

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ABSTRACT

This study compared the economic analysis of earthen pond and concrete tank production systems among fish farmers in Ikorodu Local Government Area, Lagos State, Nigeria, using a cross-sectional survey research design. A two-stage sampling procedure was adopted in selecting 120 fish farmers from Ikorodu Fish Farm Estate in Lagos State. Data were collected using an interview guide and analyzed using frequency, mean, standard deviation, budgetary technique and student-t test. Results revealed that most earthen pond fish farmers - EPFF (86.0%) and concrete tank fish farmers - CTFF (87.0%) were males. Cost-return analyses revealed that EPFF earned an average of N8,611,046.50 while CTFF earned an average of N6,387,896.10 as total revenue with gross margins of N4,229,751.10 and N1,956,991.10 for EPFF and CTFF, respectively. Also, feed costs accounted for 88.6% and 88.9% of total production costs using earthen ponds and concrete tanks, respectively. The net fish farming profits were N3,993,479.07 and N1,697,639.7 for EPFF and CTFF, respectively, while the benefit-cost ratios were 1.86 and 1.36, respectively. High cost of feed, transportation and inadequate capital were the most severe constraints in both production systems. Significant differences were established in the number of ponds ($t=5.71$, $p\leq0.01$), stocking density ($t=6.36$, $p\leq0.01$), net fish farming income ($t=3.972$, $p\leq0.01$) and gross margin ($t=3.827$, $p\leq0.01$) of the earthen pond and concrete tank fish farmers. The study concluded that the earthen pond culture system was economically better than the concrete tank culture. It was recommended that new entrants into fish farming should utilize the earthen ponds.

Keywords: Concrete tank, Culture system, Earthen Pond, Fish farming, Profitability

1. INTRODUCTION

Nigeria has long been recognized for its interest in agriculture, particularly fish farming, among other agricultural goods. Hence, fish farming is one of the most revenue-generating sub-sectors of the Nigerian agricultural industry. Fish, a significant aquaculture product, is an important source of protein for developing countries' growing populations. Fish and fisheries products are important for global food security and meeting the nutritional needs of people in emerging and developed countries (Food and Agriculture Organization - FAO, 2014).

In 2018, global fish production was expected to have reached around 179 million tonnes, with 156 million tonnes going to human consumption, equating to an annual supply of 20.5 kg per capita. Aquaculture was responsible for 46% of overall production and 52% of fish for human consumption (FAO, 2020). Fish farming is a subset of the aquaculture industry as it deals only with the production of fish under a controlled

environment for the benefit (consumption, sale or any other purpose) of mankind.

When a nation's population grows, so does the demand for basic necessities like food, water, and shelter as well as an unchecked rise in the desire for animal products with high protein content (Pasha, 2021; Sustainable Food Trust, 2018). Aquaculture remains Nigeria's fastest-growing livestock production sector (Olaoye *et al*., 2016). FAO (2016) also observed that the contribution of the Nigerian aquaculture sector has been increasing since 1995. If properly managed, fish farming, a vital aspect of agriculture, has become Nigeria's main source of income, increasing the country's gross domestic product (GDP) and helping to tackle the country's unemployment crisis for our teeming youth. Fish farming is the commercial cultivation of fish in concrete tanks, earthen ponds, and other facilities.

The artisanal capture fisheries in Nigeria are unable to meet the country's rising fish demand. To supplement the inadequate supply from capture fisheries, aquaculture, particularly fish farming, was pushed. Despite this advertising, factors like the price of fish food and seeds as well as a lack of funding limit how profitable fish farming can be (Ijigbade *et al*., 2018; Ekine *et al*., 2019). Apart from these, the culture medium affects the profitability of fish farming. Common mediums for culturing fish, especially by small-scale fish farmers in Lagos State include earthen ponds and concrete tanks, both with their inherent merits and demerits (Osawe and Salman, 2016).

An artificial lake, reservoir, or dam known as an "earthen pond" was built to retain some aspects of the natural aquatic environment for the purpose of breeding fish of various species (Marywil Farms, 2022a). Contrarily, a concrete fish tank is built without preserving the natural aquatic habitat using the proper proportions of cement, sand, and blocks (Marywil Farms, 2022b). Fish in earthen pond grow more quickly than in concrete tanks because the natural aquatic environment is preserved. Concrete tanks are simpler to maintain for feeding, counting, sorting, managing predators, and harvesting even though earthen ponds often have higher stocking capacities (Nonye, 2022).

Additionally, because they are long-term investments, earthen ponds cannot be built on rented or leased land. Concrete tanks, on the other hand, can be simply placed anywhere, such as in the backyard or in front of the home (Ekine *et al*., 2019). As fish growth can be easily observed, unlike in earthen ponds, cannibalism in concrete tanks can be easily regulated through sorting. Additionally, compared to earthen ponds, concrete tanks make it easier to carry out other management procedures like hatching fingerlings. Unlike concrete tanks, where water contamination happens more quickly, earthen ponds are able to control environmental and water pollution. Compared to concrete tanks, which are less susceptible to floods and poaching, raising fish in earthen ponds is more dangerous (Ijigbade *et al*., 2018).

The claim made by Ijigbade *et al*. (2018) that no production method, whether it be an earthen pond or a concrete pond, is fully ideal and without limitations is supported by the discussion of the benefits and drawbacks of the two cultural mediums that were just mentioned. Given that profit is the main goal of every business venture, a potential fish farmer wonders which culture medium produces a larger return on investment and profitability than the other. Hence, the broad objective of this study was to the comparative economic analysis of earthen and concrete tank production systems among fish farmers in Lagos State. The specific objectives were to describe the socio-economic characteristics of the fish farmers, examine the production characteristics of the respondents, determine the profitability of fish farming using concrete tanks and earthen ponds, and identify the constraints facing both

production systems. The research hypotheses were as follows:

Ho_1: There is no significant difference in the production characteristics of the earthen pond and concrete tank fish farmers

Ho_2: There is no significant difference in the profitability of fish cultured using an earthen pond and concrete tank.

2. MATERIALS AND METHODS

Study area

This survey was conducted in Ikorodu Local Government Area (LGA) of Lagos State, Nigeria. Ikorodu is one of 20 LGAs in Lagos State. About 36 kilometres to the north of Lagos is Ikorodu (Lagos State Government, 2023). The Epe division of Lagos State and the Lagos Lagoon share borders with the LGA, according to Manpower Nigeria (2023). Imota, Igbogbo/Bayeku, Ikorodu West, Ijede, and Ikorodu North LCDAs are the five local council development areas that make up Ikorodu LGA (Lagos State Government, 2023).

Ikorodu LGA has a projected population of 431,899 people, including residents from a variety of ethnic backgrounds (Manpower Nigeria, 2023). The Ijebu and Remo groups make up the bulk of the LGA. There is a sizable component of the Eko-Awori population in the riverine margins of Ipakodo, Ibese, Ebute, Majidun, Itowolo, and other coastal settlements. The Ikorodu Fish Farm Estate is located inside the LGA.

Sampling procedure

A two-stage sampling procedure was adopted in selecting respondents for this study. The first stage entails the purposive selection of Ikorodu Fish Farm Estate from the LGA based on the number of registered fish farmers in the Estate. The Estate is also a reference point for fish production in the State. This was followed by the random selection of 120 fish farmers, representing about 37 per cent of the 323 fish farmers registered with the Estate.

Data collection

Data were collected with an interview schedule on the socio-economic characteristics, production characteristics, the profitability of fish farming using concrete tanks and earthen ponds, and constraints facing both production systems in Lagos State. The interview guide was read to the fish farmers by the researcher, who recorded the farmers' responses immediately.

Analytical techniques

Data on the socio-economic characteristics, production characteristics and constraints to fish farming were subjected to descriptive statistics (frequencies, percentages, means, and Standard deviation). An Independent t-test was used to test the research hypotheses at 0.05 levels of significance. The budgetary technique (cost-return structure) was adopted to determine the profitability of earthen pond and concrete tank fish farming systems using the profitability indices such as gross margin, net fish farming income and benefit-cost ratio. According to Oke *et al*. (2022), the equations for the different indices are provided below.

Net fish farming income (NFFI) = Profit (π) =TR-TC…… (i)
Gross Margin (GM) = TR - TVC …….. (ii)
Benefit-Cost Ratio (BCR) = TR/TC …….. (iii)
Return on Investment (ROI) = NFFI/TC…… (iv)
Where;

Total cost (TC) = Total Fixed Cost (TFC) + Total Variable Cost (TVC)
TR = Total Revenue (₦) = Output (Q) * Price (P) = PQ
TVC = Total Variable Cost (₦)
TFC = Total Fixed Cost (₦)
Fish farming will be profitable provided NFFI and GM are positive, BCR >1, and ROI > 0.00 (Olaoye *et al*., 2016). That is, fish farming is profitable if TR > TC.

3. RESULTS AND DISCUSSION

Socio-economic characteristics of fish farmers

The results on the socio-economic characteristics of the respondents are presented in Table 1. It shows that 48.8% of Earthen Pond Fish Farmers (EPFF) were within the 41 - 50 age bracket, while 36.4% of Concrete Tank Fish Farmers (CTFF) were older than 50 years with a mean age of 45.02 and 45.52 years, respectively. This is an indication that fish farming was dominated by youths who are within the economically active population and therefore constituted a good labour force for the fish farming industry irrespective of the culture mediums. The finding agrees with previous studies (Omobepade *et al*., 2015; Olaoye *et al*., 2016; Oyediran *et al*., 2017; Ashley-Dejo *et al*., 2017) which reported the dominance of people within the active workforce in fish farming. According to these reports, such persons were considered highly productive, energetic and active in undertaking strenuous tasks associated with farm work.

Males were the highest proportion of EPFF (86.0%) and CTFF (87.0%). The dominance of males among the fish farmers, irrespective of their medium (ponds or concrete tanks) implies that fish farming in Ikorodu LGA was still gender biased in favour of the male folks. This is in tandem with that of Olaoye *et al*. (2014), who reported that fish farming using concrete tanks and earthen ponds in Oyo State was dominated by men. Ashley-Dejo *et al*. (2017) also discovered the low involvement of women in fish farming. The low involvement of the female gender in fish farming could be linked to women's inability to possess productive resources. This assertion conforms with that of Ashley-Dejo (2012), who attributed the low involvement of women in aquaculture to women's inability to own private land for the aquaculture business.

Most EPFF (97.7%) and CTFF (89.6%) were married, with household sizes of 4-6 persons accounting for 41.9% and 46.8%, respectively. The average household sizes were 5 and 6 persons for EPFF and CTFF, respectively. This suggests the dominance of moderate households which could be linked to the respondents' high education level and the study area's urban nature, which collectively tend to small family sizes. This concurs with the observation of Yarhere (2004), who noted that the more educated and urban-based an individual is, the less the family size that individual will keep.

The Yoruba ethnic group has the highest proportion among EPFF (76.7%) and CTFF (81.8%). The dominance of married persons with mean household sizes of 5 and 6 persons, respectively could not be unconnected from the fact that most of the sampled fish farmers were in their 40s and 50s when people are expected to be married and be in the reproductive age group. The fact that the marriage institution has been highly cherished in Southwest and Nigeria is another reason for the high rate of married fish farmers in the study area.

The highest proportions of EPFF and CTFF spent an average of 12 and 13 years for schooling. This could mean that most of the fish farmers, irrespective of culture mediums, had a complete secondary level of education. Also, results in Table 1 reveal that 51.2% and 39.5% of EPFF had secondary and tertiary levels of education, respectively, while the same educational qualifications were possessed by 35.1% and 57.1% of the CTFF (57.1%), respectively. This indicated that most of the fish farmers using concrete tanks were more educated than those using earthen ponds. However, fish farmers generally possessed higher levels of education, even up to the tertiary level. This implies that the fish farmers are learned, which is expected to facilitate higher output and efficiency in fish production. This agrees with the notion of Olaoye *et al*. (2017) that education could enhance fish farmers' access to productive resources. The engagement of more graduates in concrete tank

fish farming could be attributed to the fact that the youth prefer using concrete tanks to earthen ponds.

A cooperative society is a social participation that helps farmers pool their resources to have access to fisheries inputs and insights into their fishing issues. Membership in cooperatives is also a factor that influences the adoption of improved fisheries technologies and poverty alleviation. Almost all (97.7% of EPFF and 97.4% of CTFF) belonged to cooperative societies implying that fish farming in Ikorodu was dominated by members of cooperative societies. This could be linked to the fact that beneficiaries of the Ikorodu fish farm estate project were required to form fish farmers' groups which encouraged their membership in cooperative societies. Being members of cooperative societies aids the fish farmers' accessibility to credit facilities. Apart from serving as credit sources, membership in cooperative societies is also a medium which reinforces teamwork with respect to production information gathering and utilization and improves one's technical skills in fish production through training activities of the cooperative societies. This agrees with Awolumate and Owoyale's (2017) submission that members of farmers' cooperative societies would have higher access to agricultural information and better access to knowledge, inputs and credit from the government than non-members.

The majority (69.8% and 79.2%) of EPFF and CTFF practised Christianity. Also, more than half of both the EPFF (55.7%) and CTFF (53.2%) do not engage in other occupations, while some were involved in trading (14.0% of EPFF, 16.9% of CTFF) and civil service (16.3% of EPFF, 11.7% of CTFF). This implies that fish farming was the primary occupation of the sampled fish farmers. This is attributable to the fact that the aquaculture enterprise has been considered profitable; hence, fish farming plays significant roles in the lives of the fish farmers as a primary means of livelihood, employment generation, source of quality protein, and wealth creation.

Fish farming characteristics of the fish farmers

The results of the fish farming characteristics of EPFF and CTFF are presented in Table 2. It reveals that the majority of EPFF (74.4%) and CTFF (63.6%) have working experiences lesser than ten years, with mean working experience of 9.35±3.86 and 10.56±5.22 years, respectively. This means that the sampled fish farmers have been in the business for substantial years, with those using concrete tanks being slightly more experienced than those using earthen ponds. Being in the business for about ten years implies that fish farming is profitable, though with some inherent challenges. This agrees with Olaoye *et al*. (2014), who opined that fish farmers with the highest years of experience possessed good skills and better approaches to fish production and management practices.

The type of feed used by EPFF was 58.1%, and most of CTFF (72.7%) were floating feeds. This suggests that the fish farmers preferred floating over sinking feeds, which means that the accumulation of feeds at the bottom of the rearing facilities is minimized, thereby reducing the pollution of culture water. Also, 69.8% of EPFF and 51.9% of CTFF had pond numbers ranging between 6 and 10, with the dimension of 30 x 60 ft for all (100%) of EPFF and 24 x 16 x 6ft for 40.8% of CTFF. The mean pond number of 7 and 10 for EPFF and CTFF, respectively is indicative that concrete tank fish farmers were operating almost double the number of ponds than those using the earthen ponds. This could be attributed to further findings of this study which indicated that earthen ponds were generally larger in dimension than concrete tanks. The stocking densities of 65.1% of EPFF were 2001-4000, while 59.7% of CTFF stocked less than 2000.

Table 1: Socio-economic characteristics of fish farmers using earthen ponds and concrete tanks

Socio-economic Variables	Categories	Earthen pond fish farmers (n = 43)		Concrete tank fish farmers (n = 77)	
		Frequency	Percentage	Frequency	Percentage
Age (years)	≤ 30	0	0.0	4	5.2
	31 – 40	14	32.6	25	32.5
	41 – 50	21	48.8	20	26.0
	> 50	8	18.6	28	36.4
	Mean ± SD	44.11 ± 7.33		45.52 ± 9.79	
Sex	Male	37	86.0	67	87.0
	Female	6	14.0	10	13.0
Marital status	Single	1	2.3	8	10.4
	Married	42	97.7	69	89.6
Household size	1 – 3	13	30.2	12	15.6
	4 – 6	18	41.9	36	46.8
	> 6	12	27.9	29	37.7
	Mean ± SD	5.0 ± 2.0		6.0 ± 2.0	
Years spent in school	0	1	2.3	1	1.3
	1 – 5	0.0	0.0	1	1.3
	6 – 10	11	25.6	8	10.4
	11 – 15	26	60.5	47	61.0
	> 15	5	11.6	20	26.0
	Mean ± SD	12.0 ± 3.21		13.0 ± 3.23	
Membership in cooperative societies	Member	42	97.7	75	97.4
	Non-member	1	2.3	2	2.6
Educational attainment	No formal	1	2.3	1	1.3
	Primary	3	7.0	5	6.5
	Secondary	22	51.2	27	35.1
	Tertiary	17	39.5	44	57.1
Other occupations	Consultancy	0	0.0	5	6.5
	Crop farming	3	7.0	1	1.3
	Artisans	3	7.0	8	10.4
	Trading	6	14.0	13	16.9
	Civil service	7	16.3	9	11.7
	None	24	55.7	41	53.2

Source: Field Survey (2021)

The culture period for most of EPFF (60.5%) and CTFF (50.6%) was four months with three production cycles annually. It was further shown that commercial hatcheries were the source of fish seeds for the majority of the fish farmers using earthen ponds (81.4%) and concrete tanks (72.7%). The implication is that majority of both EPFF and CTFF purchased fish seeds from commercial hatcheries. Olaoye *et al*. (2014) reported similar findings and linked the patronage of reputable commercial hatcheries to the fact that fish seeds from this source are healthier and well-bred. Olaoye *et al*. (2016) also reported in their study that fish seeds were commonly sourced from known hatcheries within southwest Nigeria.

The source of water for the majority (90.7%) of EPFF was stream/river water, while 96.2% of CTFF uses boreholes as the primary water source. This result indicated that while the earthen pond fish farmers primarily sourced water from streams/rivers, their counterparts using concrete tanks used boreholes. This could be attributed to earthen ponds being mostly sited close to perennial water sources such as rivers and streams, while concrete tanks could be sited anywhere. This could mean that the water source for fish farming is mostly a function of the medium of rearing fish, and suggests that water source and quality are important variables when selecting the site for fish farming. This is expected to affect the cost of fish production, which in turn affects the profitability of the business venture due to the additional cost of drilling and maintaining boreholes as well as the costs of fueling the pump.

Credit sources are another important factor that affects productivity as it directly relates to the scale of production. Results show that 72.1% of EPFF and 83.1% of CTFF indicated personal savings as a source of their finance meaning that personal savings were the main source of financing the fish farming enterprises irrespective of the rearing facilities. This implies that the fish farmers in Ikorodu LGA still relied on informal finance sources such as personal savings, which will likely limit their chances of business expansion. The studies of Omobepade *et al*. (2015) and Olaoye *et al*. (2017) also stressed the importance of personal savings to fish farmers. Probable explanations for the low patronage of formal financial institutions such as commercial banks and cooperative societies include the high-interest rates, bureaucratic bottlenecks, and limited financial inclusion of agriculture-based enterprises such as fish farming.

Profit analysis of fish farming

Results on the cost and returns analyses of fish farming using earthen ponds and concrete tanks are presented in Table 3. It indicates that EPFF earned an average of N8,611,046.50 while CTFF earned an average of N6,387,896.10 as total revenue, with gross margins being N4,229,751.10 and N1,956,991.10 for EPFF and CTFF respectively. Also, the total costs for EPFF and CTFF were N4,617,567.70 and N4,690,256.40, respectively, with the costs of feed accounting for 88.6% and 88.9% of total costs of production using earthen ponds and concrete tanks, respectively. These are indications that using concrete tanks requires higher costs probably accounted for by the dependence on boreholes and associated costs with maintenance. However, earthen ponds gave a higher return in terms of revenue generated from fish farming.

Also, the net fish farming incomes were N3,993,479.07 and N1,697,639.7 for EPFF and CTFF, respectively, while the benefit-cost ratios were 1.86 and 1.36, respectively. The returns on investment were 0.86 and 0.36 for EPFF and CTFF, respectively. Positive values of gross margins and net profits indicated that fish farming using either earthen ponds or concrete tanks was profitable, with earthen ponds yielding higher profitability ratios. Previous findings (Tunde *et al*., 2015; Alawode *et al*., 2016) also reported benefit-cost ratio (BCR) values of greater than 1.00. However, findings from the current study contradicted those from the study of Ekine *et al*. (2019) in Rivers State, Nigeria, which established that fish farming using both concrete tanks and earthen ponds was not profitable as costs of production were higher than the accrued revenues.

Table 2: Fish farming characteristics of fish farmers using earthen ponds and concrete tanks

Fish farming characteristics	Response categories	Earthen pond fish farmers (n = 43)		Concrete tank fish farmers (n = 77)	
		Frequency	Percentage	Frequency	Percentage
Fish farming experience (years)	< 10	32	74.4	49	63.6
	11 – 20	11	25.6	23	29.9
	> 20	0	0.0	5	6.5
	Mean ± SD	9.35 ± 3.86		10.56 ± 5.22	
Type of feed	Sinking	0.0	0.0	1	1.3
	Floating	25	58.1	56	72.7
	Both	18	41.9	20	26.0
Number of ponds	< 5	9	81.8	2	2.6
	6 - 10	30	69.8	40	51.9
	11 - 15	4	9.3	21	27.3
	>15	0.0	0.0	14	18.2
	Mean ± SD	7.0 ± 2.54		12.0 ± 4.89	
Sources of fish seeds	Own hatchery	8	18.6	21	27.3
	Commercial hatchery	35	81.4	46	72.7
Sources of water	Borehole	3	7.0	74	96.1
	Deep well	1	2.3	3	3.9
	Stream/river	39	90.7	0	0.0
Source of finance	Commercial banks	5	11.6	2	2.6
	Personal savings	31	72.1	64	83.1
	Thrifts	7	16.3	9	11.7
	Cooperative societies	0	0.0	2	2.6
Pond size	20x10x5ft	0.0	0.0	21	27..3
	20x24x6ft	0.0	0.0	8	10.4
	24x16x6ft	0.0	0.0	49	40.8
	30x60ft	43	100.0	0.0	0.0
Stocking density (fingerlings)	≤2000	9	20.9	46	59.7
	2001 - 4000	28	65.1	31	40.3
	> 4000	6	14.0	0.0	0.0
Culture period (months)	3 months	15	34.9	38	49.4
	4 months	26	60.5	39	50.6
	6 months	2	4.7	0.0	0.0
Production cycles per year	2	3	7.0	2	2.6
	3	26	60.5	38	49.4
	4	14	32.6	37	48.1

Source: Field Survey (2021)

Table 3: Cost-return structure of earthen pond and concrete tanks production systems

	Earthen pond		Concrete tank	
Cost items	**Cost (N)**	**% of TC**	**Cost (N)**	**% of TC**
Variable items				
Feed	4090041.9	88.6	4169155.8	88.9
Fingerlings	236337.2	5.1	184259.7	3.9
Labour (temporary)	9604.7	0.2	5868.4	0.1
Medication	4802.3	0.1	6240.3	0.1
Fuel	6974.4	0.2	17640.6	0.4
Transportation	21302.3	0.5	23772.7	0.5
Water treatment	-	-	1019.5	0.02
Electricity	465.1	0.01	14480.5	0.3
Maintenance	11767.4	0.3	8467.5	0.2
Total variable cost (TVC)	4,381,295.4	94.88	4,430,905.0	94.47
FIXED items				
Land (Purchase/Rent)	79000	1.7	115220.3	2.5
Depreciation on buildings/ shed	-	-	48.7	0.001
Depreciation on pond construction/ rent	3488.3	0.08	3051.9	0.07
Depreciation on Plumbing and drainage	3534.9	0.08	2818.1	0.06
Depreciation on Generator	13011.6	0.3	23850.0	0.5
Depreciation on Tank (Storex)	-	-	48.7	0.001
Depreciation on Tank stand	-	-	25.3	0.0005
Depreciation on Scoop net/dragnet	4802.3	0.1	2837.7	0.06
Depreciation on Weighing scale	6202.3	0.1	6292.2	0.1
Other (basins, bowls etc.)	3814.0	0.1	3015.6	0.06
Permanent labour	115814.0	2.5	97402.6	2.1
Security	6604.7	0.1	4740.3	0.1
Total fixed cost (TFC)	236,272.3	5.12	259,351.4	5.53
Total cost	4,617,567.7		4,690,256.4	
Total revenue (TR)	8,611,046.5		6,387,896.1	
Gross margin (GM)	4,229,751.1		1,956,991.1	
Net fish farming income (NFFI)	3,993,478.8		1,697,639.7	
Benefit Cost Ratio (BCR)	1.86		1.36	
Return on investment (ROI)	0.86		0.36	

Source: Field Survey (2021)

Constraints faced by fish farmers using earthen ponds and concrete tanks

The mean severity of the constraints encountered by fish farmers using earthen ponds and concrete tanks is presented in Table 4. It reveals that fish farmers using earthen ponds and concrete tanks are considered to have a high cost of feed ($\bar{x}$ = 2.60; $\bar{x}$ = 2.56), high cost of transportation ($\bar{x}$ = 2.12; $\bar{x}$ = 2.16), and inadequate capital ($\bar{x}$ = 1.98; $\bar{x}$ = 1.66) as the most severe constraints to their fish farming activities in descending order.

Also, predators ($\bar{x}$ = 1.70), flooding ($\bar{x}$ = 1.65), water pollution ($\bar{x}$ = 1.63) and poaching ($\bar{x}$ = 1.53) were considered as additional severe constraints to earthen pond fish farmers. Other constraint items presented in Table 4 were not considered severe constraints to fish farmers using either the earthen ponds or concrete tanks, as the mean values were lower than 1.50. This suggests that the high cost of feed, transportation, and inadequate capital were the most severe constraints to fish farming using both concrete tanks and earthen ponds. Additionally, the

constraints of earthen pond fish farming were poaching /theft, predators, flooding, and water pollution. Earlier studies (Olaoye *et al*., 2014; Omobepade *et al*., 2015) also reported that feed cost gulped the bulk of production cost in fish farming enterprises. Findings from this study further indicated that earthen pond fish farming was more constrained than concrete tank fish farming.

Table 4: Mean severity of constraints experienced by the earthen pond and concrete tank fish farmers

Constraints	Earthen pond		Concrete tank	
	Mean	Rank	Mean	Rank
High cost of feed	2.60	1st	2.56	1st
High cost of transportation	2.12	2nd	2.16	2nd
Inadequate capital	1.98	3rd	1.66	3rd
Predators	1.70	4th	0.17	15th
Flooding	1.65	5th	0.06	16th
Poaching and theft	1.63	6th	0.57	12th
Water pollution	1.53	7th	0.27	14th
Unfavourable climatic conditions	1.49	8th	0.83	11th
Poor marketing channel	1.26	9th	1.06	4th
Disease outbreaks	1.07	10th	0.92	8th
Mortality	1.07	10th	1.03	5th
Poor quality of fish seed	1.02	12th	0.91	10th
Poor quality of feed	1.00	13th	0.92	8th
Scarcity of fish seed	1.00	13th	0.94	7th
Scarcity of fish feed	0.93	15th	0.95	6th
Environmental impact consideration	0.67	16th	0.47	13th

Source: Field Survey (2021)

Test of differences in the production characteristics of the earthen pond and concrete tank fish farmers

Results of the independent t-test on the difference in production variables of CTFF and EPFF are presented in Table 5. It reveals that there were significant differences in the number of ponds ($t = 5.71$, $p \leq 0.01$) and stocking density ($t = 6.36$, $p \leq 0.01$). But no significant difference in the production cycle per year ($t = 1.86$, $p > 0.05$). This illustrated that the number of fish ponds operated by concrete tank fish farmers was significantly higher than the number of ponds operated by earthen pond fish farmers, but that earthen pond fish farmers had significantly higher stocking density than those using concrete tanks.

Table 5: Student-t test results on differences in selected production characteristics

Production characteristics	Culture systems	Mean	Standard deviation	Mean Difference	t– value	p-value
Number of ponds	Earthen pond	7.0	3.0	4.57	5.71	0.001
	Concrete tank	12.0	2.0			
Stocking density	Earthen pond	3140.0	947.0	873.30	6.36	0.001
	Concrete tank	2266.0	560.0			
Production cycles per year	Earthen pond	3.0	0.581	0.20	1.86	0.072
	Concrete tank	3.0	0.551			

Source: Analyzed from Field Survey (2021)

Test of differences in the profitability of fish farming using earthen ponds and concrete tanks

Results of the independent t-test on the difference in the profitability of CTFF and EPFF are presented in Table 6. It reveals that there were significant differences in the net profits ($t = 3.972$, $p \leq 0.01$) and gross margins ($t = 3.827$, $p \leq 0.01$) realized from earthen ponds and concrete tanks. The findings indicated that the net profits and gross margins of the fish farmers using earthen ponds were significantly higher than those using concrete tanks. The higher profitability of earthen ponds could be linked to the availability of zooplankton and phytoplankton in the natural environment. Rearing fish in earthen tanks is more technically efficient than using concrete tanks. This is in tandem with the findings of Adeogun *et al*. (2014), who established that earthen ponds were more technically efficient than concrete tanks. Olaoye *et al*. (2014) also established that aquaculture was more profitable in earthen ponds than in concrete tanks.

Table 6: Student-t test results on differences in profitability of fish farming using earthen ponds and concrete tanks

	Culture system	Mean	Standard deviation	Mean Difference	t-value	p-value
Net fish farming income	Earthen pond	3,993,478.80	426,973.53	2295839.10	3.972	0.001
	Concrete tank	1,697,639.70	192,978.66			
Gross margin	Earthen pond	4,229,751.1	363,692.09	2272760.10	3.827	0.001
	Concrete tank	1,956,991.10	200,845.57			

Source: Analyzed from Field Survey (2021)

4. CONCLUSION AND RECOMMENDATION

The study concludes that fish farming is a profitable investment among fish farmers in Lagos State. Although using earthen ponds is more severely constrained, it is more profitable than using concrete tanks. Hence, the earthen pond culture system is economically better than concrete tank culture systems. Based on the findings from this study, it was suggested that

more of the youth population, irrespective of gender should be encouraged by all stakeholders to engage in fish farming, through the provision of incentives, as this will ensure the sustainable fish production by replacing the ageing population; fish farmers are advised to engage in additional income-earning activities as means of diversifying their livelihood; locally available feed ingredients should be used in compounding fish feeds that will be cost-effective in order to reduce the feed cost which accounted for the highest proportion of the total cost of production; fish farmers should employ the services of security personnel on the farms in order to minimize poaching/theft of fish; good feeder roads which are motorable should be provided by the government as this has the tendency to reduce cost of transportation to and from fish farms; access to formal financial sources (commercial banks, cooperative societies, etc.) should be enhanced by providing credit facilities at low interest rate and less cumbersome procedure; and new entrants into fish farming are encouraged to make use of earthen ponds as they are profitable than concrete tanks.

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