RETURNS TO SCALE AND PRODUCTION CONSTRAINTS IN CULTURED FISH FARMING IN OSUN STATE, NIGERIA

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ABSTRACT
Cultured fish farming contributes significantly to food security, employment generation, and fish import substitution in Nigeria. However, variations in resource-use efficiency and production constraints continue to affect farmers' productivity. This study examined the production elasticities, returns to scale, and production constraints of cultured fish farming in Osun State, Nigeria. A multistage sampling technique was used to select 120 cultured fish farmers from six Local Government Areas (LGAs) across the three Agricultural Development Programme (ADP) zones. Primary data were collected using structured questionnaires and analysed using the Cobb–Douglas production function and descriptive statistics. The results revealed that labour, feed quantity, fingerlings, and depreciation positively influenced fish output, although their elasticities varied across the LGAs. Feed elasticity ranged from 0.0190 to 0.0794, fingerlings from 0.0229 to 0.0576, and depreciation from 0.0179 to 0.6504. Farmers in Iwo, Ejigbo, and Obokun operated under decreasing returns to scale, whereas those in Ife Central, Olorunda, and Osogbo exhibited increasing returns to scale. Major production constraints included high feed costs, limited access to credit, inadequate extension services, disease outbreaks, poor access to quality fingerlings and unstable market prices. The study concludes that cultured fish farming in Osun State exhibits varying production efficiencies across the selected LGAs. Labour, feed quantity, fingerlings, and depreciation were the major determinants of fish output, while farmers in Ife Central, Olorunda, and Osogbo exhibited greater potential for output expansion under increasing returns to scale compared with those in Iwo, Ejigbo, and Obokun, who operated under decreasing returns to scale. This study recommends improving resource-use efficiency in areas with decreasing returns to scale while promoting investment, affordable credit, reduced feed costs, and strengthened extension services to enhance productivity and sustainable aquaculture development.

Keywords: R*eturns to scale; Elasticity of production; Total cost elasticity; Production constraints; Cultured fish farming*

INTRODUCTION
Aquaculture has become one of the fastest-growing food production sectors globally and is increasingly recognized as a sustainable pathway for improving food security, generating employment, reducing poverty, and easing pressure on declining capture fisheries. Global aquaculture production has continued to expand steadily, and for the first time, aquaculture has surpassed capture fisheries in supplying aquatic animals for human consumption, highlighting its growing importance in ensuring global food security and nutrition (FAO, 2024).

In Nigeria, fish remains one of the most affordable and important sources of high-quality animal protein, yet domestic production continues to fall far below national demand. Current estimates indicate that Nigeria produces approximately 1.2 million metric tonnes of fish annually against an estimated national demand of about 3.6 million metric tonnes, leaving a substantial deficit that is largely met through imports. This persistent supply gap has intensified government efforts to promote aquaculture as a strategic sector to increase domestic fish production, reduce import dependence, conserve foreign exchange, and improve rural livelihoods (FAO, 2024; Food & Beverage West Africa, 2025).

Among the various aquaculture enterprises in Nigeria, cultured fish farming has emerged as one of the most commercially viable agricultural enterprises because of its relatively short production cycle, increasing consumer demand, attractive returns on investment, and growing contribution to household income and employment. Nigeria remains the second-largest aquaculture producer in Africa and the continent's leading producer of African catfish (*Clarias gariepinus*), reflecting the strategic importance of cultured fish farming in the country's agricultural transformation agenda (Ayinla et al., 2023). Furthermore, recent studies indicate that Nigeria's aquatic food value chains are expanding rapidly in response to increasing urban demand, commercialization, and private-sector investments, creating new opportunities for fish producers across the country (Liverpool-Tasie et al., 2024). Osun State has experienced considerable growth in cultured fish farming over the past decade due to favourable agro-ecological conditions, expanding urban markets, and increasing participation by private investors and small-scale entrepreneurs. Previous empirical studies conducted in the state have established that fish farming is economically viable and profitable (Busari, 2018; Kehinde, 2022). However, profitability alone does not necessarily indicate efficient resource utilization or long-run sustainability. Farms may generate positive profits while operating below or above their economically optimal production scale. Consequently, sustainable growth in aquaculture requires understanding not only whether fish farming is profitable but also whether farmers are utilizing production resources at an optimal scale and identifying the constraints preventing them from achieving greater productivity.

Returns to scale (RTS) is a fundamental concept in production economics that measures the responsiveness of output to a proportional change in all production inputs. The concept provides valuable information for determining whether producers should expand, maintain, or reduce their scale of operation. Farms operating under increasing returns to scale can increase productivity by expanding resource use, whereas decreasing returns to scale indicate diminishing output gains from further increases in input use. Consequently, estimating RTS provides important evidence for production planning, investment decisions, and policy formulation to improve production efficiency and resource allocation in the aquaculture sector (Abbas et al., 2025).

Despite the growing importance of aquaculture in Nigeria, empirical evidence on returns to scale remains inconsistent across production environments, suggesting that production behaviour is highly location-specific. Differences in management practices, input prices, technology adoption, market access, and institutional support contribute to variations in production performance across states. At the same time, fish farmers continue to face numerous production constraints, including escalating feed costs, inadequate access to credit, poor-quality fingerlings, disease outbreaks, weak extension services, and insecurity. These constraints reduce production efficiency and may prevent farmers from expanding to economically optimal production scales (Abe & Agbugui, 2023; FAO, 2024).

In Osun State, previous studies have focused primarily on enterprise profitability, costs and returns, and technical efficiency (Busari, 2018; Kehinde, 2022), with little empirical attention to returns to scale and the production constraints that influence farmers' scale decisions. Consequently, there is limited evidence on whether cultured fish farmers in the state are operating below, at, or beyond their optimal production scale, and on the severity of the constraints that limit efficient resource use across production locations. This information gap limits farmers' ability to make informed expansion decisions and constrains policymakers' ability to design targeted interventions to improve aquaculture productivity and competitiveness.

Against this background, this study examines returns to scale and production constraints in cultured fish farming in Osun State, Nigeria. Specifically, the study estimates the returns to scale in cultured fish production and identifies and ranks the major production constraints facing fish farmers. The findings are expected to enrich the literature on aquaculture production economics and provide evidence to inform the design of policies and interventions that promote efficient resource allocation, sustainable farm expansion, and increased domestic fish production, thereby supporting Nigeria's food security and agricultural transformation agenda.

Objectives of the Study

Specifically, the study sought to

(i) estimate the elasticity of production and returns to scale of cultured fish production across six LGAs in Osun State, and

(ii) identify and rank the constraints faced by fish farmers in each LGA studied.

METHODOLOGY

Study Area and Sampling Procedure and Sample size

Osun State was carved out of Oyo State on 27 August 1991, with Osogbo as the state capital. It has a land area of approximately 14,875 km² (Government of Osun State, 2024). A three-stage sampling procedure was used: three ADP zones (Iwo, Osogbo, Ife/Ijesha) were purposively selected, two LGAs were randomly selected from each zone (Iwo and Ejigbo; Olorunda and Osogbo; Ife-Central and Obokun), and one community each were randomly selected within each LGA, yielding a total of six (6) communities for the study.

Twenty (20) fish farmers were randomly sampled from each community, yielding a total of 120 respondents for the study, as shown in Table 1. Primary data on input use, production output, and perceived constraints were collected via a structured questionnaire.

Data Analysis

Descriptive statistics (frequencies, percentages, means) were used to ascertain the socioeconomic characteristics of respondents (including age, education, gender, marital status, pond size, farming experience, income source, financing, cooperative membership, and credit access) and the constraints faced by cultured fish farmers in the study area.

Inferential statistics (Cobb–Douglas production function) were used to determine the elasticity of production and the return to scale. This was estimated in logarithmic form as:

$$InY_{\mathrm{i}} = \beta_0 + \beta_1 In(X_1) + \beta_2 In(X_2) + \beta_3 In(X_3) + \beta_4 In(X_4) + \beta_5 In(X_5) + \beta_6 In(X_6) + \beta_7 In(X_7) + V_i - U_i \ldots\ldots\ldots\ldots\ldots\ldots 2)$$

Where: i =1…n

Y_i = cultured fish production output (kg)
X_1 = rent on pond (m^2)
X_2 = labour in Man-hours (man-hours)
X_3 = quantity of feed used (kg)
X_4 = unit of fingerlings stocked
X_6 = depreciated cost of equipment (Naira)
In = Natural Logarithm (i.e. Log to base e).

The maximum likelihood estimation of the stochastic production function provides estimators for β's variance parameters ($\sigma^2 = \sigma u^2 + \sigma v^2$), gamma ($\gamma$), which is equal to $\sigma u^2/\sigma^2$ and lambda (γ) = $\sigma u/\sigma v$. The parameter gamma (γ) has a value between zero and one (Battese and Tessama, 1993). According to Battese and Corra (1977), gamma (γ) is the total output made on the frontier function which is attributed to technical efficiency. Similarly, (1- γ) measures the technical inefficiency of the firms. The parameter lambda (γ) is expected to be greater than one. Such a result according to Tadesse and Krishnamoorty (1997) indicates a good fit for the model and the correctness of the specified distributional assumptions for V_i and U_i. The distribution of the inefficiency term is very important to the estimation of the models.

Returns to Scale (RTS) was estimated as the sum of the estimated output elasticities of the production inputs obtained from the fitted Cobb–Douglas production function (Nicholson & Snyder, 2021; Varian, 2014). The estimated RTS was used to determine the production stage and the scale characteristics of cultured fish farming. Following production economic theory, the Total Cost Elasticity of Production (TCEP) was computed as the inverse of the estimated returns to scale coefficient:

The Total Cost Elasticity of Production (TCEP) is computed as:

TCEP = 1 / RTS …………………………………………………………………..… (3)

The relationship between RTS and TCEP provides useful information on the production stage, cost behaviour, and the appropriate scale of operation for cultured fish farms. The empirical implications are interpreted as follows:

- RTS > 1 (Increasing Returns to Scale): A proportional increase in all production inputs results in a more than proportional increase in output. (Coelli et al., 2005).
- RTS = 1 (Constant Returns to Scale): A proportional increase in all production inputs leads to an equivalent proportional increase in output. (Nicholson & Snyder, 2021).
- RTS < 1 (Decreasing Returns to Scale): A proportional increase in all production inputs produces a less than proportional increase in output. (Coelli et al., 2005).

RESULTS AND DISCUSSION

Socioeconomic Characteristics of Cultured Fish Farmers

Table 2 reveals the socioeconomic characteristics of cultured fish farmers in the study area. The estimated mean age of cultured fish farmers ranged from 40.0 years in Iwo and Osogbo to 47.0 years in Ejigbo, indicating that fish farming in the study area was dominated by economically active middle-aged farmers. This age group possesses the physical capacity and managerial experience required for aquaculture production and is generally more willing to adopt improved production practices. This finding agrees with Falola et al. (2022) and Fregene and Ojo (2023), who reported that age significantly influences aquaculture productivity and technology adoption. Educational attainment was generally high, with 85–95% of respondents in most LGAs having tertiary education. This suggests that the farmers are well positioned to understand improved management practices, adopt new technologies, and effectively utilize extension services. Similar findings were reported by Issa et al. (2022), who identified education as an important factor influencing aquaculture development in Nigeria.

Male farmers dominated cultured fish production (75–90%), while female participation remained relatively low (10–25%). In addition, the majority of respondents were married (55–75%), indicating the availability of family support for farm operations and greater commitment to income-generating activities. These findings are consistent with Falola et al. (2022), who observed that Nigerian aquaculture is largely male-dominated and that household characteristics influence farm performance. Most respondents operated small to medium-sized ponds (51–100 m^2), reflecting the predominantly small-scale nature of cultured fish production in the study area. Furthermore, the majority had three or more years of farming experience, with many farmers in Ejigbo, Obokun, and Olorunda having over five years. This level of experience is expected to improve managerial skills and production efficiency, supporting the findings of Fregene and Ojo (2023) that farming experience enhances the adoption of improved aquaculture technologies and overall farm performance.

Species Cultured and Source of Fingerlings

Table 3 presents species and source of fingerlings among fish farmers in Osun State. Clarias (African catfish) was the dominant species in every LGA, cultured by 55% of respondents in Iwo and as much as 75% in Osogbo, consistent with its fast growth, disease tolerance and strong market acceptance (Ige and Kolapo, 2023; Exe and Nwosu, 2023). Heterobranchus was cultured only in Iwo, Olorunda and Osogbo (25–45%), while the Clarias–Heterobranchus hybrid, valued for faster growth and higher survival, appeared only in Ejigbo, Ife Central and Obokun (30% each), and Tilapia was cultured by a small minority in three LGAs only. No LGA reported cultivating Salmon, mackerel, or other species, confirming limited species diversification across the study area and a degree of exposure to disease or price shocks specific to catfish-type species.

For fingerling sourcing, breeders and hatcheries together accounted for at least 95% of the supply in every LGA, with breeders dominant in Ejigbo (70%) and Ife Central (75%), and hatcheries dominant in Iwo, Obokun, and Osogbo (60% each). Olorunda was the only LGA where farmers also sourced fingerlings from the wild (10%) or from other farms (10%), indicating a marginally less commercialised input-supply structure there than in the other five LGAs. This pattern reflects a broader shift in Osun State's aquaculture subsector from informal to more organised, commercial input systems (Ajala *et al.,* 2017).

Table 3: Fish Species Cultured and Source of Fingerlings/Juveniles by LGA

Item	Iwo	Ejigbo	Ife Cent.	Obokun	Olorunda	Osogbo
Clarias (No. / %)	11 (55%)	12 (60%)	12 (60%)	13 (65%)	12 (60%)	15 (75%)
Heterobranchus (No. / %)	9 (45%)	0 (0%)	0 (0%)	0 (0%)	8 (40%)	5 (25%)
Clarias–Heterobranchus hybrid	0 (0%)	6 (30%)	6 (30%)	6 (30%)	0 (0%)	0 (0%)
Tilapia	0 (0%)	2 (10%)	2 (10%)	1 (5%)	0 (0%)	0 (0%)
Total respondents	20 (100%)	20 (100%)	20 (100%)	20 (100%)	20 (100%)	20 (100%)
Source: Breeders	8 (40%)	14 (70%)	15 (75%)	8 (40%)	8 (40%)	8 (40%)
Source: Fish hatcheries	12 (60%)	5 (25%)	4 (20%)	12 (60%)	8 (40%)	12 (60%)
Source: Wild	0 (0%)	1 (5%)	0 (0%)	0 (0%)	2 (10%)	0 (0%)
Source: Other farms	0 (0%)	0 (0%)	1 (5%)	0 (0%)	2 (10%)	0 (0%)
Total respondents	20 (100%)	20 (100%)	20 (100%)	20 (100%)	20 (100%)	20 (100%)

Source: Field Survey, 2025.

Elasticity of Production

Table 4 presents the estimated output elasticities of the major production inputs across the six Local Government Areas (LGAs). The results show that all production inputs exerted positive effects on cultured fish output, although the magnitude of their contributions varied across locations. Feed recorded the highest elasticity across most LGAs (0.180–0.290), confirming that it is the most important input variable in cultured fish production. Labour also contributed positively to output, with elasticity values ranging from 0.105 in Obokun to 0.175 in Osogbo. Similarly, fingerlings (0.130–0.190) and pond rent (0.205–0.315) positively influenced fish production, indicating that adequate stocking and access to suitable production facilities are essential for increasing output.

Capital input, represented by depreciation, showed elasticity values ranging from 0.110 in Iwo to 0.195 in Ife Central, suggesting that investment in production infrastructure contributes to higher fish output. Overall, the positive elasticities imply that increasing the use of these production inputs enhances fish production; however, the relatively larger elasticity values associated with feed indicate that improvements in feeding practices are likely to yield the greatest gains in productivity across the study area.

Returns to Scale and Total Cost Elasticity

Table 4, which estimated returns to scale (RTS), revealed mixed production conditions across the study area. Fish farmers in Iwo (0.800), Ejigbo (0.775), and Obokun (0.790) operated under decreasing returns to scale (DRS), indicating that a proportional increase in all production inputs would result in a less-than-proportional increase in fish output. This suggests that farmers in these LGAs have reached the rational stage of production (Stage II), where improvements in productivity should focus on efficient resource allocation and better management practices rather than indiscriminate increases in input use. In contrast, farmers in Ife Central (1.035), Olorunda (1.085), and Osogbo (1.135) operated under increasing returns to scale (IRS), implying that proportional increases in production inputs would generate more-than-proportional increases in fish output. These farmers therefore possess opportunities to profitably expand production through improved investment and efficient utilization of production resources.

The Total Cost Elasticity of Production (TCEP) further supports these findings. TCEP values were greater than unity in the DRS LGAs (1.250–1.290), indicating that production costs increase proportionately faster than output when input use is expanded beyond the current scale. Conversely, TCEP values below unity in Ife Central (0.966), Olorunda (0.922), and Osogbo (0.881) indicate economies of scale, suggesting that production expansion in these LGAs can improve productivity and profitability. These findings are consistent with the cost-and-return analysis, which showed that cultured fish farming is economically viable across the study area and highlighted the need for location-specific production strategies. Farmers operating under DRS should prioritize improving technical efficiency and optimizing input combinations, whereas those operating under IRS should be encouraged to expand production by investing more in productive inputs and adopting improved production technologies. Similar conclusions have been reported by Adewuyi et al. (2024) and Ogunniyi et al. (2023), who emphasized that efficient resource allocation and scale-appropriate investment are critical for improving aquaculture productivity and profitability.

Constraints to Cultured Fish Production

Table 5 indicates that feed-related constraints were the most important challenges affecting cultured fish production across the three ADP zones. High feed cost recorded strong agreement among 60.0%, 70.0%, and 65.0% of respondents in the Iwo, Ife/Ilesha, and Osogbo ADPs, respectively, while inadequate feed supply attracted 50.0–62.5% strong agreement. This confirms that feed remains the largest production cost and a major determinant of aquaculture profitability, consistent with the findings of Olaoye et al. (2020) and FAO (2024).

The severity of other constraints varied across the ADP zones. Disease and pest infestation were most pronounced in the Ife/Ilesha ADP (75.0% strongly agreed), whereas land and water availability were more severe in the Iwo and Osogbo ADPs (both 62.5% strongly agreed). Climate change (47.5–55.0%) and inadequate funding (37.5–55.0%) were also important constraints, indicating that environmental and financial limitations continue to affect fish production. These findings corroborate Ogunniyi et al. (2022) and Adeosun et al. (2023), who identified high input costs, inadequate finance, and poor institutional support as major constraints to sustainable aquaculture development in Nigeria. Consequently, improving access to affordable credit, quality feed, extension services, and fish health management is essential for enhancing fish productivity in the study area.

CONCLUSION AND RECOMMENDATIONS

This study examined the returns to scale and production constraints in cultured fish farming across six Local Government Areas (LGAs) in Osun State, Nigeria. The results showed that the average age of the fish farmers was approximately 43 years, indicating that cultured fish farming is dominated by economically active individuals capable of adopting improved production technologies. The majority of the farmers were married, had tertiary education, operated medium-sized ponds (51–100 m^2), possessed between three and five years of fish farming experience, and primarily cultured *Clarias* species sourced from commercial hatcheries and breeders. These characteristics suggest a relatively commercialized aquaculture sector with good prospects for productivity improvement.

The returns-to-scale analysis revealed variations in production performance across the study area. Farmers in Iwo, Ejigbo, and Obokun operated under decreasing returns to scale, implying that additional increases in production inputs generated less-than-proportional increases in output, while farmers in Ife Central, Olorunda, and Osogbo exhibited increasing returns to scale, indicating opportunities for efficient expansion through increased investment in productive resources. These findings demonstrate that production efficiency and optimal scale differ across locations, emphasizing the need for location-specific production strategies.

The study also identified inadequate finance, high feed costs, disease and pest infestation, weak extension services, climate change, insecurity, and limited access to land and water resources as the major constraints affecting cultured fish production.

Overall, improving input-use efficiency, expanding access to affordable production resources, and addressing these production constraints are essential for enhancing aquaculture productivity, increasing fish supply, improving farmers' incomes, and strengthening food security in Osun State and Nigeria at large. Based on the findings of this study, the following recommendations are made:

1. Farmers in Iwo, Ejigbo, and Obokun should prioritize improving input-use efficiency through better feed management, stocking density, and labour utilization, while farmers in Ife Central, Olorunda, and Osogbo should be encouraged to expand production since they still operate under increasing returns to scale.

2. Government and financial institutions should establish affordable credit schemes specifically for aquaculture farmers to improve access to quality inputs, modern production technologies, and capital for farm expansion.

3. Efforts should be intensified to reduce fish feed costs by promoting local feed production and encouraging the use of alternative, nutritionally balanced feed ingredients.

4. The Osun State Agricultural Development Programme (ADP) should strengthen extension services by providing regular training for farmers in improved fish production practices, disease control, climate-smart aquaculture, and efficient resource management.

5. Investment in certified hatcheries and fish health management programmes should be encouraged to ensure the availability of quality fingerlings and reduce production losses associated with diseases and poor seed quality.

6. Policies aimed at improving market access, stabilizing fish prices, and enhancing rural infrastructure should be implemented to improve the profitability and sustainability of cultured fish farming in the state.

These recommendations will enhance production efficiency, facilitate the sustainable expansion of cultured fish farming, and strengthen aquaculture's contribution to employment generation, income improvement, and food and nutritional security in Nigeria.

REFERENCES

Abbas, A. M. (2015). Economic analysis of fish farming and its contribution to household poverty alleviation in Akure South and Owo local government areas of Ondo State, Nigeria. MSc thesis, Department of Agricultural Economics, Ahmadu Bello University, Zaria.

Abbas, A. M., Aiyedun, E. A., Ebukiba, E. S., Otitoju, M. A., Iduseri, E. O., Olutumise, A. I., Adole, S. O., & AGBbonika, D. A. (2025). Technical efficiency and profitability analysis of catfish farming in Ondo State, Nigeria. *Journal of Agricultural Science and Environment, 25*(3), 39–56.

Abe, G. O., &Agbugui, M. O. (2023). Reoccurring constraints in fish culture and fish nutrition in Nigeria. *Journal of Fisheries & Livestock Production, 11*(7), 1–5. https://doi.org/10.4172/2332-2608.1000439

Adebanjo, M. A., & Abiodun, F. K. (2024). Gender dynamics in artisanal fish farming: A case from rural and peri-urban aquaculture. *African Journal of Fisheries Science*, 12(4), 67–83.

Adewuyi, S. A., Obayelu, A. E., Oparinde, L. O., & Arene, C. J. (2024). Technical efficiency of African catfish production in Nigeria: An analysis involving input quality and COVID-19 effects. *Aquaculture Economics & Management, 28*(1), 82–108. https://doi.org/10.1080/13657305.2023.2222687

Ajala, A. O., Kolawole, E. A., Owolabi, A. O., &Faseyi, S. A. (2017). Analysis of training needs of fish farmers in Ikorodu Local Government Area of Lagos State, Nigeria. *Nigerian Journal of Animal Production,* 44(5), 45–57.

Akanbi, S. O. (2015). The analysis of technical and cost efficiency of cultured fish production in Kwara State, Nigeria. Agrosearch, 15(2), 59–72.

Ashley-Dejo, S., Okanlawon, S. S., Oyetunji, O., & Durojaiye, A. (2024). Management practice adoption and productivity of small-scale commercial aquaculture production in Ogun State, Nigeria. *International Journal of Agriculture and Rural Development, 27*(1), 6894-6903.

Asiedu, B., Malcolm, D., & Iddrisu, S. (2019). *Assessing the economic impact of climate change in the small-scale aquaculture industry of Ghana, West Africa*. *AAS Open Research, 1*, Article 26. https://doi.org/10.12688/aasopenres.12911.2.

Biosecurity in Aquaculture (2023). Disease prevention and control measures in fish farming systems.

Busari, A. O. (2018). Economic analysis of homestead fish farming in Olorunda Local Government Area, Osun State. *Nigerian Journal of Fisheries and Aquaculture, 6*(2), 19–26.

Coelli, T. J., Rao, D. S. P., O'Donnell, C. J., & Battese, G. E. (2005). *An introduction to efficiency and productivity analysis* (2nd ed.). Springer. https://doi.org/10.1007/b136381Dauda, A. B., Dasuki, A., Oshoke, J. O., Nababa, A. S., & Bello, O. M. (2023). Status of fish farming in Katsina State, Nigeria: The current practices, operation, management and constraints to its development. *FUDMA Journal of Agriculture and Agricultural Technology, 9*(4). https://doi.org/10.33003/jaat.2023.0904.02

Food & Beverage West Africa (2024). Nigeria's fish import bill report.

Food & Beverage West Africa. (2025, February 13). NG allocates $1.2bn annually on fish imports as local production only meets 45% demand. *Food & Beverage West Africa*.

Food and Agriculture Organization. (2022). *Nigeria Agriculture at a Glance*. FAO.

Falola, A., Mukaila, R. O., Olonade, T. E., Adeshina, I., & Adewale, A. M. (2022). *Artisanal fish farmers' welfare in Nigeria: Drivers and challenges*. *Mustafa Kemal Üniversitesi Tarım Bilimleri Dergisi, 27*(3), 588–600. https://doi.org/10.37908/mkutbd.1114623

Fregene, B. T., & Ojo, E. O. (2023). *Effect of credit facility on aquaculture technology adoption by fish farmers in Oyo State*. *The Nigerian Journal of Rural Extension and Development*.

Gabriel, O. S., Beatrice, O. I., Dahutu, D. I., & Peace, G. H. (2024). Profitability and socioeconomic characteristics of fish production in Anambra State, Nigeria. *Journal of Multidisciplinary Science, 2*(1), 128-145.

Issa, F. O., Aderinoye-AbdulWahab, S., Kagbu, J. H., & Adisa, R. A. (2022). Assessment of aquaculture development programmes in Nigeria. *Journal of Agricultural Extension, 26*(1), 10-17.

Ijatuyi, E., & Car, W. (2015). Efficiency of resource-use and elasticity of production among catfish farmers in Kaduna, Nigeria. *Journal of Agriculture and Environmental Sciences*.

Kainga, P. E., Okpukpara, B. C., & Morgan, C. N. (2019). Technical efficiency of catfish (*Clarias gariepinus*) production in Bayelsa State, Nigeria: A stochastic approach. *African Journal of Agriculture Technology and Environment, 8*(2), 61–70.

Kehinde, A. D. (2022). Economics of catfish production in Osun State, Nigeria. *Scientific Papers Series: Management, Economic Engineering in Agriculture and Rural Development, 22*(1), 295–302.

Mebude, A. M., Sanni, M., &Oyegunwa, A. S. (2024). Socioeconomic impact and profitability analysis of fish farming in Lagos State, Nigeria. *Nigerian Journal of Agriculture and Agricultural Technology, 4*(4B), 57-68.

Nicholson, W., & Snyder, C. (2021). *Microeconomic theory: Basic principles and extensions* (13th ed.). Cengage Learning.Odetola, S. K., Awoyemi, T. T., &Ajijola, S. (2015). Impact of cooperative society on fish farming commercialization in Lagos State, Nigeria. *African Journal of Agricultural Research, 10*(18), 1982–1988. https://doi.org/10.5897/AJAR2015.9609

Ogunji, J., & Wuertz, S. (2023). Aquaculture development in Nigeria: The second biggest aquaculture producer in Africa. *Water, 15*, 4224. https://doi.org/10.3390/w15244224

Ohaemesi, C. F., Isibor, C. A., &Umebali, E. E. (2024). Determinants of technical and allocative efficiencies in catfish (*Clarias gariepinus*) production in South-East Nigeria. *International Journal of Multidisciplinary Research and Growth Evaluation, 5*(2), 548-555.

Olagunju, O. F., Kristofersson, D., Tómasson, T., & Kristjánsson, T. (2025). Scale efficiency, profitability, and production challenges in Nigeria's national catfish aquaculture sector. Aquaculture Economics and Management.

Olasunkanmi, J. B. (2012). Economic analysis of fish farming in Osun State, South-Western Nigeria. *IIFET 2012 Tanzania Proceedings*.

Oyebanjo, O., Ologbon, O. A. C., Akerele, E. O., Awotide, D. O., & Ogundipe, S. O. (2020). Factors affecting productivity of pond fish farming in Ibadan/Ibarapa agricultural zone, Oyo State, Nigeria. *African Journal of Science and Nature, 11, 53, -63* .

Salam, M. A., Hussain, S. M., Oinam, G., & Debnath, B. (2020). Perceived constraints of fish farmers in adoption of scientific fish farming in Manipur. *Journal of Krishi Vigyan*, Special Issue, 231–235.

Sambo, A. S., Abdulaziz, K., & Bada, M. M. (2021). Resource use efficiency in catfish production in Oyo State, Nigeria. *FUW Trends in Science & Technology Journal, 6*(3), 903–906.

Shubham, P. K., Chahal, B. S., Ghanghas, A. K., Rohila, Mukteshawar, R., Arulmanikandan, B., & Rohtash, K. (2023). Constraints perceived by farmers in fish farming: A review analysis. *International Journal of Environment and Climate Change, 13*(11), 1546–1550.

Ugwumba, O. A., &Chukwuji, C. O. (2010). The economics of catfish production in Anambra State, Nigeria: A profit function approach. *Journal of Agricultural and Social Sciences, 6*, 105–109.

Varian, H. R. (2014). Intermediate microeconomics: A modern approach (9th ed.). W. W. Norton & Company.

Yassien, S. A., Abd El-Rahim, S. A., Osman, M. F., Hamouda, R. E., Soliman, M. A. M., &Nageib, R. M. (2022). Factors affecting aquaculture farms' profitability and constraints facing fish farmers in Egypt. *Egyptian Journal of Aquatic Biology and Fisheries, 26*(2), 519–527.

APPENDIX

Table 1: Sampling Frame and Sample Size Distribution

ADP Zone	LGA	Community/Village	No. of Registered Fish Farmers	Sampled Respondents
Iwo	Iwo	Iwo Township	45	12
		Akinlalu	28	8
	Ejigbo	Ejigbo Township	52	14
		Erin-Osun	22	6
Subtotal — Iwo Zone			147	40
Osogbo	Olorunda	Oja-Oba	48	13
		Igbona	25	7
	Osogbo	Oke-baale	55	15
		Powerline	18	5
Subtotal — Osogbo Zone			146	40
Ife/Ijesha	Ife-Central	Ile-Ife Township	50	13
		Enuwa	20	7
	Obokun	Ijesha-Isu	42	12
		Ibodi	30	8
Subtotal — Ife/Ijesha Zone			142	40
TOTAL	6 LGAs	12 Communities	435	120

Table 2: Selected Socioeconomic Characteristics of Cultured Fish Farmers by LGA

ADP Zones	Iwo ADP		Ife/Ilesha ADP		Osogbo ADP	
LGA	**IW**	**EJ**	**IC**	**OB**	**OL**	**OS**
Ages(years)						
20 – 30	0	0	3 (15%)	1 (5%)	0	0
31 – 40	11 (55%)	6 (30%)	0	8 (40%)	7 (35%)	11 (55%)
41 – 50	9 (45%)	6 (30%)	14 (70%)	11 (55%)	11 (55%)	9 (45%)
51 – 60	0	8 (40%)	3 (15%)	0	2 (10%)	0
Total	**20 (100%)**	**20 (100%)**	**20(100%)**	**20(100%)**	**20 (100%)**	**20 (100%)**
Educational Status						
Primary	0	1 (5%)	0	0	0	0
Secondary	2 (10%)	6 (30%)	0	1 (5%)	1 (5%)	2(10%)
Tertiary	17 (17%)	7 (35%)	17 (85%)	19 (95%)	17 (85%)	17 (85%)
Qur'anic school	1 (5%)	4 (20%)	2 (10%)	0	1 (5%)	1 (5%)
No formal education	0	2 (10%)	1 (5%)	0	1 (5%)	0
Total	**20 (100%)**	**20 (100%)**	**20 (100%)**	**20 (100%)**	**20 (100%)**	**20 (100%)**
Gender						
Male	15 (75%)	18 (90%)	18 (90%)	16 (80%)	16 (80%)	15 (75%)
Female	5 (25%)	2 (10%)	2(10%)	4 (20%)	4 (20%)	5 (25%)
Total	**20(100%)**	**20 (100%)**	**20(100%)**	**20(100%)**	**20 (100%)**	**20 (100%)**
Marital Status						
Single	4 (20%)	4 (20%)	6 (30%)	1 (5%0	1 (5%)	4 (20%)
Married	14 (70%)	11 (55%)	11 (55%)	15 (75%)	12 (60%)	14 (70%)
Divorced	0	1 (5%)	1 (5%)	1 (5%)	5 (25%)	1 (5%)
Separated	2 (10%)	3 (15%)	2 (10%)	2 (10%)	2 (10%)	1 (5%)
Widowed	0	1(5%)	0	1 (5%)	0	0
Total	**20(100%)**	**20 (100%)**	**20(100%)**	**20(100%)**	**20 (100%)**	**20 (100%)**
Size of ponds (m^2)						
0 – 50	0	5 (25%)	8 (40%)	8(40%)	7 (35%)	1 (5%)
51 – 100	15 (75%)	8 (45%)	9 (45%)	7 (35%)	6 (30%)	12 (60%)
101 – 150	5 (25%)	2 (10%)	1 (5%)	5 (25%)	4 (20%)	4 (20%)
151 – 200	0	0	1 (5%)	0	3 (15%)	0
Years of Experience						
1 – 2 years	0	3 (15%)	3 (15%)	0	3 (15%)	0
2 – 3 years	3 (15%)	0	4 (20%)	4 (20%)	0	3 (15%)
3 – 4 years	8 (40%)	4 (20%)	8 (40%)	1 (5%0	5 (25%)	8 (40%)
4 – 5 years	4 (20%)	2 (10%)	5 (25%)	5 (25%)	4 (20%)	4 (20%)
5 years and above	5 (25%)	11(55%)	0	10 (50%0	8 (40%)	5 (25%)
Total	**20 (100%)**	**20 (100%)**	**20 (100%)**	**20 (100%)**	**20 (100%)**	**20 (100%)**

Source: Field Survey, 2025.

Key: IW – Iwo Zone, EJ – Ejigbo Zone, IC – Ife Central, OB – Obokun Zone, OL – OlorundaZone, OS – Osogbo Zone.

Table 3: Fish Species Cultured and Source of Fingerlings/Juveniles by LGA

Item	Iwo	Ejigbo	Ife Central	Obokun	Olorunda	Osogbo
Clarias (No. / %)	11 (55%)	12 (60%)	12 (60%)	13 (65%)	12 (60%)	15 (75%)
Heterobranchus (No. / %)	9 (45%)	0 (0%)	0 (0%)	0 (0%)	8 (40%)	5 (25%)
Clarias–Heterobranchus hybrid	0 (0%)	6 (30%)	6 (30%)	6 (30%)	0 (0%)	0 (0%)
Tilapia	0 (0%)	2 (10%)	2 (10%)	1 (5%)	0 (0%)	0 (0%)
Total respondents	20 (100%)	20 (100%)	20 (100%)	20 (100%)	20 (100%)	20 (100%)
Source: Breeders	8 (40%)	14 (70%)	15 (75%)	8 (40%)	8 (40%)	8 (40%)
Source: Fish hatcheries	12 (60%)	5 (25%)	4 (20%)	12 (60%)	8 (40%)	12 (60%)
Source: Wild	0 (0%)	1 (5%)	0 (0%)	0 (0%)	2 (10%)	0 (0%)
Source: Other farms	0 (0%)	0 (0%)	1 (5%)	0 (0%)	2 (10%)	0 (0%)
Total respondents	20 (100%)	20 (100%)	20 (100%)	20 (100%)	20 (100%)	20 (100%)

Source: Field Survey, 2025.

Table 4: Elasticity of Production and Returns to Scale of Cultured Fish Farming Across the ADP Zones

Input Variable	Iwo	Ejigbo	Ife Cent.	Obokun	Olorunda	Osogbo
Rent on pond (β_1)	0.220	0.235	0.255	0.205	0.300	0.315
Labour (β_2)	0.120	0.110	0.145	0.105	0.170	0.175
Qty of feed (β_3)	0.215	0.180	0.270	0.225	0.275	0.290
Fingerlings (β_4)	0.135	0.130	0.170	0.135	0.185	0.190
Depreciation (β_5)	0.110	0.120	0.195	0.120	0.155	0.165
RTS = Σ Elasticities ($\beta_1+\beta_2+\beta_3+\beta_4+\beta_5$)	0.800	0.775	1.035	0.790	1.085	1.135
Returns to Scale Classification	DRS	DRS	IRS	DRS	IRS	IRS
TCEP = 1/RTS (Total Cost Elasticity of Production)	1.250	1.290	0.966	1.266	0.922	0.881
Policy Implication (RTS < 1)	*All 6 LGAs operate under DECREASING RETURNS TO SCALE. TCEP > 1 in all zones (except IC where TCEP ≈ 1.05). A rational profit-maximising farmer should REDUCE inputs toward the optimal scale. Proportional increases in all inputs yield LESS than proportional increases in output — farmers are over-using inputs relative to output, consistent with the negative NFI findings in Table 10.*					

Source: Computed from MLE parameters, Field Survey Data, 2025. DRS = Decreasing Returns to Scale (RTS < 1). TCEP = Total Cost Elasticity of Production = 1/RTS.

Table 5: Combined Frequency and Percentage Distribution of Constraints to Cultured Fish Production Across ADP

ADP ZONE	Iwo ADP				Ife/Ilesha ADP				Osogbo ADP			
Possible Constraints	SA	A	D	SD	SA	A	D	SD	SA	A	D	SD
Inadequate funds	19 (47.5)	21 (52.5)	0	0	22 (55.0)	17 (42.5)	1 (2.5)	0	15 (37.5)	25 (62.5)	0	0
Insecurity/theft	14 (35.0)	26 (65.0)	0	0	17 (42.5)	23 (57.5)	0	0	11 (27.5)	29 (72.5)	0	0
Extension contact	11 (27.5)	29 (72.5)	0	0	19 (47.5)	21 (52.5)	0	0	10 (25.0)	30 (75.0)	0	0
Inadequate knowledge of fish farming	21 (52.5)	19 (47.5)	0	0	11 (27.5)	29 (72.5)	0	0	9 (22.5)	31 (77.5)	0	0
Pollution of aquatic environments	14 (35.0)	26 (65.0)	0	0	15 (37.5)	25 (62.5)	0	0	14 (35.0)	26 (65.0)	0	0
Climate change	19 (47.5)	21 (52.5)	0	0	22 (55.0)	18 (45.0)	0	0	19 (47.5)	21 (52.5)	0	0
Disease and pest infestation	18 (45.0)	22 (55.0)	0	0	30 (75.0)	10 (25.0)	0	0	21 (52.5)	19 (47.5)	0	0
High and soaring cost of fish feed	24 (60.0)	16 (40.0)	0	0	28 (70.0)	12 (30.0)	0	0	26 (65.0)	14 (35.0)	0	0
Supply of fish feed	25 (62.5)	15 (37.5)	0	0	20 (50.0)	20 (50.0)	0	0	25 (62.5)	15 (37.5)	0	0
Land and water availability	25 (62.5)	15 (37.5)	0	0	16 (40.0)	24 (60.0)	0	0	25 (62.5)	12 (30.0)	3 (7.5)	0
Market price fluctuation	22 (55.0)	15 (37.5)	3 (7.5)	0	12 (30.0)	28 (70.0)	0	0	18 (45.0)	19 (47.5)	3 (7.5)	0

Source: Field Survey Data, 2025. Frequencies and percentages represent the number/share of the 20 respondents per LGA who selected 'agreed' or 'strongly agreed' combined (out of a possible 20); the residual in Iwo and Osogbo for market price fluctuations and land/water availability reflects respondents who disagreed. SA = strongly agreed.