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Technical Efficiency of Small-Scale Fish Farmers in Lagos State, Nigeria

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Abstract

Technical efficiency is an important dimension of aquaculture performance because farmers using similar production resources may achieve different output levels. This study assessed technical efficiency and sources of inefficiency among 270 small-scale fish farmers in Ikorodu, Epe and Badagry, Lagos State, Nigeria. A stochastic frontier production function was estimated using maximum likelihood, followed by an inefficiency-effects model. Feed cost, farm size, labour, capital investment and extension service intensity were positive and statistically significant in the frontier production function. The estimated gamma parameter was 0.742. Technical-efficiency scores ranged from 0.521 to 0.981, with a mean of 0.832. Education, farming experience, extension service intensity, training participation and fish-farmer association membership significantly reduced technical inefficiency, whereas age significantly increased inefficiency. Household size was not statistically significant. The results demonstrate substantial variation in efficiency among small-scale fish farms and identify farmer knowledge, experience and institutional engagement as important correlates of efficiency. Strengthening extension intensity, practical training and producer organizations may therefore support more efficient resource use in small-scale aquaculture. The cross-sectional design, however, means that the observed relationships should not be interpreted as definitive causal effects.

Keywords: technical efficiency; stochastic frontier; aquaculture; fish farmers; inefficiency; extension intensity; Lagos State.

1. INTRODUCTION

Technical efficiency is an important dimension of aquaculture performance because farmers using similar production resources may obtain different levels of output. Differences can arise from management practices, technical knowledge, experience, information access and institutional support. Nigerian evidence also indicates that access to digital innovation and production information can improve fish-farm performance, providing a broader basis for examining how knowledge and information access may relate to efficiency outcomes (Falola et al., 2024; Komolafe et al., 2018). FAO's current aquaculture framework similarly emphasizes productivity, efficiency, resilience, capacity development and responsible management as central to sustainable sector growth (FAO, 2024, 2025). For Nigeria specifically, the national catfish value-chain assessment identifies productivity and farm-management improvement as important upgrading

priorities (FAO, 2023). Improving farm-level efficiency also has wider development relevance because aquatic food systems contribute to livelihoods, social identity and human well-being across fishing and aquaculture-dependent communities (Allison et al., 2020).

Technical-efficiency analysis is distinct from productivity analysis. Productivity asks how output is associated with production inputs, whereas technical efficiency asks how closely a producer operates to the best-practice frontier conditional on available inputs and technology. Previous work in the supplied reference library examined technical efficiency differentials in aquaculture resource use among selected fish farms (Awolumate & Inyang, 2019), providing a direct basis for examining efficiency as a separate aquaculture-economic outcome. Comparable Nigerian studies reinforce the relevance of frontier-based efficiency analysis. Olagunju et al. (2024) used a translog stochastic frontier framework for African catfish farms and reported substantial but incomplete

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technical efficiency, while Lagos-specific DEA evidence also demonstrates significant variation in efficiency across production technologies (Oluwatayo & Adediji, 2019).

Stochastic frontier analysis is useful for biological production because it distinguishes random variation from the inefficiency component. Extension services are relevant to this question because farm visits, training, demonstrations and advisory consultations can provide production information. Earlier research examined extension services and fish farming in Lagos State (Awolunate & Omosola, 2017), while studies of aquaculture information sources and communication systems examined information access and use among fish farmers (Awolunate, 2018; Awolunate & Inyang, 2019). In Lagos State specifically, mobile phones are used by fish farmers to obtain information on feed, drugs, fingerlings, equipment and harvesting from extension agents and other sources, illustrating the practical information channels through which advisory support can operate (Komolafe et al., 2018). More broadly, digital innovations in aquatic food systems can improve information flows and decision-making capacity among small-scale actors (Tilley et al., 2022). Recent evidence from other Nigerian production zones also links technical efficiency to farmer characteristics and institutional support. Extension contact was identified as an efficiency-related factor among catfish farmers in Delta State (Anthony, 2024), and extension service, experience and farm characteristics were associated with efficiency in Oyo State (Ashley-Dejo, 2022). FAO guidance likewise stresses the importance of technical capacity, extension, training and farm-management knowledge in sustainable aquaculture (FAO, 2025).

The present study therefore focuses on the efficiency mechanism. It estimates a stochastic frontier production function and an inefficiency-effects model to identify the socioeconomic and institutional characteristics associated with differences in technical efficiency among small-scale fish farmers in Lagos State.

2. Materials and Methods

A cross-sectional survey was conducted among 270 small-scale fish farmers in Ikorodu, Epe and Badagry, Lagos State. Data were collected through a structured electronic questionnaire.

Frontier variable	Role in model
Fish output	Dependent variable
Feed cost	Production input
Farm size	Production input
Labour	Production input
Capital investment	Production input
Extension intensity	Knowledge/institutional input

Inefficiency variable	Expected interpretation in model
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Age	Farmer characteristic
Education	Human-capital characteristic
Farming experience	Accumulated production knowledge
ESII	Extension engagement
Training participation	Capacity development
Household size	Household resource characteristic
Association membership	Institutional/collective-action characteristic

The stochastic frontier was specified as $Y_i = f(X_i; \beta) \exp(V_i - U_i)$, where V represents random variation and U represents non-negative technical inefficiency. Technical efficiency was represented as $TE_i = \exp(-U_i)$.

The inefficiency-effects model was specified as $U_i = \delta_0 + \delta_1 AGE + \delta_2 EDU + \delta_3 EXP + \delta_4 ESII + \delta_5 TRAIN + \delta_6 HHSIZE + \delta_7 ASSOC + \varepsilon_i$. A negative coefficient indicates reduced inefficiency, whereas a positive coefficient indicates increased inefficiency.

The project reported diagnostic procedures including variance inflation factor analysis, heteroskedasticity testing, normality assessment and likelihood-ratio testing. A pilot test involving 20 farmers excluded from the final sample produced a reported Cronbach alpha of 0.82.

3. Results and Discussion

Frontier variable	Coefficient	p-value
Constant	2.013	<0.001
Feed cost	0.437	<0.001
Farm size	0.274	<0.001
Labour	0.105	0.012
Capital investment	0.157	0.004
Extension intensity	0.228	<0.001

Variance parameter	Estimate
Sigma-squared (σ^2)	0.148
Gamma (γ)	0.742
Log likelihood	-182.43

The gamma estimate of 0.742 indicates that a substantial proportion of the modelled residual variation was associated with the inefficiency component. This supports the use of a stochastic frontier framework for distinguishing inefficiency from random variation.

Technical-efficiency scores ranged from 0.521 to 0.981, with a mean of 0.832 and standard deviation of 0.104. The distribution was concentrated in the 0.80–0.89 interval, which contained 35.6% of the sample, while 19.5% recorded scores of 0.90 or above. About 18.6% recorded scores below 0.70.

Efficiency range	Frequency	Percentage
Below 0.60	18	6.7
0.60–0.69	32	11.9
0.70–0.79	71	26.3
0.80–0.89	96	35.6
0.90 and above	53	19.5
Total	270	100.0

Statistic	Value
Mean	0.832
Minimum	0.521
Maximum	0.981
Standard deviation	0.104

The mean score of 0.832 indicates that the average farmer operated at about 83.2% of the estimated frontier. The corresponding average distance from the frontier was approximately 16.8 percentage points. This is a model-based efficiency gap and should not be interpreted as a guaranteed increase in actual output for every farmer.

Inefficiency variable	Coefficient	p-value	Direction
Age	0.006	0.048	Increases inefficiency
Education	–0.018	0.010	Reduces inefficiency
Farming experience	–0.021	0.009	Reduces inefficiency
ESII	–0.037	0.001	Reduces inefficiency
Training participation	–0.029	0.026	Reduces inefficiency
Household size	–0.009	0.134	Not significant
Association membership	–0.052	0.013	Reduces inefficiency

Education was negatively associated with inefficiency, indicating that higher educational attainment was associated with higher technical efficiency. Farming experience also reduced estimated inefficiency, consistent with an association

between accumulated production knowledge and performance.

Extension service intensity recorded a coefficient of –0.037 ($p = 0.001$). This indicates a statistically significant association between greater extension engagement and lower technical inefficiency. The result complements earlier work on extension and fish farming in Lagos State (Awolumat & Omosola, 2017) while focusing specifically on the frontier-efficiency outcome. The finding is consistent with the broader literature showing that information and innovation channels are associated with improved aquaculture performance, while not implying that those studies identify the same technical-efficiency mechanism estimated here (Falola et al., 2024; Komolafe et al., 2018). The direction of this result is consistent with evidence that extension contact and management knowledge can help explain efficiency differences among Nigerian catfish farms (Anthony, 2024; Ashley-Dejo, 2022).

Training participation also reduced inefficiency (–0.029; $p = 0.026$). Association membership was similarly associated with lower inefficiency (–0.052; $p = 0.013$). These findings suggest that knowledge transfer, capacity development and collective institutional engagement are relevant correlates of technical efficiency. It is also aligned with recent FISH4ACP experience in Nigeria, where best-management-practice training and data-led decision support were associated with improved feed conversion and stronger farm performance among participating producers (FAO, 2026).

Age had a positive coefficient (0.006; $p = 0.048$), indicating higher estimated inefficiency at higher ages after controlling for other variables. Household size was not statistically significant ($p = 0.134$), so the model does not provide sufficient evidence that household size independently explains efficiency differences.

The results complement the aquaculture-efficiency literature by showing that technical-efficiency variation is associated not only with production inputs but also with farmer characteristics and institutional engagement. However, because the study is cross-sectional, the estimates should be interpreted as associations rather than definitive causal effects.

4. Conclusion

Small-scale fish farmers in Lagos State displayed substantial variation in technical efficiency, with scores ranging from 0.521 to 0.981 and a mean of 0.832. Education, experience, extension service intensity, training participation and association membership were associated with lower technical inefficiency, while age was positively associated with inefficiency. Household size was not statistically significant.

5. Recommendations

Extension services should adopt efficiency-oriented advisory programmes that address specific sources of inefficient resource use.

Training should be continuous and practical, with emphasis on feeding, water quality, disease management, stocking and farm records.

Fish-farmer associations should be used as platforms for peer learning and extension coordination.

High-efficiency farms should be studied as potential sources of locally appropriate management practices.

Future studies should use panel or experimental/quasi-experimental designs to investigate whether changes in extension intensity affect technical efficiency.

6. Limitations

The cross-sectional design limits causal inference. Extension intensity, training and some farmer characteristics are survey-based measures. The study covers selected small-scale fish farmers in Lagos State and does not represent all Nigerian aquaculture systems. Frontier estimates are conditional on the specified functional form and variables.

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