ESTIMATING PROFIT EFFICIENCY AND PROFITABILITY OF SMALL-SCALE FISHING IN HADEJIA-JAMA'ARE KOMADUGU-YOBE BASIN, NORTHEAST NIGERIA

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ABSTRACT

This study evaluated profit efficiency and profitability of small-scale fishers in Hadejia-Jama'are Komadugu-Yobe Basin, Northeast, Nigeria by explicitly computing fishers' profit efficiency level, identifying the sources of profit inefficiency and profitability of the enterprise. A total of 200 fishers were sampled through a multi-stage random sampling procedure. Primary data which were obtained through administration of structured questionnaire were used for this study. Data obtained were subjected to stochastic profit frontier model to estimate profit efficiency level and identify the determinants of profit inefficiency. The mean profit efficiency level was 81.0%. Furthermore, age, household size and membership of cooperative society increase the inefficiency level while experience decreases the inefficiency level. Most severe constraints were lack of preservatives/storage (4.22) and inadequate finance (4.09). The study concluded that fishers profit efficiency can be improved in the study area with provision of modern storage and preservative facilities. It is therefore recommended that modern, intermediate-technology fishing equipment should be made available to fisher with flexible repayment plan.

Keywords: Capture fisheries, fish production, profitability, Northeast, stochastic profit frontier model
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INTRODUCTION

One of the cheapest, high quality, essential animal-based protein is fish, which serves as source of food for more than half of the world's population [1]. Fish production is mainly from either culture or capture fisheries (industrial and artisanal). Over 50.0% of world fish supply is from capture fisheries which is divided into marine and inland capture fisheries [2]. Africa, the second largest continent in the world is blessed with vast fish resources in marine and inland water [3]. African domestic fish supply is dominated by capture fisheries which is primarily operated by small-scale fishers. Some of the significant roles played by small-scale fisheries include serving as source of food to the populace, generating income, alleviating poverty, fighting malnutrition and being a source of livelihood to millions of people most especially in remote areas [4].
Like most Africa country, Nigeria domestic fish supply is dominated by capture fisheries ranked behind Morocco owing to her endowment of vast fish resources in marine and inland waters [5]. In Nigeria, domestic fish production is slightly above a million metric tons - 313,231 metric tons and 759,828 metric tons from culture and capture fisheries, respectively [5]. Almost 1.5 million individuals derived their daily needs from fishing [5]. Small-scale fisheries in Nigeria contribute significantly to the nation's domestic fish production. The sub-sector is categorized as subsistence or traditional fishing characterized with low technology, non-sophisticated fishing gear, low investment and majorly practiced by illiterate

Despite the country's place of pride in fish production in Africa, a wide fish supply gap exists between domestic fish demand and supply due to progressive increase in human population of over 200 million [6, 7]. At present, the country is challenged with fish shortage and this continue to persist daily as a result increase in human population and perishable nature of the product. Therefore, to salvage the unpleasant situation, domestic fish production should level up with domestic fish demand by boosting major fish production subsectors and avoiding fish wastage. In achieving this, efficiency in small-scale fisheries production needs to be improved.

Moreover, fish availability is seasonal, most abundant during raining season (April – September). During this period, fishers have abundant catch forcing them to sell at a reduced price because of lack of preservative, storage and processing facilities. Thus, having negative effects on small-scale fisher's profit efficiency and also serves as a disincentive for individuals willing to venture in the enterprise. On the order end, during dry season fishers catch drops, resulting to low supply of catch in the market leading to high demand, and a hike in price of fish. Thus, it becomes imperative to address this issue through empirical evidence with the aim of making the sub-sector to be self-dependence and sufficient.

Small-scale fishers' efficiency in Nigeria can be boosted through introduction and adoption of recent fishing technologies, preservative and processing methods or full utilization of existing innovations which drive production frontier upward [8, 9]. Most efficiency studies in Nigeria have focused mainly on fish farming and coastal/marine artisanal fisheries ignoring inland fisheries especially Northeast Nigeria. Majority of household heads in this area engaged in fishing, the enterprise should therefore be of great concern for sustainability which could be difficult to achieve if the enterprise is neglected. The study, therefore aimed at investigating the profit efficiency and profitability of small-scale fishing in Hadejia-Jama'are Komadugu-Yobe Basin, Northeast Nigeria. Specifically, the study sought to describe the socioeconomic characteristics of the fisher in the study area; determine the profit efficiency of fish production and socioeconomic factors relating to inefficiency in the study area; assess the profitability of fishers and identify the major constraints faced by the fisher in the study area.

MATERIALS AND METHODS

Study area, data, and sampling technique

The study was conducted in Hadejia-Jama'are Komadugu-Yobe Basin as an approximately catchment area of 84,000 km^2 located in Northeast Nigeria. The water body flow directly into Lake Chad and covers five Northern states (Kano, Jigawa, Bauchi, Yobe and Borno states). The two major rivers of the basin are the Hadejia, and Jama'are. The inhabitants are mainly rural dwellers with agriculture as their main occupation. The presence of this water body has made fishing activities a significant occupation that employs thousands of people (fishers, net makers, fishmongers, processors, etc). Primary data collected from small-scale fishing households was used for the study. A well-structured open and closed ended questionnaire was used to collect data through personal interviews. The questionnaire was designed into different sections to capture the set objectives.

Multi-stage sampling technique was used to select 200 fishers in the study area. The first stage involved purposive selection of two local government areas (LGAs) (Bade and Nguru) given that they contain the major fishing communities in the State. The second stage involved the use of simple random sampling technique to select eight fishing communities from the selected LGAs. The selected fishing communities were Gogaram, Dogona, Bize, Azbak, Margadu, Yan-kwarawa, Garbi and Daba; twenty-five respondents were randomly selected from each community

Theoretical framework of stochastic frontier model

Almost three decades ago, technical efficiency (TE) and allocative efficiency (AE) are the main components of production efficiency according to literature [10] However, these components (TE and AE) can be incorporated into one unit to estimate a robust efficiency by the simultaneous estimation of the unit [10]. TE component is often measured by using the popular frontier production function [11]. However, Ali and Flinn [12] opined that frontier production approach in measuring efficiency may not give appropriate estimate if, the production units are limited with different resources endowment and prices. Therefore, Ojo [13] and Tsue *et al.* [14] suggested that stochastic profit efficiency is more appropriate because it make use of both components, also, errors in the production are taken to be translated into lower profit. In the concept of this study, profit efficiency is defined as the ability of small-scale fishers to meet up with the highest possible profit/gain provided the cost of inputs and other factors are constant. Thus, the assumption is that small-scale fishers combine various inputs and outputs variables to maximize profit. Fishers found beneath the production frontier or do not operate within the frontier are considered as not profit-efficient.

Stochastic profit model was adopted for this study to determine the profit efficiency of small-scale fishers in Northeast Nigeria. Also, profit production function described by Battese and Coelli [15] was adopted assumed to behave in a manner consistent with the concept of the stochastic frontier model [16, 17]. The model adopted is mathematically expressed as

$$\pi_j = f\left(P_{ij}, Z_{kj}\right)\exp\left(v_i - u_i\right) \quad \text{--------------- (1)}$$

where π_j is the total fish output (kg) (gross margin) of the *j*th fishers, P_{ij} is the price of the normalized variable input, Z_{kj} the level of fixed factor in fishing, and $e\ i$ is the error term. v_i is the symmetric error term and assumed to be an independently and identically distributed two-sided error term representing the random effects, measurement errors, omitted explanatory variables, and statistical noise; u_i is the one-sided error term. The profit efficiency of the ith small-scale fisherman can be expressed as the ratio of the observed profit (π_j) to the predicted maximum profit ($\pi_{\max}$) and specified as

$$\pi_e = \frac{\pi_i}{\pi_{\max}} = \frac{f\left(P_{ij}, X_{ij}, \beta_i\right)\exp\left(v_i - u_i\right)}{f\left(P_{ij}, X_{ij}, \beta_i\right)\exp\left(v_i\right)} = \exp\left(-u_i\right) \quad \text{-- (2)}$$

where π_e is the profit efficiency, π_i is observed profit, and $\pi_{\max}$ is the maximum (potential) profit. The profit efficiency ranges between zero and one. That is, $0 < \pi_e < 1$. (Profit inefficiency = $1 - \pi$). The parameters were estimated using STATA 13. The maximum likelihood estimates of the stochastic profit frontier model provide the estimates of β and gamma (γ), where gamma explains the variation of the total profit from the frontier profit. The gamma estimate is specified as $\gamma = \frac{\sigma_u^2}{\sigma^2}$. Here γ lies between zero and one ($0 \leq \gamma \leq 1$) and represents the share of the inefficiency in the overall residual variance. The gamma values ranging between zero and one indicate the presence of profit inefficiency. A value of 1 indicates a deterministic frontier while that of zero suggests the absence of inefficiency. Thus, such absence of inefficiency favours the use of the average response model estimation due to the absence of the inefficiency effect term (μ_i). σ_u^2 is the variance of the error term associated with the profit inefficiency effects, and that associated with random noise factor is σ_v^2. σ^2 represents the overall variance of the model and the three are related as

$\sigma^2 = \sigma_u^2 + \sigma_v^2$ [18].

Empirical model estimation

Cobb-Douglas production function was employed for this study. According to Ogundari *et al.* [17], this method has been employed by several researchers in assessing empirical studies mainly those connecting to agriculture in developing countries and those that functional procedures meet the requirement of being self-dual (permitting economic efficiency examination). Moreover, this functional method fits well in cases where there is occurrence of high frequencies of observations [14].

The Cobb-Douglas stochastic profit frontier function is as expressed below:

$$In\,\pi_j = In\beta_0 + \beta_1 InX_1 + \beta_2 InX_2 + \beta_3 InX_3 + \beta_4 InX_4 + \beta_5 InX_5 + (v_i - u_i)$$
----------- (4)

Where:

π_j = total fish output (kg) gross margin

X_1 = Normalized cost of hired labour (₦)

X_2 = Normalized cost of maintaining fishing gear (₦)

X_3 = Normalized cost of preservation/storage (₦)

X_4= Normalized cost of canoe/boat (₦)

X_5= Normalized cost of paddle and fishing rope (₦)

$\beta_1 - \beta_5$ = unknown parameters to be estimated

$\mu_i$is characteristic of small-scale fishers related to fishing and v_i is error term. The profit efficiency of the *i*th fishers is given by exp ($-\mu_i$), where

$$u_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6$$
----------- (5)

Where:

Z_1 = age of small-scale fishers (years)

Z_2 = educational level (years)

Z_3 = household size (number)

Z_4 = fishing experience (years)

Z_5 = membership of cooperative society (dummy: yes = 1; no = 0)

Z_5 = extension contact (dummy: yes = 1; no = 0)

Profitability analysis of small-scale fishing

Gross Margin (GM)of smale − scale fishing = Total Revenue − Total Variable Cost ---- (6)

Net Income (NI)of smale − scale fishing = Gross Margin − Total Fixed ---------------- (7)

Benefit Cost Ratio (BCR)of smale − scale fishing $= \frac{\text{Total Revenue}}{\text{Total Cost}}$ --------------------------- (8)

Returns on Investment (ROI)of smale − scale fishing $= \frac{\text{Net Income}}{\text{Total Cost}}$ ------------------------ (9)

Depreciation was calculated for the fixed items to get their depreciated price which was incorporated in the calculation. Straight Line Method (SLM) was used for calculation of depreciation, which anticipated salvage value of zero.

$$\text{Annual depreciation} = \frac{(\text{Original Cost} - \text{Salvage Value})}{\text{Expected or useful life span (years)}}$$
-- (10)

The hypothesis tested in this study is whether or not there exists profit inefficiency in the operations of small-scale fishers in the study area.

H_o = there is no profit efficiency

H_A = there is profit efficiency

A 4-point Likert type scale was used to elicit data on constraints faced by small-scale fishers in the study area. The scores were weighed and the weighted average was use in ranking the constraints.

RESULTS AND DISCUSSION

Socioeconomic characteristics of small-scale fishers

The socioeconomic characteristics of small-scale fishers (Table 1) revealed that age of fishers ranged between 23 and 69 years with a mean age of 38 years. Fishers within the age bracket of 20 – 40 years form the majority (76.5%). This age bracket has been described as active, productive and economic age bracket [19]. Fishers managerial ability and resources allocation is greatly influenced by this age bracket. In the African context, individuals within this age bracket have high societal expectation and responsibilities therefore, they are mandatory to engage in economic activities to live up to expectation [20]. Majority (98.5%) of the fishers were male but the presence of female fishers might be due to migration/displacement, death of husband and economic recession. Thus, fishing activities is mainly dominated by men this could be attributed the nature of the enterprise; energy demanding and requires a lot of physical strength. This finding agrees with the study of Setsoafia *et al.* [19] and Ashley-Dejo and Adelaja [21] that the enterprise is mainly dominated by men. Table 1 further reveals that more than half (52.0%) of the sampled fishers had post primary education. This implies that fishers in the study area have the tendency of adopting improved fishing techniques which could enhance their productivity. Fishing experience in the study area ranged from 6 – 31 years with mean experience of 18 years. This implies that fishers have substantial years of experience. Most (73.0%) of the fishers engaged in other income generating enterprise to augment income generated from fishing. Such enterprise includes arable farming, livestock, security and petty trading mostly during non-active fishing period. This agrees with the finding of Setsoafia *et al.* [19] that African fishers engage in other economic generating activities mainly during dry season. Fishers household size ranged from 3 to 14 persons with mean household of 8 person.

Table 1: Socioeconomic characteristics of small-scale fishers (n = 200)

Variables	Frequency	Percentage
Age (years)		
20 – 30	90	45.0
31 – 40	63	31.5
41 – 50	39	19.5
Above 50	8	4.0
Mean±std	37.73+8.368	
Gender		
Male	197	98.5
Female	3	1.5
Marital Status		
Single	16	8.0
Married	147	73.5
Divorced	9	4.5
Widow	28	14
Education		
Non-formal (Arabic)	37	18.5
Primary	59	29.5
Secondary	84	42.0
Tertiary	20	10.0
Fishing experience		
Less than 10	40	20
10 – 15	85	42.5
16 – 20	52	26
21 – 25	18	9
Above 25	5	2.5
Mean±std	18.45±6.76	
Off-farm activities		
Yes	132	66.0
No	68	34.0
Household size		
Less than 5	111	55.5
5– 10	76	38.0
Above 10	13	6.5
Mean±SD	7.6±1.31	
Member of fish association group		
Yes	146	73.0
No	54	27.0
Access to credit facilities		
Yes	15	7.5
No	185	92.5

Source: Field Survey, 2021

Catch inefficiency determinant

Table 2 revealed factors influencing profit efficiency of small-scale fishers in the study area. The estimated sigma square (δ^2) was 0.278 ($p > 0.1$) suggesting correctness and a good fit of the distributional assumption of the composite error term. Also, it indicates that the profit efficiency equation explains the profit with regard to each decision-making unit as well as the profit of the frontier function. The gamma (γ) coefficient implies that 72% of shortfall below the frontier output of the enterprise was due to technical inefficiency. This implies that most substantial proportion of the variation in fishers' profit could be ascribed to their managerial ability and fishing inputs used.

Also, stochastic noise contributes a relatively smaller proportion of the deviation from the potential profit. The value of LR was 46.27 ($p < 0.1$) implies that the null hypothesis of inefficiency effects in the profit frontier function is rejected. Table 2 further revealed that cost of labour and canoe/boat ($p < 0.1$) and preservation/storage ($p < 0.05$) are positive while price of paddle and fishing rope ($p < 0.05$) is negative. This implies that for a 10.0% increase in the cost incurred in the labour, preservative/storage and canoe/boat, the profit is increased by 4.14%, 1.52% and 4.91%, respectively, provided other variables are constant. Also, a 10.0% increase in cost of paddle and fishing rope will cause a decrease in fishers profit by 16.3%.

Efficiency model revealed that age, household size and membership of cooperative society were all positive and significant. This implies that unit increase in household size and access to cooperative society led to increase in technical inefficiency but decrease in technical efficiency while an increase in fishing experience decreased technical inefficiency leading to an increase in technical efficiency. As fishers aged, efficiency level reduces leading to increase in fisher's inefficiency. The enterprise demand physical strength thus, young, active and energetic fishers are likely to have higher efficiency. Household size was also positive and significant at 5% probability level. This suggest that, as household size increases, the profit efficiency level reduces and vice versa. The level of experience had a negative sign and is significant at 5% probability level. This suggest that as fishers experience increases, profit efficiency level increases. Thus, fishers with more years of fishing experience have higher levels of efficiency than their counterpart with lesser fishing years of experience

Table 2: Maximum likelihood estimates of parameters of stochastic frontier production function small-scale fishers

Variable	Coefficient	Standard error
Production model		
Constant	0.416	
Cost of Labour	0.414***	0.112
Cost of maintaining fishing gear	-0.0217	0.078
Cost of preservation/storage	0.152**	0.053
Cost of canoe/boat	0.491***	0.108
Cost of paddle and fishing rope	-1.634**	0.833

Inefficiency model		
Constant	-5.138	
Age (years)	0.0637**	0.043
Educational qualification (years)	0.032	0.147
Household size (number)	0.452**	0.174
Fishing experience (years)	-0.136**	0.057
Membership of cooperative society	0.137**	0.053
Extension contact	0.193	0.017
Sigma-squared (σ^2) = $\sigma^2_\mu + \sigma^2_v$	0.278***	
Gamma (γ) = $\sigma^2_\mu / (\sigma^2_\mu + \sigma^2_v)$	0.719***	
LR test of the one-sided error	46.27	

Source: Field Survey, 2021; ***Significant at 1%, **Significant at 5%,

Frequency distribution of profit efficiency small-scale fishers

Table 3 shows the frequency of distribution of profit efficiency of small-scale fishers in the study area. There exits variation in the level of efficiency, ranging from 36 - 95% with a mean efficiency level of 81.0%. This implies that fishers are losing about 19% of their potential profits as a result inefficiency. This finding is consistent with the study of Setsoafia et al. [19] who obtained a mean efficiency of 81.66% among artisanal fishers in Ghana. Result obtained implies that fishers in the study area are able to obtain 81% of potential output from a given mix of production inputs. In the short run, there is hope for increasing fisher's profit by 19.0% through the adoption of improved fishing and preservative techniques.

Table 3: Frequency distribution of profit efficiency small-scale fishers

Efficiency Range	Frequency	Percentage
30 – 49	9	4.5
50 – 69	15	7.5
70 – 89	64	32.0
90 – 99	112	56.0
Total	200	100.0
Mean	0.81	
Minimum	0.36	
Maximum	0.95	

Source: Field Survey, 2021

Profitability analysis of small-scale fishers

Small-scale fisher's profitability analysis is presented in Table 4. The estimate revealed that more than two-thirds of the overall cost of production were expended on fixed items. This implies that fishers need to invest huge capital on fixed variables. Net income of ₦15,172.70 was generated with Benefit Cost Ratio (BCR) of 1.70. Olagunju *et al.* [23] and Ashley-Dejo and Adelaja [22] opined that any enterprise with BCR above 1.00 is profitable and viable, thus fishing enterprise is the study area is viable. Also, Return on Investment (ROI) revealed that for every ₦ 1.00 invested in the enterprise, ₦ 0.42 is a potential profit.

Table 4: Profitability analysis of small-scale fishers

Cost of items	Amount (₦)	% Total Cost
Total Variable Cost (TVC)	24,954.73	30.62
Total Fixed Cost (TFC)	11,014.57	69.38
Total Cost (TC)	35,969.30	100.00
Total Revenue (TR)	61,142:00	
Gross Margin (GM) = (TR - TVC)	26,187.27	
Net Income (NI) = (GM - TFC)	15,172.70	
Benefit Cost Ratio (BCR) = (TR/TC)	1.70	
Return on Investment (ROI) = (NI/TC)	0.42	

Source: Field Survey, 2021, Note: $1 = ₦600:07 at the time of the study.

Constraints faced by small-scale fishers

Various constraints faced by small-scale fishers were weight scores, ranked and presented in Table 5. The most critical constraint was lack of storage/preservative facilities. Yohanna *et al*. [24] submitted that inappropriate handling practices and preservative facilities expose fish catch to spoilage. Also, Diei-Ouadi and Mgawe [25] and Nguvava [26] opined that when fish catch is not well preserved, it deteriorates faster compared to preserved fish, thus resulting to economic loss. Lack of finance was ranked second, this agrees with the submission of Itam [27] who ranked unavailability of credit as the second most pressing need of the artisans. Fishing like any other enterprise involves cost such as labour, maintenance, storage, and other variable inputs. Meeting the financial need of fishers in the study area will enhance domestic fish production and huge amount spend annually in augmenting fish deficit will reduce. Most (92.5%) (Table 1) of the fishers indicated that they do not have access to finance to fund their fishing enterprise adequately which has negative effect on production and profit level. Price fluctuation was ranked third, this is similar to the findings of Setsoafia *et al.* [19] who ranked unstable prices as the second most pressing need of fishers in Ghana. The enterprise is seasonal like other agricultural practices, fishers have abundance catch during raining season and experience low catch in dry season resulting to surplus and drastic reduction during raining and dry season respectively. Consequently, this result to unstable profit level thus fishers are clamoring for price ceiling policy. Seasonality in catch, high price of fishing equipment and unstable weather condition are ranked fourth, fifth and sixth respectively.

Table 5: Constraints faced by small-scale fishers

Constraints	Weight score	Weight mean	Ranking
Lack of storage/preservative facilities	843	4.22	1st
Inadequate finance	817	4.09	2nd
Price fluctuation	765	3.83	3rd
Seasonality in catch	734	3.67	4th
High price of fishing equipment	722	3.61	5th
Unsuitable weather condition	712	3.56	6th

Source: Field Survey, 2021

CONCLUSION AND RECOMMENDATIONS

The study concluded that there was an observed inefficiency among the small-scale fishers in the study area. However, there is possibility of increasing fishers' profit by 19% through adoption of fishing techniques and technology employed by the best fishers as the average profit efficiency was 81%. The policy implication is that it will increase fish production in the State in particular and in the country as a whole, assist in the socioeconomic development of the fishers as well as check the government expenditure on fish importation. It is recommended that Nigerian government should strengthen its extension education outreach, subsidize some of the fishing gadget and processing/preservative facilities for fishers.

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