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Technical efficiency of artisanal fish production in Yobe State, North East, Nigeria

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ABSTRACT

The technological effectiveness of artisanal fish production in Yobe State, Northeastern Nigeria, was examined in this study. The study's precise goals were to define the socioeconomic traits of the fishermen, assess the technical effectiveness of fish production, and pinpoint the main challenges the fishers in the study area faced. Through a multi-stage random sampling technique, 240 artisanal fishermen in total were sampled. Descriptive statistics and the stochastic frontier production function were used to analyze the data. The findings showed that the majority of fishermen were married men in the 35–45 age range who had an average of 16 years of fishing experience. The stochastic frontier analysis showed that the amount of fishing nets, lines, canoes, workers, and hooks considerably enhanced the level of catch. Age, educational attainment, fishing experience, and income of artisanal fishers all increased capture inefficiency, according to the inefficiency model. The major constraint was the lack of processing and storage facilities. The study found out that with greater use of farmer-friendly input and technology fish catch efficiency can be increased. It is advised that fishers should have access to contemporary, intermediate-technology processing and storage facilities with a flexible repayment schedule.

Keywords: Artisanal fishers, Household, Technical efficiency, River.

INTRODUCTION

In both industrialized and developing countries, fish is a staple diet. Fish is one of the main animal proteins consumed in Africa and is a vital component of the continent's agri-food system. Fish has been acknowledged as a food commodity with the potential to lower food and nutrition insecurity in Africa (Chan *et al*., 2019). According to Chan *et al*. (2019), fish provide around 19% of the animal-based protein consumed in Africa. Fish also provides long-chain polyunsaturated fatty acids, which are lacking in other animal-based proteins (Bene *et al*., 2015; Kassebaum *et al*., 2014; Tacon and Metian, 2013). The significance goes beyond the aforementioned; it also plays a key role in socioeconomic development and the reduction of poverty. According to de Graaf and Garibaldi (2019), the worldwide fisheries sector employs over 12.3 million people, over 4 million of them are women who are considered to be the poorest, most disadvantaged, and from developing countries.

Culture fisheries and capture fisheries are the two main methods of producing fish. Culture fisheries in Africa make for around 2.5% of global fish production. Because the continent is endowed with abundant fish resources in both coastal and inland waters, this shows that African culture fisheries are still expanding and that the continent depends on capture fisheries opined that Nigeria holds a significant position in Africa's fish production, but the nation's domestic fish production is unable to keep up with demand, leading to a significant gap between supply and demand for fish in Nigeria(FAO, 2018 Ashley-Dejo *et al*., 2017; Ogunmefun and Achike 2018). This situation is deteriorating on a daily basis as a result of the country's rapid population growth and fish losses due to post-harvest losses. These have caused the nation to be listed as one of those dealing with food insecurity. In order to redeem the image of the nation, all hands must be on deck by all important stakeholder's food/fish industry. This will ensure that domestic fish output will at least match local demand for fish, if not exceed it. This could be achieved by enhancing her major fish production subsector and avoid fish wastage.

Most of Nigeria's capture fisheries are dominated by artisanal fisheries, whose catches are frequently influenced by a variety of environmental circumstances, making fishermen's catches unpredictable. Artisanal fishermen most frequently report a plentiful catch from April to September, when it rains. Fishers during this time sold their catch at a discount in order to avoid wastage and financial loss. The quantity of the catch during this time should have increased fishermen's earnings, but instead, the opposite impact was seen, which also acts as a deterrent to others who may otherwise be interested in engaging in the industry. Therefore, it is crucial to solve this issue using empirical data in order to make this fishing industry self-sufficient and independent.

The main goal of fishers is to maximize profit; in order to maintain this motivation, intensive effort and efficient resource management are required. Therefore, a fruitful proposal must prioritize fisher's efficiency. In order to maximize profits, a unit must be as efficient as possible in producing a high volume of output. Efficiency is now still an important area for empirical research, particularly in developing nations where the majority depends on agricultural-related goods for subsistence (Umoh, 2006). Technical efficiency, on the other hand, is the farmer's capacity to generate a specific level of output with a minimal amount of inputs using a particular technology (Umoh, 2006). With the objectives of: describing the socio-economic traits of artisanal fishers; figuring out the technical efficiency of artisanal fishers and socio-economic factors relating to inefficiency of artisanal fisher's study area; and identifying the main challenges faced by artisanal fishers in the study area. This study is intended to examine the technical efficiency of artisanal fishers in Yobe State, North East, Nigeria.

THEORETICAL FRAMEWORK

Technical efficiency across various production processes, particularly in developing nations, is one of the most frequently addressed topics in development literature. This presumption is mostly motivated by Schultz's (1964) claim that farm households in emerging nations are "efficient but poor." However, the assumption has been understood to suggest that the distribution of the factors of production in agriculture in developing nations is generally relatively efficient. Instead of focusing just on farmer rationality, Ali and Byerlee (1991) suggested that both allocative efficiency (AE) and technical efficiency (TE) (economic efficiency (EC)) might be understood in terms of system performance and farmers and farm support systems. The ability to produce (firm/farm) a reasonable output with the least amount of resources (inputs) using a particular technology is known as TE, whereas EC is the output of both AE and TE. AE is the measure of degree of success by combining the best different input/resources to produce specific level of output while taking the relative prices of inputs used. Farms operate on the production potential frontier that is open to them, rather than within it, which is a crucial hypothesis that cannot be overlooked and governs production efficiency. With the best technologies available, TE is therefore defined as the highest level of productivity (outputs) that can be achieved for a given level of production input, whereas AE is the alteration of resources (inputs) and productivity (outputs) to reflect relative pricing, having chosen the production technologies. The purpose of these modifications is profit maximization, which specifies that the MVP per unit of an input should be the same for various outputs and that the MVP and MFC for any single variable input should be equal. The greatest output feasible from a specific combination of inputs and production technology was described by Aigner *et al*. (1977) and Meeusen and van den Broeck (1977) as the fisherman's TE, which is a measure of fishermen's ability to produce in relation to the other best-practice frontier. Because fishing is subject to erratic factors including weather, resource availability, and environmental influences, the calculated frontier is stochastic (Kirkley *et al*., 1995).

MATERIAL AND METHODS

The study was conducted in Yobe State, North East Nigeria. where the study was conducted. Several water bodies that took their path from the River Yobe and flow continuously into Lake Chad are a blessing for Yobe State (Ashley-Dejo *et al*., 2022a).

The study adopted multi-stage sampling technique in which two hundred and fourth (240) fishers were selected. The first stage involved purposive selection of two local government areas (Bade and Bursari). The selected local government areas are usually refers to as home of fish in the State. The second stage involved the use of simple random sampling techniques to select four fishing communities from the selected local government areas. The selected fishing communities were Gogaram, Dagona, Bize, Azbak, Daskum, Dadigar, Gadine and Masaba, thirty respondents were randomly selected from each community Before the commencement of the survey, fishers' permission was sought individually. Using the study's objectives as a guide, the research materials were divided into sections. The study uses a stochastic frontier model to assess the technical proficiency of the local artisanal fishers. Researchers have utilized this model multiple times to identify inefficiencies and efficiencies in agricultural production systems (Coelli *et al*., 2005).

The model as specified by Greene (2008) in question (1)

$$Inq_i = f(InX) + v_i - u_i \quad \text{.....................} \quad (1)$$

Where *qi* is the artisanal fisher's output (kg) v_i denotes the stochastic (white noise) error term and u_i denotes one-sided error representing the technical inefficiency. Both v_i and u_i taken to be independently and identically distributed.

Therefore, this can be estimated as;

$$Inq_i = f(InX) - u_i \quad \text{.....................} \quad (2)$$

while the efficient level of production can be defined as;

$$Inq^* = f(InX) \quad \text{.....................} \quad (3)$$

Technical efficiency (TE) is given as Chukwuji*et al*. (2007):

$$InTE_i = Inq_i - Inq^* = -u_i \quad \text{.....................} \quad (4)$$

Thus,

$$TE_i = e^{-ui}$$

Whenever u_j equals zero, TE also equals one and production is said to be technically efficient. Technical efficiency is a relative measure of its output as a proportion of the corresponding frontier output.

Cobb-Douglas functional method was designated for this study. According to Setsoafia*et al*., (2017), this method has been used for empirical studies mainly those connecting to agriculture in developing countries. Moreover, this functional method fits well in cases where there is occurrence of high frequencies of observations.

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

$$Inq_i = \beta_0 + \beta_1 lnX_1 + \beta_2 lnX_2 + \beta_3 lnX_3 + \beta_4 lnX_4 + \beta_5 lnX_5 + \beta_6 lnX_6 + v_i - u_i \quad \text{..................} \quad (5)$$

Where;

$Inqi$ =Natural Logarithm of q

q_i = Catch/Output of fish (kg)*

X_1 = number of fishing net

X_2 = number of fishing line

X_3 = number of canoes

X_4 = number of hooks

X_5 = number of batteries (average quantity (pair) of battery used per fishing trip)

X_6 = Labour (man days)

$\beta_o - \beta_6$ = unknown parameters to be estimated

U_i = inefficiency effects which are assumed to be half normal (because artisanal fishers are assumed rational in their production behavior and hence negative output is not expected) and independently distributed of V_i.

The presence of technical inefficiency effects was tested using the generalized likelihood ratio test (λ), which is defined by

$$\lambda = -2(L_R - L_U) \quad \text{.....................} \quad (6)$$

Where;

L_R=log likelihood of the restricted model (Model 1)

L_U=log likelihood of the unrestricted model (Model 2)

λ has a chi-square distribution with degree of freedom equal to the number of parameters excluded in the unrestricted model.

The inefficiency model

The U_i are the technical inefficiency effects and for this study, this is defined as

$$U_i = \partial_0 + \partial_1 Z_1 + \partial_2 Z_2 + \partial_3 Z_3 + \partial_4 Z_4 + \partial_5 Z_5 \quad \text{.....................} \quad (7)$$

Where:
Z_1 = age of artisanal fishers (years)
Z_2 = educational qualification (years) of artisanal fishers
Z_3 = household size (number of people)
Z_4 = artisanal fishers fishing experience (years)
Z_5 = income of artisanal fishers (₦)
$\partial_0, \partial_1, \partial_2, \partial_3, \partial_4, \partial_5$ = parameters to be estimated.

The unknown parameters of the models β's and ∂'s and the variance parameter were simultaneously estimated.

$$\sigma^2 = \sigma^2_\mu + \sigma^2_v \quad \ldots\ldots\ldots\ldots (8)$$

$$\gamma = \sigma^2_\mu/(\sigma^2_\mu + \sigma^2_v) \quad \ldots\ldots\ldots\ldots (9)$$

Constraints faced by artisanal fishers in the study area were ranked by adopting 'Garrett ranking technique'. The fishers were initially allowed to rank constraints using Five-Point Likert Scale which were latter converted into score value using formula specified in equation (10): $Percentage\ position\ of\ constraint\ = 100(\frac{R_{ij}-0.5}{N_j}) \ldots\ldots\ldots\ldots (10)$

where R_{ij} is rank of constraint, N_j is number of constraints ranked by fishers.

RESULTS

The majority of fishers were found to be men (92.1%), as shown in Table 1. Fishers ranged in age from 23 to 67 years, with a mean age of 43 years. The majority (67.9%) of fishers in the study area had a formal education, and 79.6% were married. The average household size was 13 individuals. The mean fishing experience of fishermen in the study area was 16 years. Table 1 further showed that 28.8% fishers earned between ₦ 50,001 and ₦ 100,000 per month, while 46.3% earned between ₦ 100,101 and ₦ 150,000 in gross income per month. The average gross monthly income was ₦ 127,731. In addition, majority (74.2%) of the fishers engaged in other revenue-generating activities to supplement household needs. Also, majority (72.9%) of the fishers in the study area fish during the day time and night as well. This could be as a result of family responsibility awaiting them.

Table 1. Distribution of household heads based on socio-economic characteristics

Characteristics	Frequency	Percentage	Mean±SD
Gender			
Male	221	92.1	
Female	19	7.9	
Age (years)			
Less than 25	23	8.8	
26 – 25	59	22.5	
36 – 45	92	38.3	42.5±14.2
46 – 55	61	25.4	
56 and above	12	5.0	
Educational level			
Arabic Education Only	77	32.1	
Primary Education	104	43.3	
Secondary Education	36	15.0	
Technical Education	23	9.6	
Marital Status			
Single	17	7.1	
Married	191	79.6	
Divorced	32	13.3	
Household size			
Less than 5	46	19.2	
5 – 10	67	27.9	12.7±5.24
11 – 15	104	43.3	
16 and above	23	9.6	
Fishing experience (years)			
Less than 11	41	17.1	
11 – 20	89	37.1	
21 – 30	76	31.7	16.3±6.14
31 – 40	27	11.3	
41 and above	7	2.9	
Monthly income from fishing (₦)			
Less than 50,000	27	11.3	
50,000-100,000	69	28.8	
100,001-150,000	111	46.3	127,731±65.24
Above 150,000	33	13.8	
Other sources of income aside fishing			
Yes	178	74.2	
No	62	25.8	
Fishing time			
Day	21	8.8	
Night	44	18.3	
Day and Night	175	72.9	

Source: Field Survey 2021.

The estimated parameters for the stochastic fish catch function among artisanal fishers considered in the study area is presented in Table 2. From the adopted model, it was revealed that all the estimated coefficients considered in this study were positive except for number of batteries. The coefficient of number of fishing nets, number of fishing line, number of canoes, number of hooks and labour imply that any unit increase in any of the mentioned variables will result to increase in fish output. On the other hand, number of batteries does not conform to the *a priori* expectations as its estimated coefficient was negative. This could be due to the fact that the fishers do not use batteries regularly like they do for other fishing equipment. The t-ratio test revealed that all parameters test in this study were statistically significant at different probability levels (1% and 5%) except for number of batteries used that was not significantly different.

The coefficient of number of fishing nets (0.741), line (0.574), canoes (0.563) and hooks (0.281) were positive and significant ($p < 0.01$ and 0.05). Thus, 1% increment in the usage of number of nets, line and canoes will increase catch level by 0.741%, 0. 574% and 0.563% respectively. Also, 0.5% increment in the usage of hooks will result to increase in catch level by 0.281%. This implies that the more the fisher in the study area use these inputs, the better their output (catch).

The coefficient of labour (0.415) was also positive and significant at ($p < 0.01$) showing the importance of labour in fishing activities. Thus, 1% increase in man day of labour increase output (fishers catch) by 0.415%.

The determinants of catch inefficiency are the factors that limit efficient production. Results in Table 2 revealed that not all the modeled variables have the expected sign. It was observed that fisher's age decrease catch inefficiency as it was negative and significant ($p<0.05$). This implies that older fishers are more catch-efficient. Also, fisher's experience follows the same trend as fisher's age. However, fisher's literacy level was found to decrease catch inefficiency as it was negative and significant ($p<0.05$). This implies that literate fishers are more catch-efficient. Likewise, fisher's income was negative and significant ($p<0.05$). This implies that income play a significant role in fishers catch-efficiency.

The estimate of the σ^2 which was significantly ($p<0.001$) different from zero revealed the goodness of fit of the model while the γ was estimated to be 0.358. It suggests that the systematic influences that are unexplained by the production function are dominant sources of error. This implies that 35.8% of the variation in fishers catch value was as a result of disparity in technical efficiency

Table 2. Maximum Likelihood Estimates of Stocastic Production Frontier For Artisanal Fishers

Variables	Parameters	Coefficients	Standard Error	T-ratio
Production Model				
Constant	β_0	8.541	0.320	26.663
Number of fishing net	β_1	0.741***	3.075	0.241
Number of fishing lines	β_2	0.574***	2.382	0.241
Number of canoes	β_3	0.563***	5.262	0.107
Number of hooks	β_4	0.281**	0.165	1.704
Number of batteries	β_5	-0.027	-0.162	0.167
Labour (man days)	β_6	0.415***	3.578	0.116
Inefficiency Model				
Constant	∂_0	-5.714	1.863	3.067
Age (years)	∂_1	-0.034***	0.458	0.0743
Educational qualification (years)	∂_2	-0.076***	-1.652	0.117
Household size (number of people)	∂_3	0.254	2.032	0.125
Artisanal fishers fishing experience (years)	∂_4	-0.108**	0.072	1.503
Income of artisanal fishers	∂_5	-0.054**	-0.051	1.052
Sigma-squared	σ^2	0.141***	0.022	6.417
Gamma	γ	0.287***	0.802	0.358

Source: Field Survey 2021. *** and ** denote significance levels at 1% and 5%, respectively

A summary of the catch efficiency index, which was examined using technological efficiency derived from the projected production borders (Table 3). The capture efficiency ranged from 44.6% to 97.12%, with the bulk of fishers concentrating between 61.0% and 90.0%. Of them, 17.5% reached between 81.0% and 90.0%, and 13.5% achieved 91.0% to 97.0%. The study's average catch efficiency was calculated to be 0.87. This suggests that fishers in Yobe state Nigeria captures fish at a rate of about 87.0% of the maximum possible catch, which means the catch level was almost 13.0% below the boundary. Furthermore, it was indicated that catch inefficiency issues resulted in the loss of 13.0% of the overall catch. The difference in catch seen here may be related to some aspects of fishing, such as the type of inputs used, technology, and the fisher's managerial skills for achieving better levels of catch efficiency.

Table 3. Frequency Distribution of Technical Efficiency of Artisanal Fisher in the Study Area

Efficiency Range 100%	Frequency	Percentage
Less than 50	24	10.0
51 – 60	27	11.3
61- 70	35	14.6
71 – 80	44	18.3
81 – 90	78	32.5
91 – 100	32	13.3
Minimum catch efficiency	21	
Maximum catch efficiency	94	
Mean catch efficiency	87	

Source: Field Survey 2021

In the study area, artisanal fishers were interviewed and given the opportunity to rank some obstacles to their livelihoods. Table 4 displays the ranking's executive summary. The biggest constraint, according to the respondents, was the absence of storage and preservation facilities, with a mean score of 76, unstable catch price was rated as the second-most significant limitation with a mean score of 71, the presence of typha grass was ranked as the third most significant limitation. Fishermen claim that typha grass hinders their ability to fish. Operating costs for fishing, like those for any other economic activity, include the price of both fixed and variable inputs. The majority of fishers who were interviewed said that the fluctuating cost of fishing gear was hurting their ability to make a profit. Unsuitable and unwelcoming weather conditions were ranked fifth. Fishers in the study use canoes without technology (outboard motors), inappropriate and unfriendly weather conditions endanger their lives because they are unable to venture outside to fish in such conditions. The fishers ranked finance (availability to financing) as the constraint with the least importance.

Table 4. Constraints Faced by Artisanal Fisher in the Study Area

Constraints	Percentage position of constraints	Mean score	Rank
Absence of preservative and storage facilities	7.813	76	1st
Unstable price of catch	12.621	71	2nd
Presence of typha grass	14.314	64	3rd
Unstable price of fishing equipment	19.243	61	4th
Unsuitable and unfriendly weather condition	27.493	57	5th
Finance (access to credit)	11.543	53	6th

Source: Field Survey 2021.

DISCUSSION

Majority of the fishers in the study area were males this might be due to the nature of fishing which involves physical strength. In African setting, females' fishers are mainly engaged in fish processing and marketing, unfortunately few females were found fishing which could be as a result of insurgency or displacement from their respective home towns. Fishing activities in the study area was dominated by young, active, energetic youth which accounted for about two third of the sampled population. This age group has been internationally described as active, productive and economic age group (Setsoafia *et al*., 2017). The fishers in the study area are at advantage because majority were literate with large family size. These could assist in adoption of new fishing techniques and labour force. From the study, it was affirmed that most of the fishers were married individuals with relatively large household size which tend to influence the magnitude of fishing activities because fisher's in the study area often depend on family labour. The observation was in line with the study carried out by Ashley-Dejo and Adelaja (2021) and Aminu *et al*. (2014) in coastal area and inland water of Nigeria. Fishing experience is important in determining the profit levels of artisanal fisher, the greater the experience, the more artisanal fisher understand the system, conditions, fishing terrains, prices and also help in reducing management risk (Ashley-Dejo *et al*., 2022b). The relatively high artisan fishing experience in the study area place the fishers at advantage level. Also, majority of artisanal fishers in the study area fish during day and night. This could be as a result of family responsibility awaiting them at their respective household.

The determinants of catch inefficiency are factors that limit efficient production. The analysis of the technical inefficiency model showed that not all the modeled variables have the expected sign as revealed. The finding was in line with the assertion of Setsoafia *et al*. (2017) and Aminu *et al*. (2014) who reported that fisher folks' experience and income serves as catalyst in fisher catch-efficiency. Catch efficiency index observed in this study was in line with the findings of Squires *et al.* (2020), who reported in a study on technical efficiency in the Malaysian artisanal fisheries, that most fishers exhibit a high degree of technical efficiency.

Absence of preservative and storage facilities as topmost constraint in the study area. Itam *et al*. (2014) ranked absence of processing and storage facilities as most pressing need of the fishers in Nigeria. Also, Setsoafia *et al.* (2017) and Itam *et al*. (2014) ranked unfavorable prices of fish the as second and fourth most pressing need of the fishers respectively.

CONCLUSION

The result of the stochastic frontier analysis revealed that number of fishing net, number of fishing lines, number of canoes, number of hooks and labour were the significant factors affecting the fisher's efficiency in the study area. The analysis of inefficiency model showed that age, educational qualification, fishing experience and fishers' income were the major factors affecting fisher's inefficiency. The technical efficiency observed from this study ranged from 44.64% to 97.12% with mean catch efficiency estimated to be 87%%. This implied that the fishers in Yobe State were catching fish at about 87% of the potential production fish catch level, indicating that the catch level was about 13% below the frontier. This also meant that a significant proportion of the fish catch was lost due to technical inefficiency. Major constraint recorded include absence of preservative and storage facilities which makes fishers to sell catch at giveaway price to avoid spoilage. Other major constraints identified by fishers in the study area include unstable price of catch, presence of typha grass, unstable price of fishing equipment, unsuitable and unfriendly weather condition. However, it is therefore recommended that modern, intermediate-technology processing and storage facilities should be made available to the fisher with flexible repayment plan, this becomes imperative since fishers in the study area have proved efficient use of production resources. Likewise, policy that favours price celling and contract sale should be formulated and implemented.

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