Technical Efficiency of Artisanal Fishing Business along Rivers Niger and Benue, Kogi State, Nigeria

This study sought to ascertain the factors that influence technical efficiency of the fisher folks. The socioeconomic characteristics were mapped, resources use efficiency were estimated and technical efficiency level of artisanal fisheries resources use along Rivers Niger (RN) and Benue (RB) in Kogi State were analyzed using descriptive statistics and Stochastic Frontier Model. Three-stage sampling technique was adopted in selecting 235 artisanal fishing households along RN (n=176) and RB (n=59). Data were collected from artisanal fisherfolks using of structured questionnaires. The result showed majority of fishers were male (100% and 98.30%) with an average age of 47.52±8.15 and 51.76±12.89 years and fishing experience of 27.53±11.00 and 35.38±11.52 years in RN and RB, respectively. The results of stochastic production function showed that fishing hours, crew size and length of fishing gears were significant determinants of fish output in River Benue, while education, fishing experience, age of fishermen and extension visits significantly reduced inefficiency. The average technical efficiency was found to be 64% (RN) and 79% (RB) indicating that efficiency can be improved by as much as 36% and 21% in RN and RB, respectively. Policies for capacity building of the fishermen and better access to production technology are recommended.

Keywords: *Artisanal, Fisheries, Resource use, Technical Efficiency, River Niger, River Benue Nigeria*

Introduction

The artisanal fisheries sector within the fisheries sector of agriculture constitutes the most important social and economic development sector in Nigeria. It contributes about 3.00–5.00% to the agriculture share of the Gross Domestic Product (Olaoye et. al., 2018). In 2016, Nigeria produced 734,731 tonnes which has increase rapidly to 916,284 tonnes in 2017 (FAO, 2017). Globally, fish consumption rates is growing faster than the global population growth, because of increased incomes and awareness of the health benefits associated with consuming fish, as well as rising urbanization (Anderson et. al., 2017). According to FAOSTAT, Fish consumption per capita reached 13.3kg in 2017 in Nigeria, below to the world's average of 20.5kg in 2017.

The sub-sector has maintained a steady contribution of 3.5 to 4% to total gross domestic product (GDP) between 2008 and 2018 and thus, plays a crucial role with regards to the sustenance of socio-economic well being of fishers in the inland and coastal communities. The immense significance of this sector has led to numerous strategic management polices to primarily motivate increased production in low-income communities which depend on fish as their primary source of protein and to boost productivity in Nigeria. However, the traditional open access nature, which generally reduces fishing harvesting directly or indirectly, coupled with the growing number of people who depend on fisheries exploitation, has put such natural resources under severe strain.

This has led to over-exploitation and, consequently, depletion. The current demand estimate of fish production 2.66 million metric tons (MMT) has also created a staggering demand-supply gap of about 1.8MMT (Oyinbo and Rekwot, 2013). This shortfall of fish supply and the expanding population has led to a low annual per capita fish consumption rate of only 7.5 kilogrammes as against 15 kilogrammes per annum recommended by the Food and Agriculture Organization (FAO, 2011). This situation induced several innovative management strategies in the past to boost productivity through institutional reforms and economic measures to increase and conserve fish resources to ensure sufficient and sustainable production in Nigeria (FEPA, 1999).

Despite external interventions through fisheries development programmes, there are repeated episodes of declining yields and economic returns, and loss of biodiversity, which has made the major objective to make Nigeria self-sufficient in fish production and supply still a mirage. These problems are further aggravated for lack of relevant information to fishing communities to organize their resources to achieve their goals. This so because, low level of education is a common demographic characteristic of fishing settlement because of its extractive nature and the acts of fishing is less desirous of higher learning for effective fishing operations. It is evident from socio-economic studies outcomes of fishing communities in Nigeria, high incidences of illiteracy were observed and the rates ranges between 51.4 – 66.07%, Baruwa et. al., (2012) had earlier explained the persistent low universal basic education attainment. He argued that educational provision has been usually of poor quality, and unresponsive to the culture and livelihoods of fishing communities. Aside formal education, there is prevalence of non-formal knowledge; tailored towards the job proficiency (McGoodwin, 2001). Ikiara (1999) and Squires et al., (2003) observed that hands on task experience during the years of fishing do provides better knowledge about the location of fish, weather patterns, currents and tides, bottom conditions, and how to best catch the fish.

Attaining production efficiency is not always a straightforward interaction of but complex mix of direct and indirect variables that includes the environmental elements, the background characteristics of the producers and the fishing enterprise operational behavior. This prompt the activities of the fisherfolks to address what is perceived as threats to their sustainable livelihood and income generation in the fishing communities. The multiple income activities engagements are means of survival in fishing business and strategy for poverty alleviation, Fregene (2015) and (Oluwatayo, 2009). Also, technical fishing efficiency has been noted to be sex bias as the low participation of women in actual fishing voyage could be attributed to the energy demanding and risky nature of fishing, especially in deep waters. Brummett et al. (2010) in their study of women's traditional fishery and alternative aquatic resource livelihood strategies in the Southern Cameroonian rainforest reported that fishing activities were mostly dominated by men. Other socio-cultural factors that could limit women full participation in the small-scale fisheries sector are restricted access to water resources, low technical know-how and lack of credit facilities. Another socioeconomic factor worth considering that influence the technical fishing efficiency is the age bracket, which has been noted for innovativeness and self-motivation, more energetic, enthusiastic and healthier with better entrepreneurial drive in the society, Fakoya and Daramola (2005) and Malgwi (2000).

Fisher Folks are noted to reproduce many children and many wives; therefore, marriage is very common indicators of social status. Social status of married men is often enhanced by being married and their wives always observe traditional expectation of bearing as many children as possible to ensure the provision of adequate labour force for family chores and processing of fish for better income (Olaoye et at., 2012). Because of the extra privileges that this variable has on the fishing turnover, household size becomes a very important variable to labour supply in fishing household as Large fishing households are essential in artisanal fishing because of the intensive labour nature of fish harvesting and post-harvest activities often require the contribution of labour from the fisher's family, Okeowo et al. (2015).

Sound knowledge and understanding of the socio-economic variables that influence artisanal fish harvesting, and sources of technical inefficiency among the artisanal fisher in Rivers Niger and Benue in Kogi State are important. This study, therefore, sought to ascertain significant determinants and levels of fishing productivity across the fisherfolks in Kogi State, Nigeria. Therefore, study was focused on the following specific objectives were: to examine the socio-economic characteristics of the artisanal fisher folk in the study area; to estimate the technical efficiency of the artisanal fisher folks in the study area; and to analyze the extent of technical efficiencies among the artisanal fisher folks in the study area.

Literature Review

Artisanal fisheries are of great significance in developing countries in terms of job opportunities and support to the economy of coastal communities. It is an essential tool for rural development through its provision of income, high-quality protein, and socioeconomic development of fishing communities in Nigeria. It has been estimated that Fisheries contribute to Africa's economy. Currently, fisheries and aquaculture directly contribute $24 billion to the African economy, representing 1.3% of the total African GDP in 2011. The sector provides employment to over 12 million people (58% in the fishing and 42% in the processing sector) (World Bank, 2019). Despite this importance, the sector is still poorly understood, statistics are limited and there still exist a lack of universal and straightforward definition for artisanal fisheries. The necessity to describe artisanal fisheries is a recurrent issue in policy, management and research debates (e.g. Guyader et al., 2013, Symes, 2013). For example, sometimes the term is used interchangeably with ‘‘small scale fishery’’, “local”, “coastal”, “traditional”, “small”, “subsistence”, “non-industrial”, “low-tech”, “poor” – is suggestive of the many values and characteristics underpinning their definition. Thus, “artisanal fisheries” are often denoted to as “small- scale fisheries”, though as Di Franco et al. (2014) report, some delicate differences between the two definitions are sometimes highlighted. The term "artisanal" refers to the little technology used on fishing trips without reference to vessel size, while the term "small-scale" refers to the small size of the vessels without any implication of the degree of technology used (Di Franco et al., 2014).

However, FAO, 2016 elucidate the general characteristics to artisanal or small-scale fisheries as "traditional fisheries involving fishing households (as opposed to commercial companies), using relatively small amount of capital and energy, relatively small fishing vessels (if any), making short fishing trips, close to shore, mainly for local consumption. In practice, the definition varies between countries, e.g. from gleaning or a one- man canoe in poor developing countries, to more than 20-m. trawlers, seiners, or longliners in developed ones. Artisanal fisheries can be subsistence or commercial fisheries, providing for local consumption or export. They are sometimes referred to as small-scale fisheries. Numerous authors (Guyader et al., 2013, Symes, 2013, García-Flórez et al., 2014) based their definition for artisanal on characteristics simply on vessel size, such as modes of enterprise organisation, spatial–temporal dimension of operations, social organisation, economic behaviour and dependence on local ecosystems.

According to Symes (2013), Artisanal fisheries can be seen as a social phenomenon, a choice of life which is accompanied by limitations in fishing activity and operational range. Artisanal fisheries or small scale fisheries are better integrated in local, social–ecological systems and this makes them more resilient. García-Flórez et al. (2014) address the issue of defining artisanal fisheries or small-scale fisheries through a set of structural (vessel length, gross tonnage, engine power, of gear type) and functional descriptors (duration of fishing trip, number of fishermen per boat, fishing licences). According to Olaoye et al. (2013) participants in artisanal fishery comprise local fishermen and women who fish either on part-time or full-time basis employing all sorts of gears and techniques, which may be destructive, cheap, and locally sourced. It is usually functioned at subsistence level (although, some are for commercial purposes) in rural areas. It covers the activities of small-scale canoes operating in the coastal areas, creeks, lagoons, inshore water, and the inland rivers (Baruwa et al., 2012) Artisanal fishing involves the use of crude fishing tools and implements, little or no credit and lack of infrastructural facilities, and lack of skills (Oladimeji et al., 2013).

Artisanal fisheries or small scale fisheries in contrasts to large-scale commercial fishing known as Industrial fishing provides a large quantity of food to many countries around the earth, practices is often more wasteful and stressful on fish populations than artisanal fishing. Small-scale and artisanal fisheries often compete, and conflict, with industrial fisheries (Carolyn et al., 2012). This depends on local contexts and is difficult to generalize. The artisanal fishing sector regardless of any technical debate over its precise definition provides direct employment to tens of millions of people, and indirect employment to tens of millions more (many of them women involved in fish processing) FAO, 2015. Most small-scale fisheries are exploited under some sort of open access regime and artisanal fishermen often fish during the closed season, and in protected areas when it is not allowed (Sjösted, et al., 2013), sometimes close season are enforced by modern governments, even though traditionally social mechanisms may have existed to restrict such access. The combination of increasing fish demand and commercialization has led to excess fishing capacity, resource depletion, waste of economic and human resources, and poor returns on development efforts (Luc, 2017).

Artisanal fisheries sector is also similar to other agricultural production sector that utilizes factors of production to extract the produce for economic return. Fishing at any scale utilizes some basic resources to maximize it output. It is observed that proficiency of resources combination and utilization differs among entrepreneurs and variations in the levels of efficiencies are influences by some other factors that unique to the human and social capacities of the business managers. Stochastic frontier analysis (SFA) is based on regression and thus can only deal with a single dependent variable or output (Bukenya et al. 2013; Kim et al. 2011). Several studies that focused on estimating the technical resource use efficiencies of the production based business even though there is dearth of information on artisanal fisheries business sector and the stochastic production frontier function models have been applied in a number of studies, most especially, in agricultural economics studies.

Estimation of technical efficiency is important for informing fisheries management (Yang, Lou, Matsui, & Zhang, 2016), and there are no prior reasons in favour of the use of input measures in fisheries efficiency. A review of applications of frontier production models covered in literatures within the last two decades had been discussed under five main sections: deterministic frontiers; stochastic frontiers; panel data frontiers, the data envelopment analysis and probabilistic frontiers. However, this study adopted the applications of stochastic frontier models. Dawang et al., (2011) estimated profitability index and technical efficiency of artisanal fishing in five natural lakes in plateau state, central Nigeria using the translog function of the stochastic frontier production function for natural lakes fishers. They observed that gamma coefficient was 0.72 and statistically different from zero at 1% level of significance, suggesting that about 72% of variation in output of fishers at the fisheries were as a result technical inefficiency effects. The results further reveal that technical efficiency ranges between 20.74-94.57% with a mean technical efficiency of 83.19% suggesting a relatively high technical efficiency level existing in the fisheries, pointing to a frightening level of exploitation and a wide range of efficiency level existing in the fisheries.

Kareem et al., (2013) analyzed the technical efficiency of artisanal fisheries in Ijebu waterside of Ogun State, Nigeria. Stochastic production frontier model was used to estimate the technical efficiencies and factors influencing the technical efficiencies of the fishers. The results of the maximum likelihood estimates of the parameters for the technical efficiency of the fisher folks revealed that number of fishing gears, outboard engine, litres of kerosene used and quantity of bait used were found to be significant variables in the fish catch level. Sigma squared of 0.97 is significant at 10% probability level. This however implies a wide variation in the level of technical efficiency. The gamma value of 0.99 shows the amount of variation resulting from the technical inefficiencies of the fisher folks. The mean technical efficiency (TE) is estimated to be 0.77, indicating that the realized output could be increased by about 23% by adopting the practices of the best fisher folks. Ele, et al. (2014) adopted Cobb-Douglas stochastic frontier production function to estimate Socioeconomics, costs and returns and technical efficiency of Bonga fishermen in the Lower Cross River Basin, Nigeria. The result showed that mean technical efficiency was 85.65% while the mean for dry and rainy season were 73.55% and 74.85% respectively.

Ele et al., 2014 studies of production determinants and technical efficiency in Crayfish production in the Lower Cross River Basin Nigeria revealed that shows that labor, credit, mesh size and motorization were all significant variables at 5% level for aggregate data. However credit was not significant in the dry season while mesh size was not significant in the wet season. The signs of the coefficients of credit and motorization were not in conformity with a priori expectation. Technical efficiency shows that crayfish producers were not fully technically efficient. The mean technical efficiency was 79% for aggregate data but 49.7% and 62.8% for dry and rainy seasons respectively. The determinants of technical efficiency were age, fishing experience and educational levels.

Catch as a function of inputs to production, random error and inefficiency on efficiency among boats and over time of the Pacific Hike Fishery was investigated by Tomberlin, Lrz and Holbway (2006). They still used the composed error model first formulated by Aigner, Lovell and Schmidt (1977) and reported a mean percent efficiency score of 0.81 and 0.96 for six different models estimated. They demonstrated the relevance of the Bayesian methods to technical efficiency analysis and highlighted some particular strength of the method. Akanni, (2006) investigated actors that are responsible for the low catch in artisanal fisheries in Lagos Sate using stochastic catch frontier model. The result revealed that mean technical (TE) and allocative efficiency (AE) indexes for the artisanal fisher folks (manual propulsion fisheries) were, 0.6450 and 0.6317, respectively and 0.7971 and 0.7049, respectively for the motorized fisheries. However; the technical efficiency of the MF operators can be improved through a better fishing education and timely provision of credit facilities to acquire the needed fishing equipment and materials.

Cobb-Douglas catch function was used for comparative analysis of capture fisheries in the Western and Eastern shores of kainji lake basin. Rahji (2003) noted that explanatory variables were age of fishermen, family labor, education, capital expenses, motorization variables, fishing experience and credit use were significant. Akah (2004) estimated only linear and Cobb Douglas functions for the input utilization of fishermen in Esuk Nsidung in Calabar. The significant independent variables were age, hired labor, fishing experience and capital expenses.

Wategire et al., (2015) used Cobb Douglas stochastic production frontier function to examine the technical efficiency of small-scale shrimp fishers and specific factors that affect the efficiency level of non-motorized small-scale shrimp fishers in the coastal areas of Delta State. The results showed that the mean technical efficiency (TE) was 73% for non-motorized shrimp fishers in the study area. The result also showed that boat capacity, nets and labour impacted positively on output of shrimps with nets being significant at 5%

while the technical efficiency of these fishers were positively and significantly related with age, education, access to credit, distance covered and membership of local cooperative groups.

A recent study of Terubok fisheries in Malaysia by Ashraf-Roszopor et al., (2018) show that, most fishing units exhibit a low level of technical efficiency. This implies that either fishing inputs were used inefficiently, or insufficient inputs were used in fishing operations. The mean technical efficiency of the sample was estimated to be 0.304 using CRS Model, 0.406 using VRS Model and Scale Efficiency is 0.805. The determinant factors of efficiency among Terubok fishermen was among all, hours in a day, days spent in fishing per month, engine horsepower and fisherman association show positive sign towards efficiency contradictorily other determinant such as age, education, distance and length of vessels possess negative sign towards efficiency.

Methodology

The study was carried out in Kogi State, situated in the savannah region between longitude 05°20" and 08°00" East and latitude 05°30"and 08°50" North. Kogi State is located at the confluence of the two major rivers in Nigeria, River Niger and River Benue. Three-stage sampling procedure was used in selection of respondents for this study. Ten fishing households were randomly selected from three fishing villages each in the six and two Local Government Areas (LGAs) along River Niger (Ibaji, Ajaokuta, Ufo, Lokoja, Igalamelaand Idah) and River Benue (Omala and Bassa) in Kogi State (see Table 1), respectively. Fishing villages were selected based on intensity of fishing activities. In all, a total of two hundred and forty (240) fishing households were interviewed. However, only two hundred and thirty-five (235) provided meaningful information for analysis. Information on costs, earnings, revenue, on-board catch and effort appraisal was extracted on a per-boat basis through actual fishing operations and interview, using a structured questionnaire. Each fishing household was sampled once a month for a period of eighteen (18) months, between July 2009 and December 2010. This study employed a number of analytical tools based on the objectives of the study. Descriptive statistics, such as tables, frequencies, mean and percentages were used for socio-economic variables. With respect to technical efficiency of artisanal fisher folks, Stochastic Frontier Production function analysis (SFA) was carried out using FRONTIER version 4.1c (Coelli, 1996) and this has the advantage of splitting the impact of weather and chance from influence of variation in technical efficiency. A frontier model with output-oriented technical efficiency is specified as follows:

$$Y_i = X_i \beta\omega + (\varepsilon_i = V_i - U_i) \quad \text{...} (1)$$

where, Yi is output in kg of individual i (i = 1, 2,... N) X_i is the corresponding matrix of K inputs and β is a k×1 vector of unknown parameter to be estimated. The disturbance term is made up of two independent components, $\varepsilon i = V_i - U_i$

where V_i ~N $(0,\delta_v^2)$, and U_i is a one-side error term. The noise component V_i is assumed to be i.i.d and symmetrically distributed independent of U_i. The term V_i allows random variation of the production function across individual and captures the effects of statistical noise, measurement error and exogenous shocks beyond the control of the individuals. If Ui = 0, then, $_i = V_i$ suggesting that production lies on the frontier and production is said to be technically efficient. If $U_i>0$, production lies below the frontier and thus there is evidence of inefficiency.

As indicated by Jondrow et al. (1992), ε_i contains information about Ui and makes it possible to estimate mean technical efficiency over all observations. It is also shown that firm-specific technical efficiency can be inferred from asymmetry in the residuals around a fitted production and its calculation rests on the higher moments of these residuals. Following Jondrow *et al*. (1992), the expected value of Ui conditional on the value of ε_i i.e. E (Ui/ε_i). The maximum likelihood estimation of equation (i) provides the estimators for βs and variance parameters $\delta^2 = \delta_v^2+\delta_u^2$ and $r = \delta_u^2/\delta^2$. Technical Efficiency (TE) of each individual is obtained by TE = Y/f (x; β) *exp (-u); hence we can define TEi exp (-u); exp is the exponential operator (Battese *et al*., 1996). The range of technical efficiency for individual i, (TE_i) is in the range of 0-1, where $TE_i = 1$ represents the achievement of the achievement of maximum output (adjusted for random fluctuations) for the given input.

The stochastic frontier production function model is specified as:

$Yi =f(xi,\beta)+Vi -Ui$ ....(Eqn. 2)

Where, Y_i is quantity of fish catch (output) by fisherman *i* (in kg), *Xi* denotes the inputs utilized, β is the vector of production function parameters, *Vi* is the stochastic error component, which is independently and identically distributed (iid) with zero mean and variance $(\sigma^2 v)$, while *Ui* is a non- negative, one-sided error term obtained by truncation (at zero) of the normal distribution. As indicated above, *Ui* captures the technical inefficiency relative to the frontier production function and is assumed to be independently distributed with mean μi and variance $(\sigma^2 u)$ (Tadesse *et al*., 1997). The variances of the random errors $(\sigma^2 v)$ and that of the technical inefficiency effects $(\sigma^2 u)$ and overall model variance (σ^2) are related thus: $\sigma^2 = \sigma^2 u + \sigma^2 v$, and the ratio, $\sigma^2 u/\sigma^2$ is called gamma. Gamma measures the total variation of output from the frontier, which can be attributed to technical inefficiency (Battese *et al.*, 1976).

The technical efficiency (TE) of an individual firm is defined in terms of the observed output *(Yi)* to the corresponding frontier output *(Ymax)*. The *Ymax* is maximum output achievable from inputs mix at the existing level of technology, assuming that 100 % efficiency is obtainable. According to Coeli et al, (2005) technical efficiency can be expressed as:

$$TE = \frac{Tt}{Ymax} = \frac{\exp(X_i\beta + u_i - u_i}{\exp(X_i\beta + v_i} = \exp(u_i) \qquad \text{(Eqn. 3)}$$

In the specification for stochastic frontier in this study, I used production function of the artisanal fishermen expressed in Cobb-Douglas functional form as follows:

$InY_i = \beta_0 + \beta_1 InX_{1i} + \beta_2 InX_{2i} + \beta_3 InX_{3i} + \beta_4 InX_{4i} + \beta_5 InX_{5i} + Vi\text{-}Ui$ ....(Eqn. 4)

Where,

Y = fishing output of the i^{th} fisherman
X_1 = the crew size
X_2 = the time taken for passive gears to remain active in water (h) per fishing trip as a proxy for hours fished (Sharma and Leung, 1999)
X_3 = Length of fishing gears measured in meters
X_4 = Number of fishing gears owned by the individual fisher that were in activity during survey period.
X_5 = Motorized boats (Mo) or Non-Motorized (NMo)
In = Natural logarithm

The inefficiency parameters of the fisher folks were estimated using the inefficiency model given as:

$U_i = \delta_0 + \delta_1 Z_{1i} + \delta_2 Z_{2i} + \delta_3 Z_{3i} + \delta_4 Z_{4i} + \delta_5 Z_{5i} + \delta_6 Z_{6i} + e_{i\ i}$ ....(Eqn. 5)

Where

Ui = Individual fishers' technical inefficiency measure
Z_1 = Fishing experience
Z_2 = Co-operative membership (Yes=1, No=0)
Z_3 = Age of fishers (years)
Z_4 = Year of formal education
Z_5 = Household size
Z_6 = Extension visit (Yes=1, No=0)
e_i = Error term

These socio-economic variables are included in the model to capture their possible influence on technical inefficiencies of the fishermen. The β's and δ's are scalar parameters to be estimated.

Results and Discussions

Socio-Economic Characteristics of the Artisanal folks along Rivers Niger and

Benue

The result on the socio-economic characteristics of the artisanal fisher folks along Rivers Niger and Benue as presented in Table 1 revealed that sex composition of fisher folks in River Niger was exclusively male while 1.7% of the populations were females in River Benue. The age group 41 - 50 years dominated the study area with 54% of fisher folk's population in River Niger and 33.9% in River Benue belonging to this age group. Age group of less than 30 years were the least in the population with 0.6% in River Niger and 5.1% in River Benue, population, respectively. Mean age in River Niger (47.52 ± 8.15yrs) was lower compared to their counterpart along River Benue (51.76 ± 12.89yrs) (Table 4.1). Therefore, the middle age group of 40-50 years were the most active. Majority of fisher folks in both study area were married with 99.4% of fisher folks in River Niger and 98.3% in River Benue, respectively. Unmarried fisher folks (divorced, widowed, single parent) constituted 0.6 % in River Niger and 1.7% in River Benue population. Fisherfolks household size structure was common in both study areas. 43.3% and 40.7% of the household size in Rivers Niger and Benue were 3-6 persons, respectively. Household size of < 3 persons was the least represented in the population of the study area with 19.9% in River Niger and 20.3% in River Benue. With regards to educational attainment, majority of the fisher folks in both locations had no basic formal education. This group constituted 58% of fisherfolks population in River Niger and 40.7% of fisher in Benue. The number of fisher folks with tertiary education constituted the least in the population with only 10.2% of fisher folks in River Niger and 0% in River Benue. There were marked differences between educational levels of fishing communities of Rivers Niger and Benue. With regards to fishing experience, majority of fisher folks fishing experience fell within the age range of 31 – 60 years with 57.4% of the fishing population in River Niger and 74.6% in River Benue. Age range of < 30 years in the population was 42.6% and 25.4% in Rivers Niger and Benue, respectively. The result of this study indicated that majority of the respondents in both locations fell within the age range of 31 – 60 yrs were more than fisher folk that were < 30 yrs. Fisher folks in the trading business constituted 71% and 47% in River Niger and Benue fishing population, respectively. There was evidence of income diversification of the fisher folks. The number of fisher folks in civil service and tailoring in both locations were 17% and 5% in Rivers Niger and Benue, respectively. Majority of the fisher folks in both Rivers Niger and Benue were involved in other non- agricultural income-generating activities to augment from fishing activities. Generally, the socio-economic indices of fisher folks in Rivers Niger and Benue as presented in Table 1 revealed that respective demographic structure in terms of age (47.53±8.16; 51.76±12.90), household size (5.51 ±2.88; 5.43±2.85), educational status (18.82 ±11.65; 10.29 ±5.13) and year of fishing activities (27.53 ±11.00; 35.39 ±11.53) of fisher folks along Rivers Niger and Benue were not significantly different.

Table 1. *Socio-economic characteristics of artisanal folks along Rivers Niger and Benue, Kogi State*

	River Niger (N=176)	River Benue (N=59)
Range	**Frequency (%)**	**Frequency (%)**
Sex		
Male	176 (100)	58 (98.3)
Female	0 (0)	1 (1.7)
Age		
30 years	1 (0.6)	3 (5.1)
30-40 years	3 (20.4)	9 (15.3)
41-50 years	95 (54)	20 (33.9)
51-60 years	37 (21)	13 (22)
60 years	7 (4)	14 (23.7)
Marital Status		
Married	175 (99.4)	58 (98.3)
Single	1 (0.6)	1 (1.7)
Household Size		
3 persons	35 (19.9)	12 (20.3)
3-6 persons	71 (40.3)	24 (40.7)
7-10 persons	70 (39.8)	23 (39)
10 persons		
Educational Status		
No formal	102 (58)	24 (40.7)
Primary	37 (21)	20 (33.9)
Secondary	19 (10.8)	15 (25.4)
Tertiary	18 (10.2)	0 (0)
Experience		
< 30 years	75 (42.6)	15 (25.4)
31-60 years	101 (57.7)	44 (74.6)
Total	176 (100)	59 (100)
Non-Agriculture Generating Income		
Trading	125 (71)	28 (47)
Waged labour	6 (3)	5 (8)
Civil service	30 (17)	10 (17)
Artisanship	7 (4)	13 (22)
Tailoring	8 (5)	3 (5.1)

Parameter Estimate of Cobb-Douglas Stochastic Frontier and Inefficiency Model for Fish Harvesting in Rivers Niger and Benue

The results of maximum likelihood estimate of the stochastic frontier production function and inefficiency models for fishers in Rivers Niger and Benue are presented in Table 2. Maximum likelihood estimates of the parameters of the Cobb-Douglas production function with their corresponding standard errors help to establish which factors are affecting the efficiency and production process. The magnitude, algebraic sign and significance of the estimated coefficient can reveal factors affecting technical efficiency. When positive coefficients of the estimated parameters of the frontier model showed positive relationship with the output, a percentage increase in the positive parameters estimated would lead to a percentage increase in the fish catch level while negative estimate coefficients show a negative relationship with the level of output (Jamnia, 2015).

As shown in Table 2, catch variables considered in the estimation of the technical efficiency model of the fisher folks in River Benue have no contribution to fish catch. The estimation in River Niger contributed positively to fish catch at varying percentages. Specifically, a unit increase in fishing hours would lead to increase catch by 1.4%. Increased catches in capture fisheries positively relate to increase in number of hours fished (Thomsen, 2005). Reducing the amount of time vessels are allowed to fish is often a very effective way of controlling over-fishing (FAO, 1997).

Large crew size plays an important role in the ability of a captain to easily adjust the level of other inputs in larger vessels (Nguyen *et.al*, 2011). The number of crew size and length of fishing gears in River Niger positively influenced the quantity of fish harvested suggesting that a unit increase in crew size and length of fishing gears would lead to increase in catch by 3.8% and 3.0%, respectively. However, these variables had no significant influence on quantity of fish catch in River Benue. Mwakubo et al., (2007) and Karrem, et al., (2013) reported that the numbers of fishing gears were found to be significant variables determining the level of fish output.

The coefficients of inefficiency function in Table 2 explain the levels of technical inefficiency among the respondents. Adebayo (2014) stated that the signs of the coefficient in the inefficiency model are interpreted in the opposite way and, as such, a negative sign means that the variable increases efficiency and a positive sign decreases efficiency. That is, a positive sign on the parameters in the inefficiency models results in negative effects on technical efficiency, and vice versa.

Years of fisherfolks experience play an important role in efficiency because an experienced fisher is able to allocate inputs used optimally, to determine location of fish stock more accurately compared with an inexperienced fisher (Sharma and Leung, (1999) and Esmaeili, 2006). Estimates of the coefficients of inefficiency model revealed that years of experience of fisher folks in River Benue positively influenced technical efficiency more than fisher folks in River Niger, suggesting that inefficiency of fisher folks was reduced by 77% and 22.9% by the year of fishing activity of fisher folks in River Benue and Niger, respectively. Squires et al., (2003) noted that factors such as fishing experience of captains often provides better knowledge about the location of fish, weather pattern, currents and tides, bottom conditions and how best to catch fish contributed to the technical efficiency. Kareem et. al., (2013) study of economic efficiency artisanal of fisheries in Ijebu waterside of Ogun State noted that an increased in number of years in fishing experience positively led to increased technical efficiency.

Cooperative membership, age of fisher folks and years of formal education in River Niger and years of fishing activity and extension visits in River Benue positively influenced technical efficiency. In other words, increasing cooperative membership, age of fisher folks and years of education in River Niger and extension visits in River Benue would contribute positively to technical efficiency or decrease technical inefficiency. This finding clearly underscores the role of organizational membership in increasing productivity (Ajibefun et al., 2003). Members of the fish cooperative groups tend to be more technically efficient because they have better access to knowledge, inputs and credit than non-members. Also, members of farmers' cooperative societies who had access to agricultural information and other production inputs tend to have enhanced ability to pay attention to such information and adopt innovations than non-members (Amos, 2007).

Extension visits to artisanal fisher folks positively influence technical efficiency suggesting that a unit increase in extension visit increased technical efficiency by 31.7% in River Benue. This may be explained by the fact that, extension contacts often change the perception and thinking of fisher folks, thereby increasing their technical efficiency. Dawang et al., (2011) and Namso et at., (2016) noted that increased technical efficiency of extension contacts reflected the fact that extension education was relevant to fishers and sustainable environmental fishing.

Years of education positively influenced technical efficiency in River Niger suggesting that fisher folks with higher level of education are likely to be more technically efficient because they have higher tendency to pay attention to effective management of their fishing activities. Similar to this study Akanni (2006) noted that educated artisanal fisherfolks in Lagos had greater likelihood of understanding the working mechanism of the motorized engines and therefore should be able to use it more efficiently than uneducated fisherfolks.

Fishing efficiency of artisanal fisher folks in River Niger was higher than their counterpart in River Benue suggesting that fisher folks in River Niger were more efficient in the use of their inputs than their counterpart in River Benue. This could be due to distance to fishing ground and assess to fishing inputs and market. Lokina (2008) in artisanal Lake Victoria Fisheries noted that fisher folks in Mwanza region was efficient than Mara and Kagera because of market potential in Mwanza region of the fisheries and Kareem et at., (2013) noted that distance to fishing ground positively influence technical efficiency.

There was variation in the level of technical efficiency of the fisher folks in both locations with 33.4% variation in River Niger and 8.2% in River Benue. More so, it showed the correctness of the specified distribution assumption of the composite error term. Similarly, gamma (γ) measures the share of changes in the technical inefficiency with respect to the total variability of the model errors. Thus, the estimator of gamma (γ) indicated that 99.8% and 94.0% of the variation in the fisher-folks output in the fisheries were as a result of technical inefficiency effects in Rivers Niger and Benue, respectively. The remaining portion was due to factors beyond the control of the fishers. The log likelihood function is often used to determine the differences between the restricted and unrestricted models while the likelihood Ratio (LR) test is used to determine the goodness of the model using the table of Kodde and Palm (1986). However, the value showed the rejection of the null hypothesis that (Ho: $\beta1=\beta2...\beta11 = 0$ and Ho: $= \delta_1 = \delta_2....\delta_5 = 0$) and the acceptance of the alternative hypothesis, which specified the significance of the variables as a determinant of the efficiency level in the study area. The mean technical efficiency suggested that fisher folks in River Benue (78.5%) used their inputs more efficiently than fisher folks in River Niger (64.3%). The implication of this is that fisher folks in Rivers Niger and Benue used 35.7 % and 21.5% of inputs inefficiently, respectively. This estimate compared fairly well with the mean technical efficiency of 64% estimate of Gbigbi *et al*., (2014) for artisanal fisheries of Niger Delta, indicating that efficiency can be improved by as much as 36%.

Table 2. *Parameter of the Cobb-Douglas Stochastic Frontier and Efficiency Model for Fish Harvesting in Rivers Niger and Benue*

	River Niger	River Benue
Variable	Coefficients	Coefficients
Frontier Model		
Constant	6.6582***(0.0502)	5.8902***(0.3641)
Crew Size	0.038***(0.0094)	0.0987(0.0616)
Hours Fished	0.0141***(0.0038)	0.0211(0.0227)
Length of Fishing Gears	0.0247***(0.0065)	0.0295(0.024)
Number of fishing Gears	0.0289**(0.0132)	-0.0073(0.1248)
Inefficiency model		
Constant	8.7858***(0.8526)	2.1935(1.3788)
Fishing experience	-0.2293(0.1404)	-0.774**(0.4576)
Co-operative membership	-0.02686068	-0.0877(0.1638)
Age of fishers	-1.793***(0.1864)	0.3242(0.4237)
Year of formal education	-0.0458***(0.0096)	-0.0218(0.0189)
Household size	-0.0277(0.0525)	0.0272(0.0308)
Extension visit	-0.1803(0.1172)	-0.05948213
Mechanized Boats	0.1561(0.1634)	-0.2755(0.1777)
Location (Niger=1, Benue=0)	-0.6006***(0.1144)	
Diagnostics Statistics		
Sigma squared	0.3336***(0.0434)	0.0815**(0.0332)
Gamma	0.9999***(0.0000)	0.8407***(0.0895)
Log likelihood function	-31.55	14.42
Mean technical efficiency	0.643	0.785
LR test of the one sided error	107.324	40.9

***Significant at 1%, **significant at 5%, *significant at 10%

Technical Efficiency Level among the Artisanal Fishermen in Rivers Niger and Benue

Furthermore, in Table 3, a large proportion of the fisher folks in Rivers Niger (64.7%) and Benue (86.5%) operated technical efficiency levels of >50%. This estimate compared fairly well with technical efficiency levels reported by

Squires et al., (2003) for the Malaysian gillnet fleets of artisan fishermen, lokina (2008) for Lake Victoria artisanal fisheries and Dawang et al., (2011) for natural lakes from Plateau State. The range of efficiency scores and the mean technical efficiency with the inefficiency model suggested greater potentials for improving performance in River Niger than River Benue because fisher folks operation were still below the efficient frontier. However, the current open access nature of fisheries where neither effort nor catch is limited could lead to further depletion of stock, hence, the need reduces the current level of exploitation existing in Rivers Niger and Benue fisheries.

Table 3. *Deciles Range of Frequency Distribution for Technical Efficiency of Artisanal Fishermen*

Range of Frequency	Niger	Benue
	Frequency (%)	Frequency (%)
< 20	2 (1.1)	0 (0)
21 – 30	18 (10.2)	0 (0)
31 – 40	24 (13.6)	1 (1.7)
41 – 50	18 (10.2)	7 (11.9)
51 – 60	15 (8.5)	5 (8.5)
61 -70	7 (4)	1 (1.7)
71 – 80	27 (15.3)	7 (11.9)
81 – 90	37 (21)	18 (30.5)
Above 90	28 (15.9)	20 (33.9)
Grand Total	176 (100)	59 (100)
Mean/ Std. Deviation	0.64±30.249	0.785±0.173

Discussion

The demographic dynamics of the artisanal fisheries upholds sex composition is still more tilted to the male and female appears more supportive in the roles. Williams (2002, 2006) observed that women still use traps and nets to catch fish in most fishing communities in Nigeria. Similarly, Hitomi (2009) in a study of women in Japanese fishing communities reported that fish catching received central attraction by men where they played a leading role and female roles were mainly dedicated to fish handling, grading and small-scale home-based processing. With regards to age, the predominance of middle-aged group of 40 – 50yrs in fishing activities in both Rivers Niger and Benue suggested that this age group represent the energetic and economically active age. A similar report on age group and fishing activities by FAO (1997) indicated this age range as the active group in fishing activities. This age distribution seems to cut across all fisheries sectors.

Majority of the fisher folks in Rivers Niger and Benue were married suggesting that marriage institution was still cherished and is an indication of economic responsibilities of fisherfolks care for their dependents (FAO, 1996 and Olaoye et. at., 2012). In this study, household size structure of 3 – 10 persons in Rivers Niger and Benue was relatively large and similar. This suggests that fisher folks can have access to family labour especially when there is scarcity of hired labour (Okeowo et. al., 2015). Inoni and Oyaide (2007) in their study of socio-economic analysis of artisanal fisheries resources exploitation in Delta State, Nigeria, reported that large household size contributes to the labour demand, mainly in post-fishing activities. Majority of fisherfolks in Rivers Niger and Benue had no basic formal education suggesting that fisherfolks would likely have poor capacity for assimilation, awareness and receptivity to innovation of fisheries practices in the study area. Low literacy rates in artisanal fishing communities was a major barrier to many aspects of development (Adams et al., 2000 and World Bank, 2018). The percentage of fisher folks with no basic education was higher in River Niger compared to their counterpart in River Benue suggesting their inability to comprehend modern fishing techniques for sustainable harvest. Fatunla (1996) attributed this to the socio-cultural dynamics of the communities, patterns of fishing livelihoods and seasonal migration coupled with children's labour in fishing and post-catch processing reducing the educational aspirations of children and parents. Fishing experience is the number of years that the fishermen spent in fishing business. The result of this study indicated that majority of the respondents in both locations fell within the age range of 31 – 60 yrs were more than fisher folk that were < 30 yrs. This implied that fishing experience and better performances in fishing activities comes with years in fish harvesting. An experienced fisher folk can manage their fishing activities and make sound decision to enhance their performance. Olaoye (2010) in his study of the dynamics of the adoption process of improved fisheries technologies in Lagos and Ogun State, noted that years of fishing activity was an important determinant of profit levels of artisanal fisher folks. Fisher folks in both locations were involved in non-Agriculture generating income to augment revenue from fishing activities. This suggest that diversification of income is required to support fish income, which is relatively uncertain from unpredictable catch per unit of effort in the study area. A related study on relationship between fish harvesting and other non- agricultural activities by Salas et al., (2004) indicated that fisheries with high variability and uncertainty, or in open-access conditions would likely have a higher proportion of income diversification among fishers.

Trading ranked highest among non-agricultural activities because fisher folks were directly involved in selling fish and fishing accessories, tailoring followed probably because fishers are involved in mending their nets. Others are civil service, Artisanship and waged labour. This implies that respondents in the study area sourced for other means of income to meet up with the basic necessity of life and other commitments and/or social obligations. Hallam and Machado (1996) also reported that other non-agricultural activities are often the only means of asset accumulation and risk diversification that can prevent the rural poor in marginal areas from sliding into poverty.

The stochastic frontier model indicated that Rivers Niger and Benue have the possibilities for improving performance in the fisheries by 35.7% and 21.5%, respectively. Cooperative membership, age of fisher folks and years of education in River Niger and years of experience and extension visits in River Benue were significant variables for improving technical efficiency. The range of efficiency scores and the mean technical efficiency with the inefficiency model suggested greater potentials for improving performance in River Niger than River Benue because fisher folks operation were still below the efficient frontier. However, the current open access nature of fisheries where neither effort nor catch is limited could lead to additional depletion of stock, hence, the need reduces the current level of exploitation existing in Rivers Niger and Benue fisheries.

Conclusion

The distribution of technical efficiency scores revealed that the mean efficiency level for fisher folks along River Niger and River Benue were 46% and 75%, respectively. Thus on the average, the observed outputs of the fisher folks along River Niger and River Benue were 54% and 25% less than the maximum outputs which can potentially be achieved from the existing input levels. These values accounted for the levels of inefficiency for the two artisanal fishermen groups, which can be attributed to technical production constraints, as well as socio-economic and environmental factors. Unlike River Niger, the high degree of technical efficiency along River Benue suggested that very little marketable outputs are sacrificed to resource waste. The observed output also suggested that the fisher folks along River Benue were currently operating closer to the frontier than the fisher folks along River Niger. Therefore, there existed 25% and 46% potential for increasing output by fisher folks along the River Niger and Benue groups, respectively indicating that output-oriented technical inefficiency is important in explaining the total variability of fish harvest. Moreover, the result in this study showed that fisher folks along River Niger possessed higher capacity for expansion than the fisher folks along Benue. The pooled results further revealed that docile ranges of 20-80% resulted in a mean technical efficiency of 77%. This suggested a relatively high technical efficiency level existing in the fisheries, pointing to a frightening level of exploitation and a wide range of efficiency level in the fisheries.

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