SOCIO-ECONOMIC ANALYSIS OF ARTISANAL FISHING IN THE SOUTH AGRO-ECOLOGICAL ZONE OF DELTA STATE, NIGERIA

INONI O.E., OYAIDE W.J.

Abstract

Using data obtained from 198 small-scale fishers, the paper examined the effects of socio-economic factors on artisanal fish output in the South Agro-ecological zone of Delta State, Nigeria. The results showed that average fixed costs and average variable costs were ₦ 116,005.14/fisher/year and ₦ 181,877.56/fisher/year respectively. Fishing crafts and gears accounted for 76.54%of total fixed costs of production; while labour, fuel, and repair and maintenance made up 76.85% of total variable costs. While net margin/fisher/year was ₦ 111,677.62 for the study area, it was ₦ 140,492.74 among motorised units and ₦ 84,012.15 for fishers in the non-motorised segment. Net margin-to-cost ratio was 34% in the motorised sector, 45% in the non-motorised segment, and 37% for the entire area studied. Regression results indicated that household size, gender of fisher, fishing experience, season, fishing craft, labour, capital depreciation, and non-fishing income had statistically significant effects ($p < 0.05$) on fish catch. Output elasticity estimates showed that a percentage increase in labour utilisation caused a 0.82% rise in fish catch, while a proportionate increase in non-fishing income depressed fish catch by 0.1%.

Key words: small-scale fishing, profitability ratios, regression analysis, output elasticity, Delta State Nigeria

INTRODUCTION

Total domestic fish production in Nigeria fluctuated between 242,525 and 562,972 metric tonnes from 1981 to the year 2003. Of these totals, coastal/brackish water fisheries made up between 42.07 and 75.96 %, while the balance was from industrial fisheries and aquaculture. In Delta State, however, artisanal fish production ranged between 11,591 and 26,038 metric tonnes between 1991 and the year 2000 (Federal Department of Fisheries (2004). Nigeria, like many other countries in sub-Saharan Africa, is endowed with substantial marine and inland fisheries resources, upon which the fisheries sector is based. However, since the 1980’s, production trend in the sector has been very unstable particularly, in the coastal/brackish water artisanal sector which provides the bulk of the domestic production. From a peak output of 377,683 tonnes in 1982, artisanal production plummeted to 106,276 tonnes in 1993, the lowest during the period under review (Table 1). Similar trend is revealed by data from four coastal States in Nigeria, Rivers, Akwa Ibom, Delta and Lagos (Figure 1). The intense fishing pressure arising from the increase in the number of fishers may have greatly reduced fish stocks in the coastal areas. Furthermore, the incessant oil pollution in the coastal waters is another factor that could be implicated for the dwindling fish catches in the South Agro-ecological zone of Delta State, Nigeria. However, since fisheries resources are renewable, appropriate management strategies must be adopted to ensure their sustainability if fisheries must continue to play its triple role of a food supplier, employment provider and foreign exchange earner, in the Nigerian economy.

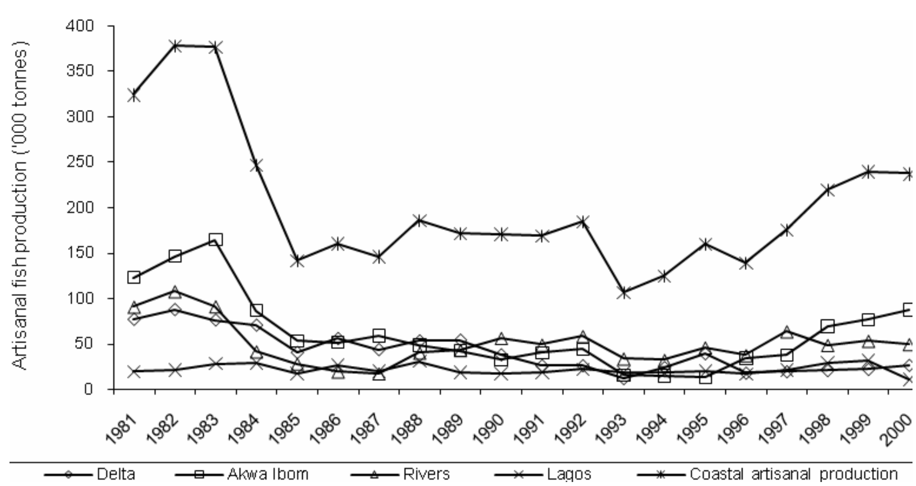
Artisanal or small-scale fisheries have been variously described in the literature. According to Mathew (2001), ‘traditional’, ‘small-scale’ or ‘artisanal’ fisheries is used to characterise those fisheries that were mainly non-mechanised withlow level of production. However, they are the predominant fishery in tropical developing countries (Berkes et. al., 2001). In Nigeria, the coastal artisanal fishers use the traditional dug-out canoes or pirogue ranging from 3–18 metres in length while the gears used include cast nets, handlines, basket traps, longlines, set gillnets and beach and purse seines. The operating range of small-scale fisheries is around the 20 metres depth contour, with operations extending occasionally to a maximum depth of 40 metres (Gnanadoss and Aderounmu, 1982). In fact, artisanal fisheries include coastal, brackish water and all inland fishery sources such as rivers, reservoirs, dams, lakes, lagoons, as well as the floodplains of the Niger Delta and other major rivers.
The capacity of artisanal fisheries to play its triple role of a food supplier, employment provider and income earner in the Nigerian economy depends on the adoption of appropriate management strategies that will ensure their sustainability in the face of intense fishing pressure. The objectives of this study therefore, are to profile the socio-economic characteristics of fishers in the study area; determine the costs and returns in artisanal fishing as well as, identify and quantify socio-economic factors that determine output in artisanal fishing, The identification of socio-economic variables that are crucial to the exploitation of common pool fisheries resources will provide a framework for their sustainable management in Delta State. Furthermore, it will enable small-scale fishers make rational production decisions that will affect the profitability of their operations.

Tab. 1: Domestic fish production in Nigeria by sectors (metric tonnes)

Year	Domestic fish production	Coastal/ brackish water	Inland Lakes/Rivers	Aquaculture	Coastal/brackish as % of domestic production
1981	491 394	323 916	157 867	n.a	65.92
1982	516 371	377 683	119 527	n.a	73.14
1983	562 972	376 984	146 267	20 476	66.96
1984	406 665	246 784	112 219	22 012	60.68
1985	242 525	140 873	60 510	15 000	58.09
1986	307 059	160 169	106 967	14 881	52.16
1987	289 108	145 755	103 232	15 221	50.42
1988	348 996	185 181	112 443	15 764	53.06
1989	362 706	171 332	132 112	25 607	47.24
1990	316 360	170 459	115 044	7 297	53.88
1991	343 352	168 221	123 045	15 840	48.99
1992	343 078	184 407	99 536	19 770	53.75
1993	255 523	106 276	94 900	18 703	41.59
1994	283 193	124 117	110 484	18 104	43.83
1995	371 053	159 201	161 754	20 755	42.91
1996	355 934	138 274	170 926	19 490	38.85
1997	413 187.6	175 126	185 096	25 265	42.38
1998	483 482.27	219 073	213 996	20 458	45.31
1999	479 663	239 228	187 558	21 738	49.87
2000	467 098	236 801	181 268	25 720	50.70
2001	474 077	209 183	181 000	47 000	44.12
2002	504 371	218 496	195 000	50 000	43.32
2003	524 706	229 107	201 700	52 000	43.66

n.a. = not available
Source: Federal Department of Fisheries; Fisheries Statistics of Nigeria, various editions

Figure 1: Artisanal fish production in selected Coastal States in Nigeria

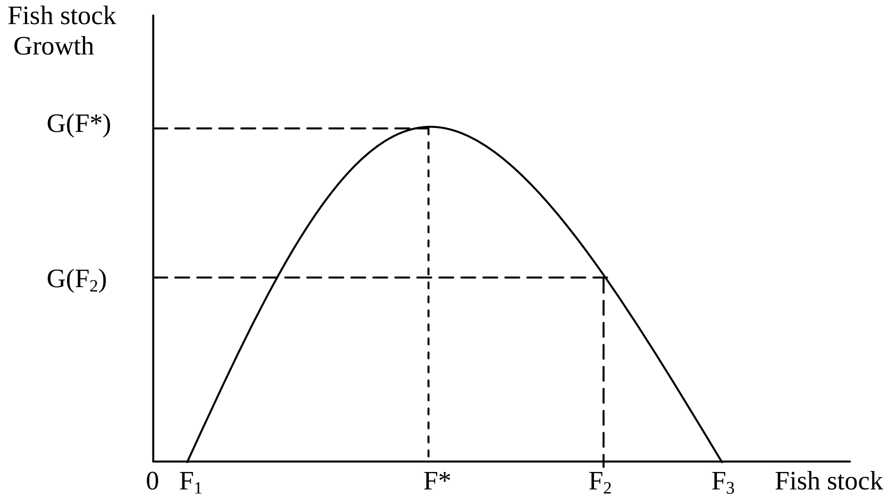


Note: For Akwa Ibom State, data for 1981 – 1988 include those of Cross River State; and for 1981–1990; data for Delta State include those of Edo State.
Source: Federal Department of Fisheries; Fisheries Statistics of Nigeria, various edition

THEORETICAL FRAME WORK

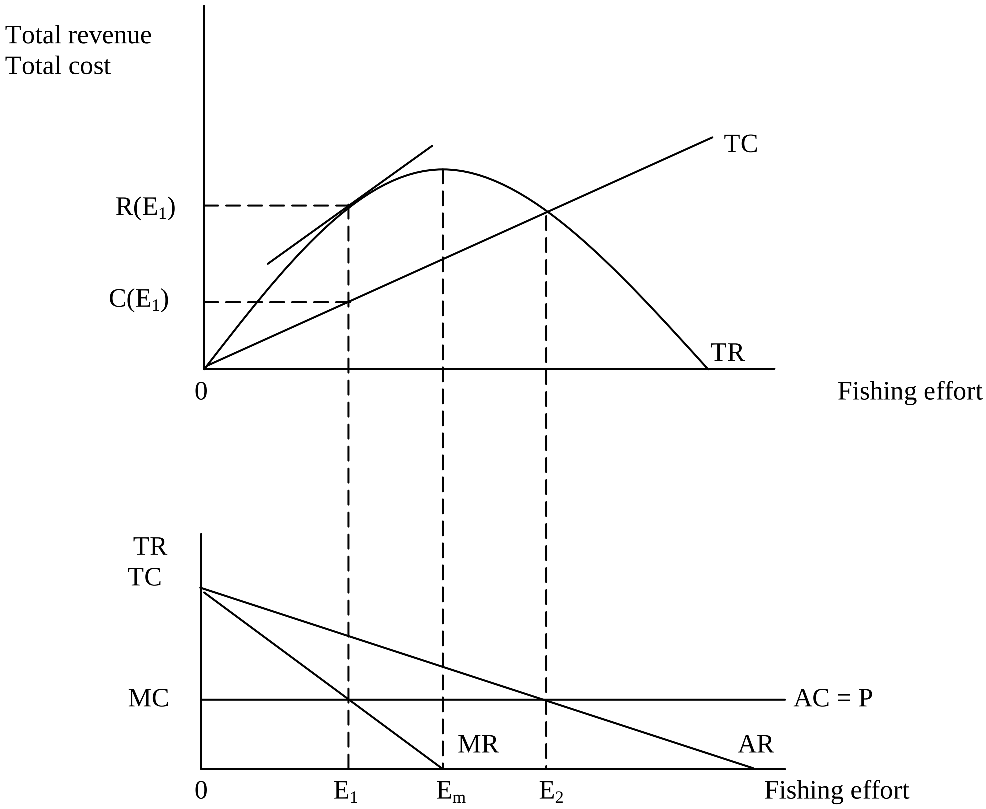
Fisheries are renewable resources in the sense that their stock can be replenished. However, their renewability critically depends on the quality of management they are subjected to. Poor management arising from wanton exploitation makes fishery resources prone to depletion. Tietenberg (2000) advanced a biological model similar to an earlier one proposed by Shaefer (1957), which related growth in fish stocks to the size of the fish stock (Figure 2). According to the model, a range of fish population such as F_1 and F* exists in which the growth in fish stock increases with the fish population, and another range F* and F_3 in which the growth in fish stock declines as the population of stock increases. F_3 is referred to as the natural equilibrium point where the aggregate annual stock growth would equal natural losses in the absence of external influences such as human exploitation. This natural equilibrium population is stable and therefore tends to persist. It is stable because disturbances are followed by a restoration of the population. Unlike F_3, F_1 is an unstable equilibrium and represents the level of fish population below which population growth is negative, and this could lead to extinction. Fish catch levels represent sustainable yields when they are equal to or less than the growth rate of the fish population. Given the biological characteristics, as long as the population remains constant so does the growth rate. Thus the catch F* is the biological maximum sustainable yield population, since it is the population yielding maximum growth. Similarly, the yield corresponding to such maximum growth rate is also the maximum sustainable yield (MSY). Thus G(F*) in Figure 2 is the maximum sustainable yield (Tietenberg, 2000), although it is not economically efficient. An efficient sustainable yield is a fish catch level which produces the largest net benefit. A basic economic model assumes constant fish prices, constant marginal cost of units of fishing efforts, and that the amount of fish caught per unit of effort is proportional to the stock size. Therefore, as stock size increases, the fish caught per unit of effort will also increase. Figure 3 represents an efficient sustainable yield. The upper chart links fishing effort with fishing costs and revenues. A forty-five degree (45^o) line arising from the origin represents costs. The total cost function is a straight line parallel to the horizontal axis because of the assumption of constant marginal costs. Revenues are given as catch volume times price. Therefore, the revenue curve has the same shape as the curve in Figure 1 since fish prices are assumed to be constant while total catch increases, attains a maximum, and declines. The slope of the revenue curve reflects marginal revenue. An increase in fishing effort is thus represented by a movement from left to right in Figure 2. As fishing effort is increased from the left axis to the right on the upper chart, a point is reached where additional effort will reduce the sustainable harvest and revenue. The point E_m is the same biological maximum sustainable yield shown in Figure 2. Net benefits are represented by the difference between total revenues and total costs; and maximum net benefits occur where the vertical distance between total costs and the revenue curve is greatest. That is where MC equals MR at point E_1. As can be seen, the economically efficient yield (E_1) is well below the biological MSY. In a static economic model with a zero discount rate, the optimum level is point E_1. However in a dynamic model with positive discount rates, gradually increasing the discount rate will tend to expand the efficient level of effort to the right. At an infinite discount rate, the equilibrium position will be E_2. The

Figure 2: Relationship between growth and population of fish stock



Source: Tietenberg T. (2000). Environmental and Natural Resource Economics. Reading, Massachusetts: Addison-Willey Publishers

Figure 3: Optimal Fishing Levels, Costs and Revenues



Source: Tietenberg, T. (2000). Environmental and Natural Resource Economics. Reading, Massachusetts: Addison-Willey Publishers

point E_1 reflects a situation of efficient property rights. Property owners would behave rationally and maximise their net returns where MC equals MR (Baland and Platteau, 1996).

MATERIALS AND METHODS

Area of study

Delta State, which is one of the nine states in the Niger Delta region of Nigeria is the location of the study. Delta State is located approximately between longitude $5^o\ 00^/$ and $6^o\ 45^/$ east and latitude $5^o\ 00^/$ and $6^o\ 30^/$ north of the equator. The State is comprised of 25 local government councils with Asaba as its capital. It occupies a total land area of 17,698 square kilometres with a population of 2,570,181 people (National Population Commission, 1993).

The natural vegetation in the State varies from the mangrove swamp forests in the south, to the freshwater swamp forests and rainforests in the central agro-ecological zone, and the derived savannah belt in the northern part of the State. The prevailing climatic and hydrographic conditions thus favour a thriving fishery and agricultural economy. This study however was restricted to the South Agro- ecological zone of Delta State made up of the following eight (8) local government areas (LGAs); Patani, Warri Southwest, Burutu, Warri North, Bomadi, Warri South, Isoko South and Ughelli South.

Sampling procedure and data collection

Primary data for the study were collected from a cross-section of fishers using interview schedules that were conducted by the researchers, with the assistance of enumerators that were fluent were in both English Language and the local dialects of the respondents. Multistage sampling technique was used to draw samples for the study. Firstly five LGAs of Bomadi, Burutu, Patani, Ughelli South, and Warri Southwest were selected out of the eight LGAs that comprised the study area using simple random sampling technique. Secondly, four fishing communities were selected from each of the five LGAs earlier chosen to give a total of

20 fishing communities covered in the survey. Subsequently, 10 fishers were randomly selected from each of the 20 communities, to give a total sample size of 200. The 10 fishers selected included five using motorised boats and five using non-motorised boats. However due to inadequate information, two copies of the questionnaire were discarded, and data from 198 respondents were used for the analysis.

Data collected include social characteristics such as household size, educational level, sex, age and fishing experience; production data such as fish input and output, input and output prices, revenue, income, and the expected economic life of crafts and gears. Furthermore, data on problems and availability of infrastructures and membership of local groups and co-operative societies, were also obtained from the survey. The survey was conducted between April, 2004 and March, 2005.

Model specification and estimation

The postulated econometric model shows that the volume of fish catch is determined by both social and economic variables. The general model is of the form:

$$F_{qty} = f\,(EDU, HHZ, EXP_f, K_d, L_b, F_l, NF_y, CST_{frm}, GEN_r, C_f, S_p, u) \qquad (1)$$

Where:

F_{qty} = quantity of fish caught (kg)
EDU = level of formal education attained by respondents coded as 1, no formal education; 2, primary school; 3, secondary school; 4, tertiary education
HHZ = household size of respondents
EXP_f = fishing experience measured as number of years in fishing
K_d = depreciation of capital inputs such as boats, engines, gears and accessories
L_b = labour input measured as number of fishing trips per week
F_l = cost of fuel and lubricants per fishing trip.
NF_l = non-fishing income, that is income from sources other than fishing
CST_{frm} = cost of food, repairs and maintenance.
GEN_r = gender of respondents (Male = 2, Female = 1)
C_f = type of fishing craft (motorised boat = 2, non-motorised boat = 1)
S_p = dummy variable for season (dry season = 2, rainy season = 1)
U = error term

Because economic theory does not indicate the precise mathematical form of the relationship among the variables, different functional forms of the above model such as the linear, semi-log, power, and exponential functions were fitted, in order to estimate the relevant parameters using the Ordinary Least Squares (OLS) technique. However, the logarithmic model had the best fit, and is as specified below (equation 2).

The logarithmic function is one of the most widely used in empirical studies because the regression coefficients are also direct elasticities (Olayemi, 1998). Also Almeida *et al.* (2001), affirmed that the advantage of the double-log function is its reasonable proximity with economic theory and facility for calculating the partial elasticity of the dependent variable, with respect to the explanatory variables in such a model.

$$F_{qty} = \beta_0 (EDU^{\beta_1} HHZ^{\beta_2} EXP^{\beta_3}{}_f K_d{}^{\beta_4} L_b{}^{\beta_5} F_l{}^{\beta_6} NF_y{}^{\beta_7} CST_{frm}{}^{\beta_8} GEN_r{}^{\beta_9} C_f{}^{\beta_{10}} S_p{}^{\beta_{11}} u^e) \qquad (2)$$

where e = the base of the natural logarithms and other variables are as defined in equation (1) above. When equation (2) is transformed logarithmically it becomes:

$$\ln F_{qty} = \ln\beta_0 + \beta_1 \ln EDU + \beta_2 \ln HHZ + \beta_3 \ln EXP_f + \beta_4 \ln K_d + \beta_5 \ln L_b + \beta_6 \ln F_l + \beta_7 \ln NF_y + \beta_8 \ln CST_{frm} + \beta_9 \ln GEN_r + \beta_{10} \ln C_f + \beta_{11} \ln S_p \qquad (3)$$

Assuming

$$\ln\beta_0 = \delta$$

then the estimated equation becomes;

$$\ln F_{qty} = \delta + \beta_1 \ln EDU + \beta_2 \ln HHZ + \beta_3 \ln EXP_f + \beta_4 \ln K_d + \beta_5 \ln L_b + \beta_6 \ln F_l + \beta_7 \ln NF_y + \beta_8 \ln CST_{frm} + \beta_9 \ln GEN_r + \beta_{10} \ln C_f + \beta_{11} \ln S_p \qquad (4)$$

RESULTS AND DISCUSSION

Socio-economic characteristics of artisanal fishers

The socio-economic characteristics of the artisanal fishers presented in Table 2 revealed that both men and women are actively involved in artisanal fishing in Delta South agro-ecological zone, with 45 female and 153 male fishers. Women comprised 22.7% of all the respondents while men were 77.3%. Although the results showed the dominance of the artisanal fisheries sector by men, the contribution of the women folk in active fishing cannot be undermined. According to Williams and Awoyomi (1998), women still use traps and nets to catch fish in

Tab. 2: Distribution of socio-economic characteristics of artisanal fishers (n = 198)

Parameter	Frequency	Mean (Mode)	Std. Deviation	Minimum	Maximum
Gender					
Male	153 (77.3)*	(Male)	0.500	0	1
Female	45 (22.7)				
Household size					
4–6	35 (17.7)				
7–9	65 (32.8)	9 persons	2.95	3	17
10–12	53 (26.8)				
13–15	38 (19.2)				
16–18	7 (3.5)				
Educational level					
No formal education (1)	71 (35.9)				
Primary school (2)	65 (32.8)	2.0	0.94	1	4
Secondary school (3)	48 (24.2)				
Tertiary education (4)	14 (7.1)				
Fishing experience (years)					
1–3					
4–6	30 (15.1)				
7–9	99 (50)				
10–12	53 (26.8)	6 years	2.35	1	14
13–15	1 (0.5)				14
Labour (fishing trips/week)					
Twice	50 (25.3)				
Thrice	75 (37.9)	3.15	1.05	2	5
Four times	67 (33.8)				
Five times	6 (3.0)				
Fish output (kg)					
158–873	75 (37.9)				
874–1589	56 (28.3)				
1590–2305	34 (17.2)	1,391.51	932.29	158	4,450
2306–3021	18 (9)				
3022–3737	8(4)				
3738–4453	7 (3.5)				
Fishery income/year (₦)**					
(–83132.84)–(–2916.80)	35 (17.7)				
1280–82 280	65 (32.8)				
82,281–163,281	34 (17.2)	111,677.62	129,665.04	–83,132.84	405,333.96
163,282–244,282	25 (12.6)				
244,283–325,283	18 (9.1)				
325,284–406,284	21 (10.6)				

* Figures in parentheses are percentages; ******USD$1 = ₦135 (Nigerian Naira) by 2004 average exchange rate
Source: Computed from Survey data, 2005

most fishing communities in Nigeria. However, a number of socio-cultural factors, restricted access to water resources, low technical know-how and lack of credit facilities limit women full participation in the small-scale fisheries sector (Williams, 2002).

A relatively large household size was found in the study with an average size of 9 persons per household, though 49.3% of the households have a family size ranging between 10 and 18 persons . The finding supports the preponderance of large family sizes among the poor in rural areas (Eboh, 1995). However, small-scale fishing is very labour intensive, requiring labour contribution from the fisher's family, particularly in post-harvest activities such as fish processing, distribution and marketing. Because of these ancillary roles undertaken by women and other members of the fisher's household, many fishers tend to have larger families that can contribute positively to their livelihood.

The level of educational attainment of the respondents are also revealed in Table 2. About 64 percent of the fishers had some form of formal education while 36% did not. The mean level of educational attainment for all the fishers sampled is primary education. Lack of education among men and women in fishing communities in West Africa posed significant constraints on sustainability in artisanal fisheries, just as it will do in farm production in general (Williams, 2002). Generally, education and particularly fishing-related training, is expected to impact positively on the productivity of fishers. According to Biswanger (1989), educated farmers tend to be more likely to adopt modern agricultural practices. However, a higher level of educational attainment may discourage some people from participating actively artisanal fishing operations.

Fishing experience, the number of years spent in fishing among fishers in the study area, ranged between 1–14 years, with a mean experience of 6 years. In fact, 65 percent of the fishers have fished for between 1 and 6 years, while 35 percent of them have been in the business for 7 to 14 years. The distribution indicates that the respondents are relatively young in the business. Fishers, particularly those in the motorised sector of the artisanal fishery, require adequate experience to be able to exploit more valuable fish species in deeper waters.

Labour supply is a very crucial factor in the artisanal fisheries sector. This is because of the labour intensive nature of fishing operations. Utilisation of labour in the study area was measured by the number of fishing trips per week. The number of fishing trips per week ranged between 2–5, with a mean value of 3.15 trips per week. About 63 percent of the respondents made 2 or 3 trips per week. However, increasing fishing frequency may be an indication of dwindling fisheries resources, and possible depletion of resources in nearby fishing grounds. Therefore in order to sustain their livelihood, fishers particularly motorised ones, have to travel further into sea to exploit marine resources. Under this scenario, labour productivity is bound to fall with attendant unemployment in fishing communities.

The level of fish production indicated by fish catch per fisher per year in Delta South hydro- ecological zone ranged between 158–4,450 kg, with an average annual output of 1,391.51 kg. Though the mean catch is some

Tab. 3: Average fixed costs in artisanal fishing: motorised and non-motorised segments

Fixed cost items	Motorised units (n = 96)	Non-motorised units (n = 102)	Entire study area (n = 198)
Outboard engine	59,119.38 (38.93)*	–	28,663.94 (24.71)
Boat	39,511.57 (26.01)	36,742.34 (44.68)	38,085.00 (32.83)
Nets	25,557.01 (16.83)	18,734.39 (22.78)	22,042.33 (19.00)
Twines	7,798.51 (5.13)	7,642.05 (9.29)	7,717.91 (6.65)
Floats/Sinks/Hooks	9,345.83 (6.15)	7,188.78 (8.74)	8,234.62 (7.10)
Accessories	10,548.63 (6.95)	11,932.14 (14.51)	11,261.34 (9.71)
Average fixed cost (N,=)**	**151,880.92 (100)**	**82,239.70 (100)**	**116,005.14 (100)**

* Figures in parentheses are percentages of total fixed cost in each sector; **USD $1 = ₦ 135 (Nigerian Naira) by 2004 average exchange rate

Source: Computed from Survey data, 2005

what low, it is also subject to great variability as shown by the standard deviation of 932.29. About 66% of the fishers had yearly fish catch of 158–1,589 kg, while only 16.5% of them caught fish ranging between 2,306–4,450 kg per annum. The low level of fish output may be due to over-fishing; a condition that may be implicated for the low and unstable level of income from artisanal fishing. A great variability was also found in income from fishing in the study area. In fact, 35 fishers representing about 18% of all fishers sampled, had a net loss from fishing ranging between (₦ 83,132.84)–(₦ 2,916.80). Therefore, there is the need to explore alternative income generating opportunities for small- scale fishing communities, given the current level of resource exploitation and the large number of people involved in fishing (FAO, 2002).

Structure of costs in artisanal fish production

Costs involved in artisanal fisheries operations include fixed and variable costs. Fixed costs include the depreciation costs of fishing gears, crafts and accessories. The depreciation costs represented the loss in value of the fishing assets as a result of their use in one production year. Items of fixed costs identified in the study included outboard engines, boats/canoes, nets, twines and floats/sinks/hooks. As shown in Table 3, average annual fixed costs per fisher was ₦ 151,880.92 in the motorised segment, ₦ 82,239.70 in the non-motorised segment, while it was ₦ 116,005.14 per fisher in the entire area of study. The differences in costs may be attributable to the organisational differences in production activities by the operators in different parts of the State. For instance, fishers in the marine environment used mainly motorised crafts that require higher initial investment costs, and this must have translated into the relatively higher fixed costs per fisher per year, among fishers in the motorised sector.

Boat, outboard engine, and nets were respectively the most critical items of fixed costs in fish production. The proportion of boats in total fixed assets ranged from 26.01–44.68%, with a mean contribution of 32.83%. Boat/canoe is the most important asset upon which the livelihood of fishers depend. Thus it is a most valuable input. Apart from being the input around which fishing activity revolves, fishers also use it as a security for short–term credit for their operations during periods of cash squeeze. Outboard engine was the second most critical asset in artisanal fish production, with a depreciation cost of ₦ 28,663.94 which accounted for 24.71% of all such costs.

Total variable costs in artisanal fisheries depend essentially on the fishing effort. For a fishing unit, fishing effort is the number of fishing trips done and fishing power used to harvest fish during a given period of time (FAO, 2004; Njifonjou, 1998). Unlike fixed costs, operating costs depend on the volume of production, and they included fuel and lubricants expenses, food, ice, labour, repairs and maintenance. The annual operating cost per fishing unit was N,= 265,876.65 for the motorised units, and N,= 102,819.60 for the non-motorised units. The average variable cost per fishing unit in the entire study area was N,= 181,877.56. A comparative analysis of operating costs in the motorised and non-motorised segments of the artisanal fisheries sector revealed that labour and repair and maintenance costs are the major expenditure item in the non-motorised sector accounting for a whooping 55.5 and17.7% respectively of an-

Tab. 4: Average variable costs in artisanal fishing: motorised and non-motorised segments

Variable cost items	Motorised units (n = 96)	Non-motorised units (n = 102)	Entire study area (n = 198)
Fuel	99,067.11 (37.26)*	–	48,032.54 (26.41)
Labour	74,375.19 (27.97)	57,066.09 (55.50)	65,458.38 (35.99)
Ice	16,004.42 (6.02)	412.31 (0.40)	7,972.12 (4.38)
Food	20,601.18 (7.75)	14,327.92 (13.94)	17,369.5 (9.55)
Repairs& Maintenance	34,847.64 (13.11)	18,202.28 (17.70)	26,272.76 (14.45)
Miscellaneous Expenses	20,981.11 (7.89)	12,811.01 (12.46)	16,772.27 (9.22)
Average variable cost (N,=)**	**265,876.65 (100)**	**102,819.60 (100)**	**181,877.56 (100)**

*Figures in parentheses are percentages of total variable cost in each sector; **USD$1 = ₦ 135 (Nigerian Naira) by 2004 average exchange rate

Source: Computed from Survey data, 2005.

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nual variable costs of production per fishing unit. Among the motorised units however, fuel, labour and, repairs and maintenance are the most critical items of operating costs. They accounted for 37.26, 27.97 and 13.11% respectively of annual variable costs of production (Table 4). The continual increase in prices of petroleum products during the period under study is implicated for the high cost of fuel and lubricants. Furthermore, the remote nature of most of the locations and their distance from fuel loading depot may have raised the prices of petroleum products, and consequently retail pump prices of the products to fishers in the motorised segment. Datta *et al.* (1989) reported that the contribution of fuel to annual variable costs ranged between 60–71% for motorised units; while repairs and maintenance accounted for 43 to 53% of operating costs per fishing unit. Variations in the number of fishing trips, wage rates across locations, as well as access to trained technicians and boat builders are other factors implicated for the differences in operational costs by fishers in the South agro-ecological zone of Delta State, Nigeria.

Net margin analysis

The net margin per fisher is gross returns less total cost of production (TC). It is the income the fisher receives after all costs have been deducted from the gross revenue from artisanal fishing operations. The results of the net margin analysis are presented in Table 5. Net margin per fisher per year was N,= 140,492.74 among motorised units, N, = 84,012.15 for the non-motorised operators, and N, = 111,677.62 per fisher per year in the entire study area. The net margin analysis has shown that small-scale fishing operations in the South agro-ecological zone of Delta State, Nigeria is profitable. However, operations in the motorised segment appear to be more lucrative. In fact, average net margin was 67 percent higher among the motorised units than the non- motorised ones. But in order to determine the level of profitability in artisanal fishing in the South Agro-ecological zone of Delta State, a number of indices of profitability and efficiency such as total cost/kg, net margin/kg, net margin-to-cost ratio, return on sales as well as operating ratio were computed, and presented in Table 6. Net margin per kilogramme was N, = 91.67/kg and N, = 72.95/kg respectively for operators in the motorised and non-motorised segments of the artisanal fishing sub-sector; but with an average value of N, = 80.26/kg for the entire area of study. The combined effects of low yield and high cost of production, particularly of variable costs components, are implicated for the rather low net margin per kilogramme. The implications of the results however, are that for every kilogramme of fish caught, the fisher earns a profit of N,= 80.26 on the average in the South Agro-ecological zone of Delta State. The results are significantly different from those reported by Mabawonku (1980) for Bendel State.

Although the net margin per kilogramme revealed the level of profitability, it is not a very critical measure because it does not take into consideration the total cost incurred by the fisher to earn that margin. Therefore, the relative profitability of artisanal fishing operations in the different locations, as well as between the two segments of the small-scale fisheries sector cannot be compared. The net margin-to-cost ratio indicates the relative profitability of artisanal fishing in the segments, because it relates the net margin realised to the total cost of production. The ratio was 34% and 45% respectively in the motorised and non-motorised segments of the artisanal fisheries sub-sector but, with a value of 37% for the entire area. The results imply that investment in the small-scale fisheries sector can earn as high as 45% return on capital, as was the case among fishers in the non-motorised segment. The results are comparable to the net margin-to-cost ratio of 25.7% reported by Njifonjou (1998), among artisanal fishing units in the Limbe region of Cameroon The return on sales, which indicates the magnitude of operating margin the fishers have on their fish sale is another measure of profitability in small-scale fisheries applied in the study. This was determined by dividingthe net margin by the gross revenue. The lower the return on sales, the lower the operating margin, and thus the greater the revenue that must be made in order to make an adequate return on investment (Gittinger, 1982). Return on sales in Delta South ranged from 25% to 31%, with a mean value of 27% for the entire area studied. The results showed very low operating margin in fish production in the Delta South agro-ecological zone; a condition that can be attributed to very high cost of production. The results imply that profit was only 27% of gross revenue on the average. Thus, while the average net margin in the motorised segment was better, the non-motorised units were more profitable because they had a higher return on investment (45 > 34%) as well as a higher operating margin (31 > 25), than their motorised counterparts.

The operating ratio is a measure of efficiency in the use of financial resources, and it was obtained by dividing total production cost by gross revenue. The operating ratio is an indicator of the ability of fishers to control cost of operation. A rising ratio shows that variable costs are increasing or that revenue is declining due to falling fish prices. The operating ratio in artisanal fish production in Southern Delta State, Nigeria was 73%; though the ratio was 75 and 69% respectively for motorised and non- motorised fishing units. According to Gittinger (1982), enterprises with very high operating ratios in the neighbourhood of 90% have difficulty in making adequate returns on investment, due to the triple effects of high operating expenses, dwindling fish catches, and falling prices; while an abysmally low ratio, say 50%, implied that some costs may have been omitted or grossly underestimated.

Tab. 5: Cost and returns in artisanal fishing: motorised and non-motorised sectors, Delta South agro-ecological zone

Parameter	Motorised	Non-motorised	Entire Study Area
Gross Revenue from Fish (N,=)*	**558,250.31**	**269,071.45**	**409,560.32**
Less Variable Costs			
Fuel & lubricants	99,067.11	–	48,032.54
Labour	74,375.19	57,066.09	65,458.37
Food & ice	36,605.60	14,740.23	25,341.62
Repairs & maintenance	34,847.64	18,202.28	26,272.76
Miscellaneous expenses	20,981.11	12,811.01	16,772.27
Total Variable Costs(TVC)	**265,876.65**	**102,819.60**	**181,877.56**
Gross Margin (N,=)	**292,373.66**	**166,251.85**	**227,682.76**
Less Fixed Costs			
Depreciation of fishing craft	98,630.95	36,742.34	66,748.94
” fishing gears	42,701.35	33,565.22	37,994.86
” accessories	10,548.63	11,932.14	11,261.34
Total Fixed Costs (TFC)	**151,880.92**	**82,239.70**	**116,005.14**
Net Margin/fisher/year (N,=)	**140,492.74**	**84,012.15**	**111,677.62**

Source: Computed from Survey data, 2005

***USD$1 = ₦ 135 (Nigerian Naira) by 2004 average exchange rate

Tab. 6: Efficiency and profitability ratios in artisanal fishing: Delta south agro-ecological zone

Parameter	**Sectors**		
	motorised	**non motorised**	**entire study area**
Average Output (kg)	1,532.56	1,151.70	1,391.51
Gross Revenue (N,=)	558,250.31	269,071.45	409,560.32
Total Cost (N,=)	417,757.57	185,059.30	297,882.70
Net Margin (N,=)	140,492.74	84,012.15	111,677.62
Total cost/kg (N,=)	272.59	160.68	214.07
Net Margin/kg (N,=)	91.67	72.95	80.26
Net margin-to-cost ratio (%)	34	45	37
Return on Sales (%)	25	31	27
Operating Ratio (%)	75	69	73

Source: Computed from Survey data, 2005

Household size had a positive influence on fish output. This implies that the larger the size of the family of the fisher, the higher the quantity of fish caught. The positive influence of household size may be due to the desire of fishermen to meet financial obligations to their families since only few fishers had viable alternative income generating activities outside fishing. Furthermore, household members may constitute a significant proportion of the labour force in fishing. Although the fisher’s household may not be involved directly in fishing activities, family members actively engage in fish retailing, processing, fish distribution and marketing. This may explain the highly significant effect of household size on fish catch. Like household size, fishing experience, measured by the number of years in fishing, also exerted a positive and statistically significant effect on fish output. The more experience a fisher has, the higher his capability in fishing in the face of competition and dwindling fish stocks. With experience, a fisher is able to discern when and where to fish at a particular season.

The effect of labour input is also positive and highly statistically significant, indicating that its another very critical input in artisanal fish production. Small-scale fishing is very labour intensive and every activity in the business, from going to sea, mending of gears and crafts, unloading the catch, grading, processing to marketing of fish require an adequate amount human effort. In fact, it could be said that labour input is the factor around which small-scale fishing revolves. Because without an adequate number of men ready to undertake a fishing trip there will be no catch. The result implies that as the supply of labour increases, other things being equal, fish catch will increase. Thus given existing fish stock, the input of labour in the artisanal fisheries sector will have to be raised if fish output must be increased to meet

Tab. 7: Regression results of determinants of output in artisanal fishing, Delta south agro-ecological zone

Variable	**SEGMENTS**		
	motorised (linear function)	**non-motorised (linear function)**	**entire study area (logarithmic function)**
Educational level	65.75 (1.45)	78.31 (1.65)	0.05 (0.84)
Household size	5.53 (0.38)	52.62 (3.08)**	0.20 (2.31)*
Gender	328.96 (3.46)**	385.51 (2.99)**	0.45 (4.51)**
Fishing experience	156.90 (6.55)**	75.39 (2.84)**	0.34 (4.01)**
Season	272.88 (2.63)**	383.73 (2.87)**	0.35 (3.24)**
Fishing craft	–	–	0.33 (3.76)**
Labour	236.98 (4.91)**	271.58 (5.03)**	0.82 (6.75)**
Depreciation of capital inputs	0.0009 (0.65)	0.003 (1.64)	0.27 (2.48)**
Food, repairs and maintenance	0.005 (1.98)*	0.0005 (0.01)	–0.08 (–1.13)
Fuel and lubricants cost	–0.001 (–1.14)	–0.001 (–0.79)	–0.01 (–1.47)
Non-fishing income	–0.007 (–4.04)**	–0.006 (–2.81)**	–0.10 (–2.90)**
Adjusted R-squared =	0.87	0.83	0.80
D-W statistic =	1.93	2.04	1.74
F-statistic =	62.92	50.07	71.13
n =	96	102	198

Figures in parentheses are t-statistics
* significant at the 5% level, ** significant at the 1% level
Source: Computed from Survey data, 2005

the widening local demand. Almeida *et al.*, (2001) found comparable results in a study in the Brazilian Lower Amazon where labour was found to contribute fundamentally to small-scale fish production. The effect of non-fishing income was negative and significant. indicating that as the proportion of income from economic activities other than fishing grows, fish catch will fall. In areas where there are more profitable alternative economic activities, increased non-fishing income is a disincentive to fishing; thus direct participation in fishing will reduce and consequently fish output will fall. The social and economic conditions in most river-rine and fishing communities in Delta State have improved with the initiation of alternative sources of livelihood to reduce poverty in such communities. There is no doubt that such a strategy of rural poverty alleviation and youth empowerment may have stimulated alternative income generating activities in fishing communities, to the extent that the propensity to fish has reduced.

Adequate investment and re-investment in fishing gears and crafts is required to sustain optimal levels of output in artisanal fishing. Thus, the higher the levels of capital input employed, the higher production is likely to be. This may explain why depreciation of capital input exerted positive and statistically significant impact on fish output. It must be noted, however, that uncontrolled capital investment can lead to overcapitalisation in the fisheries and consequently result in over-fishing. Overcapitalisation and over-fishing are indicators of the absence of well-defined property or user rights. If fishers enjoyed exclusive and more secure rights, they will be able to adjust their harvesting capacity to that needed to catch the sustainable yield (FAO, 2004). However, the fact that capital had a positive and statistically significant effect on fish output imply that the level of artisanal fisheries exploitation in Delta State is still below the maximum sustainable yield, and the potential for further investment exists. The effect of other variables on fish output in small-scale fisheries in South agro-ecological zone of Delta State, Nigeria are also shown.

The estimated regression results for the motorised and non-motorised segments are also shown in Table 7. They are similar, as the same set of six independent variables (except household size for non-motorised units, and food, repairs and maintenance for motorised units) significantly determined fish catch in both segments. While household size did not exert a significant influence on fish output in the motorised segment of the small-scale fisheries sector, its effect among the non- motorised unit was very strong and highly statistically significant.

The operations of the motorised fishing units is somewhat devoid of the participation of household members, as some post harvest activities are carried out by crew members; though processing, preservation as well as fish marketing are still undertaken by fishers families. Furthermore, most motorised fishing units in the study area operate like joint businesses and fishers co- finance fishing operations. This mode of operation with reduced participation of the fishers' family may have accounted for the non-significant influence of the variable household size in the model. In the non-motorised segment however, members of the fisher household play very active and important roles in artisanal fishing operations. While some are involved in active fishing, others are engaged in post harvest activities such as mending of gears, processing and marketing of fish. Thus, a larger family size constitutes a pool of labour supply from which the fisher can draw as the need arises.

Operators in the motorised segment of small-scale fisheries in Delta State exert greater fishing effort on available fish stocks due to their greater fishing power, than their non- motorised counterparts. Therefore in order to sustain their fishing effort, routine repairs and maintenance of fishing gears and crafts must be undertaken. As shown by the results, adequate maintenance of fishing materials impacted positively on fish output. Therefore, as physical capital inputs are adequately and routinely repaired and maintained, artisanal fish production is bound to increase.

Output elasticities

The results of the elasticity of output with respect to specified explanatory variables in the study area are presented in Table 8. The elasticity estimates give an indication of how much fish catch will vary as a result of a variation in a specified independent variable, while holding all others constant. In other words, it is a measure of the degree of responsiveness of fish output to changes in factors affecting it. The elasticity estimates with respect to the explanatory variables are quite high, particularly for variables that had statistically significant influence on small-scale fish production.

Labour was the dominant factor with an elasticity estimate of 0.82, followed by gender 0.45, season 0.35, fishing experience 0.34, fishing craft 0.33, and capital depreciation 0.27. The results show that increased labour input will contribute substantially to fish output than all other explanatory variables. In fact, a 10 percentage increase in fishing trip will stimulate an 8.2% rise in fish catch. But a commensurate change in fishing experience and fishing craft will cause only a 3.4 and 3.3% increase in fish output. As shown in Table 8, a change in non-fishing income will cause a negative response in catch levels. That is, a 10 percentage increase in income from sources outside fishing will depress fish output by 1.6%. Therefore, as sources of income are diversified away from fishing, output will fall. Quantitative reduction of fishing effort has been advocated as a means of regulating overcapacity and overfishing in commercial fisheries (FAO, 2004). Since increasing fishing power by artisanal fishers is a strategy to sustain

Tab. 8: Elasticity of fish output with respect to specified explanatory variables in Delta south agro-ecological zone

Independent variable	Motorised units	Non–motorised units	Entire study area
Educational level	0.09	0.12	0.05
Household size	0.03	0.34*	0.2*
Gender	0.12*	0.41*	0.45*
Fishing experience	0.66*	0.32*	0.34*
Season	0.08*	0.39*	0.35*
Fishing craft			0.33*
Labour	0.69*	0.81*	0.82*
Depreciation of capital inputs	0.08	0.26	0.27*
Food, repairs and maintenance	0.17*	0.002	–0.08
Fuel and lubricants cost	–0.04	–0.04	–0.01
Non–fishing income	–0.17*	–0.16*	–0.10*

*Variables that exerted statistically significant influence on fish catch
Source: Computed from Survey data, 2005

livelihood in the face of declining yields and shrinking fish stocks, a negative response of fish catch to non-fishing income is thus a policy indicator that can be explored to promote sustainability of artisanal fisheries resources.

Fishing craft and fishing experience also contribute significantly to fish production as indicated by the positive response of fish catch to these variables. A 10 percentage increase in the number of experienced fishers engaged has the propensity to raise output by 3.4%. But, a commensurate increase in the number of motorised fishing boats will boost fish catch by 3.3%. Thus, a combination of experienced fishers using motorised crafts is a strategy that can be used to boost catch levels in artisanal fisheries in Delta State, Nigeria.

CONCLUSION

The contribution of the small-scale fisheries sub-sector to food security, and employment and income generation in both regional and national economies in developing countries is well known. However the capacity of artisanal fisheries to play this triple role depends on the profitability of fishing operations, and the sustainable and efficient management of fisheries resources given the rate of exploitation and the level of poverty in fishing communities.

Although small-scale fishing was found to be profitable, the low operating margin, particularly amongst fishers using motorised crafts is a cause for concern due to the high cost of production, dwindling catches and the need to safeguard the livelihood of fishing-dependent people in coastal communities. The authors recommend therefore, that the policy of input subsidisation and production credit, to small-scale fishers be pursued with renewed vigour by both the Federal and State governments, in order to boost fish supply, increase income, and reduce rural poverty.

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Received for publication on June 21, 2007
Accepted for publication on November 11, 2007

Corresponding author:

O. E. Inoni, Ph.D.
Department of Agricultural Economics and Extension
Delta State University, Asaba Campus, Asaba
Delta State, Nigeria
Tel: +234 803 3746 331; e-mail: inoniemma2003@yahoo.com