

Economics of Adoption of Environmental Sustainable Fishing Techniques in Coastal Mangrove Niger Delta, Nigeria

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ABSTRACT

Reduction in social benefits in form of fishery stock depletion has some fishing techniques seriously fingered as low economic performance among fisher folks is leading to low revenue and unemployment in Mangrove Swamp Zone (MSZ) of Nigeria. Data were obtained from a two-stage sampling technique from 206 artisanal fishermen in two states within MSZ. Data on fisher folks' socioeconomic features, adoption level of environmental sustainable fishing techniques (ESFT), quantity and unit selling prices of species of catch as well as inputs were elicited using a well-structured questionnaire and analyzed using both descriptive and budgetary tools. Majority (68.9% and 64.2%) of fishing activities are done with dugout canoes with only a few (16.0% and 16.7%) motorized vessels that goes further off-shore in Bayelsa and Rivers State respectively. Adption level of ESFT of 26.1% and 24.1% for Bayelsa and River State respectively is low. *Nematopalaemon hastatis* recorded the highest (46.6%) returns of USD 345.77/fisherman, as fleet dominated sea-shore for it. Though artisanal fishing in MSZ seems economically sustainable with benefit-cost across different adopters greater than unity and rate of returns to investment ratio of 1.37, ranging from 1.33 in Rivers to 1.44 in Bayelsa State, but poses a high marginal social cost to the breeding areas as catch is very concentrated at the sea shore of less than 5nm. There is a low catch of some pelagic species (*Etamopterus penyl*). The study recommends a persuasive extension demonstartion, litigation and the use water poilce to enforce strict adherence to principles ESFT for sustainable artisanal fishing activities in the mangrove region of Niger Delta.

Key Words: Environmental, Sustaianble, Artisanal Fisheries, Fishing Techniques, Mangrove

INTRODUCTION

An economic sustainable fishing practices must aim to save the natural stock, enhance biodiversity and ensure a steady returns without fishing beyond maximum sustainable yeild. Emperical studies have shown that continous catch that seems profitable to a large number of fishfolks, has become detrimental to the future welfare and environment of the fish folks. Mmom and Arokoyu (2010) observed that continous removal of fish from aquatic habitat is posing a threat to both the environment and the future welfare of fisherfolks in Mangroove

Swamp Zones (MSZ). Eboh (1995) had already noted that the efforts of farmers towards increasing the output and achieving economic goals inadvertently destabilize environmental goals, hence obstructing the sustainable economic development. In the same way, fishfolks in the mangrove swamp zone who strive to increase catch per unit fishing effort are inadvertently fishing beyond maximum sustainable yield. Hardin (1968) called this situation '*tragedy of the common*,' because the continuous removal of fish from the aquatic environment in an area beyond socially efficient level will definitely decline the natural stock, thus the future benefits derivable from such resource in the area. Fishing requires the use of Environmental Sustainable Fishing Technique (ESFT). ESFT are technicalities designed to ensure that the natural fish stock are not destroyed while the fishfolks embarked on continuous fishing expedition for their livelihood (Ita, 1992; Abiodun 1994 and NDDC, 2004).

Although the growing population and economic activities of Niger Delta Region (NDR) pre-supposed intensified oil exploration and industrialization, which no doubt deplete the ecosystem, excessive fishing with sophisticated and dangerous fishing techniques further complicate biodiversity depletion in the mangrove swamp (Bisong, 2001). Aquatic organisms may have modified features that enable them withstand the adverse effects of oil pollutions and industrial effluent in the zone (Adeyemo, 2003 and Olanike et. al., 2009), but identified malaise of environmental degradation due to excessive catch has been fingered to some endangered species and fishing beyond maximum sustainable yield (NDDC, 2004; Mmom and Arokoyu, 2010). Some fishing skills and techniques in the area may appear rewarding at first instant (because they increase catch), but they can destabilize the ecosystem, make aquatic organism go extinct and increase future returns impossible (Adedeji et. al., 2011).

Mangrove Swamp Zone (MSZ) is an ecological zone that stretches between 5000 - 8580 km² along Nigerian coastline with a spread of brackish water that is rich in alluvial deposits and natural fish stock (Mmom, 2007). The area is a suitable breeding ground for different species of fish (James, 2008 and James et. al., 2007) though it is saddled with rapid biodiversity depletion and annual decimation of aquatic population (David and Gianna, 2005; Mmom and Arokoyu, 2010). In view of the fact that indiscriminate use of traditional fishing input does not only destabilize the ecosystem but also reduced the future catch, Oko and Zelin (2010) and Naylor *et.al.* (2001) recommends that aquatic resources in the MSZ can be harness for economic growth if fishing technologies are ecologically friendly and efficiently managed. A policy that will not only put the use of obnoxious fishing inputs in check but facilitates a stable ecosystem and ensures a steady increase in returns in MSZ anchors this study. This study investigates the degree of adoption of ESFT and its effect on rate of returns to investment in artisanal fishing in MSZ of the Niger Delta Region of Nigeria.

CONCEPTUAL FRAME WORK

Sustainable fishery is usually compromised when fishersfolk struggle for improved livelihood. Destructive fishing practices are not part of sustainable fishery, hence management practices that allows more fleets in the water without monitoring whether clean fishing practices are performed by them is a gate way for environmental degradation. Incidental catch for instance removes juvenile fishes and the use of certain gear and vessel beyond certain areas and time as well as poison, dynamite and cyanide fishing are some of bad fishing practices that should be discouraged. Contrary to the earlier believe that ESFT will reduce catch, consequent to livelihood as fishersfolk fear being made job with these management techniques., Ehirim *et. al.* (2013) noted that a continuous fishing with instant increase in catch without following the environmental regulations is devastating in the long-run. Hussen (2004) noted that the unit price of catch may rise above the equilibrium price while its catch level drops in the long run.

The decline in output could lead to a reduction in Gross National Product (GNP) while factors of production falls due to the reduction in output, hence increasing the level of unemployment in the sector.

Ita (1992) and Abiodun (1994) differently acknowledged some techniques that can galvanize, a sustainable livelihood and a balanced aquatic ecosystem. Registration of vessels, gears and gear members and their licensing when they meet some criteria, standard mesh size regulation, close area and season fishing and other clean fishing practices. Others are the use of a recommended mesh size for some dominant species in mangrove as well as the use of clap with gill nets in the flood plains, will ensure that only suitable table fishes are caught while the juvenile fishes are retained in water at all time. Again, catch-sort and drop otherwise called by-catch and discard method according to Eayrs (2005), creates a second chance for already trapped fish to grow to full maturity, produce more fishes before they are finally harvested. Adopting other techniques such as, water tenure system and Fishing beyond nautical miles, complying with close area and close season fishing practices, intensifying the use of flood plains by applying organic manure in the flood plains and around the continental shelves and encouraging aquaculture along artisanal fishing will reduce the pressure mounted on the natural stock by continuous fishing. Also registration and licensing of the fishermen as well as keeping catch data, complying with gear regulation and quota restriction and prohibiting the use of poison and dynamites or explosives will not only check over-exploitation, but also ensure a healthy ecosystem, sustainable fishing and livelihood of the fish communities (Ita, 1992).

Strict enforcement of environmental regulation in artisanal fishing sector may reduce the marginal social cost and increase marginal social benefit but have a significant effect on the private cost of production, reduce output and increases unit price of catch of fish. However, the cost effect of enforcing environmental regulation on certain productive economic activities such as artisanal fisheries may be quite significant. Porter (1990, 1991) has hypothesized that strictly enforced environmental policy could have the effect of forcing firms to adopt more efficient production technologies that can reduce the production costs, increase returns and further stimulate economic growth in the long run. Resource use efficiency consciousness among artisanal fisher folks that strictly enforced environmental policies can stimulate multiplier effect on reduction in inflation and consumer price index, sustained output maximization, hence high gross national revenue and a reduction in employment

MATERIALS AND METHOD

The mangrove swamp zone (MSZ) is within the Niger Delta region of Nigeria. It consists the brackish water front of the coastal line of Atlantic Ocean. It is located within latitude 5° and 7°N and longitude 5° to 8°E of Greenwich. It covers the state like Rivers, Delta, Bayelsa and Akwa-Ibom States of Nigeria. The area is a breeding site for different species of fish, accommodated the largest and highest number of fish settlements but the most destabilized ecosystem. A two-stage sampling technique was used in this study. First was a purposeful selection of two (2) states: Bayelsa and Rivers State with predominant fishing settlements were selected out of the four states in the zone. The second stage was a purposive selection of the two largest fishing settlements in each of the states. Nembe and Brass watersides were selected from Bayelsa State while Kai and Oyorokoto-Opobo watersides in Rivers State were selected.

A random selection of artisanal fishermen from the list of fishermen per settlement kept with the Ministry of Agriculture and Natural Resources in each state. The list showed that Nembe and Brass Water sides has 132 and 121 registered fishermen respectively while Kai and Oyorokoto-Opobo waterside has 176 and 184 fishermen respectively. A random selection

of 80% of the fishermen from each of the list gave a total selection of 202 and 289 fishermen from Bayelsa and Rivers State respectively but only 106 and 120 responses were found useful for the study. A well structured questionnaire was used to elicit information on socio-economic characteristics, adoption level of environmental sustainable fishing techniques, the quantity and prices of fishing inputs and output in the area between May and September 2010.

ANALYTICAL METHOD AND MODEL SPECIFICATIONS

Data were analyzed using descriptive, inferential and econometric tools. Descriptive statistics was used to identify ESFT that were adopted. The ESFT identified in this study were those of Ita (1992) and Eayrs (2005) as shown in 3.1

$$EST = \{V_i : i,1...10\} \tag{3.1}$$

Where

V_1 = The use of recommended mesh size for some species that is dominant in an area, V_2 = Catch-sort and Drop technique or By-catch and Discard Method (Eayrs, 2005). V_3 = Complying with Close Area and Close season fishing practice, V_4 = Intensifying the use of flood plains and the addition of organic manure in the flood plains and the continental shelves, V_5 = Use of clap nets and gill nets in the flood plains, V_6 = Encouraging aquaculture along artisanal fishing, V_7 = Adopting water tenure system and Maintaining about 5 or more nautical miles in fishing, V_8 = Registration and licensing of the fishermen as well as keeping catch data, V_9 = Complying with gear regulation and quota restriction, V_{10} = Prohibition of the use of poison and dynamites or explosives. These were actually the techniques that can sustain the maximum sustainable yield (MYS) which the fish community is expected to adhere to strictly (Ita, 1992).

Ozor and Madukwe (2001) noted that adoption process follows a seven-point likert type of scale (called NAEITA + D), with assigned ordinal values of between 0 and 6 (Lionberger, 1960 and Cameron, 1999). Therefore, adoption score of a fisherman for each ESFT his maximum stage in adoption process.

The mean and standard mid value as shown in 3.2 and 3.3 respectively were compared to select the adopted ESFT. An ESFT is adopted when $M \geq a \text{ standard mid value of } 3.0$

$$\bar{M} = \frac{\sum_{i=1}^7 FX}{\sum F} \text{ where } 0 \leq \bar{M} \leq 6 \tag{3.1}$$

$$GMA = \frac{\sum_{j=1}^{10} \bar{M}}{10} \tag{3.2}$$

Where $i = 1,2...7$ and $j = 1,2,3...10$

$$SMV = \frac{0 + 1 + 2 + 3 + 4 + 5 + 6}{7} = 3.0 \tag{3.3}$$

Where;

\bar{M} = Mean Adoption of an ESFT

GMA = Grandmean adoption

X_{ij} = Adoption stage in the adoption process of an i th farmer in j th technique obtained from ordinal values attached to the adoption process.

F = Frequency of Fishermen within the same adoption stage in a particular technology.

SMV = Standard mid value

Fishermen were further differentiated to various adopters category based on their adoption potential. Adoption potential is the possible degree of adoption level an i th fisherman in all the available ESFT as at the period of this study. This is expressed as the mean adoption level in all ESFT. A fisherman is at the highest adoption potential if he shows aggressive tendencies in adopting all the ESFT with the shortest period of time but becomes the least if otherwise. The categorization is done thus

$$AP = \frac{\sum_{i=1}^N ADL_i}{N} \pm Std.Dev(n) \quad 3.5$$

Where;

AP = Adoption Potential of an i th fisherman

ADL = Adoption Level of an i th fisherman in all the ESFT

N = Total number of ESFT introduced and used by at least a fisherman the area.

Std. Dev(n) = The standard deviation of the mean adoption level, and n is the successive category level.

Adoption potential is highly influenced by extension effectiveness, technology practicability and compaticability, cost and most importantly time.

The economic sustainability of artisanal fishing in the area based on states in mangrove swamp zone and adopters categories were obtained using a budgetary analysis such as gross margin analysis and rate of returns to investment. The gros margin and rate of trturns model are expressed as;

$$\text{Gross Margin} = \sum_{i=1}^n YP_y - \sum_{i=1}^n P_x X_i + \dots + P_x X_i \quad 3.6$$

$$RTI_i = 100 \frac{\sum_{i=1}^n YP_y - \sum_{i=1}^n P_x X_i + K}{\sum_{i=1}^n P_x X_{ij} + \dots + P_{xn} X_{ij}} \quad 3.7$$

0 RTI_i 1 when the enterprise is economically sustainable

Where;

RTI is already defined,

Y_i is the quantity of catch of an i th fisherman,

P_{yi} is the unit price of catch,

P_{xi} is the unit input price of an i th input used

X_{ij} is the quantity of j th input used by an i th fisherman.

K is the fixed inputs such as depreciation

$$\text{Benefit/Cost ratio} = \frac{D_{Benefit @ 19\%}}{D_{Cost @ 19\%}}$$

Where;

$D_{\text{benefit@19}}$ = Discounted Benefit at 19% discount factor

$D_{\text{cost19\%}}$ = Discounted cost at 19% discount factor

When the ratio is equal to 1, then the returns can comfortably take care of the investment even in the long run, but if it is less than 1, then the enterprise is expected to continue to operate in the very short run as it can meet its immediate financial obligations while economic sustainability is expected to take place in the long run. When the ratio is less than zero (0), the enterprise fails to be economically sustainable both in the short and the long run. The fisherman closes down at this stage.

RESULTS AND DISCUSSIONS

Descriptive Statistics of Artisanal Fish folks in Mangrove Swamp Zone of Niger Delta, Nigeria

Table 1 presents the socio-economic distribution of the fishermen in the mangrove zone of Niger Delta Region of Nigeria. The result shows that there are more male fishermen in the area with 86.8% and 83.3% of them from Bayelsa and River State respectively. Their mean age is 39.9 and 33.3 years for Bayelsa and Rivers State respectively with majority (33.9%) of them in Bayelsa between 31 to 40 years 33.3% of them between 21 to 30 years of age in River State. Few of them (17.0%) are older than 60 years of age in Bayelsa and River State. Again, few (15% and 8.3%) of them have relatively higher fishing experience of above 20 years, implying that artisanal fisheries is centered more around the young age category than the old people. The level of formal education among the fishfolk is high with 44.3% and 38.3% of them in Bayelsa and River State having up to secondary education. Extension contact is as low as 6 times per fishing season just as they try to keep a relatively small household size of less than 5 persons per household.

Table 1. Socio-Economic Characteristic of the Fishermen

Variable	Bayelsa State		Rivers State	
	Frequency	Relative (%)	Frequency	Relative (%)
Age (Years)				
20 or less	2	1.9	19	15.8
21-30	21	19.8	40	33.3
31-40	36	33.9	21	17.5
41-50	29	27.4	20	16.7
51-60	10	9.4	15	12.5
61-70	6	5.7	4	3.3
More than 70 Years	2	1.9	1	0.8
Total	106	100.0	120	100.0
Mean	39.9	-	35.2	-
Level of Formal Education				
No Formal Education	20	18.9	36	30.0
Adult Education	11	10.3	10	8.3
Primary Education	21	19.8	23	19.2
Secondary Education	47	44.3	46	38.3
Tertiary Education	7	6.6	5	4.2
Total	106	100.0	120	100.0
Mean	7.9	-	6.6	-
Years of Fishing Experience				
1-10	65	61.3	65	54.2
11-20	25	23.6	45	37.5
21-30	7	6.6	5	4.2
31-40	8	7.5	2	1.6
Above 40 Years	1	0.9	3	2.5
Total	106	100.0	120	100.0
Mean`	13.1	-	11.3	-
Extension Contacts Made				
No Extension Contact	49	46.2	38	31.6
1-5	21	19.8	32	26.7
6-10	17	16.0	31	25.8
11-15	14	13.2	15	12.5
More than 15	5	4.7	4	3.3
Total	106	100.0	120	100.0
Mean	4.9	-	5.4	-
Household Size				
1-5	78	73.6	81	67.5
6-10	21	19.8	26	21.7
11 or More	7	6.6	13	10.0
Total	106	100.0	120	100.0
Mean	5	-	5	-
Gender				
Male	92	86.8	100	83.3
Female	14	13.2	20	16.7
Total	106	100.0	120	100.0
Marital Status				
Single	27	25.5	53	44.2
Married	78	73.6	66	55.0
Divorce/Separated	1	0.4	1	0.8
Total	106	100.0	120	100.0

Source: Field Survey 2011

Source Field Survey 2013

Fishing Assets and Fishing Activities in Mangrove Swamp Zone of Niger Delta Nigeria

Table 2 below shows the distribution of fishermen based on their level of fishing assets and fishing activities in the mangrove areas. The result showed that there is an open access to fishing in the area with majority of the respondents engaging in only artisanal fishing as source

of livelihood. Mean fishing distance off-shore is lower than 5 nautical miles (nm). About 83.0% of them in Bayelsa and over 91.6% of them in Rivers state are fishing in less than 5 nautical miles (nm) off-shore. Such fishing distance has a devastating effect on the growth of juvenile fishes and fish breeding in the mangrove. Few fishermen of less than 17.3% in Bayelsa and 8.4% in Rivers State were actually complying with the regulations of fishing beyond 5nm off-shore. Since fishing is a common means of livelihood, it means that the natural stock is at risk as the breeding areas within the mangrove will be quickly and easily destroyed with excessive fishing activities by fishfolks. The use of cast nets is common (45.2%) in Bayelsa and long lines and hook is the commonest (45.8%) in Rivers State. The use of dugout that do not move far into the mid ocean is common in both states with 68.9% and 64.2% of fisher folk in Bayelsa and Rivers state using such vessel for fishing around the mangrove swamp zone. The large concentration of this type of vessel on the breeding area may not be socially desirable since it increases the marginal social cost. The result showed a few used motorized vessel by the fishers folk with only 16.0% and 16.7% of fishermen in Bayelsa and Rivers state using such vessels for fishing. This implies that the fisher folk may not have enough capital to acquire this motorized fishing vessel that can facilitate off-shore fishing expedition to the mid ocean for pelagic fishes.

Table 2. Distribution of Fishermen by their Assets and Fishing Activities

Variable	Bayelsa State		Rivers State	
	Freq	%	Freq	%
Fishing Distance				
Less than 1 Nautical mile	52	49.0	62	51.6
1 - 5	36	34.0	48	40.0
6 - 10	12	11.3	8	6.7
Greater than 10 Nautical miles	6	5.7	2	1.7
Total	106	100.0	120	100.0
Mean Distance covered	2.9		2.2	
Fishing Gears				
Long lines/Hooks	47	44.3	55	45.8
Cast Netting	48	45.2	32	26.7
Drift Netting	17	16.0	28	23.3
Trapping	12	11.3	13	10.8
Others	4	3.8	3	2.5
Total	128+	-	131+	-
Fishing Vessel				
Dugout Canoes	73	68.9	77	64.2
Plank Canoes	41	36.6	32	26.7
Motorized Canoes	17	16.0	20	16.7
Total	131+	-	129+	-
Access to Water				
Open Access	89	84.0	117	97.5
Closed Access	17	16.0	3	2.5
Total	106	100.0	120	100.0
Occupation				
Fishing Only	86	81.1	75	62.5
Fishing and Farming Only	1	0.9	13	10.8
Fishing and Trading Only	2	1.9	7	5.8
Fishing and Schooling Only	9	8.5	15	12.5
Fishing and Civil Service	8	7.5	2	1.7
Fishing and Craft	0	0	8	6.7
Total	106	100.0	120	100.0
Technology Compatibility and Practicability				
Yes	32	30.2	16	13.4
No	28	26.4	43	35.8
Indifference	106	100.0	120	100.0
Total				

Source: Field Survey 2013

The level of Adoption of Environmental Sustainable Fishing Technologies in Mangrove Zone

Table 3b. presents the mean adoption levels of Environmental sustainable fishing techniques (ESFT) in Mangrove Swamp zone of Niger Delta, Nigeria. ESFT were not massively adopted in the mangrove swamp zone of Nigeria given the low grand mean adoption score of 1.82 and 1.69 in Bayelsa and Rivers State respectively. There is a total adoption level of 26.1% and 24.1% of the total adoption in Bayelsa and River State, implying that about 73.9% and 75.9% of ESFTs have not been adopted in Bayelsa and Rivers States respectively. Judging from the mean adoption of the 10 included technologies, the mean scores are less than the standard mid value of 3.0 except the close area and season technology and avoidance of dynamites and explosions with mean adoption score of 3.21 and 3.27 respectively in Bayelsa State. It therefore implies that the two ESFT were the only technologies adopted by fishermen in Bayelsa. In the same way, avoidance of dynamites with a mean adoption score of 3.56 which is greater than 3.0 was the only ESFT adopted in River State. Though other ESFT in the two states were at various level of adoption score, there is no strong evidence that they are capable of keeping breeding areas

sustainable. This finding suggests that environmental regulations in artisanal fisheries are highly violated in the mangrove areas, hence a possible increase in marginal social cost associated with artisanal fisheries in the area. Ehirim et al. (2013) opined that the poor rate of adoption may be due to declined extension effectiveness in the use of sustainable environmental fishing technologies for their fishing activities in the area

It could be the recent strict enforcement of the policy on close area and close season fishing as well as the use of dynamite in the mangrove by the state house assembly that enhanced the adoption of these practices in artisanal fisheries. It is advised by this study that a strict enforcement of the other environmental regulations in captured fisheries be made by the legislatures to facilitate not only a sustainable livelihood for fisher folks but reduces the marginal social cost and enhance the marginal social benefit of the fishing communities around the mangrove area. This study also suggests an effective extension education approach that can lead to a change in fishing behaviour by persuading the use of ESFT by fisher folk so as to save the areas from total environmental destruction.

Adopters Category of ESFT by Fishermen in MSZ of Nigeria

The result in Table 3a. reveals the level of different adopters of environmental sustainable fishing techniques in MSZ. It could be seen from the result that majority (41.5% and 36.7%) of fishermen in Bayelsa and Rivers State are within late adopters category respectively while 28.3% and 25.0% are laggards in Bayelsa and Rivers State respectively. Few (15.1% and 10.0%) of the fishermen is aggregate of innovator and early majority in Bayelsa and Rivers State respectively. This finding reveals that majority of these fishermen are laggards and late adopters hence, adoption of environmental sustainable fishing techniques must be more pragmatic to enable the never adopters move into the early majority category with time.

Table 3a. Adoption Score/Intensity and Adopters Categories of Sustainable Fishing Practices in the Niger Delta of Nigeria

States	Adoption Intensity Class Limits	Bayelsa		Rivers State	
		Frequency	%	Frequency	%
Laggards/Never Adopters	0 - 8.0	30	28.3	30	25.0
Late Majority	8.5 - 19.0	44	41.5	44	36.7
Late Majorities	19.5 - 30.0	16	15.1	34	28.3
Early Adopters	30.5 - 41.0	14	13.2	10	8.3
Innovators	41.5 - 60.0	2	1.9	2	1.7
Total	-	106	100.0	120	100.0
Mean	-	16.5		18.8	
Adoption Potential		19.0± 11n			

Source Field survey 2013 (n = 0, 1, 2 ... N represents the level of Adoption intensities)

Table 3b. Mean Adoption and Adopted Technology in Mangrove Swamp Region of Nigeria.

States in Mangrove Zone		Bayelsa State (n = 106)		Rivers State (n = 120)	
Environmental Sustainable Fishing Techniques		\bar{X}	Remark	\bar{X}	Remark
1	Recommended Mesh Size	1.51	Na	2.75	Na
2	Catch sort and Drop Method	0.72	Na	0.69	Na
3	Close Area and Season Fishing	3.21	Ad	1.02	Na
4	Use of Flood Plains	1.26	Na	0.78	Na
5	Use of Gill and Clap net in the Flood Plains	1.66	Na	0.70	Na
6	Practicing Agriculture	1.41	Na	1.57	Na
7	Practicing Water Tenure	1.31	Na	1.28	Na
8	Registration/ License	1.85	Na	2.38	Na
9	Quota Restriction	2.08	Na	2.15	Na
10	Avoiding Dynamited Poison	3.27	Ad	3.56	Ad
Grand Mean Adoption		1.82		1.69	
Percentage Adoption		26.1%		24.1%	

Source: Field Survey 2013

Economic Sustainability by States in the Mangrove Swamp Zone of Niger Delta Nigeria

Table 4 presents the cost and returns of artisanal fishing activities across the states in the mangrove swamp zone in the Niger Delta region of Nigeria. The result reveals that shrimps *Nematopalaemon hastatis* caught in artisanal fisheries in MSZ generated about USD 345.77/fisherman or 46.6% of a fisherman's total returns. This is followed by the catch of shark *Etamopterus penyi* with USD 250.04/fisherman or 33.7% of his total returns. A critical look across the states studied shows that about USD 320.07/fisherman and USD 232.48/fisherman or 48.8% and 34.93% of the returns from the catch in Bayelsa are made from shrimps and sardines respectively. In the same way, about USD 345.77/fisherman and USD 250.04 or 46.6% and 33.7% of the total returns are made from shrimps and shark respectively in Rivers state. The high contributions of shrimps and sardine to the total revenue of the fishermen in MSZ could be the reason for large the concentration of fishing activities within swamp zones than farther off shore.

The implication of this finding to the MSZ ecosystem is the fast and continuous loss of some endangered species of fish. Apart from being suitable breeding, World Bank (1995) and NDDC (2004) have observed that fishing close to the sea shore or the MSZ will lead to the collapse of targeted fish species like Sardines *Sardinella maderenis* and other species. Hence, the social benefit drawn from this excessive shoreline fishing will drop drastically in the long run with an attendant high marginal social cost. Fisher folks have little or no fishing effort on the catch of pelagic fishes and other highly valued species such as suitable table sized sharks farther off-shore. There is a significant implication of this to MSZ. Just as the disturbances caused as a result of concentrated fishing in MSZ or ocean shoreline can reduce the breeding performance of fishes, extinction of endangered species from the mangrove swamp is eminent with a high external cost, which may not be socially desirable for the economy (Hussen, 2004). The consequences may include reduction in gross national product due to low output, high unemployment resulting from the reduction in use of factors of production and high unit cost of fishes leading to inflation in the economy.

The result further shows that depreciation of fixed inputs, labour cost, lubricants and fuel constitute the highest cost of artisanal fisheries in area while charges on gross vessel length and penalty on abuse of water resources are the least. This suggests that artisanal fishing in the area is gradually experiencing a very high private cost per unit catch without a reduction in marginal social cost. A higher charge and strict penalty could caution the bad use of water

resources and reduce the marginal cost in the area but apparently, the open access to water and lack of strict litigation policies in the area may be the reason for such serious abuse of water use. This is threatening the natural stock. It could be deduced from the finding that since fish folks can escape the consequences of the abuse to water use, less attention will be paid to ESFT in the area.

The gross margin for artisanal fisheries in MSZ of Niger Delta region is USD513.50 per fisherman, which is about 69.2% of the total cost of catch. The value ranges from USD557.54 or 68.2% of the total cost of catch in River state to USD488.88 per fishermen or 73.3% of the total cost of catch in Bayelsa. It could be deduced from the result that the rate of return to investment in artisanal fisheries in MSZ is 36.7% with Bayelsa and Rivers state having 41.1% and 33.1% respectively. Artisanal fisheries in Mangrove area of Niger Delta region is economically sustainable despite the low adoption of environmental sustainable fishing techniques in the area. An increase in total cost of catch by 100% will give a more than 41.1% increase in return in the Bayelsa State, 33.1% increase in returns in Rivers State and about 36.7% increase in returns for all the fish folk in the Mangrove swamp zone of Niger Delta region of Nigeria. A benefit-cost ratio of 1.37 from the pooled result is an indication that the enterprise is viable now but the viability in future is questionable giving the rate of removal of juvenile fishes from the swamp.

Economic Sustainability by Adopters of ESFT in the Mangrove Swamp Zone, Niger Delta, Nigeria.

Table 5. presents the cost and returns of artisanal fishery activities of different adopters of environmental sustainable fishing techniques in MSZ of Niger Delta, Nigeria. The benefit-cost ratio that is greater than unity for different adopters showed that enterprise is economically sustainable the different adopters. However, there is an interesting finding from this study. Some species like shark *Etamopterus penyl* that are mostly found off-shore contributed more to revenue of adopters of ESFT than others. The Principle of ESFT believed that fishing farther off shore will help sustain the breeding areas provided by the MSZ and adopters of ESFT are abided by this particular principle (Naylor *et.al.*, 2001 and Oko and Zelin, 2010). It could be revealed from this result that about USD 332.08/innovator or 39.1% of his total returns, USD 332.58/early majority adopter or 40.9% of his total returns and USD 312.58/late majority adopter or 39.7% of his total returns is relatively higher than only USD 124.78 per late adopter or 20.7% of his returns and USD 158.18 per laggard or 23.2% of his total return. This provides a strong evidence that despite the difficulties associated with adoption of ESFT, the techniques may accommodate more returns after all. The innovators, early majority and late majority fishermen are taking advantage of species farther off-shore to generate more revenue than the late adopters and the laggards in MSZ. This is due to their adherence to the principles of ESFT than the rest of the adopters in the area.

The study therefore suggests that although shrimps and sardine that are close to sea shores contributed more to their revenue of individual adopters, it is important to remove the mind of these group of fishermen from existing trend of fishing close to the sea-shore so as to achieve a stable ecosystem in the MSZ. This can be achieved through a persuasive extension education and good artisanal fishing demonstration that must abide strictly with the principles of ESFT by model agents or extension agents.

Table 4. Budgetary Analysis According the States in Mangrove Swamp Zone, Niger Delta Region, Nigeria

States Items	Bayelsa State (n = 106)			Rivers State (n = 120)		Pooled (n = 206)	
	Unit	USD/Fisherma n	(%)	USD/Fisherma n	(%)	USD/Fisherma n	(%)
Revenue							
Sardines: <i>Sardinella maderensis</i>	USD	232.48	34.9	216.69	26.5	224.59	30.3
Brackish: Catfish <i>Chrysichthys nigrodigitatus</i>		208.38	31.3	179.78	22.0	194.08	26.2
Sharks: <i>Etamopterus penyi</i>		180.00	27.0	320.07	39.2	250.04	33.7
Shrimps: <i>Nematopalaemon hastatis</i>		320.07	48.0	371.47	45.4	345.77	46.6
(A) Total Revenue		940.93		1088.01		1014.47	
Variable Cost							
Items							
Labour (manday)	Mandays	184.45	27.7	209.80	25.7	197.13	26.5
Bait (Kilogramme)	Kilogramme	24.83	3.7	27.00	3.3	25.92	3.5
Fuel (liters)	Litres	110.07	16.5	135.34	16.6	122.71	16.5
Lubricants (liters)	"	118.01	17.7	142.42	17.4	130.21	17.5
Charge on Gross Vessel Length	USD	8.92	1.3	21.56	2.6	15.24	2.1
Water Penalty	"	5.76	0.8	13.75	1.7	9.75	1.3
(B) Total Variable Cost		452.05	67.8	549.87	67.3	500.96	67.5
Fixed Cost							
Items							
Depreciation		155.64	23.3	167.16	20.4	161.40	21.7
Registration and Training	"	45.55	6.8	79.79	9.8	62.67	8.4
<i>Dues</i>		13.41	2.0	20.75	2.5	17.08	2.3
(C) Total Fixed Cost		214.60	32.2	267.71	32.7	241.15	32.5
(D) Total Cost (B + C)		666.65	100.	817.58	100.	742.11	100.
(E) Gross Margin {A - B}							
(F) Net Income (NI) {A - (B+C)}		274.28	41.1	270.43	33.1	272.35	36.7
(G) RTI {100(F/C)}	Percentage	41.1		33.1		36.7	
(F) Benefit/Cost Ratio (@ 0.19)	Ratio	1.41		1.33		1.37	

Source: Field Survey 2013

Table 5. Budgetary Analysis Based on Adoption Categories of ESFT in Mangrove Swamp Zone of Niger Delta Region of Nigeria

Adopters Categories	Innovators		Early Majority		Late Majority		Late Adopters		Lagards		Pooled	
	Amount		Amount		Amount		Amount		Amount		Amount	
Amount Per Fisherman												
Revenue (Naira)	USD	%	USD	%	USD	%	USD	%	USD	%	USD	%
Sardines: <i>Sardinella maderenis</i>	378.37	44.5	338.41	42.8	202.01	25.7	105.70	17.5	98.46	14.4	224.59	30.3
Brackish Catfish: <i>Chrysichthys nigrodigitatus</i>	106.81	12.6	113.77	14.4	218.53	27.8	205.10	34.0	326.19	47.7	194.08	26.2
Sharks: <i>Etamopterus penyi</i>	332.08	39.1	322.58	40.9	312.58	39.7	124.78	20.7	158.18	23.2	250.04	33.7
Shrimps: <i>Nematopalaem on hastatis</i>	417.64	49.2	371.79	47.1	380.70	48.4	269.02	44.6	289.71	42.4	345.77	46.6
A. Total Revenue	1234.90		1146.55		1113.82		704.60		872.54		1014.47	
Labour (manday)	222.20	26.2	221.73	28.1	203.21	25.9	191.97	31.7	146.54	21.4	197.13	26.5
Bait (Kilogramme)	26.30	3.1	33.77	4.3	22.79	2.9	26.77	4.4	19.97	2.9	25.92	3.5
Fuel (liters)	150.16	17.7	138.18	17.5	151.48	19.3	53.61	8.9	120.12	17.6	122.71	16.5
Lubricants (liters)	155.00	18.2	128.32	16.3	150.09	19.1	85.19	14.1	132.45	19.4	130.21	17.5
Charge on Gross Vessel Length (Naira)	17.03	2.0	20.01	2.5	15.00	1.9	12.08	2.0	12.08	1.8	15.24	2.1
Water Penalty (Naira)	16.70	1.9	13.00	1.6	7.10	0.9	7.00	1.2	5.00	0.7	9.75	1.3
B. Total Variable Cost	587.39	69.2	555.01	70.3	549.67	69.9	376.62	62.5	436.16	63.8	500.96	67.5
Depreciation (Naira)	140.00	16.5	148.00	18.7	160.03	20.4	171.00	28.3	187.97	27.5	161.40	21.7
Registration and Training (Naira)	102.00	12.0	70.00	8.9	60.00	7.6	38.55	6.4	42.80	6.3	62.67	8.4
Dues (Naira)	20.00	2.3	16.35	2.1	16.35	2.1	16.35	2.7	16.35	2.4	17.08	2.3
C. Total Fixed Cost	262.00	30.8	234.35	29.7	236.38	30.1	225.90	37.49	247.12	36.2	241.15	32.5
D. Total Cost in Naira (B + C)	849.39	100.0	789.36	100.0	786.05	100.0	602.52	100.0	683.28	100.0	742.11	100.0
E. Gross Margin in Naira {A - B}	647.51	76.2	591.54	74.9	564.15	71.8	327.98	54.4	436.38	63.8	513.50	69.2
F. Net	385.5	45.4	357.1	45.3	327.7	41.7	102.16	16.9	189.27	27.7	272.3	36.7

	1	9	7	08	26	5
Incom e in Naira {A - (B+C)}						
G. RTI {100(F /D)} (Perce ntage)	45.4	45.3	41.7	16.9	27.7	36.7
H. Benefi t Cost Ratio	1.454	1.453	1.417	1.169	1.277	1.367

Source: Field Survey 2013

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