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Vulnerability of Coastal Livelihood to Sea Level Rise and Climate Change in Eastern Niger Region of Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author UEA designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors RUU and RIU managed the analyses of the study and managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Studies were carried out to assess the vulnerability of Coastal livelihood to sea level rise and effect of climate change in Eastern Niger Region of Nigeria. The study area covered the major estuaries in the south-eastern Nigeria. questionnaires, Focus Group Discussions were used in the study on the basis of finding, The primary occupation of households surveyed is fishing (64%), followed by forestry (mangrove resource) (26%) and daily wage laborer (10%); with significant difference of 0.310 (2-sided), livelihood ratio of 0.292 and linear by linear association of 0.740 at (0.05) significant

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level. It was observed that more income was spent on maintaining fishing gear, purchasing gasoline and health care with significant difference of p-value 0.002 (2-sided), livelihood ratio of 0.002 and linear by linear association of 0.008, as such the effect of flood on fish production in south-eastern Nigeria was on the increasing (80% at risk). The study concluded that, flooding is currently a major threat to the fishermen's livelihoods especially the resultant decline in mangrove abundance and diversity causing a reduction in fish production/catch. As such, a well-planned and managed mangrove reforestation programme is necessary, educating communities about the impacts of climate change and involving them in adaptation planning is essential for building resilience. Programs that raise awareness about sustainable practices and disaster preparedness can help mitigate climate risks also, establishing and managing protected areas such as marine parks and wildlife sanctuaries help conserve critical habitats and biodiversity to serve as hot spot to affected areas. It is also recommended that further research be carried out to investigate the physiological response of mangrove related to temperature and salinity.

Keywords: Coastal livelihood; climate change; salinity; temperature.

1. INTRODUCTION

Coastal communities in the tropics are blessed with mangroves wetlands that occupies a narrow strip of land bordering the seas [1]. Sixty percent of the world's major cities are located in coastal zones, and 40% of all the people on the planet live within 100 km of a coastal zone" [2]. "About 70.8% of the surface of the earth or 360 million square kilometers is ocean and coastal water. Over 90% of the planet's living and non-living resources are found within a few hundred kilometers of the coast" [3]. "On or near these coasts live about two-third of the world's population (over 4 billion people), usually within 60 km of the coast" [4]. "The mangrove forest is typically a tropical salt tolerant group of plants that occupy the inter-tidal zone of sheltered coasts around estuaries and lagoons" [5]. "The mangrove forests are known to serve various socio-economic and ecological functions especially in the coastal communities. They are the most productive and valued ecosystems" [6]. Mangrove provides breeding grounds for fish species and provide numerous non-wood products that contribute to rural livelihoods [5,7], the forests were earlier considered to be the least disturbed of the forest zones of Nigeria [8]. Nigeria's mangrove forests cover an area of about 105,000 hectares and is known to be the largest in Africa and the third largest in the world [9]. The Nigerian coastline which is approximately 853km long stretches from the western border with the Republic of Benin to the Eastern border with Cameroon, with mangroves and estuaries extending from 10-150km inland [10]. Mangroves are found in all the coastal States of Nigeria, namely; Akwa-Ibom, Bayelsa, Cross River, Delta, Edo, Lagos, Ogun, Ondo, and Rivers State.

"The ongoing global warming is causing climate change in several regions of the Niger Delta, resulting in various impacts where the South-easter Nigerian coast is located" [11,12]. "One of these impacts affects coastal areas, the rise in sea levels causing flood and intrusion of the sea water into the estuaries and adjoining rivers with subsequent inundation of the fringing mangrove ecosystem" [1]. "The mangrove ecosystem is one of the coastal ecosystems with a crucial role in both ecological and economic aspects of life" [13]. "This ecosystem is more susceptible to damage due to climate change and human activities. The sea-level rise in the Sayung coastal area is approximately 0.5-1.85 meters per year, which falls into the high-risk category" [4,14].

Livelihood is a process by which people make a living through specific capabilities, assets, and activities [15,16,17,18]. Rural coastal livelihoods in many areas of Nigerian coast are complex, diversified, and undergoing change continuously [19]. The livelihood of Nigerian coastal dwellers dependent largely on the mangrove ecosystem, as their main occupation is fishing. Local fish production in Nigeria is about 600,000 metric tons yearly of which the majority comes from the Niger Delta coastal region [20]. The dependence on water for primary livelihood makes the region extremely vulnerable to flooding which impacts the primary economy.

"The economic activities of the communities in the region are either land-based or water-based to include crop and animal farming, fishing and fish farming, forest resources utilization and trading" [21,22]. "However, the traditional coastal livelihood portfolio has been rearranged due to environmental and ecological change, infrastructural developments and introduction of

new occupational sectors. Some current coastal livelihood activities are no longer economically, environmentally and socially viable and need to be replaced with alternatives" [23,24]. For this reason, coastal communities are changing their livelihood activities at different time periods, which make their income uncertain. "If a coastal rural household has different options, they choose the most cost-effective opportunity to ensure the maintenance of their living standards. In Nigeria, coastal communities have less opportunity for cost-effective livelihood options and the present livelihood options are not satisfactory. For example, youth unemployment rate is more than 20%" [25] and "61% of the population is living without basic livelihood needs" [26]. Also, "ecosystem-based commodities, such as firewood, charcoal and crops, are often not captured with retail value, and hence, are not subject to market competition. Coastal livelihoods have evolved to be very dependent on natural resources. For example, 47% of the population depends directly on the fishing" [27]. Furthermore, "this dependence varies from village to village due to the variation in distribution of resources, family traditions, income efficiency and others" [28]. "Natural resource management efforts have highlighted the need for better understanding of the ecosystem dynamics" [29]. "However, poverty reduction programs often fail to take into account the dependency between poverty and natural resources that are supposed to enhance the livelihood strategies by unlocking the value of those ecosystems" [30,31]. "Rural coastal livelihoods in many areas of the south-eastern are complex, diversified, and undergoing change continuously. Historically, most coastal livelihood activities are related to fisheries and forestry (i.e., mangrove) sectors" [32,33]. "Thousands of coastal people struggle for daily survival and many of them are aware of the importance of ecosystem services to their everyday lives" [34].

Despite the extensive research conducted on mangrove ecosystem and their importance to coastal community, there remains a significant gap in understanding how varying environmental conditions, such as salinity and temperature fluctuations due to sea-level rise, affect the livelihood of coastal dwellers. There is less or no documentation on vulnerability of Coastal livelihood to sea level rise and effect of climate change in Eastern Niger Region of Nigeria. The main aim of this research is to assess the vulnerability of Coastal livelihood to sea level rise and effect of climate change in Eastern Niger Region of Nigeria.

2. MATERIALS AND METHODS

2.1 Study Area

This research span through the three major River Estuaries of the South-eastern Nigeria to include, as follows: Cross River Estuary as *Calabar Estuary include Ibaka and esuk nsidung,* Ibeno Estuary as Ibeno include Ukpenekang and Mkpanak while Iko River Estuary include Iko, Okoroette and *Uta ewa* with coordinate of the study area extent 4033′ N – 4050′ N; 7045′ E – 7055′ E and about 650m above sea level in the tropical mangrove forest belt east of the Niger Delta.

The tidal regime here is a semidiurnal and has a range of about 0.8m at neap tides and 2.20 m during spring tides with little fresh water input joined by tributaries [35], Extensive tidal mud flats and marshes define the areas adjacent to the channels. This area experience two seasons, the dry (October to March) and wet (April to September) with an annual rainfall averaging about 2500 mm [36]. The mean annual daily evaporation of the area is 4.6 mm per day [37], the hydrology of Eastern Obolo is affected by tides, although seasonal influences which are related to the climatic regime, are evident. Eastern Obolo is directly influenced by processes in the Atlantic coastal waters [1].

2.2 Study Design

The study made use of a survey research design, and it is designed as a tool to gain access to the study population. It helps to accurately extract required data on sea level rise and climate change impact on coastal livelihood from the fishermen / fisherwomen in the study area. These were done with the use of set of questions as contained in the questionnaire and also, directly focus on group discussions.

2.3 Types of Data

The types of data used in this study are a continuous data. They include;

i Data on fishing activities in the target studied area.
ii Data on the effect of surrounding alteration on fishing activities, socio-economic income and ecology of the Cross River Estuary.

iii Data on the awareness level of the respondent fishers to climate change in the area.
iv Data on the adaptation/coping strategy to climate change adopted by respondent fishers in the area.
v Data on the problems of adaptation to climate change by the fishermen/women in the area.

2.4 Data Collection Instruments

The main instruments used in this study were questionnaires and Focus Group Discussions. The questionnaire were first pre-tested with a small sample of fishers to detect ambiguities, poorly worded and unclear questions, choices and instructions this has been used by [38,39].

2.5 Assessing coastal livelihood across the sampling areas

This study was designed with emphasis on traditional resource of survival (livelihood) of the coastal dwellers in the area of interest with response to the effect of flooding events as a result of sea level rise. In effect, the focus was on seven (7) riverine communities within the three major River Estuaries of the South-eastern Nigeria with dense mangrove forest vegetation, as follows: *Ibaka, esuk nsidung,* Ukpenekang, Mkpanak Iko, Okoroette and *Uta ewa*.

The authors used a simple random sampling technique to select the seven communities. Firstly, using the Cochran's formula for determining the sample size, that is given below.

This help to point to the number of coastal dwellers to be administered with the questionnaire using the formular:

$$n = Z^2pq/ e^2$$

where:
n = sample size
Z = standard normal deviation at 95% confidence interval (which was 1.96)
P = proportion of target population (p = 0.77)
q = alternate proportion (q = 0.22)
e = desired level of precision (e = 0.05)
n = ((1.96)^2)(0.67*(0.22)) / (0.05)^2
n = 3.8416×0.15/0.0025
n = 0.576/0.0025
n = 230.5

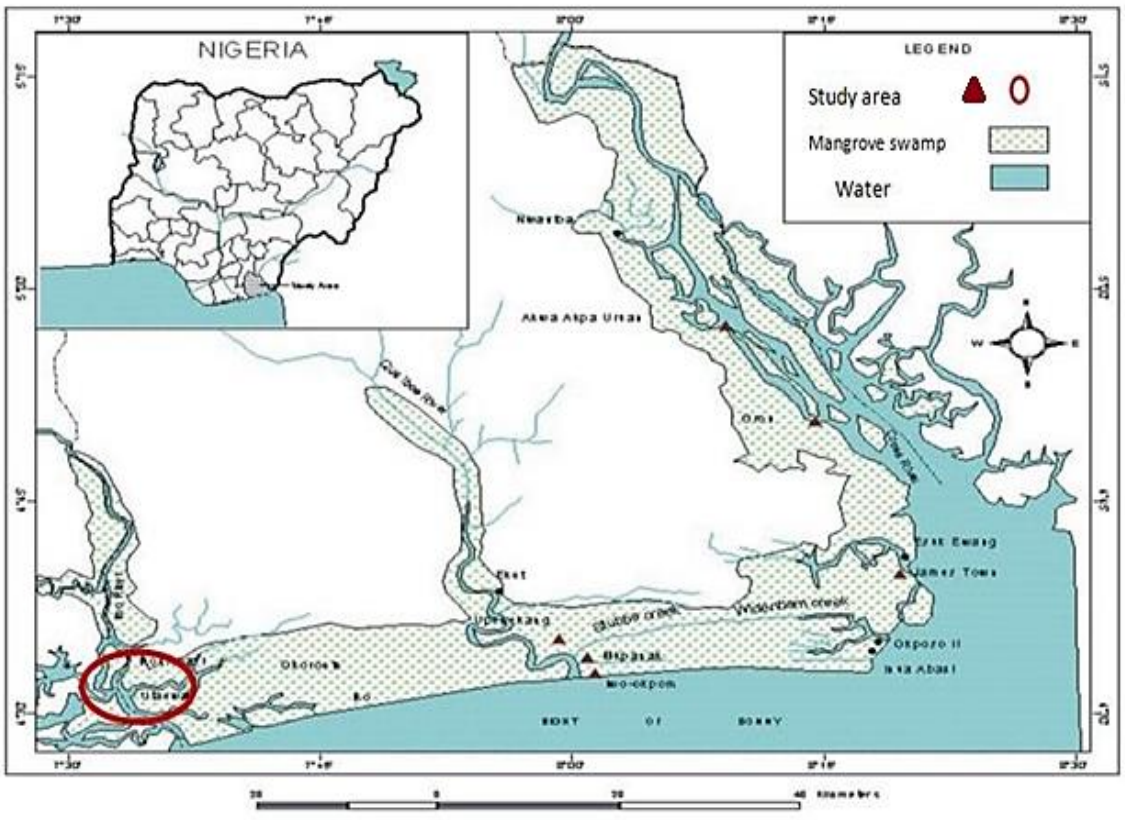

Fig. 1. Map of south-eastern Nigeria showing sampling location

2.6 Data Analysis

All data values were analysed and graphs plotted using Statistical package for Social Sciences (SPSS) version 20 for compute Mean, Mean Error, correlation andchi-square test. The probability level was set at p = 0.05.

3. RESULTS

3.1 Impact of Flood on the Livelihood of the Coastal Dwellers

3.1.1 Effect of flood fish productivity

The fish productivity in the area of interest was seen to be reducing as flooding event in the area increases. This was confirmed as the count and expected count of the respondent shows 80 (80%) of the total being increasing effect sea level rise while reducing effect of flood to fish productivity count and expected count is 20 (20%) (Table 1 and Fig. 2). For further confirmation of the effect of flood fish productivity and livelihood of the coastal dwellers, the effect on fish species distribution, fish stock, migrant fish, effect of flood on fishing as the only occupation, monthly income and household income were considered.

3.2 Effect of Flood on Fish Species Distribution

The effect of flooding event in the region as revealed by the coastal correspondents as shown in the Table 2 shows that there has been an increase effect of flooding sea water in their various fishing ground causing low and scanty species distributed within the fishing ground with 74(72.0%) of total correspondent ascertaining the increasing effect thereby reducing fish species at the fishing ground. This could be as a result of change in the environmental factors such as temperature, dissolved oxygen and salinity above their tolerant limit and change in the habitat and feeding ground, there has been a significance different of at ($p<0.05$) as seen in Table 3 and Fig. 3 between flooding and fish species distribution in the sampling areas of the southeastern Nigeria.

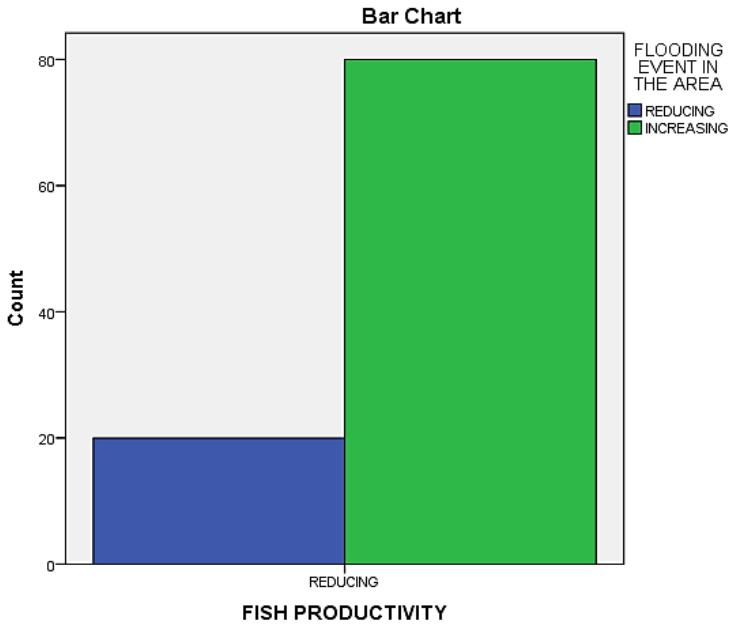

Fig. 2. flooding event and fish production

Table 1. Flooding Event in the Area and Fish Productivity

			Flooding Event in the Area		Total
			Reducing	Increasing	
Fish productivity	Reducing	Count	20	80	100
		Expected Count	20.0	80.0	100.0
Total		Count	20	80	100
		Expected Count	20.0	80.0	100.0

3.3 Effect of Flood on Fish Stock

Fish stock is the available fish that is present to enter into the fisheries or biological fish stock is a group of fish of the same species that live in the same geographic area and mix enough to breed with each other when mature. The effect of flooding event in the region as revealed by the coastal dwellers correspondents as shown in the Table 3, Fig. 4 shows that there has been an increasing effect of flooding sea water in their various fishing ground which could be responsible for the low and scanty fish stock in the fishery within the fishing ground with 80(80.0%) of total correspondent ascertaining the increasing effect thereby reducing fish species at the fishing ground. This could be as a result of change in the tidal current might and other environmental factors such as temperature, dissolved oxygen and salinity above their tolerant limit and change in the habitat and feeding ground, there has been a significance different at ($p<0.05$) as seen in Table 3 between flooding and fish species distribution in the sampling areas of the south-eastern Nigeria.

3.4 Impact of Flood on Migrant Fishes

The south-eastern Nigerian coastal waters have experienced increased migration of fish out of the fishing ground due to flooding. One elderly respondent disclosed this when he started fishing with his father, they had the whole estuary covered with mangroves, mostly *Rhizophora mangle* and *R. racemosa* [40] where their root was attached by whitish organism that fishes feed on, as a result, lots of fish migrate in to estuary to feed and spawn and then there was much fish to catch and make more money which enticed many coastal dwellers to venture into fishing and hence their sole occupation. But now, the whole estuarine mangrove is being replace Nypa palm. Also, the replacement of the true mangrove with Nipa palm reduces fish species abundance, fish stock and enhance the rapid change the ecosystem. Coupled with the changing ecological factors, causes the migration of fish 57(56%) out of the fishing ground as confirmed by the respondents in Tables 4,5,6. This also show a link between mangroves and species availability, stock availability and general livelihood of the coastal dwellers.

Table 2. Flooding Event in the Area and Fish Species Distribution

			Flooding Event in the Area		Total
			Reducing	Increasing	
Fish species distribution	Reducing	Count	16	74	90
		Expected Count	18.0	72.0	90.0
	Increasing	Count	4	6	10
		Expected Count	2.0	8.0	10.0
Total		Count	20	80	100
		Expected Count	20.0	80.0	100.0

Table 3. Chi-Square Tests: testing effect of flood on fish species distribution

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	2.778[a]	1	.096		
Continuity Correction[b]	1.563	1	.211		
Likelihood Ratio	2.379	1	.123		
Fisher's Exact Test				.110	.110
Linear-by-Linear Association	2.750	1	.097		
N of Valid Cases	100				

a. 1 cells (25.0%) have expected count less than 5. The minimum expected count is 2.00.
b. Computed only for a 2x2 table

Table 4. Flooding Event in the Area and Fish Stock

			Flooding Event in the Area		Total
			Reducing	Increasing	
Fish Stock	Reducing	Count	20	80	100
		Expected Count	20.0	80.0	100.0
Total		Count	20	80	100
		Expected Count	20.0	80.0	100.0

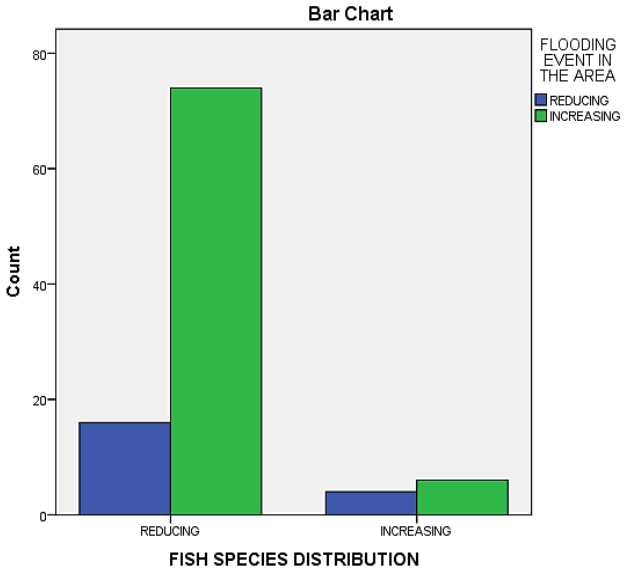

Fig. 3. Flooding event and fish species distribution

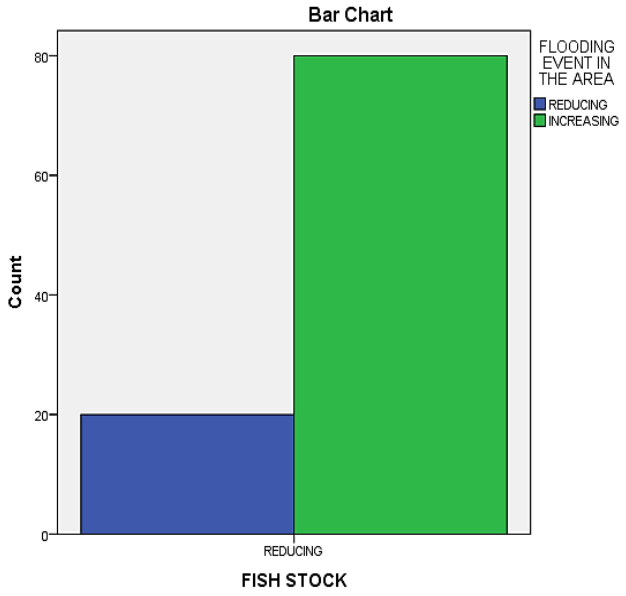

Fig. 4. Flooding event and fish stock

3.5 Effect of Flood on Fishing as the Only Occupation

The increase in sea level and consequential flooding of sea water into coastal waters of South-eastern Nigeria makes it difficult for the local fishermen to lunch deep during fishing, hence, creates unemployment, except those that have modern fishing boats/gears, high cost of fishing gears maintenance, acquisition of fuel and reduce fish stock with low monthly incomecould be the reason for diversifying occupation such as relative logging activities (30 count), boating and transportation business (35 count) and non-timber collection (15 count) by the coastal dwellers to make ends might Table 7. Also, some toggled between one occupation to another such as fishing only 88(88%), fishing and boating 5(5.0%), boating only 4(4.0%), company work 2(2.0%), company and boating 1(1.0%) Table 8.

Table 5. Flooding Event in the Area and Impact of Flood on Migrant Fishes

			Flooding event in the area		Total
			Reducing	Increasing	
Impact of Flood on Migrant Fishes	Migrant fish move out of community always	Count	13	57	70
		Expected Count	14.0	56.0	70.0
	Migrant fish move into of community always	Count	7	23	30
		Expected Count	6.0	24.0	30.0
Total		Count	20	80	100
		Expected Count	20.0	80.0	100.0

Table 6. Chi-Square Tests: testing effect of flood on migrant fish

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.298[a]	1	.585		
Continuity Correction[b]	.074	1	.785		
Likelihood Ratio	.291	1	.589		
Fisher's Exact Test				.594	.385
Linear-by-Linear Association	.295	1	.587		
N of Valid Cases	100				

[a]. 0 cells (.0%) have expected count less than 5. The minimum expected count is 6.00.

[b]. Computed only for a 2x2 table

Table 7. Flooding event in the area and Effect of flood on fishing as the only occupation

			Flooding event in the area		Total
			Reducing	Increasing	
Mpact of flood on fishing as the only occupation	Relative profitable of logging activities	Count	10	30	40
		Expected Count	8.0	32.0	40.0
	Involve in transportation business	Count	5	35	40
		Expected Count	8.0	32.0	40.0
	Involve in non-timber product collection	Count	5	15	20
		Expected Count	4.0	16.0	20.0
Total		Count	20	80	100
		Expected Count	20.0	80.0	100.0

Table 8. Chi-Square Tests: testing effect of flood on fishing as the only occupation

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.344[a]	2	.310
Likelihood Ratio	2.459	2	.292
Linear-by-Linear Association	.110	1	.740
N of Valid Cases	100		

[a] 1 cells (16.7%) have expected count less than 5. The minimum expected count is 4.00.

Table 9. Occupation of the Interviewee

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Fishing only	88	87.1	88.0	88.0
	Fishing and boating	5	5.0	5.0	93.0
	Boating only	4	4.0	4.0	97.0
	Company work	2	2.0	2.0	99.0
	Boating and company work	1	1.0	1.0	100.0
	Total	100	99.0	100.0	
Missing	System	1	1.0		
Total		101	100.0		

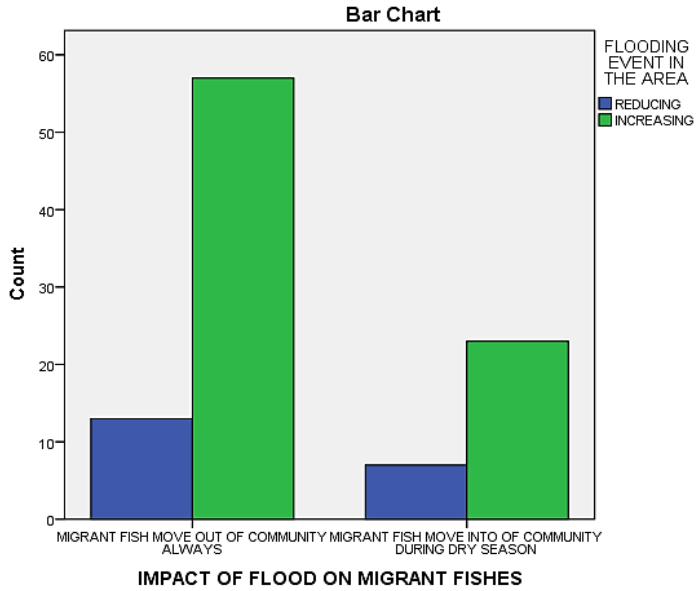

Fig. 5. Flooding event and fish migration

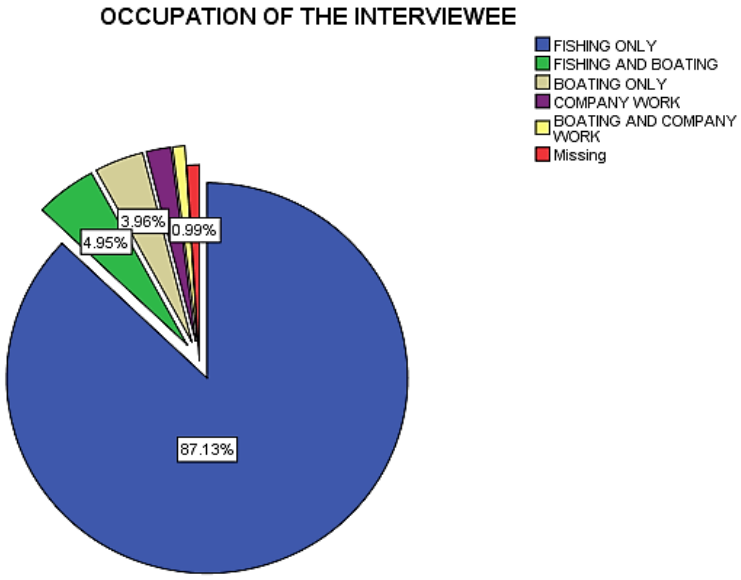

Fig. 6. The different occupational activities of the coastal dwellers in South-eastern Nigeria

3.6 Effect of Flood on Monthly Income of the coastal dwellers

Flooding was found to have a significant effect on the sea's water volume, quantity and quality of fish caught, family business and income. Where the quantity and quality of fish caught during fishing yielded much less as expected. As such one of the respondents revealed that sometimes he gets less the money put in to prepare a boat for fishing, for instance, the least money he prepares a boat for fishing is ₦ 10,000 including getting gasoline (fuel) but the fish caught may not be amount to ₦ 8, 000. Unlike when the forest where mainly mangroves and thick in their coverage, on normal fishing days, they will make gain more than ₦ 150, 000 and above per one time fishing. This is when the respondent calls good fishing days. From the field survey, fishermen with monthly income between 10,100 to 20,000 had the highest count of 39 respondents, followed by less than or

equals to ₦ 10,000 with 22 counts, next in line was ₦ 20,100 to 30,000 with 11 counts then finally, ₦ 30,100 to 40,000 with 9 count respondents (₦ local currency). The less and equal to ₦ 10,000 monthly income fishermen comprises of those with local fishing gears such as hook and line, basket for shell fish gatherers, wooden canoe, some with large families and young children involve in the fishing activities within the confine of the shores and inner creeks. While those with 10, 100 and above comprises of fishermen with motorized boats, gill net, other young fishers working to earn a living from their master's pay (Table 10; [63,64]).

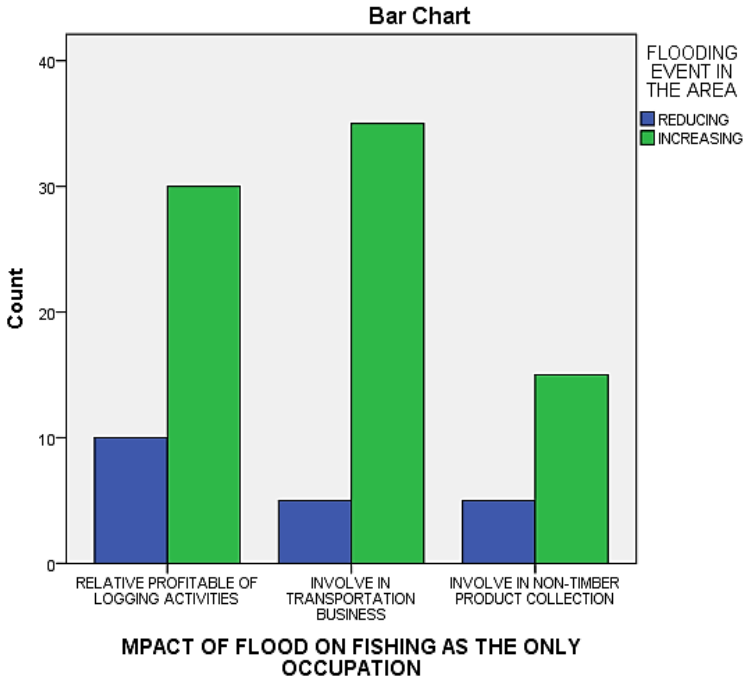

Fig. 7. Impact of flood on fishing as the only occupation

Table 10. Flooding Event in the Area and Monthly Income

			Flooding event in the area		Total
			Reducing	Increasing	
Monthly Income	BELOW 10,000	Count	5	22	27
		Expected Count	5.4	21.6	27.0
	10,100-20,000	Count	12	39	51
		Expected Count	10.2	40.8	51.0
	20,100-30,000	Count	2	11	13
		Expected Count	2.6	10.4	13.0
	30,100-40,000	Count	1	8	9
		Expected Count	1.8	7.2	9.0
Total		Count	20	80	100
		Expected Count	20.0	80.0	100.0

Table 11. Chi-Square Tests: testing effect of flood on monthly income of the coastal dwellers

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.052[a]	3	.789
Likelihood Ratio	1.114	3	.774
Linear-by-Linear Association	.264	1	.607
N of Valid Cases	100		

[a] 2 cells (25.0%) have expected count less than 5. The minimum expected count is 1.80.

Table 12. Symmetric Measurement of monthly income of the coastal dwellers

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Nominal by Nominal	Phi	.103			.789
	Cramer's V	.103			.789
Interval by Interval	Pearson's R	.052	.089	.512	.610[c]
Ordinal by Ordinal	Spearman Correlation	.036	.092	.355	.724[c]
N of Valid Cases		100			

[a] Not assuming the null hypothesis.
[b] Using the asymptotic standard error assuming the null hypothesis.
[c] Based on normal approximation.

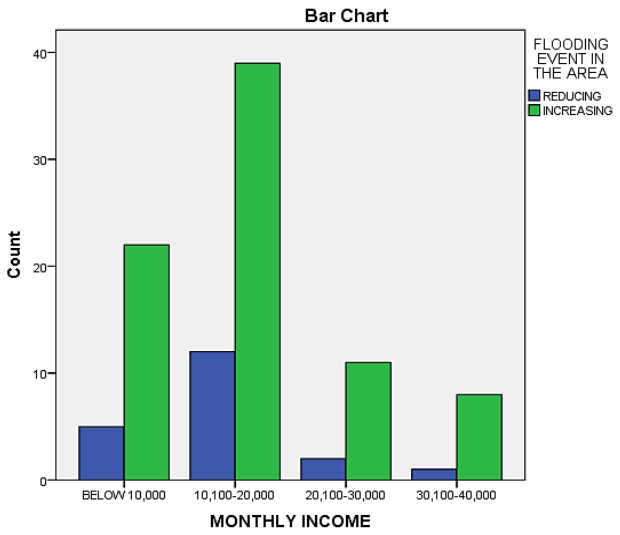

Fig. 8. Flooding event and Monthly Income

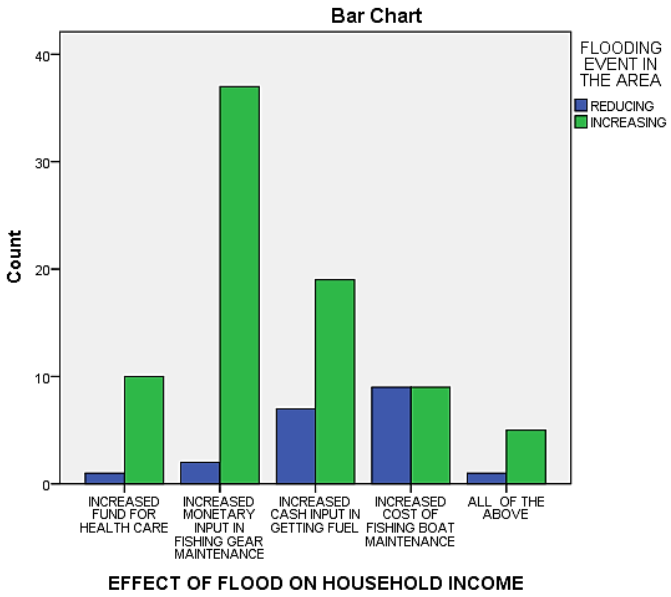

Fig. 9. Flooding event and Household income

Table 13. Flooding event in the area and Effect of Flood on Household Income and (b) Chi-Square Tests: testing effect of flood on household income

a			Flooding event in the area		Total
			Reducing	Increasing	
Effect of flood on household income	Increased fund for health care	Count	1	10	11
		Expected Count	2.2	8.8	11.0
	Increased monetary input in fishing gear maintenance	Count	2	37	39
		Expected Count	7.8	31.2	39.0
	Increased cash input in getting fuel	Count	7	19	26
		Expected Count	5.2	20.8	26.0
	Increased cost of fishing boat maintenance	Count	9	9	18
		Expected Count	3.6	14.4	18.0
	All of the above	Count	1	5	6
		Expected Count	1.2	4.8	6.0
Total		Count	20	80	100
		Expected Count	20.0	80.0	100.0

b	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	17.155[a]	4	.002
Likelihood Ratio	16.952	4	.002
Linear-by-Linear Association	7.030	1	.008
N of Valid Cases	100		

[a]. 4 cells (40.0%) have expected count less than 5. The minimum expected count is 1.20.

3.7 Effect of Flood on Household Income

Majority of the fishermen encountered loss due to flooding. The loss included destruction of the fishing gears resulting to increased monetary input in fishing gear maintenance (37 collected respondent), Increased cash input in getting fuel (19 collected respondent), Increased cost of fishing boat maintenance (9 collected respondent). Due to reduction in fish catches and monthly income, consequently family income. Other than the above mentioned, flooding causes high incidences of malaria infection and infection to water borne diseases resulting to increased fund for health care (10 collected respondent). Hence, the need for additional source of income

4. DISCUSSION

4.1 Fish Productivity

The expansion of coastal populations, economic activity and settlement growth in developing countries has resulted in growing pressures on coastal and near-shore ecosystems, such as mangroves, marsh, coral reefs, oyster reefs, seagrass beds and barrier islands in general [41,42,43,44,45,46]. As these ecosystems disappear or are degraded, there will be less protection against short-lived natural disasters with immediate and often extreme impacts, such as flooding, as well as long-term climatic changes with more gradual impacts, such as sea-level rise, saline intrusion and erosion [47,42,48,50,51]. In addition, the changes in precipitation, temperature and hydrology accompanying climate change are likely to threaten remaining coastal and near-shore ecosystems [52,53,54,49,50,55]

Fish production in south-eastern Nigeria in no doubt has faced a lot of anthropogenic and environmental stresses. However, there is strong global evidence for these effects. Rising ocean temperatures [56] is radically altering marine aquatic ecosystems, while freshwater ecosystems are being impacted by changes in water temperature, water flow, and fish habitat loss (*USEPA, 2015*). Climate change is modifying fish distribution [57] and the productivity of marine and freshwater species. Coupled with the fishing gears, the fishermen (artisanal fishermen) use artisanal gear, such as hook and line, seine or gillnets, are more likely to select specific species or size classes [58,59]. During this survey, it was observed that the effect of flood on fish production in south-eastern Nigeria was on the increasing (80% at risk) (Fig. 2) with reduction in total fish catch, causing reduction in species distribution to 74% with significant difference of both single and double sided of 0.110 (Table 3), reduction in fish stock to

approximately 80% (Table 4, Fig. 4), also causing fish migration out of the fishing ground to about 57% with significant difference of both single and double sided of 0.385 and 0.594 respectively, (Table 5 and 6).The occupation of the coastal dwellers in the study area was also affected. For this reason, coastal communities are changing their livelihood activities at different time periods, which make their income uncertain and insecure. For instant, Table 7 shows the effect of flood on fishing activity as the only occupation where most of the fishermen now turn their fishing boat (motorized boat) into transportation business, some show interest in relative profitable logging activity while some embrace non-timber product to enhance standard of living. In this study area, the primary occupation of households surveyed is fishing (64%), followed by forestry (mangrove resource) (26%) and daily wage laborer (10%); [60,61], with significant difference of 0.310 (2-sided), livelihood ratio of 0.292 and linear by linear association of 0.740 (Table 8). The monthly income stood at 10,100-20,000 > below 10,000 > 20,100-30,000 > 30,100-40,000 and above, with significant difference of 0.789 (2-sided), livelihood ratio of 0.774 and linear by linear association of 0.607 (Table 12). the household income is faced with lots of responsibilities such as health care funding, fishing gear maintenance, getting gas (fuel), fishing boat maintenance and others, as such, when analyzed, it was seen that more income was spent on maintenance of fishing gear, getting gasoline and health care with significant difference of 0.002 (2-sided), livelihood ratio of 0.002 and linear by linear association of 0.008 (Table 13 and Fig. 8). The household significant level support the fact that changing coastal environment as a result of flood due to sea level rise affect the livelihood of the coastal dweller which in turn affect their monthly household income (Fig. 9). Hence the need for diversified source of livelihood as also was reported by [19,62].

5. CONCLUSION

This survey presents a case study of household dwellers in coastal community of the south-eastern of Nigeria whose lives depend only on fishing but now a variety of income-generating activities for sustainability. Many of the coastal dwellers depend on forest resources (mangrove wetland) and fishing, which are at risk from the disruptions and losses caused by flood as a result of sea-level rise and other coastal hazards, such as coastal erosion and saltwater intrusion. However, the traditional coastal livelihood portfolio has been rearranged due to environmental change, infrastructural developments and introduction of new occupational sectors, where current coastal livelihood activities are no longer economically, environmentally and socially viable and need to be replaced with alternatives. For this reason, coastal communities are changing their livelihood activities at different time periods, which make their income uncertain and insecure. the effect of flood on fishing activity as the only occupation where most of the fishermen now turn their fishing boat (motorized boat) into transportation business, some show interest in relative profitable logging activity while some embrace non-timber product to enhance standard of living. If a coastal rural household has different options, they choose the most cost-effective opportunity to ensure the maintenance of their living standards. In the south-eastern where this study was carried out, coastal communities have less opportunity for cost-effective livelihood options and the present livelihood options are not satisfactory. For example, change in spawning and feeding ground of fishes in the study area, fish production, fish species diversity, fish stock drastically reduced thereby creating a toll on the fishermen's monthly income and household income. In order to meet up with life demands, occupation diversity was seen as an option where fishermen involving in transportation business, relative profitable of logging activities, involve in non-timber product collection as well as engage in laborer work in an establishment/company is on the increasing. Also, ecosystem-based commodities, such as firewood, charcoal and crops, are often not captured, with retail value, and hence, are not subject to market competition. These surveys of coastal households confirm this diversified livelihood strategy. In this study area, the most dominant primary occupation of households surveyed is fishing (64%), followed by forestry (mangrove resource) (26%) and daily wage laborer (10%).

Therefore, this research findings showed that the majority fishermen are mainly family owners and they incorporate their young once in the fishing business which consequently can be deduced that they have the potential to develop, sustain and run the fishery. However, flooding as a result of sea-level rise and other coastal hazards, such as coastal erosion and saltwater intrusion is currently a major threat to the fishermen's livelihoods especially the resultant decline in

mangrove abundance and diversity, fish catches which then threaten family income and the prevalence of water borne diseases.

6. RECOMMENDATION

Despite the many valuable ecosystem services, mangroves have been lost around the world at an alarming rate. Mangroves have been lost to conversion for aquaculture, cutting for charcoal production, or development of shorelines including the rate of wetland decline over the last few decades. Coupled with sea level rise influence, flooding and inundating the coastal wetland, in no distant time, the whole ecosystem may be erased due to human and climatic pressure. Hence, resource management is critical, particularly in South-eastern Nigeria where many people both coastal dwellers and those in the hinterlands are reliant on natural resources for their livelihood

1. Therefore, the importance of managing the coasts in a comprehensive and flexible manner, with regard to the need to better conserve natural habitats, while at the same time maximizing the socio-economic and cultural benefits that mankind derives from them can be achieved.
   However, by depending on a single enterprise (such as fishing), households will still have insoluble problems of declining sustainability/livelihood.
2. Thus, to reduce threats to current livelihoods there is a need for a collaborative approach to enhance the livelihood security. This is because the collaborative approach provides environmental protection, new market chains for enhancing income and a social safety net for households.
3. Also, Fishermen and women in these areas should be encouraged by way of training and provision of modern fishing equipment as to meet up the demands for fish and improve their own economy.
   Strategy for protecting coastal populations, especially the vulnerable coastal communities in south-eastern Nigeria, should have two objectives: (i) protecting coastlines and populations from risks posed by damaging flood as a result of sea-level rise and other coastal hazards, such as coastal erosion and saltwater intrusion and (ii) restoring valuable coastal systems - such as mangroves.
4. Comprehensive plans to reduce coastal vulnerability should also include key infrastructure investments - such as seawalls, dikes, barrages, and diversions – and improved institutional and coastal community response capability.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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