# Analysis of Factors influencing Vulnerability of Fishing Systems to Climate Change among Artisanal Fisher-folks in Coastal area of Lagos, Nigeria

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## Abstract

Climate change poses serious challenges to the sustainability of fisheries and aquaculture systems, with severe implications for the majority people who depend on them largely for their livelihoods. Therefore, this study investigates factors influencing the vulnerability of fishing activities to climate change among artisanal fisher-folks in coastal area of Lagos, Nigeria. A three-stage random sampling technique was used to select 342 artisanal fishers from the study area. Data were collected with the aid of structured questionnaire and subjected to factor analysis and descriptive statistics. The results of data analysis revealed that artisanal fishers are vulnerable to external shocks (climate change) due to their high reliance on fishing activities with occupational pluralism being considered as risk-reduction mechanism. Factor analysis revealed that socioeconomic, occupational activities, social cohesion/organization, and market opportunities and biodiversity conservation policy factors among fishers, with Eigen values of 2.2532, 1.5713, 1.3314, and 1.1024 respectively, accounted for their vulnerability to change in climate. The study recommends proper sensitization and capacity building among the coastal fishers on the threats of climate change to their fishing activities. There is also a need for devising adaptation strategies to minimize their vulnerabilities to the effects of adverse weather conditions over resources abundance and availability.

**Keywords:** Artisanal fisher-folk, Climate change, Coastal communities, Vulnerability index, Factor analysis

## INTRODUCTION

Agriculture is at the core of environmental vulnerability and concerns the management of natural resources, such as land degradation, water scarcity, deforestation, and the threat to biodiversity. Climate change could cause irreversible damage to land and water ecosystems, and lead to loss of production potential. Stresses as a result of climate change will compound existing pressure on fisheries and aquaculture and threaten their capacity to provide food and livelihoods. Worldwide, fish products provide 15% or more of the protein consumed by nearly 3 billion people and support the livelihoods of 520 million people, many of them women (FAO 2009, The WorldFish Center, 2008). The impacts of climate change can be direct, including changes to wind, temperature and other climatic variables that affect stratification and circulation of water. This would therefore affect productivity and abundance of various species (e.g., Cheung *et al.,* 2010). Rise in sea level and increased extreme weather events can damage coastal habitats, including mangroves that are important for fish breeding and shelter. Extreme weather can also disrupt fishing patterns and damage landing sites, which affects the livelihoods of coastal communities (Katikiro and Macusi, 2012). The fishing systems are affected by a range of factors apart from climate change, including overfishing, pollution and eutrophication could lead to similar effects, and it may be difficult to ascertain the causes. A crucial climate issue involves factors that affect the upwelling processes off the coast that can strongly affect nutrients and food supplies for fish, so that fish stocks along the coast of West Africa are affected (Katikiro and Macusi, 2012). Fluctuations in fish catch are linked to changes in upwelling, rainfall, recruitment and migration of fish. The decline in coastal fisheries means that coastal fishing communities are having much lower harvests for the small pelagic species that are critical for their livelihoods (CRC, 2013). Poor governance and open access without controls on fishing effort has led to a boom in the numbers of both artisanal and semi-industrial fishing vessels, causing overfishing.

Coastal fishing communities are vulnerable to multiple stressors including climate change. They face a spectrum of impacts due to flooding caused by storm surge and future sea level rise. Social and cultural factors increase the complexity of these issues, potentially hindering institutional capacity to effectively adapt (Belmont, 2016). Many coastal shorelines will be eroded while low-lying areas will tend to be flooded more frequently or permanently, by the rising sea level. The fisheries sector and fisher folk may be impacted by change in climate in a wide range of ways. The distribution or productivity of marine and fresh water fish stocks might be affected owing to the processes such as ocean acidification, habitat damage, changes in oceanography, disruption to precipitation and fresh water availability (Daw *et al*., 2009). Accelerated sea level rise (SLR) represents a significant planning and management challenge to coastal nations, especially in the coast of west Africa countries where vulnerability is high, adaptation options are limited, and spatial data and information are limited for planning purposes (Brown *et al*., 2014). Sea level rise has already resulted in increased erosion and inundation of vulnerable areas, threatening both lives of people who inhabit coastal environments and property as well as marine resources. Many capture fisheries worldwide have declined sharply in recent decades or have already collapsed from overfishing, and major fishing grounds are concentrated in zones threatened by pollution, the mismanagement of freshwater, and habitat and coastal zone modification. According to Brander (2010) approximately 20 to 30 percent of fish species may be at increased risk of extinction if increases in average global warming exceed 1.5–2.5°C. Aquaculture needs to expand sustainably to fill supply shortfalls as demand for fish for human consumption continues to rise but, even more than fisheries; aquaculture is concentrated in areas with intense competition for environmental services. Sustaining fishing systems in the face of these challenges, and ensuring that they contribute to development as effectively as possible, will be more difficult as the climate changes.

In Nigeria quite a sizeable proportion of the population depends on fishing as a source of livelihood income. This demand for fish in Nigeria stands at about 1.5 million metric tonnes per annum while domestic production is just 511,700 metric tonnes. The nation spends about N150 billion (US$1billion) annually to bridge the gap between supply and demand (CBN, 2011). In recent times, the sustainability of Nigeria fishery subsector has been an integral part of the nation's development programmes in other to achieve the vision 20-20-20 food-for-all agenda. But, of the major challenges facing rural development especially coastal fishing communities is the continuous depletion of natural resources. This depletion has been linked to several factors including climate change. The loss of coastal habitats and resources is likely through sea level rise, warming sea temperatures, extremes of nutrient enrichment and invasive species. Coastal fishing communities are likely to face a double exposure of reduced fisheries resources, increased risks of and vulnerability to coastal flooding and storm surges.

Climate change not only influence the fishing directly by affecting various physiological process, developmental rates, reproduction, behavior and survival of individual but also affects indirectly by altering ecosystem, food availability, prey-predator relationship (Brander, 2010) . Also, recent studies have been forecasted about the imminent future where the capture fisheries will get severely affected by climate change and thus affecting the national economics (Allison *et al.,* 2009). These findings provide insightful perceptive for vulnerability assessment of fisheries ecosystem which supports livelihood of over a half a billion people (Allison *et al.,* 2009 and FAO, 2010).

The vulnerability of fishery- and aquaculture dependent communities and regions to climate change is complex, reflecting a combination of three key factors: the exposure of a particular system to climate change, the degree of sensitivity to climate impacts, and the adaptive capacity of the group or society experiencing those impacts. Vulnerability of coastal populations and ecosystems is a multi-concept which includes *hazard exposure, sensitivity* (the magnitude of losses that potentially result from exposure to the hazard) and *adaptive capacity*, or the capacity to respond to impacts and prepare ahead of them, through coping strategies and long-term adaptation to a certain threat (Füssel, 2007). Exposure to these threats is directly linked to the position of human settlements and ecosystems on which they depend in relation to the sea and to regions prone to the occurrence of sea-level rise and extreme weather events (Smit & Wandel 2006). Sensitivity, often treated as equivalent to exposure, depends on the number of people, the infrastructure and the extension of ecosystems exposed to the hazard, and on the level of dependency on natural resources of the considered population (Tuler *et al.* 2008). Adaptive capacity depends, in the case of human populations, on a series of factors linked to access to assets. Adaptation planning to address the impacts of global change is becoming increasingly common, yet lacks consistency in framing, methods and assumptions. These contradictions and contrasts often lead to maladaptation. However, vulnerability varies greatly across production systems, households, communities, nations and regions. It is influenced by changing demographics, the degree of market globalization and emerging agricultural development policy. Poor and marginalized groups, including women, are likely to be the most vulnerable because climate change will likely exacerbate the unequal access to natural resources, productive assets, information and technology that already exists.

Over the years, several studies conducted indicate that Nigeria's is very vulnerable to climate change impacts and particularly sea level rise, flooding, inundation and coastal erosion. Vulnerability indicators of topography, coastal slope, relative sea level rise, annual shoreline erosion rate, mean tidal gauge, population density and proximity to the coast testify to the vulnerabilities of coastal communities and population in the past, presently and into the future (Rosmorduc, 2012; Musa, *et al*., 2014; Oyegun, *et al*., 2016). Many of the settlements are exposed to shoreline dynamics owing to distance from the shoreline. For now, affected communities have developed some ingenuous local strategies to fight their problems. The common adaptation techniques employed include: i) use of *Sand Bags* along the shore; ii) river embankments; iii) construction of canals and channels; iv) building of dwellings on stilts/raised platforms to prevent homes from being washed away by flood and rising sea water; and v) government interventions in form of construction of engineered walls/shore protection embankments.

The artisanal fishers cover the operations of small-scale canoes, fisheries operating in the coastal areas, creeks, lagoons, inshore water and the inland rivers. The artisanal fishery is characterized by low capital outlay, low operational costs, low technology application and it is labor intensive (Bolarinwa, 2014). These fishers and their host communities have had effective coping strategies in response to the natural fluctuations in upwelling dynamics. These include more intensive exploitation of natural resources, diversifying income sources, investing in supportive social networks and seasonal or permanent migration (Perry and Sumaila, 2007). Several policy measures have been put in place by successful government in the country to stimulate local fish farming. Till date, the results from the colossal investment and policy have not yielded the desired results. It is therefore imperative to assess the factors influencing the vulnerability of coastal fishers and their immediate communities to climate change in coastal areas of Lagos State, Nigeria. The specific objectives are to:

a. describe the socioeconomic profile of the artisanal fishers in the study area;
b. investigate the vulnerability of the artisanal fishers to climate change;
c. ascertain the adaptive capacity employed by artisanal fishers to ameliorate their vulnerability to climate change; and
d. determine the factors associated with their vulnerability to climate change in the study area.

**Concept of Vulnerability**

Vulnerability to climate change is made up of a number of components including exposure to impacts, sensitivity, and the capacity to adapt. Vulnerability has been defined differently in the various scientific areas in which it has been used (Füssel, 2010). The Intergovernmental Panel on Climate Change (IPCC, 2007) defnes vulnerability as the extent to which a natural or social system is susceptible to sustaining damage from climate change. Vulnerability is a function of the sensitivity of a system to changes in climate and the system's ability to adapt to these changes. Vulnerability analysis provides a good tool to study and understand the impacts of climate change on fishers' livelihood. It is necessary to study the physical and human conditions that could create vulnerability to climate change. The vulnerability of coastal communities to climate change is usually characterized by their exposure to environmental hazardous events and how this affects people and structures; the second views vulnerability in terms of human relationships rather than as physical, i.e. social vulnerability; and the third integrates the physical event and the underlying characteristics of populations that lead to risk exposure and limited capacity of communities to respond. Coastal communities in sub-Saharan Africa are characterized of high populations with extensive concentration of residential, industrial, commercial and other human activities. Their proximity to the ocean has exposed the coastal dweller to effects of climate change which include sea-level rise and floods arising from increasing frequency of storm surges, increased frequency and intensity of extreme weather events, saltwater intrusion and heavy rainfall of long duration or high intensity. Therefore, assessing the vulnerability of artisanal fishers and coastal fishing communities will help in identifying and characterizing timely actions to be taken in order to combat with the negative impacts of climate change, and will help in successful implementation of various climate resilient policies by raising awareness, mitigation, and adaptation options.

**METHODOLOGY**

**T**he study was carried out in coastal areas of Lagos State, Nigeria. Lagos is situated within latitudes $6^0$ 23′N and $6^0$ 41′N and longitudes $2^0$ 42′E and $3^0$ 42′E. It is bordered on the west by the Republic of Benin and in the south and stretches for 180 km along the coast of the Atlantic Ocean. It therefore has 22.5% of Nigeria's coastline and occupies an area of 3,577 sq. km landmass with 786.94 sq. km. (22%) of it being lagoons and creeks in Lagos, Ikorodu, Badagry and Epe. There is a large concentration of mangrove and fresh water swamps. The area is subject to tidal fluctuations' with salt water incursion, between two to ten months of the year. The State is endowed with marine; brackish and fresh water ecological zones with varying fish species that provide productive fishing opportunity for fishermen. The primary occupation of people in the study area is mainly fishing with dredging. Fishery activities are concentrated in the coastal areas of Epe, Ibeju-Lekki, Eti-osa and, Badagry.

A two-stage sampling technique was used to select respondents for the study. In the first stage purposive sampling was used to select four Local Government areas from the coastal axis of the study area. The second stage involved the selection of the respondents from the sample frame (2,349) of artisanal fishers obtained from State Agricultural Development Programme. And finally, the sample size was calculated based on Fisher *et al.* (2007) as shown below. According to Fisher *et al.* (2007), at 95% confidence level and 50% target population of artisanal fishers randomly selected from each of the coastal communities and assumed to have characteristics of interest with a Z-statistic of 1.96, sample size was calculated using the following formula:

$$n = {}^{N}\!/_{[1 + (Ne^2)]}$$

Where $n$= desired sample size

$N$=population sample

$e$= error level or percent confidence interval or alpha level (0.05)

For 0.95 confidence interval, e=0.05; putting all values in Yamane's formula

$$n = {}^{2349}\!/_{[1 + (2349x0.05^2)]}$$

$$n = 342$$

Thus, a total number of 342 artisanal fishers were eventually selected for the study. Data were collected with the aid of structured questionnaire on socioeconomic characteristics of artisanal fishers, perception of respondents and vulnerability to climate change and factors associated with vulnerability in the study area. The collected data were subjected to both descriptive and inferential statistics such as frequency counts, percentages, charts and mean, vulnerability and factor analyses.

**Measurement of variables**

The adaptive capacity employed used by artisanal fishers in coastal communities of the study area was measured using, a list of known variables of possible adaptation strategies on fishing along the coastal line was provided. The artisanal fishers were asked to rate specific adaptive capacity on a 5-point Likert scale involving statement relating to possible adaptation strategies. The values on the scale were summed together and divided by 5 to obtain the cut-off mean value of 3. Variables with a mean score value ≥ 3 are considered to be as high, while variables with a mean score below 3 were regarded as low.

**Climate Vulnerability Analysis**

To determine the vulnerability of artisanal fishers and their host communities to climate change, climate vulnerability index analysis was adopted for this study. Also, knowing that vulnerability of a certain coastal community or system has an exogenous, biophysical dimension, as well as an internal, socio-economic dimension, we opted to construct a vulnerability index based on the IPCC definition of vulnerability using the indicators approach to assess socio-economic and biophysical factors contributing to vulnerability. Going by IPCC definition of vulnerability, vulnerability to climate change and variability is represented by three elements: exposure, sensitivity, and adaptive capacity (IPCC, 2001). According to the framework proposed by Füssel and Klein (2006) exposure and sensitivity together compose the potential impact, while adaptive capacity is the potential of a system to cope with these impacts. Thus, vulnerability can be expressed with the following mathematical equation (Equation (1)):

$$V = f(PI - AC) \dots\dots\dots\dots\dots\dots\dots.(1)$$

where $V$ =vulnerability,

$PI$= potential impact, and

$AC$= adaptive capacity.

Therefore, vulnerability can be defined as a function of biophysical and social indicators, which constitute the three components of vulnerability. For each component of vulnerability, the collected data are then arranged in the form of a rectangular matrix with rows representing coastal communities and columns representing indicators. The description is illustrated in the table below.

**Table 1: Illustration of arrangement of data in statistical analysis**

| Coastal communities | Vulnerability Indicators | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | - | - | K |
| Eti-osa | $X_{1j}$ | $X_{2j}$ | - | - | $X_{ijk}$ |
| Ibeju-Lekki | $X_{ij1}$ | $X_{ij2}$ | - | - | $X_{ijk}$ |
| Epe | $X_{ij1}$ | $X_{ij2}$ | - | - | $X_{ijk}$ |
| Badagry | $X_{ij1}$ | $X_{ij2}$ | - | - | $X_{ijk}$ |

For this study, the adaptive indicators assessed have negative or inverse relationship with vulnerability. The actual values of the adaptive indicators are in different units and scales. Therefore, to generate the vulnerability indices on each of the indicators investigated, the methodology used by (UNDP, 2006) and for assessing Human Development Index and adopted by Amusa, Okoye and Enete (2015) was followed to normalize and standardize the values to lie between 0 and 1. Before doing this, it is important to identify the functional relationship between the indicators and vulnerability. Two types of functional relationship are possible: vulnerability increases with increase (decrease) in the value of the indicator. Assume that higher the value of the indicator more is the vulnerability.

$$yij = \frac{Max\{X_{ij}\} - X_{ij}}{Max\{X_{ij}\} - Min\{X_{ij}\}} \dots\dots\dots\dots\dots\dots .(2)$$

where $Xij$ = value of the vulnerability indicator for the individual fisher for $x$ indicator

*Max* & *Min* = maximum and minimum values of indicators respectively for the variables of interest.

When equal weights are obtained for the vulnerability indicators, simple average of all the normalized scores is then computed to construct the vulnerability index using:

$$VI = \frac{\sum_j x_{ij} + \sum_j y_{ij}}{K} \dots\dots\dots\dots\dots\dots\dots .(3)$$

Where $VI$= vulnerability indicator

$K$= number of indicator used

Finally, after normalization of score, the average index for the sources of vulnerability is determined to compute overall vulnerability index for the study and therefore vulnerability indices are used to rank the different coastal communities in terms of vulnerability. The vulnerability index so computed lies between 0 and 1, with 1 indicating maximum vulnerability and 0 indicating no vulnerability at all. For instance, a coastal community with highest index is said to be most vulnerable and it is given the rank 1, the region with next highest index is assigned rank 2 and so on. For the purpose of this study ten (10) variables were considered for vulnerability indicators and were used to assess the adaptive capacity of artisanal fishers in four coastal communities of the study area. They include: level of education ($X_1$), ownership of canoe/boat ($X_2$), monthly income ($X_3$), household size ($X_4$), fishing experience ($X_5$), access to labour ($X_6$), access to fishing gears ($X_7$), catches per day ($X_8$), extension contact ($X_9$) and membership of cooperative society ($X_{10}$)

**Use of Factor Analysis**

Factor analysis is used to identify latent constructs or factors. According to Chua (2009) suggested that factor analysis is the procedure which always been used by the researchers to organize, identify and minimize big items from the questionnaire to certain constructs under one dependent variable in a research. It is commonly used to reduce variables into a smaller set to save time and facilitate easier interpretations. To perform a factor analysis, there has to be univariate and multivariate normality within the data (Child, 2006). It is also important that there is an absence of univariate and multivariate outliers (Field, 2009). Also, a determining factor is based on the assumption that there is a linear relationship between the factors and the variables when computing the correlations. For something to be labeled as a factor it should have at least 3 variables, although this depends on the design of the study (Tabachnick & Fidell, 2007). As a general guide, rotated factors that have 2 or fewer variables should be interpreted with caution. A factor with 2 variables is only considered reliable when the variables are highly correlated with each another ($r$ > .70) but fairly uncorrelated with other variables. The recommended sample size is at least 300 participants, and the variables that are subjected to factor analysis each should have at least 5 to 10 observations (Comrey & Lee, 1992). For this study there are several factors that were subjected to oblique rotation so as to ensure that all the variables are ascribed to a particular factor and none is allocated to two or more factors.

Factors are rotated for better interpretation since unrotated factors are ambiguous. There are many extraction techniques such as Principal Axis Factor and Maximum Likelihood. Factor analysis is mathematically complex and the criteria used to determine the number and significance of factors are vast. There are two types of rotation techniques – orthogonal rotation and oblique rotation. Orthogonal rotation (e.g., Varimax and Quartimax) involves uncorrelated factors whereas oblique rotation (e.g., Direct Oblimin and Promax) involves correlated factors. The interpretation of factor analysis is based on rotated factor loadings, rotated eigen values, and scree test. In reality, researchers often use more than one extraction and rotation technique based on pragmatic reasoning rather than theoretical reasoning. The data used for the analysis were measured at interval level of 5-point Likert-type scale for all the possible variables observed.

The factor analysis model as stated by Johnson and Wichern in (2002) is:

$$X_1 - \mu_1 = \ell_{11} F_1 + \ell_{12} F_2 + \dots + \ell_{1m} F_m + \varepsilon_1$$

$$X_2 - \mu_2 = \ell_{21} F_1 + \ell_{22} F_2 + \ldots + \ell_{2m} F_m + \varepsilon_2$$

$$\vdots \qquad\qquad\qquad\qquad \vdots \cdots\cdots\cdots\cdots (4)$$

$$X_p - \mu_p = \ell_{p1} F_1 + \ell_{p2} F_p + \ldots + \ell_{pm} F_m + \varepsilon_p$$

Johnson and Wichern in (2002) stated the orthogonal factor model with $m$ common factors as follows:

$$\underset{(pX_1)}{X} = \underset{(pX_1)}{\mu} + \underset{(pX_m)}{L} \underset{(_{pm}X_m)}{F} + \underset{(pX_1)}{\varepsilon} \cdots\cdots\cdots\cdots\cdots\cdots (5)$$

Where: $\mu i$ = mean of variable $i$

$\varepsilon_i = ith\ specific\ factor$

$F_j = jth\ common\ factor$

$\ell_{ij} = loading\ of\ the\ ith\ variable\ on\ the\ jth\ factor$

Johnson and Wichern in (2002) also estimated the communalities as

$$\tilde{h}_i^{\,2} = \tilde{\ell}_{i1}^{\,2} + \tilde{\ell}_{i2}^{\,2} + \cdots + \tilde{\ell}_{im}^{\,2} \cdots\cdots\cdots\cdots\cdots\cdots (6)$$

The principal component factor analysis of the sample covariance matrix S is specified in terms of its eigen value-eigenvector pairs ( $\hat{\lambda}_1, \hat{e}_1$), ( $\hat{\lambda}_2, \hat{e}_2$), $\cdots$ , ( $\hat{\lambda}_p, \hat{e}_p$), where ( $\hat{\lambda}_1 \geq \hat{\lambda}_2 \geq \cdots \geq \hat{\lambda}_p$). Let $m < p$ be the number of common factors. Then the matrix of estimated factor loadings

$\{\tilde{\ell}_{ij}\}$ is given by

$$L = \left[\sqrt{\hat{\lambda}_1}\hat{e}_1 \vdots \sqrt{\hat{\lambda}_2}\hat{e}_2 \vdots \cdots \vdots \sqrt{\hat{\lambda}_m}\hat{e}_m\right] \cdots\cdots\cdots\cdots (7)$$

And finally, Johnson and Wichern (2002) stated that the estimated specific variances are provided by the diagonal elements of the matrix $S - \tilde{L}\tilde{L}'$, so

$$\tilde{\psi} = \begin{bmatrix} \tilde{\psi}_1 & 0 & \cdots & 0 \\ 0 & \tilde{\psi}_1 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \widetilde{\psi_p} \end{bmatrix} with\ \tilde{\psi}_1 = S_{ij} - \sum_{j=1}^{m} \tilde{\ell}_{ij}^{\,2} \cdots\cdots\cdots (8)$$

## RESULTS AND DISCUSSION

### *Socioeconomic characteristics of respondents*

The results in Table 2 present some socioeconomic characteristics of respondents in the study area. Results revealed that the mean age of respondents was 45.4years with most fell within the age bracket 41-50years. This implies that the artisanal fishers are still within their active and productive age. Also, the mean household size was 8 persons per household with majority of the household were between 6 – 10 persons. This finding corroborates the work of Okeowo, Bolarinwa and Dauda (2014) who observed similar large family size among artisanal fishers in Lagos State. The implication of relative large household size is that there are more people to cater for and, more helping hands available for fishing activities.

**Table 2: Distribution of respondents by age, household size and fishing experience and monthly income (N=342)**

| *Category* | *Socioeconomic characteristics* | | | |
|---|---|---|---|---|
| | | *Frequency (f)* | *Percentage (%)* | *Mean* |
| *Age (Years)* | ≤30 | 35 | 10.3 | 45.4 |
| | 31-40 | 83 | 24.2 | |
| | 41-50 | 125 | 36.6 | |
| | 51-60 | 70 | 20.4 | |
| | >60 | 29 | 8.5 | |
| *Household size* | 1-5 | 133 | 38.9 | 8 |
| | 6-10 | 156 | 45.5 | |
| | >10 | 53 | 15.6 | |
| *Fishing experience (Years)* | 1-10 | 63 | 18.3 | 23.7 |
| | 11-20 | 124 | 36.4 | |
| | 21-30 | 135 | 39.5 | |
| | >30 | 20 | 5.8 | |
| *Monthly income (N'000)* | ≤25 | 41 | 12.1 | 66,295 |
| | 26-50 | 91 | 26.5 | |
| | 51-75 | 136 | 39.8 | |
| | 76-100 | 74 | 21.6 | |

Source: Field survey, 2018

Results in Table 2 showed that the mean fishing experience among the respondents was 23.7 years. This suggests that most of the artisanal fishers have been in fishing business for more than two decades and may have gathered series of experience in tackling climate-related problems. It would be noted that artisanal fishers with longer years of experience might determine factors that influence their fishing time and also able to forecast weather. The average monthly income of the respondents was N66,295 and this implies that provided all things being equal coastal fishing is lucrative business and if properly harnessed and supported by successful government would serve as avenue to revive the nation's economy.

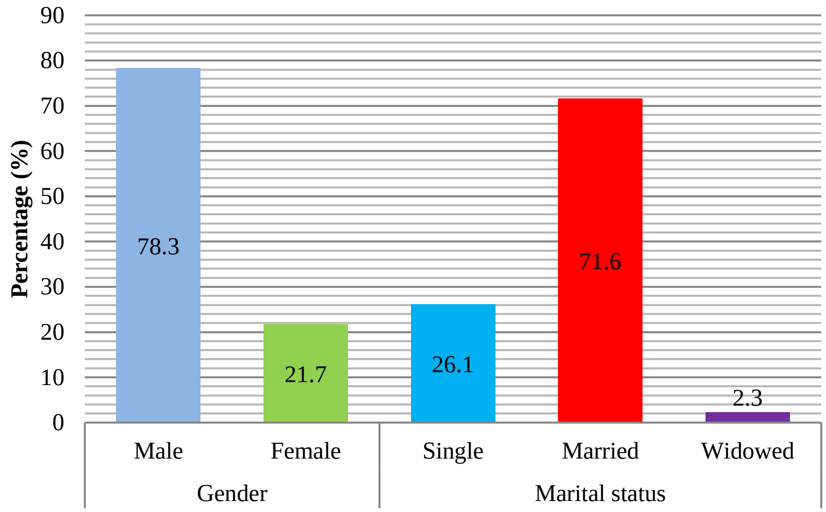


Fig. 1: Distribution of respondents by gender and marital status
Source: Field survey, 2018

The results in Figure 1 revealed that majority of the respondents (78.3%) who depended on fishing activities for their livelihood were males, while 21.7% were females. Most of the fishing activities, especially, direct fishing in the sea, lagoon or mangrove was done by men whereas women did other fishing activities that involved processing for final consumption. Fishing activities in this study area were mostly performed by married respondents (71.6%) single were (26.1%) and widow/widower (2.3%). The implication of this finding is that majority of artisanal fishers are responsible and have family to cater for.

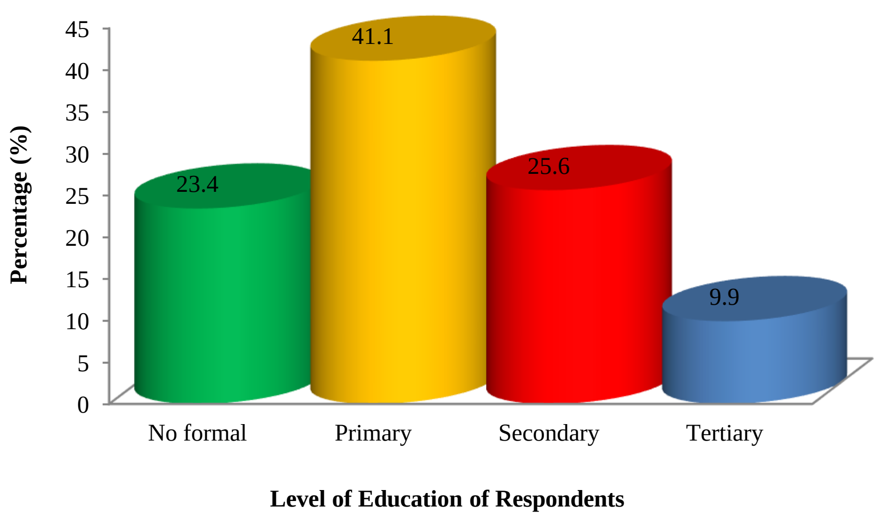


Fig. 2: Distribution of respondents by level of education
Source: Field survey, 2018

Figure 2 showed that the most of the respondents (41.1%) had attained primary education level. Whereas some of them (25.6 and 23.4%) had secondary education and no formal education with fewer of the respondents (9.9%) had tertiary education. Since most of the respondents (83%) had attained primary education; this suggests that artisanal fishers have some understanding and knowledge on matters pertaining to climate change, and its implication on food security. It was therefore adduced from the finding that, artisanal fisher had basic literacy education.

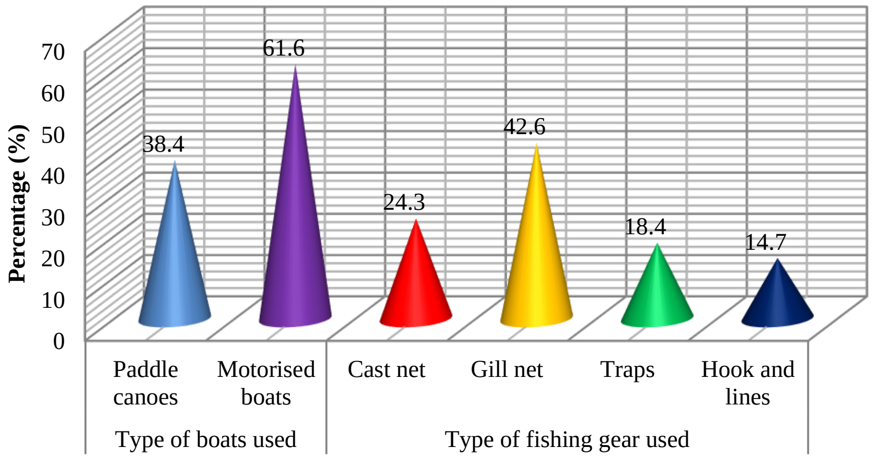


Fig. 3: Distribution of respondents by types of boats and fishing gears used
Source: Field survey, 2018

Results in Figure 3, revealed that majority of respondents (61.6%) were either owned or have access to motorized boats or canoes while 38.4% used paddle canoes for fishing. The use of motorized boats has enhanced the fishing activities among the artisanal fishers in the coastal communities. Further results in Figure 3 showed that most (42.6%) of the respondents use gills net, 24.3% used cast net while 18.4 and 14.7% use traps and hooks and lines respectively. It was observed that the gills net are the commonest net and it consist of rectangular, light weight nets joined together from end to end to form a very long horizontal curtain of netting which hangs loosely in water.

***Vulnerability of the artisanal fishers to climate change***

Data presented in Table 3 showed the vulnerability of respondents in four different coastal communities of the study area. The vulnerability indices are used to rank the different coastal communities in terms of vulnerability. A coastal community with highest index is said to be most vulnerable and it is given the rank 1, the community with next highest index is assigned rank 2 and so on. Thus the results in Table 3 revealed that Badagry with vulnerability index of 0.551 was the most vulnerable among coastal communities under investigation followed by Eti-Osa (0.547), followed by Ibeju-Lekki (0.468) and Epe (0.369) was the least vulnerable coastal community.

**Table 3: Vulnerability analysis of respondents to climate change in coastal communities**

| *Coastal communities* | *Vulnerability Indicators* | | | | | | | | | | *Sum of the Scores* | *Average Vulnerability Index (AVI)* | *Ranking* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Level of Education* | *Ownership of boats* | *Monthly income* | *Household size* | *Fishing experience* | *Access to labour* | *Access to fishing gears* | *Catches per day* | *Extension visit* | *Membership of coop. society* | | | |
| Eti-Osa | 1.001 | 0.521 | 0.452 | 0.572 | 0.448 | 0.620 | 0.601 | 0.058 | 0.622 | 0.575 | 5.470 | 0.547 | 2nd |
| Ibeju-Lekki | 0.168 | 0.563 | 0.634 | 0.626 | 0.601 | 0.551 | 0.422 | 0.387 | 0.696 | 0.036 | 4.684 | 0.468 | 3rd |
| Epe | 0.203 | 0.384 | 0.156 | 0.690 | 0.704 | 0.439 | 0.780 | 0.000 | 0.122 | 0.214 | 3.692 | 0.369 | 4th |
| Badagry | 0.139 | 0.676 | 0.349 | 0.900 | 0.000 | 1.000 | 0.560 | 0.274 | 0.610 | 1.000 | 5.508 | 0.551 | 1st |

Source: Analyzed from Field survey, 2018

Similarly, for each variable using educational of the coastal areas as an indicator, Eti-Osa having vulnerability index of 1.001 were more vulnerable to effect of climate change compare to other coastal communities with relative vulnerability index of 0.168, 0.203 and 0.139 for Ibeju-Lekki, Epe and Badagry respectively. Taking ownership of boats or canoes as indicator, coastal communities of Epe have low vulnerability index of 0.384 compared to other coastal communities with vulnerability index of Eti-Osa (0.521), Ibeju-Lekki (0.563) and Badagry (0.676). Monthly income from fishing activities, the vulnerability index of coastal communities Eti-Osa (0.452), Epe (0.156) and Badagry (0.349) were low while that of Ibeju-Lekki was 0.634 and relatively high. This indicated that coastal communities in Ibeju-Lekki earn more income from fishing activities and this could as a result stem and increases their chances of adopting of various adaptation strategies to cope with challenge of climate change. This finding corroborated that of Agabi (2012) and Amusa *et al.* (2015) that, increase in farmers' income in North-central Nigeria increased coping capacity and access to more adaptive technologies among the farmers. The vulnerability index was relatively high for all the coastal communities with Eti-Osa (0.527), Ibeju-Lekki (0.626) and Epe (0.690) and Badagry (0.900) using household size as indicator. The higher the number of family members involved in fishing activities consequently the higher the adaptive capacity in terms of stock.

Furthermore, using fishing experience as an indicator Badagry coastal community was the least vulnerable (0.000), followed by Eti-Osa (0.448) and while Ibeju-Lekki and Epe were more vulnerable with index of 0.601 and 0.704 respectively. This implies that artisanal fishers in coastal area of Badagry have more years of fishing experience and which help them in ameliorating the impact of climate change. Access to labour for coastal fishing activities have made some communities such as Badagry (1.000) and Eti-Osa (0.620) more vulnerable to climate change due to shortage of labour. According to Onyeneke and Madukwe (2010) found that shortage of labour constitute a major barrier to climate change mitigation strategies. Also, using access to fishing gears as an indicator the vulnerability index of coastal fishers in Epe (0.780), Eti-Osa (0.601) and Badagry (0.560) were relatively high compare to Ibeju-Lekki (0.422) which was low. This finding suggests that gear diversification among the coastal fishers could serve as adaptive capacity and reduce their vulnerability to climate change.

The vulnerability index of number of extension contacts in Epe coastal axis was very low (0.122) where as a high vulnerability was observed in Eti-Osa (0.622), Ibeju-Lekki (0.696) and Badagry (0.610). This high vulnerability index observed in other three coastal communities account for shortage or no contact of extension workers with artisanal fishers and this would affect inflow of information of climate change adaptation strategies to the fishers.

***Adaptive capacity employed by artisanal fishers to ameliorate their vulnerability to climate change***

The results in Table 4 present the adaptation strategies used among the respondents to ameliorate their vulnerability to climate change. Adaptive capacity/strategies are important measures that enable people to absorb the impact of shock (for any emergence). Communities have different levels of coping strategies that allow them either respond to climate change or to prevent potential hazard. Communities with greater adaptive capacity face a lower risk of disaster. Using mean score and rank, the results showed that occupational mobility with mean score 3.812 was highly used adaptation strategy among the respondents and ranked 1st followed fishing gear diversity (mean=3.673). This finding implies that fishers should not only rely on coastal fishing, but also engaged in or should think of alternative activities to augment their earnings and to have resources to tackle climate change at all year round. Also, other adaptive capacity employed by the respondents include access to credit facilities (mean=3.477), environmental conservation (mean=3.449), access to information on climate change adaptation strategies (mean=3.331) and organize fishers association (mean=3.012) were ranked 3rd, 4th, 5th, and 6th respectively. The use of access to fishing technology (mean=2.993) and community infrastructure (mean=2.869) were low and thereby rankled 7th and 8th among the coastal fishers in the study area.

**Table 4: Adaptive capacity to climate change among artisanal fishers**

| Adaptive capacity | Mean score | Rank | Remark |
|---|---|---|---|
| Gear diversity | 3.673 | 2nd | High |
| Occupational mobility (Diversification) | 3.812 | 1st | High |
| Access to credit | 3.477 | 3rd | High |
| Access to information | 3.331 | 5th | High |
| Organize fishers association | 3.012 | 6th | High |
| Community infrastructure | 2.869 | 8th | Low |
| Access to fishing technology | 2.993 | 7th | Low |
| Environmental conservation | 3.449 | 4th | High |

Source: Field survey, 2018

***Factors associated with artisanal fishers' vulnerability to climate change***

Factor analysis was used to construct factors influencing the vulnerability of artisanal fishers to climate change in the study area. Results in Table 5 showed the first output in factor analysis and which is the extraction of components/factors among the respondents in the sample. Six factors namely: socioeconomic, occupational activities, social cohesion/organization, market opportunities, biodiversity conservation and government policies were a priori anticipated for the analysis.

**Table 5: Extraction of component factors**

| *Factors* | *Eigen values* | *Percentage (%) of variance* | *Cumulative percentage (%) of variance* |
|---|---|---|---|
| Socioeconomic | 2.2532 | 39.4 | 39.4 |
| Occupational activities | 1.5713 | 26.1 | 65.5 |
| Social cohesion/organization | 1.3314 | 14.9 | 80.4 |
| Market opportunities | 1.1024 | 11.7 | 92.1 |
| Biodiversity conservation | 0.5991 | 5.4 | 97.5 |
| Government policies | 0.4635 | 2.5 | 100 |

Source: Computed from field survey, 2018

Results in Table 5 revealed the eigen values and percentage of variance for the factors examined. Six factors were extracted because their eigen values greater than 1. This is only factors with Eigen values greater than 1were considered for further analysis. When six factors were extracted, then 100 percent of the variance would be explained. Therefore, only factors: socioeconomic, occupational activities, social cohesion/organization and market opportunities were considered and have eigen values greater than 1 with all the four factors representing 92.1 percent of the variance in the data. Factors 5 and 6 which are biodiversity conservation and government policies with eigen values of 0.991 and 0.4635 respectively and representing 7.9 percent of variance are eventually excluded for further investigations. Because their eigen values were relatively lesser than 1. This suggests that biodiversity conservation and government policies were not significant variables among the artisanal fishers in their vulnerability to climate change.

**Table 6: Oblique rotated factor matrix component correlation (factor loading)**

| *Variables* | *Socioeconomic factors* | *Occupational diversification factors* | *Social cohesion /organization factors* | *Market opportunity factors* |
|---|---|---|---|---|
| Age | 0.092 | 0.008 | 0.106 | 0.063 |
| Sex | -0.067 | 0.024 | 0.004 | 0.108 |
| Level of education | 0.611 | 0.212 | 0.031 | 0.002 |
| Household size | 0.518 | 0.241 | 0.048 | 4.22E-01 |
| Fishing experience | 0.568 | 0.024 | 0.092 | 0.142 |
| Income | 0.019 | 2.46E-02 | 0.002 | 0.811 |
| Consumer' preference of fish caught | 0.047 | 0.062 | 0.026 | 0.639 |
| Ownership of boats/canoes | 0.002 | 0.535 | 0.226 | -0.052 |
| Catches per day | 0.068 | 0.669 | 0.039 | 0.027 |
| Fishing gears | -0.210 | 0.684 | 0.044 | 0.093 |
| Membership of cooperative | 0.036 | 0.031 | 0.743 | 0.213 |
| Extension contact | 1.33E-01 | 0.262 | 0.559 | 0.208 |
| Knowledge of fishing | 0.003 | -0.164 | 0.001 | 0.056 |

| | | | | |
|---|---|---|---|---|
| Government policy | 0.041 | -0.051 | 0.496 | 0.017 |
| Market information | 0.001 | 0.034 | -0.036 | 0.555 |

Source: Computed from field survey, 2018

The results in Table 6 showed the rotated factor matrix for the factors considered and the factor loadings for each of the 15 variables were thus revealed. According to Kaiser's rule which says that variables with coefficients of 0.3 and above may be used to name a factor. Under socioeconomic factor, some of the variables with high loading are; level of education (0.611), fishing experience (0.568) and household size (0.518). These variables in Factor 1 ranged from 0.5 to 0.6 are socioeconomic and could be regarded as socioeconomic factors. The educational level of the household head is not only an important determinant of vulnerability in most developing Asian Highlands but also in the sub-Saharan Africa region (Baiyegunhi & Fraser, 2014). Meanwhile, Sampei and Aoyagi (2009), observed that lack of knowledge and low level of education hinder a person to have access to climate change information and thus increase their vulnerability. Also, Edoumiekumo *et al.* (2013) in a similar used a logistic regression model to show that the major factors of poverty in Nigeria were household size, per capita expenditure on education, health, and food, in addition to female-headed household and engagement in agriculture activity only.

In the second factor, three variables with factor loadings ranging from 0.535 to 0.669 were high. The variables in Factor 2 are ownership of boats/canoes (0.535), number of catches per day (0. 669) and fishing gears (0.684). This Factor 2 was therefore described as "Occupational activities Factors". This findings was supported by Tagago *et al*., (2011), different fishing gears are used for targeting fish because of habitat changes and seasonal variations in species availability. Increasing the catches per day among the artisanal fishers would help to reduce the vulnerability to climate change. This finding is also supported by Mustapha who reported about reduced productivity of commercially important species and that allowable catch per unit efforts by the fishermen are some of the possible consequences of climate change scenarios on artisanal fisheries (Mustapha, 2012). However, the present findings suggests that the number of catches and hours spend on fishing activities per day/week may not determine fisher's weekly income. This was also noted by Tafida *et al.* (2011) that the number of activities does not determine the amount of fishermen total income.

Factor 3, comprised of three variables with high loadings ranging from 0.496 to 0.743 and in tandem regarded as "Social cohesion/organization". The items or variables in Factor 3 are membership of cooperative society (0.743), extension contact (0.559) and government policies (0.496). Formation of artisanal fishers into group or society helps them to tackle any challenges collectively and improved individual as whole. Kingdom and Kwen (2009) reported that fishers who are not members of cooperative societies have the difficulties to get support and attention from the administration (Government), non-governmental organizations and financial institutions. Also, having access or contact with extension agents among artisanal fishers could reduce their vulnerability to climate challenges. This is corroborated by Akponikpe *et al* (2010) that farmers in sub-Saharan West Africa have adopted new farming techniques through information dissemination by extension agents to mitigate the effects of climate change on their farming activities.

Finally, under Factor 4 which is considered as "Market opportunities", comprised of items or variables that are of high loadings such as income (0.811), consumer's preference of fish caught (0.639) and market information (0.555). This implies that artisanal fishers with high monthly income would have resources to acquire large number of gears and capacity to reduce their vulnerability to challenges of climate change. Agbontale (2009) reported that income of fishermen determines their ability to purchase improved fishing gears to a greater extent. Having timely and adequate information about climate variability and changes would enables individual fisher take the right decision at the appropriate time which will in-turn reduce their vulnerability. This is agreement with Banmeke and Olowu (2005) who opined that information has the tendency to stimulate the energy to act in an individual.

**CONCLUSION**

Based on this study, six factors were successfully constructed using factor analysis and considered as major factors influencing the vulnerability of artisanal fishers to climate change; which are socioeconomic, occupational activities, social cohesion/organization and market opportunity factors. Using to adaptive capacity strategy, vulnerability analysis showed that all coastal communities in the study area are vulnerable to climate change. The vulnerability was high in Badagry followed by Eti-Osa, Ibeju-Lekki and Epe. Occupational mobility or diversification of livelihood was the most adaptive capacity strategy used by artisanal fishers to ameliorate or cope with climate change. The study recommends proper sensitization and capacity building among the coastal fishers on the threats of climate change to their fishing activities. Access to technology that helps artisanal fishers receive timely information on climate and innovative ways to improve agriculture would help improve adaptive capacity and reduce vulnerability. Also, improving the vulnerability indicators identified in this research could help reduce the vulnerability of these four coastal communities, and possibly other coastal communities in the study area.

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