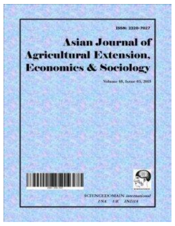

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Vulnerability of Food Crop Farmers to Climate Change in South Eastern Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Author CC designed the study and wrote the first draft of the manuscript. Authors UCI and DOO performed the statistical analysis and managed the analyses of the study. Author JSO managed the literature searches. Author OBI wrote the protocol. All authors read and approved the final manuscript.

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ABSTRACT

Micro-level assessment of vulnerability to climate change creates basis for policy formulation. The study specifically ascertained the levels and determinants of vulnerability to climate change among selected food crop farmers. Data collected were analysed using descriptive statistics and ordinary least square regression analysis. The result revealed that 15.95%, 68.97% and 15.08% of the households were highly vulnerable, moderately vulnerable and less vulnerable to climate change respectively. This implies a varied effect on crop farmers. The result also showed that amount saved, extension contacts, household expenditure and value of crop were significant at 1% level. The study recommended the provision of basic amenities and soft loans to farmers as well as an improvement in extension services. It also advocated the introduction of effective climate change mitigation and adaptive measures to boost agricultural output in their area.

Keywords: Vulnerability; climate change; food crops farmers; adaptation.

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1. INTRODUCTION

Climate has always been changing, but the pace at which it is now happening is alarming. It threatens to make the planet uninhabitable. It is disheartening to observe the climate changing with other developmental stresses such as dwindling oil prices, extreme terrorism, economic recession and massive migration [1]. According to [2], the rising sea is forcefully sweeping out coastlines, causing many people to be displaced and food insecure. Climate change, as defined by [3], is the average state of the weather for a long time due to human activities and natural variability. According to [4], anthropogenic activities are the major cause of increase in the concentrations of greenhouse gases (GHGs) in the atmosphere and the consequent warming of the planet. [5] also noted that GHGs are released when ecosystems are altered and vegetation is either burned or removed; resulting to excessive evaporation, rising sea level, flooding and drought.

It is a fact that developing countries are the most hit of climate change. This is especially true of those in low-lying coastline, whose economy is highly dependent on agriculture with fewer resources and low adaptive capacity. Nigerian rural dwellers, whose major occupation is farming, are mostly affected by climate change with considerable social and economic consequences [6]. It is observed that in the last few decades, changes in temperature have had a remarkable impact on crop yield and animal performances [7]. According to [8], crop yields are projected to decrease further in most tropical and subtropical regions due to changes in temperature and rainfall. It is also projected that crop yield in Nigeria may fall by 20-30% by 2030 due to climate change [9]. Consequently, climate change may worsen food security and aggravate hunger among farmers in South-East, Nigeria where agriculture is largely rain-fed. An understanding of and response to climate variability at all levels of social organisation and sectors will help in future studies of the effects and responses to climate change and in identifying effective effective adaptation strategies [10].

In spite of the global concern and the obvious vulnerability of the South-East region of Nigeria to climate change, household level vulnerability to climate change has not received sufficient research attention. Majority of studies on climate change in Africa concentrated on impacts of climate change and adaptation strategies on national and global scale [11,12,7]. However, developing adaptation measures will first require the assessment of the vulnerability of the farmers at local levels. This is supported by some authors [13,14] who argue that, studying adaptation to climate change should begin with the assessment of farmers' vulnerability to climate stresses. According to these researchers, assessment of vulnerability to climate change analysis is needed at the level that would enable policy makers to tackle climate change problems with the precision that is necessary. Against this background, the study specifically ascertained the levels and determinants of household vulnerability to climate change among food crop farmers in South-East, Nigeria.

There is a long and multidisciplinary history of scientific research associated with adaptation and the definition of adaptation has varied by fields and practice [15], this paper however, defines adaptation in the context of agricultural vulnerability to climate change. The increasing focus on adaptation of agriculture to climate change indicates the need for climate-smart agricultural practices which could see to the reduction of GHG emissions and their adverse effects [16]. Furthermore, considering that climate change do not act on farmers in isolation, it therefore implies that the farmers collectively face similar challenges and would likewise adopt similar response measures [17]. Adaptive measures that have been identified include improved transport infrastructure, improved irrigation efficiency and water management. A high proportion of surface water is allocated to agriculture in South Africa [18].

2. METHODS AND MATERIALS

The study was conducted in South-East, Nigeria, which is made up of Abia, Imo, Enugu, Anambra and Ebonyi States. It falls within the rainforest zone, characterised by tall trees and undergrowth of shorter tree species. The climate is humid with mean annual rainfall of 2,150 mm and mean annual temperature of 28°c [19]. The topography varies from plain, hilly, gently undulated and low lands. The inhabitants are mainly traders, farmers, civil servants and artisans. The major crops grown in the state are yam, cassava, cocoyam, maize and oil palm. The predominant soil is deep well drained sandy loam soil derived from coastal main sand parent materials. These soils are generally deep, porous and acidic [20].

Multistage sampling technique was adopted for sample selection. First, three states (Abia, Ebonyi and Anambra state) were purposively selected as a result of the differences in topography and vegetative covers in the area. Based on the disparity in the number of communities and LGAs in each agricultural zone of the selected States, a proportionate sampling technique was adopted. The selection was based on 40% in the first three stages and 30% in the final level. A total of 370 questionnaire booklets were distributed and only 320 were valid. The breakdown of the sample selection is presented on Table 1.

2.1 Principal Component Analysis

The common methods for analysing vulnerability to climate change are the econometric and indicator methods. For this paper, indicator method was adopted because of its vast application. The indicator method involves the selection of indicators from a set of metrics (exposure, sensitivity and adaptive capacity metrics) and construction of composite indices. The selection and standardisation of indicators were based on literature for constructing household indices. Standardisation was necessary because of the different units of the indicators selected [21]. For indicators that are positively related to vulnerability to climate change, the formula is given as:

$$a_{ij} = (X_{IJ} - Min\ X_{IJ}) / (Max\ X_{ij} - Min\ X_{ij}) \quad (1)$$

For indicators negatively related to vulnerability to climate change:

$$a_{ij} = (Max\ X_{ij} - X_{ij}) / (Max\ X_{ij} - Min\ X_{ij}) \quad (2)$$

Where a_{ij} = denote the *i*th vulnerability indicator in the *j*th metric set.

From the matrix of standardised values, the composite vulnerability index is constructed as follows:

Vulnerability Index = (Adaptive capacity – (Sensitivity – Exposure) (3)

This is further expressed as:

$$V_{index} = (A_1X_{1J} + A_2X_{2J} + \dots A_{2n}X_n) - (A_{n+1}Y_{1J} + A_{n+2}Y_{2J} + \dots + A_{n+n}X_{nJ}) \quad (4)$$

Where V_{index} is the vulnerability index, X variables are adaptive capacity metrics, and Y variables are exposure and sensitivity metrics.

Next was to assign weight to the normalised indicators and Principal Component Analysis (PCA) was used for this purpose. Principal Component technique is a multivariate technique for finding patterns in data of high dimension. The chosen variables were transformed as linear combinations of a set of underlying components for each individual *j* as specified by [22]:

$$a_{1j} = \gamma_{11} A_{1j} + \gamma_{12}A_{2j} + \dots + \gamma_{1K}A_{Kj}$$
$$j = 1 \dots J$$
$$a_{Kij} = \gamma_{K1}A_{1j} + \gamma_{K2}A_{2j} + \dots + \gamma_{KK}A_{Kj} \quad (5)$$

Where the ***A*** s are the components and the **γ** s are the coefficients on each component for each variable. The solution to the problem is indeterminate but the indeterminacy is overcome by finding the linear combination of the variables with maximum variance which is usually the first principal component a1*j* and then a second linear combination of the variables orthogonal to the first. After attaching weight using PCA and constructing households' vulnerability indices, the indices were classified into categories of vulnerability to climate change following normal distribution.

2.2 Ordinary Least Square Regression Analysis

With the individual vulnerability indices constructed, determinants of vulnerability were analysed using the Ordinary Least Squares Regression technique. However, considering that the indices generated from PCA were mix positive-negative variables, a log-module

Table 1. Sample selection of food crop farmers

	Abia State	Ebonyi State	Anambra State	Total
Total LGAs	17	13	21	51
Selected LGAs	6	5	8	19
Total Communities	57	41	67	165
Selected Communities	24	16	27	67
Total Villages	161	144	196	501
Selected Villages	64	57	78	199
Total Registered Farmers	428	306	506	1240
Selected Farmers	128	91	151	370

transformation was used to handle the negative values before subjecting them to ordinary least square regression analysis and this idea followed [23].

Vulnerability function is specified implicitly as follows:

$$V_{index} = \alpha + Bi \sum_{k=1}^{n} X\,i + ei \quad (6)$$

Where V_{index} = vulnerability index of each farmer.

X*i* = explanatory variables which include: Sex (1 for male, 0 if otherwise), farm size (Ha), amount saved (naira), amount of credit received (naira), extension contact (1 for access, 0 if otherwise), household expenditure (naira), value of crop output (naira), level of education (years), age of household head (years), cooperative membership (1 for membership, 0 if otherwise), household size (numbers), and fragmentation (Number fragmented land owned by each respondent), non-farm income (Naira), land ownership statues (1= permanent ownership, 0 = rent only), location of farm category A (Anambra State = 1, otherwise = 0,) location of farm category B (Abia State = 1, otherwise = 0) and location of farm category C (Ebonyi State = 1, otherwise = 0). Note: Dummy variable for Abia, Anambra and Ebonyi States were included as State effect to take care of clustering, Abia state served as the base category.

3. RESULTS AND DISCUSSION

3.1 Levels of Household Vulnerability to Climate Change

The categorisation based on normal distribution according to their level of vulnerability is represented on Table 2.

Majority of households fell within the moderately vulnerable category, with 68.97% households having indices from -2.07912 to 1.95995. The less vulnerable households constitute 15.08% of the respondents with indices ranging from 1.96000 to 4.899319, while the highly vulnerable households had indices of -7.65285 to -2.079115 and constitute 15.95% of the total households sampled. When a farmer is vulnerable to climate change, it means that his exposure and sensitivity to climate change are more than his ability to cope with the harshness of weather. This assertion is in line with [24] who explained that the extent to which ecosystems are vulnerable to climate change depend both on exposures to changes in climate and on the ability of the system to adapt. However, being moderately vulnerable, it implies that they may not need urgent attention but temporary assistance should be made available in case of shock and stresses [25].

3.2 Determinants of Vulnerability to Climate Change

Based on the econometric, statistical and economic a priori expectation, the linear form was chosen as the lead equation as shown in Table 3.

The result shows that the coefficient of determination (R^2) value of 0.4694 meaning that 46.94% of the variations in the level of household vulnerability was explained by determining factors symbolised by x_3, x_5, x_6, x_7, x_9, x_{14} and x_{16}. However, the F-value of 16.16, was statistically significant at ($p<0.01$) and this implies that the model produced a good fit for the data. The result also showed that savings, extension contacts, household expenditure and value of crops were significant at 1% level of significance while age, land ownership and residence in Anambra State were significant at 5% level of significance.

All the significant variables were negatively related to vulnerability to climate change. This implies that when savings, household expenditure, value of crops and number of extension contacts increase, farmers become less vulnerable to climate change. Further, it was not surprising that the farmers had indicated lack of adequate rainfall as a pressing challenge; water is very significant for horticultural crops like

Table 2. Distribution of households by Range of vulnerability indices

Vulnerability level	Vulnerability indices	Frequency	Percentage of households (%)
Highly vulnerable	-7.65285 to -2.079115	37	15.95
Moderately vulnerable	-2.07912 to 1.95995	160	68.97
Less vulnerable	1.96000 to 4.899319	35	15.08
Total		232	100.00

Table 3. Results of multiple regressions with robust standard error

Variables	Linear	Semi-log	Double-log	Exponential
Sex (X_1)	.0341619	-.0065431	.0104461	.0468834
	(0.16)	(-0.06)	(0.09)	(0.20)
Farm size (X_2)	-.1148595	-.0835563	-.1963992	-.2975815
	(-0.46)	(-0.62)	(-0.70)	(-0.56)
Saving (X_3)	-.0000178***	-8.61e-06***	-.0457943**	-.1035546**
	(-6.19)	(-7.09)	(-2.13)	(-2.41)
Credit (X_4)	-.2611589	-.1669389	-.0876767	-.0723877
	(-1.12)	(-1.47)	(-0.64)	(-0.25)
Extension (X_5)	-.7089335***	-.3745739***	-.4700842***	-.930319***
	(-3.14)	(-3.24)	(-3.78)	(-3.76)
Household exp. (X_6)	-.0174134***	-.0061973**	-.1284661**	-.3022214**
	(-3.60)	(-2.66)	(-2.12)	(-2.33)
Value of crop (X_7)	-.0176954***	-.0088478***	-.0948276	-.2040219
	(-3.22)	(-3.41)	(-1.76)	(-1.85)
Education (X_8)	.0158128	.0059262	.1672498	.3522846
	(0.61)	(0.46)	(1.82)	(1.94)
Age (X_9)	-.0192366**	-.0077628	-.4434184**	-1.074452**
	(-2.41)	(-1.94)	(-2.42)	(-2.86)
Cooperative mgt.	-.1542046	-.0683969	-.1440576	-.313033
(X_{10})	(-0.70)	(-0.61)	(-1.21)	(-1.34)
Household size (X_{11})	.0306452	.0065936	.0699409	.3101798
	(1.09)	(0.46)	(0.48)	(1.09)
Land frag. (X_{12})	.3081883	.0861553	.1836503	.5055387**
	(1.34)	(0.76)	(1.53)	(2.05)
Non-farm income	-.0763276	-.0658966	-.0313635	-.0139753
(X_{13})	(-0.26)	(-0.48)	(-0.22)	(-0.04)
Land ownership	-.4484502**	.2014819	.1361641	.2831158
(X_{14})	(-2.00)	(1.74)	(1.05)	(1.10)
Ebonyi (X_{15})	-.4058287	-.1404747	-.3293275**	-.778692**
	(-1.20)	(-0.88)	(-2.02)	(-2.25)
Anambra (X_{16})	-.5953051**	-.1976701	-.2962029	-.7647458**
	(-2.05)	(-1.33)	(-1.92)	(-2.54)
Constant	2.278511***	1.173199***	2.624454***	5.668215***
	(3.33)	(3.31)	(3.19)	(3.39)
R^2	0.4694	0.4408	0.3095	0.3300
F-Value	16.16	19.00	7.02	5.90
Standard error	.6843022	.3544531	.8220838	1.669729

Source: Field Survey Data, 2014; values in parenthesis are t- ratios
*N/B *** = Significant at 1%; ** = Significant at 5%*

cabbage and potato [26] it affects the farmer's ability to produce seasonally or through the year and also enables farmers to grow diversified crops instead of practising single cropping [27]; [28]. Reportedly, the experience of the farmers corroborated with the higher levels of temperature observed from the weather data analysis. Consequently, farmers' awareness of climate change through various media and by their observation could help them to plan easily for future mitigation strategies [29].

With adequate savings, therefore, food crop farmers could invest in alternative businesses, thereby reducing the impact of climate change. This is consistent with the findings of [30] which showed that farmers' savings especially during bumper harvests would help to give them adequate security against impending negative climate events. The result of the effect of household expenditure on farmers' vulnerability to climate change is similar to findings of BNRCC [19] which showed that higher expenditure (especially on health care) limits farmers' access to adaptive instruments and consequently greater vulnerability for the household. The result of age is not consistent with *a priori* expectation and findings of [31] which found that the aged are easily disposed to ill-health and hardly can withstand stress. This, by implication, means that, the aged are more vulnerable to climate related hazards than younger ones. For state effect, it also means that farmers in Anambra State were more vulnerable to climate change than farmers in Abia State.

4. CONCLUSION AND RECOMMENDATIONS

This paper constructed vulnerability index at the household levels; thereby, forming a framework for developing effective adaptation policies. The study recommended the provision of basic amenities and soft loans to farmers as well as an improvement in extension services. Efforts should be geared toward the provision of drought and disease resistant varieties to farmers at an affordable rate. Also, Running waters should be properly channelled to avoid the blocking of drainages and flooding of pathways. Conclusively, the paper provides empirical data to support the perceived assertion of climate change and farmers' responses. It also revealed that Nigerian farmers are already adapting to climate change, although, an integrated approach that addresses multiple stressors and combines indigenous knowledge and experience with scientific insights is needed.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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