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Rural Households Vulnerability to Weather Changes by Cassava Farmers' in Ondo State, Nigeria.

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Abstract

Data collected from 120 respondents were analysed using descriptive statistics and Climate Change Vulnerability Index (CCVI). The statistical analysis of the climate data revealed that temperature and rainfall were increasing. The average age of the respondents was 55 years. The computed Climate Change Vulnerability Index (CCVI) showed that cassava farmers in Irele LGA are more vulnerable than those in Okitipupa LGA. The vulnerability ranking of the two Agro Ecological Zones presented signified that Cassava farmers in the tropical forest zone (irele) with -0.139 vulnerability index is more extremely vulnerable to climatic variability than in Okitipupa with vulnerability index of -0.105, although they were still on the same interval scale on the ranking. Government policies and investment strategies must focus on how to intensify awareness on climate change, investments in generating reliable and accurate weather forecast at community level and access to credit in order to rescue the poor rural farming households from the danger of climate change in the study area.

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1. Introduction

The climate of West Africa is highly variable and unpredictable and the region is prone to extreme weather conditions, including droughts and floods (Department for International Development, DFID, 2004). Climate change with expected long-term changes in rainfall patterns and shifting temperature zones are expected to have significant negative effects on agriculture, food and water security and economic growth in Africa; and increased frequency and intensity of droughts and floods is expected to negatively affect agricultural production and food security (DFID, 2004). Although estimates suggest that global food production is likely to be robust, experts predict tropical regions will see both a reduction in agricultural yields and a rise in poverty levels as livelihood opportunities for many engaged in the agricultural sector become increasingly susceptible to expected climate pressures (World Bank, 2007).

2. Conceptual definitions of vulnerability

Vulnerability is the susceptibility of a system to disturbances determined by exposure to perturbations, sensitivity to perturbations, and the capacity to adapt (Nelson *et al,* 2010). Cutter *et al* (2009) defined vulnerability as the susceptibility of a given population, system, or place to harm from exposure to the hazard and direct affects and the ability to prepare for, respond to, and recover from hazards and disasters. Both these definitions agree that vulnerability refers to the susceptibility to harm, rather than the measure of harm itself, which may be due to exposure to threats or drivers of change. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity' (IPCC, 2001).

Adger and Kelly (2007) elaborated on the IPCC definition as follows; "The assessment of vulnerability is the end point of a sequence of analyses beginning with projections of future emission trends, moving on to the development of climate scenarios, thence to biophysical impact studies and the identification of adaptation options. At the final stage any consequences define levels of vulnerability". While the above approach provides a definition of vulnerability that stays clear of socioeconomic and political issues and enables the IPCC to operate within a framework of consensus decision-making, this definition has been found to have limitations by a number of observers. Vulnerability is a term usually associated with natural hazards like flood, droughts, and social hazards like poverty, drought, flood etc. Of late it is extensively used in climate change literature to denote the extent of damage a region is expected to be affected by various factors affected by climate change. In the context of climate change there are many studies on vulnerability and its definitions vary according to the perception of the researchers, O'Brien *et al*. (2004).

2.1 Problem Statement

The general consensus is that changes in temperature and precipitation will result in changes in land and water regimes that will subsequently affect agricultural productivity. Although estimates suggest that global food production is likely to be robust, experts predict tropical regions will see both a reduction in agricultural yields and a rise in poverty levels as livelihood opportunities for many engaged in the agricultural sector become increasingly susceptible to expected climate pressures (World Bank, 2007). While contemporary policy dialogue has focused on mitigating emissions that induce climate change, there has been relatively limited discussion of policies that can address climate vulnerability, hence adaptation. In Nigeria, few studies have been carried out to address rural vulnerability to climatic changes at a local scale and farm level adaptation to the impacts. This study will enable us to bridge this gap by examine the Rural Households Vulnerability to Weather Changes by cassava Farmers' in Ondo State, Nigeria.

2.2 Research Questions?

i. What is the Temperature and Rainfall pattern in the study area?
ii. What are the common indices used to determine the extent of the vulnerability among the respondents in the study area?
iii. What are the factors considered in the ranking of Cassava farmers in the study area?

2.3 Objectives of the Study

i. describe the rainfall and temperature pattern for year 2013 in the study area;
ii. determine the extent of Vulnerability among the respondents; and
iii. examine the factors needed in ranking of cassava farmers in the study area.

3. Materials and Methods

3.1 Study Area

This study was carried out in Ondo State in the Southwest part of Nigeria The State is located between latitudes 06º 42¹ and 07º 14¹ North of the equator and longitudes 05º 00¹ and 05º 32¹ East of the Greenwich Meridian. There are two distinct geographical seasons occasion by the rainy and the dry seasons. The mean annual temperature varies between 22 ºC and 32 ºC. The annual rainfall is between 800mm and 1500mm and the soil is relatively acidic but fertile with high clay content and good drainage (Ondo State Government, 2012). Ondo State has a population of 3,440,000 according to 2006 census with the land surface area of 15,500 km^2 (6,000 sq mi) (Ondo State Government, 2014).

3.2 Sampling Techniques

Multi-stage sampling technique was used to select respondents for this study. The first stage involved purposive sampling of tropical forest and the mangrove swamp Agro-Ecological Zones (AEZs) where cassava production is very prominent. In the second stage, Irele local government area (LGA) was randomly selected in the tropical forest while Okitipupa was randomly selected in the mangrove forest AEZ. The third stage involved random selection of four communities in each LGA which totaling eight (8) selected communities while in the fourth stage sixteen respondents were randomly selected. A total of one hundred and twenty eight (128) respondents were sampled for the study.

3.3 Method of Data Collection

Primary data were collected on farmers' perceptions on impacts, socioeconomic profiles and adaptation strategies) were collected using a well-structured questionnaire administered to rural households. Interviews and Focus Group Discussions (FGDs) were also used to collect cross section on perceptions and adaptations to climate changes among respondents.

3.4 Climate Change Vulnerability Index (CCVI)

Step 1: Select Component Indicators

After the selection of study area which consisted of several communities. A set of indicators was selected for each of the three components of vulnerability in each community. The indicators were selected based on data availability and previous research. Since vulnerability is dynamic over time, it is important that all the indicators relate to the particular year chosen.

Implicitly; *CCVI* (of community *i*) $= V_i = F(E_i, S_i, A_i)$ ………….1 Explicitly; V_i = [Exposure + Sensitivity + (1 - Adaptive capacity)]…………2

where, CCVI = V_i = Vulnerability Index; E_i =Exposure to hazards; S_i = Sensitivity; A_i = Adaptive Capacity

Step 2: Conduct Multivariate Analysis to choose Valid Indicators: Principal Component Analysis

For each component of vulnerability, the collected data were arranged in form of a rectangular matrix with rows representing regions and columns representing indicators. The overall structure of the dataset, its suitability and methodological choices were guided. The underlying structure of the data was checked along the dimension of individual indicators using a Principal Components Analysis (PCA). The basic aim of a PCA is to reduce a complex set of many correlated variables into a set of fewer, uncorrelated components.

Step 3: Normalization of Indicators

Since the indicators were in different units and scales was required to normalize them. This was in order to obtain figures which indicators were free from the units and also to standardize their values. First they were normalized so that the value is between 0 and 1. Before doing this, the functional relationships between the indicators and vulnerability were identified. Two types of functional relationship exist: vulnerability increases with increase (decrease) in the value of an indicator. Firstly, if the higher the value of an indicator resulted in higher vulnerability, then the variable (indicator) has an upward functional relationship with vulnerability. The Min-Max Method normalization equation is:

$$x_{ij} = \left\{\frac{X_{ij} - Min_i(X_{ij})}{Max_i(X_{ij}) - Min_i(X_{ij})}\right\} . 10 \qquad \text{……….3}$$

Where, x_{ij} = normalized component score X_{ij} = value of component

The standardized value ranges between 0 and 1. The value 1 correspond maximum value and 0 correspond to minimum value (Briguglio, 2003). Secondly, if the higher value of an indicator resulted in lower vulnerability, then the variable indicator has a downward functional relationship with vulnerability. The normalization equation becomes:

$$y_{ij} = \left\{ \frac{Max_i(X_{ij}) - X_{ij}}{Max_i(X_{ij}) - Min_i(X_{ij})} \right\} . 10 \qquad \text{……….4}$$

where, y_{ij} is the normalized component score, X_{ij} = value of component.

If the functional relationship is ignored and if the variables are normalized simply by applying equation (1), the resulting index will be misleading.

Step 4: Weighting and Aggregation

After computing the normalized scores, the overall vulnerability index (*CCVI)* was computed by running a PCA with all the indicators, giving weights to all indicators/components. The assigned weights to the indicators on selected component were then used to construct an overall vulnerability index by applying the equation below:

$$V_j = \frac{\sum_{i=1}^{k} [b_i(a_{ji} - x_i)]}{S_i} \qquad \text{……...5}$$

Where,

v = vulnerability index,

b = weight from PCA 1,

a = the indicator value,

x= *the* mean indicator value

s = standard deviation of the indicators.

The climate composite vulnerability scale were determined such a location with 0 represents zero vulnerability (highest resilience) and maximum value of 1 corresponds to highest vulnerability (least resilient). Index of 0.0-0.20 classifies the *least vulnerable;* 0.21-0.40 classifies the *moderately vulnerable*; 0.41-0.60 classifies the *vulnerable;* 0.61-0.80 classifies the *highly vulnerable* while index of 0.81-1.00 identifies the *extremely vulnerable* based on 20% interval scale.

4. Results and Discussions

4.1 Age of the Respondents

Table 1 revealed that 42.5% of the respondents fall between 51 and 60 years and 27.5% are between 41 and 50 age brackets indicating that majority of the sampled cassava farmers are still in their productive working age with a mean of 54.65 years (although 0.8% of the respondents are less than 30 years of age and 6.7% are in 31 and 40 years brackets). Further distribution shows that 21.7% of the respondents fall between ages of 61 and 70 years. The oldest respondent is 80 years old while the youngest respondent is 25 years old. This implied that an average cassava farmer is still in their middle age, agile, and have ability to take decisions associated with climate adaptation risks in the study area.

Table 1: Distribution of Respondents by Age

Age of the respondents (years)	Frequency	Percentage
Less than 30	1	0.8
31-4	8	6.7
41-50	33	27.5
51-60	51	42.5
61-70	26	21.7
Above 70	1	0.8
Total	120	100.0

Source: Field data, 2014

Mean age=54.65 years.

Std dev=9.13

4.2 Analysis of Observable Climatic Variability in the Study Area

4.2.1 Comparative Monthly Temperature Distributions in Okitipupa in 2013

Figures 1 reveal a sharp declining average maximum temperature in Okitipupa from March up to September because it was a period of constant raining season. Increasing minimum temperatures were observed from February but declines from April alongside maximum temperatures. A widening divergence is noted in which the maximum temperature keeps rising with minimum temperature, until minimum temperature start to decease in November. The trend reveals a fairly moderate inter-monthly variations in both temperatures with an annual maximum temperature of 30.5°C and annual minimum temperature of 24.3°C. The implication is that these variations are moderate enough for adequate crop production requirements and suitable farm households' healthy conditions, fit for cassava farm activities in the study area.

Similar findings from Emenekwe *et al*, 2020 revealed that the variations in annual means in all major agro-ecological zones in Nigerian experienced significantly increased in temperature over time across the country. The correlation coefficients of temperature and time across the major agro-ecological zones exhibited strong and positive relationships, implying that the temperatures of the major agro-ecological zones of Nigeria significantly increased within the period under study.

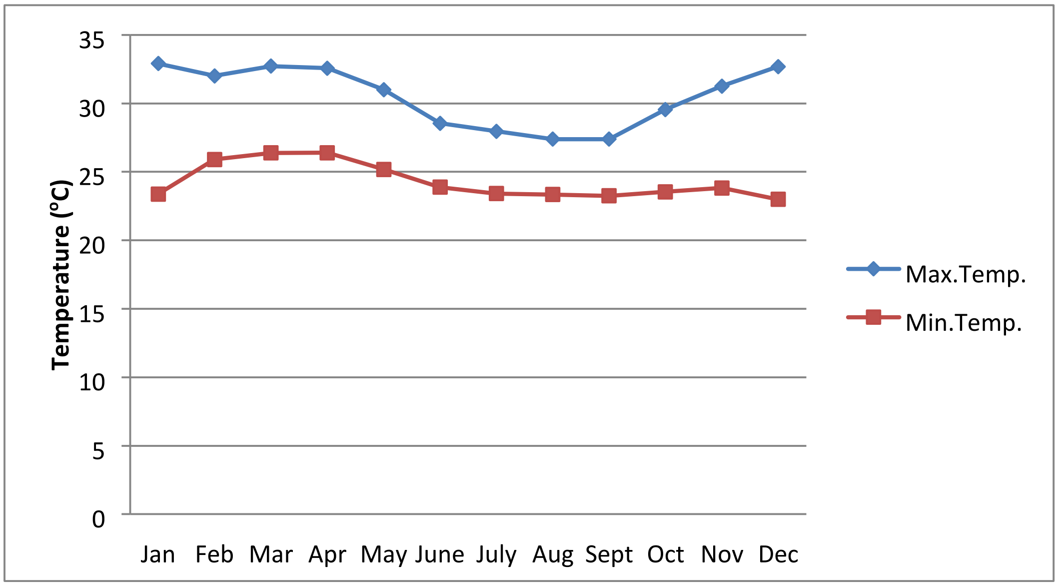

Figure 1: Monthly Maximum and Minimum Temperatures Distribution in Okitipupa

4.2.2 Comparative Monthly Temperature Distributions in Irele in 2013

Figure 2 shows that increase in average of maximum temperatures was observed in Irele between January and March followed by November and December. This is because less rainfall quantities were observed during these months. Increasing minimum temperatures were however observed from February but declined from April alongside maximum temperatures. A stable trend in minimum temperature was later observed until September when an increasing divergence occurred such that maximum temperatures keep rising while minimum temperatures were deceasing. The trend reveals a fairly moderate inter-monthly variation in both temperatures with an annual maximum temperature of 31.2°C and annual minimum temperature of 23.5°C. The implication is that these variations are moderate enough for adequate crop production requirements and suitable farm families' health conditions in Irele.

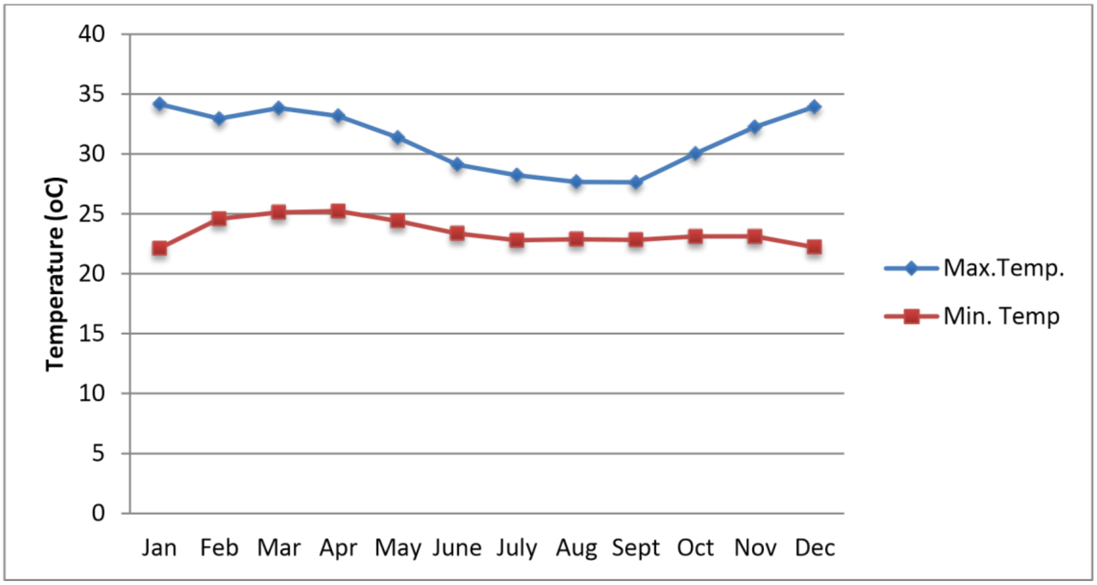

Figure 2: Monthly Maximum and Minimum Temperatures Distribution in Irele.

4.2.3 Comparative Monthly Rainfall Distribution between Okitipupa and Irele in 2013

Figure 3 shows the comparative total monthly averages of rainfall observed in Okitipupa and Irele Local Government Areas. The two distributions show a bi-modal rainfall distribution in June and September in both locations. In June, a peak total monthly rainfall of 418mm was recorded in Okitipupa but while 385mm was recorded in Irele. In August, a peak total monthly rainfall of 610mm was reported in Okitipupa while 550mm was recorded in Irele. There was an increase in total monthly rainfall at the beginning of wet season in February till June, with a sharp decline between June and July as observed in in both areas. The total rainfall pattern in Irele was fairly lower compared with Okitipupa throughout the year. The trend shows similar inter-monthly distribution patterns in both locations with an average annual rainfall quantity of 288.49mm in Okitipupa and 250.50mm in Irele LGA. Overall, the implication is that these distributions give similar trend and close variations in these two areas. It is therefore expected that farm families will experience similar exposure characteristics to climate shocks attributed to either excess rainfall or rainfall deficits in the study area. Precipitation results are similar to other studies conducted in Nigeria. Akinbile *et al*, 2019 found that temperature increased in the major agro-ecological zones of Nigeria, while precipitation increased significantly from 1971 to 2010 (40 years) in the rainforest and coastal agro-ecological zones. Furthermore, similarly to our results, they found increasing trends in maximum rainfall across the major agro-ecological zones, except in the Sahel Savanna, where we found a significantly increasing trend in temperature.

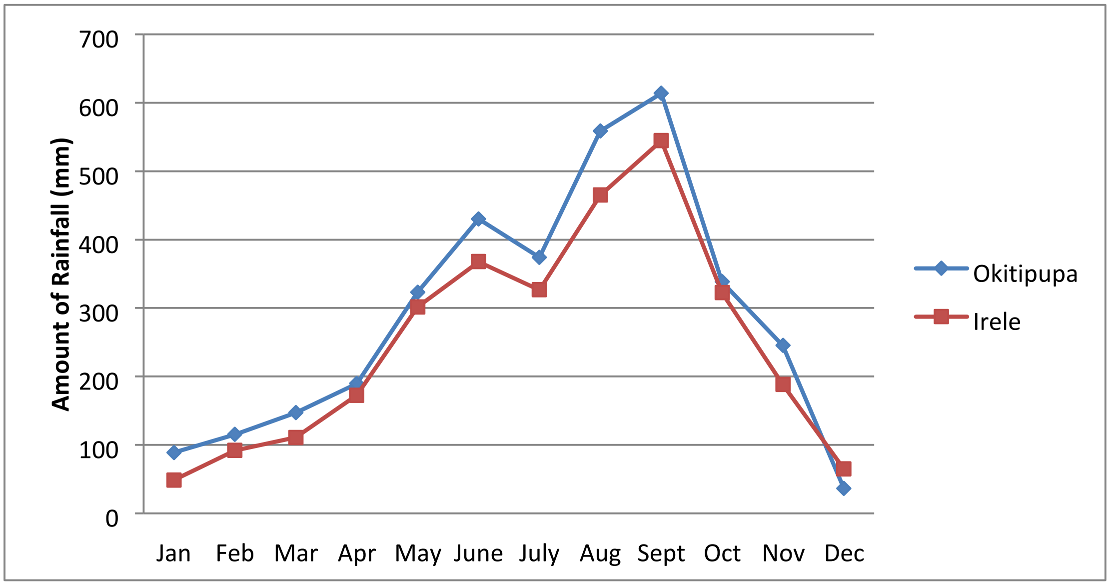

Figure 3: Monthly Rainfall distribution in Okitipupa and Irele.

4.3 Extent of vulnerability Among Respondents

Table 2 reveal that few (3.3%) of the sampled respondents observed that drought was primary problem to their farm operations while 65.8% of cassava farmers sampled observed that drought was secondary problem on their farm. Further responses show that 62.5% of the respondents experienced delay in the time of water availability for use, 92.5% experienced water scarcity in the first quarter of last year while 64.2% experienced low crop yield. Some of the respondents (30.0%) have borrowed money from fellow farmers due to crop failure, 14.2% do not go to farm due to bad weather while 23.3% have experienced land degradation. Few of the respondents (17.5%) said that they experienced communal conflicts on land due to erosion and drought. Erosion has claimed some large hectarage parcels of agricultural lands while droughts have also limited farmers' access to productive lands. Therefore, community boundary conflicts have been reoccurrences. These indicate that extreme weather conditions, change in seasonality and delayed rainfall have pose serious threats on cassava production and make farmers vulnerable to climate change which might affect food security and farmers' income in the study area.

Table 2: Distribution Showing Extent of Vulnerability among Respondents

Extent of Vulnerability	**Response %**
Drought as primary problem	4(3.3%)
Drought as secondary problem	79(65.8%)
Delay in water availability	75(62.5%)
Water scarcity in first quarter	111(92.5%)
Low crop yield	77(64.2%)
Borrow money due to crop failure	36(30.0%)
Do not go to farm due to harsh weather	17(14.2%)
Land constrains	28(23.3%)
Experienced communal conflicts	21(17.5%)

Source: Field data, 2014.

***Multiple responses**

4.4 Climate Vulnerability Ranking of Cassava Farming Households

The computed Climate Change Vulnerability Index (CCVI) shows that farmers in Irele LGA were more vulnerable than those in Okitipupa LGA. Table 4 shows that Irele LGA in the forest zone had -0.139 vulnerability index while Okitipupa LGA had -0.105 index on the vulnerability scale. The vulnerability ranking of the two AEZs presented signified that cassava farmers in the tropical forest zone were more extremely vulnerable to climatic change in comparison with farmers in Okitipupa, although they were still on the same interval scale on the ranking. This is well associated with their differences in indexes from the three components of vulnerability, namely exposure, sensitivity and adaptive capacity which varies between farming households, and also differ from one location to the other.

This result confirms previous studies that vulnerability to the impacts of climatic changes, variability and extremes does not follow geographic location or topographic landscape. Other important parameters are also responsible for such differences in vulnerability that do not follow normal expectations (Awolala, Ajibefun and Imoudu, 2014).

Table 3: Vulnerability Ranking of Cassava Farmers to Climate Variability

LGA	Vulnerability Index	Ranking	Overall Status
Irele	-0.139	1st	More Extremely Vulnerable
Okitipupa	-0.105	2nd	Extremely Vulnerable

Source: Field data, 2014.

4.5 Disaggregated Sub-component Vulnerability Indices

In terms of contribution of each composite vulnerability component, Table 4 show that Exposure components were higher in irele LGA when compared with Okitipupa LGA, Sensitivity were also higher in irele LGA than Okitipupa LGA. Adaptive capacity indices were lower in Okitipupa LGA in comparison with Irele LGA though they were on almost equal average. This implied that Exposure and sensitivity components contribute more to the overall vulnerability index in the study area. It also a major factor that contribute to the reason why irele LGA is more vulnerable than Okitipupa LGA.

Table 4: Disaggregated component index of climatic vulnerability

LGA	Exposure	Sensitivity	Adaptive capacity	Index	Rank
Irele	0.045	0.124	0.030	-0.139	1
Okitipupa	0.015	0.114	0.024	-0.105	2

Source: Field data, 2014.

4.6 Sensitivity Subcomponents Indicators and Cassava Farmers' Vulnerability

Figure 4 shows the magnitude of each sub-component of sensitivity variable contribution to the overall CCVI rank scores in Irele and Okitipupa LGAs respectively. Critical observations reveal that socio-economic variables were the major contributors to vulnerability in Irele LGA and Okitipupa LGA. Therefore, geographic and human capitals were less important indicators to contribute to climatic variability in study area.

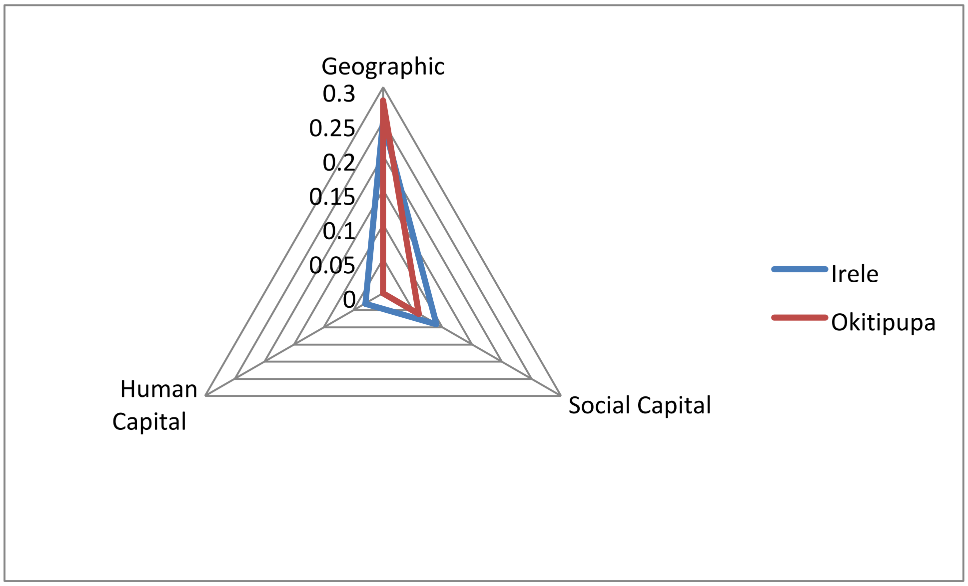

Figure 4: Disaggregated sensitivity component indicators

Source: Field data, 2014.

4.7 Adaptive Capacity Subcomponents Indicators and Farmers' Vulnerability

Figure 5 provide insight that basic amenities and social capital were not important to adaptive capacity in Irele while in Okitipupa it was only productive assets sub-component that limited households' vulnerability. However, presence of social capital in Irele was a major coping factor reducing vulnerability. It thus clearly showed that outside inadequate social capital in Irele, there were other factors such as household assets, basic amenities (roads, electricity) and productive assets were responsible for higher vulnerability in comparison with other components of vulnerability. The interactions among indicators of the sub-components of vulnerability supported earlier empirical study on farmers' vulnerability to negative impacts of climate change (Awolala and Ajibefun, 2015).

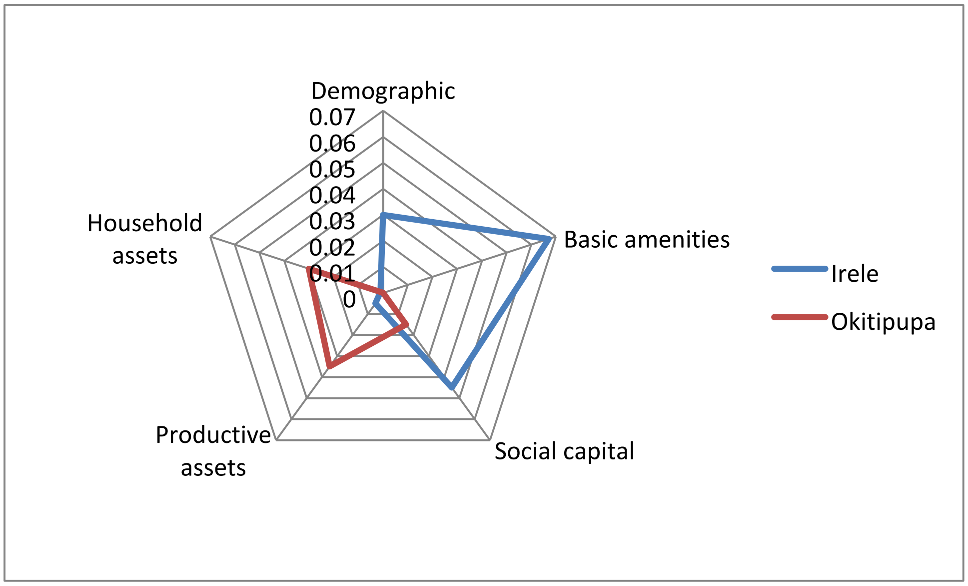

Figure 5: Disaggregated adaptive capacity component indicators Source: Field data, 2014.

5. Conclusions and Policy Issues

The study analyzed rural households' vulnerability to weather changes by cassava farmers' in Ondo State, Nigeria. The results of the analysis showed that average age of the respondents was 55 years old which means that the average cassava farmer in the study area was aged. The computed Climate Change Vulnerability Index (CCVI) showed that cassava farmers in Irele LGA were more vulnerable to climate change impacts than those in Okitipupa LGA. The vulnerability ranking of the two AEZs presented signified that Cassava farmers in the tropical forest zone (Irele) were more Extreme vulnerable to climatic variability than in Okitipupa, although they were still on the same interval scale on the ranking. Continuous monitoring of the degree of vulnerability will serve as a pointer on the development scale and give reliable information for adaptation distributions towards a broader development planning in Ondo state.

References

Adger, W.N and P.M Kelly (2007). “Developing Credible Vulnerability Indicators for Climate Adaptation Policy Assessment: Mitigation and Adaptation Strategies for Global Change”, May 2007, Volume 12, Issue 4, pp 495-524.

Akinbile, C.O., Ogunmola, O.O., Abolude, A.T., and Akande, S.O. (2019). Trends and Spatial Analysis of Temperature and Rainfall Patterns on Rice Yields in Nigeria. Atmos. Sci. Lett.2019, 1-13, doi: 10.1002/asl.944.

Awolala, D.O. Ajibefun, I. A and P.B Imoudu (2014). “Human Vulnerability to Climatic Variability: An Integrated Assessment of the Southern Senatorial District of Ondo State, Nigeria”, In proceedings of the International Conference on *Climate Change, Agriculture and Food Security,* the Nigerian Association of Agricultural Economists, Federal University of Technology Akure.

Awolala, D. O and I. A. Ajibefun (2015). “Rice Farmers’ Vulnerability to Extreme Climate: Deploying Local Adaptation Finance in Ekiti State, Nigeria”, *World Environment 5(3): 91-100.*

Cutter, S. L., Emrich, C. T., Webb, J. J., & Morath, D. (2009). “Social Vulnerability to Climate Variability Hazards”: A Review of the Literature. Final Report to Oxfam America, Columbia: Hazards and Vulnerability Research Institute, University of South Carolina.

Department for International Development, DfID, (2004). Climate Change in Africa. Key Sheets on Climate Change and Poverty.

IPCC. (2001). Climate Change 2001: Impacts, Adaptation, and Vulnerability. (J. McCarthy, O. Canziani, N. Leary, D. Dokken, & K. White, Eds.) Cambridge: Cambridge University Press.

Nelson, R., Kokic, P., Crimp, S., Meinke, H and Howden, S. M. (2010a). The Vulnerability of Australian Rural Communities to Climate Variability and Change: Part I: Conceptualizing and Measuring Vulnerability. *Environmental Science and Policy, 13,* 8 - 17.

O’Brien, K., R. Leichenko, U. Kelkar, H. Venema, G. Aandahl, H. Tompkins, A. Javed, S. Bhadwal, S. Barg, N. Nygaard, and J. West (2004). *Mapping Vulnerability to Multiplestressors: Climate Change and Globalization in India. Global Environmental Change 14(4): 303–313.*

Ondo State Government (2012). Ondo State Profile. *en.wikipedia.org/wiki/Ondo_State*.

Ondo State Government (2014). Ondo State Profile *en.wikipedia.org/wiki/Ondo_State*.

Onyeneke, R.U, Emenekwe, C.C, Munonye, J.O, Nwajuiba, C.A, Uwazie, U.I, Amadi, M.U, Izuogu, C.U, Njoku, C.L and Onyeneke, L.U (2020). Progress in Climate-Agricultural Vulnerability Assessment in Nigeria. Article in Atmosphere. February, 2020. Doi: 10.3390jatmos 11020190.

World Bank (2007). Ethiopia Climate Fact Sheet: site resources.worldbank.org//Ethiopia_ Country_Note.pdfs.