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SPATIAL VULNERABILITY OF RURAL HOUSEHOLDS TO CLIMATE CHANGE IN NIGERIA:

IMPLICATIONS FOR INTERNAL SECURITY

By Ignatius A. Madu

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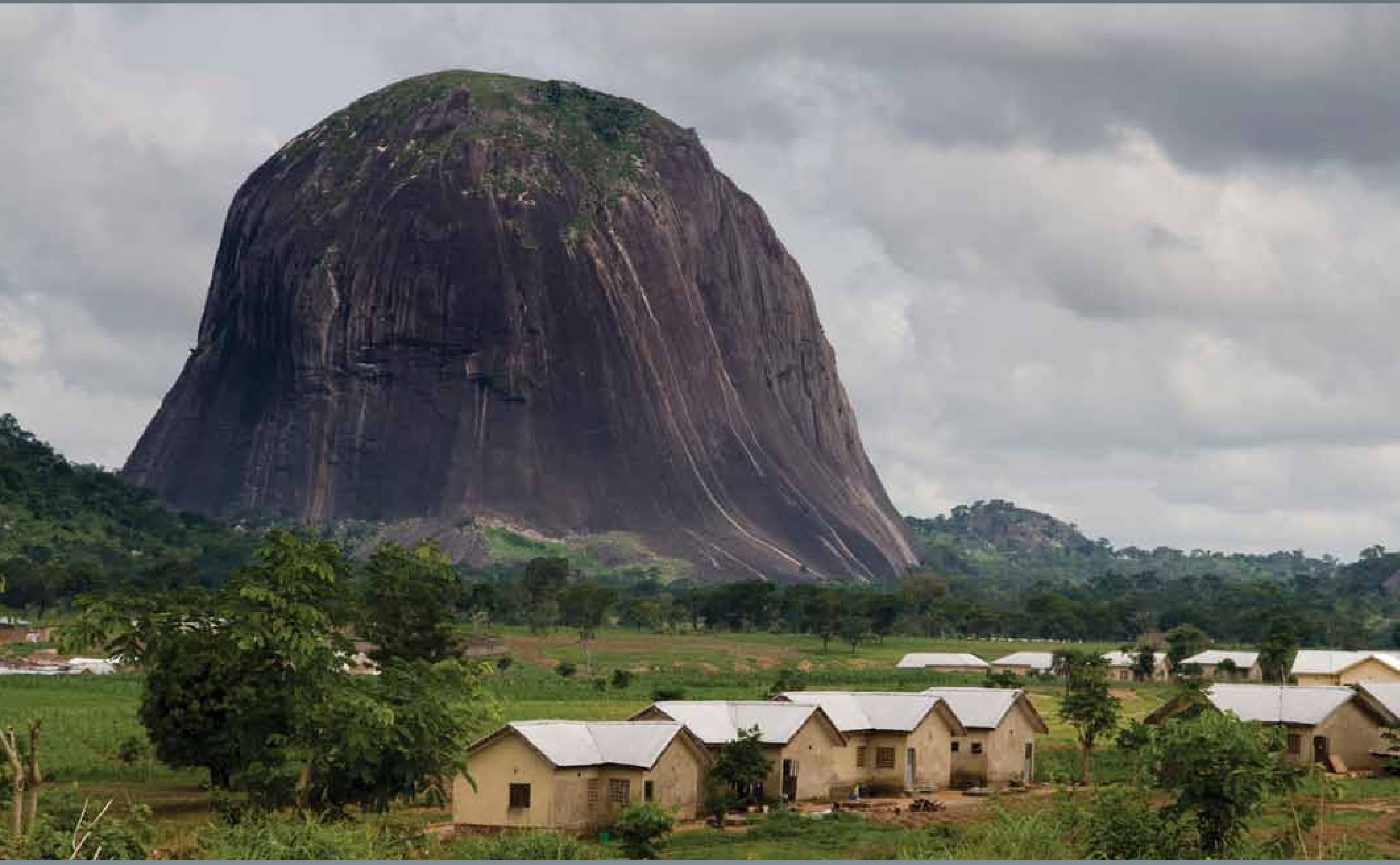

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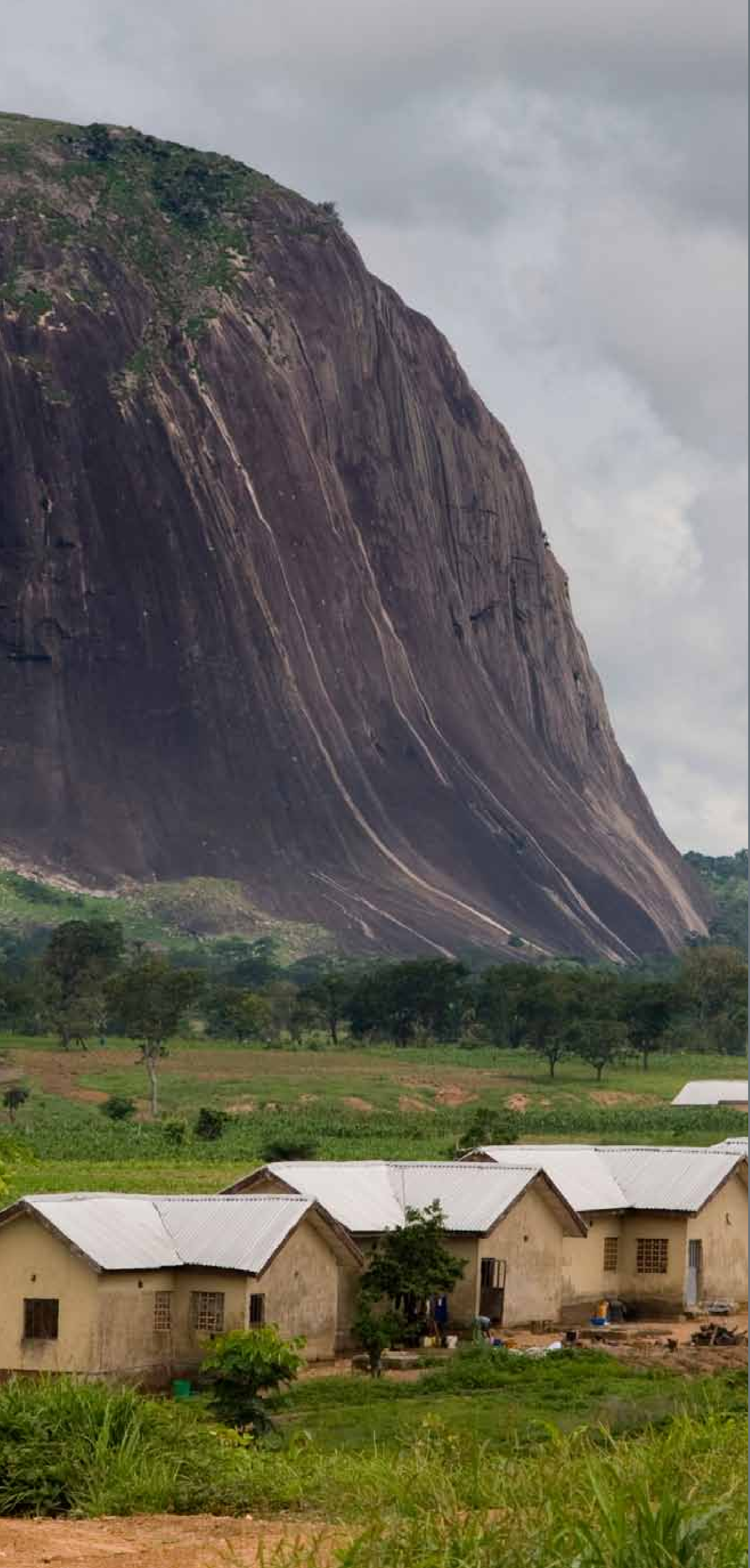

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ABOUT THE AUTHOR

Dr. Ignatius A. Madu is a Professor of Geography at the University of Nigeria, Nsukka and a Coordinator of Programme at the Centre for Environmental Management and Control (CEMAC) at the Enugu campus of the University. His university teaching and research span over one and half decades with special interests on environmental management, population and development, rural development, and climate change. He has attended many local and international conferences and has published extensively in both local and international journals and publishing houses. ignatius.madu@unn.edu.ng

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EXECUTIVE SUMMARY

This study assesses the spatial patterns of vulnerability to climate change in Nigeria as a backdrop to highlighting the security implications of these patterns and underscores the need to mainstream climate change adaptation into the rural development process. Policies on climate change adaptation in the country have often been made without empirical underpinnings and, thus, without sufficient analytical rigor placed on the spatial patterns of vulnerability to climate change. To achieve this, an integrated vulnerability assessment approach was employed by classifying socioeconomic and biophysical indicators of vulnerability into adaptive capacity, sensitivity, and exposure to ascertain the degree of vulnerability of each state in Nigeria based on rural household data. The states were then grouped on the basis of similarity using hierarchical cluster analysis and mapped using 3.20a GIS software. The data for the research were obtained from Annual Abstract of Statistics 2006, General Household Survey 2006, and the Nigerian Core Welfare Indicator Questionnaire Survey (CWIQ) 2006.

The analysis of the patterns shows that there are four classes of vulnerability to climate change in the country: high, moderate, low, and very low, with average vulnerability indices of -0.01, 1.02, 2.70, and 5.04, respectively (with negative scores indicating greater vulnerability). The analysis also shows that the more vulnerable households are in the northern states which experience frequent drought and are characterized by a high degree of rurality and poor socioeconomic development. Based on the spatial picture of vulnerability to climate change and the security implications to the country, it is recommended that measures are taken to mainstream climate change adaptation into the rural development process. This could include improvement in farming technology and development of grazing reserves.

INTRODUCTION

Climate change is undoubtedly one of the greatest environmental, social, and economic threats our planet faces today (Aggarwal and Pasricha, 2011). This is why climate change attracts ever more attention from the media, academics, politicians, and businesses as evidence of its scale, rate, and seriousness mount. In fact, over the past two decades, a multitude of studies have analyzed the possible effects of climate change on a range of natural and social systems (Klein, 2004). As a result, much has been written on the ways in which unchecked climate change might negatively impact countries' prospects for sustainable development (United Nations Conference on Trade and Development [UNCTD], 2009).

The impact of climate change is, however, spatially heterogeneous across a diverse range of geopolitical scales. For instance, the risk is generally believed to be more acute in developing countries because they rely heavily on climate-sensitive sectors, such as agriculture and fisheries, and have low GDPs, high levels of poverty, low levels of education, and limited human, institutional, economic, technical, and financial capacity (Intergovernmental Panel on Climate Change [IPCC], 2007; United Nations Framework Convention on Climate Change [UNFCCC], 2007; Preston et al., 2008; German Advisory Council on Global Change [WBGU], 2004; 2008).

The implication is that vulnerability of countries and societies to the effects of climate change depends not only on the magnitude of climatic stress but also on the sensitivity and capacity of affected societies to adapt to or cope with such stress (Nigerian Environmental Study/Action Team [NEST], 2004). Therefore, vulnerability is the degree to which a system is susceptible or unable to cope with the adverse effects of climate change, including climate variability and extremes. 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).

A number of climate change impact studies have been conducted in many countries on specific sectors such as water resources, agriculture, health, coastal zones, and forestry by using impact models and to a lesser extent socioeconomic analyses (Deressa et al., 2008; Pearson and Langridge, 2008; Odjugo, 2010). The IPCC has collected data that show global warming affects weather and the environment in a number of ways (Pender, 2008). However, more work on vulnerability using an integrated assessment approach is needed, particularly in Africa at the national scale (UNFCCC, 2006). Moreover, Rishi, Omprakash, and Mudaliar (2010) have shown that there is a pressing need to address issues related to climate change adaptation, vulnerability, and coping in developing nations as these regions have the largest deficiencies in adaptive capacity.

An analysis of vulnerability to climate change is needed at the level that would enable policy makers to tackle climate change problems with the precision that is necessary (Klein, 2004). After all, it is by understanding, planning for, and adapting to a changing climate that individuals and societies can take advantage of opportunities and reduce risks (USAID, 2007). This is particularly necessary in Nigeria, the most populous country in Africa and 7th in the world with 162 million people, of which 51 percent reside in rural areas (Population Reference Bureau, 2011). More importantly, there is no national-level analysis of climate change vulnerability that provides the spatial picture that is needed to understand where and how climate change might constitute a threat to security in the country (Busby et al., 2010), even though studies indicate that Nigeria lies within a high vulnerability region in Africa (Sahel and West Africa Club/OECD, 2009; Busby at al., 2010).

It is against this background that this research sets out to determine quantitatively the magnitudes and patterns of rural households' vulnerability to climate change in Nigeria. The purpose is to determine the degree of exposure of rural households and their sensitivity and adaptive capacity to climate change in the country. The objective is to highlight the security implications of the vulnerability patterns and to provide the basis for the design and mainstreaming of climate change adaptation into the country's rural development process.

CONCEPTUAL FRAMEWORK

Vulnerability can be conceptualized in many different ways along a continuum from outcome to contextual vulnerability. Outcome vulnerability is characterized by the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Contextual vulnerability assesses the susceptibility of a system to disturbances determined by exposure, sensitivity, and the capacity to adapt to climate change (IPCC, 2001). Furthermore, vulnerability is influenced by both physical and socioeconomic characteristics, which are not static. This implies that vulnerability is specific to place, context, time, and the perspective of those assessing it. As a result, there can be no single, unified, or general-purpose approach to conceptualizing vulnerability (Pearson and Langridge, 2008).

There are, however, three major conceptual approaches to analyzing vulnerability to climate change, namely: the socioeconomic, the biophysical, and the integrated assessment approaches.

Socioeconomic Approach

The socioeconomic vulnerability assessment approach focuses on the socioeconomic and political status of individuals or social groups. Individuals in a community often vary in terms of education, gender, wealth, health status, access to credit, access to information and technology, formal and informal (social) capital, political power, and so on, which are responsible for the variations in vulnerability levels (Füssel, 2007; Deressa, Hassan, and Ringler, 2008). Consequently, vulnerability is considered to be a starting point or a state that exists within a system before it encounters a hazard event (Kelly and Adger, 2000). In this regard, vulnerability is constructed by society as a result of institutional and economic changes. This explains why the socioeconomic approach focuses on identifying the adaptive capacity of individuals or communities based on their internal characteristics.

TABLE 1: Variables Used in the Analysis

No.	Indicator	Variable	Conceptual Basis	Source
1	Ownership of livestock	Wealth	Adaptive capacity	CIWQ 2006
2	Ownership of radio	Wealth	Adaptive capacity	CIWQ 2006
3	Ownership of canoe	Wealth	Adaptive capacity	CIWQ 2006
4	Quality of house	Wealth	Adaptive capacity	CIWQ 2006
5	Insecticide and pesticide supply	Technology	Adaptive capacity	CIWQ 2006
6	Fertilizer supply	Technology	Adaptive capacity	CIWQ 2006
7	Improved seeds supply	Technology	Adaptive capacity	CIWQ 2006
8	Health services	Infrastructure	Adaptive capacity	ABS 2006
9	Telephone services	Infrastructure	Adaptive capacity	ABS 2006
10	Access to food market	Infrastructure	Adaptive capacity	CIWQ 2006
11	Irrigation potential	Infrastructure	Adaptive capacity	CIWQ 2006
12	Literacy rate	Education	Adaptive capacity	ABS 2006
13	Use of stove	Wealth	Adaptive capacity	CIWQ 2006
14	Non-farm employment	Wealth	Adaptive capacity	ABS 2006
15	Access to public transport	Infrastructure	Adaptive capacity	CIWQ 2006
16	Household size	Household characteristics	Adaptive capacity	ABS 2006
17	Access to large farmland	Infrastructure	Adaptive capacity	CIWQ 2006
18	Access to improved water source	Infrastructure	Adaptive capacity	CIWQ 2006
19	Household income	Wealth	Adaptive capacity	ABS 2006
20	Primary and secondary school enrollment	Education	Adaptive capacity	GHS 2006
21	Availability of electricity	Infrastructure	Adaptive capacity	ABS 2006
22	Temperature variation	Climate change	Sensitivity	Computed from ABS 2006
23	Rainfall variability	Climate change	Sensitivity	Computed from ABS 2006
24	Drought	Climate extreme	Exposure	Dummy
25	Flood	Climate extreme	Exposure	Dummy

Source: Annual Abstract of Statistics (ABS) 2006, General Household Survey (GHS) 2006, Nigerian Core Welfare Indicator Questionnaire Survey (CWIQ) 2006.

One major limitation of the socioeconomic approach is that it focuses only on variations within society, but in reality, societies vary not only due to sociopolitical factors but also to environmental factors. Secondly, it does not account for the availability of natural resource bases to potentially counteract the negative impacts of these environmental shocks. For example, areas with easily accessible underground water can better cope with drought by utilizing this resource (Deressa, Hassan, and Ringler, 2008).

Biophysical Approach

The biophysical approach assesses the level of damage that a given environmental stress causes on both social and biological systems. It is sometimes known as an impact assessment. The emphasis is on the vulnerability or degradation of biophysical conditions (Liverman, 1990). It is a dominant approach employed in studies of vulnerability to natural hazards and climate change (Hewitt, 1995). Füssel (2007) identified this approach as a risk-hazard approach.

The biophysical approach, although very informative, has its limitations. A major limitation is that the assessment of biophysical factors is not a sufficient condition for understanding the complex dynamics of vulnerability. It also neglects structural factors and human agency both in producing vulnerability and in coping or adapting to it. The approach overemphasizes extreme events while neglecting root causes and everyday social processes that influence differential vulnerability (Liverman, 1990; Hewitt, 1995; Pulwarty and Riebsame, 1997).

Integrated Assessment Approach

The integrated assessment approach combines both socioeconomic and biophysical approaches to determine vulnerability. The IPCC (2001) definition—which conceptualizes vulnerability to climate as a function of adaptive capacity, sensitivity, and exposure—accommodates the integrated approach to vulnerability analysis (Füssel, 2007; Füssel and Klein, 2006). According to Füssel and Klein (2006), the risk-hazard framework (biophysical approach) corresponds most closely to sensitivity in the IPCC terminology while the adaptive capacity (broader social development) is largely consistent with the socioeconomic approach. Furthermore, in the IPCC framework, exposure has an external dimension, whereas both sensitivity and adaptive capacity have an internal dimension, which is implicitly assumed in the integrated vulnerability assessment framework (Füssel, 2007).

Although the integrated assessment approach corrects the weaknesses of the other approaches, it also has its limitations. The main limitation is that there is no standard method for combining the biophysical and socioeconomic indicators. This approach uses different datasets, ranging from socioeconomic datasets to biophysical factors. These datasets certainly have different yet unknown weights (Cutter, Mitchell, and Scott, 2000). The other weakness of this approach is that it does not account for the dynamism in vulnerability. Despite its weaknesses, the approach has much to offer in terms of policy decisions (Deressa, Hassan, and Ringler, 2008). Vulnerability in this context is a physical risk and a social response within a defined geographic territory (Dolan and Walker, 2004). As a result, several studies have integrated in some way both physical and social vulnerability perspectives (Wu, Yarnal, and Fisher, 2002).

This study thus analyzes the vulnerability to climate change based on the integrated vulnerability assessment approach. This is done by employing vulnerability indicators which consist of different socioeconomic and biophysical attributes of the 36 states and Federal Capital Territory (FCT) in Nigeria. Consequently, the different socioeconomic and biophysical indicators are classified into adaptive capacity, sensitivity, and exposure based on the IPPC definition of vulnerability (IPCC, 2001).

METHODS

The data for the research were obtained from diverse sources. Adaptive capacity data were obtained from Nigerian Annual Abstract of Statistics 2006, General Household Survey 2006, and the Core Welfare Indicator Questionnaire Survey (CWIQ) 2006 on the basis of availability and were calculated as percentages. The variables were based on rural household data aggregated at state levels. The exposure variables used were coastal/river floods and drought. Data were not available at the state level and therefore dummies were used. Thus, values of 1 or 0 were assigned to a state depending on whether it lies on a coastal/major river flood plain area or is located in the dry Sahel region, respectively. Values were determined from physical maps of the country. The dummies are, therefore, expected to have negative effects on a state's ability to withstand climate change impacts. The sensitivity variables used were rainfall variability and change in temperature, which were represented by the coefficient of variation (calculated as the standard deviation divided by the mean expressed as a percentage) and annual temperature range, respectively. The data for the two variables were obtained from the Annual Abstract of Statistics of 2006. Again, the variables were aggregated at state levels. The variables are listed in Table 1.

The data were normalized by converting them into natural logarithms and were then analyzed in stages. This was done in order to combine the variables denominated in different units. The first stage of analysis was the descriptive analysis of the socioeconomic and environmental characteristics that describe the adaptive capacity, sensitivity, and exposure of the states to climate change. Second, the vulnerability indices were obtained by applying Principal Component Analysis (PCA) on the adaptive, sensitivity, and exposure variables. PCA is frequently used in research that constructs indices for which there are no well-defined weights, such as asset-based indices used for the measurements of wealth across different social groups (Sahn and Stifel, 2002). The argument here is that, as with the asset-based indices for wealth comparison, there are no well-defined weights assigned to the vulnerability indices used for this study. Therefore, PCA generated the weights, the assumption being that there is a common factor that explains the variance in the vulnerability. Intuitively, the first principal component of a set of variables is the linear index of all the variables that captures the largest amount of information common to all the variables (Deressa, Hassan, and Ringler 2008). Accordingly, the first component scores from the PCA were allowed to define that as a weighted sum of the individual variables given as follows:

$$V = (Wa1X1 + Wa2X2 + Wa3X3....WanXn) - (Ws1Y1 + Ws2Ys + WelZ1 + We2Z2)$$

Where V is vulnerability, while X, Y and Z are adaptive capacity, exposure, and sensitivity, respectively, and W is the first component score of each variable. Therefore, Equation 1 simply stated implies that:

$$\text{Vulnerability} = (\text{adaptive capacity}) - (\text{sensitivity} + \text{exposure})$$

In calculating the direction of relationship in vulnerability indicators (i.e., their sign), a negative value was assigned to both exposure and sensitivity. The justification is that areas that are highly exposed to damaging climate are more sensitive to damages, assuming constant adaptive capacity (Deressa, Hassan, and Ringler, 2008). The implication is that a higher net value indicates lesser vulnerability and vice versa. Finally, cluster analysis was performed on the vulnerability indices to group the states according to their degree of similarity in vulnerability, using Ward's (1963) method of agglomeration, and then pattern mapped using 3.20a GIS software.

RESULTS

The results of the descriptive statistics indicate that the socioeconomic variables vary widely within the states, with the highest range recorded for electricity, availability of telephone services, access to large farmlands, and ownership of canoes. This is an indication of disparity in natural endowment and in the provision of infrastructure in rural areas of the country. The variations in the sensitivity variables are also remarkable. For example, an analysis of the temperature range shows that Adamawa experiences the highest range of 11.60, while the lowest annual range of 0.50 is recorded in Osun. Furthermore, the pattern of temperature variations shows that the northern states generally experience a higher annual range of temperature than the southern states.

The result of the Principal Component Analysis shows six components with eigenvalues of 1 or above, accounting for 74.36 percent of the total variance. The first component has an eigenvalue of 7.38 and accounts for 29.53 percent of the total variance, followed by the second component with an eigenvalue of 4.45 and percentage explanation of 17.83 (Table 2). The analysis also produced the component scores, and as earlier stated, only the component scores of the first component were used in weighting the variables. This was done by multiplying each variable by the corresponding component score as earlier shown in equation 1. The component scores used in weighting the variables are shown in Table 3.

TABLE 2: Total Variance Explained by Principle Component Analysis

Component	Initial eigenvalues			Extraction sum of squared loading			Rotation sum of squared loading		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7.385	29.539	29.539	7.385	29.539	29.539	6.900	27.598	27.598
2	4.458	17.832	47.371	4.458	17.832	47.371	4.276	17.104	44.702
3	2.303	9.212	56.583	2.303	9.212	56.583	2.036	8.145	52.847
4	1.745	6.981	63.564	1.745	6.981	63.564	2.033	8.132	60.979
5	1.534	6.138	69.702	1.534	6.138	69.702	1.920	7.680	68.659
6	1.167	4.668	74.369	1.167	4.668	74.369	1.428	5.710	74.369

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

TABLE 3: Component Scores Used for Constructing the Vulnerability Indices

Indicator	Component score
Rainfall variability	.155
Ownership of canoe	.143
Irrigation potential	.102
Telephone services	.094
Availability of electricity	.063
Access to food market	.062
Access to large farm land	.039
Drought	.035
Non-farm employment	.024
Fertilizer supply	.019
Improved seeds supply	.019
Quality of house	.018
Temperature variation	.002

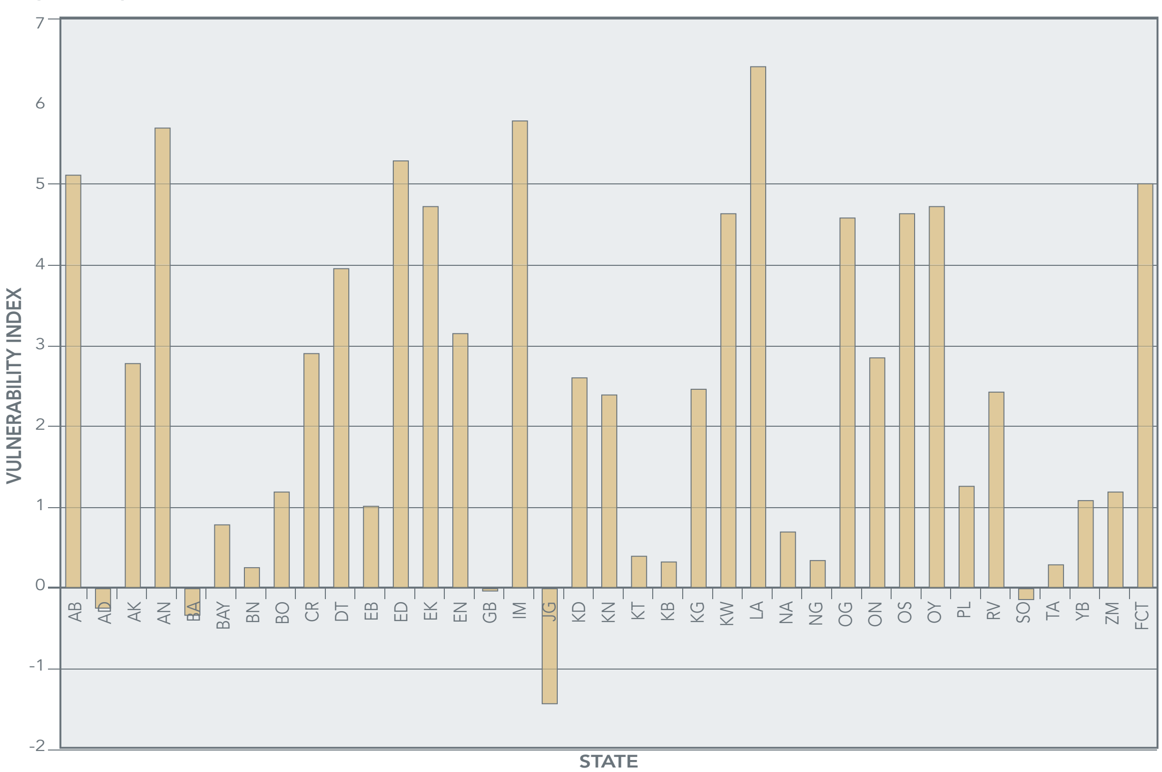
Indicator	Component score
Temperature variation	.002
Health services	.000
Ownership of radio	-.020
Household income	-.034
Insecticide supply	-.036
Access to public transport	-.042
Use of stove	-.051
Flood	-.053
Household size	-.063
Primary and secondary school enrollment	-.110
Access to improved water source	-.137
Ownership of livestock	-.155
Literacy rate	-.158

The calculations of the vulnerability indices show that generally the majority of the states have moderate to low vulnerability. This is line with the recent mapping by Busby, Smith, and White (2011) which places Nigeria among the countries that have low vulnerability to climate change relative to other African countries. However, some states are in a better position to withstand climate change than others (Table 4 and Figure 1). Thus, Lagos, Imo, Anambra, Abia, and FCT with indices of 6.44, 5.79, 5.69, 5.11, and 5.02, respectively, are less vulnerable. The most vulnerable states on the other hand, are Jigawa (-1.43), Bauchi (-0.31), Adamawa (-0.23), Sokoto (-0.14), and Gombe (-0.03). These states are all located in the north, a region with low scores in the socioeconomic variables investigated. This supports an earlier finding which shows that the northern, drier regions are more vulnerable than the southern, wetter, coastal zone as a result of higher levels of poverty, child dependence burden, low health status, and low levels of educational attainment which impose limits on adaptive capacity (Adejuwon, 2006).

TABLE 4: Degree of Rural Households' Vulnerability to Climate Change in Nigeria

No.	State/FCT	Index	Degree of vulnerability
1	Jigawa	-1.43	High
2	Bauchi	-.31	High
3	Adamawa	-.23	High
4	Sokoto	-.14	High
5	Gombe	-.03	High
6	Benue	.25	High
7	Taraba	.28	High
8	Kebbi	.34	High
9	Niger	.35	High
10	Katsina	.40	High
11	Nassarawa	.70	Moderate
12	Bayelsa	.78	Moderate
13	Ebonyi	1.03	Moderate
14	Yobe	1.01	Moderate
15	Borno	1.18	Moderate
16	Zamfara	1.19	Moderate
17	Plateau	1.27	Moderate
18	Kano	2.38	Low
19	Rivers	2.42	Low
20	Kogi	2.47	Low
21	Kaduna	2.60	Low
22	Akwa Ibom	2.78	Low
23	Ondo	2.85	Low
24	Cross River	2.92	Low
25	Enugu	3.16	Low
26	Delta	3.96	Very low
27	Ogun	4.39	Very low
28	Kwara	4.63	Very low
29	Osun	4.64	Very low
30	Oyo	4.71	Very low
31	Ekiti	4.72	Very low
32	FCT	5.02	Very low
33	Abia	5.11	Very low
34	Edo	5.32	Very low
35	Anambra	5.69	Very low
36	Imo	5.79	Very low
37	Lagos	6.44	Very low

FIGURE 1: Graphical Illustration of Rural Households' Vulnerability to Climate Change in Nigeria by States and the FCT



The results of the cluster analysis indicate that there are four categories of vulnerability (Table 5). The first category (Cluster A), which comprises 10 states with an average vulnerability index of -0.01, is relatively the most vulnerable. The states in this category are all in the north and usually experience frequent incidence of drought. They are also characterized by low levels of technology and education as well as poor infrastructural facilities. The second category (Cluster B) has seven states consisting of five northern states of Borno, Nassarawa, Plateau, Yobe and Zamfara, as well as Bayelsa and Ebonyi states in the south. The group has an average index of 1.02 and the states here have low positive values and are described as moderate vulnerability states. They, like the first group, are also characterized by low levels of technology and education and poor infrastructural facilities. Furthermore, the five northern states have moderate vulnerability because they like the first group experience frequent incidence of drought.

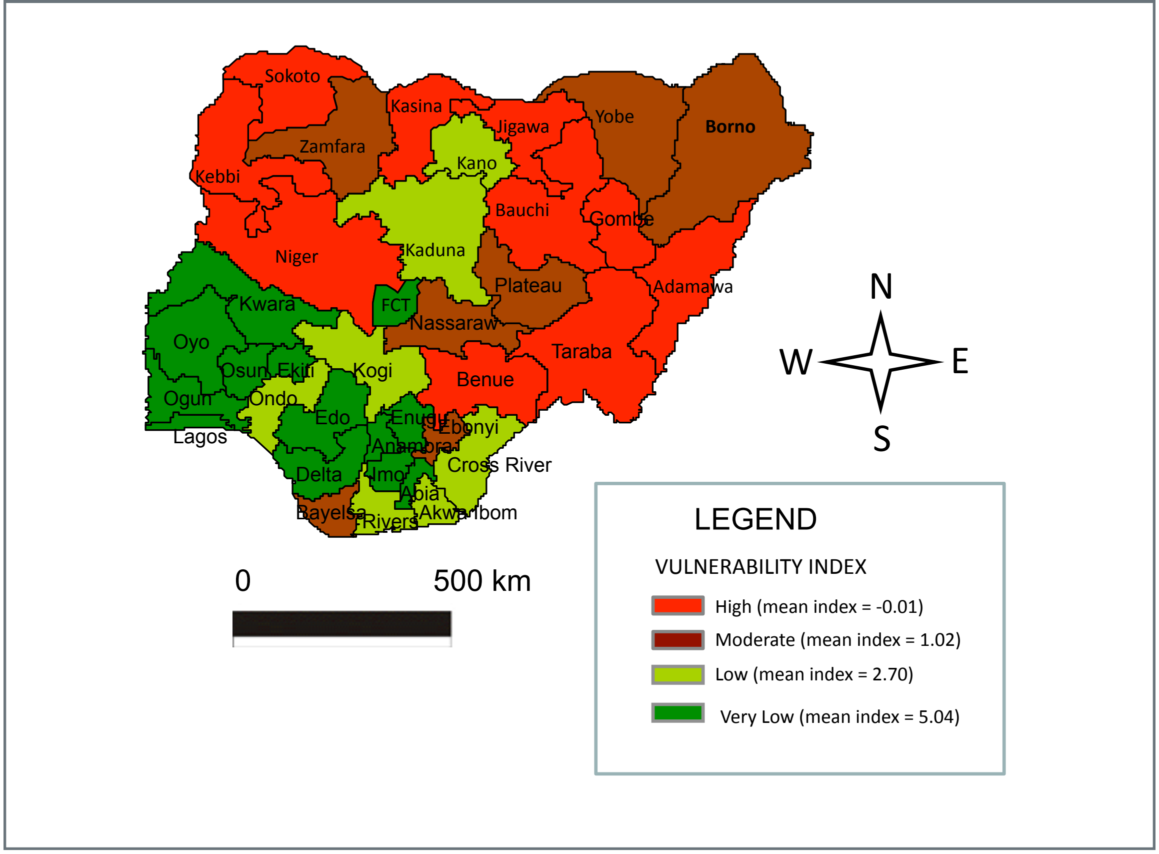
TABLE 5: A Summary of Results of the Cluster Analysis on Vulnerability by States and The FCT

Cluster A High vulnerability (Mean index = -0.01)	Cluster B Moderate vulnerability (Mean index = 1.02)	Cluster C Low vulnerability (Mean index = 2.70)	Cluster D Very low vulnerability (Mean index = 5.04)
Benue	Borno	Kano	Anambra
Taraba	Zamfara	Rivers	Imo
Kebbi	Plateau	Kogi	Lagos
Niger	Ebonyi	Kaduna	Abia
Katsina	Yobe	Akwa Ibom	FCT
Adamawa	Bayelsa	Ondo	Edo
Bauchi	Nassarawa	Cross River	Ekiti
Gombe		Enugu	Oyo
Sokoto			Kwara
Jigawa			Osun
			Ogun
			Delta

The relatively moderate vulnerability of Bayelsa state, located in the oil rich Niger Delta, to climate change is a result of lack of development in the state. Although other states in the region like Delta and Rivers suffer similar environmental and social problems, their relatively higher levels of industrialization, population concentration, and infrastructures development make them less vulnerable than Bayelsa.

The third and fourth categories (Clusters C and D) are made up of 8 and 12 states with average indices of 2.70 and 5.04, respectively. The states in these groups are the least vulnerable to climate change in the country given their high positive indices. They are experiencing low to very low vulnerabilities to climate change because of high literacy rates, high household incomes, and access to infrastructure and technology. They are also characterized by high degrees of non-farm employment. The diversification of economic activities and access to infrastructure and technology, particularly in the fourth group, makes the households less reliant on agriculture which is more sensitive to climate change. It is also important to note that, although flood occasionally occurs in these states, drought rarely occurs, which explains why they are less vulnerable to climate change. The pattern is shown in Figure 2.

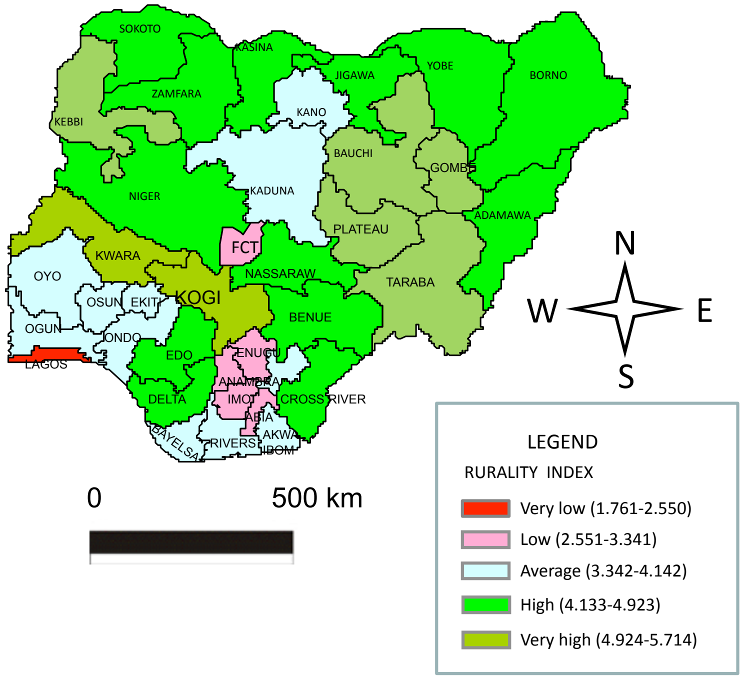
FIGURE 2: Patterns of Rural Households' Vulnerability to Climate Change in Nigeria



Source: Madu 2012

The degree of vulnerability shows close similarity with the degree of rurality in Nigeria. The pattern indicates that the northern states have higher degrees of rurality described in terms of low population density, extensive utilization of land, and exhibition of distinctive sociocultural characteristics that are associated with rural settings (Madu, 2010). Consequently, the map of rurality in Nigeria (Figure 3) shows that most of the states in the north are in the high to very high categories of rurality (Madu, 2010). The results are also in line with earlier findings by FAO and OEDC (2007) which show that 50 to 80 percent of the northern states in Nigeria are predominantly rural while the majority of the southern states are less than 15 percent rural. The higher degree of rurality is an indication that the north relies more heavily on agriculture, a climate-sensitive sector, which is the dominant occupation in rural areas of Nigeria. It has also been shown that the northern Nigeria has a lower GDP, high levels of poverty, and lower levels of education (Erubami and Young 2003; Madu, 2009). All of this accounts for the higher vulnerability to climate change in northern Nigeria.

FIGURE 3: Degree of Rurality in Nigeria by States and the FCT



Source: Madu 2010

SECURITY IMPLICATIONS FOR NIGERIA

Climate change may pose threats to the security situation in a country through increasing water scarcity, decreasing food security, increasing climate-induced migration, and increasing poverty (Madu and Ayogu, 2009a). As a result, climate change is now a top agenda item for the global security community (Madu, 2011). In particular, rainfall has a key influence on the prevalence of social conflict. As the new Social Conflict in Africa Database (SCAD) has revealed, conflict events have been more common in extremely wet and dry years than in years of normal rainfall (Hendrix and Salehyan, 2011).

Consequently, the pattern of vulnerability to climate change in Nigeria poses a number of security implications for the country. The pattern indicates that the most vulnerable states are the least developed and are mostly found in the northern geo-political regions of the country. This is unfortunate because a greater proportion of food crops, particularly grain crops, grown in Nigeria are found in the north (National Bureau of Statistics, 2009). Therefore, the high vulnerability of states in northern Nigeria to climate change poses a serious threat to food security in the country.

Again, the pattern is an indication of an existence of a widespread spatial inequality in the country. Spatial inequality refers to uneven distribution of income or other welfare indicators across different spatial locations (Kanbur, Venables, and Wan, 2003). Spatial inequality influences conflict and, in the case of Nigeria, poses severe threats to security because it coincides with the divisions of socioeconomic groups based on different ethnicities and religions (Madu, 2006). This study has again emphasized that in terms of the distribution of socioeconomic variables, the northern states are disadvantaged.

Furthermore, climate change poses a security threat to Nigeria through conflict over resources. Presently, increasing water scarcity, decreasing crop yields, and increasing climate-induced migration are being experienced in many parts of the country. For instance, it has been shown that about 80 percent of the households in Taraba state have access to less than 30 liters of water per person per day and that, because of low water availability, there is a prevalence of water-related diseases (Uzomah and Scholz, 2007). For the entire country, Benoit (2009) shows that less than 65 percent of the population has access to an improved water supply.

Similarly, decreasing crop yields in the country have been linked to climate change, among other factors (Madu and Ayogu, 2009a). The overall effect is that climate change could fuel existing conflicts over depleting resources in the country. This may also explain in part why struggles over grazing lands are a common feature between the migrating Fulani herdsmen and crop farmers in Nigeria. In fact, conflict between farmers and Fulani herdsmen claims lives and properties in many parts of the country, especially in the northern parts. The migration is a result of the pattern and variability of rainfall in the country. In Benue state, for example, the Tivs have experienced a number of violent conflicts with Fulani nomads over grazing lands (Madu and Ayogu, 2009b).

The high degree of vulnerability of rural households to climate change in some states may likely exacerbate rural-urban migration in the country. This is particularly worrisome since urbanization in Nigeria is mostly fueled by rural-urban migration as a result of rural-urban imbalance in development (Nwafor and Madu, 2002). This may result in many negative consequences including conflicts and security threats. For example, if a large proportion of the rural-urban migrants fail to realize their expectations, they may end up having to face life in urban slums, where they will likely find things much more difficult than their villages. This may lead a number of them into crimes thereby increasing the security problems of urban centers in the country.

Finally, it has been shown that rainfall variability resulting from climate change brings about decreased yield of some crops in Nigeria (Madu and Ayogu, 2009a). The reduction in crop yields may lead to falling agricultural production and higher prices for food, which could trigger regional food crises. This may lead to greater food insecurity in the country. Consequently, the pattern of vulnerability to climate change in Nigeria is very worrisome because, as already noted, the more vulnerable states are the major food producing states.

RECOMMENDATIONS

There is a general consensus that climate change is best addressed in the context of sustainable development (OECD, 2009). This implies that, while in certain situations stand-alone adaptation measures will be needed, in most other cases these measures will need to be implemented as part of a broader suite of measures within existing development processes and decision cycles. In this regard, the following practical steps for mainstreaming climate change adaptation into rural development process in the country are suggested.

1) Integrate climate change adaptation into agriculture and rural development plans: Development planning is the process of setting goals for human and economic development, and designing strategies to achieve these goals through the allocation and management of human, financial, and natural resources (OECD, 2009). Rural development plans in particular focus on the distribution and management of natural resources in sustainable production systems and associated human resource development, in addition to the effective delivery of public services. The aim is to protect and strengthen rural livelihoods, contributing to poverty reduction and economic development at all scales. Climate change considerations including knowledge about climate risks, local vulnerability, and coping experiences need to be incorporated into rural planning processes. The process of integrating climate change adaptation into agriculture and rural development plans is currently lacking in Nigeria and should be given urgent attention by its federal government.

2) Pursue the development of grazing reserves: To combat climate change and to forestall the possibility of a catastrophe from conflicts between herdsmen and farmers, it is necessary that the federal, state, and local governments in Nigeria pursue the development of grazing reserves in their respective domains. Limited grazing reserves and pressure from farmers have often forced Fulanis to move in search of pasture which has often resulted in conflict.

3) Adopt improved land clearing methods: A technique that is being increasingly applied to maintain farmland productivity in the dry regions in other countries of Africa is that of improved land clearing. It is a technique that cultivates land without completely depleting soil resources by allowing some shrubs and small trees to grow together with the crops in the farm (Sahel and West Africa Club/OECD, 2009). In particular, at least two to three shoots (sap drawer) per shrub or small tree are left while doing the clearing in order to facilitate the re-growth of vegetation. These techniques can be popularized in Nigeria using agricultural extension agents to demonstrate their operations to farmers.

4) Improve farming technology: There is a need for farmers in the country to improve on their technology. This will include changes in crop management practices like increased irrigation water, increased fertilizer application, use of pesticide, and improved seedling and disease control. Also, the use of traditional soil protection techniques are recommended, including digging pits (compost-filled planting pits which hold water and help crops grow), building up grass and rock barriers around crops to protect them from soil erosion, and using compost manure to fertilize the soil.

5) Encourage rural land use change: Land use change in places where the threat of climate change makes the continuation of an economic activity impossible or extremely risky should be encouraged. For instance, rural dwellers in drought-prone northern Nigeria should resort to more drought-tolerant crops like millet or switch to varieties with lower moisture requirement. In the same way, crop land may be returned to pasture or forest or other uses may be found such as recreation, wildlife refuges, or national parks.

6) Raise awareness and utilize targeted messaging on climate change: Farmers and rural dwellers should know why they might have to make different decisions. Thus, they need to know about the changing risk context, how it may affect them, and what they can do to prepare and protect themselves. Awareness should be raised in rural areas on climate change and adaptation using appropriate communication tools such as local radio, drama, flyers, posters, workshops, video, town criers, and so on. Town hall meetings where climate change issues can discussed should also be organized.

CONCLUSION

The analysis of the pattern of rural areas' vulnerability to climate change in Nigeria has shown that, generally, the northern states are more vulnerable to climate change than the southern states. This results from the greater exposure to drought and climate extremes as well as low levels of technology and socioeconomic and infrastructure development found in the north.

One major contribution of this paper is that by providing the spatial picture of vulnerability of states in Nigeria to the effects of climate change, it provides policymakers and other stakeholders the framework for policy and evidence-based climate change adaptation measures. Furthermore, one of the strategically important issues in the context of the environment-human security relationship is the geography of insecurity resulting from environmental change. Climate change is an aspect of such environmental change, which not only poses security challenges in many regions of the world but also undermines the economic and political stability of many parts of the world. An examination of the patterns of vulnerability to climate change is an important step in analyses of such climate change impacts on security.

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