Spatial vulnerability assessments of rural households to climate change in Nigeria: Towards evidence-based adaptation policies

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ABSTRACT

The ability to identify and understand the extent of vulnerability to climate change is an essential pre-requisite for reducing climate change impacts. This is because a reasonable starting point for any climate adaptation process is to assess the vulnerability of the target community or stakeholders. Consequently, the study assesses the spatial patterns of vulnerability to climate change in Nigeria in order to provide empirical evidence necessary for climate change adaptation policies and strategies in the country. The data for the research were obtained from Annual Abstract of Statistics 2009, General Household Survey 2006 and the Nigerian Core Welfare Indicator Questionnaire Survey (CWIQ) 2006. An integrated assessment approach was employed to analyse vulnerability of rural households' data comprising socio-economic and biophysical indicators aggregated at state levels. The results show that rural households in the northern states are more vulnerable because of greater exposure to climate induced environmental hazards and low adaptive capacity which results from poor local economies, inadequate healthcare and education systems and poor infrastructure. Based on the results of the assessment, measures to prioritise and target the vulnerable states for appropriate climate change adaptation within the context of sustainable rural development were suggested.

Key words: Adaptation**,** Climate change, Nigeria, spatial vulnerability and sustainable rural development.

INTRODUCTION

The world's climate has always been changing between hotter and cooler periods due to various factors. Recent evidence and projections however, indicate that the changes are accelerating and will lead to wide-ranging shifts in climate variables (Madu, 2012) .Obviously, the foremost evidence for world- wide climate change has been global warming (United Nations Conference on Trade and Development (UNCTD, 2009). According to Karl et al. (2009), there is growing scientific evidence that global warming due to greenhouse gas emission is causing climate change at an alarming rate thereby posing serious challenge to social, economic and ecological system across the globe.

Similarly, Agawam and Pasricha (2011) are of the opinion that the warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperature, widespread melting of snow and ice, and rising global mean sea level. These changes are in-turn likely to drive changes in the ecosystems upon which billions of people depend for their livelihoods and well-being (Nath and Behera, 2011).

It is to a large extent perceived that the poorest people in developing countries are going to be worst affected as they are heavily dependent on climate sensitive sectors (Nanda 2009). Also, Mani et al. (2008) opine that the poorest countries and communities are likely to suffer the most because of their geographic location, low income and low institutional capacity, as well as their greater reliance on climate sensitive sectors like agriculture. Moreover, ecologically fragile areas are more prone to stresses created by climate change and it is more so for the marginalized communities, who are dependent upon nature-based resources (Nath and Behera, 2011). It has also been shown that even within regions or sectors, extent of

vulnerability varies because their adaptation to multiple stresses differ (IPCC 2001, Acosta-Michlik and Espaldon 2008).

Vulnerability is a central concept in climate change research and policy. Recently, policy interest in vulnerability research has increased, particularly now that climate change impacts are being observed and so that developing and implementing adaptation policy has become a policy priority (IPCC, 2007).As a result, a number of climate change impact studies have been carried out on specific sectors, in many countries on most vulnerable sectors such as water resources, agriculture, health, coastal zones and forestry, using impact models and to a lesser extent, using socio-economic analyses(Deressa ,et al,2008; Pearson and Langridge, 2008; Odjugo,2010). More work on vulnerability using integrated assessment approach is however needed, particularly in Africa at the national scale (UNFCCC, 2006). In particular, 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.

Therefore, an analysis of vulnerability to climate change at the level that would enable policy makers tackle climate change problems with precision especially in developing countries is necessary since it is by understanding, planning for and adapting to a changing climate that individuals and societies can take advantage of opportunities and reduce risks (Klein, 2004,USAID, 2007) This is particularly important in Nigeria, the most populous country in Africa and 7th in the world with 160.2 million people out of which 57% resides in rural areas (Population Reference Bureau, 2011, Madu ,2012).

CONCEPTUAL FRAMEWORK

It is now widely appreciated that the changes and variations in climate system cannot be viewed in isolation from those of the human systems since it is the interplay of both natural and human systems that result in biophysical and socioeconomic impacts. The sensitivity of the system to changes in climate on the other depends on its resilience. It is the dynamic, evolving nature of the overall system that presents opportunities for adaptation (responses that lessen adverse impacts or enhance beneficial effects) and mitigation (responses that prevent the climate changes) as feed-backs over time (Warrick, 2000).

In this study, therefore, vulnerability to climate change is conceived on the basis of contextual vulnerability which assesses the degree to which geophysical, biological and socio-economic systems are susceptible to, and unable to cope with, adverse impacts of climate change (Füssel 2007, IPCC, 2007, Hinkel, 2011). Vulnerability in this context is a physical risk and a social response within a defined geographic territory and is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity'' (McCarthy et al., 2001; Dolan and Walker, 2003).

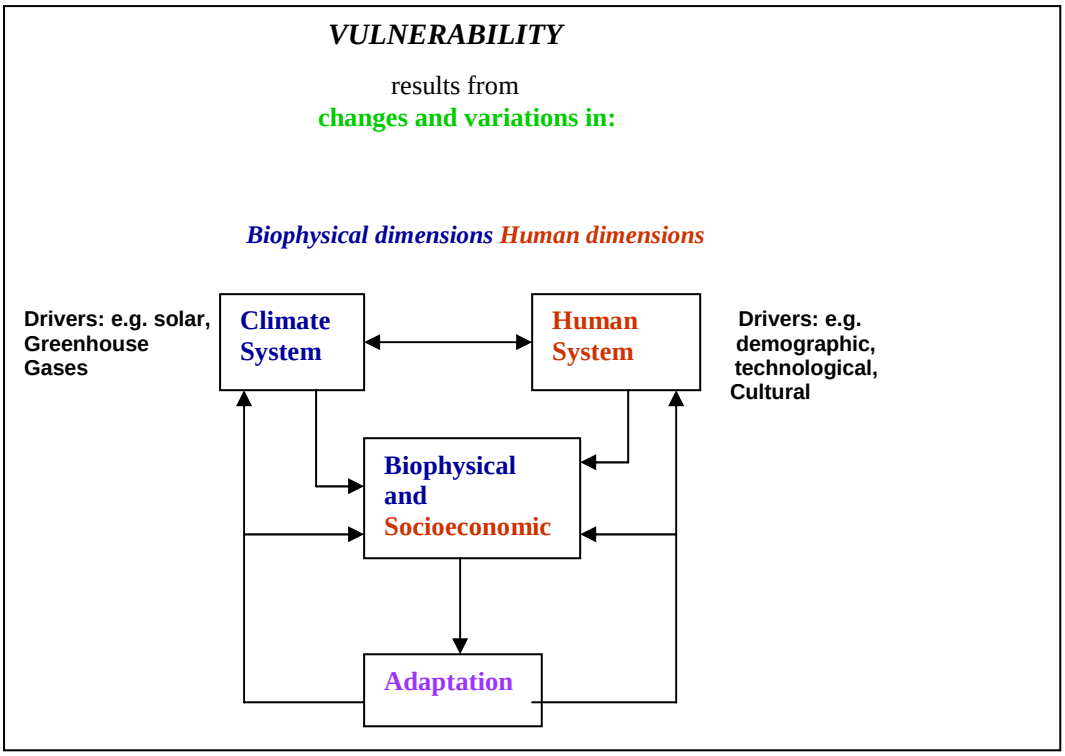

Figure 1: A conceptual framework for climate change vulnerability and adaptation
Source: Adapted from Warrick (2000)

METHODS

The study made use of secondary data obtained from Nigerian Annual Abstract of Statistics 2009, General Household Survey 2006 and the Core Welfare indicator Questionnaire Survey (CWIQ) 2006. All the variables were aggregated at state levels and an indicator method whereby different socio-economic and biophysical attributes are integrated and classified into adaptive capacity, sensitivity, and exposure was used (Table1).The data generated were normalised by converting them to natural Logarithms before analyzing them in order to be able to combine the variables since they are denominated in different units.

The first stage of analyses was the descriptive analysis of the socio-economic and environmental characteristics that describe the adaptive capacity, sensitivity and

exposure of the states to climate change. Second, Principal Component Analysis was performed to obtain the component scores, which were used to weight the variables. The purpose of using weights obtained from the PCA is to avoid the uncertainty of equal weighting, given the diversity of indicators used (Deressa, Hassan and Ringler 2008). Next, vulnerability was calculated as in Equation 1.

$$V = (Wa1X1 + Wa2X2 + Wa3X3.....WanXn) - (Ws1Y1 + Ws2Y2 + We1Z1 + We2Z2).....(1)$$

Where V is vulnerability, while X, Y and Z are adaptive capacity, exposure and sensitivity respectively and W is the weight from the component score (Madu, 2012).

In calculating the direction of relationship in vulnerability indicators (i.e., their sign), 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 (Madu, 2012). Finally, cluster analysis was performed on the vulnerability indices to group the states according to their degree of similarity in vulnerability, using Ward (1963) Method of Agglomeration and the pattern mapped using 3.20a GIS software.

Table: Variables used in the study

Adaptive Capacity	**Sensitivity**	**Exposure**
Ownership of livestock Ownership of radio Ownership of canoe Quality of house Insecticide and pesticide supply Fertilizer supply Improved seeds supply Health services Telephone services Access to Food market Irrigation potential Literacy rate Use of stove Non- farm employment Access to public transport Household size Access to large farm land Access to improved water source Household income Primary and secondary School enrolment Availability of electricity	Temperature Variation Rainfall variability	Drought Flood

Table1:Variabled used for the analysis

RESULTS

The results of the descriptive statistics show that there is an indication of disparity in natural endowment like land and in the provision of infrastructure in rural areas of the country. The variations in the sensitivity variables are also remarkable. For example, the pattern of temperature variations shows that the northern states generally, experience higher annual range of temperature than the southern counterparts.

The result of the Principal Component Analysis shows six components with Eigen value of 1 or greater accounting for 74.3% of the total variance. The first component has an Eigen value of 7.38 and accounts for 29.359%, followed by the second component with an Eigen value of 4.458 and percentage explanation of 17.832 .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 for the construction of the vulnerability indices.

The calculations of vulnerability indices show that generally, majority of the states have low vulnerability although some states are in better position to withstand climate change than others (table 2). The states with relatively lower vulnerability are Lagos, Imo, Anambra, Abia and FCT with indices of 6.44, 5.79, 5.69, 5.11 and 5.02 respectively while the most vulnerable states are Jigawa (-1.43), Bauchi (-0.31), Adamawa (-0.23), Sotoko (-0.14) and Gombe (-0.03). The high vulnerable states are all located in the north and all have low scores in socio- economic variables investigated.

The pattern of vulnerability shows close similarity with the patterns of rurality and rural welfares in Nigeria (table 3). Accordingly, the degree of rurality described in terms of low population density, extensive utilization of land, and exhibition of distinctive socio-cultural characteristics that are associated with rural settings

indicates that the northern states are more rural in character than the southern states (Madu, 2009a, Madu, 2010). Similarly, the welfare index which is a measure of the disparities in living standards indicates that the rural areas in southern Nigeria enjoy higher welfare standards than the southern counterparts (Madu, Muhammed and Liman, 2011) .The implication is that the more rural an area is in character and the less the living standard, the more vulnerable to climate change .This is particularly true for Nigeria where it has been shown that the rural areas are characterised by high level of poverty and various inadequacies of infrastructures and social amenities (Madu, 2009b).

The result of the cluster analysis shows four groups. The first group (Cluster A), comprises 10 states with an average vulnerability index of -0.01 and is the most vulnerable. The states in this group 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 group (Cluster B) has seven states consisting of five northern states of Borno, Nassarawa, Plateau, Yobe and Zamfara and Bayelsa and Ebonyi states in the south. The group has an average index of 1.02 and the states here have low positive vulnerability indices. The states like in the first group are also characterized by low levels of technology and education and poor infrastructural facilities. Furthermore, the five northern states are vulnerable because they like the first group experience frequent incidence of drought. The vulnerability of the northern states has a very serious food security implication for the country because the states are the major food producing areas in the country.

The reasons for the vulnerability of Bayelsa state in the oil rich Niger Delta to climate change on the other hand, is that there are high incidence of rural poverty

resulting from decades of neglect by successive governments and a large scale environmental degradation which results from oil exploration and exploitation. This again poses a serious security threat to the country as many youth restiveness and violet conflicts in the country are attributed to the unfavourable environmental and socio-economic conditions in the Delta region.

The third and fourth groups (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 by their high positive indices are the least vulnerable to climate change in the country. They are experiencing low to very low vulnerabilities to climate change respectively, because the rural households in them have high literacy rate, high household income and have more access to infrastructure and technology. They are also characterized by high degree of non-farm employments. 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 and all this explains why they are less vulnerable to climate change. The pattern is shown in Figure 2

Table 2: Degree of Rural Vulnerability to Climate Change in Nigeria

S/No	**State/FCT**	**Index**	**Degree of vulnerability**

1	Jigawa	-1.43	very high
2	Bauchi	-.31	Very high
3	Adamawa	-.23	Very high
4	Sokoto	-.14	Very high
5	Gombe	-.03	Very high
6	Benue	.25	Very high
7	Taraba	.28	Very high
8	Kebbi	.34	Very low
9	Niger	.35	Very high
10	Katsina	.40	Very high
11	Nassarawa	.70	High
12	Bayelsa	.78	High
13	Ebonyi	1.03	High
14	Yobe	1.01	High
15	Borno	1.18	High
16	Zamfara	1.19	High
17	Plateau	1.27	High
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

Table 3: Rurality and welfare indices by states and FCT in Nigeria

S/NO	State &	**Rurality**	**Welfare**

	FCT	**index** *	**index * ***
1	Lagos	1.761	17.81
2	Anambra	2.994	13.25
3	Abia	3.266	12.96
4	FCT	3.096	12.03
5	Delta	4.304	11.89
6	Imo	3.274	11.67
7	Rivers	3.794	11.49
8	Edo	4.180	11.04
9	Oyo	3.854	9.95
10	Enugu	3.072	9.80
11	Akwa Ibom	3.717	9.39
12	Osun	3.925	9.28
13	Ogun	3.917	9.11
14	Bayelsa	3.454	8.84
15	Benue	4.791	8.76
16	Kwara	4.990	8.71
17	Cross River	4.643	8.43
18	Ekiti	3.698	8.17
19	Ondo	3.920	8.07
20	Kaduna	4.132	7.96
21	Kogi	5.045	7.76
22	Niger	4.681	7.22
23	Ebonyi	3.724	6.17
24	Plateau	5.018	5.85
25	Nassarawa	4.905	5.52
26	Kano	3.944	4.71
27	Adamawa	4.529	4.53
28	Borno	4.603	4.00
29	Taraba	4.973	3.91
30	Yobe	4.672	2.96
31	Bauchi	5.014	2.66
32	Katsina	4.586	2.28
33	Gombe	5.706	2.25
34	Kebbi	4.976	2.02
35	Jigawa	4.406	1.60
36	Sokoto	4.565	1.54
37	Zamfara	4.239	1.52

Sources: *Madu (2010); **Madu, Muhammed, and Liman, (2011):

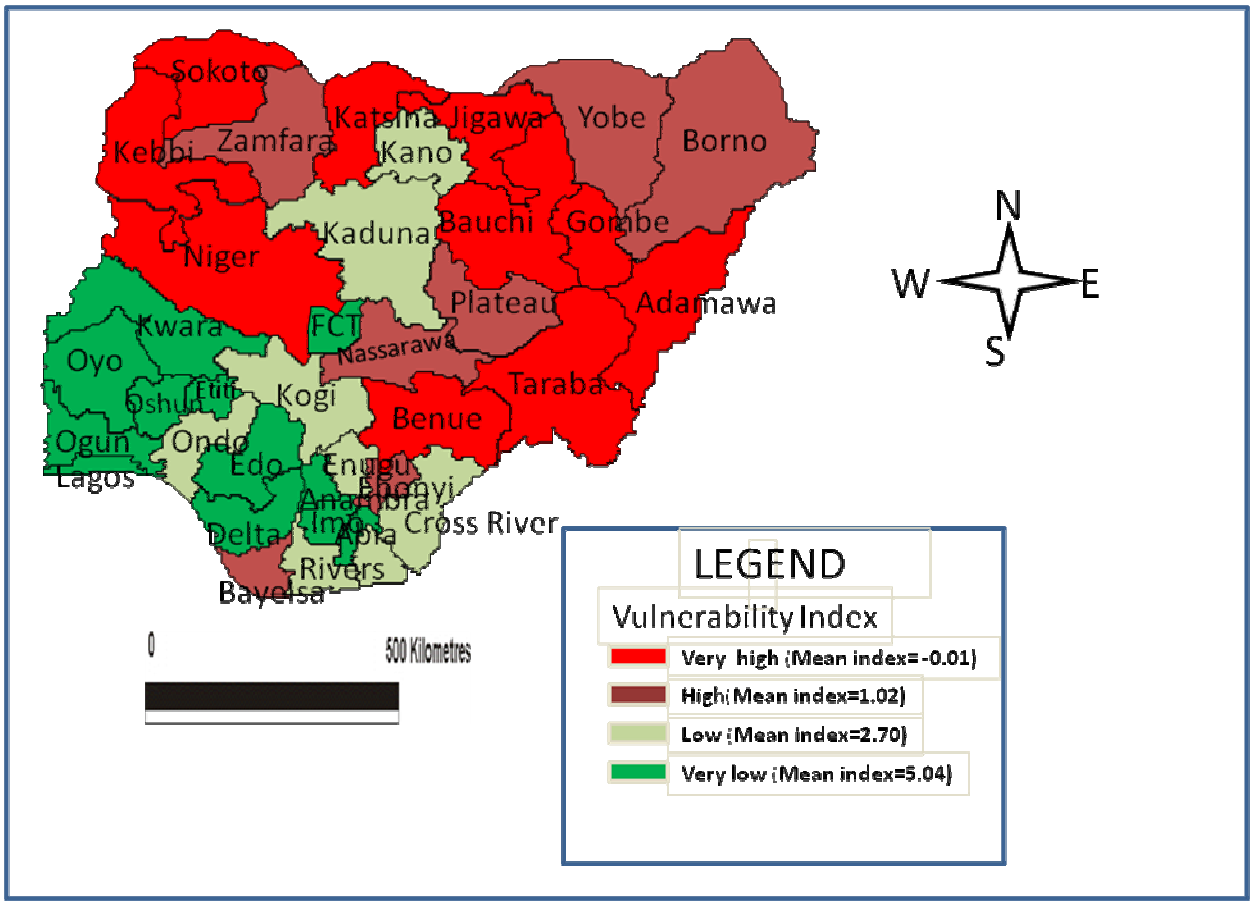

Fig.2: Patterns of rural vulnerability to climate change in Nigeria

IMPLICATIONS FOR CLIMATE CHANGE ADAPTAION POLICY

Adaptation to climate change requires robust decision making-planning over a long time horizon and considering a broad range of climate and socioeconomic scenarios (World Bank, 2010).There is however a general consensus that climate change is best addressed in the context of sustainable development. This is why a number of country experiences point to the need to mainstream adaptation strategies into existing development policies and processes (Kaur, and Nicol, 2008; OECD, 2009).Accordingly, Madu (2011) argues that while in certain situations, stand-alone adaptation measures may be needed, in most cases the measures need to be implemented as part of a broader suite of measures within existing development processes and decision cycles.

This implies, first, that adaptation responses should be based on a thorough assessment and understanding of available knowledge on climate change and poverty, so that the most appropriate interventions are chosen; and second, that these should support existing government programme priorities, rather than separate climate change programmes and projects(Kaur, and Nicol, 2008).Therefore, tackling the problem of vulnerability to climate change among the states in Nigeria which results from the differences in a number of physical and socioeconomic factors requires climate change adaptation policies that are implemented within the framework of integrated rural development. Specially, the rural policies should address the following:

- Provision of basic education
- Provision of infrastructure
- Improvement in technology
- Agriculture development
- Tackling of climate induced hazards like flood, drought and desertification

●Rural poverty alleviation
●Creation of employment and income generation opportunities
●Diversification of economic activities in rural areas

Consequently, the following policy considerations are recommended:

1) Integrating climate change adaptation into agriculture and rural development

A major focus of rural development plans should be on the distribution and management of natural resources in sustainable production systems and associated human resource development. 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. This process of integrating climate change adaptation into agriculture and rural development plan is currently lacking in Nigeria and should be given urgent attention by its federal government.

2) Provision of Irrigation facilities: Irrigation is a very effective tool to combat the harmful effects of either warming or drying. The incomes of irrigated farms are also generally less vulnerable to warming than rain-fed farms (Mendelsohn 2009). Moreover, the provision of irrigation facilities will ensure that food crops can be produced all year round. This will not only ensure food security in the country but will increase farm income and rural household welfare all of which will make the household less vulnerable to climate change. Therefore the federal government should strengthen the River Basin Development Authorities to provide irrigation facilities to rural communities in the country.

4) **Improvement in farming technology**: There is 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, recommended is the use of traditional soil protection techniques which include, 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 use of compost manure to fertilize the soil.

Climate change and security

Climate change is an aspect of an 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. Therefore an examination of the pattern of vulnerability to climate change is an important step in the analyses of climate change impact on security. Accordingly, the pattern of vulnerability to climate change in Nigeria has some development and security implications including conflicts over resources, reduction in agricultural production, increased food insecurity, pressure on water availability, accessibility and demand, and environmentally induced migration. There is the need for the climate change adaptation policy to address these environmental induced security problems.

Rural poverty alleviation: The strong link between poverty and vulnerability to climate change makes it imperative for a concerted effort towards rural poverty alleviation. More over, the deplorable conditions of rural areas in Nigeria require that a more accelerated and coordinated rural development programmes that should address the diverse rural characteristics that perpetuate poverty be pursued. This calls for an integrated rural development strategy which will ensure simultaneous development of agriculture, education, health, infrastructures and industries.

5) 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 the 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) Awareness-raising and targeted messaging on climate change: Farmers and rural dwellers should know why they might have to take 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 them including tree planting and water protection programmes. Unfortunately, in rural communities most of the rural households are either ignorant about the alternative strategies or are starved of this basic support system which makes them highly susceptible to environmental change. Basic education should be provided and awareness raised in rural areas on climate change and adaptation using appropriate communication tools such as local radio, drama, flyers, posters, workshops, video, and town criers and so on.

CONCLUSION

The analysis of the pattern of vulnerability of rural areas 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, socio-economic and infrastructure development and higher incidence of poverty found in the north. The research therefore provides the spatial picture of vulnerability of states in Nigeria to the effects of climate change which is necessary to policymakers and other stakeholders for policy and evidence-based climate change adaptation measures.

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