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Climate Change Vulnerability Assessment in the Northern Part of Katsina State, Nigeria: A Quantitative Approach

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Abstract

The aim of this study is to assess the degree of vulnerability of people to climate change in eight Local Government Areas of northwestern part of Katsina State. Data and information for this research work were obtained from a direct field study based on the result of 404 questionnaires that were administered to household heads in the eight Local Government Areas namely: Kurfi, Charanchi, Batsari, Rimi, Batagarawa, Katsina, Jibia and Kaita. Simple descriptive statistics was used to describe the socioeconomic characteristics of the respondents. In order to assess the degree of vulnerability, normalization of indicators using functional relationship was done so that they all lie between 0 and 1. The result of the study revealed that Kurfi (VI = 0.251) and Kaita (VI = 0.291) were less vulnerable, ranking 8 and 7 respectively; Katsina (VI = 0.410), Rimi (VI = 0.432), Charanchi (VI = 0.461), Batsari (VI = 0.524), and Batagarawa (VI = 0.525) were moderately vulnerable, ranking

6, 5, 4, 3, and 2 respectively; while Jibia (VI = 0.648) was highly vulnerable and was ranked 1. Findings also revealed that households that do not own livestock were highly vulnerable, as were large households with small number of active people in agricultural production. Furthermore, households that were far from the nearest market were also found to be highly vulnerable. The study recommends that in areas found to be moderately and highly vulnerable, measures should be taken for effective management of environmental resources such as soil, vegetation and water; and to stimulate both agricultural intensification and diversification of livelihoods away from risky agriculture. Finally, these areas should be targeted for infrastructure investments by policymakers.

Keywords: climate change, environmental resources, household, indicators, vulnerability index

1. Introduction

Climate change which is brought about by the complex interactive of the climate system (atmosphere, oceans, cryosphere, surface lithosphere, and biosphere) is one of the greatest socioeconomic and biophysical challenges confronting the world today (Le Treut *et al.*, 2007). Several observations of the behavior of the climate system by various scientists over the past decades to the present have highlighted the rate at which the system is currently changing (Steffen, 2009).

The scientific use of vulnerability has its roots in geography and natural hazards research such as floods, droughts, etc. However, it is used in different ways by different scholars depending on their area of specialization (Fussel, 2005, 2010). Vulnerability generally refers to exposure to contingencies and stress, and the difficulties in coping with them. Vulnerability thus has two sides. One is an external side of risks, shocks, and stress to which an individual or household is subject to climate change while the other one is an internal side which is defenselessness, meaning a lack of means to cope without damaging loss (Shahbaz, 2008; Ranganathan, Singh, Bantilan, Padmaja, & Rupsha, 2009). Vulnerability is used in climate change researches to denote the extent of damage an environment or a region is affected or expected to be affected by the various factors affected by climate change (Ranganathan *et al.,* 2009).

Vulnerability to climate change differs considerably across countries, sectors, vulnerable areas, households and individuals. It is considered to be high in developing countries as reported in IPCC (2007). The IPCC (2007) report highlighted the vulnerability of African countries to climate change. Even though they are least responsible for these changes, they are prone to greater impacts because their economies are highly dependent on natural resources that are sensitive to climate in addition to the fewer resources and options they have to combat the impacts of climate change.

The climate of Nigeria has shown considerable temporal and spatial shifts in its variability and change since the late 1960s and early 1970s through a careful study of meteorological data (Nigerian Meteorological Agency (NIMET), 2015). Extreme weather and climate events such as drought, flood, ocean surges, etc have become more regular. Though the impacts of these extreme events may be gradual but the vulnerability can be high. This is because they are often accompanied by damage to infrastructures, disruption of socioeconomic activities, loss of lives and property, and the displacement of people in the affected areas.

Flood, for example, have become more of annual occurrences especially in the northern parts of the country with increasing intensity each year, leaving vast losses and serious injuries (Abaje & Giwa, 2010; NIMET, 2015; Abaje, Jeje & Abdullahi, 2016). A significant proportion of the population in the northern parts of the country is vulnerable to the hazards of this extreme weather and climate event.

Most of the researches dealing with climate change in northern Nigeria by various scholars have been in the aspect of perception studies and adaptation strategies. In Katsina State, vital information regarding vulnerability to climate change, especially at communities' level is still lacking. This forms the basis for this research with particular reference to eight Local Government Areas (LGAs) of the northwestern parts of Katsina State. The aim of the study is to assess and map the degree of vulnerability of climate change in the eight LGAs.

2. Study Area

The study area is the northwestern part of Katsina State (Figure 1). Katsina State is located between latitude 11°00′N and 13°20′N and longitude 7°00′E and 8°55′E. It shares boarder with Niger Republic to the North, Kaduna State to the South, Jigawa and Kano States to the East, and Zamfara State to the West.

The climate of these LGAs is the tropical wet and dry type (Koppen Aw Climate). It has an annual rainfall of about 700mm per annum around Kurfi and Charanchi in the southern part of the study area to about 550mm per annum around Kaita LGA in the northern part of the study area. Seasonal variation in rainfall is directly influenced by the interaction of two air masses: the relative warm and moist tropical maritime (mT) air mass, which originates from the Atlantic Ocean associated with southwest winds in Nigeria; and the relatively cool, dry and stable tropical continental (cT) air mass that originates from the Sahara Desert and is associated with the dry, cool and dusty North-East Trades known as the Harmattan. The boundary zone between these two air streams is called the Inter-tropical Discontinuity (ITD). The movement of the ITD northwards across the state in August marks the height of the rainy season in the whole state while its movement to the southernmost part around February marks the peak of the dry season in the state (Odekunle, 2006; Abaje *et al*, 2012; Abaje *et al*, 2014). The temperatures are always high. The highest air temperature is about 38°C – 40°C and above in some areas and normally occurs in April/May and the lowest temperature occurs in December through February. Evapo-transpiration is generally high throughout the year. The highest amount of evaporation occurs during the dry season.

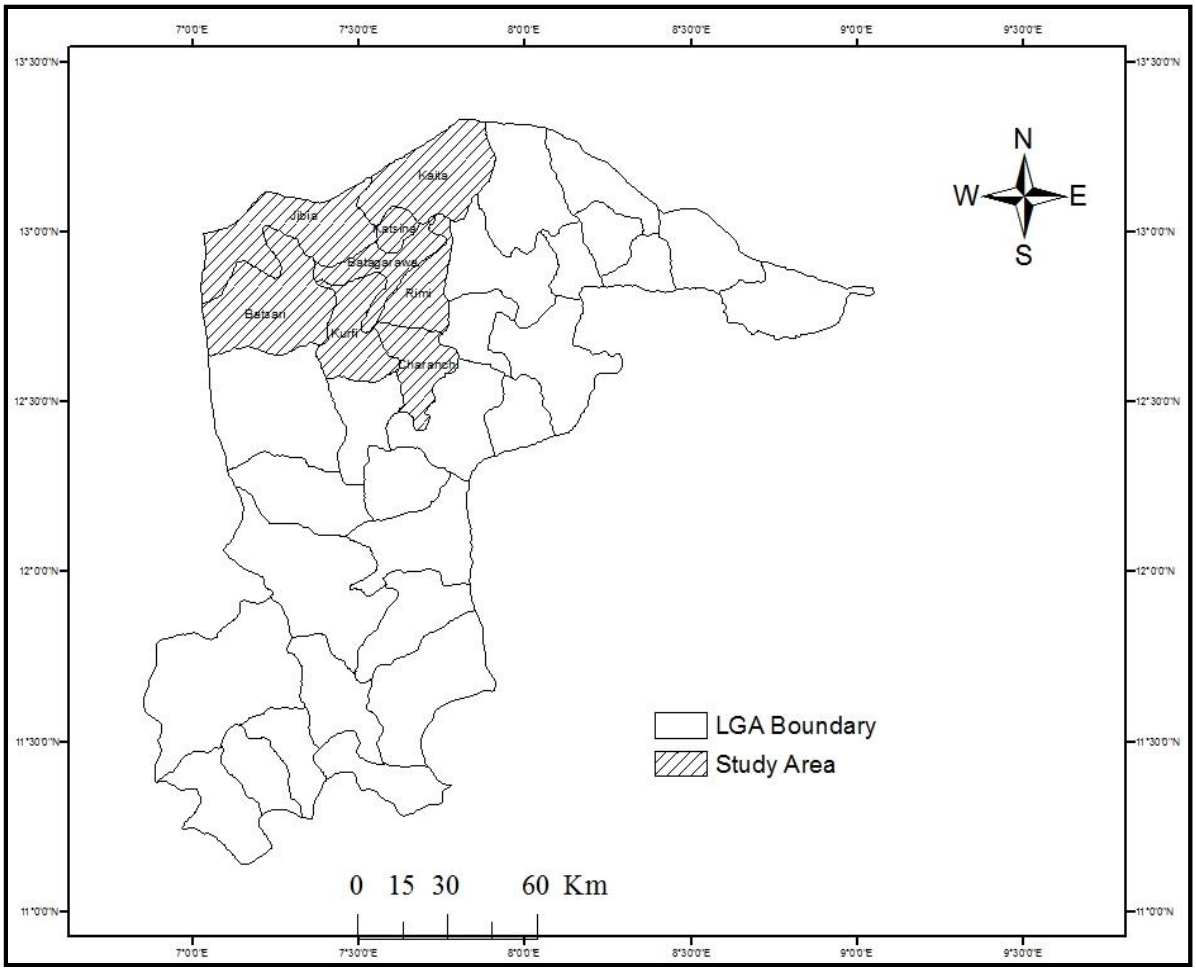

Figure 1: Map of Katsina State Showing the Study Area
Source: Adapted from Katsina State Ministry of Lands and Survey

The study area is, therefore, characterized by four seasons based on the effect of climatic controls and temperature conditions namely: the dry and cool season (*Kaka*) which last from mid-November to the end of February; the dry and hot dry season (*Bazara*) which lasts from March to April and may extend to mid-May; the wet and warm season (*Damina*) which begins around May and ends in September, over 90% of the annual rainfall is recorded during this season; and the dry and warm season (*Rani*) which starts at the end of the rains, and ends about mid-November with the onset of the harmattan (Abaje *et al,* 2016). The soil type of the region is mostly sandy loam which support crops like millet, beans, sorghum, cotton, and sesame. The vegetation of the area is the Sudan Savanna type which combines the characteristics and species of both the Guinea and Sahel Savanna (Olorode, 2002; Abaje, 2007).

3. Materials and Methods

The study area, which covers the whole northwestern LGAs (Kurfi, Charanchi, Batsari, Rimi, Batagarawa, Katsina, Jibia and Kaita) of Katsina State, during the 2006 census had a population of 1,472,686 people with an annual growth rate of 3.04% (FRN, 2010). The 2006 population figure was projected to the year 2016 using the method of Mehta (2004), which was found suitable for this study when compared with other methods, to give the study area a population of 2,377,946 people (Table

1). This was done in order to determine the required number of respondents. The method is determined as:

$$P_n = P_o(1+R/100)^n \text{ ....eq. 1}$$

where: Pn = population in the current year
Po = population in the base year.
R = annual growth rate.
n = number of intermediary years.

Table 1: Number of Respondents (Household Heads) in each LGA

LGA	Population (2006)	Projected Population (2016)	No. of Respondents
Kurfi	116 700	188 435	32
Charanchi	136 989	221 196	38
Batsari	207 874	335 654	57
Rimi	154 092	248 812	42
Batagarawa	189 059	305 274	52
Katsina	318 132	513 688	87
Jibia	167 435	270 357	46
Kaita	182 405	294 529	50
Total	**1 472 686**	**2 377 946**	**404**

Source: Field Survey (2016)

Data and information for this study were obtained from both primary and secondary sources. In order to determine the sample size and anticipated response rate of the population, Bartlett, Kotrlik and Higgins (2001) method which was found suitable for this study was adopted. The method is computed as:

$$n_0 = \frac{(t)^2 \times (p)(q)}{(d)^2} \text{ ---------------------------------- eq. 2}$$

for sample size of not more than 5%.

Therefore, the required sample size for the population (N) of the study area is calculated as:

$$n_1 = \frac{n_o}{1 + n_o/N} \text{ ------------------------------------- eq. 3}$$

and

$$n_2 = n_0 \Big/ \left(\frac{r}{100}\right) \text{ ----------------------------------- eq. 4}$$

for adjusted sample size for response rate

where: t = value for selected alpha level of 0.025 in each tail which is 1.96
(p)(q) = estimate of variance which is 0.25
d = acceptable margin of error for proportion being estimated which is 0.05
n_0 = sample size of not more than 5%
n_1 = required return sample size

n_2 = sample size adjusted for respond rate
N = population size
r = anticipated response rate

Based on this method, a total of 404 copies of a questionnaire with anticipated response rate of 95% were administered to the eight (8) LGAs of the northwestern part of the State based on simple proportion (see Table 1). Two (2) communities were sampled in each of the eight LGAs using simple random sampling. The questionnaires were purposively administered to household heads who were 42 years and above, and must have been residing in the community for at least 30 years. The basis for this was to gather information from respondents who have had experiences with their environment over the years and are more concerned and conscious about the imminent impacts and vulnerability on their environment and livelihood assets (Ishaya & Abaje, 2008; Abaje, Sawa & Ati, 2014). Simple descriptive statistics such as mean, percentage and frequency distribution were used to describe the socioeconomic characteristics of the respondents using Microsoft Excel 2013.

The interview was conducted in September, 2016. Sixteen (16) Research Assistants (two representing a LGA) with first degree who were indigenes of the selected LGAs that understood the local dialect (Hausa) were trained to conduct the interview. Regular supervision was carried out by the authors to ensure effective administration and collation of the questionnaires.

The vulnerability index approach method as defined by Ranganathan *et al.,* (2009) was used to determine the degree of vulnerability of the people in the study area. This is because the approach is based on several sets of indicators that result in vulnerability of an area and can be applied at any scale to compare the vulnerability of different areas. A set of indicators in each of the LGA of the study was selected for all the components of vulnerability (exposure, sensitivity and adaptive capacity) (Table 2). Let there be M LGAs and let us say we have collected K indicators. Let Xij be the value of the indicator j corresponding to LGA i. There are two types of functional relationship. When the observed values are related positively to the vulnerability, the normalization is achieved by employing the formula:

$$Pij = \frac{Xij - \underset{i}{Min}(Xij)}{\underset{i}{Max}(Xij) - \underset{i}{Min}(Xij)} \quad \text{------------------------------- eq. 5}$$

but when the observed values are related negatively to the vulnerability, the normalized score is computed using the formula:

$$Nij = \frac{\underset{i}{Max}(Xij) - Xij}{\underset{i}{Max}(Xij) - Min(Xij)} \quad \text{-------------------------------- eq. 6}$$

where: *Max* = Maximum value of indicator
Min = Minimum value of indicators
Xij = values of indicator j corresponding to LGA i
Pij = normalized score for observed values that are positively related to the vulnerability
Nij = normalized score for observed values that are negatively related to the vulnerability

All the normalized scores for the two types of functional relationship will lie between 0 and 1. The value 1 will correspond to the LGA with highest vulnerability and 0 will correspond to the LGA with lowest vulnerability. After computing the normalized scores, the *Vulnerability Index (VI)* is constructed by giving equal weights to all indicators using single average of all the scores. The formula is given as:

$$VI = \frac{\sum_j Pij + \sum_j Nij}{K} \quad \text{-------------------------------- eq. 7}$$

Table 2: Indicators and Variables Used in Computing Vulnerability Indices

Determinants of Vulnerability	Component of Indicators	Description of the Indicator	Unit of Measurement	Functional Relationship
Exposure	Extreme climate events	Frequency of floods	Number of floods events from 1987-2016	+
		Frequency of droughts	Number of droughts events from 1987-2016	+
Sensitivity	Population density	Total population per area	Population/km^2	+
	Irrigated land	Percentage of irrigated land	Percentage	-
	Civil insecurity	Frequency of insecurity	Number of occurrence	+
	Occurrence pests and diseases	Frequency of pest/diseases	Number of occurrence	+
	Fertilizer use	Consumption of fertilizer per hectare	Number of bags used	-
Adaptive Capacity	Land size	Average farm size	Hectare	-
	Literacy rate	Proportion of persons who can read and write	Percentage	-
	Crop production	Average total value of crop produced	Naira	-
	Ownership of livestock	Number of livestock	Sum total	-
	Access to market	Distance travelled to nearest market	Kilometers	-
	Insecticides/Pesticides supply	Percentage of population with access	Percentage	-
	Improved seed supply	Percentage of population with access	Percentage	-
	Veterinary services	Percentage of population with access	Percentage	-
	Health care services	Percentage of population with access	Percentage	-

Note: (+) Positive relationship to vulnerability, (-) Negative relationship to vulnerability
Source: Field Survey (2016)

In order to map the degree of vulnerability, this study modified the five classes of vulnerability index (less vulnerable, moderately vulnerable, vulnerable, highly vulnerable, and very highly vulnerable) as defined by Ranganathan *et al.*, (2009) into three classes. This is because vulnerable and very highly vulnerable conditions were very infrequent throughout the period of study. Table 3 shows the descriptions and classifications of the modified vulnerability index.

Table 3: Modified Vulnerability Classification Values

Index	Stage of Vulnerability
0.00 - 0.40	Less Vulnerable
0.41 - 0.60	Moderately Vulnerable
0.61 – 1.00	Highly Vulnerable

4. Results and Discussion

4.1 Socioeconomic Characteristics of Respondents

Table 4 shows the socioeconomics characteristics of respondents in the study area. The results of the finding show that the majority of the respondents were males (94.5%) while only 5.5% were females. This may not be unconnected with the culture and religion of the people in which most of the women are always confined inside their houses. The result is in agreement with other related studies on climate change carried out by Ishaya and Abaje (2008), Abraham, Bamidele, Adebola, and Kobe (2012), and Abaje, Sawa and Ati (2014) in which the percentage of males were higher than females. The table shows that out of the 404 respondents, 32.8% attended primary school, 26.9% Quranic School, 14.4% have tertiary education, and 21.9% have secondary education, while 4.0% have no education at all. The average age of the respondents is 51 years. 46% are between 42-51 years while 42% are between 52-61 years. Only 4% are 72 years and above. Age in terms of climate change vulnerability in the area is an important factor. This is because the younger ones that are still active and agile commit more of their energy in crop and livestock production in order to reduce the vulnerability of climate change in their households while the older ones have had experiences in climate vulnerability over the years (Abaje, 2016).

Table 4: Socioeconomic Characteristics of Respondents

Household Characteristics	Variable	Frequency	Percentage	Mean
Gender	Male	382	94.5	
	Female	22	5.5	
Age (Years)	42-51	186	46	
	52-61	170	42	
	62-71	32	8.0	51
	≥ 72	16	4.0	
Marital status	Single	14	3.5	
	Married	364	90	
	Divorced	4	1.0	
	Widowed	22	5.5	

Level of education	Primary	133	32.8	
	Secondary	88	21.9	
	Tertiary	58	14.4	
	Quranic	109	26.9	
	No Education	16	4.0	
Household size	≤ 5	48	12	10
	6-10	215	53.2	
	11-15	102	25.3	
	16-20	24	6.0	
	≥ 21	14	3.5	
Occupation	Farming	229	56.7	
	Livestock production	70	17.4	
	Civil servants	82	20.4	
	Traders and others	22	5.5	
Income per annum (₦)	≤ 100 000	165	40.8	₦187 711
	100 001-300 000	183	45.2	
	300 001-500 000	40	10	
	500 001-700 000	12	3	
	≥ 700 001	4	1	
Number of years living in the area	30-34	82	20.4	41
	35-40	130	32.3	
	41-50	121	29.9	
	≥ 51	70	17.4	

Source: Field Survey (2016)

The majority of the respondents (90%) are married; and the average household size is 10. The large household size is believed to provide cheap labor that will assist in adaptation practices that will reduce climate change vulnerability in the area. This is because some of the resources and items that could be used in combating the impacts of climate change in order to reduce the vulnerability cannot be afforded by a majority of the people (Abaje, 2016). This can be seen from the average annual income of the respondents which is ₦187 711. The respondents have been living in the area for an average of 41 years and their major occupation is farming which represent 56.7%, while 17.4% engaged in livestock production. Civil servants represent 20.4% while traders and others 10%. Based on this result, it is a clear that most of the respondents depend heavily on environmental resources for their livelihood.

4.2 Vulnerability to Climate Change

Results of the analysis of climate change indicators (Table 5) showed that Jibia (ranked 1) is the most vulnerable LGA in the study area, and it happens to be one of the drought prone areas of the region. This local government is characterized as highly vulnerable in the region (Figure 2). A closer examination of the vulnerability indices of the indicators in Jibia LGA revealed that literacy rate is very low and that most of the households are far away from where farm inputs such as fertilizers, improved seeds, insecticides and pesticides are been sold or supplied, and the communities or households are therefore highly vulnerable. Furthermore, most of the households are highly vulnerable because they do not own livestock and they are mostly located far away from veterinary services.

LGAs that are moderately vulnerable include Batagarawa, Batsari, Charanchi, Katsina and Rimi LGAs. Kurfi was found to be less vulnerable (ranking 8); and surprisingly, Kaita LGA that is bordering Niger Republic was equally less vulnerable (ranking 7).

Table 5: Vulnerability Index of the Local Government Areas

Determinants of Vulnerability	Indicators	Local Government Areas								Average Index
		Kurfi	Charanchi	Batsari	Rimi	Batagarawa	Katsina	Jibia	Kaita	
Exposure	Frequency of Floods	0.219	1.000	0.000	0.135	0.639	0.441	0.633	0.241	0.414
	Frequency of Droughts	0.187	0.629	0.816	1.000	0.677	0.000	0.712	0.101	0.515
Sensitivity	Population Density	0.008	0.051	0.000	0.075	0.122	1.000	0.356	0.004	0.202
	Civil Insecurity	0.191	0.000	0.583	0.108	0.363	1.000	0.456	0.012	0.339
	Occurrence of Pests/ Diseases	0.333	0.612	0.333	0.667	0.493	0.000	0.439	1.000	0.485
	Fertilizer use	0.014	0.074	0.875	0.500	0.505	0.022	1.000	0.000	0.374
	Irrigated Land	1.000	0.600	0.700	0.508	0.000	0.201	0.453	0.038	0.438
Adaptive Capacity	Farm holding Size	0.485	0.493	0.818	0.544	0.848	1.000	0.278	0.000	0.558
	Literacy Rate	0.233	0.461	0.524	0.432	0.525	0.000	1.000	0.272	0.431
	Crop Production	0.678	0.556	0.000	0.444	1.000	0.855	0.556	0.444	0.567
	Number of Livestock	0.661	0.111	0.778	0.674	0.972	0.878	1.000	0.000	0.634
	Distance to Nearest Market	0.000	1.000	0.445	0.455	0.545	0.364	0.182	0.955	0.493
	Insecticides/Pesticides Supply	0.000	0.122	0.321	0.283	0.428	0.137	1.000	0.286	0.322
	Improved Seed Supply	0.000	0.430	0.924	0.610	0.230	0.201	1.000	0.200	0.449
	Veterinary Services	0.000	0.236	0.476	0.196	0.800	0.202	1.000	0.601	0.439
	Health Care Services	0.000	1.000	0.788	0.285	0.251	0.259	0.309	0.502	0.424
Vulnerability Index		0.251	0.461	0.524	0.432	0.525	0.410	0.648	0.291	0.443
Rank		**8**	**4**	**3**	**5**	**2**	**6**	**1**	**7**	

Note: 0.00 - 0.40 = Less Vulnerable
0.41 - 0.60 = Moderately Vulnerable
0.61 - 1.00 = Highly Vulnerable

Source: Field Survey (2016)

Kurfi is less vulnerable because most of the households are closer to sources of farm inputs supply (for examples, fertilizers, improved seeds, insecticides and pesticides supply) as well as availability of veterinary services and proximity to market. Kaita LGA on the other hand has a low population density (the lower the population of the area, the lower the vulnerability and vice-versa), with large farmland for cultivation, and proximity of the communities to fertilizer supply. The large farm size of the area and the proximity to fertilizer supply may be some of the reasons crop production is increasing in the area and hence the people are less vulnerable to the impacts of climate change. This is because less efforts and money will be needed to travel to get available farm inputs in order to boost crop production. There is also less occurrences of pests and diseases in the area and most of the households have livestock to sale for both coping and adaptation strategies to climate change and hence the low vulnerability in the area. The sale of livestock, according to one of the respondent, will also augment the cost of crop production in years of low yield. This result is in agreement with the works of Gbetibouo, Ringler, and Hassan, (2010), Prasertsak (2011), and Abaje (2016).

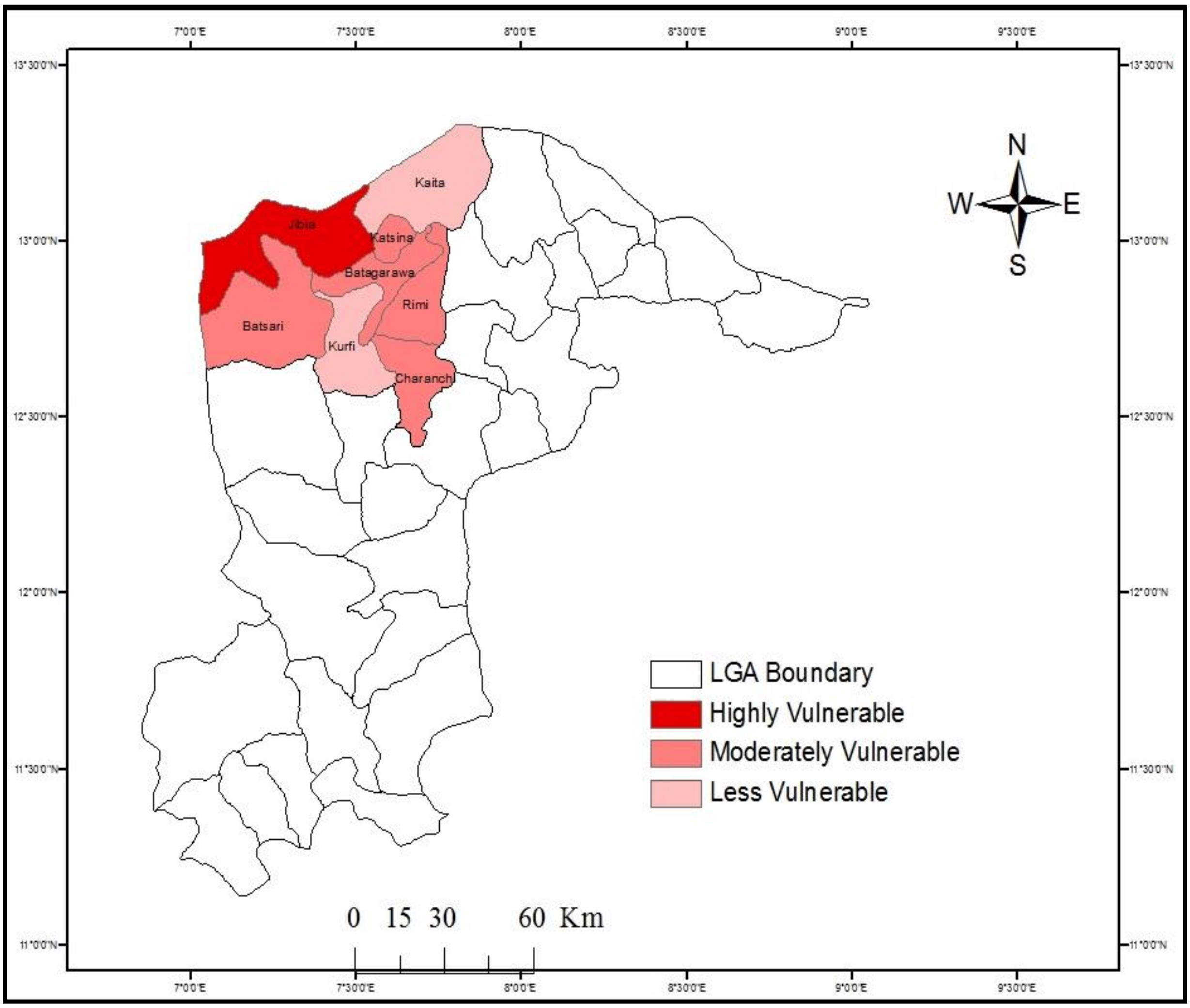

Figure 2: Map of Vulnerability Indices across the Eight Local Government Areas

Generally, the result of the normalized scores revealed that households that do not own farmlands and livestock are highly vulnerable, as were large households with small number of active people in agricultural production. Furthermore, households that are far from the nearest market and from sources of improved seeds supply were also found to be highly vulnerable. On the other hand, the average vulnerability index for the total population per kilometer square of the study area is 0.202. This implies that the study area, in terms of population density, is less vulnerable (the lesser the population density the lesser the vulnerability and vice versa). The average vulnerability of the study area is 0.443 meaning that the whole of northwestern part of Katsina State is moderately vulnerable.

5. Summary and Conclusions

This paper analyses the vulnerability of people to climate change in eight LGAs of the northwestern parts of Katsina State by constructing a vulnerability index and comparing vulnerability indicators across the eight LGAs. The study assessed 16 environmental and socio- economic indicators to reflect the three components of vulnerability. Findings revealed that vulnerability to climate change is inherently linked with level of socio-economic development of the people. Jibia LGA that was identified as highly vulnerable is characterized by low literacy level, lack of livestock, and it is farther away from farm inputs supply.

The study recommends that areas found to be highly and moderately vulnerable as a result of poor socio-economic development, measures should be enacted by policymakers to support the effective management of environmental resources such as soil, vegetation and water; and to stimulate both agricultural intensification and diversification of livelihoods away from risky agriculture. Enlightenment programs on climate change should be organized for these communities and the State at large; and these areas should be targeted for rural infrastructure investments by policymakers. Finally, meteorological stations should be established in all LGAs of State and the country at large for continues record of climatological data.

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