Assessing the Vulnerability and Adaptive Capacity of Rural Farmers to Climate Change in Girei Local Government Area, Adamawa State, Nigeria

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Abstract

This study was formulated to evaluate the climatic characteristics and to determine rural farmers' vulnerability and adaptive capacity to climate change in Girei Local Government Area. Forty-one years records of temperature and rainfall of the growing season were used for the study. Additionally, farmers' responses regarding their vulnerability and adaptive capacity to climate change were obtained through questionnaire administration. The use of Functional relationship as well as vulnerability and adaptive capacity indices analysis were employed in analyzing the data. Results show that majority of the rural communities studied (six out of seven) were found to be highly vulnerable (with indices ranging from 0.63 to 0.83) to climate change. Only one was moderately vulnerable (0.58). Exposure to climate vagaries was discovered to make farmers most vulnerable to climate change, followed by their adaptive capacity and then their sensitivity to environmental hazards social violence. All the communities were found to possess moderate capacity to cope with climate change effects. This is owing to their wealth accumulation, access to farm inputs, irrigation potentials, literacy level and infrastructural and institutional availability. It was recommended that government should intensify efforts in providing credit facilities to the farmers to enable them cushion the impacts of climate change. Adequate infrastructures such as good roads, power supply, healthcare and veterinary services should also be made available to them.

Key words: *Climate, Climate Change, vulnerability, adaptive capacity, Girei*

Introduction

The Inter-governmental Panel on Climate Change (IPCC 2007a) defined climate change as a statistically significant deviation or shift from the average weather condition of climatic elements, which persists for several decades. No doubt, climate change is the greatest challenge facing our planet in this century, which must be recognized as a global issue of extreme concern (Adebayo and Oruonye 2013).

Vulnerability is the degree to which the geophysical, biological and socio-economic systems are susceptible to, and unable to cope with, diverse impacts of climate change, including climate variability and extremes (Schneider *et al*, 2007). It is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity (IPCC, 2007a). Vulnerability to climate change differs considerably among countries, sectors, vulnerable areas and populations. For instance, marginalized groups in the poorest regions, particularly in Africa, are more vulnerable than those living in more prosperous nations even though the former is least responsible for these changes (USAID, 2007; UNDP, 2009).

Adaptation strategies to be adopted therefore, depend on the adaptive capacity of a system, region, community, or household. Adaptive capacity is, therefore, the whole capabilities, resources and institutions of a country, region, community, or household to implement effective adaptation strategies. It characterizes the responsiveness of the system and its ability to exploit opportunities and resist or recover from the negative effect of a changing environment (Boko *et al,* 2007).

At the local or rural level, the ability to undertake adaptations can be influenced by livelihood assets such as financial capacity, physical capital, infrastructure and institutions, technological and information resources among others (Moser and Satterhwaite, 2008; Deressa *et al,* 2008a; Deressa *et al*, 2008b, Gbetibou *et al*, 2010). These are the key determinants of individual, household, or communities' adaptive capacity both to reduce risk and cope with and adapt to increased risk levels of climate change (Moser and Satterhwaite, 2008; Deressa, et al, 2008b, Gbetibouo et al, 2010).

In view of the fact that different regions have different vulnerability and adaptive capacity to climate change, this study was formulated to analyse the situation in a typical rural setting in norther Nigeria. Adebayo *et al* (2013) has reported that climate change awareness is relatively high in Adamawa State. Zemba and Adebayo (2010) and Zemba *et al* (2013) also confirmed that climate change impact was effective and deleterious to mostly the low-income groups of Adamawa State. However, this study focused mainly on the local farmers, who mostly practice subsistence agriculture.

Study Area and Methods
Study Area

Girei Local government Area is one of the twenty-one local government areas in Adamawa State. It is situated between latitudes 9^0 13' and 9^0 37'N and longitudes 12^0 16'and 12^0 42'E (Figure 1). The area experiences two distinct seasons:- dry season (November to March) and rainy season (April to October) with a mean annual rainfall of about 950mm covering an average annual rain days of about 80 days (Zemba and Adebayo, 2010). The annual mean temperature of 28^0C (Zemba 2004), coupled with rainfall, makes the area a good place for cultivation of a variety of crops.

The presence of River Benue, which serves as boundary demarcation of the local government area in the southern through southwestern fringes provides extensive floodplain with great potentials for irrigation activities. About 85% of the inhabitants of Girei Local Government Area are farmers, who either engage in crops cultivation or livestock rearing, especially cattle. Rice cultivation is extensively practised along the River Benue floodplain. Modibbo Adama University of Technology, Yola is hosted in the local government and provides additional opportunity for agricultural-based researches that facilitates the promotion of agricultural activities generally in the area.
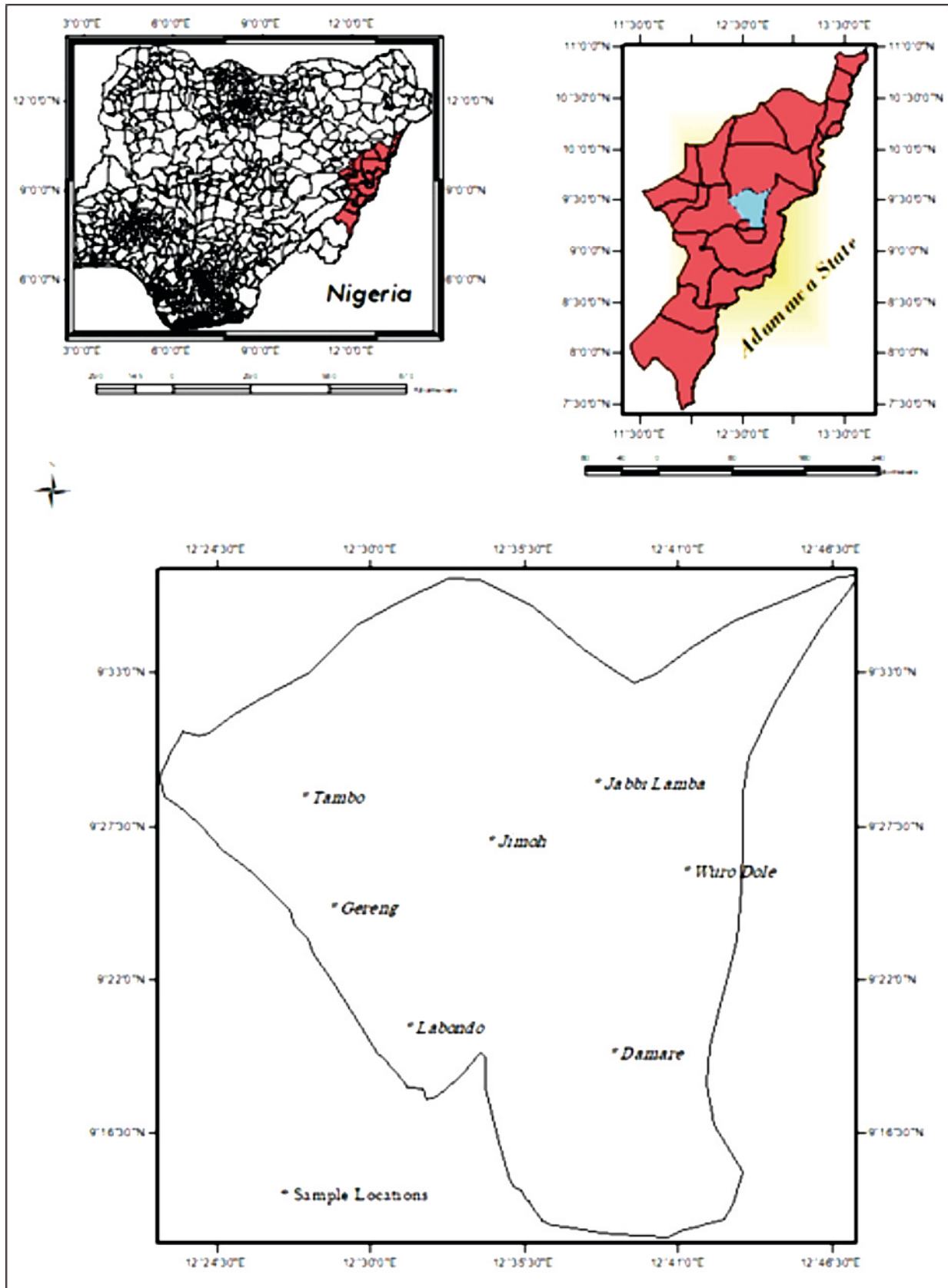
Figure 1: Study Area and Sample Locations

Methods

Data Types and Sources

The data used for this study were majorly climatic data of annual rainfall and temperature obtained from the Nigerian Meteorological Agency, Yola. The data covered a period of forty-one years (1979-2019).

Responses obtained from the rural farmers regarding their vulnerability and adaptive capacity to climate change was other important data obtained from questionnaire administration. Additionally, other supplementary data sourced from observations, oral interviews and focused group discussion

(FGD) were utilized in the work.

The study area's population from 1991 census stood at 23, 358. This figure was projected to the year 2019 for the purpose of this study using the method of Mehta (2004) (equation 1):

$$p_n = p_0 (1+R/100)^n - - - - - - - - - - - - - - - (1)$$

Where: p_n = population in the current year

p_0 = population in the base year.

R = annual growth rate

n = number of intermediary years.

Based on the above, the projected population of the study area for the year 2019 was 25,308 people. The study basically targeted rural farmers. In the whole of Girei LGA, only Girei, Sangere-FUTY and Vunoklang settlements had populations of over 20, 000 people. Going by United Nations Economic Commission for Africa's definition of rurality as having a population of less than 20, 000, the three settlements above were eliminated. Seven settlements were then randomly selected from the remaining settlements including Damare, Gereng, Jabbi Lamba, Jimoh, Labondo, Tambo and Wurodole. 10% of the population of these settlements were used as sample for this study (Table 1).

Table 1: Sampling of the Respondents

Settlement	1991 Population	2019 Population (Projected)	Sample size (10%
Damare	1,336	2,895	29
Gereng	2,412	5,226	52
Jabbi Lamba	3,559	7,713	77
Jimoh	2,325	2,872	29
Labondo	867	1,878	19
Tambo	449	972	10
Wurodole	1,731	3,752	38
Total	23,358	25,308	254

Data collection techniques

Both closed and open-ended questions were used. The closed questions were in form of Likert scale (LS) and fixed question format. The interview schedule had five sections (A-E), eliciting information on the socio-economic characteristics of the correspondents (gender, age, literacy level, household size, income, among others); vulnerability; and adaptive capacity of the rural farmers towards minimizing the impacts of the climate change. Survey questions for FGD were focused on a more comprehensive range of climate change issues such as impacts on livelihoods, vulnerability and factors exacerbating vulnerability, and efforts made in addressing climate change within the community among other issues.

Assessing the Degree of Climate Change Vulnerability

The vulnerability index by Ranganathan *et al* (2009) was used to assess the degree of vulnerability of the rural people in the study area. The approach is based on several sets of indicators that result in vulnerability of an area. It can also be applied on any scale to compare the vulnerability of different areas. Additionally, the indicators can be selected based on the availability of data.

The first thing was the selection of the set of indicators for all the settlements of the study for each of the three components of vulnerability (exposure, sensitivity and adaptive capacity). In this way, both primary and secondary indicators were used. The selected secondary indicators were based on their vulnerability. A total of 19 indicators were included in the vulnerability analysis index. Details of description of the indicators can be found in Abaje (2015).

The data collected were then arranged in the form of matrix with rows representing settlements and columns representing indicators. Afterwards, equation (2) and (3) were used to normalize functional relationship and equation (4) used to determine vulnerability index. This was done in recognition of the fact that, mathematically, there are *M* settlements and *K* indicators. Let *Xij* be the value of the indicator *j* corresponding to settlement *i*. The fact that the indicators will be in different units and scales, they have to be normalized.

I. *Use of functional relationship to normalize indicators:* Two types of functional relationship are possible:

when the observed value is related positively to the vulnerability (for example, the higher the variation in rainfall, the higher vulnerability), the normalization was achieved by employing the formula:

$$PIJ = \frac{XIJ - MIN(XIJ)}{MAX(XIJ) - MIN(XIJ)} \quad 2$$

On the other hand, when the values are negatively related to the vulnerability (for example, the higher the productivity of a crop in a region, the lower the vulnerability), the normalized score was computed using the formula:

$$NIJ = \frac{MAX(XIJ) - XIJ}{MAX(XIJ) - MIN(XIJ)} \quad 3$$

Where, MAX = Maximum value of indicator
MIN = Minimum value of indicator
XIJ = Value of indicator j corresponding to settlement I
PIJ = Normalized score for the observed values that are positively related to the vulnerability
NIJ = Normalized score for observed values that are negatively related to the vulnerability

The normalized scores for the two types of functional relationship range from 0 and 1. The value 1 corresponds to the settlement with the highest vulnerability and 0 corresponds to the settlement with the lowest vulnerability.

I. *Construction of vulnerability index:* After computing the normalized scores, the index was constructed by giving equal weight to all indicators using average of all the scores. The formula is given as:

$$VI = \frac{\sum Pij + \sum Nij}{K} \quad 4$$

Where, Pij = Normalized score for the observed values that are positively related to the vulnerability
Nij = normalized score for observed values that are negatively related to the vulnerability
K = indicators
VI = vulnerability index

The vulnerability indices were used to rank the different settlements in terms of vulnerability. A settlement with highest index is said to be most vulnerable and it is given the rank 1; the settlement with next highest index is assigned rank 2 and so on. For the purpose of further analysis in this study, vulnerability index was classified into three (Table 2). The classes were adopted from Ranganathan *et al* (2009), which are given against a scale of numerical value of the vulnerability index.

Table 2: Vulnerability Classes

Index	Class
0.0 – 0.40	Less vulnerable
0.41 – 0.60	Moderate vulnerable
0.61 – 1.00	Highly vulnerable

Assessing Adaptive Capacity to the Changing Climate

In this study, the major indices influencing rural farmers' capacity as employed by Deressa, *et al,* (2008b) and Gbetibouo *et al,* (2010) was adopted. This stipulates that climate change adaptive capacity depends on five livelihood assets: wealth, farm-inputs, availability of infrastructures and institutions, irrigation potential and literacy level.

These five livelihood assets were selected because they are the major indicators of adaptive capacity of rural communities to climate change on which data can be obtained using questionnaire. In the same vein, these indicators are the most cited in several studies (for example: Moss *et al*, 2010; Cutter *et al*, 2003; Fothergill and Peek, 2004; O'Brien *et al*, 2004; Adger *et al*, 2004; Deressa *et al*, 2008a; Cutter *et al*, 2009; and Gbetibouo *et al*, 2010) of rural communities' adaptive capacity to climate change. A five-point Likert Scale (5=strongly agree, 4=agree, 3= undecided, 2= disagree and 1= strongly disagree) was also used to assess the adaptive capacity to the changing climate. The adaptive capacity of settlements was therefore calculated using equation (5) and Table 3 used to interpret the results.

$$CA = \frac{W + FI + AII + IP + LL}{5} \quad 5$$

Where, W = wealth
FI = Farm inputs
AII = availability of infrastructure and institutions
IP = irrigation potential
LL = literacy level

Table 3: Classification of the Adaptive Capacity

Mean score	Level of adaptive capacity
0.00-2.49	Low adaptive capacity
2.50-3.49	Moderate adaptive capacity
3.50-5.00	High adaptive capacity

Findings of the Research

The results of this research are presented in three sections. These include characteristics of climatic elements; vulnerability; and adaptive capacity of the communities to climate change.

Characteristics of the Climatic Elements in the Study Area

The characteristics of the major climatic elements (mean annual rainfall of growing season and temperature) revealed high variations. For instance, Zemba *et al* (in press) have reported an annual increase in temperature of about 1^0C and a decrease in rainfall of the growing season of about 24.6mm. This confirms the incidence of climate change and/or variability in the area. This has significant impact on the ecology, lives and livelihood of the inhabitants of the area.

Vulnerability of the Framers to Climate Change

Results of the 19 indicators that were included in the vulnerability analysis are presented in Table 4. Here, the indices and rank of vulnerability of each of the selected rural settlement are depicted. Result of the analysis showed that all the seven rural settlements are highly vulnerable to climate change, though with variations in magnitude. They are therefore ranked from first to seventh, according their level of vulnerability. The indices of their vulnerability are 0.83, 0.78.0.74, 0.73, 0.68, 0.63 and 0.58 for Jimoh, Gereng, Tambo, Labondo, Wurodole, Damare and Jabbi Lamba respectively ranked in this order from 1st to 7th. This means that the first six are highly vulnerable while the last is moderately vulnerable to climate change.

Table 4: Vulnerability Index of the Studied Settlements

	Indicators	Settlements							Average
		Damare	Gereng	Jabbi Lamba	Jimoh	Labondo	Tambo	Wurodole	
Exposur	Change in annual rainfall	0.95	1.00	0.80	1.00	0.89	1.00	1.00	0.95
	Change in Temperature	0.00	0.80	0.90	0.97	0.40	0.58	0.76	0.63
	Frequency of floods	0.58	1.00	0.05	0.85	1.00	1.00	0.50	0.71
	Frequency of droughts	1.00	0.75	0.80	1.00	1.00	0.89	1.00	0.92
Sensitivity	Population density	0.02	0.00	0.08	0.00	0.00	0.00	0.05	0.02
	Civil insecurity	0.34	1.00	0.86	1.00	0.95	1.00	0.86	0.86
	Pests & diseases	0.59	0.74	0.60	0.68	0.65	0.75	0.85	0.70
	Fertilizer use	0.76	0.88	0.75	0.90	0.85	0.65	0.81	0.80
	Irrigated land	0.25	0.00	1.00	0.85	0.00	0.90	1.00	0.57
	Farm holding size	0.92	0.60	0.89	0.70	0.90	0.55	0.42	0.71
	Literary rate	0.86	0.90	0.82	0.88	0.85	0.89	0.58	0.80
Adaptive capacity	Crop production	0.67	0.70	0.75	0.80	0.77	0.71	0.80	0.74
	Number of livestock	0.23	1.00	0.25	0.99	1.00	0.05	0.00	0.50
	Distance to nearest market	0.84	0.99	0.00	0.96	0.90	1.00	0.45	0.73
	Insecticides & herbicides	0.52	0.86	0.00	0.82	0.80	0.80	0.35	0.59
	Improved seed supply	0.75	0.89	0.30	0.75	0.50	0.75	0.68	0.66
	Veterinary services	0.98	0.84	0.50	0.87	0.45	0.65	0.98	0.75
	Health care services	0.87	0.91	0.65	0.84	0.88	0.90	0.88	0.84
	Access to credit facility	0.89	1.00	1.00	1.00	0.99	1.00	1.00	0.98
	Vulnerability Index	**0.63**	**0.78**	**0.58**	**0.83**	**0.73**	**0.74**	**0.68**	
	Rank	**5**	**2**	**7**	**1**	**4**	**3**	**6**	

0.00 – 0.40 = Less vulnerable
0.41 – 0.60 = Moderately vulnerable
0.61 – 1.00 = Highly vulnerable

A close examination of the vulnerability indices of the 19 indicators revealed that all the seven settlements are vulnerable to changes in rainfall with values ranging from 0.80 to 1.00 resulting to an average of 0.95. This means that the higher the changes in rainfall, the more vulnerable these settlements are. Other factors that present high vulnerability for all the communities are drought occurrences (0.92), civil insecurity (0.86), Lack of access to credit facilities (0.98), lack of access to healthcare (0.84), unavailability of chemical fertilizer and illiteracy (0.80). On the other hand, population density has low values (i.e. presents low risk) because these are rural settlements with low population density. Other indicators with minimal vulnerability potentials include number of livestock and availability of irrigable lands. These are relatively in abundance and greatly enable the farmers cushion the effects of climate change.

Generally, results of the analysis of 19 indicators revealed that households with lower numbers of livestock, farmlands and/or irrigable lands in addition to low literacy level were highly vulnerable as were the large households with no access to fertilizer to boost agricultural production. Households that were far from markets and farm inputs, such as improved seeds, herbicides etc., were vulnerable, as were communities without healthcare and veterinary services and no access to credit facilities.

Further examinations of the three components of vulnerability (Table 4) revealed an average index of 0.80 for exposure, 0.59 for sensitivity and 0.73 for adaptive capacity. This means that exposure is the greatest component contributing to climate change vulnerability in the area. This is followed by adaptive capacity and lastly sensitivity. This result is in contrast with that of Prasertsak (2011), who found adaptive capacity to be the most important contributing component to climate change risk.

Adaptive Capacity to Climate Change

Wealth, farm inputs, infrastructural and institutional availability, irrigation potentials, and literacy level are the variables used in this study to assess rural farmers adaptive capacity to climate change in Girei Local Government Area (Table 5). An evaluation of the mean adaptive capacity among rural settlements show that Damare ranked first, followed by Wurodole

(2nd), Labondo (3rd), Tambo (4th), Jabbi Lamba (5th), Gereng (6th), and Jimoh 7th) with corresponding mean capacity value of 3.12, 3.08, 3.05, 3.04, 3.02, 2.96 and 2.90 respectively.

Results on wealth consideration as index of adaptive capacity by rural communities in study area revealed moderate capacity ranging from 2.98 at Jimoh to 3.44 for Wurodole. Wealth is one of the major determinants of adaptive capacity. With large wealth, the impact of climate change and hence the vulnerability of rural communities will be reduced. This is because wealth enables people to absorb and recover from losses and other impacts of climate change quickly due to insurance, number of livestock, economic trees, good quality residential houses etc. People living in poverty are more vulnerable because they have less resource to spend on preventive measures, emergency supplies and recovery efforts (Cutter *et al,* 2009).

The rural communities were found to have markets, though not of the higher order in all cases. People sometimes travel for more than 10km to the nearest higher order markets like Jimeta. This portends some problems considering the fact that availability of and proximity to supplies of farm inputs within 1-4km are identified as indicators of modern adaptation to climate change in rural areas (Derresa *et al* 2008b). In the same vein, availability of infrastructures like motorable roads, electricity supply and institutions such as healthcare/veterinary centres, good markets, formal/informal loaning institutions etc., are lacking or are inadequate.

The use of irrigation potentials is based on the assumption that communities with more potentially irrigable lands are expected to have higher capacity to adapt to climate change conditions and other economic shocks. Interestingly, River Benue valley provides vast floodplain for irrigation in the Local Government Area. Communities such as Wurodole, Labondo, Gereng, Vunoklang etc. are situated directly at the bank of this River with enormous irrigation potentials. Literacy level of rural communities is considered to help ascertain the level of skills and education among the rural people. Deressa *et al* (2008a) argued that communities with high level of knowledgeable people are considered to have greater adaptive capacity than those with low

literacy level. The studied communities have relatively significant level of literacy levels ranging from 3.01 at Labondo to 3.61 at Jabbi Lamba, which provides good medium for adapting to climate change.

Table 5: Adaptive Capacity to Climate Change in Girei

Adaptive Capacity Variables		Settlements						
		Damare	Gereng	Jabbi Lamba	Jimoh	Labondo	Tambo	Wurodole
I	Wealth consideration	3.21	3.08	3.10	2.98	2.98	3.11	3.74
Ii	Farm inputs consideration	2.76	3.01	3.12	3.00	3.12	3.20	3.13
Iii	Infrastructural & institutional availability	3.65	2.23	2.97	2.62	2.45	2.50	2.77
Iv	Irrigation potentials	2.54	3.42	2.31	2.53	3.71	2.87	2.26
V	Literacy level	3.42	3.08	3.61	3.39	3.01	3.50	3.48
Mean		**3.12**	**2.96**	**3.02**	**2.90**	**3.05**	**3.04**	**3.08**
Rank		**1**	**6**	**5**	**7**	**3**	**4**	**2**

Conclusion

It is on record that climate change presents enormous risk to ecology and human existence in the world. Girei Local Government, the study area is not an exception. The forty-one years climate data of the area revealed evidence of significant variations and climate change with temperature increase of 1^0C and rainfall decrease of 24.6mm.

Most of the communities were observed to be highly vulnerable to climate change as majority of them (six out of seven) exhibited evidences by way of their indices. However, all of the communities have moderate adaptive capacity to contain the effects of this risk. Variables such as wealth accumulation, farm inputs, irrigation potentials, literacy level, and availability of infrastructures and institutions provide catalysts for ameliorating the impacts of the change. Government should intensify efforts in providing credit facilities to aid the farmers in safeguarding their means of livelihoods. There is need to also make provision for available infrastructural facilities such as good roads, power supply as well as provision of healthcare and veterinary services.

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