Assessment of Rural Communities' Adaptive Capacity to Climate Change in Kaduna State, Nigeria

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Abstract
This research is aimed at assessing the adaptive capacity of rural people to climate change in Kaduna State with particular reference to some selected communities in six Local Government Areas of the state. Data and information for this study were obtained from a direct field study based on the result of 426 questionnaires that were administered to household heads in the selected communities. Simple descriptive statistics was used to describe the socioeconomic characteristics of the respondents. In this study, five indices (wealth, farm inputs, availability of infrastructures and institutions, irrigation potentials, and literacy level) influencing rural people adaptive capacity to climate change were selected; and a five point Likert scale was used to assess the adaptive capacity to the changing climate. The results revealed that rural communities' people in Kajuru LGA had the highest adaptive capacity to the impacts of climate change. Moderate adaptive capacity was recorded among the rural people in Kagarko, Soba and Sanga LGAs; while a low adaptive capacity was recorded in Ikara and Kauru LGAs. Therefore, Ikara and Kauru LGAs would likely be the most threatened LGAs in the state to the impacts of climate change in terms of adaptive capacity. The study recommends the development of climate change policies that would enhance the adaptive capacities of rural communities at both the state and local government levels. These policies should be specifically geared toward low adaptive capacity areas with emphasis on poverty reduction.
Keywords: Adaptive capacity index, climate change, households, impacts, vulnerability

1. Introduction

Human and natural systems have the capacity to cope with adverse circumstances, but with continuing climate change, adaptation is needed to maintain this capacity (Noble *et al*, 2014). The tendency of systems to adapt to impacts of climate change is influenced by certain system characteristics called determinants of adaptation (Olmos, 2001). These terms, among others include: sensitivity (degree to which a system is affected by, or responsive to, climate stimuli); vulnerability (degree to which a system is susceptible to injury, damage or harm); *resilience* (degree to which a system rebounds, recoups or recovers from a stimulus); and, *adaptive capacity* (the potential or capability of a system to adapt or alter to better suit climatic stimuli).

Adaptation depends greatly on the adaptive capacity of an affected system, region, or community to cope with the impacts and risks of climate change (IPCC, 2001). Therefore, enhancement of adaptive capacity reduces the vulnerability of any region, community or household and promotes sustainable development.

At the local or rural level, the key determinant of individuals, households or communities' adaptive capacity both to reduce risk and to cope with and adapt to increased risk levels of climate change are their livelihood assets such as financial, physical, natural, social, and human capital (Smit and Wandel, 2006; Moser and Satterthwaite, 2008; Deressa *et al*, 2008a; Deressa *et al*, 2008b; Gbetibouo *et al,* 2010).

Most of the research works on adaptive capacity, for examples, Dolan and Walker (2003), Smit and Wandel (2006), Wall and Marzall (2006), Fussel and Klein (2006), Deressa *et al*, 2008a, Deressa, *et al*, 2008b; Kuriakose *et al* (2009), Nelson *et al* (2010), Gbetibouo *et al*, (2010) and Ruhl (2011) among others, are closely linked to vulnerability assessments. This may be due to the fact that adaptive capacity helps in reducing climate change vulnerability.

Adaptive capacity varies from country to country, from state to state, from community to community, from household to household, among social groups and individuals, and over time. It varies not only in terms of its value but also according to its nature. The scales of adaptive capacity are not independent or separate. The capacity of a household to cope with climate impacts or risks depends to some degree on the enabling environment of the community, and the adaptive capacity of the community is reflective of the resources and processes of the region (Yohe and Tol, 2002; Smit and Wandel, 2006, Abaje and Giwa, 2010)

With specific reference to the northern part of Nigeria, poor communities tend to be more vulnerable to the impacts of climate change especially when located in high risk areas, as they have lower adaptive capacity and depend solely on the natural environment, which is climate-sensitive, for their livelihoods (Ishaya and Abaje, 2008; Abaje *et al,* 2014).

Thus, an assessment of the adaptive capacity of the rural people to the changing climatic conditions in Kaduna State is imperative to facilitating appropriate strategies to ameliorate the scourge of climate change in the state. This forms the basis for this research with emphasis on some selected rural communities in six LGAs of the state.

2. Study Area

Kaduna State is located between latitude 09^0 02'N and 11^0 32'N and between longitude 06^0 15'E and 08^0 38'E (Figure 1). The climate of the state is the tropical dry-and-wet type, classified by Koppen's as Aw. The wet season lasts from April through mid-October with a peak in August, while the dry season extends from mid-October of one calendar-year to April of the next (Abaje *et al*, 2010). The annual average rainfall in the state is about 1323mm. The spatial and temporal distribution of the rain varies, decreasing from an average of about 1733mm in Kafanchan-Kagoro areas in the South of the study area to about 1203mm in the central part (Kaduna) and about 1032mm in Zaria, lkara and Makarfi LGAs in the north.

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 (Sawa, 2002; Abaje *et al*, 2012a). The boundary zone between these two air streams is called the Intertropical Discontinuity (ITD). The movement of the ITD northwards across the state in August (around latitude 21 to 22^0N) marks the height of the rainy season in the whole state while its movement to the southernmost part around January/February (approximately at 6^0N) marks the peak of the dry season in the state (Odekunle, 2006; Odekunle *et al*, 2008; Abaje *et al,* 2010; Abaje *et al*, 2012b). The highest average air temperature normally occurs in April (28.9^0C) and the lowest in December (22.9^0C) through January (23.1^0C). The mean atmospheric relative humidity ranges between 70-90% and 25-30% for the rainy and dry seasons respectively. The highest amount of evaporation occurs during the dry season.

The geology of the study area is underlain by gneisses, migmatites and metasediments of the Precambrian age which have been intruded by a series of granitic rocks of late Precambrian to lower Palaeozoic age (McCurry, 1989). The entire land structure consists of an undulating Plateau with major rivers in the State including River Kaduna, River Wonderful in Kafanchan, River Kagom, River Gurara and River Galma in addition to several streams.

The whole state is covered by the red-brown to red-yellow ferruginous tropical soils which are heavily weathered and markedly laterized. They are mostly formed on granite and gneiss parent materials, and on aeolian and many sedimentary deposits. The whole state is covered by the tropical grassland vegetation with the density of trees and other plants decreasing as one move northwards (Abaje, 2007).

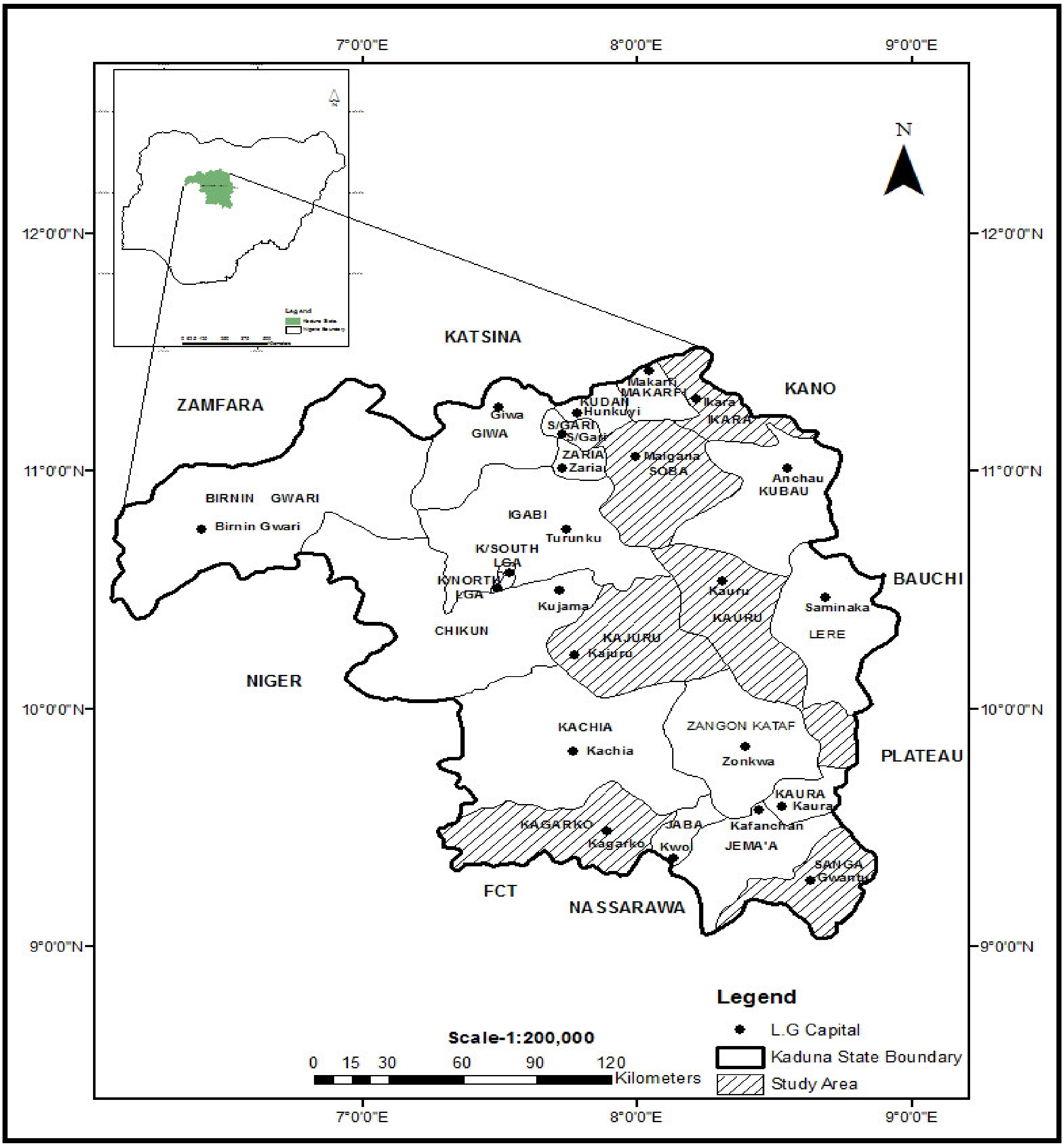

Figure 1: Map of Kaduna State Showing the Study Area

3. Materials and Methods

Data and information for this research work were obtained from a direct field study. Bartlett, Kotrlik and Higgins (2001) method of determining sample size was adopted. The method is computed as:

$$n_0 = \frac{(t)^2 \times (p)(q)}{(d)^2} \tag{1}$$

for sample size of not more than 5% and

$$n_1 = n_0 \Big/ \left(\frac{r}{100} \right) \tag{2}$$

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
r = anticipated response rate
n_0 = sample size of not more than 5%

Based on this method, the sample size used with anticipated response rate of 90% was 426. The questionnaires were proportionally administered to household heads in six LGAs namely: Sanga (52), Kagarko (58), Kajuru (40), Kauru (75), Soba (112), and Ikara (89). These LGAs were selected based on their rurality. Three (3) communities were sampled in each of the six LGAs using simple random sampling. Research assistants specializing in geography were trained to conduct the interview. The questionnaires were purposively administered to household heads who are 45 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 in climate change over the years and are more concerned and conscious about the impacts and vulnerability of climate change on their livelihoods and the environment (Ishaya and Abaje, 2008; Abaje *et al*, 2014). Only respondents who were willing and interested on the subject matter were purposively administered questionnaires. Simple descriptive statistics was used to describe the socioeconomic characteristics of the respondents using Microsoft Excel 2013.

In this very study, the major indices influencing rural peoples' adaptive capacity were considered as employed by Deressa, *et al* (2008b) and Gbetibouo *et al* (2010) that climate change adaptive capacity depends on five livelihood assets: wealth, farm inputs, availability of infrastructures and institutions, irrigation potentials, and literacy level. These five indices 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. At the same vein, these indicators are the most cited in several studies (for examples: Moss *et al*, 2001; 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 was then used (5=strongly agree, 4=agree, 3=undecided, 2=disagree and 1=strongly disagree) to assess the adaptive capacity to the changing climate. The adaptive capacity (*AC*) of each LGA was therefore calculated as:

$$AC = \frac{W + FI + AII + IP + LL}{5} \quad (3)$$

where: W = wealth
FI = farm inputs
AII = availability of infrastructure and institutions
IP = irrigation potentials
LL = literacy level

Using the interval scale of 0.50, the upper cut-off point was determined as 3.00 + 0.50 = 3.50; the lower limit as 3.00 – 0.50 = 2.50. Table 1 shows the classification of the adaptation capacity.

Table 1: Classification of Adaptation 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

The calculated result of the adaptive capacity of the people to the changing climatic conditions was then used to produce a map of adaptive capacity of the studied LGAs of the state.

4. Results

4.1 Socioeconomic Characteristics of Respondents

The results of the finding show that the majority of the respondents were males (86.2%) while only 13.8% were females. Out of the 426 respondents, 37.3% attended primary school, 12.9% Qur'anic School, 16.0% have tertiary education, and 18.5% have secondary education, while 15.3% have no formal education. The average age of the respondents is 53 years, and majority of them (86.6%) are married with an average household size of 10. The average annual income of the respondents is ₦195 970. The respondents have been living in the area for an average of 48 years and their major occupation is farming which represent 58.7%, while 13.6% engaged in livestock production, civil servants represent 20.2%, traders (5.6%), while craft and others 1.6%. Based on this result, it is a clear that most of the respondents depend heavily on environmental resources for their livelihood.

4.2 Adaptive Capacity of Rural Communities to Climate Change

The results of the rural communities' adaptive capacity to climate change in all the LGAs based on the five livelihoods assets (wealth, farm inputs, availability of infrastructures and institutions, potentials for irrigation, and literacy level) are presented in Table 2.

Table 2: Adaptive Capacity to Climate Change Based on Local Government Area

Adaptive Capacity Variables		Local Government Areas					
		Sanga	**Kagarko**	**Kajuru**	**Kauru**	**Soba**	**Ikara**
a	Wealth consideration as indices of adaptive capacity to climate change	2.79	3.27	3.82	2.26	3.19	2.28
b	Farm inputs consideration as indices of adaptive capacity to climate change	3.48	3.41	4.03	2.41	3.52	2.53
c	Infrastructural and institutional availability as indices of adaptive capacity to climate change	2.70	2.92	3.69	2.00	2.74	2.42
d	Irrigation potentials as indices of adaptive capacity to climate change	2.98	3.53	3.73	2.46	3.01	2.47
e	Literacy level consideration as indices of adaptive capacity to climate change	3.38	3.20	4.08	2.61	3.16	2.38
Mean		**3.07**	**3.27**	**3.87**	**2.35**	**3.12**	**2.42**
Rank		**4**	**2**	**1**	**6**	**3**	**5**

Note: 0.00 – 2.49 = Low adaptive capacity
2.50 – 3.49 = Moderate adaptive capacity
3.50 – 5.00 = High adaptive capacity

Source: Data Analysis (2015)

The result on wealth consideration as indices of adaptive capacity to climate change (Table 2) revealed high adaptive capacity (3.82) among the rural communities' people in Kajuru LGA, moderate adaptive capacity among the rural communities in Sanga, Kagarko, and Soba LGAs with adaptive capacity index of 2.79, 3.27 and 3.17 respectively, and low adaptive capacity among the rural communities of Kauru and Ikara with adaptive capacity index of 2.26 and 2.28 respectively. As stated in most of the literature, wealth is one of the major determinants of adaptive capacity. With large wealth, the impacts of climate change and hence the vulnerability of the rural communities or households to climate change will be reduced. Wealth, according to Cutter *et al*, (2003) enables rural communities to absorb and recover from losses and other impacts of climate change more quickly due to insurance, entitlement programs, number of livestock and economic trees owned, ownership of radio and television, and good quality of residential houses which are commonly used as indicators of wealth in African rural communities. People living in poverty are more vulnerable because they have less money to spend on preventive measures, emergency supplies and recovery efforts (Fothergill andPeek, 2004; Cutter *et al*, 2009). The findings of this study is supported by the work of Marlin *et al* (2007) that adaptive capacity is higher in Canadian communities because of their large wealth and therefore, the communities are less vulnerable to the impacts of climate change.

In terms of farm inputs consideration as indices of adaptive capacity to climate change, the result (Table 2) revealed high adaptive capacity among the people in all the rural communities of Kajuru, Soba, Sanga and Kagarko LGAs with adaptive capacity index of 4.03, 3.52, 3.48, and 3.41 respectively. Moderate adaptive capacity (2.53) among the rural people of Ikara LGA, and low adaptive capacity (2.41) in Kauru LGA. The availability and proximity to supplies of farm inputs within 1-4 km are identified as indicators of modern (or technological) adaptation to climate change in rural communities (Deressa *et al*, 2008b).

Considering infrastructural and institutional availability as indices of adaptive capacity to climate change, the result (Table 2) shows that only Kajuru LGA recorded a high adaptive capacity (3.69) among the rural people. Moderate adaptive capacity was recorded among the rural people of Kagarko, Soba, and Sanga LGAs with adaptive capacity index of 2.92, 2.74, and 2.70 respectively; whereas Kauru LGA recorded a low adaptive capacity (2.00) among the rural community people. The availability of infrastructure and institutions such as good roads network, rural electric power supply, health/veterinary services, formal and informal credit-based loaning institutions, and good markets among others are of great important in terms of adaptation to climate change in rural communities by facilitating access to resources. This is in line with the result of Deressa *et al* (2008a) that infrastructure and institutional factors influence the use of adaptation methods by rural farmers in the Nile Basin of Ethiopia.

Irrigation potential is another important and prominent adaptive capacity in checking the impacts of climate change and vulnerability among the rural communities in the study area. Irrigation potentials as indices of adaptive capacity among the rural people is considered high (3.73) in Kajuru, high (3.53) in Kagarko, moderate (3.01) in Soba and also moderate (2.98) in Sanga LGAs; whereas, this same variable is considered low (2.46) in Kauru and low (2.47) in Ikara LGAs. The use of irrigation potential as put forward by O'Brien *et al* (2004) is based on the assumption that communities with more potentially irrigable lands are expected to have a higher capacity to adapt to adverse climatic conditions and other economic shocks.

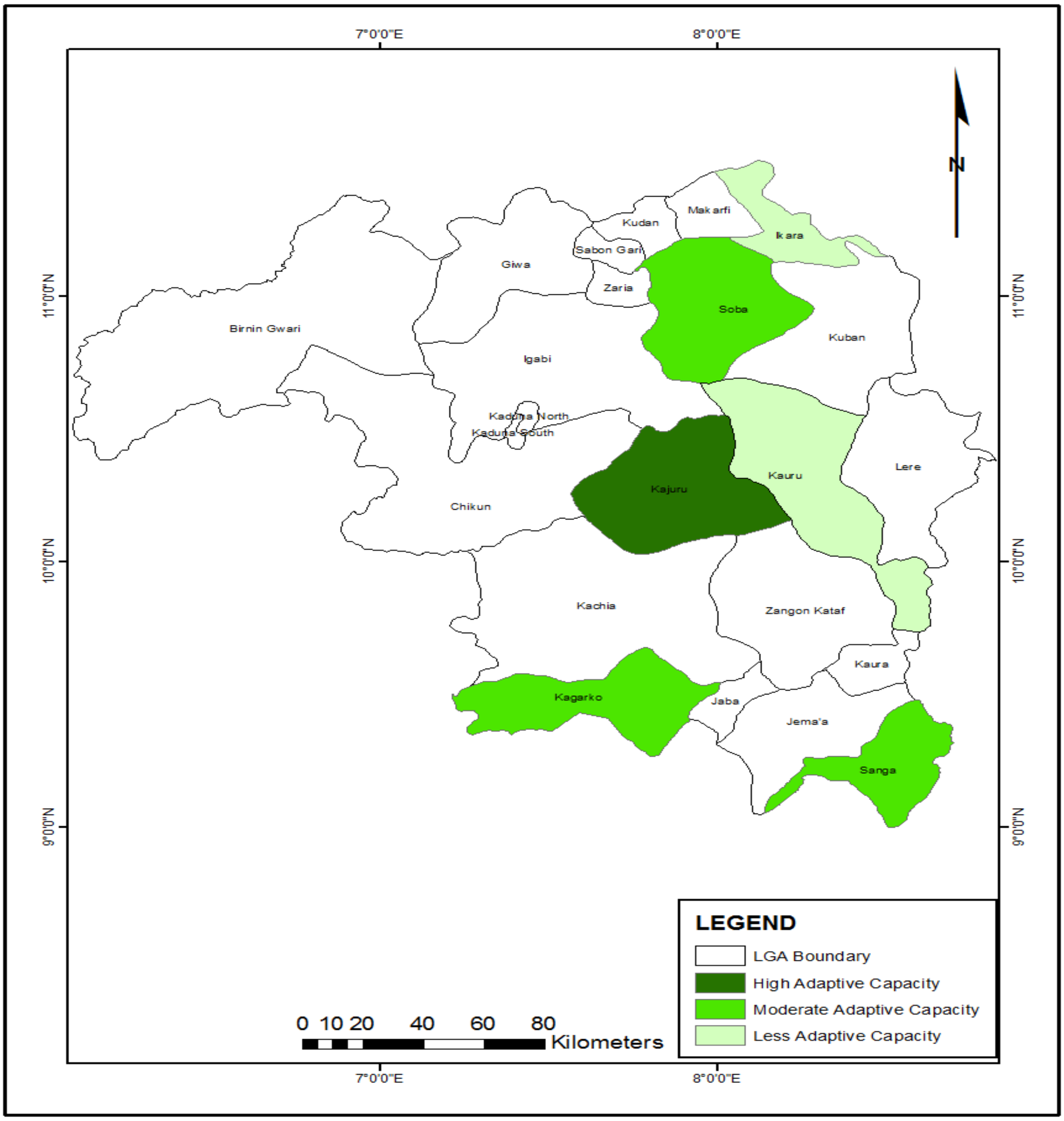

Figure 2: Map of Adaptive Capacity Across the Local Government Areas
Source: Author's elaboration

Literacy level as an adaptive capacity among the rural people in study area was considered high (4.08) in Kajuru LGA; whereas it was considered moderate among the rural people of Sanga, Kagarko, Soba, and Kauru LGAs with adaptive capacity index of 3.38, 3.20, 3.16, and 2.61 respectively. In Ikara LGA, the literacy level was low (2.38) among the rural people. The literacy level of rural communities is considered to help ascertain the level of skills and education among the rural people. Deressa *et al*, (2008b) argued that communities or nations with high level of knowledgeable people are considered to have greater adaptive capacity than those with low literacy level.

A map of the adaptive capacity of the studied LGAs is presented graphically in Figure 2. A general examination of the mean adaptive capacity among the rural communities in all the LGAs of the state (Table 2) shows that rural communities' people in Kajuru LGA have the highest adaptive capacity (3.87) to the impacts of climate change and is ranked first (1st). Moderate adaptive capacity (3.27) is recorded among the rural people in Kagarko LGA and is ranked second (2nd), followed by Soba with moderate adaptive capacity index of 3.12 (ranked 3rd), and then Sanga with moderate adaptive capacity index of 3.07 (ranked 4th). Ikara LGA with a low adaptive capacity index of 2.42 among the rural people is ranked fifth (5th), while Kauru LGA with low adaptive capacity index of 2.35 is the least (ranked 6th) and therefore, it will likely be the most threatened LGA in the state to the impacts of climate change and vulnerability in terms of adaptive capacity.

5. Discussions

Adaptive capacity affects vulnerability through modulating exposure and sensitivity and thereby influencing both the biophysical and the social elements of a system. The more the adaptive capacity within a system, the greater the likelihood that system will be resilient in the face of climate change stresses. The capacity of individuals or households to adapt to climate change impacts is a function of their access to resources.

Adaptation to climate change is costly and the need for intensive labor use also contributes to this cost. Therefore, wealth is an important variable of adaptive capacity to climate change in rural communities. Its enables rural communities to absorb and recover from losses and other impacts of climate change more quickly than communities or households that lack wealth (poverty) (Cutter *et al,* 2003). Lack of wealth is the primary contributor to vulnerability in the study area as fewer individuals and communities' resources for recovery shocks are available, thereby making the communities less resilient to the impacts of climate change. Households with small family labor and lack the financial backing to hire labor are likely to be restricted from adaptation practices that will mitigate the impacts of climate change in order to reduce the vulnerability in their households and the community (Deressa *et al,* 2008b; Abaje *et al*, 2014). Wealth generally provides access to markets, farm inputs, technology and other resources that can be used to adapt to climate change (Gbetibouo *et al*, 2010). Based on this, rural communities in Kajuru LGA with high adaptive capacity (3.82) are most likely to adapt to the impacts of climate change more strongly than communities in Kauru and Ikara with low adaptive capacity, and will likely be the most threatened to the impacts and vulnerability of climate change in terms of wealth consideration.

The availability and access to agricultural inputs recorded high adaptive capacity among the rural people of Kajuru and Soba LGAs. For examples, the use of pest and diseases resistance seeds, the use of drought tolerant or early maturing varieties of crops, and accessibility to complementary inputs such as fertilizers, herbicides and pesticides in those LGAs will contribute positively to their successful adaptation measures. According to Gbetibouo *et al* (2010), access to farm inputs (or agricultural) provide a general picture of the financial status of a household or community. Kauru with a low adaptive capacity (2.41) in terms of availability and access to agricultural inputs will be worst hit.

The quality and availability of infrastructure and institutions in a LGA is an important measure of adaptive capacity of a given community. For examples, the availability of infrastructures such as good roads permit the distribution of necessary agricultural inputs to rural farmers at all-time. These roads also influence the feasibility and effectiveness of aid distribution programs in response to disasters resulting from climate change such as floods, droughts and famines (Gbetibouo *et al*, 2010). The availability of health services can assist in the provision of preventive treatments to the rural dwellers for diseases such as malaria and cholera that are associated with climatic changes (Deressa *et al,* 2008b). Likewise, institutions such as microfinance often supports rural communities by providing credits for technology packages which are important variables of adaptive capacity to climate change; and the availability and access to good markets also help the rural people in facilitating the sale of livestock and other farms produce in times of crisis. Therefore, communities having well developed and organized infrastructures and institutions are considered to be better able to adapt to climatic stresses than those with less effective infrastructure and institutional arrangements (Moss *et al*, 2001; Adger *et al*, 2004; O'Brien *et al*, 2004). This scenario which is common in communities of Kajuru LGA contributed to the high adaptive capacity of the LGA. Rural people living in marginal environments and areas with low or without infrastructures and/or institutions are those with low adaptive capacity to climate change. This is the case of Kauru LGA with a low adaptive capacity index of 2.00, and therefore, it will likely be the most threatened to the impacts and vulnerability of climate change because the rural people lack the capacity to support their livelihoods which is primarily crop production.

Based on irrigation potentials, rural people in Kajuru and Kagarko LGAs with high adaptive capacities are more likely to adapt to climate change better than those in Kauru and Ikara LGAs with low adaptive capacity. The high adaptive capacity of Kajuru and Kagarko LGAs may not be unconnected with the presence of River Kaduna passing through Kajuru LGA and River Gurrara passing through Kagarko LGA in which the flood plains of these two rivers are often use for irrigation farming during the dry season. Investment in irrigation in places with high irrigation potentials can increase the food supply of the area, the state and the country at large. This food supply according to Deressa *et al* (2008b) could then be stored by the farmers and sold out during extreme climatic events like drought and flood instead of depending on food aid.

In terms of literacy rate, the assumption is that higher literacy levels increase adaptive capacity by increasing people's capabilities and access to information, thereby enhancing their ability to cope with adversities (Thornton *et al*, 2006; Gbetibouo *et al*, 2010). Based on that assumption, Kajuru LGA with high literacy rate is therefore considered to have high adaptive capacity to climate change than Ikara LGA with low literacy rate. Lower education according to Cutter *et al,* (2003) constrains the ability to understand warning information and access to recovery information.

The mean adaptive capacity of all the LGAs showed that all the variables recorded high adaptive capacity among the rural communities' people of Kajuru LGA, placing the LGA as having the high adaptive capacity to climate change (ranked 1). Here, it is important to note that all the determinants or variables of adaptive capacity are not independent of each other (Smit and Wandel, 2006). The availability of wealth will increase adaptive capacity of a household or community by providing greater access to farm inputs, markets, infrastructure and institutions, and other resources that can be used to adapt to climate change impacts.

Higher literacy level (or educational attainment) always result in greater earnings and the ability of one having access to farm inputs, infrastructures and to understand warning information and access to recovery that can also be used to adapt to climate change (Cutter *et al*, 2003; Gbetibouo *et al*, 2010). This is the case of Kajuru LGA where wealth and literacy level recorded high adaptive capacity. These two variables (wealth and literacy rate) might have helped the rural people having access to other resources that could be used for climate change adaptation, and hence the LGA is less threatened to the impacts of climate change. The presence of the two major rivers, River Kaduna cutting through Kajuru LGA and River Gurara cutting through Kagarko LGA might have contributed to the richness in water resources and soil nutrients particularly at the flood plains of the rivers. This makes irrigation farming possible in these LGAs. With their moderate wealth and literacy rates, rural people in Kagarko LGA where able to have access to farm inputs and other resources that can help them adapt to climate change through the utilization of the irrigation potentials especially the presence of Gurara Dam. This may be the major reason irrigation potential is considered high (3.53) among the rural people in all the communities of the LGA. Ikara LGA on the other hand has the least adaptive capacity among the LGAs and hence, the most threatened.

A critical examination of the mean adaptive capacity for all the LGAs show that adaptive capacity to climate change decreases from the southern part of the state to the northern part. This may be due to the rural people's dependent on rain-fed agriculture for their livelihood that is climate-sensitive, which coincide with the decrease in rainfall from the southern part of the state to the northern part. The southern part of the state (Kafanchan) is having an annual rainfall of about 1733 mm, the central part (Kaduna) is having an annual rainfall of about 1203 mm, while the northern part (Zaria) is having an annual rainfall of about 1032 mm.

6. Conclusion and Policy Recommendations

The capacity of individuals or households to adapt to climate change impacts is a function of their access to resources. The mean adaptive capacity among the rural communities in all the LGAs studied show that rural communities' people in Kajuru LGA have the highest adaptive capacity (3.87) to the impacts of climate change (ranked 1st), while Kauru LGA with low adaptive capacity index of 2.35 is the least (ranked 6th) and therefore, it will likely be the most threatened LGA in the state to the impacts of climate change and vulnerability in terms of adaptive capacity. Findings also revealed that the mean adaptive capacity for the state decreases from the southern part to the northern part. This may be due to the rural people's dependent on rain-fed agriculture for their livelihood that is climate-sensitive, which also coincide with the decrease in rainfall from the southern part to the northern part of the study area.

The study recommends the development of climate change policy that will enhance the adaptive capacities of the rural communities at both the state and local government that is specifically geared toward more vulnerable areas of the state with emphasis on poverty reduction. Such policies should streamline roles and responsibilities, strategies for adaptation and mitigation of climate change, and stakeholders' involvement in a systematic manner; and there should be regular workshops and conferences, and international affiliations should be used to provide updates on climate change issues.

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