Land Use Change and Rural Livelihood in Changing Climate in Semi-Arid Akko LGA, Gombe, Nigeria

By

[1]R. D. Abu, PhD [2]G. O. Abu

[1,2]Department of Geography, Federal University, Kashere, P.M.B. 0182, Gombe State, Nigeria

and L. A. Mbaya, PhD

Department of Geography, Gombe State University, P.M.B. 127, Gombe State, Nigeria

abdaray@yahoo.com

Abstract

This study examines land-use/land-cover (LULC) dynamics and farmers' perception of climate change and their adaptation strategies in semiarid Akko towards sustainable rural livelihoods. LULC analysis was carried out to generate the static area of the land-cover classes while the extent of climate variability in the study area was established from archival temperature and rainfall data. Farmers' survey was conducted in five farming communities of Akko with a sample of 150 farmers that were on their farms as at the time of the survey. The results of the study reveals high rate of conversion of woodland and shrub-land vegetation to farmland. It also shows that temperature is on the increase while the total annual rainfall has been on a decrease during the last 30 years. The result also shows that farmers understanding of climate change is related to decreasing annual rainfall amount, increasing temperature, early drying up of surface water sources, intermittent drought and drier environment, reduction in vegetal cover/deforestation, increasing incidence of flooding, decrease crop productivity, increased pest and disease infestation and reduction in the severity of harmattan season. Major adaptation strategies adopted by the farmers include growing of drought resistant crop varieties and early maturing crop varieties, organic, compost and inorganic fertilizer application, prayers for divine intervention, mixed cropping, among others. The findings revealed that farmers are increasingly engaging in off-farm sources of livelihood. Recommendations made based on the findings include making drought resistant crop varieties and fertilizers more affordable, provision of sustainable household alternative source of energy to reduce greenhouse gas emissions which accentuate climate change, increased access to extension services as well as adequate and timely dissemination of climate information to farmers.

Keywords: Climate change, Climate variability, Adaptation strategies, Land use, Rural livelihood

Introduction

The climate crisis is one of the greatest challenges facing our world today and indications are that climate change is taking place faster than previously predicted.

Without significant efforts to address the impact of climate change and land degradation, the livelihoods of the African drylands populations will be in jeopardy (UNEP, 2007). The AR4 estimates that by 2020 between 75 and 250 million people are likely to be exposed to increased water stress and that rain-fed agricultural yields could be reduced by up to 50 per cent in some countries in Africa if production practices remain unchanged (IPCC, 2007). Changes in climate will place an additional pressure on already over stretched food supply systems and undermine further the livelihoods of pastoralists and agro-pastoralists in drylands (Cooper *et al*, 2008). Majority of the inhabitants of the semi-arid zones are typically pastoralists and agro-pastoralists who make their livelihoods from a combination of rain-fed crop production and livestock rearing, a situation that makes them particularly vulnerable to climate change. Many are unable to grow sufficient food to feed the household and often engaged in off farm work as a supplementary source of income or are dependent on remittances. However, the need to produce more food to meet the demands of an increasing population has led to overgrazing, cultivation of marginal lands of poor soil fertility and conversion of woodlands and rangelands to cultivated farmland. Unsustainable cultivation practices in the semi-arid zone had resulted largely in land use and land cover change and land degradation which in turn leads to a reduction in food productivity and long-term food insecurity. Climate change is now aggravating these challenges ((IPCC, 2007; Garedew, 2009; UNEP, 2007). Odjugo (2010) reportedspatial and temporal variations in temperatures over Nigeria. The temperature anomalies show that climate change is stronger from the 1970s. Within the 105 years of meteorological evidence, temperatures increased by 1.2°C in the coastal cities of the Niger Delta and 2°C in the northern extreme of Nigeria. A mean air temperature increase of 1.7°C was observed in Nigeria for the past 105 years and the rising temperature may have led to the rising evaporation, drought and desertification that are widespread in north-western and north- eastern part of Nigeria and consequently loss of prime arable lands due to climate change.

Materials and Methods

The study area is Akko located on 10^0 15'02''N -$10^0$20'00''N and $11^0$05'00''E - $11^0$15' 00''E (Fig.1). Temperature is high all year round with a mean annual air temperature of 30^0C. The highest temperatures are recorded during the dry heat wave months of between March and May with maximum air temperature of above 37^0c. During the rainy season, the temperature drops considerably due to dense cloud cover between July and August as well as during the harmattan period of November to February. Rainfall is strongly seasonal due to the oscillation of the inter-tropical convergence zone (ITCZ) which controls the Tropical Maritime and the Tropical Continental air masses of contrasting air moisture and relative humidity over the study area. The mean annual precipitation is 835 mm. Landsat imageries covering the period of 1995-2015 were processed and classified into suitable Land-

cover classes using the supervised maximum likelihood scheme to generate the static area of the Land-cover classes. To establish the extent of climate variability in the study area over the last forty-six years (1970-2016) archival temperature and rainfall data were sourced from NIMET station in Gombe. Farmers' interview involve a cross sectional farmers' survey conducted in five communities of Akko with a sample of 150 farmers that were on their farms as at the time of the survey.

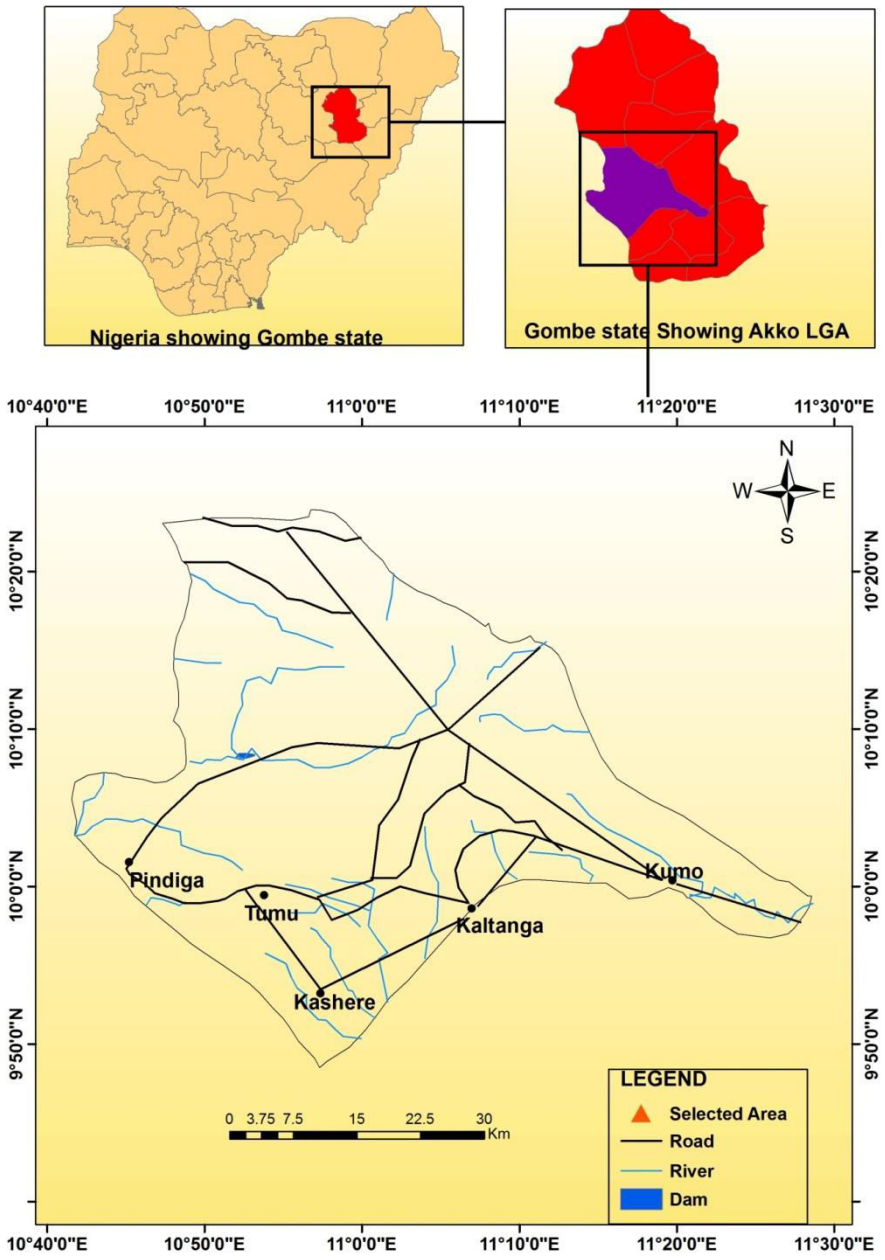

Fig. 1: Location of the study Area

Results and Discussion

The spatial extent of the classified land use and land cover type is presented in Table I. The categories of land use/landcover identified in the study area are built-up areas, farmland, bare surface, shrubland and woodland.

Table1: LULC change in Akko (1995- 2015)

Landuse/ Landcover Classes	Area Extent in 1995 (km^2)	Area Extent in 2005 (km^2)	Area Extent in 2015 (km^2)	Change in Area Extent from 1995-2015 (Km^2)
Built-up area	13	16	29	+16
Farmland	907	1036	1469	+562
Bare Surface	60	113	163	+103
Shrubland	334	280	224	-110
Woodland	602	471	31	-571
Total	**1916**	**1916**	**1916**	

Source: Author's GIS Analysis, 2016

During the past decade, changes in landuse/landcover have altered the environment and the ecosystem services it provided. Extensive areas of shrubland and wooded vegetation have been converted to agricultural cropland. Built-up areas have expanded and the resultant use of earth materials and vegetal resources in construction of dwelling places created bad-land, burrow pit and extend bare surfaces and gullies that have devastated the land recourses. Built-up Area had the lowest extent in 1995 covering an area of 13 km^2. However, it maintained consistent increase and by 2005 it covers an extent of 16 km^2. This trend continued and increased to 29 km^2 in 2015. This unbroken increase in built-up area resulted from the displacement and resettlement of people from the emerging new state capital. Farmland area in 1995 had the highest area extent of 907 km^2. This was so because the majority of the indigenous people of Akko were engaged in farming activities. In 2005 and 2015, the extent increased to 1036 km^2 and 1469 km^2 respectively. This increase may have resulted from more people depending upon the natural resource base for their livelihood and also abandonment of farmland as a result of land degradation and inadequate land use practice of slash and burn subsistence agriculture on the fragile resource base of low soil fertility. Bare surface had an extent of 60 km^2 in 1995. In 2005 and 2015 it increased to 113 km^2 and 163 km^2 respectively. This increases resulted from the deforestation, vegetal cover loss, poor land management and land degradation occasioned by overgrazing and the increasing dimensions of gullies. Shrub land and Woodland had an extent of 334 km^2 and 602 km^2 respectively in 1995. But in 2005, it had reduced to 280 km^2 and 471 km^2 respectively. The reduction continued in 2015 when it decreased to 224

km^2 and 31 km^2 respectively. The reduction observed obviously resulted from expansion of cropland and pastureland and increasing number of people seeking livelihoods from off farm activities of logging, fuel wood marketing and charcoal production to meet the energy needs of the rural populace. The implications of extensive changes in land use and land cover are increases in surface temperature and contributions to greenhouse gas emission that accentuate climate change.

The results of the variation in the annual temperature and rainfall (1970-2016) are presented infigures 2 and 3 respectively. The result revealed an increasing trend for temperature. Temperature has consistently increased from 27.9^{0}C in 1970 to 36.8^{0}C in 2016. Most agricultural crops are negatively affected by increase in the maximum temperature, extremely warmer condition leads to decrease in crop yield because the soil-water availability is impaired. In addition, higher maximum temperature increases the rate evapotranspiration over photosynthesis thereby leading to reduction in the net crop yield (IPCC, 2007, Moyo, 2012; Simatele et al, 2012).

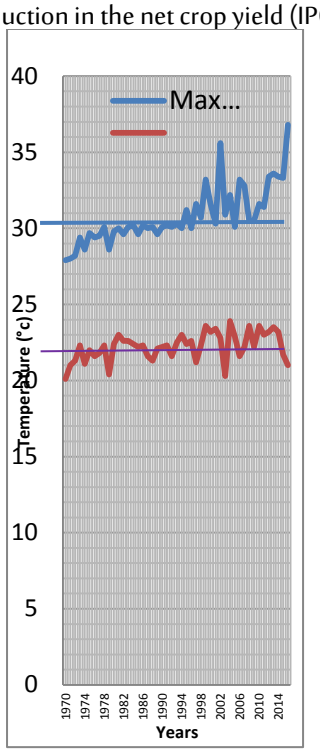

Fig. 2Variations in annual Temperature (1970-2016)

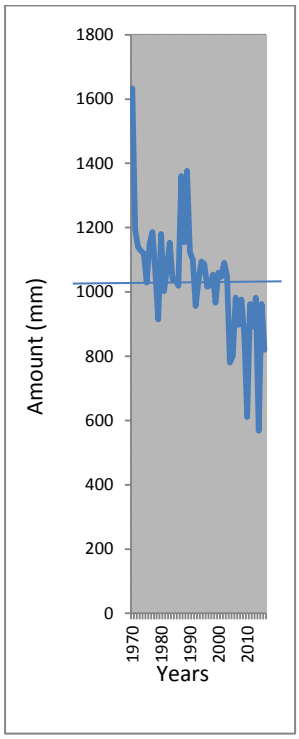

Fig. 3:Variations in annual Rainfall (1970-2016)

Total annual rainfall has been on a decrease during the last 30 years and it was observed from figure 3 that the year 1970 recorded the highest annual rainfall value of 1633mm. The total annual rainfall recorded for 1980, 1990, 2000 and 2010 was 1180mm, 1123.8mm, 1060.2mm and 610.6mm respectively. The threshold of rainfall in the preceding years of 2011, 2012, 2013, 2014, 2015 and 2016 recorded a value of 962mm, 892.6mm, 982.4mm, 567.9mm, 962.5mm and 820mm respectively. The year 2014 recorded the lowest rainfall value of 567.9 mm. The variable rainfall pattern impacts agricultural production and rural livelihoods. Sawa and Adebayo (2011) reported a decrease in the onset and cessation dates of rainfall which invariably results to decrease in the length of the rainy season as well as the associated reduction in the yield of the crops in parts of Northern Nigeria.

The socio-economic characteristics of the sampled farmers largely influence their perception of climate change and adaptation strategies. Table 2 shows that 20.7 % of the respondents were averagely 30 years, while 26.7% were between 31-40 years. Those within the age of 41-50 constitute 26%, 51-60 age bracket account for 19.3% of the respondents, while 61-70 years accounted for 7.3% of the respondents.

Table 2: Respondents Demographic and Socio-economic Characteristics

Characteristics	**Total** N=150 (%)		**Characteristics**	**Total** N=150 (%)	
Age group			**Level of Education**		
21-30	31	20.7	Non formal	33	22.0
31-40	40	26.7	Primary	40	26.7
41-50	39	26.0	Secondary	60	40.0
51-60	29	19.3	Tertiary	17	11.3
61-70	11	7.3			
Gender			**Length of farming (yrs)**		
Female	43	28.7			
Male	107	71.3	≤ 5	20	13.3
			6 -10	31	20.7
			11 - 15	64	42.7
			16 - 20	18	12.0
			21 - 25	11	7.3
			26 – 30	6	4.0
House hold size			**Hectares under cultivation**		
1-5	47	31.3			
6-10	47	31.3	≤ 5	24	16.0
11-15	32	21.3	6-10	36	24.0
16-20	14	9.3	11 - 15	55	36.7

21-25	5	3.3	16 - 20	14	9.3
>25	5	3.3	21 - 25	11	7.3
			26 – 30	5	3.3
			> 30	5	3.3

The average farmers age of 50 years represent experience in farming while the highest 42.7% of the respondents have been engaged in farming operation for an average of 20 years and are largely expected to have been exposed to past and present climatic variability. The gender composition of the respondents reveals that 71.3 % were male while 28.3% were female. The reason likely resulted from the fact that agriculture is a male dominated occupation. Household size is associated with cheap farm labour endowment that translates to larger farm size. The household size of 11-15 persons represents 21.3% of the respondents while 6-10 persons accounted for the highest 31.3%. Others are 1-5 persons (31.3%), 16-20 persons (9.3%), 21-25 persons (3.3%) and above 25 persons (3.3%). An average farm size of 15 hectares under cultivation accounted for the highest respondents of 36.7%. This is closely followed by 6-10 hectares (24%), average of 5 hectares (16%), 16-20 hectares (9.3%), 21-25 hectares (7.3%), 26-30 hectares (3.3%) and above 30 hectares (3.3%). Educational attainment helps farmers to understand linkages between climate change and various livelihood issues and also choice of sustainable adaptation measures that would reduce the impact of climate change. Table 2 reveals that about 22% of the respondents had no formal education, while 26.7% attained primary education, 40% attained secondary education. Only 11.3% attained tertiary education. The study reveals that 78% of the respondents have some form of formal education. The study of Adebayo et al (2012) shows that adoption of measures that could result in climate change adaptation is easier and faster among the educated farmers than the uneducated farmers.

Table 3: Farmers awareness and perception of climate change

Characteristics	Total N=150	(%)	Characteristics	Total N=150	(%)
Decreasing annual rainfall amount			**Reduction in vegetal cover/deforestation**		
Agree	122	81.3	Agree	127	84.7
Disagree	14	9.3	Disagree	11	7.3
Indifferent	14	9.3	Indifferent	12	8.0
Increasing Temperature			**Increasing incidence of flooding**		
Agree	145	96.7			
Disagree	3	2.0	Agree	123	82.0
Indifferent	2	1.3	Disagree	21	14.0
			Indifferent	6	4.0
Early drying up of surface water sources	132	88.0	**Decrease crop productivity**		
	7	4.7			
	11	7.3			
Agree			Agree	111	74.0
Disagree			Disagree	33	22.0
Indifferent			Indifferent	6	4.0
Intermittent drought and drier environment			**Increased pest and disease infestation**		
			Agree	105	70.0
Agree	143	95.3	Disagree	38	25.3
Disagree	1	0.7	Indifferent	7	4.7
Indifferent	6	4.0			
Reduction in the severity of Harmattan season					
Agree	136	90.7			
Disagree	11	7.3			
Indifferent	3	2.0			

Adoption of adaptation strategies by farmers depends on the level of awareness and perception of climate change. This study indicates that farmers have a clear understanding of climate change in terms of various meteorological indicators and decreased crop productivity among others as presented in Table 3. Annual rainfall Pattern has been decreasing over the years as expressed by 81.3% of the respondents, while 9.3% believed that rainfall trend has been on the increase. The

remaining 9.3% of the respondents claimed not to have noticed any change in rainfall trend in the area. The general respondent concern on decreasing annual rainfall is supported by the data presented in figure 3. This opinion also corroborated the previous research findings on general decline in annual rainfall in many part of Nigeria (Odjugo, 2009; Adebayo, 2011). Regarding temperature, 96.7% of the respondents perceived that temperature is on the increase in the area while 2% ascertained that temperature trend has been on the decrease and 1.3% of the respondents claimed not to have noticed any change in temperature trend in the area. The increasing trend in temperature is evident in the meteorological data of the study area presented in figure 2. Majority of the respondents also perceived climate change in terms of early drying up of surface water sources (88%), intermittent drought and drier environment (95.3%), reduction in vegetal cover/deforestation (84.7%), increasing incidence of flooding (82%),decrease crop productivity (74%), increased pest and disease infestation (70%) and reduction in the severity of Harmattan season (90.7%). The results of this study corroborates the findings of Adebayo et al (2012) and Adesiji et al (2012) in which reduction in crop yield, reduction in surface water, reduction in grass and biomass, crop pest infestation and increasing problem of flooding and drought were attributed to climate change thereby threatening the livelihood of the farmers.

Adaptation strategies	Total N=150 (%)		Adaptation strategies	Total N=150 (%)	
Increase farm land under cultivation	26	17.3	Planting drought tolerant crop	11	7.3
Mixed cropping	18	12.0	Improved cropping techniques	4	2.7
Use of compost and organic manure	17	11.3	Increased prayers for divine intervention	12	8.0
Use of inorganic fertilizer application	14	9.3	Irrigation and cultivation of fadama land	2	1.3
Planting early maturing crop variety	18	12.0	Seek off-farm jobs	15	10.0
livestock keeping	13	8.7			

Table 4: Farmers Adaptation Strategies to Climate Change

Adaptation measures employed by the farmers to minimize the effect of climate change in the area are presented in Table 4. The distribution reveals that 17.3% of the farmers increase their farm land under cultivation, while 12% adopt mixed cropping, use of compost and organic manure accounted for 11.3%. Farmers using inorganic fertilizer application represent 9.3% of the respondents. Use of early maturing crop variety account for 12% of the sampled farmers, while 8.7% of the farmers are raising livestock comprising chicken, goats, sheep, cattle etc for sales to cushion their revenue short fall from crop production. Planting drought tolerant crop represent 7.3% of the respondents, while improved cropping techniques account for 2.7% of the respondents. Increased prayers for divine intervention, irrigation and cultivation of fadama land and seeking off-farm jobs accounted for 8%, 1.3% and 10% respectively.

Implications of Climate Change on Rural Livelihoods

Rural livelihoods in semi-arid Akko and other Sub-Saharan African Countries mostly revolve around rain-fed crop production and small holder livestock rearing. Changes in the rainfall pattern negatively impact on rural livelihoods. Decreasing rainfall constrains the rural farmers that depend on rain-fed cultivation. It also reduced pasture, forage, and water for pastoralists. For the pastoralists, prolonged drier conditions also mean increased grazing distance. This situation is partly responsible for incessant conflicts between nomadic herdsmen and the settled farmers in parts of Nigeria. Intermittent droughts and flooding hamper farming activities by reducing

crop yields. Increasing temperatures often causes wilting of crops and the dry spells experienced between rains worsen the situation which sometimes necessitates some replanting. The poor farm harvest places a high debt burden on the farmer thereby increasing the rate of farm abandonment for off- farm jobs and increasing the problem of food insecurity.

Conclusion and Recommendations

The findings of this study indicated that farmers have sufficient knowledge of climate change and how it affect their farming operations and have employed varying degree of adaptation methods in recent years. The results also show that education level and farming experience are the factors that enhance farmers' adaptive capacity to climate change and variability. However, dissemination of climate information through extension services is lacking and the area is faced with increasing food insecurity, hunger, decreased nutrition base for the rural majority and rising poverty levels thereby making livelihoods unsustainable. Based on the findings, the following recommendations were made:

i. Farmers should adjust planting dates to avoid crop failure due to late onset and early cessation of rains.
ii. Effort should be made to improve farmer's access to climate information and prediction so as to increase their ability and flexibility to adopt adaptation measures in response to the forecasted climate conditions.
iii. Extension service should be improved and made accessible to farmers so as to serve a key element of appropriate adaptation measures or strategies.
iv. Government, NGOs and research institutions should foster initiatives for improving food production towards reducing hunger and malnutrition.
v. Where crop production becomes non-viable, intensive gardening and small livestock production such as poultry, goats and sheep rearing should be developed to secure rural livelihood.
vi. Provision of sustainable household alternative source of energy so as reduce reliance on fuel wood and charcoal toward reduction of greenhouse gas emissions which accentuate climate change.

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