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Editorial Remarks

Dear Reader,

CHSUD Journal of Settlement Research and Development (CHSUDJ) in the last one year focused its articles on problem-solving and the dynamics in increase knowledge. This is responsible for the gap experienced between the last and current edition.

The Editorial team has been jiggled in line with the recent changes at CHSUD in other to inject more resourceful and highly motivated academia and professionals to improve on our outputs and service delivery.

The current edition presents well researched papers which our assessors have reviewed without bias. It covers a range of topical issues within the built environment as it relates to sustainability of the 21st century cities: climate change, housing, safety in buildings, architecture transformation, land use change and land value, energy coping strategies, land administration, planning and governance, rainfall variability, child poverty, spatial framework for schools and accident hazards in the construction industry geared to create socially inclusive, resilient and self-sustaining cities and towns in the globe.

We hope this edition keeps you better informed with value addition and research motivated.

Dr. M.B. Nuhu, FNIVS
(Associate Professor)
Editor in-Chief
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HUMAN ADAPTATION TO LAND USE AND CLIMATE CHANGE IN GUNU AND ITS ENVIRONS, IN SHIRORO AREA OF NIGER STATE NIGERIA

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Abstract

The global understanding on the dynamics of land use land cover change has been established to trigger several environmental issues at all scales with climate change inclusive. As a consequence, an insight on how humans have adapted to these changes has become extremely important, particularly at a local scale where the adaptive capacity may be low or inadequate. Gunu was considered as a case study in Niger state, Nigeria with the aim of examining land use land cover change of the area using geospatial techniques, as well as the trend of climate vagaries. Landsat images of 1990, 2006 and 2015 were obtained from theUSGS. Climatic trends were established using 1975-2014 data (rainfall and temperature) acquired from NIMET. The result obtained from the Landsat imageries shows that within the time period, vegetation decreased by 35 %, while built up areas, farmlands and bare surfaces increased by 20%, 8% and 6% respectively. The rainfall and temperature of the area shows increasing trend with mean values of 1200mm and 27.75°C respectively. The agricultural implications for human adaptation include: momentary disengagement from farming by 75% of the respondents and the adoption of combined adaptation options by most of the farmers. This was evident by the high acceptance value of most of the adaptation options (i.e. farmers adaptation actions ranges between 56% and 76%). The outcome of the research suggested that climate friendly practices such as Conservation Agriculture (CA) should be encouraged in the area by relevant stakeholders. Also a need to promote sustainable land management on a local scale and community land use planning and action should be implemented and strengthened to address climate change in the study area while scaling up the people's adaptation.

Keywords: Adaptation, Climate Change, Human, Land Use

Introduction

Land is the stage on which human activity is laid and the source of the materials required for human existence (Briassoulis, 2000). Human utilization of land assets is referred to as "Land Use". The utilization differs with the reason it serves, such as food production, procurement of safe housing, amusement, extraction and handling of materials, etc. Land use is shaped under the influence of two expansive arrangements of forces; which incorporates human needs and

the natural elements and procedure. Land use is a major driving force in global change and intricately connected to climate change (Glison *et al,* 2012).Deforestation, urban sprawl, farming, and other human impacts have considerably modified landscapes. Such disturbances on the land surface have changed the global atmospheric concentration of carbon dioxide, and have additional impacts on nearby, provincial, and the global atmosphere as it changes the vitality equalization on the earth's surface ((IPCC, 2001, 2007). Human adaptation is firmly connected to the advancement of human capacities with changes and instabilities (IPCC 2001, Kitano, 2002). Land use change has risen as one of the key issues in the global change, climate change, earth framework and reasonability investigation programs (Gutman *et al.,* 2004). The normal impacts of land use change have been documented in urban, rural, and open space zones. For example, Awoniran (2011) opined that land use change happens at the edges of huge urban centres where weights of urbanization and industrialization often result in the loss of prime farming grounds and land cover while Ramankutty *et al.* (2005) noted that land use dynamic occurs at various scales.

Globally, the conditions that either create helplessness or advance human adaptation to land use and climate changes are affected by accelerating procedures of social, political, financial and ecological changes (Smith, *et al.,* 2000). Different appraisals demonstrate that free land surfaces have been influenced or changed in a few courses by human activities (Vitousek *et al.,* 1997), while 10 to 55% of the net essential profitability has been cut by human land use activities (Rojstaczer*et al.,* 2001). In Nigeria, more land is particularly demanded for expansion of cultivated land and built-up areas due to rapid human activities particularly population growth and urbanization. Like other West Africa countries, Nigeria's climate is also likely to see a growing shift in temperature, rainfall, storms, and sea levels throughout the twenty-first century (IPCC, 2001). These challenges, if unaddressed, will further aggravate pressure on the already stressed resources such as land and water. Moreover, poor responses to resource shortages could have serious negative secondary effects. In Niger State like every other state in Nigeria; the use to which land is put changes at alarming rates just as the rate of changes in climate is glaring (NFNC, 2003). This probably is already playing out on a limited scale, especially in farming communities. For farmers in the state, adaptation measures and strategies are expedient in reducing vulnerability to climate change impact and other land uses. Effective adjustment to these changes require individual and aggregate efforts at group, national and worldwide levels with the specific end goal of diminishing the immediate and aberrant effects on human wellbeing.

The problem in Gunu, Shiroro Local Government Area of Niger State, Nigeria therefore lie on the glaring land and climate changes and degradations over the past decades as a result of various human activities, particularly deforestation. These changes have informed a lot human of decisions aimed at adapting to them.

As humans respond to these changes more of these changes still occur.The study, therefore, aimed at assessing how the local people in Gunu have been adapting to the changes in land use and climate change/variability in their environment. The study specifically examined the changes in land use/ land cover of Gunu and her neighborhoods, considered the trend of climatic element by focusing on rainfall and temperature parameters, examined the people's perceptions and the human (Agricultural) implications for adaptation to land use land cover and climatevariability in the area.

The Study Area

Gunu in Shiroro local Government area of Niger State, lies between latitude $9^0 40^1 22^{11}$ N and $9^0 39^1 5^{11}$ N and longitude $6^0 42^1 44^{11}$E $6^0 43^1 51^{11}$E and covers an area of 5.015 km^2.The exact population of the community could not be ascertained but the approximate population of the entire Shiroro local government area as at 2006 is 235,404. The community is a nucleated settlement located along Minna –Sarkin Pawa road (Figure 1). The area experiences two distinct seasons; the dry and wet seasons in a year. The annual rainfall varies from 1,100mm to 1,600mm.The duration of the rainy season is about 150 to 210 days. The maximum temperature (usually not more than 94°F) is recorded between March and June. The minimum temperature is usually recorded between December and January when most parts of the state are under the influence of the Harmattan. Mean maximum temperature remains high throughout the year, hovering about 32°F, particularly in March and June.

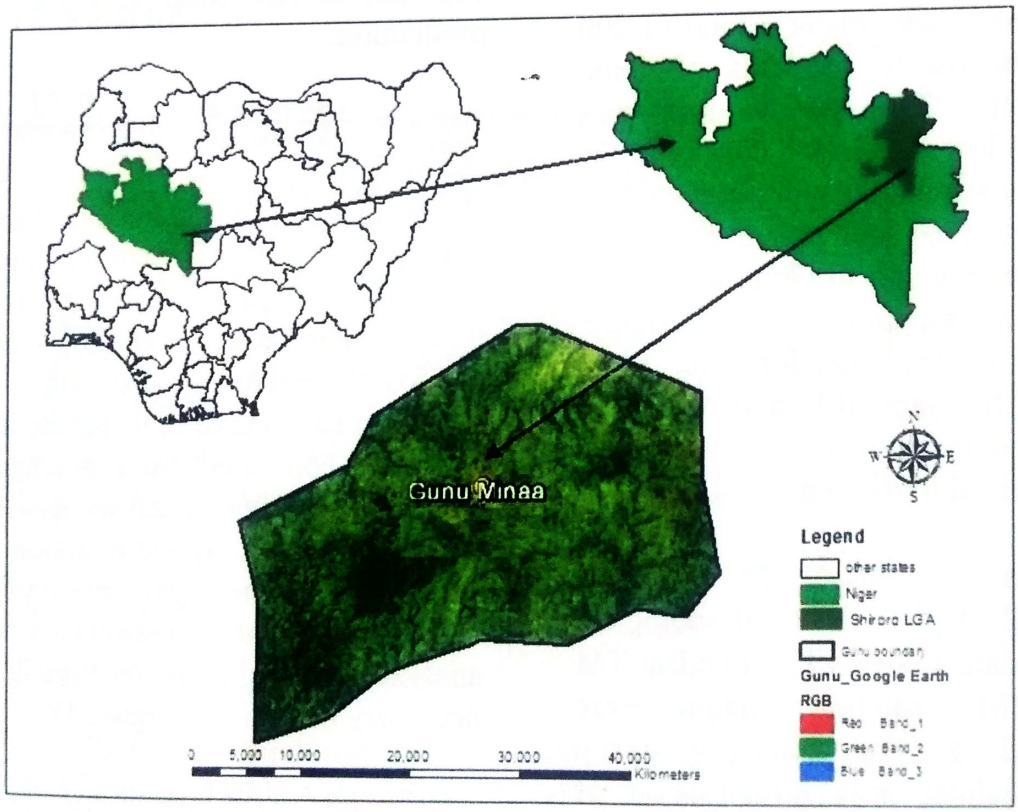


Figure 1: The study area (Source: Authors, 2015)

Materials and Methods

Data

Different data sets were utilized for the study. Remotely sensed Landsat Thematic Mapper (TM), Enhanced Thematic Mapper (ETM+) and Operational Land Imager (OLI) 30 meter resolution data sets of 1990, 2006 and 2015 respectively acquired fromthe Global Land Cover Facilities (GLCF) and United State Geologic Survey (USGS) were used in mapping and analyzing land use over the period. Temperature and rainfall data of Minna (located less than 20km away from the study) spanning forty (40) years (1975-2014) obtained from NIMET were analyzed to establish the climatic trend of the area. Questionnaires were used to extract information on the local community's perceptions of changes and how it has adapted to these changes over time. Simple random sampling method was employed to administer a total of 200 questionnaires to residents of Gunu community. The sample size was based on low population density in the area. The sampled respondents were of age thirty (30) and above who have lived long enough in Gunu to provide reliable information on the different sections of the questionnaire. Idrisi Selva, Arc Map 10.1, and Microsoft word and excel spreadsheet package were utilized in data analysis.

Methods

Figure: 2, depicts the Methodological flow of data analysis.The Landsat TM and ETM+ satellite images were displayed in False Color Composite (FCC), which is a combination of band (4,3,2) while Landsat 8 (Landsat OLI) was displayed in 5,4,3 combination because of the extra bands present in it. The FCC provided a better visualization and identification of the major land use\land cover classes. The 2015 image was resampled from sixteen (16) bits to eight (8) bitto correlate with the 1990 and 2006 image and to cater for the error bugs generated by Idrisi software. Supervised Maximum likelihood algorithm was used to classify the three imageries. The images were classified into four dominant land use classes, namely: built up area, farmlands, vegetation and bare surfaces using IdrisiSelva software. The area coverage of each classes identified were obtained and their percentage changes were calculated using the equation 1. The processed images were subsequently exported to Arc Map 10.1 for map production.

$$\% \text{ change} = \frac{\text{observe change}}{\text{sum of chnge}} \times 100 \quad \text{(Equation 1)}$$

To examine the trend in the climatic parameters, the yearly total rainfall and the maximum average annual temperatures were computed using Microsoft excel spreadsheet. The yearly mean maximum temperature was also computed from average of each month. Trend analysis was then carried out and R square equation was used to show the significance of the relationship. The questionnaire was analyzed descriptively to furnish the necessary objectives (Figure 3)

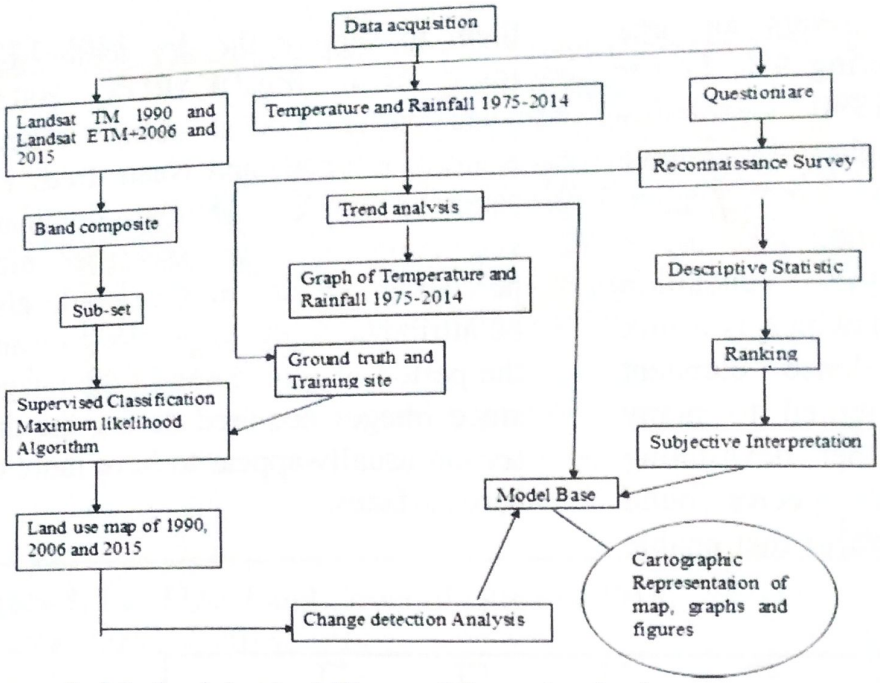


Figure 2: Methodological Flow of Data Analysis
(Source: Authors, 2015)

Results and Discussions

Gunu Land Use Land Cover (LULC)

The land use/land cover of Gunu in 1990, 2006 and 2015were classified into four dominant classes; vegetation, farmlands, built up areas and bare surfaces which were depicted with green, yellow, purple, and brown colors respectively. (See figures 4, 5 and 6)

LULC 1990

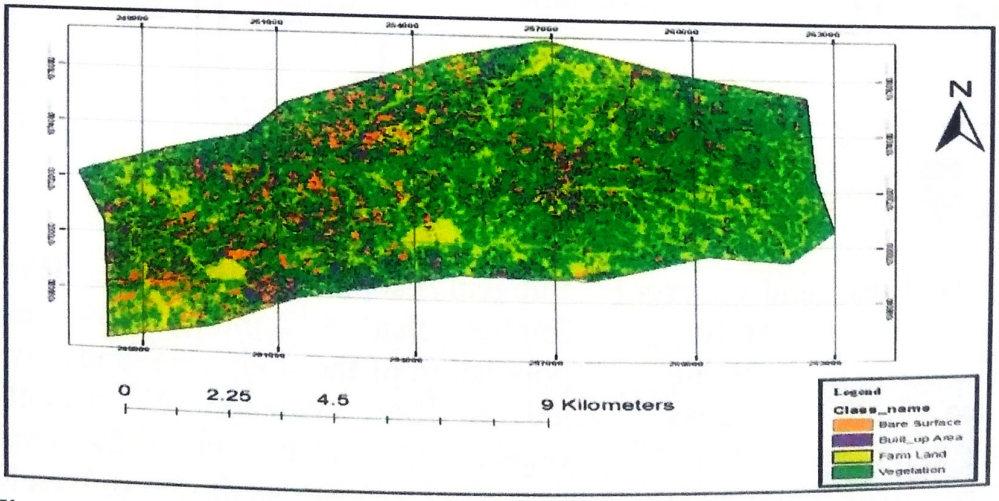


Figure 3: Land Use Land Cover Change of Gunu in 1990
(Source: Authors, 2015)

Figure: 3 shows the land use land cover of Gunu in 1990. Vegetation covered an area of 60.220 (Ha) representing 52% of the area while built up areas accounted for 16.866 (Ha) representing 15% of the area. Farmlands covered an area of 27.560 (Ha) representing 24% of the area

while bare surface covers an area 10.109 (Ha) representing 9%. Lower population in 1990 probably accounted for the highest percentage of vegetal cover and lower percentages of built up areas. Characteristically, the vegetation typeis Guinea Savannawhich is a mix of treeswith tall, dense elephant grasses. This is attributed to many years of fire and other devastating experiences. The plant species found in the area have structures that enable them to survive the dry season and resist bush fires(WARDA, 2002). Shea butter, Locust bean, Cashew, Mango, Baobab, and Neem trees are some examples of the dominant vegetation in the area.The high percentage of bare surface could also be attributed to the vegetation typeand the period of acquisition of the image, since images acquired during the dry season usually appear to have more of bare surfaces.

LULC 2006

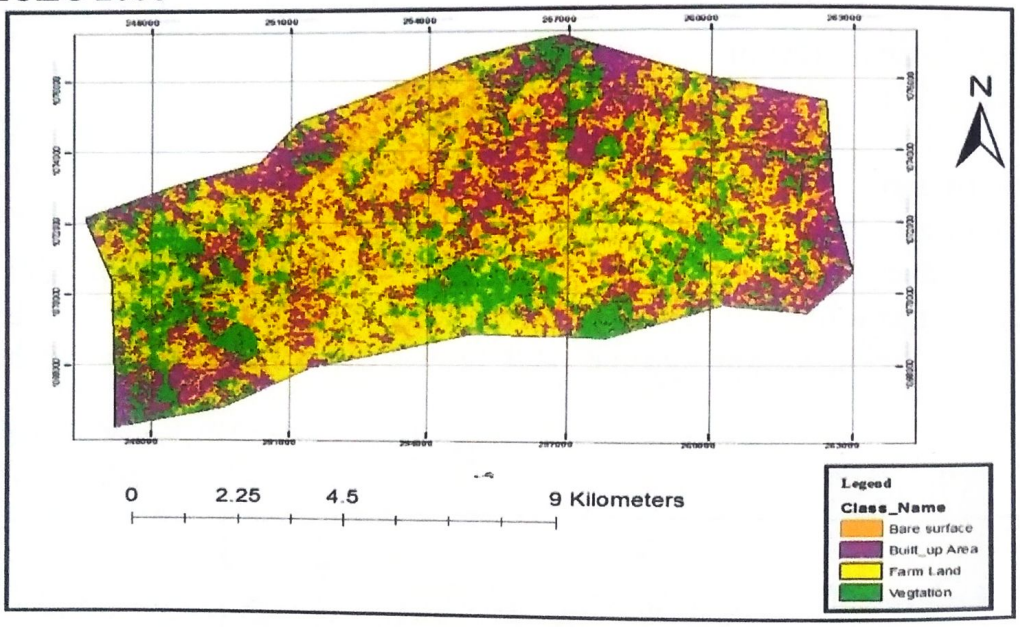


Figure 4: Area Coverage and Percentage of Change in 2006
(Source: Authors, 2015)

Figure 4, depicts land use land cover of Gunu in 2006. Vegetation covered a total area of 22.2186 (Ha) representing 19% of the area. Built up areas covered 33.5854 (Ha) representing 29% of the total area. Farmlands accounted for an area of 47.2551 (Ha) representing 41% of the total area, while bare surfaces covered11.6964 (Ha) representing 10% of the area. There was a decrease in vegetation as a result of other land use activities occasioned by the influx of non-indigent people into the area. This implies that a rapid increase in population of the study area gradually led to the depletion of natural vegetation, since the dwellers converted vegetal lands for different purposes such as fuel wood fetching, construction works, and increased cultivation for the production of food, cash crop such as rice, yam, groundnut millet and other economic trees to earn a living.

LULC 2015

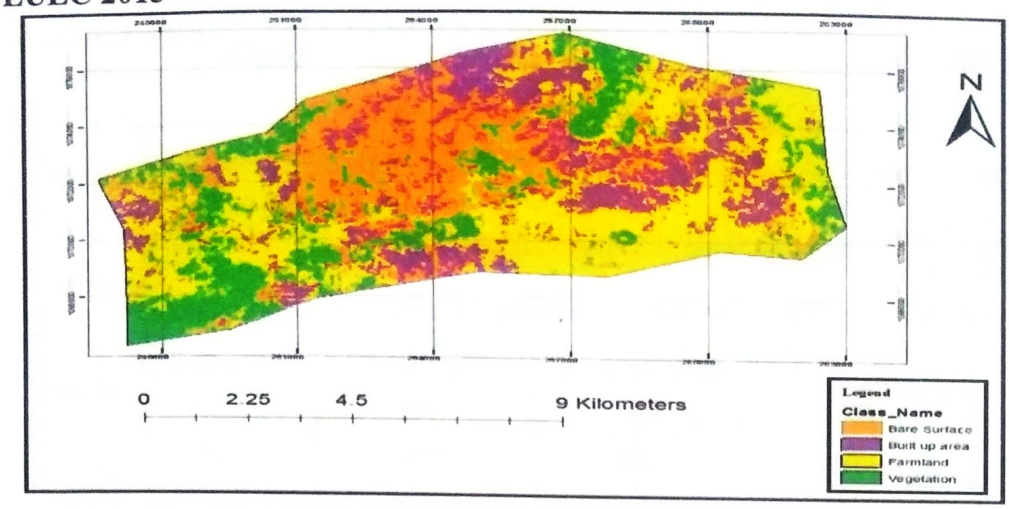
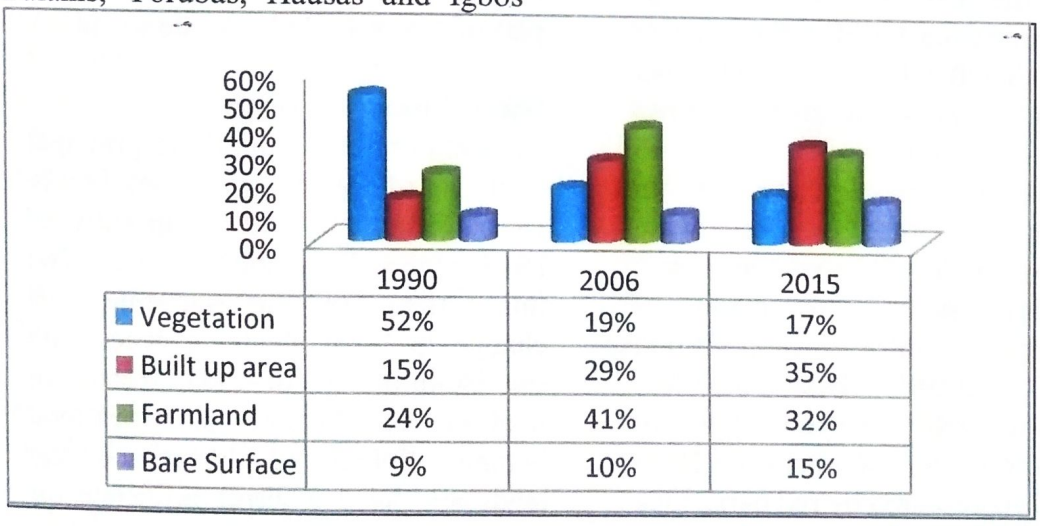


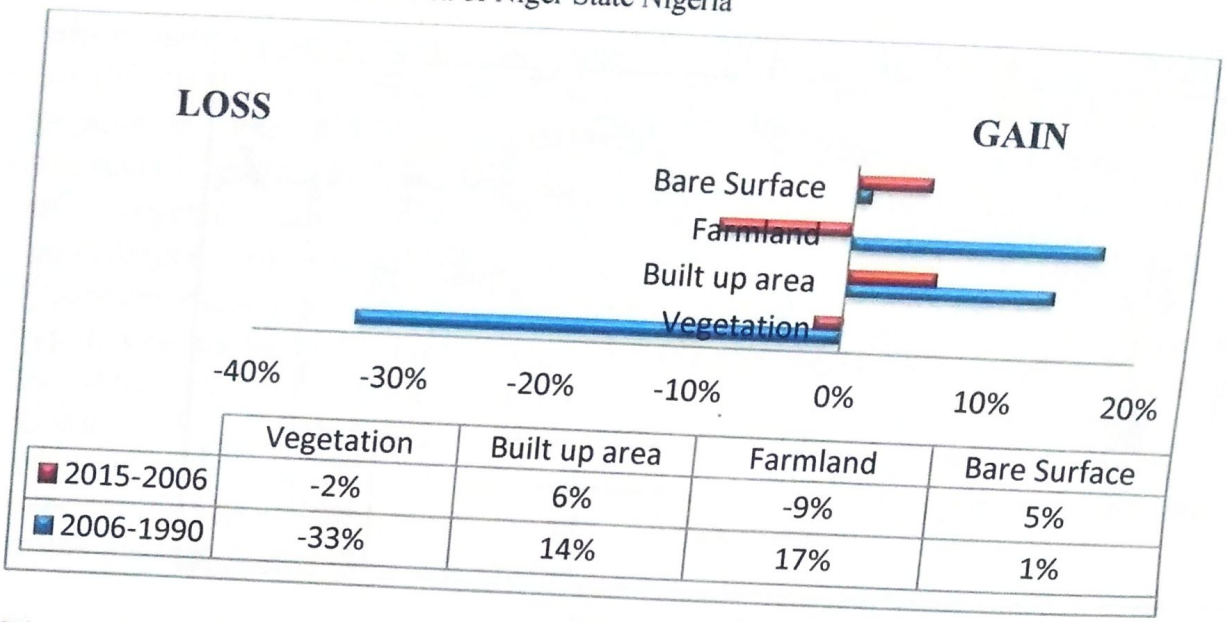
Figure 5: Land Use Land Cover of Gunu in 2015
(Source: Authors, 2015)

Figure5: reveals the land use and land cover of Gunu area in 2015. Vegetation occupied an area of 19.3546 (Ha) representing 17% of the area. The further reduction in vegetation during this period is because the area witnessed more influx of various tribes such as the Fulanis, Yorubas, Hausas and Igbos for several economic purposes. Built up area covered an area of 40.5445 (Ha) representing 35% of the total land area, farmland occupied 37.2282 (Ha) representing 32% of the area while bare surfaces covered an area of 17.628 (Ha) 15% of the total land area.



	1990	2006	2015
Vegetation	52%	19%	17%
Built up area	15%	29%	35%
Farmland	24%	41%	32%
Bare Surface	9%	10%	15%

Figure 6: Percentage of Land Use Land Cover Classes of Gunu in 1990, 2006 and 2015 (Source: Author's work 2015)



	Vegetation	Built up area	Farmland	Bare Surface
2015-2006	-2%	6%	-9%	5%
2006-1990	-33%	14%	17%	1%

Figure 7: The Percentage Gains and Losses between Years
(Source: Author's work 2015)

Figure 6 shows the percentages of land the various land use/land cover classes from 1990 to 2015. To further depict the changes in Gunu land use land cover, the percentage gain and losses were determined. Figure 7 represents the percentage gain and losses between the years. For years 1990 and 2006 represented by blue bars, it was obvious that the land use land cover condition of the study area has been dynamic over the years. This is an indication of drastic changes in conditions of the area.Vegetation decreased, built up areas increased, farmlandincreased as a result of notable agricultural expansion (Wood *et al.* 2004, Braimoh&Vlek, 2005),while bare surface exposure persisted. For the years between 2006 and 2015 represented by red bars, 33% of vegetation was lost while the other land use types namely: built up areas, farmlands and bare surface gained 14%, 17% and 1% respectively. In year 2006 to 2015, vegetation and farmland reduced by 2% and 9% while built up and bare surface gained by 6%and 5% respectively. From these values it is certain that LULC is occurring in Gunu like every other part of Nigeria as well as the world.

Gunu Climatic Trend

Temperature and rainfall are principal elements of weather which are highly variable spatially and temporally at local, regional and global scales. The implications of the variability or change in these elements necessitate the examination of their trends in relation to human activitiessince human activities and adaptation on the landscape have a direct influence on the climate of an area and vice versa (Sara and Sajal, 2009).

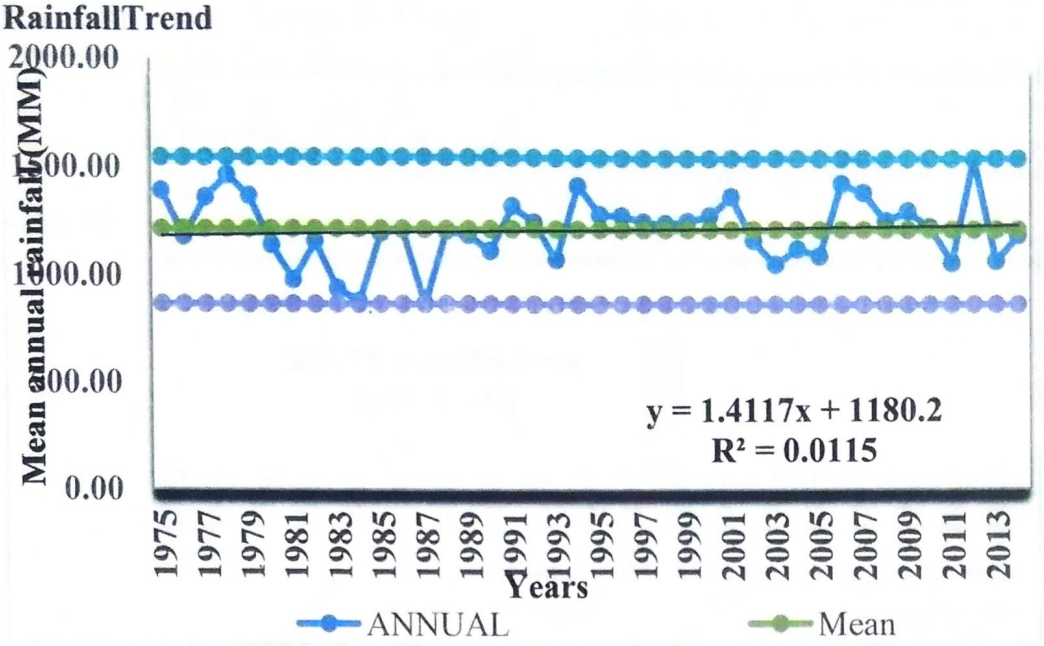


Figure 8: Trend of mean annual rainfall
(Source: Author's work 2015)

The Rainfall trend of the study community over a period of 40 years (1975-2014) is shown in Figure 8. With a mean rainfall of 1200mm, the graph shows that rainfall in the area is highly variable; the maximum being 1500mm in 2012 and minimum of about 820 (mm) in 1986. From the trend, however, there seems to be a general increase in rainfall over the area, noticeably since 1990.The trend alsoreveals a slight steady increase in the rainfall pattern between 1995 and 2003.

The model for the rainfall trend is presented using the equation:

$y = 1.411x+1180$ (Equation 2)

Where y = year, x = the mean rainfall amount.

The coefficient of the long term mean annual rainfall is 1.411 which indicates a positive increase in the amount of rainfall throughout the year while 1180 is the constant. The R^2 in figure 9 indicates the strength of the trend line for rainfall of 0.011 variations observed throughout the period. By implication, it is deduced that rainfall contributes 1% of the observed climate trend in the area. The increase in rainfall may gradually result in extreme events such as flood and other disasters which have a toll on the livelihood system of the people.

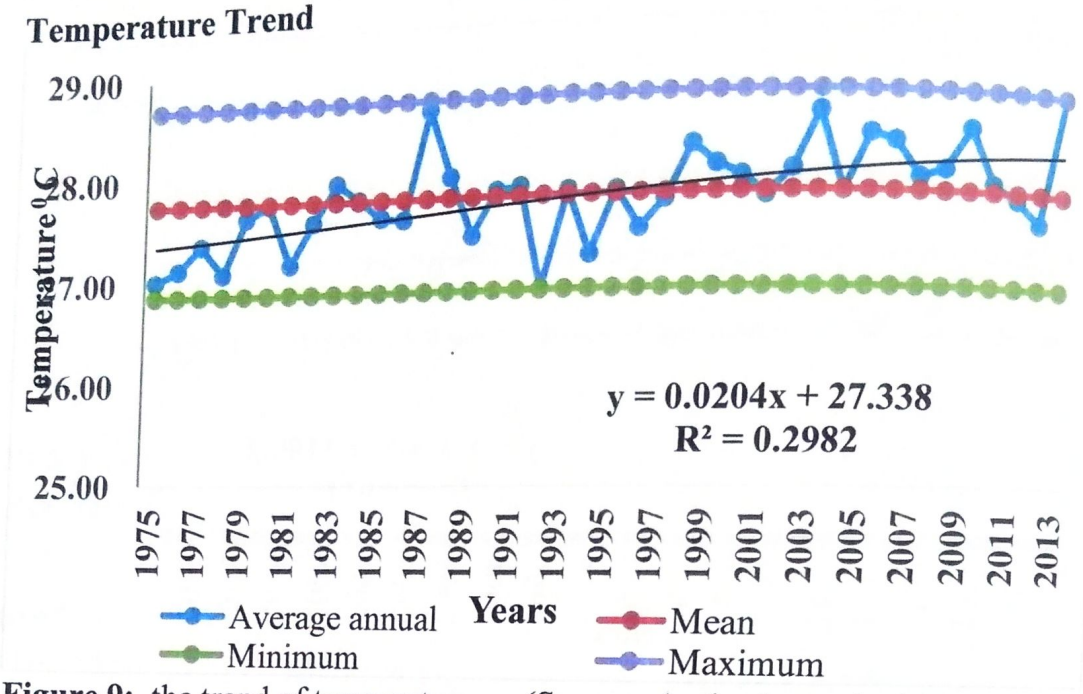


Figure 9: the trend of temperature (Source: Author's work, 2015)

Figure 9 shows the trend of the average maximum temperature data for the forty year period (1975-2014). The maximum average annual temperature was computed to be 28.69°C while the minimum average annual temperature was computed at 26.86°C. The mean annual temperature was 27.75°C. The trend line in figure 10 indicates that the temperature of the area is increasing,contrary to the decrease in temperature observed in the early years (1975-1995).

The behavior of the temperature is given by the equation;

$y=0.020x + 27.33$ (Equation 3)

Where y = year, x = temperature, 0.020 = the coefficient of temperature and 27.33= constant.

It can be deduced that a positive increase in the value of temperature occurer throughout the period of study with an increase of 0.02. The R^2 which was found to be 0.298 represents the goodness of the trend line. By implication, it is deduced that temperature contributes 3% of the observed climate condition of the study area throughout the period under consideration. The equation shows a positive increase in temperature from 1975 to 2014. The results also reveal a pattern of variations with alternating warm and cool years over the study period.

This validates the findings of Adesina and Odekunle (2011) and PANSDI (2014) that Nigeria is experiencing shifts in climate event.Generally, global warming is expected to have a positive impact on the environment and the societal activities, especially on agriculture because high temperatures lead to increase or decrease in agricultural production (IPCC, 2007). Consequently, the gradual increase in temperature of the study area during the study period indicates a warming community with possible effects on agricultural yield.

Local People's Perception on Land use/Land cover changes in Gunu

The general perception of the local people in Gunu is that there are changes in land use and cover as revealed by the remotely sensed images of the area.Their knowledge about these changes is important in explaining their adaptation to land use land cover change in the study area.

4.3.1 Major land uses

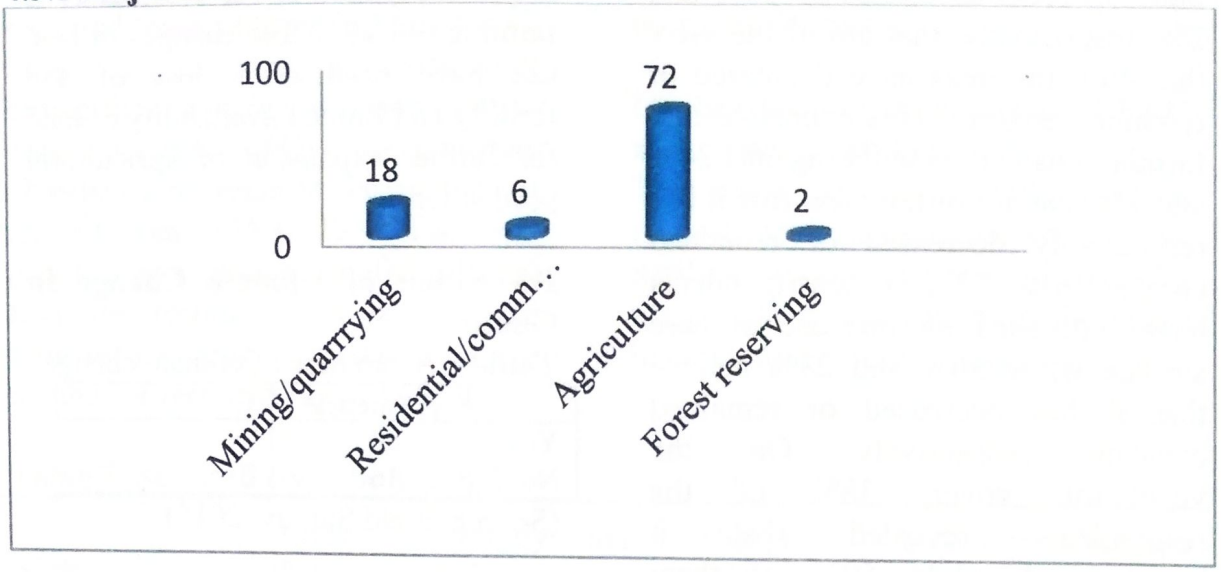
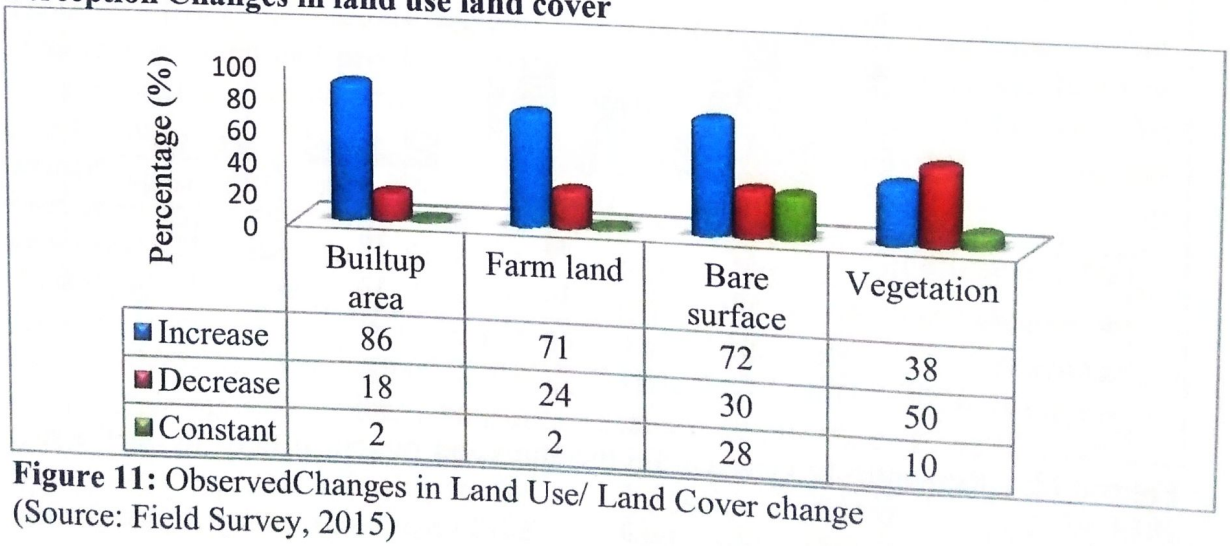


Figure 10: Main Land Use Activities in Gunu
(Source: Field Survey, 2015)

Figure 10 indicates people's views on the major land uses in Gunu. The major land uses given by the respondents include mining and quarrying (18%), residential and commercial purpose (6%), agriculture (72%) and forest reserve (2%). This implies that the dominant use is subsistence agriculture. Despite the fact that Gunu's land use land cover is changing Figure 8, the response still shows that farming is still pervasive in the area.

Perception Changes in land use land cover



	Builtup area	Farm land	Bare surface	Vegetation
Increase	86	71	72	38
Decrease	18	24	30	50
Constant	2	2	28	10

Figure 11: ObservedChanges in Land Use/ Land Cover change
(Source: Field Survey, 2015)

The land use and land cover changes in Gunu as observed by the community as depicted in figure 11. About 86% of the respondents observed that there is an increase in built up areas compared to 18% and 2%, respectively, that are of the view that built up areas have decreased or remained constant.71% expressed that farmland has increased as against 24% and 2% that are of the view that it has respectively decreased or remained constant.Also, 72% of the respondents have witnessed an increase in bare surface while 30% and 28% believe that it has decreased or remained constant respectively. On the vegetation cover, 38% of the respondents revealed that it hasincreased while 50% of them perceived that vegetation has decreased. This is corroborated with the result of remote sensing analysis, which shows an increase in farmland and built up areas as well as bare surface and a decrease in vegetation. The comparatively high rate of increase in farmland is an indication that farming is the major activities of the people in Gunu. This could also be linked to the response of the personal information obtained from the respondents, which reveals that the major occupation of the community is farming (44%). These changes in land use have resulted in loss of soil fertility and limited availability of land for further expansion of agricultural production.

Perception of Climate Change in Gunu

Table 1 Awareness of climate change

	Awareness	O
Yes	56	6
No	36	2

(Source: Field Survey, 2015)

Table 1 is the awareness of climate change in Gunu, 56% of the people in Gunu community are very much aware about climate change and 60% of them have also noticed some major environmental changes such as a decrease in the amount of rainfall and increase in temperature.

Perception of Temperature and Rainfall pattern of the area from1975 to 2014

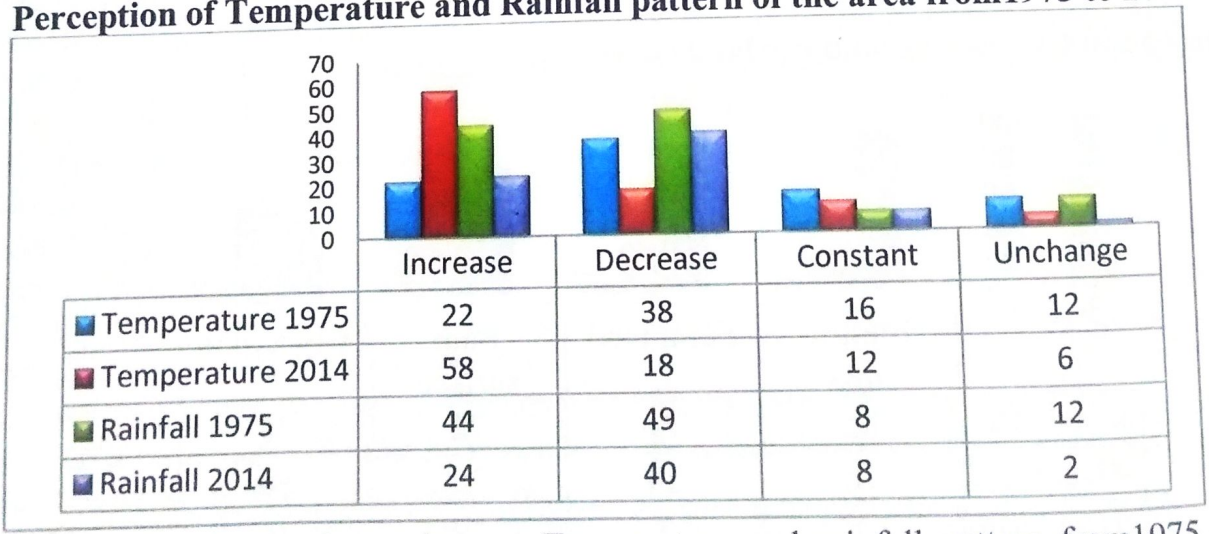


Figure 12: Respondents view on Temperature and rainfall pattern from1975 to 2014

Respondents view on temperature and rainfall pattern of Gunu from 1975 to 2014 are presented in figure 12. Fifty-eight percent (58%) of the respondents in the community perceived an increase in temperature from 1975 to 2014.This view is supported by the analyzed temperature trend line which shows an increase in temperature during the period under review. Forty-nine percent (49%) respondents observed a decrease in the amount of rainfall from 1975 to 2014. The local people's perception of rainfall differed from the recorded data because the farmers are largely interested in the number of recorded rainy days, which they perceive to be on a decline, not the recorded amount. It is evident that the community has generally experienced variations in annual rainfall and temperature. Therefore, understanding the implication for adaptation as a result of these changes becomes necessary.

Implications as a result of LULC and climate trend in Gunu

The result of LULC and trend of climatic elementsis expected to have implications and trigger adaptations by the people. Sectors likely to be affect in community were studied.

Table 2: Sector likely to be affected

Sectors	Agree (%)	Strongly agree (%)	Disagree (%)	Strongly Disagree (%)
Crop production	68	16	8	4
Water supply	53	36	4	2
Animal production	65	24	4	2
Business activities	48	30	10	6
Health	58	22	12	2
Forest	58	18	8	8

(Source: Field Survey 2015)

Table 2: shows the various sectors identified in Gunu and people's view on the sector mostly affected by LULC and the trend of climatic element.This view is significant because there is high climate awareness in the area (Table1). Thishelped in identifying areas to focus interventions on with respect to human adaptation.From Table 2, the general implication for human adaptation to LUCL and climate change will be more effective in the agricultural sector because most of the respondents have high agreements that agricultural related sector will be most affected. 68% and 65% of the respondents agreed that the changes have a major impact on crop production, and animal production. Water supply, business activities, health and forest have 53%,48% 58% and 58% respectively. Generally, agriculture, which is the mainstay of people in Gunu will be affected by these changes, agricultural is highly dependent and affected by climate and land use change (IPCC, 2001,

2007).The projected changes is expected to present both opportunity and risk (Wall *et al.*, 2004; Weber and Hauer, 2003).

Implications as aresult of LULC change in Gunu

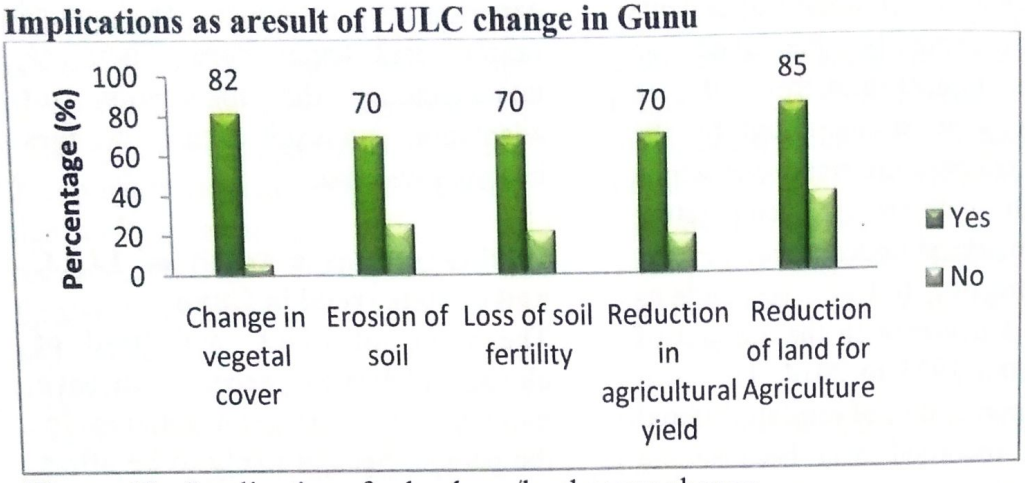


Figure 13: Implications for land use/land cover change
(Source: Field Survey 2015)

Respondents' views on the implication of LULC in and around the study community are presented in figure 13. Eighty percent (80%) of the respondents indicates that LULC has a direct influence on vegetal cover. Seventy percent (70%) of them revealed that land use change has impact on soil erosion, loss of soil fertility and reduction in agricultural yield. About 85% of the respondents perceived a reduction of land for further expansion of agriculture. The general implication of the change is that dwellers in Gunu and other communities are compelled to look for alternative sources of livelihood such as small scale businesses, hunting etc. as adaptations to land use change which is affecting their agricultural activities.

Adaptation Actions to LULC in Gunu
Table 3: Adaptation to LULC in Gunu

Adaptation to Land Use/Land cover change	Agree (%)	Strongly Agree (%)	Disagree (%)	Strongly Disagree (%)	Don't know (%)
Carry on as usual	54	16	4	12	0
Shifting cultivation relocation	58	18	10	8	4
Stop farming	68	8	8	6	6
Sales of land	42	14	28	10	4
Build on the land	49	20	22	8	2
Look for other jobs	46	16	26	6	0
Acquire more land	48	8	8	6	6

(Source: Field Survey 2015)

The adaptation actions to LULC are highlighted in Table 3. The major adaptation strategy to LULC adopted by most of the farmers in the study are basically: carryingon as usual, shifting cultivation, abandoning farming and looking for alternative sources of livelihoodthese have 72%,76 % and 76% total acceptance respectively. Othersincludes the sale of land (56 %) building on their lands (69%), lookingfor alternative jobs (62 %)and acquisition of more land as a result of land use land cover change (56%). From the responses it is obvious that the people are ill equipped when it comes to LULCadaptation. This is connected with the challenges faced by the country in addressing and planning the use of the nation's land.

Adaptation Actions to Climatic Trend in Gunu

The implications of changes in trend of climatic trend on agricultural activities in Gunu is not expected to deviate from most documented in other local and international studies because climate change is a global phenomenon whose impacts pervasive (IPCC,2001).

Table 4: Adaptationto Climate Trend in Gunu

AdaptationMeasures	Agree (%)	Strongly agree (%)	Disagre e (%)	Strongly Disagree (%)
Prepare for dry season by storage of food stock	52	28	14	2
Accept the climate condition	10	80	0	8
Start other business	32	50	18	4
Rainfall water harvesting for storage	42	32	20	2
Climate tolerant seedling	48	30	10	6
Expansion of agricultural land	46	31	8	8
Stop farming for a while	51	24	10	

(Source: Field Survey, 2015)

Table 4: present the adaptation to climate trend in Gunu. The respondents highlighted some adaptation and coping strategies to the impacts of climate variability and change. A total of 80% respondents agreed and strongly agree that they adapt to climate change by storing food, 90% expressed that they have become resilient to the shocks of the climate condition, while 82% adapt by embracing other businesses. Rain water harvesting for storage is a common practice among a total of

74% the respondent while 78% of the respondents now cultivate climate tolerant seedling. Expansion of agricultural land to prevent reduced yield as result of climate change was embraced by 76% of the respondents. Finally 75% of the respondents have totally disengaged farming. As earlier observed, it is clear that the adaptation options by the local people in Gunu are not sufficient to cope with climate change. This implies that the locals are still neglected when it comes to climate adaptation options as supported by Agwu and Okhimamhe (2009) who opined that Nigeria is unprepared for the environmental consequences of climate change because of ineffective collaboration and communication between affected local communities and their governments.

Conclusion

This study has shown clearly that land use land cover change and climate change is being experienced in Gunu community. The land use land cover change for 25 years was determined as well as the climate pattern which has been observed. As a consequence of these changes, the people have in their own modest way adapted to these changes. The adaptation is more prominent in agricultural sector because most of the people combine farming with other activities as a way of adjusting to the impact of land use land cover change and climate change in the area.

The science is clear; climate change is here and is a challenge that people need to deal with over coming decades. Human activities have already caused some irreversible changes to ecosystems and further damage is likely to emanate. It is necessary to think how we will adjust not only to these specific changes but to the new uncertainties about our future climate. This is particularly relevant for rural areas such as Gunu, where it will be necessary to address many institutional and capacity issues in order to ensure sustainable adaptation to climate change.

Recommendations

Based on the above findings and conclusion, the following are recommended as an adaptive response to land use change and climate change in Gunu like every other place and the country in general:

1. Programs that can reverse or manage the changes should be encouraged such as afforestation program through restoration of already degraded land.
2. Climate friendly practices such as Conservation Agriculture (CA) should be encouraged in the area by rural development agencies, farmers' organizations, non-governmental organizations, and private agricultural businesses to promote sustainable land management on a large scale.
3. Community land use planning and action models can be implemented and strengthened to address climate change mitigation as well as adaptation in the study area.

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