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Climate Change Manifestations and Impacts in The Sokoto Close-Settled Zone, Northwestern Nigeria

Manifestasi Perubahan Iklim Dan Kesannya Ke Atassokoto Close-Settled Zone, Barat Laut Nigeria.

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ABSTRACT

Located within the Semi-Arid zone of Northwestern Nigeria, Sokoto Close-Settled Zone (SCSZ), has over the years been suffering from climate change and its associated socio-economic consequences. These negatively affects both the natural ecosystem and the livelihood of the inhabitant of the area. Using multi-temporal Landsat data and meteorological data such as rainfall and temperature records, as well as geospatial analyses such as Normalised Difference Vegetation Index (NDVI), image differencing and simple statistical techniques, this research identified and assess differentmanifestations of climate change in the area. Implications of these on the livelihoods of the people in the area were also discussed. The result indicated an increasing trend in both minimum and maximum temperatures as well as a progressive decline in the rainfall pattern of the area over the last 10 years. Also, the area recorded over 40% loss of vegetation cover within the same period. The cumulative effects of the above scenarios, leads to decline in crop and livestock productivity, destruction of farmlands and grazing areas and increasing water scarcity, among others, all of which negatively affect the livelihood of the inhabitant of the area, leading to declining family income, food shortages, and in some extreme cases malnutrition and diseases. Mitigation and adaptation strategies including sustainable land and water management practices, ecosystem-based adaptations, afforestation, agroforestry, alternative sources of livelihood as well as civic and environmental education were also suggested.

Keywords: Climate change; Sokoto close-settled zone; livelihood; meteorology; remote sensing

ABSTRAK

Sokoto Close-Settled Zone (SCSZ) terletak di zon separa gersang Barat Laut Nigeria, mengalami perubahan iklim semenjak bertahun dan pelbagai kesan sosio-ekonomi yang serius. Perubahan iklim memberi kesan negatif kepada ekosistem semulajadi, kehidupan dan mata pencarian penduduk di Sokota. Kajian ini menggunakan data multi-temporal Landsat dan data meteorology seperti rekod hujan dan suhu, serta analisis geospatial iaitu Indeks Vegetasi Perbezaan Normal (NDVI), perbezaan imej dan teknik statistik mudah bagi mengenal pasti dan menilai impak perubahan iklim yang berbeza terhadap kawasan kajian. Selain itu, implikasi manifestasi perubahan iklim terhadap kehidupan dan mata pencarian masyarakat di Sokoto turut dibincangkan. Hasil kajian mendapati kedua-dua suhu minimum dan maksimum menunjukkan trend yang meningkat serta penurunan progresif dalam pola hujan di kawasan kajian dalam tempoh 10 tahun. Selain itu, kawasan kajian mencatatkan lebih daripada 40 peratus kehilangan litupan tumbuhan dalam tempoh masa yang sama. Kesan kumulatif daripada senario perubahan suhu yang ketara sejak 10 tahun lalu, menyebabkan kemerosotan produktiviti tanaman dan ternakan, kemusnahan tanah ladang dan kawasan ragut serta peningkatan kekurangan air. Keadaan ini menyebabkan wujud kesan negatif terhadap kehidupan dan mata pencarian penduduk di kawasan kajian. Seperti penurunan pendapatan keluarga, kekurangan makanan, dan dalam masa yang sama wujud beberapa kes malnutrisi dan penyakit

yang melampau. Sehubungan itu beberapa strategi tebatan dan penyesuaian amalan pengurusan tanah dan air secara lestari telah dijalankan. Di samping itu penyesuaian berasaskan ekosistem, penanaman semula hutan, hutan ladang, sumber alternatif mata pencarian serta pendidikan sivik dan alam sekitar turut dicadangkan.

Kata kunci: Perubahan iklim; Sokoto close-settled zone; mata pencarian; meteorologi; penderiaan jarak jauh.

INTRODUCTION

In the recent decades, climate change and the challenges related to it are among the issues of serious global concern. In fact, the issues attracted the attention of scholars across the globe and from different disciplines, who are not only concerned with the understanding its processes and causes, but equally investigating is present and future implications on the environment and people (Iliya 2012). The syndrome has been describedin a number of waysby different scholars across different fields. However, all the descriptions portray itas a variation in the long-term mean weather conditions of an area, resulting from both natural events and anthropogenic activities (Bello 2014; Ikehi et al. 2014; Idrisa et al. 2012; Rahman et al. 2014). Although, some natural drivers contribute in altering the climatic condition of an area, human induced factors are mostly considered as the dominant causes and aggravating drivers of climate change syndrome that presents the biggest environmental, social and economic challenges of our time. This is because, the consequences of climate change pose a great challenge to the entire ecosystem, threaten food security, damages physical infrastructures and cause social dislocation. In fact, climate change and associatedchallenges to a very large extent, affects every aspect of human endeavour including our environment, natural resources, production systems, economic development, as well as urban and sub-urban systems (Ekpoh 2009).

The dryland ecosystem of Northwestern Nigeria, is for many decades under the threat of climate change and associated natural and anthropogenic drivers of change which together threaten not only the ecosystem, but also the livelihood and economic opportunities of the area. These drivers of change increases the stress to the already fragile ecosystem of the area, suffering from considerable water deficit and insufficient soil moisture emanating from the low-variable rainfall and high rate of evapotranspiration in the area (Davis 1982).Moreover, vast majority of the people inhabiting this area are peasants, largely depending on crop cultivation, animal husbandry and artisanal fishing for livelihoods. The sensitivity of these means of livelihoods to the climate change and other related challenges puts the livelihood and overall economic development of this area in a state of risk that calls for a serious attention.

However, there are enough evidences pointing to the deteriorating state of the health and functions of the ecosystem in this area. This is largely caused long period interactions between climate and other drivers of change such as dessert encroachment, land degradation, population growth, urbanisation badland and water management practices, and deforestation among others (Jibrillah 2013; UNEP 2009). Climate change is now aggravating these challenges with serious implication on the livelihood and overall economic development of the area (Rose et al. 2015; UNEP 2009). Addressing the threats and challenges associated with climate change and equipping the communities with effective mitigation and adaptation measures to its impact is thus, critical for ensuring sustainable livelihoods and improved economic opportunities of the inhabitant of the area. In this article, an attempt has been made to identify anddiscusseddifferent climate change manifestations in the study area, using evidences from remote sensing and meteorological data. The articlefurtherdiscussed theeffects of these on the environment, livelihoods and overall development of the region and alsosuggest some strategies necessary minimisingthe adverse effects of climate change in order to secure sustainable and improved

livelihoods of the inhabitants of the area.

BACKGROUND STUDY

CLIMATE CHANGE

As elucidated in the preceding discussions, the phenomenon of climate change attracted the attention of many scholars across many disciplines, describing it in a number of ways relative to their backgrounds. They were however, unanimous in the dominant role of man in causing and aggravating climate change syndrome. They both described climate change as a shift from the long-term average weather condition of a given geographical location, that is largely caused by certain human activities either directly or indirectly (Bello 2014; Ikehi et al. 2014; Rahman et al. 2014; Idrisa et al. 2012). Umar (2012), further observe that, climate change syndrome transcends both local, regional and international boundaries as no part of the globe is immune from it and its diverse associated challenges. Hedge et al. (2012), also associated climate change withboth conscious and unconscious human activities that facilitates the concentration of greenhouse gasses into the atmosphere. These according to him, include exhaust from domestic and industrial fossils, land clearance, exhausts from automobiles and bush burning among others, all of which contribute andaggravateclimate change syndrome.

Climate change is the greatest challenge of this time to the human existence and sustainable economic development particularly in the less developed countries of the world. It is responsible for many environmental, social and economic problems that ravages the world today. Its impacts are felt on both global regional and local scales. Jibrillah (2013), observed that, climate change presentsserious challenges to the fragile ecosystem of the Northwestern Nigeria, threaten food security and human livelihoods. It also destroys farmlands, residential areas, schools, offices, infrastructure and services as well as causes social dislocations (Ikehi et al. 2014; Jibrillah 2013). Other adverse effects that could results from it depending on the nature and the degree of exposure of the particular area, includes frequent droughts, declining biodiversity including depletion of wild life and vegetal resources. It could also causedeplete soil moisture and organic content, bring about health related challenges as well as changing livelihood systems (Bello 2014; Ikehi et al. 2014; Idrisa et al. 2012; Jibrillah 2013; Rahman et al. 2014).

Nigeria, as part of the global community, is among the most severely affected African countries by the menace of climate change. Sokoto Close-settled Zone in the Northwestern Nigeria is particularly among the areas heavily threaten by the challenges associated with the climate change, which is further compounded bymany natural and human induced factors. This in turn, negatively affects the livelihoods of the significant proportions of the inhabitants of this area, due to their heavy reliance on the economic activities that are climate change sensitive such as crops cultivation, dairy farming, artisanal fishing and forestry. Understanding the different manifestations of climate change is very crucial to addressing it and its associated consequences.

Umar (2013), opined that, the nature and extent of variations and change in climate could be discerned through an empirical analysis of a long term meteorological data of an area using appropriate statistical methods. In the same way, multi-temporal remotely sensed data acquired by the land observationsatellitesincludingLandsat, MODIS and AVHRR depicting same area, can be used to study the impacts of climate change and associated drivers on the environment and different components of ecosystem (Cristobal et al. 2011; Vogelmann et al. 2012; Wallis 2015).Although, many researchers (Aliyu 2013; Bello 2013;Fada 2013 and Umar 2013), took look at different issues related to climate change in some parts of Sokoto Close-settle Zone, such as its impact on agriculture, forestry, health and soil, but no serious attempt seems to havebeen embarked upon to look at different manifestations of climate change in the area, particularly using remote sensing techniques.

STUDY AREA

The study area is the central Sokoto Close-Settled Zone, comprising the Sokoto town and its immediate hinterlands, covering a territorial extentof 6000squarekilometres. It extends to about 120 kilometresfrom North to South and about 50 kilometresfrom East to West of the capital city of Sokoto. This area according to Goddard (1972) and Iliya (1999), is generally noted for its high population density and intensive crop cultivation. Average population density throughout the zone is above 300 persons per kilometre, whileover 80%

of the of land area is under permanent intensive cultivation (Mamman 1989). Sokoto State, is situated to the extreme Northwestern part of Nigeria, extending from latitudes 11° 30" to 13°50" N and longitudes 4° 00" to 6° 00" E (Figure 1). It is bordered by the Niger Republic to the North and West and the Nigerian states of Zamfara and Kebbi to the East and South respectively.

The ecosystem in this region, is greatly influenced by the prevailing tropical continental climate with acute water deficit, rendering the ecosystem very fragile. Temperatures are high throughout the year whilerainfall, low and erratic which barely lasts for more than five months in a year. Average annual rainfall is around 630 mm while temperatures could be as high as 39°C or even higher. The month of April which usually records the highest degree of temperature. The area is also characterized by the Sudan Savannah type of vegetation, with abundant grasses and shrubs interspaced by short woody trees. Grasses looks green in the rainy season, but eventually withered and die during the dry season (Davis 1982).

Crop cultivation and animal husbandry constitutes the major sources of livelihood for the inhabitants of the area. Grains, including millet, corn and sorghum, as well as legumes such as beans and groundnut are the dominant crops cultivated in the upland areas. Irrigation farming is usually restricted to the lowland areas and along the banks and flood plains of the major river where crops such as Tomato, onions, garlic and rice are cultivated. Some inhabitants of the area also engage in artisanal fishing along rivers Sokoto and Rima as well as along some seasonal streams and ponds. In the more recent time, declining agricultural productivities and dwindling income from both agriculture, animal husbandry and fishing has compelled many people in this region to pursue some off-farm activities as a means of income diversification both during the wet and dry seasons (Iliya 1999). This accounts for the need to pay a serious attention on the issue of climate in the area as majority of the inhabitants of the area engage on climate sensitive activities as their means of livelihood.

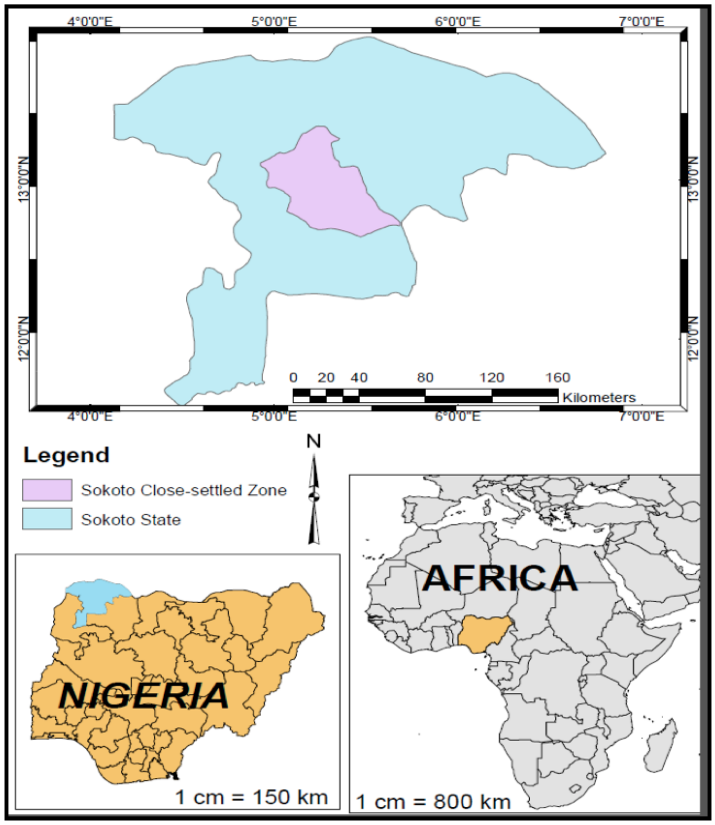

FIGURE 1. The Study Area.

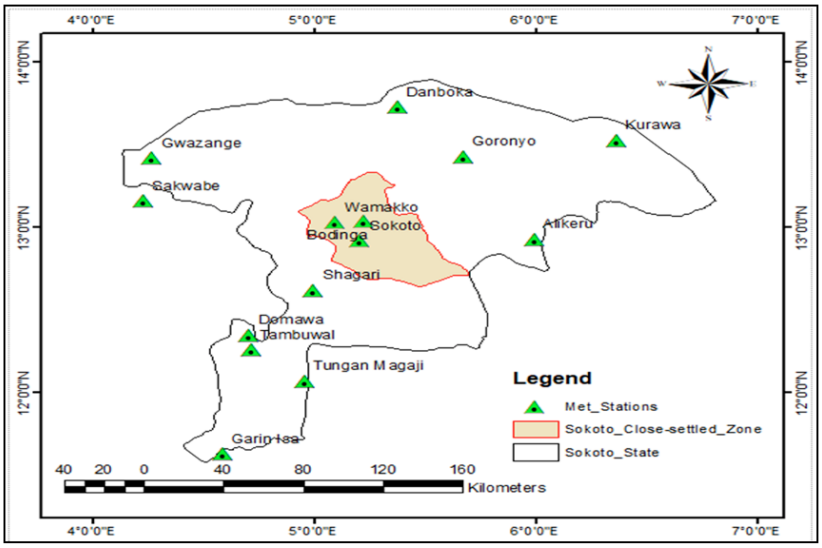

FIGURE 2. Locations meteorological stations

MATERIAL AND METHODS

DATA

The data requirement for this research includes rainfall and temperatures data collected from 12 synoptic stations that are spatially distributed around the study area (figure 2) from 2002 to 2015 (14 years), obtained from the Nigerian Metrological Agency (NIMET).Satellite data of the study area, for September 2002(ETM+) and September 2015 (OLI/TIRS) obtained from the official site of the United State Geological Survey (USGS) via the Earth Explorer was also used to monitor the change in vegetation cover of the area.

METHODOLOGY

A combination of meteorological data and multi-temporal satellite images were used in this study. Due to the time and resource constraints, the study was restricted to 3 major indicators of climate change namely, temperature, rainfall and vegetation cover.

Trends of temperatures and rainfall from 2002 to 2015 was analysed using meteorological data and statistical techniques such as simple means (averages) and line graphs. Vegetation change was measured through the analysis of multi-temporal satellite data, acquired by the Enhanced Thematic Mapper Plus (Landsat 7) in 2002and Operational Land Imager (Landsat 8) in 2015. These Landsat satellite images were subjected to several image processing steps such as conversion to surface reflectance values, image normalization and image clipping. Then, the converted and clipped Landsat images were further processed to derive the Normalised Difference Vegetation Index (NDVI), which were used in the change detection analysis. NDVI images are produced by the ratio of the differencesin reflectance between near infrared band and red band of the electromagnetic spectrum. Thus, NDVI = NIR-RED/NIR+RED.

Where:

NIR = Reflectance value in the Near-infrared band.

RED = reflectance value in the Red band.

Using the Landsat 7 ETM+ image, NDVI is thus calculated as: Band4-Band3/Band4+Band3. While using Landsat 8 OLI/TIRS image it is calculated as: Band5-Band4/Band5+Band4. This is based on the fact that, green and healthy vegetation reflects less visible light that falls on it due to its high absorption capacity of light in this region, while it absorbs less and reflects very high in the near-infrared region. On the other hand, unhealthy and sparse vegetation, reflects more visible light and less near-infrared light. The NDVI algorithm therefore, subtracts the red reflectance values from the near-infrared reflectance value and then divides it by the sum of near-infrared and red reflectance. The values range from -1 to 1, with extreme negative values depicting water body, values close to zero

indicating bare soil and values abovezero represent varying densities of vegetation cover. NDVI has been widely used to study climate change impact on vegetation and ecosystem at different spatial scales with high degree of accuracy (Chen et al. 2014; Vogelmann et al. 2012; Zhou et al. 2015; Zhao et al. 2014). Erdas Imagine 2014 version software was used for the processing of NDVI images and image differencing while ArcGIS version 10.3 was used for map production. Figure 3 summarizes the major steps involved in research methodology.

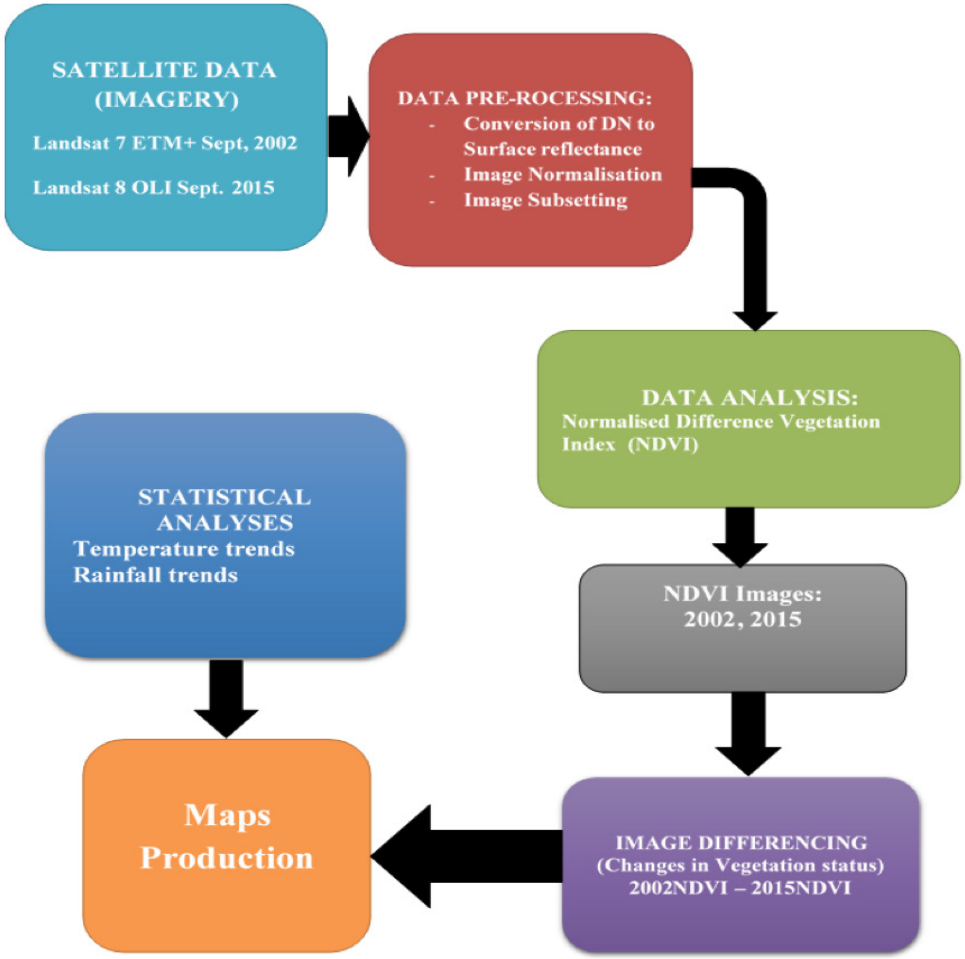

FIGURE 3. Flowchart of the Research Methodology

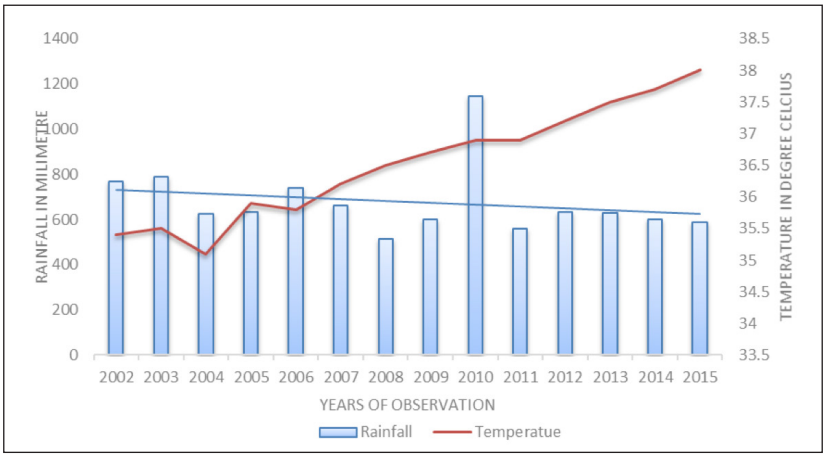

FIGURE 4. Temperature and Rainfall trends in Sokoto Close-settled zone 2002 – 2015
Source: NIMET (2016).

RESULTS AND DISCUSSIONS

As part of the global community, Sokoto Close-Settled Zone equally suffers some the adverse effects of climate change such increasing air temperature, decrease in the amount, duration including the alterations in the rainfall patterns, decreasing vegetation cover, violent windstorms and extreme climatic events notably, floods and droughts. This section of the paper discusses some manifestation of climate change namely, rise in temperature, decrease in rainfall and loss of vegetation cover in the area.

RISE IN TEMPERATURE

Figure 4, shows an increasing trend in the average annualtemperatures of the area within the last 13 years (2002-2015). This also conforms to the findings of Umar (2013), who observed an upward trend in both minimum and maximum temperatures in some selected stations within the study area. Temperature, as an important climatic element, it variability lasting for a long period of time in any area, is a strong indicator of climate change. This is regardless of whether such changes are due to natural or anthropogenic factors.

DECLINING RAINFALL

With the exception of the year 2010, which experience abnormal rainfall (NIMET2010), the rainfall data shows a progressive decline in the total annual rainfall in the area (Figure 4). This is also a strong indicator of climate change syndrome in the area which, in conjunction with increasing temperature observed could have a negative impact on both the ecosystem and the livelihood of the inhabitant of the area. Some of the likely implication of the above scenario is the reduction in both annual and seasonal rainfall, which can affect crop water requirement that could lead to drought. This could in turn lead to crop failure and reduction in livestock pasture thereby, negatively affecting the livelihoods of the teeming inhabitants of the area who are mostly farmers and livestock pastoralists.

LOSS OF VEGETATION COVER

The increasing of temperatures and declining of rainfall would logically leads to loss of vegetation cover in the area. These with other anthropogenic factors in the area which in themselves exacerbate climate change syndrome in the area kept the vegetation cover progressively declining. This could have a serious implication on the area considering the importance of vegetation in the ecosystem as a natural link connecting the land, water and atmosphere. Vegetation also play vital roles of primary productivity, climate modification, soil protection and flood regulation, all of which could be negatively affected by the declining vegetation cover (Adegboyega et al. 2016; Zhigila et al. 2015). Other benefits man derived from the vegetation such as food, shelter, raw materials pasture and fuel wood would also be limited in supply if this trend left unchecked. The declining nature of the vegetation in the area could be better understood by analysing multi-temporal remote sensing images of the area as revealed by figure 5.

Figure 5 depicts the vegetation cover status and changeinthe study areabetween September 2002 and September 2015. Normalised Difference Vegetation Index (NDVI) of the area was calculated using Landsat ETM+ image ofSeptember 2002 and Landsat OLI image of September 2015 using Erdas Imagine 2014 image processing and GIS software to produce the vegetation statusmaps. Simple image differencing was also used to monitor and determine the rate of change in vegetation cover. The result of this analysis revealed that, within the 14 years period, the area has lost close to 40% of its vegetation cover.

The statistics (figure 6) also revealed that over that period, close to 75 percent of the total land area experience a decrease in vegetation while only about 25 percent of the total land in the area recorded an increase in vegetation cover. The trend will likely continue if serious preventive measures are taken. This is yet another strong manifestation of climate change in the area which together with those discussed above and many others, may impact negatively on the life and livelihood of millions of people who are inhabitants of the area as discussed below. This trend is particularly serious considering the important roles of vegetation in an ecosystem and to human livelihood as enumerated above

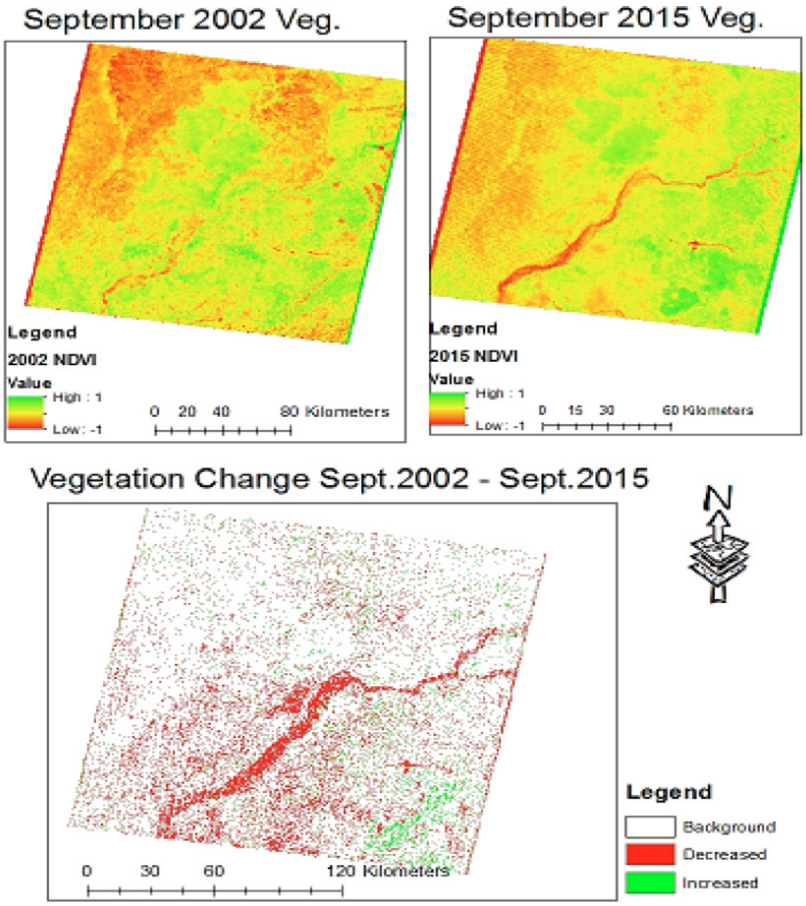

FIGURE 5. Loss of Vegetation Cover

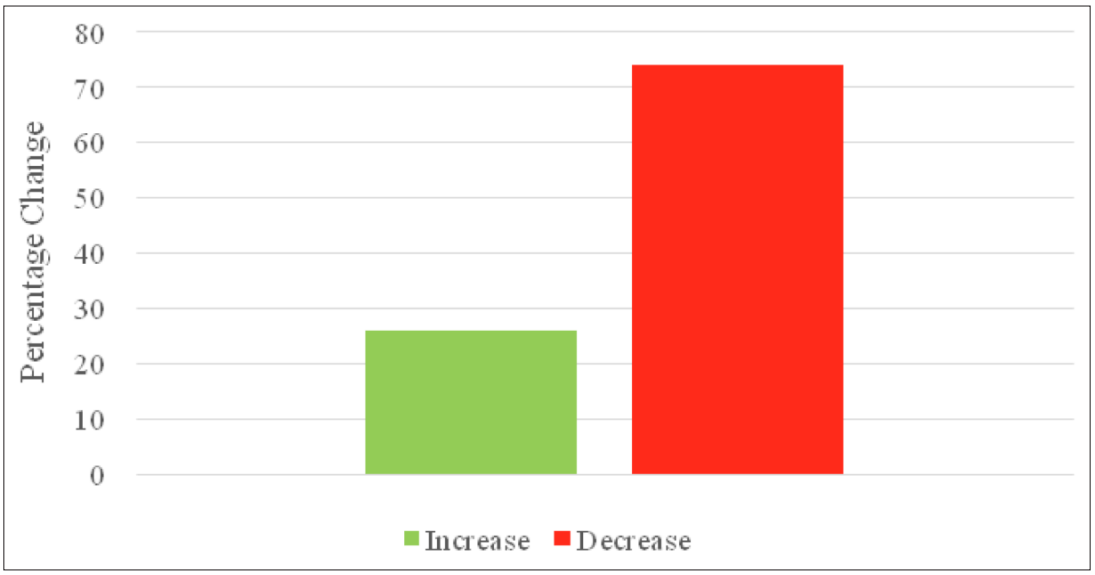

FIGURE 6. Percentage Vegetation Change

IMPACTS OF CLIMATE CHANGE ON THE STUDY AREA

Some of the negative challenges posed by climate change on the environment, ecosystem and livelihood of the people in the study area include the following among others:

DESTRUCTION OF FARMLAND AND GRAZING AREAS

This is more pronounced in the Northern parts of the study area, wherethe phenomenon of climate change results in the formation of sand dunes which destroyed large expense of the agricultural land and grazing lands. For example, Aliyu (2013), reported that, between 1986 to 1999, Gudu local government which is part of the study area lost over 50% of its agricultural land to sand deposit due to desertification and desert encroachment, all of which are manifestation of climate in the area. In addition, vast extent of grazing land is also lost due to the same processes. This has led to the out migration of particularly able-bodied males to other areas in search of fertile agricultural land, rich grazing areas and other alternative means of livelihood.

DECLINE IN CROPS AND LIVESTOCK PRODUCTIVITY

With decreasing rainfall, increasing temperature and destruction of agricultural and grazing land caused by the climate change and associated drivers in the area, crop and livestock productivity in the area are also negatively affected. A research conducted by Abdulrahim (2004), in some parts of the study area revealed that, most farmers were only able to harvest less than 50% of what was their usual harvest in the last 10-15 years. Aliyu (2013), also observed that, drought condition caused by decreasing rainfall in the area will negatively affect crop yield. In the same way, Yahaya and Abubakar (2013), specifically noted that, low rainfall in terms of amount and duration, negatively affects fodder supply, whileincrease in air temperature causes physical stress and increases the risk of diseases to the livestock. All these, will negatively affect livestock productivity including the productions of meat, wool, cheese, butter, milk, egg and other vital products and bye products derived from the livestock. In addition to the declining rainfall, flooding due to the excessive rainfall caused by the extreme weather events also affects agricultural negatively. Excessive rainfall recorded in area in the year 2010 for example, lead to the decline the rice production by 50% as against 2009 production due to wide spread flooding of farmland in the study area. In addition, other crops such as millet, sorghum, cowpeas also recorded lower output as compared to the previous years (NIMET 2010).

WATER SCARCITY

Reduction in the supply of water for domestic, agricultural and other uses is amongst the major negative consequences associated with climate change in the area. The principal causes of water shortages in the area includes decreasing amount and duration of rainfall, resulting in poor recharge of both surface and sub-surface water bodies. Another cause is the increased air temperature which accelerates the process of evapo-transpiration in the area, thereby creating more water deficit. The cumulative effects of all these is the shrinking and drying up of many water sources in the area including streams and lakes (such as Kalmalo Lake), as well as may open-dug well and boreholes. These has led to the increasing difficulty in sourcing water for domestic and other uses, which is prevalent in both urban and rural communities. Ekpoh and Nsa (2011), attributed this reduction in water supply in the area to the alterations in the prevailing climatic condition of the area, particularly rainfall and temperature. They noted that, good rainfall years leads to improve water yield while poor rainfall years are associated with declining water yield in the study area. In the same vein, Udeoka (1995), observed up to 3.7mm annual decrease in rainfall and about 0.03 ^{o}C annual rise in temperature, leading to drastic fall in water yield in the area.

DESTRUCTION OF INFRASTRUCTURES

Increased instances of flooding and severe windstorm in the area due to climate change also resulted in the destruction of many residential areas and other buildings schools, offices, hospitals. Other infrastructures such as roads, bridges and power lines are also mostly affected. The closure of the Usmanu Danfodiyo University Sokoto due to the breakage of the main bridge leading to the university in 2010 for a couple of months is a typical case example. During that period, local government areas such as Kware, Gada, Illela, Goronyo, Tangaza, Gudu etc were also completely

cut-off from Sokoto town, which is the state capital, thereby limiting their access to many economic opportunities, social and other services in the town including education.

ADAPTATION AND MITIGATION MEASURES

There is the ardent need for both pragmatic and holistic approaches to combat the menace of climate change if any meaningful development in the area is to be achieved. This will however, require an integrated approach involving both local management practices and macro-level approaches that would ensure sustainable use and conservation of environmental resources. More emphasis should however, be geared towards preventive rather than control measures. This is because restoration of the areas destroyed by this menace though possible, but are costly and tend to deliver limited results. Thus, climate change impacts in this region, can be prevented/controlled through the following integrated approaches:

INTEGRATED AND SUSTAINABLE LAND AND WATER MANAGEMENT PRACTICES

These should comprise both local and modern techniques aimed at conserving soil and minimising erosion, pollution, salinization, and other forms of land and water degradation. Efforts should be intensified to control over cultivation of land without measures to restore its lost nutrients through manuring and fertilizer application. Overgrazing of land should also be minimized through transhumance which will ensure rational use of rangelands. Unsustainable irrigation practices should be checked, whiledifferent water harvesting techniques should be employed to ensure effective storage and conservation of rain water for useduring the long dry season.

PROTECTION OF VEGETATIVE COVER OF THE SOIL

This is very vital as a means of mitigating soil erosion by the wind and running water, control flooding, minimizes desertification and halt the process of dessert encroachment. Healthy and dense vegetation also stabilises ecosystem prevents loss of ecosystem services during drought episodes. To protect the vegetation in the area, measures should be put in place to control over cultivation and overgrazing in the area. Also, harnessing and developing alternative sources of energy such as solar and wing electricity, would drastically curtail indiscriminate cutting of trees for fuel woods. Illegal mining activities which destroys vast expense of vegetative land should also be checked.

MIXED FARMING

Integrating livestock and crops on a single farmland. This will allow a more efficient land management practices, effective cycling of nutrients within the agricultural system, enhances and diversified food production and increased income to the farmers. Farmers in the area should be empowered to embark on mixed farming through the provision of improved crops and livestock varieties, farm inputs, extension services and credit facilities.

AGRO-FORESTRY

This is a modern form of agriculture that combines crops and animal production as well as raising of trees to provide fuel, fruits, forage, shade and other environmental protection benefits. This is another effective measure for mitigating the impacts of climate change, with multiple socio-economic and environmental benefits. Although expensive to setup and maintained, agro-forestry will facilitate increased crop production and economic gains; increase soil organic and moisture contents; minimizes the concentration of harmful gassesin the atmosphere due to its carbon sequestration advantages; ensures ecosystem health and improved biodiversity; provide flood mitigation benefits and prevent land degradations others.

ALTERNATIVE MEANS OF LIVELIHOODS

Adverse effects of climate change can also be mitigated by turning to alternative means of livelihoods that exertsno or less pressure on the environment and its resources, but at the same time, yields sustainable sources of income. Example of these activities comprises dryland aquaculture for the production of fish and crustaceans, commercial motorcycling, tourism related activities and other skilled jobs such as modern carpentry, blacksmithing, tie and dye etc. All these generate relatively high income with less environmental

disturbance. This will also reduce pressure on the scarce land resources, thereby, conserving the fragile ecosystem in the area. This will also reduce conflicts over land and its resource amongst different resource users in the area. Implementation of such practices in dryland areas will however require institutional buildings, access to markets, transfer of appropriate technology and capital.

ECOSYSTEM-BASED ADAPTATION (EbA)

The concept and idea of EbA, advocates wise and sustainable use of ecosystem goods and services as a measure to ameliorate the adverse effects of climate change on the people and environment (CBD2009). The concept revolves on the general understanding that, globally, people needs a healthy and functional ecosystem and the numerous good and services it provides for their sustenance and economic development. EbA therefore, suggest and encourages sustainable management, conservation and restoration of degraded ecosystems as effective measure for reducing the scourges induced by climate change and associated challenges. These will ensure uninterrupted supply of the essential goods and services required to cope with the challenges associated current climate variability and the possible future climate change (Colls et al. 2009). Advocating, practicing and fully integrating EbA strategy into development policies, programmes and projectswill therefore, greatlycurtail vulnerabilities and enhances resilience of both the ecosystem and people to climate change and associated challenges by providing multiple benefits to the environment and people. Some of the EbA strategies applicable in the study area includes the followings among others:

1. Effective and sustainable management of existing water resourece in the area. This requires that, river basins, aquifers, flood plains, and their associated vegetation are managed to provide water storage for domestic and agricultural uses as well as flood regulatory services. These should also include the measures to restore the degraded water resources such as pond streams and lakes including the dried Wurno and Kalmalo lakes.
2. Protection, conservation and sustainable use of rangelands and associated resources to enhance pastoral livelihoods and increase resilience to drought and flooding. This could also to a very large extent minimizes the conflicts between farmers and pastoralist in the area, which sometimes claims many lives and properties.
3. Development of effective robust and diverse agricultural systems that incorporates both indigenous and scientific knowledge and techniques of raising specific crop and livestock varieties, maintaining genetic diversity of crops and livestock, and conserving diverse agricultural landscapes. These would secure food provision in changing local climatic conditions. Efforts should be intensified to restored the degraded agricultural lands and those lost to large scale deposit of sand dunes in the areas adjoining the Northern parts of the study area.
4. Sustainable use and management of shrublands and deciduous forest in some parts of the study area that serves as alternative source of pasture during the dry season and sources of fuel woods.
5. Establishment and effective management of protected areas to ensure the continued delivery of essential ecosystem services that increase resilience to climate change.

CIVIC AND ENVIRONMENTAL EDUCATION

This is necessary to ensure and maintained people's responsive behaviours, informed decisions and constructive actions towards the physical environment (Flournoy 1993). To achieve this, people in the study area need to be equipped with the basic knowledge, through training, workshops and seminars, that would help them understand and appreciate environmental dynamics and equipped them with basic skills required in interacting and handling with some environmental issues that are prevalent in the area. Advocacy programmes projects geared towards raising public awareness on the need to protect environment, should also be pursued.

CONCLUSION AND RECOMMENDATIONS

It is worthy of note that, although there are both physical and human causes of climate change,

human activities account for about 90% of the causes. With the rapid increase in human population in the recent decades, more pressure is exerted on the natural environment and its resources. More so, man's ability to conquer, transform and harness the environmental resources to satisfy his ever increasing needs become more complex and diversified. In the process of doing this, man afflicted serious and sometimes irreversible injuries to the physical environment through such activities as deforestation, bush burning, and discharge of pollutants into the atmosphere from homes and factories, discharge of toxic substances into rivers and other water sources etc. all of which are the principal causes of climate change and its resultant varied consequences on both the physical environment, ecosystem and people.

To avert this ugly situation therefore, people need to imbibe ways of life that are more friendly to the environment. There is the need for collaborations among all stake holders in mapping out strategies foraddressing the challenges posed by theclimate change such as curtailing the emissions of greenhouse gases. Enhancing environment consciousness to the general public and taking necessary precautions to prevent negative environmental attitudes is also necessary. Educational institutions can serve as key strategic areas to introduce environment education. The contents and curriculum of education should provide skills to students to enhance their understanding ofthe causes of climate change, its effects on environment and various social groups, adaptation and mitigation measure as well as how they can participate in improving their local environment. Integration into development policies and full application of ecosystem-based adaptation to climate change should also be given utmost priority as its need in the present situation is more than ever before. Regular and effective environmental monitoring and assessment in order to keep the track of the environment conditions and assesses the effects of development programmes and projects on the environment, as well as the effectiveness of mitigation and adaptation policies and projects should also be put in place. The task of maintaining environmental integrity and using its diverse resources judiciously and sustainably so that it can be handed in a good, healthy and useful state to the generations yet unborn rest on all and sundry.

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