

Assessment of Changes in Land use and Variation in Climate over Ilorin, North Central Nigeria

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Abstract

Existing studies have shown that land use land cover changes over many urban areas have significantly contributed to variation in climate. The study examined the spatial and temporal variability of land cover changes of Ilorin, North central Nigeria from 1986 to 2015. It also quantified the possible long term seasonal and annual climate conditions over the area with a view to assessing the effects of land use land cover changes on climate. A medium resolution Landsat satellite images was downloaded from the earth explorer website and was used to classify the land use land cover change of Ilorin, Kwara State into 1986, 2000 and 2015 scenarios respectively. Subsequently, temperature and rainfall raw data were also obtained through the global Climate Forecast System Reanalysis (CFSR) in twenty-one weather stations Data obtained was subjected to appropriate descriptive and inferential statistics. The results showed that urban built up area increased by 17.93% and water body by 1.04% while cropland and savannah areas decreased by 15.19% and 63.30% respectively between 1986 and 2015. However, there were gradual decline in the inter annual rainfall trend for the period (1986- 2015) by 16.44 mm as well as increase in annual temperature trends by 1.04°C. The study concluded that land use land cover changes may have negative implications on climate in the north central Nigeria. There is therefore need to encourage conservation practices, including afforestation for sustainable development.

Keywords: climate variability, land use land cover change, rainfall, temperature

1. Introduction

Climate variability means natural changes in climate that fall within normal range of extremes for a particular region as measured by temperature, rainfall and frequency of events (Okeke and Okorie, 2011). Climate is normally influenced by external (astronomical and orbital), internal (earth – geophysical, geological and geographical) and anthropogenic factors respectively (Nikola and Nikolov, 2014) while Climate variability is the change in patterns of climate elements such as rainfall and temperature distributions and magnitudes. Climate variability may lead to extreme events (Christidis, 2005).

The effects of climate variability include increase in wild fire, insect infestations, proliferation of invasive species, increased flooding, erosion, and movement of sediment into streams and increased droughts (James and Toral, 2012). A gradual increase in temperature may alter the growing environment of many tree species, thereby leading to more extreme weather events and climatic conditions. Nigeria has demonstrated high level of vulnerability to the effects of climate variability over the years, ranging from recurrent droughts to shrinkage and disappearance of lake chad (Okpara, 2007).

The land use land cover changes are important driver of climatic variability (Selcuk, 2008). Land

use land cover change is the conversion of forested areas into other uses (IPCC, 2013). Land use land cover change has been identified as a contributing factor to climate change, accounting for 33 percent of the increase in atmospheric CO₂ since 1850, and a leading factor in the loss of biological diversity (IPCC, 2007b). Land use change results in changing the physical and biological properties of the land surface (IPCC, 2007a). In Nigeria, the uncontrolled and unsustainable urbanization and land use management have negatively impacted climate and extreme events (Otubu, 2010). Today for examples, there has been increasing menace of frequency of flood in the lower Niger basin, due to intense falls of short duration particularly for the years 2005, 1999, 1994 and 1988 and the resulting water accessibility and water demand problems in the region (IPCC, 2007b).

Climate models, quantitative analyses, and qualitative evaluations, sensitivity attributes and third component, adaptive capacity methods have been used by scientists to assess the effects of climate variability (Wendy *et al.*, 2015). However, these methods were usually limited to point estimates that do not consider the inherent variability and uncertainty of climatic and socio - economic variables (Carlos, Cecilia and Francisca, 2012). Remote sensing and Geographical Information Systems (GIS) on the other hand has been found to complement these deficiencies because it provides accurate and timely information on the spatial and temporal distribution of climate variability (Barnsley, Donna and Longley, 2001). It also offers more uniform measurements of effects land use changes on regional climate.

1.2 The Study Area

This study was carried out in Ilorin, Kwara State, North Central Nigeria, which is mainly a derived savannah region (Olorunfemi, 2007). It is located on latitude 8° 24'N and 8° 36'N and longitude 4° 10'E and 4° 36'E (Figure 2), and located in the

traditional zone between the deciduous woodland and dry savannah north of Nigeria (Olorunfemi, 2007). Like the rest of West Africa, the climate of the region is controlled largely by the two dominant air masses affecting the sub-region (Adefolalu, 2007) These are the dry, dusty, tropical- continental (cT) air mass (which originates from the Sahara Desert), and the warm, tropical- maritime (mT) air mass (which originates from the Atlantic Ocean. (Adefolalu, 2007) The influence of both air masses on the region is determined largely by the movement of the Inter-Tropical Convergence Zone (ITCZ), a zone representing the surface demarcation between the two air masses. The interplay of these two air masses gives rise to two distinct seasons within the sub-region namely the wet and dry seasons respectively. The wet season is associated with the tropical maritime air mass, while the dry season is a product of the tropical continental air mass. The influence and intensity of the wet season decreases from the West African coast northwards (Adefolalu, 2007).

The soils of Ilorin are loamy with sodium and low fertility because of high seasonal rainfall, coupled with high temperature. There is tendency for lateritic soil to constitute the major soil type due to the leaching of mineral nutrients of the nutrients (Olorunfemi, 2007). The population of Ilorin has continued to increase from 41000 in 1952 to over 3 million in recent times (Olorunfemi, 2007). Ilorin has witnessed rapid and continuous urbanization over decades with attendant implications on climate variation (Ibrahim *et al.*, 2014). The vegetation type comprises of tall grasses, interspersed with scattered trees. Amongst the grasses in the area are spear grass, elephant grass, and goat weed of height of 3.5 meters. Trees in the area include shear butter, acacia and locust beans trees. agricultural activities in Ilorin are limited to small garden plots of groundnut, maize, beans and vegetables cultivated mainly for domestic consumption. cultivation of yam, cassava,

guinea-corn, vegetables are increasingly cultivated at the outskirts of the city (Olorunfemi, 2007). Both the climate and soil of Ilorin support the growth of cereal crops.

2. Materials and Methods

A Medium resolution landsat satellite images of Ilorin, Kwara State were obtained from the USGS through its website, <http://earthexplorer.usgs.gov>, to classify the land use/ land cover patterns of the systematically selected 1986, 2000, and 2015 scenarios respectively. The images were retrieved through the paths 190 and 191 respectively and Row 54. The images were already geometrically corrected and were used for the land use/ land cover change analysis. The image was then imported band by band from GeoTiff to (.img) extension. After that, the bands were stacked, before it was pan-sharpened to 15m resolution using the panchromatic band respectively. This procedure was repeated for all the six images used and the resulting images were named accordingly, bands 5,3 and 2 were selected for the 1986, 2000 and 2015 images respectively due to the fact that they are good for the identification of urban features and also display contrast appearance of vegetation and water bodies (NASA, 2004).

The main operation in image pre-processings included atmospheric correction, image registration, correction of distortion due to imaging system and condition, masking (for cloud, water and irrelevant features) In addition, correction was done to remove or reduce the occurrence of water vapour and suspended particles in the atmosphere, which may result in low image contrast and affect visible and infra-red ETM⁺ bands as described by Fan et al., (2007). Secondly, image enhancement was carried out for better image visualization and interpretation, thereby improving image quality and visual impacts (Zhao and Shaohong, 2013).

Third, the georeferenced images were mosaicked two by two into three images according to their years. The colour of the overlapping areas between the adjacent raster datasets were balanced using histogram balancing in Arc map. Consequently, the land use/Land cover change was determined using the Zonal Geometry using supervised classification in Arc map 10.3 (Zhao and Shaohong, 2013). Change maps were generated, through the eqn A.1 below;

$$\% \Delta = \frac{\Delta}{\Sigma \Delta} \times \frac{100}{1} \quad (\text{eqn. A.1})$$

Where Δ = change (in ha) between 1986 and 2015 respectively.

Further, accuracy assessment was carried out to determine the accuracies of the land use classes for the three years' study period.

Lastly, 30 years (1986 – 2015) temperature and rainfall raw data was downloaded from the National Centers for Environmental Prediction (NCEP) global Climate Forecast System Reanalysis (CFSR) in twenty weather stations) covering Ilorin, North Central Nigeria through the website, <http://globalweather.tamu.edu>. Variability in rainfall was identified using coefficient of variability (CV). The trend and pattern were depicted on time series graph. The coefficient of variability follows the model equation 2;

$$CV = \frac{SD}{\bar{x}} \times \frac{100}{1} \quad (\text{eqn. A.2})$$

Where $\bar{x}$ stands for mean and SD stands for standard deviation respectively.

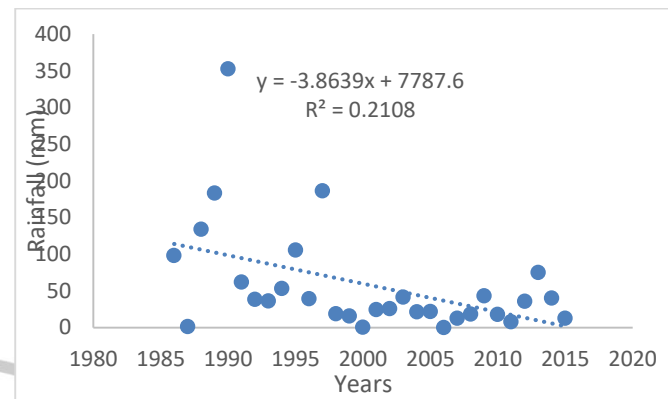
3. Result and Discussion

The result indicates that there were drastic and rapid increase in urban built up and water areas and a decrease in cropland and savannah areas respectively. The savannah area reduced by 63.30% (81574.2 - 21958.2ha) between the year 1986 and 2015. The Cropland reduced by 15.19% (5149602 - 4367386ha)

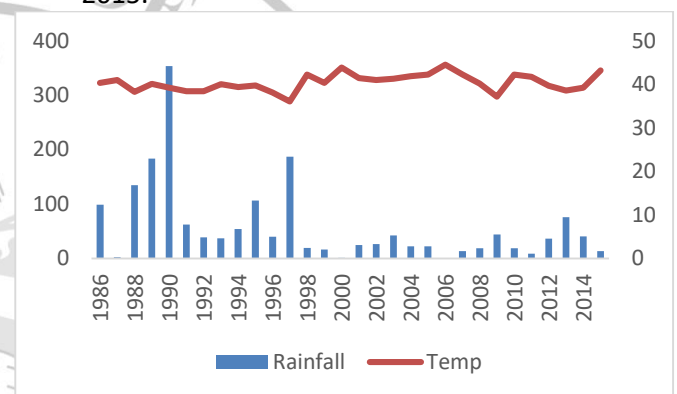
between the year 1986 and 2015. The urban built up area increased by 17.93% (46909.8 - 887789.7ha) between 1986 and 2015. The water also increased in area by 1.04% (22968-23920.2ha) between 1986 and 2015 active population category that is always physically and mentally alert to responsibility.

Generally, there were gradual decline in the inter annual rainfall trend for the period (1986-2015) by 16.44 mm and increase in average annual temperature difference by 1.04°C. The year 1986 recorded the total annual rainfall value of 1065.96 mm at 33.02°C while the total annual rainfall value for the year 2015 was 1049.52 mm at 34.06°C. The highest rainfall of 1461.56 was recorded in 1995 at the annual temperature of 31.98 respectively. The lowest rainfall value of 372.76 mm was obtained in the year 2000 at the annual average temperature of 37.15°C. There were increase in rainfall trends in August and September for the thirty years period respectively. The lowest level of decline was obtained in April, followed by October with average monthly values of 57.91 and 94.71 mm respectively.

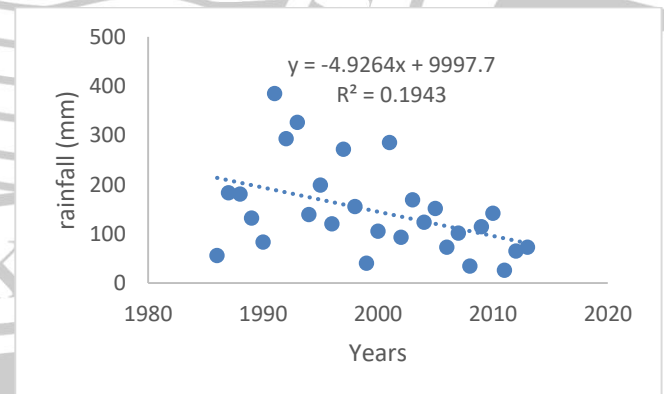
The result of average monthly temperature for August, September, April and October was 29.14, 30.44, 40.39 and 33.42°C respectively. However, between 1986 – 2015, the monthly records showed that from April to October, the study period, the average total of 156.39 mm of rainfall was recorded, the month of September recorded the highest rainfall with average monthly rainfall value of 265.16 mm while April recorded the lowest rainfall value of 57.91mm, the monthly average temperature value of 30.44°C was recorded in September and 40.39°C in April respectively. Other month with highest temperature values included April with average rainfall values of 57.91 mm at average temperature values of 40.39°C respectively.



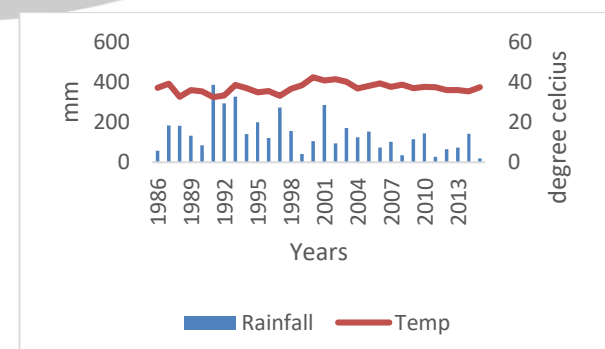
(a) Rainfall variability for April, 1986 – 2015.



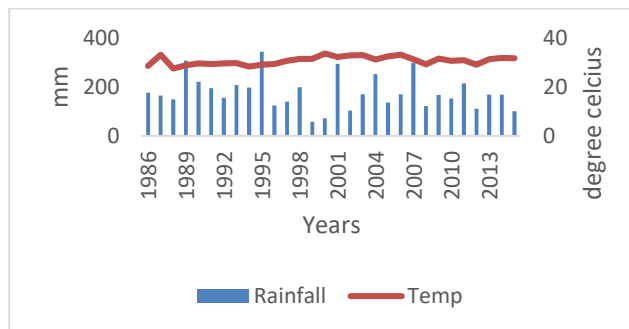
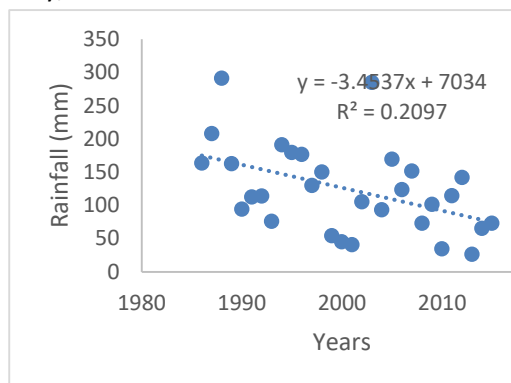
(a) Rainfall and temperature variability for April, 1986 – 2015.



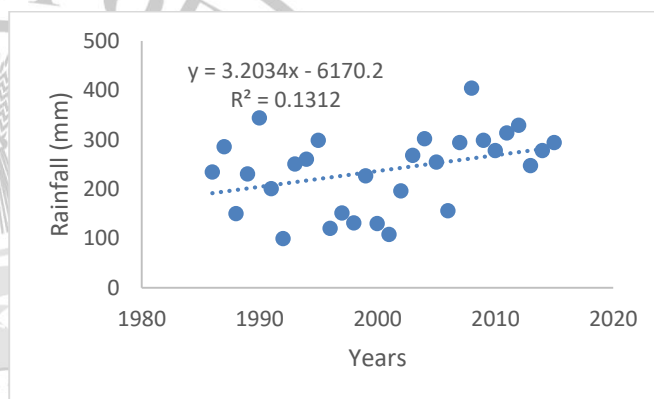
Rainfall variability for April, 1986 – 2015.



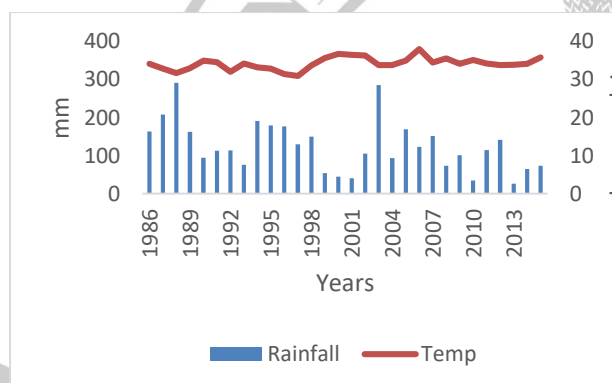
(b) Rainfall and temperature variability for
May, 1986 – 2015.



(d) Rainfall and temperature variability for
July, 1986 – 2015.

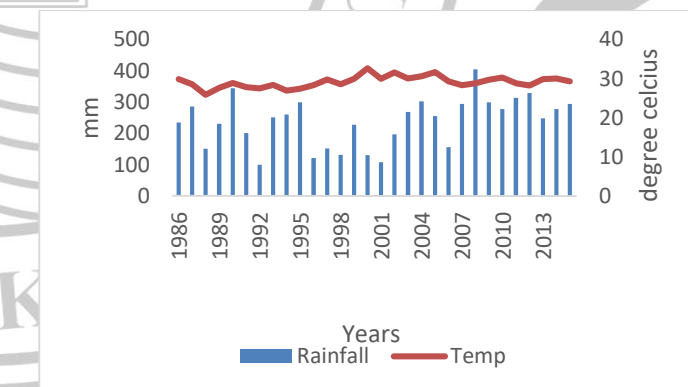
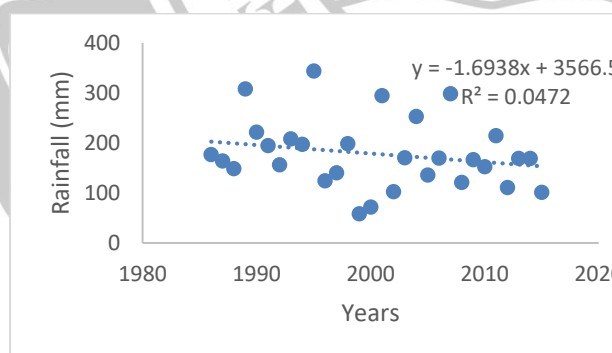


Rainfall variability for April, 1986 – 2015.



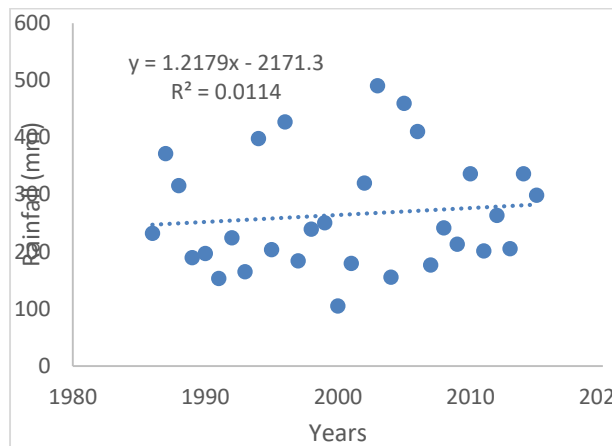
Rainfall variability for April, 1986 – 2015.

(c) Rainfall and temperature variability for June,
1986 – 2015.

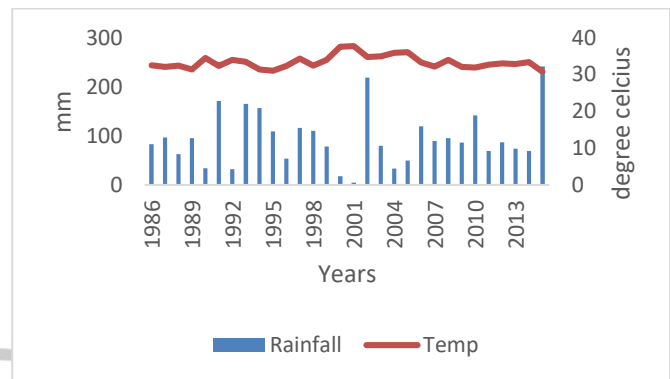


(e) Rainfall and temperature variability for
August, 1986 – 2015.

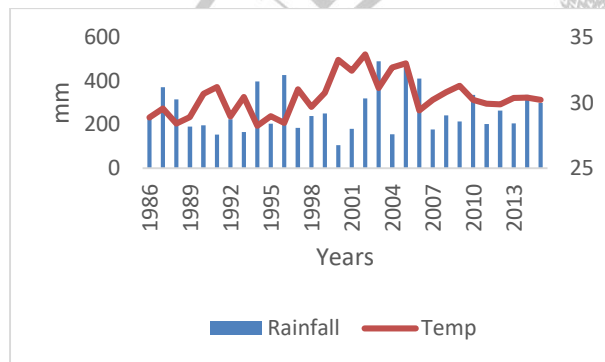
Rainfall variability for April, 1986 – 2015.



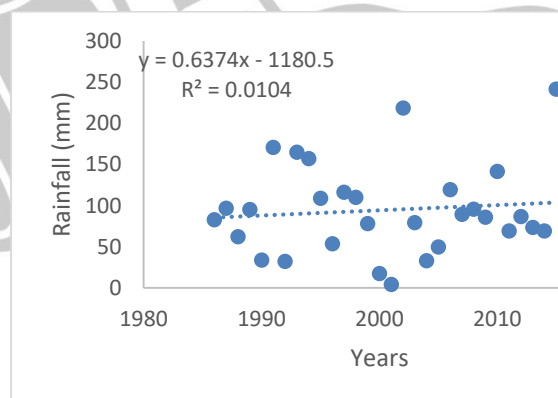
Rainfall variability for April, 1986 – 2015.



(g) Rainfall and temperature variability for October, 1986 – 2015.



(f) Rainfall and temperature variability for September, 1986 – 2015.



Rainfall variability for April, 1986 – 2015.

Figure 1 (a – g): long term (1986-2015) temperature and rainfall variability charts (Source: Author's Compilation, 2017).

Conclusion

This study examined the land use land cover change of Ilorin, North Central Nigeria from 1986 to 2015 and also investigated urban the heat Island distribution. as well as investigated the long term seasonal and annual climate variability. The result obtained from the spatio-temporal studies of the impacts of variability in climate over Ilorin has shown that there was an increase in the impervious surfaces of vegetative parts of Ilorin North Central Nigeria due to land use land cover change. Evidence has shown that apart from increase in the water basin by approximately 1%, about 63.30% of derived Savannah and 15.19% of cropland areas have been lost to urban built up areas since 1986, leading to net gain of 17.93% more areas of land due to urbanization. There is need for the implementation of development control mechanisms, environmental impacts assessment guidelines and also promoting water conservation strategies to ensure sustainable environment.

Acknowledgement

Special thanks go to the university of Ilorin for sponsoring the presentation of this paper in the

COPHYS conference which culminated in its publication in the conference proceedings.

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