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The Impact of Climate Change on Landforms in Nigeria

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Abstract

This paper examined the impact of climate change on landforms in Nigeria. Today, different landforms are changing from one state to another as a result of human activities, weathering and soil erosion brought about by agents of denudation and fluvial processes. Therefore, the objectives for which this study was carried out are: .To examine whether or not there is actually climate change in Nigeria in terms of rainfall, examine the different relief regions in Nigeria, examine causes of climate change and to determine the consequences of climate change in Nigeria. For this reason, the data used for the study were collected from both the primary and secondary sources of data collection. The primary data used were erosion pins to determine the level of sediments that are eroded from most of the steep slopes associated with highlands. The secondary data used were collected from articles in journals and related text books analyzed descriptively and statistically. The different relief regions in Nigeria were looked at. It was discovered that as the highlands are getting reduced as a result of climatic elements especially rainfall the lowland areas are filled up with the loads and sediments that are deposited on them. And recommendations were therefore made on the need for proper land use zoning systems to curtain elements of climate and the need for everyone to protect the environment and not by destroying it in the name of human activities through agriculture, construction and services.

Key words: Relief, Erosion, Flood and Tectonic

Introduction

The history of man the World over, shows that landforms have always been viewed as a resource. The present day form of land surfaces (landforms) is a result of different earth surface processes that operated over long geological times. Landforms are usually the first and easiest thing we observe when we study global change and the impacts of human activities on our environment and may contain important clues to past processes relating to global change and human impacts. In order to be able to improve, maintain and understand the sustainability of our earth surfaces and then predict the nature of these land surfaces in the future, we need to have a basic understanding of the general configuration of landforms and of the surface processes. Also, important here are the environmental factors involved in their formation and evolution of landforms.

Landform evolution is an important aspect of earth sciences and involves complicated interactions among different physical processes and environmental factors such as tectonic movement, underlying rock structure, type of surface rocks, climatic changes and human activities, all occurring over a wide range of spatial and temporal scales. However, because of the degree of complexity in spatial and temporal scales, long term landforms evolution cannot be observed directly.

The issue of landforms has enabled us to know the geological time periods our physical landscape has passed through. Geologically, areas of highlands and lowlands constitute 50 percent each of the total land surfaces in Nigeria. However, the geological history of Nigeria can be divided into five periods. These are the Ancient or Precambrian era, primary or Paleozoic era, secondary or Mesozoic era, Tertiary or Cenozoic era and the Quaternary or recent times. During these geological periods, the rocks of the earth were formed and these rocks go by the name of the appropriate period. Thus we have the Precambrian rocks, Primary rocks to the quaternary times.

Over the years, there have been changes in climates and weather globally. This change is made visible when we particularly focus on climatic elements especially rainfall, temperature and relative humidity. Rainfall data for example, have been changing in the past few decades resulting into flooding. The problem of flooding is not necessarily resulting because of increased amount of rainfall when we examine rainfall data for the past 10-15 years as shown in Table 1. The change is due mainly to urbanization problems.

Intense and long lasting precipitation is probably the most common single factor producing floods (Ayoade 2003). All other factors are hinged on peak discharge of an area. Table 1 shows monthly rainfall in Benin City from 1995 – 2011 in millimeters, which is one of the major Cities in Nigeria. When the infiltration capacity of soil or maximum rate at which water can be absorbed by it is exceeded and rainfall continues, runoff increases to flood proportions (Aziegbe 2006). Intensity is the most important of the rainfall characteristics. All other factors being equal, the more intense the rainfall, the larger will be the discharge from a given watershed. The storm duration or time of rainfall is the time from the beginning of rainfall to the point where the mass curve becomes horizontal indicating no further accumulation of precipitation. The most direct effect of storm duration is on the volume of surface runoff with longer storms producing more runoff than shorter duration storms of the same intensity. The observed monthly rainfall occurrence between 1995 and 2011 is 2177.8 in 1996 and 1565.4

in 1998. In 2010 the average monthly rainfall was 2094.9 and 2127.2 in 2011. This fluctuations clearly shows that the major cause of flooding today is not necessarily increased rainfall but the problem of urbanization and lack of proper land use zoning system coupled with other factors like dam failure and lack of drains (Eseigbe 2014).

TABLE 1 Monthly rainfalls in Benin City, Nigeria. From 1995-2011 in Millimeters

Months	January	February	March	April	May	June	July	August	September	October	November	December	**Total**
1995	5.2	6.8	151.2	127.2	210.6	234.4	266.5	264.4	342.2	281.2	19.1	1	**1909.8**
1996	27	22.6	96.4	216.7	281.2	232.2	371.4	287.4	351.7	263.1	16.7	6.4	**2177.8**
1997	41.6	0	114.1	108.6	280.1	315	161.5	152	232.1	253.3	47.8	0.9	**1706.9**
1998	9.5	20	50.4	129.8	143.2	177.5	246.6	59.5	449.5	251	28	0	**1565.4**
1999	29.8	54.4	89.1	166.6	262.1	236	241.5	172.9	399.3	282.5	23.8	0	**1957.7**
2000	5.8	11.8	61.9	153.1	92.4	423.9	220.8	241.9	348.8	228.2	16.7	0	**1912.3**
2001	11	1	152.3	237.7	182.1	251.9	253.2	139.8	343.3	114.4	8.9	3.9	**1809.5**
2002	0	27.8	133.6	209.8	201.5	356.6	437.3	308.5	180.9	237.1	42.7	0	**2135.8**
2003	49.3	26.9	68.3	250.8	181.2	162.9	155	170.1	313.5	293.7	31.3	0	**1703**
2004	35.2	13.5	55.3	106.4	323.4	355.7	214.3	298.6	251.1	247	28.3	0	**1928.8**
2005	0	15.7	167.2	114.1	138.9	292.7	406.8	80.9	177.3	167.2	33.9	0	**1595**
2006	22.5	10.5	61.5	158	246.8	172.5	289	335.9	347.4	304.5	24.7	0	**1972.9**
2007	0	104.2	56.2	197.7	246.2	380.9	284.7	171.4	256	285	37.1	17.1	**2036.5**
2008	1.2	4.6	72.4	187.2	208.6	360.7	297.5	186.4	266.6	270.1	32.4	4	**1819.7**
2009	1.6	134.9	78.3	226.6	248.6	207.7	148.7	254	278.1	192.8	109.4	1.3	**1882**
2010	0	57.5	38.7	219.9	125.4	174.6	257.8	455.8	282.1	373.8	109.3	0	**2094.9**
2011	0	116.2	84.9	118.3	264	275.2	430.3	277.8	250.9	240.8	68.8	0	**2127.2**

Source: Nigerian Institute for Oil Palm Research (NIFOR), Benin City, 2012.

Many researchers have defined climate change as a mean permanent departure of climatic patterns from mean values of observed climatic indices. Obioh (2001) includes departure in climatic indices to mean change in climate. Indicators for assessing evidence of climate change in a region are increasing temperature, increasing evapotranspiration, decreasing rainfall amount in the continental interiors, increasing rainfall amount in the coastal areas, increasing disruption in climate patterns and increasing frequencies and intensities of extreme weather (IPCC, 2001, NEST 2003, Hengeveled et al 2005 and Onyenechere 2010).

According to Intergovernmental Panel on Climate Change IPCC (1995, 2001) the main evidence of climate change from scientific studies and observations so far are: the Earth's surface temperature is rising faster now than it has done for 1000 years, the general mean temperature of 15^0C has risen by 0.3 – 0.6^0C since 1900. Also, micro level research shows variability in rainfall. This is also shown in researches carried out by Adejuwon (2002) in Nigeria. Obioha (2008) and Odjugo (2009) have observed decreasing rainfall in Nigeria especially in the Northern part of the country. The decreasing rainfall, increasing temperature and evapotranspiration have resulted in either reduction of water levels or total drying up of some rivers and lakes in Northern Nigeria. The Lake Chad is reported to have been shrinking in size at an alarming rate since 1970s (Nyelong, 2001, Nkomo et al 2006; Molega, 2006 and Odjugo, (2009). The existence of unusual extreme weather related events such as erratic rainfall pattern, floods and sea level rise in Nigeria was also confirmed by Onyenechere, (2010). Climate change is a very serious challenge for development because landforms are the bane of resources required for the growth of any nation. However, climate change can also bring opportunities to enhance development by integrating research in areas that have been neglected for too long and to engage actors and strengthen partnerships at all spheres.

Aim and Objectives

The main aim of this research is to evaluate the impact of climate change on the physical landscape in Nigeria. Therefore, the following objectives are examined:

(i) Examine the different relief regions in Nigeria

(ii) Examine the main factors that can cause changes on landforms in Nigeria
(iii) Determine the consequences of climate change on landforms in Nigeria.

Methodology

This study utilized both the primary and secondary sources of data. Erosion pins were mainly used to determine the level of wash on hill slopes as a result of rainfall impact on landforms. Also, the secondary data used were collected from consulted articles in journals and textbooks. The different relief regions in Nigeria were studied in order to have knowledge of how the different climatic elements have affected the different landscape features.

Relief Regions in Nigeria

The relief of any area describes the height or depth above or below a certain level. The relief of a given area depends on three major factors. These are the type of erosion at work which is responsible for the wear and tear of the landscape, the nature of rocks and the time required for the change to take place. Figure 1 shows the different relief regions in Nigeria.

In Nigeria, the Eastern part of the country is over 1500 meters. While the North has a general average relief of 600 meters and the West has an average of 300 meters in height. The areas below 300 meters are found in the South and at the center of the country (Iloeje, 1982). The general relief of Nigeria can be categorized into areas of high plateau and the lowlands. Figure 1 shows how the three trunks of Niger-Benue river system cut the highlands into three blocks. The swells form the highest parts of the country within which the following major physiological units may be recognized (Jimoh, 2012). These are the central plateau in the North, the Eastern and North eastern highlands in the east and the Western uplands in the west. Suffice to note that the Jos Plateau is the highe st landscape with an elevation of about 1500 to 1800 meters. Other plateaus as high as Jos Plateau are found in the North East with a range of 1800-2400 meters separating Cameroon and Nigeria (Iloeje, 1982).

It is significant that these highlands correspond with the areas of volcanic rocks and uplifted areas of basement complex rocks. This shows that these areas were initially high and offer great resistance to soil erosion. The rest of the country can be divided into lowland areas which include: (a) Sokoto plains in the North West. (b) Interior coastal lowlands of western Nigeria (c) The lowlands and scarplands of South-eastern Nigeria (d) The Niger Delta plains (e) Plains of Southern Nigeria and swamps which lie adjacent to the Atlantic ocean (f) the Gongola Trough and (g) the Niger-Benue Trough. These areas are mainly made up of sedimentary rock formations.

Many streams and rivers rise from these highlands. In the North central we have the Hadejia and Gongola Rivers which flow to the east while the Sokoto and Kaduna Rivers flow towards the Niger. Others are Mada and Gbako Rivers which flow southwards. From the Eastern highlands we have the Yedseram and Gana Rivers which flow into Lake Chad. In the western highlands, we have such rivers like Ogun, Osun and Osse flow southward to the Atlantic. We also have the Awum River which flow northward to the Niger. We must note that most of these rivers in addition to insequent and subsequent streams flowing into them through consequent streams help in the wear and tear of these highlands coupled with increased amount of rainfall we are experiencing today. Changes in climatic elements such as rainfall, temperature, relative humidity and the wind systems (the tropical maritime air mass and the tropical continental air mass) coupled with human activities especially the demand for farm lands, the landscape has been seriously modified.

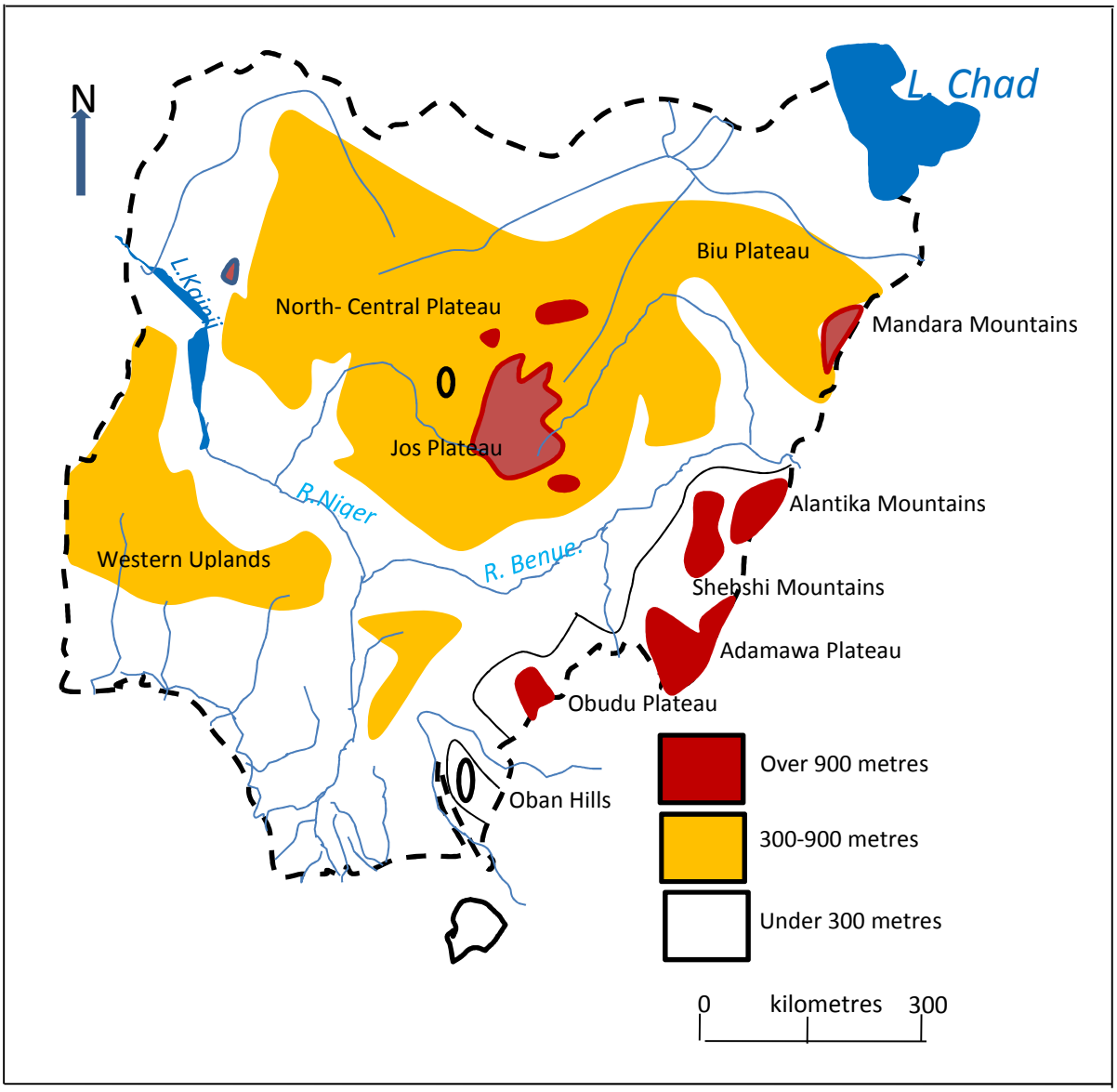

Fig. 1: RELIEF REGIONS OF

Climate Change and Landforms

Changes in landforms can be approached in two ways. These are structural divisions and erosion surfaces. The structural division emphasizes the geological basis of an area including rock type and more importantly tectonic history. The latter lays emphasis on process and time and is thus best defined in terms of denudation chronology and the cycle of erosion concept. These processes affect greatly the type of landforms found in an area.

The impact of climate change on landforms can as well be looked at in two ways. These are the study of the way in which mass movement affect slope and through the study of the characteristics and development of slope profile. Mass movement can be grouped into two, depending on the amount of liquid in the moving mass as well as on the degree of slope along which movement takes place. This is usually affected by such factors like topography, soil characteristics, vegetation, human activities on the surface and geomorphological factors.

Weathering which is the breaking down of rock materials from massive to classic states is a very crucial process in geomorphology. It is best defined as the physical disintegration, chemical decomposition and biological decay of rock fragments insitu. In which case, no movement is attached. The movement of such materials is mass wasting. Most removal processes are ineffective when they act on fresh (hard) rocks but are very potent on loose materials especially those within certain caliber ranges. Consequently, the idea that landform development is a function of the relationship between weathering and removal processes is widely

accepted. Depending on the relative rates of these two processes in an area, the landscape may be characterized by dominantly mantled feature or by fresh rock outcrops (Faniran, 1986).

Changes in the distribution of land and water bodies would bring about a change in energy distribution and hence general atmospheric circulation and climate because of characteristics of land and water surfaces. Rainfall especially has affected the landscape greatly that most of the land surfaces have greatly been reduced. And it will continue to be so because it is almost impossible to address the problems of flood and soil erosion in undeveloped zones. This phenomenon of rainfall event has resulted into massive reduction in height of the various highland areas in Nigeria. Single erosion pins mounted on the slopes of most of these highlands shows remarkable wear and tear of these surfaces across Nigeria year in year out.

In humid tropical region, chemical weathering is more pronounced and rocks are known to have weathered to more than 70m (Faniran et al 2006). It is the organic acids derived from abundant decaying vegetal cover that aid chemical weathering. Also, physical and biological weathering are viable too on the different landscape features.

In Nigeria, rainfall is the dominant factor that can cause mass movement. It causes the slow movements of soil creeps, resulting into the transportation of both bed load and suspended load materials. The level of regional erosion exemplified by Faniran et al (2006) shows that in the tropics, mountains have regional erosion in (m^{3}'') of 40 while that of plain areas is 20. Mass movement exhibits great variety which reflects the diversity of the factors responsible for their origin. The most important of these factors are geology (tectonic geology), slope gradient, climate, the nature of the waste mantle that is being moved, the type and density of the groundcover, land use and the degree of human interference as revealed by this study.

CONCLUSION AND RECOMMENDATIONS

From the preceding, it is clear that some form of relationship exist between climate and landforms. In Nigeria, detailed outline of landforms have resulted from exogenic forces of weathering and erosion by mass movement. These processes vary in intensity over time and space and are controlled by the factors of climate and soil character. The processes of climate change has made possible the general configuration of the earth surface in Nigeria to have passed through Precambrian era, primary era, secondary era and the quaternary era to the present times.

Climatic variations do affect the behaviour of geomorphological processes directly and indirectly (Faniran, Jeje and Ebisemiju, 2006). In Nigeria today, flood has profound impact on geomorphological processes and the nature of the resultant landforms. Nigeria is characterized by deeply weathered soil covered landscape. Chemical weathering which involves the process of rock decay by the combined action of agents of the atmosphere, biosphere and hydrosphere have equally affected the Nigeria landscape. This is because high incidence of rainfall, temperature and presence of thick vegetal cover have enhanced chemical weathering. The process of physical, chemical and biological weathering brought about by climate change have greatly affected the land surfaces of Nigeria. However, it is strongly recommended that proper land use system should be adhered to so as to protect the landscape. Also, everyone must be ready to protect the landscape and not by destroying it in the name of human activities like construction, agriculture and through provision of services.

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