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The Effects and Linkages of Deforestation and Temperature on Climate Change in Nigeria

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Keywords: deforestation, greenhouse gases, temperature change, global warming, climate change, forest protection/conservation, nigeria.

I. Introduction

A forest is a land which is covered with more than 10 percent of trees and an area of more than half a hectare (FAO, 2005; Inyang and Esohe, 2014). Forests currently cover around 30% of the Earth's land surface, but are being lost at an "alarming rate" (FAO, 2010; Miller and Cotter, 2013). Forests serve many purposes. Through photosynthesis, forests serve as carbon sinks reducing the amount of CO_2 in the atmosphere thereby curtailing global warming. Forests serve as shade to the soil thereby preserving soil biodiversity. They control the rates of evapo-transpiration and transpiration due to the heat they absorb. They provide the raw material needed in the pharmaceutical industry, lumbering industry, for construction, for firewood, for the production of charcoal and so on. Spore, 2011 reported that forests also play a pivotal role in providing water resources, due to their influence on volumes and distribution of rainfall, the dynamics of water in soil and the quantities of water discharged into the atmosphere in the form of vapour. The importance of forests as a resource cannot be overstated. In line with the socioeconomic and climatic importance of forests there is need for protection and conservation. Most scientists agree that, in the past two decades, tropical deforestation has been responsible for the largest share of CO_2 released to the atmosphere from land use changes (IPCC, 2007; Gorte and Sheikh, 2010). At current rates of deforestation, clearing tropical forests could release an additional 87 to 130GtC of CO_2 to the atmosphere by 2100 (Houghton, 2005; Gorte and Sheikh, 2010). According to the Union of Concerned Scientists (2013), tropical deforestation accounts for about 10 percent of the world's heat-trapping emissions. They reported that tropical deforestation contributes about 3.0 billion tons of CO_2 a year to global warming pollution (Union of Concerned Scientists, 2013). This value of 3 billion tonnnes could be as a result of the loss in carbon sequestration and the added input of CO_2 to the atmosphere as a byproduct from the use of forest resources. Inyang and Esohe, 2014 also cited that deforestation accounts for 87 percent of total carbon emission in Nigeria. With more CO_2 in the atmosphere, more of the sun's radiation is reflected back to earth, instead of space, and this causes average temperature to rise. In this way, deforestation is a major issue when it comes to global warming (Jakubowski, 2013). As terrible the consequences of deforestation are, Nigeria has one of the highest rates of forest loss (3.3%) in the world (Butler, 2006). This study is therefore aimed at discussing the effect deforestation poses to temperature and invariably on climate change.

The forest resources of Nigeria as classified in Figure 1 are classified into rain forest, deciduous forest, savannah forest, thorn forest, fresh and salt water swamp

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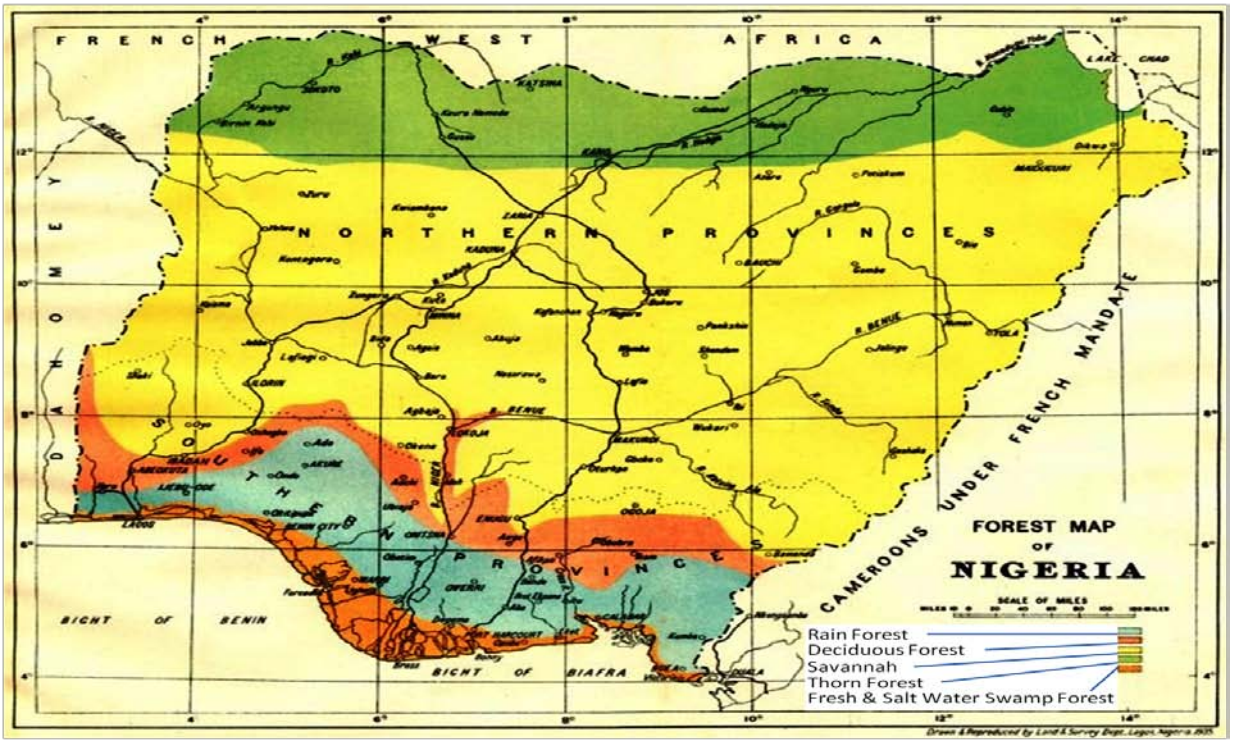

Figure 1 : Map showing the forest classification of Nigeria

Source: http://www.antiquaprintgallery.com/ekmps/shops/richben90/images/nigeria-forest-map-of-nigeria-1936-75130-p.jpg

Deforestation is the removal of a forest or stand of trees where the land is thereafter converted to a non-forest use (Dictionary of Forestry, 2008). It is the clearing or thinning of forests, the cause of which is normally implied to be human activity (Encyclopædia Britannica, 2012b). Deforestation also refers to indiscriminate cutting or over-harvesting of trees for lumber or pulp, or to clear the land for agriculture, ranching, construction, or other human activities (Microsoft Corporation, 2008).

It refers to measurable increases in the average temperature of Earth's atmosphere, oceans, and landmasses. Here, the terms global warming and climate change are used interchangeably (Mastrandea and Schneider, 2008). It also refers to the phenomenon of increasing average air temperatures near the surface of Earth over the past one to two centuries (Encyclopædia Britannica, 2012c)

It is the periodic modification of Earth's climate brought about as a result of changes in the atmosphere as well as interactions between the atmosphere and various other geologic, chemical, biological, and geographic factors within the Earth system (Encyclopædia Britannica, 2012a). Climate change means a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods (UNFCCC, 1994). Climate change can also be defined as a change in the statistical properties of the climate system when considered over long periods of time, regardless of cause (NSIDC, 2001).

II. Theoretical Review

a) Climate Change in Nigeria

According to Odjugo, 2010 who inferred from his research that for 105 years, temperature has increased by 1.1°C and rainfall has decreased by 81 mm. This was caused by high deforestation rate thus leading to increase in desertification (Inyang and Esohe, 2014). The Nigerian Meteorological Agency (NIMET) also reported weather anomalies, extreme weather events and their impact on the socioeconomic status of Nigeria (NIMET, 2010). The summary is as follows:

b) Weather Anomalies in Nigeria

i. Temperature Anomaly

NIMET, 2010 reported that warmer than normal maximum temperatures prevailed over most places in the country with high positive values between 1.9 – 2.9°C over Yelwa, Bauchi, Maiduguri, Potiskum and Ogoja. However, colder than normal weather conditions were experienced in a few places especially over Eket that recorded negative maximum temperature departures as low as 2.4°C. NIMET, 2010 also reported warmer than normal minimum temperatures of 0.5 – 1.5°C during the cold season (January) over most parts of the country with places such as Eket, Enugu, Gusau, Ibadan, Oshogbo, Owerri and Ikeja recording values

which were 2.0 – 3.1°C warmer. On the other hand, Ibi, Yelwa, Jos and Kaduna were 0.8-1.8°C colder than normal. Extremely high daily temperatures in the range of 40.0°C and above were recorded in the northern part of the country for consecutive days beginning from the third week in February to the end of May. Also, Potiskum and Maiduguri in the northeast recorded the highest daily temperatures of 46.1°C and 45.5°C respectively (NIMET, 2010).

ii. *Rainfall Anomaly*

NIMET, 2010 further reported that wetter than normal conditions were experienced in the extreme northeast, northwest and cities such as Bauchi, Jos and part of Minna in the central states. Other areas that recorded wetter than normal rainfall conditions included southwest and Ogoja, Calabar and Eket in the southeast. Isolated case of drier than normal rainfall was recorded at Ilorin. The rest of the country had normal rainfall. In the last three years, the extreme northwest had experienced drier than normal rainfall condition but became wetter than normal in year 2010. Daily heavy rainfalls ranging from 103.00m and 199.50m were recorded. Highest daily rainfalls of 199.5mm, 184.6mm and 183.8mm were recorded at Uyo (June), Benin (September) and Umuahia (June) respectively (NIMET, 2010)

iii. *Inter-Tropical Discontinuity (ITD) Anomaly:*

It was also NIMET, 2010 who reported that the Inter-Tropical Discontinuity (ITD) was located at an average position of latitude 7.9°N in January. It then oscillated northwards to reach a northernmost position of latitude 20.9°N in August. Thereafter, the ITD began its seasonal southward movement to reach latitude 7.8°N in December. The decadal movements and average monthly positions of the ITD were, in most cases, above normal but lagged behind long term conditions in April and December but were near normal in May and November. The higher than normal ITD positions accounted for the high rainfall in many cities across the country, particularly in the north.

III. Effect of Weather Anomalies on the Socio-Economic Status of Nigeria

The extreme weather events had an impact on the agriculture, health, education, hydrology and aviation sectors of the country. The summary is as follows:

a) Effect on Agriculture

The Northern states of Borno and Yobe experienced a reduction in rainfall amount in August which led to a drop in millet, sorghum and cowpea production by about 10% as reported by NIMET 2010. Reports also indicated that Sokoto, Kebbi and Jigawa states had a reduction in rice production by 50% due to excessive flooding in September as compared to the same period in 2009 (FEWSNET 2010 report; NIMET, 2010). In the south, higher crop harvest was reported particularly in crops such as yam, maize and cassava. However, high relative humidity in September and October delayed maize and cassava drying which led to losses. Fishing activities were affected particularly in the coastal states of Bayelsa and Rivers due to rise in water levels and flooding caused by above normal rainfall (NIMET, 2010).

b) Effect on Health

Incidences of flood related diseases such as cholera were reported to have infected nearly 40,000 people and killed more than 1,500 in some parts of the country in October. This was the worst outbreak of cholera in the country for nearly two decades. The highest death tolls were in the north (Borno, Katsina and Bauchi) that experienced heavy rain falls. There were also cases of cholera outbreak in the south, including Rivers and Cross River states in the Niger Delta (NIMET, 2010).

c) Effect on Education

The educational sector also felt the effect of the floods in the country with the closure of the Usman Danfodio University, Sokoto as a result of the collapse of the bridge leading to the institution in September. The Lagos State University was also cut off as a result of the collapse of the bridge leading to the school in June. A number of schools at the primary and secondary levels were also forced to close down or relocate due to the

d) Effect on Hydrology

The wet season starts normally between March/April in the South and between late May/June in the North. Excessive flooding was reported in most parts of the country between August and September, particularly, occurring along major rivers in Jigawa, Sokoto and Ogun states. Coastal flooding was also reported in states such as Delta, Rivers and Bayelsa states. Communities along the Lagos/Ogun borders also suffered spillover effect of the Ogun flooding which resulted into loss of farmlands, sources of income, loss of lives and properties and displacement of people from their homes. The high impact of flooding in the country could be assessed, for example, from the recorded flow volume of about 17.27 billion m^3 of water between June 1- September 30, 2010 at Jiderebode (gauged station in Nigeria) which was the highest ever recorded during the period in recent years and about twice the total mean flow of the five-year return period (NIMET, 2010).

e) Effect on Aviation

NIMET, 2010 reported severe dust hazy spell and early morning fogs across the country which reduced horizontal visibility to between 200m-800m for several days causing disruptions in areas such as: Lagos, Abuja, Kano, Kaduna, Minna, Maiduguri, Sokoto, Enugu, Owerri, Port Harcourt and Calabar which led to

flight cancellations. Also thousand of Europe-bound Nigerians were stranded at the Murtala Mohammed International Airport (MMIA) Lagos, as heavy snow pounded European airports in December. These harsh weather conditions affected the number of inbound and outbound flights at the Murtala Mohammed International Airport during the period (NIMET, 2010).

All these weather anomalies and climate change could be attributed in part to unregulated deforestation activities.

IV. Deforestation in Nigeria

According to FORMECU data, between 1976/1978 and 1993/1995, the area occupied by natural forest (excluding plantations) shrubs/grassland decreased from 23,439,000 ha, which is 26% of the country to 15,097,000 ha (16.6%) (NACGRAB/FDA, 2008). Since 1990, the country has lost some 6.1 million hectares or 35.7 percent of its forest cover. Worse, Nigeria's most biodiverse ecosystems—its old-growth forests—are disappearing at an even faster rate. Between 1990 and 2005, the country lost a staggering 79 percent of these forests and since 2000 Nigeria has been losing an average of 11 percent of its primary forests per year. This doubles the rate of the 1990s. These figures give Nigeria the dubious distinction of having the highest deforestation rate of natural forest on the planet (Butler, 2006). According to NACGRAB/FDA (2008), deforestation in Nigeria is put at about 3.5% per annum translating to a loss of 350,000 – 400,000 hectares of forest land per annum. Recent studies showed that forests occupy about 92,377 km or about 10 percent of Nigeria's land area. This is well below the Food and Agriculture Organization of the United Nations (FAO) recommended national minimum of 25 percent. In addition, forest estates are de-reserved by some State Governments. The State Forest Departments have been unable to curtail the spate of requests from the forest estate for the establishment of agricultural crops. The unfortunate impression has thus been created that the forest estate exists as a land bank for other sectors as the demands for de-reservation continue nationwide. Ola-Adams *et al*., 2006 reported 64 vulnerable, 14 endangered and 9 critically endangered tree species in Nigeria. NACGRAB/FDA also reported that while deforestation of off-reserve land is due to the reasons given above, the most important cause for deforestation in the forest reserves can be linked to the State Departments of Forestry who have abandoned any form of forest management for natural forests since the 1970s. As a result, reserve forests are being treated as an infinite resource, with no effective management practices in place to regulate the harvest. This finding is also backed up by Oduntan *et* al., 2013 who reported that all the protected areas surveyed in Yewa division of Ogun state are threatened by all the identified human activities; though at different level of severity. Sustainability of the forest resources is further threatened by the practice of short-term concession allocation tenures of 1-3 years that encourage annual re-entries. Other reasons for degradation in the reserves include inefficient wood utilization by industry and, therefore, a higher demand for industrial grade timber, and illegal logging (NACGRAB/FDA, 2008).

V. The Effect of Deforestation with Respect to Temperature Change

Trees serve as cover to the soil thereby protecting the variety of life existing in it from extreme temperatures. They serve as carbon sink by absorbing CO_2 which is a potent greenhouse gas that causes global warming. It is alarming that despite the importance and contribution of forests to global warming and climate change mitigation, many forests are being converted to agricultural lands, for industrialization and so on. This deforestation activities increase the amount of CO_2 released into the atmosphere directly and indirectly (Figure 2). Directly in the sense that, all the uses except lumbering for which the products of deforestation (such as wood) are used release CO_2 and sometimes CH_4 (in the case of decay) into the atmosphere. Deforestation increases the amount of CO_2 indirectly in the sense that there is greenhouse gas absorption deficit resulting from fewer carbon sinks thereby causing a surplus of CO_2 emissions. Canziani and Benitez, (2012) investigated the climate impacts of deforestation/land-use changes in Central South America in the PRECIS regional climate model. They concluded from their research that for temperature, significant changes are found within deforested areas and beyond, with major temperature enhancements during winter and spring. Mi Zhang *et al.,* (2014) reported in their research that along the North - South Transect of Eastern China (NSTEC) in Eastern China, deforestation caused cooling at the Changbaishan temperate mixed forest (CBS site) pair and warming at the subtropical and tropical site pairs. They inferred that deforestation increased the diurnal temperature range (DTR), especially in the temperate area. They also reported that precipitation was an important driver of the latitudinal and inter-annual variations in the deforestation effect. Green and Lindgren, 2012 reported that temperature change of -0.8°C, -0.04°C, +0.7°C respectively occur when either a boreal, temperate or tropical forest is deforested. This shows that tropical deforestation has a higher global warming potential compared to others. Gorte and Sheikh, 2010 cited that deforestation has been shown to reduce evapotranspiration (water loss to the atmosphere) by plants, which reduces cloud formation and downwind precipitation. Miller and Cotter, 2013 also

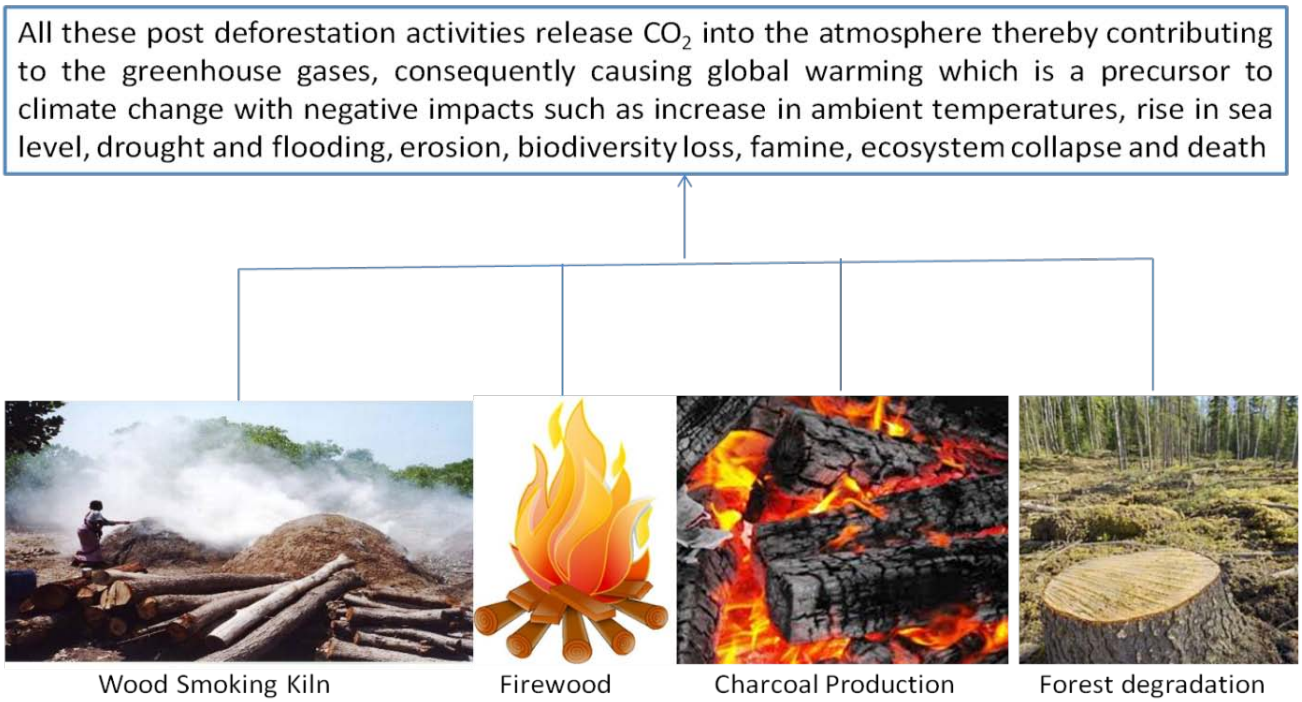

Figure 2 : The effect of deforestation with respect to temperature on Climate change

Source: www.biocoal/resources

cited that reduction in evapotranspiration and moisture circulation is indicated to weaken the hydrological cycle, with models suggesting up to 80% reduction in annual rainfall in deforested areas. Lal, 1995 inferred from their research that deforestation decreases the maximum relative humidity (Figure 3), especially during mid-day. There is also a corresponding increase in air temperature (Figure 4) and evaporation rate. Perhaps the most drastic effect of deforestation is on soil temperature (Figure 5). Lal, 1995 stated that maximum soil temperature at 1 to 5 cm depth can be 5°C to 20°C higher on cleared land on a sunny day compared with land under Forest cover. Lal, 1995 also stated that because of high soil evaporation, the soil moisture content of the surface layer is also lower in cleared than in forested soil.

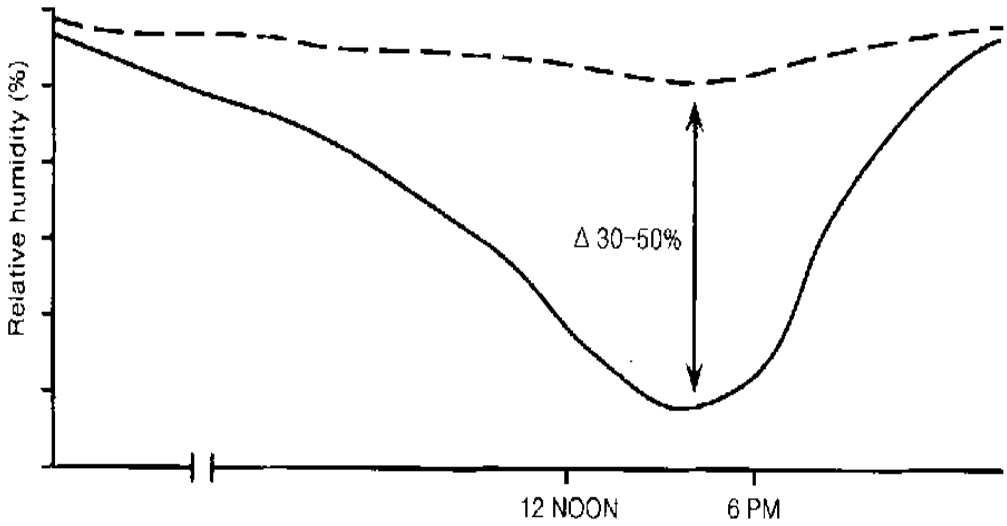

Figure 3 : Effects of deforestation on Relative humidity

Source: Lal, 1995

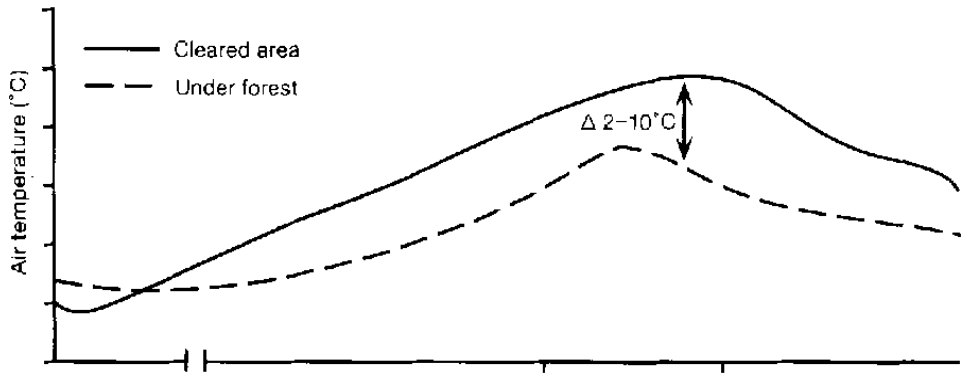

Figure 4 : Effects of deforestation on air temperature

Source: Lal, 1995

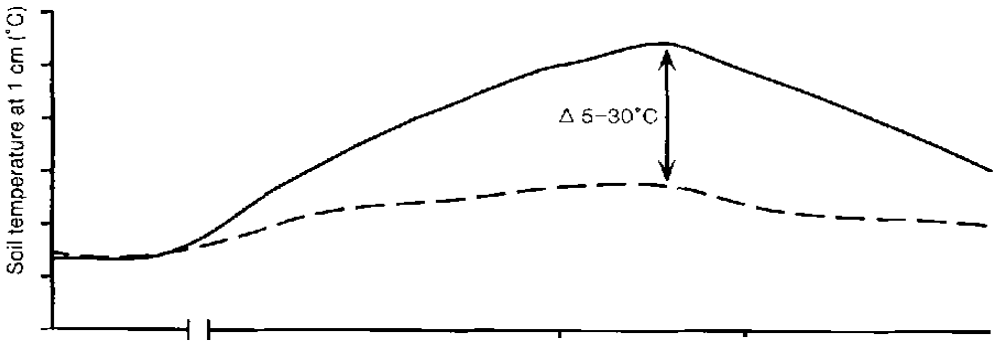

Figure 5 : Effects of deforestation on soil temperature

Source: Lal, 1995

VI. Materials and Method

Mean monthly and annual temperatures and rainfall from 30 synoptic stations between 1901-1938 and 1971-2012 in Nigeria were collected from the Nigerian Meteorological Agency, Lagos and Meteorological Department in some Airports. Although there are more than 30 meteorological stations in Nigeria, the study was limited to 30 stations because of consistency in available climatic data since the establishment of the stations.

Moreover the selected stations are true representative of the various climatic zones of Nigeria. The Two most important climatic elements (temperature and rainfall) were used in this study. These climatic elements were measured regularly in the stations used and these climatic elements best determine the prospects as well as the ecological and socio-economic problems of Nigeria. Data from different secondary sources were also used.

Eighty years period were covered in this research work. This is important because we were able to capture the period when climate change signals were not an issue (1901-1938) and when they are stronger (1971-2012). With 80 years, two climatic periods of 38 and 42 years can be studied and this will provide a better platform to investigate the changes within the climatic periods. The mean annual temperature data were used to construct the isothermal maps of Nigeria, while the rainfall data were used to construct the isohyets maps of Nigeria for the two climatic periods. With these maps, the analysis of the spatial pattern of rainfall and temperature with implication to climate change in Nigeria was carried out. The temporal climatic changes over the years were examined by employing the time series.

Also data from World Resources Institute via Climatic Analysis Indicator Tools (WRI-CAIT) were also employed to analysed recent and current Green House Gases with respect to Nigeria and the World at large.

VII. The Greenhouse gas Emissions Attributed to Deforestation in Nigeria

WRI/CAIT 2.0., 2014 reported the annual emission of greenhouse gases attributed to deforestation in Nigeria (Figure 6). It ranged from 168.64MTCO$_2$ (2006) to 171.93MTCO$_2$ (1999). The trend showed that the emission of greenhouse gases attributed to deforestation experienced a sharp drop in years 2001 and 2006. The sharp drop in greenhouse gas emissions in the years 2001 and 2006 must have been due to change in government policy. A new Nigerian Agricultural Policy with more focused direction and better articulation was launched in the year 2001

(NIPC, 2001). So also, a new National Forest Policy which was to encourage and support an aggressive establishment of plantations of economic trees of both exotic species, such as teak and indigenous species; and foster the redirection of development resources was approved on June 14th, 2006 (Federal Ministry of Environment, 2006). The trend also showed that ever since the later sharp drop in the year 2006, the greenhouse gas emissions attributed to deforestation has been on the increase. This means that if deforestation is not curtailed any time soon, Nigeria will join the League of Nations with highest greenhouse gas emissions. Mfon *et al*., 2014 stated that based on visible results, so far only half-hearted efforts have been made to control deforestation. It can therefore be concluded that continued increase in greenhouse gas emissions after the sharp drops were as a result of the forestry policies not being sustainably implemented.

VIII. The Percentage Contribution of the Greenhouse Gas Emissions Attributed to Deforestation to the Overall Greenhouse Gas Emissions in Nigeria

From the WRI/CAIT, 2.0, 2014 data, deforestation contributed to between 34.59% in 2006 and 43.15% in1999 to the overall greenhouse gas emissions. There was a clear downward trend in the greenhouse gas emission contribution of deforestation to the overall (Figure 7). This is a pointer that apart from the contribution of deforestation to greenhouse gas emissions in Nigeria there have been some competitive increases in other greenhouse gas emitting sectors of the economy over the years.

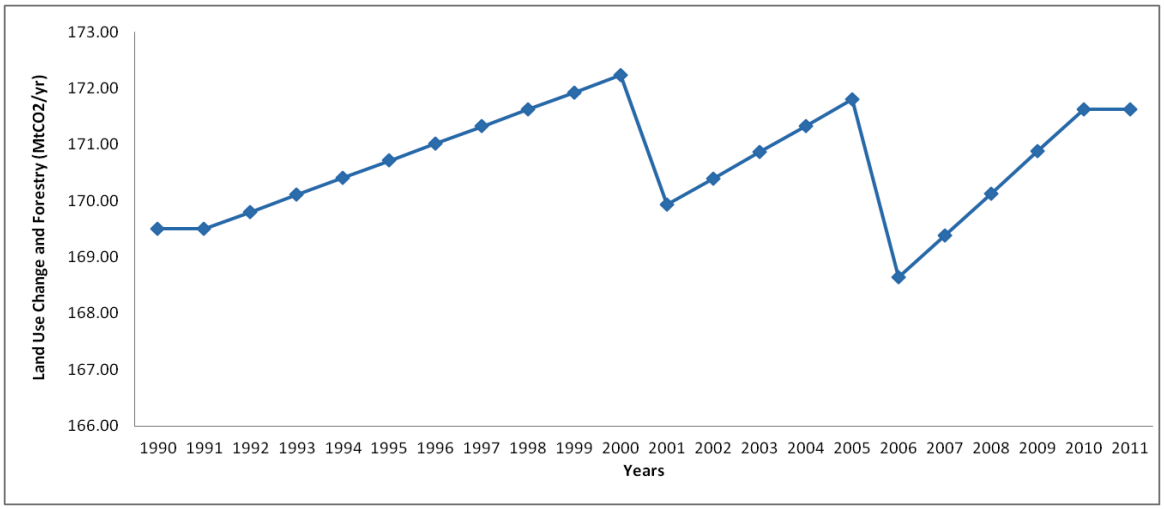

Figure 6 : The annual emission of greenhouse gases attributed to deforestation in Nigeria (1990 - 2011)

Source: Graph was built based on WRI/CAIT 2.0., 2014 and FAO, 2014 data

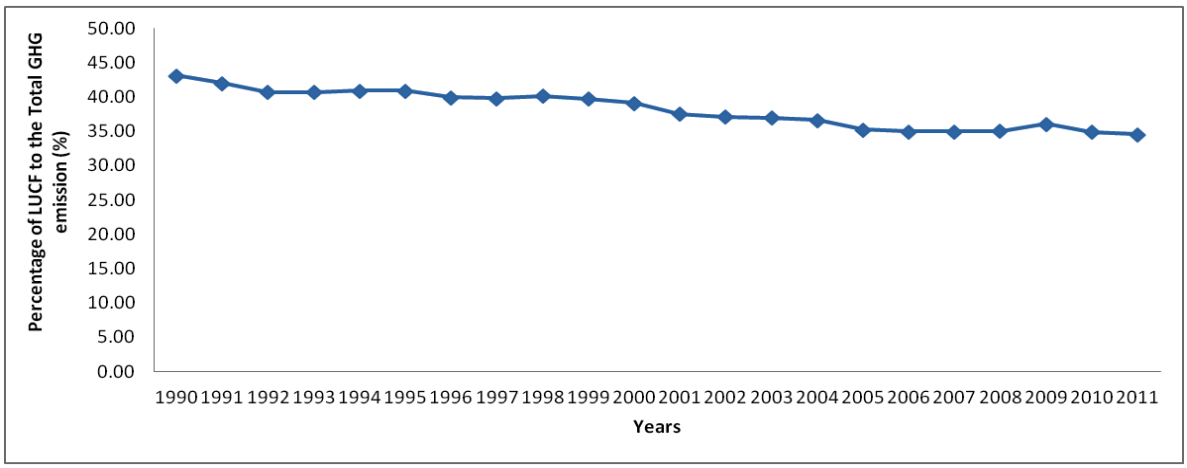

Figure 7 : The percentage contribution of GHG emissions attributed to Deforestation to the Overall GHG emissions in Nigeria (1990 - 2011)

Source: Graph was built based on WRI/CAIT 2.0., 2014 and FAO, 2014 data

IX. Implication to Nigeria's Policies Formulation with Regards to Protection and Conservation its Forests

The forestry act which was promulgated in 1958 provides for the preservation of forests and the setting up of forest reserves. It is an offence, punishable with up to six months imprisonment, to cut down trees over 2ft in girth or to set fire to the forest except under special circumstances. The Federal Ministry of Environment, (2006) reported that one of the factors that militate against sustainable forest management is the absence of a National Forestry Act. Apart from using the provision of the Act to regulate forestry practices in Nigeria and to give also a legal backing for the National Forest Policy, it would further enable us to meet the obligations on the treaties and conventions relevant to forestry development to which Nigeria is a signatory. The Federal Ministry of Environment, (2006) also reported that the first ever National Forestry Act has been evolved to back the policy and have since been presented to the Council for ratification and to be passed into law.

X. Implication of Global Treaty to Protection and Conservation of Forests

To tackle deforestation, World Land Trust (WLT) is backing an initiative entitled Reducing Emissions from Deforestation and Forest Degradation (REDD). REDD is a way of putting a financial value on the carbon stored in forests, offering incentives to protect them. REDD+ goes beyond avoided deforestation and forest degradation to include the role of conservation, sustainable management of forests, and enhancement of forest carbon stocks (World Land Trust, 2012).

XI. Conclusion

It has been established that forests serve as Carbon sinks. Therefore, improper deforestation practice will only add to the amount of CO_2 already in the atmosphere. If this goes on unchecked, the resultant effects will be global warming which will invariably bring about other climate change conditions such as increase in ambient temperature, wind and water erosion causing health hazard and siltation of water body; rise in sea level, coral reef destruction, loss of biodiversity, flooding (e.g. Haiti), , drought, famine, starvation and death. The negative implications of unregulated and improper deforestation are numerous as observed in many facet of the Nigeria sectors which by extension have global consequences. This calls for protection and conservation of forests vis-avis the following measures;

With the ever growing need for reduction in greenhouse gas emissions, unregulated and improper deforestation should be discouraged or with the fall one and plant ten seedling sustainable measures be put in place in Nigeria as is still be done in the United State of America.

There is a law that borders on conservation and protection of forests. This law should therefore be properly implemented and enforced to the law with proper policing and monitoring and stringent punishment.

Aforestation and Reforestation programmes with incentives should be organized to recuperate the dwindling forests.

Moderate Resolution Imaging Spectrometer (MODIS) should be launched onboard Nigeria's satellite so as to enable the monitoring of deforestation and necessitate quick action in case of unlawful deforestation.

More studies using advanced models should be carried out to investigate the actual impact deforestation has on global warming/temperature increase and climate change in Nigeria.

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Appendix 1

Year	LUCF ($MtCO_2$)	Total GHG Emissions Including Land-Use Change and Forestry ($MtCO_2e$)	Percentage Contribution of Deforestation to the Overall Greenhouse Gas emissions in Nigeria (%)
1990	169.50	392.83	43.15
1991	169.50	403.52	42.01
1992	169.81	416.76	40.74
1993	170.11	417.43	40.75
1994	170.41	416.20	40.94
1995	170.72	417.32	40.91
1996	171.02	428.08	39.95
1997	171.32	429.92	39.85
1998	171.62	427.51	40.15
1999	171.93	432.39	39.76
2000	172.23	440.01	39.14
2001	169.93	452.47	37.56
2002	170.40	459.29	37.10
2003	170.87	461.64	37.01
2004	171.33	467.70	36.63
2005	171.80	487.00	35.28
2006	168.64	481.64	35.01
2007	169.39	483.74	35.02
2008	170.13	485.03	35.08
2009	170.88	473.87	36.06
2010	171.63	491.67	34.91
2011	171.63	496.13	34.59

Source: Table was built based on WRI/CAIT 2.0., 2014 and FAO, 2014 data