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Research Paper

Forest Depletion And It's Implication On Rainfall And Temperature In Imo State

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Abstract: *This research focused on the use of remote sensing and GIS application to investigate the implication of forest depletion on rainfall and temperature in Imo State. The study used majorly secondary data which were vegetation maps, rainfall and temperature data of the study area between the year 1987 – 2016. The vegetation maps were extracted from the LandSat satelite imageries of the study area.The vegetation maps were further subjected to GIS analysis with the use of Normalized Difference Vegetation Index (NDVI) to calculate the extent of forest cover in the study area. Pearson's Product Moment Correlation Coefficient model was used to ascertain the type of relationship between forest depletion, rainfall and temperature. The result of the data analysis revealed that Imo State forest cover has depleted from the initial 5530.2km^2 to 1803.9km^2 in the first decade (1987 -1996), 1452.0km^2 in the second decade and further decreased to 1248.7km^2 in the last decade (2007-2016). Rainfall on the other hand, increased by 5.8cm(1%) between the first and second decade and further increased by 8.8cm (1.7%) between the second and the third decades. Also, temperature rose by 0.02^{0}C between the first and the second decades and consequently rose by 0.18^{0}C between the second and the third decade. Finally, rise in temperature can not be attributed to forest depletion. However, forest depletion accounts for the increase in rainfall. Therefore, the study recommended that forest management should be made paramount by the government to avert the impending dangers of forest depletion.*
KEYWORDS: Rainfall, Temperature, Forest Depletion, Vegetation Cover, Imo State.

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I. INTRODUCTION

Plants are the most visible and valuable aspect of the biotic landscape, and they play an important role in the Earth's terrestrial ecosystem. Plants represent Earth's physical systems in their growth, form, and distribution: its energy patterns; atmospheric composition; temperature and winds; air masses; water quantity, quality, and seasonal timing; soils; regional climates; geomorphic processes; and ecosystem dynamics (Christopherson, 2006). The unpleasant reality is that the world's forested regions are rapidly disappearing.

Forest depletion is defined by Van and Bulte (2000) as the conversion of forest to a permanent non-forested land use such as agriculture, grazing, or urban development. According to Sumit et al. (2012), forest covers 30% of the earth's surface area, or around 3.9 billion hectares. Bryant et al. (1993) previously calculated that the earth's original forest cover was roughly 6 billion hectares. This is a clear sign of rapid loss of vegetative cover as a result of natural and man-made factors. According to a 2010 report by the Food and Agriculture Organization of the United Nations (FAO), forests currently cover roughly 30% of the earth's land surface, but they are disappearing at an alarming rate. The survey also revealed that tropical forest depletion is greatest in South America, Central West Africa, South and Southeast Asia, with 13 million hectares of global forest lost each year. Meanwhile, Greenpeace (2013) revealed that forest depletion not only causes direct loss of forest habitat but also has indirect consequences as ecosystem services worsen or fail.

Prior to the colonisation of Nigeria, it was widely assumed that forests were managed and safeguarded by the indigenous people in all localities. For example, in Imo State, forest is regarded as extremely precious because most people rely on it for a living. Unfortunately, when colonialism became more prominent, the people's forests were heavily plundered in order to send them outside the country's borders. This was the start of large-scale forest depletion. Although locals have previously harvested firewood from the forests, this had no substantial negative influence on the state of the forest and the ecology in general. Today, we observe uncontrolled logging of forest trees for wood, clearance of main forest for agriculture, oil exploration, and other purposes. Similarly, Keay (1995) found that a combination of dense human settlements in rainforest zones and concurrently intensive land use systems of farming, timber exploitation, grazing, forest regeneration, and fire has resulted in vegetation alterations as plant groups fail to reach their climax. Nzeh (2012) backed this up by linking the depletion of natural forests to numerous land use abuses, resulting in major forms of land degradation such as soil erosion, loss of watershed, and desert encroachment, all of which are prevalent in various parts of Nigeria, including Imo State. According to another Food and Agriculture Organization report (2005), Nigeria has the highest rate of primary forest decline. According to the organisation, the country lost 55.7% of its primary forests between 2000 and 2005, which are defined as woods with no evident evidence of past or present human activity.

Greenpeace (2013) stated in a separate report that changes in land cover (for example, conversion of forest to agriculture land) affect the interchange of moisture and heat between the soil, vegetation, and atmosphere, affecting natural cycles and influencing atmospheric circulation. This impacts local and regional surface temperatures as well as rainfall patterns. Similarly, Vidal (2017) discovered that forest depletion in Africa, Asia, and Latin America has a global impact on rainfall and climatic conditions. As a result, the purpose of this study is to explore the impact of forest depletion on rainfall and temperature in Imo State's meteorological conditions.

II. LITERATURE REVIEW

According to Adeofun (1991), the total global forest area has decreased significantly during the last century, from around 5 to 4 billion hectares. Similarly, Ejenma et al. (2016) observed that the world's forest area accounts for around 30% of total land area, but that half of this area has been reduced owing to man's impact. According to an August 2000 report by the Inter-Ministerial Committee on Combating Deforestation and Desertification (ICCDD), over 60% of Nigerians living in rural areas use fuel wood, amounting to approximately 50 million metric tonnes consumed annually - a rate that exceeds the replenishment rate through various afforestation programmes. The committee also claimed that obtaining fuel wood for domestic and commercial purposes is a major cause of forest depletion, which leads to desertification in arid-zone states and erosion in the country's south. In line with the preceding report, the committee acknowledged that forest depletion in Nigeria is occurring at a pace of 350,000 hectares per year, equivalent to 3.6% of the current area of forests and woodlands, while replanting is only around 10% of the forest depletion rate.

Nzeh (2012) stated that forest depletion has a significant impact on water resources since it causes substantial water resource difficulties due to the vast degradation of watersheds. According to Adeofun (1991), the results of hydrologic experiments from tropical Asia demonstrate the importance of forest cover in the proper and effective management of soil and watershed resources. Nzeh (2012) also highlighted that removing vegetation affects rainfall interception, which can range from a few percent to up to 50% of total annual precipitation. He stated once more that deforestation increases the rate and amount of run-off, resulting in increased stream flow, which frequently causes flooding and has terrible repercussions for life and property. According to the same study, adjacent water bodies may be sedimented, resulting in a steady decrease in volume and depth of water bodies, causing them to become seasonal or perish eventually due to increased rate and volume of run-off caused by forest depletion. The study also stated that another effect of forest depletion is lowering of the water table, particularly when such depletion is permanent and irreversible, as in the case of Nigeria's semi-arid regions. According to Adeofun's (1991) findings, deforestation caused by indiscriminate land clearance and bush burning in Nigeria's savannah regions has been highlighted as a factor increasing the hydrological problems in these areas.

On a global scale, Werth and Avissar (2005) predicted that if forest cover is completely lost, Southeast Asia will experience a 1mm/day decrease in rainfall throughout the year, whereas Sen et al. (2010) reported that southern China and Vietnam will experience a 20-30% decrease in rainfall under the same conditions. Werth and Avissar (2005b) demonstrated regional patterns in one of their analyses, indicating that Mozambique will have reduced rainfall whereas Botswana, Zambia, and the southern Democratic Republic of the Congo would see greater rainfall regardless of gross forest loss. Moore et al. (2007) estimated (predicted) a 10-20% decrease in yearly rainfall across the whole Amazon basin following total Amazon deforestation. According to Medvigy et al. (2011), the northwest Amazon basin will grow dryer by up to 2mm/day, whereas the southeast will become wetter by up to 1.5mm/day.

According to Werth and Avissar (2005b), a total African forest depletion would result in a drop in rainfall of up to 1mm/day, especially during the dry season. Similarly, full forest depletion in the Congo Basin, as found by Nogherotto et al. (2013), will result in up to 50% less precipitation. As per their findings, overall forest decline in the Congo Basin will have an impact on the African monsoon system. According to the experts, forest degradation in the Congo Basin has both local and remote repercussions on other parts of the African continent. They observed less precipitation locally and increased precipitation over the Sahel and Southern Africa. Other researchers, such as Otieno and Anya (2012), have linked a drop in monthly rainfall to forest loss, indicating that it could cause to a shift in moisture covergence zone.

Nzeh (2012) recognised the reports of many works of literature regarding the likely increase of carbon dioxide percentage in the atmosphere by up to 10% and a subsequent increase in global temperature via the green house effect, which could be a possible effect of total forest depletion of all tropical rainforests. Meanwhile, Njoku et al. (2009) confirmed that the rise in temperature in Nigeria's southeastern region is a result of forest depletion. They identified temperature rise as the primary driver of forest cover, exerting 57.2% pressure on forest cover. They also discovered that temperature, daylight hours, and rainfall all have a greater than 89.7% influence on forest cover.In the same study, these researchers discovered that rising mean annual temperature causes accelerated stress and reductions in forest cover quality and health between 1970 and 2000. However, temperature showed a rising trend in their findings, with the regional average temperature for the 31 years studied being 25.40C, the decadal average air temperature of southeastern Nigeria for 1970 - 1979 being 27.30C, 1980 - 1989 being 26.700C, and 1990 - 1999 being 27.30C, with the mean minimum air temperature for 2001 - 2005 being 22.800C and the mean maximum for the period being 320C. All of these discoveries were linked to the quantity of forest cover throughout the years investigated. Hasler et al. (2009) documented suggestions from other models to include a reduced annual rainfall of up to 80% within deforested regions, although rainfall variations also affect regions beyond the deforested area. However, on the Arabian Peninsula, they expected a 15-30% increase in rainfall as a result of African forest depletion, or a 45% increase as a result of Amazon forest depletion.

Olchev et al. (2008) found that a 15% reduction in forest cover on Sulawesi, Indonesia, resulted in a 2% decrease in monthly evapotranspiration and a 21% increase in soil evaporation. Meanwhile, Njoku et al. (2009) confirmed that the rise in temperature in Nigeria's southeastern region was caused by forest depletion.

III. METHODS

Imo State gets its name from the Imo River, which flows from the Okigwe/Awka upland. The state is located between Latitude 4045'N and Longitude 6050'E and 7025'E. It lies between the lower Niger River and the upper and middle Imo Rivers. Imo State is bordered on the east by Abia State, on the west by the River Niger and Delta State, on the north by Anambra State, and on the south by Rivers State. The state has a land area of approximately 5,530 square kilometres. According to the 2006 population census, Imo state has a population of approximately 3,927,563 people.The population density ranges from 230 people per square kilometre in Oguta/Egbema to around 1400 people per square kilometre in Mbaise, Orlu, Mbano, and Mbaitolu. The state's population projection for 2011 is 4,609,000 people, ranking it 13th in Nigeria in terms of population. The state is divided into 27 local government districts and three senatorial districts.

The state's high temperature and humidity encourage luxuriant plant growth, which should result in tropical rainforest climax vegetation. The weather is humid here. Rainfall occurs in two waves, with peaks in July and September and a two-week break in August. The rainy season lasts from March to October or early November. Rainfall is typically greatest at night and in the early morning hours. The amount of rainfall varies from year to year. The annual rainfall ranges between 1900mm and 2,200mm. Imo state has an average annual relative humidity of 75%, which peaks during the rainy season at around 90%.

This study was intended to cover all forested areas in Imo State. This data was derived from satellite images of the study area from 1987 to 2016. The decadal study used vegetation maps from 1996, 2006, and 2016 to represent thirty years of forest cover in the state. To improve classification results, the Normalized Difference Vegetation Index (NDVI) was developed to classify and calculate vegetation cover of the study area using Landsat images over three decades.Between 1987 and 2016, the Normalized Difference Vegetation Index (NDVI) was used to determine the extent of vegetation change in the study area. To be more specific, 1996 represented the first decade (1987-1996), 2006 represented the second decade (1997-2006), and 2016 represented the third decade (2007 -2016). The zero value represents non-vegetated land, while the positive value represents vegetated land. For analysing the relationship between forest depletion and both temperature and rainfall in the study area, the Pearson's Product Moment Correlation Coefficient model was

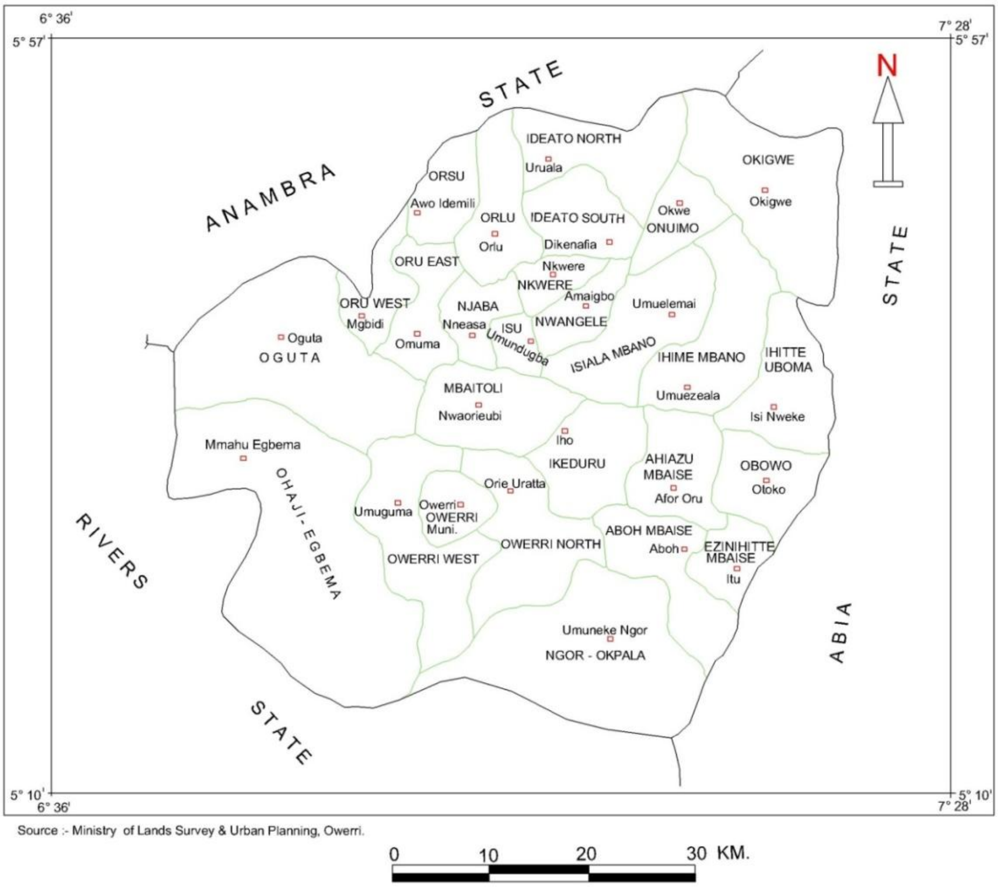
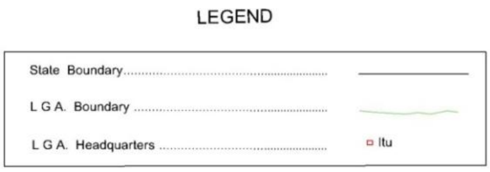


Fig. 2. IMO STATE SHOWING THE L.G.As



used.

IV. RESULTS AND FINDINGS

The pace of forest depletion is an important topic in this study. In Imo state, variations in the extent of forest cover and vigour have been noted, however the focus of this section is mostly on the extent of cover. The NDVI was used to calculate the extent of forest coverage. Tables 1–4 show the outcomes for each decade from 1987 to 2016.

Table 1: The Size/AreaCoverage of Forest in the StudyArea in the year 1996.

Land use	**Frequency (km^2)**	**Percentage (%)**
Forest	1803.9	32.6
Other land use	3726.3	67.4
Total	**5530.2**	**100.0**

Source: Author's GIS Analysis 2017

Table 1 depicts the extent of forest coverage in Imo State from 1987 to 1996, the first decade of the research. This data was collected from the state's vegetation map, as shown in Fig.1, which was taken from LandSat photos of the research region and then analysed using GIS techniques. The investigation revealed that from 1987 to 1996, forest covered 32.6% of the entire geographical area of Imo state. Other land use categories, on the other hand, accounted for the remaining (67.4%) of the area.

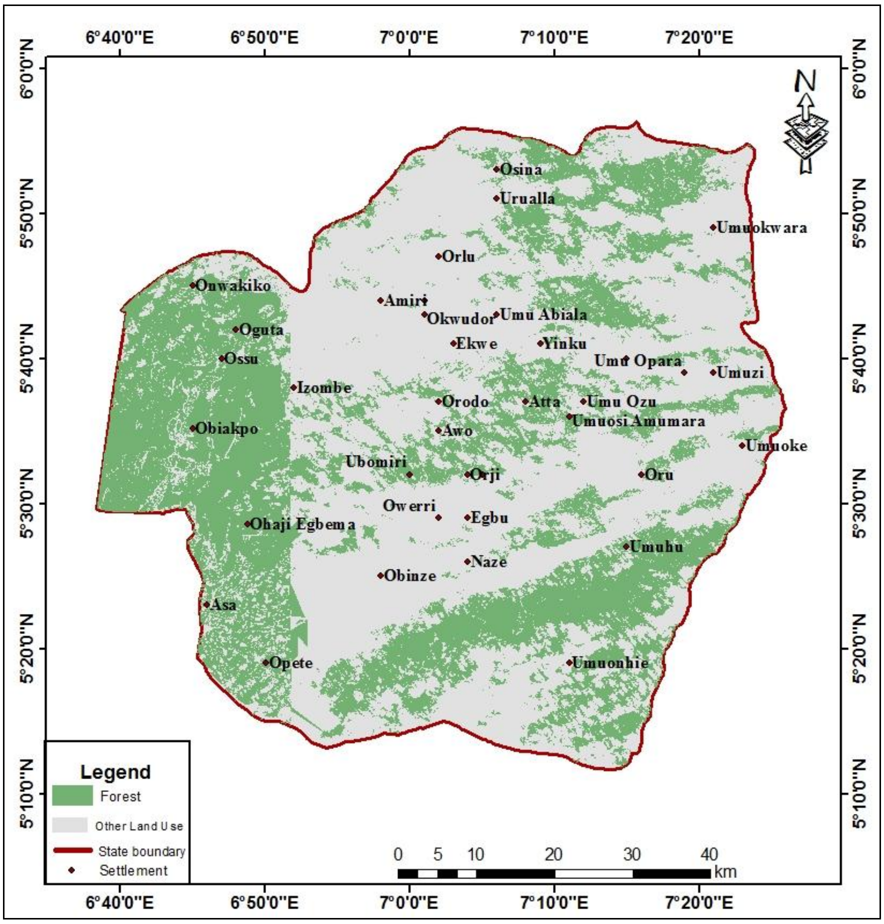


Fig.2: Imo State Forest, 1996
Source: Author's GIS Analysis 2017

Table 2: The Size/AreaCoverage of Forest in the StudyAreafrom 1997-2006.

Land use	**Frequency (km^2)**	**Percentage (%)**
Forest	1452.0	26.3
Other land use	3940.2	73.7
Total	**5530.2**	**100.0**

Source: Author's GIS Analysis 2017

Table 2 depicts the second decade of this research. It indicated the area extent of forest in the research region between 1997 and 2006, revealing that forest comprised 26.3% (1452.0km2) of the entire land area, while the remaining 73.7% (3940.2km2) was exposed to various uses. Figure 2 depicts this.

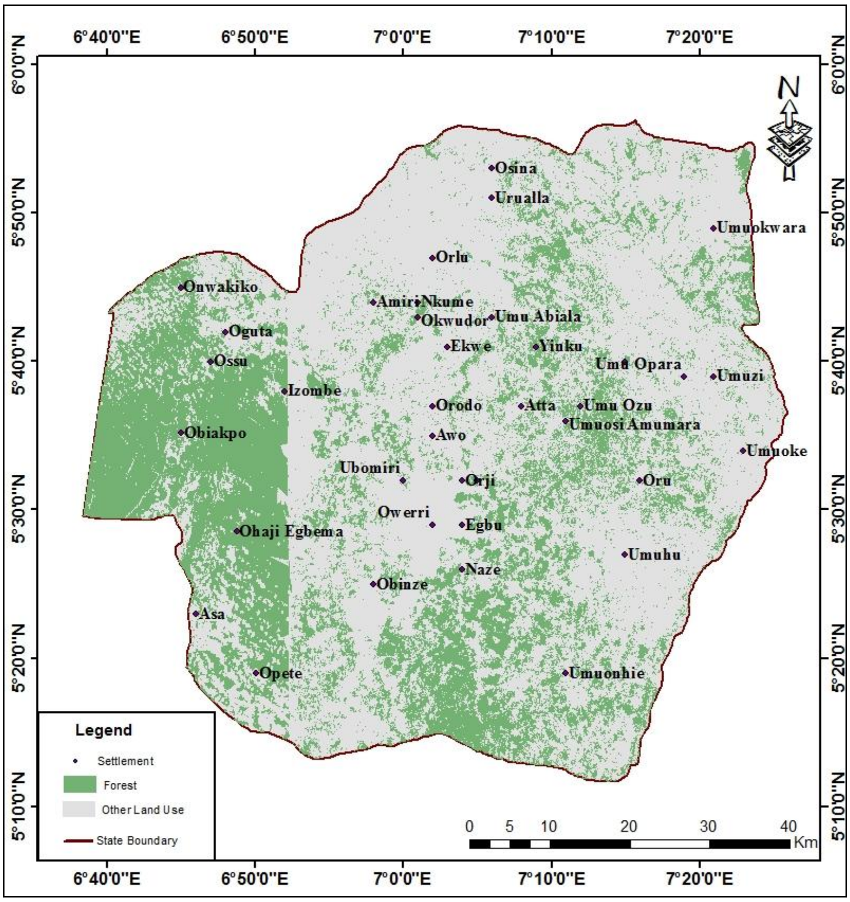


Fig.4.2: Imo State Forest, 2006

Source: Author's GIS Analysis 2017

Table 3: The Size/AreaCoverage of Forest in the StudyAreabetween 2007-2016.

Land use	**Frequency (km^2)**	**Percentage (%)**
Forest	1248.7	22.6
Other land uses	4281.5	77.4
Total	**5530.2**	**100.0**

Source: Author's GIS Analysis 2017

Table 3 clearly show the extent of forest depletion between 2007-2016 in Imo State. It indicates that forest occupied only 22.6% (1248.7km) of the total land area of the state while other land uses occupied the remaining 77.4% (4281.5km). See figure 3.

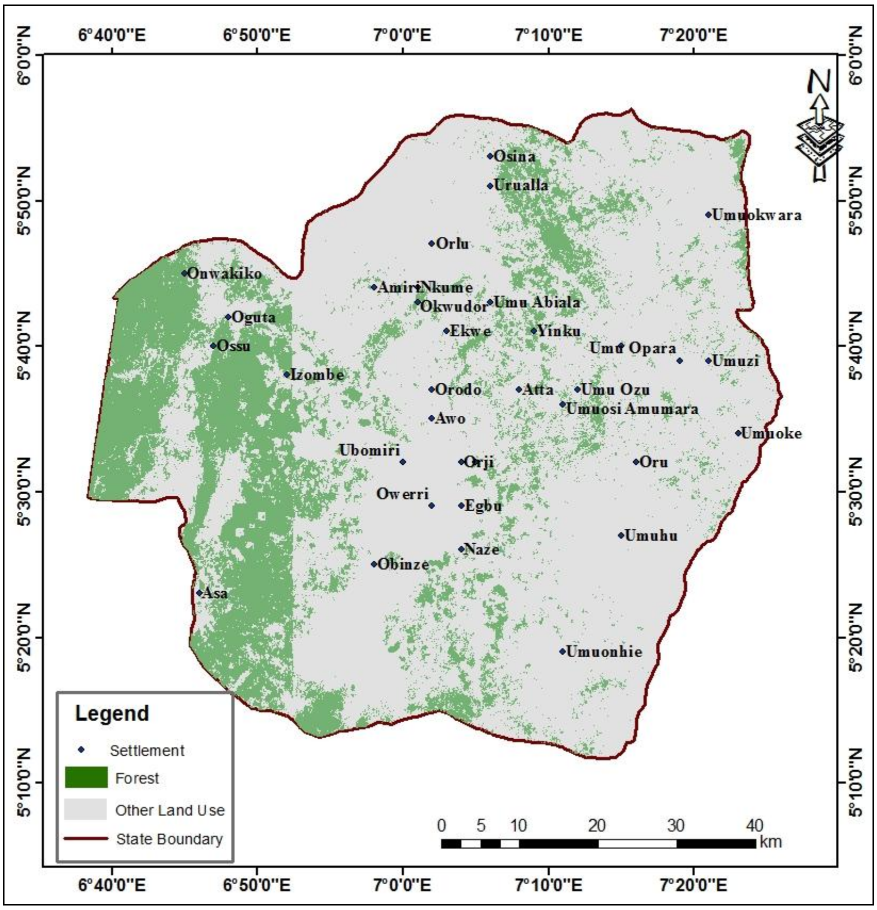


Figure 3: Imo state forest 2016

Source: Author's GIS analysis, 2017

The NDVI change detection analysis indicated substantial decrease in forest coverage between 1996and 2016. The study revealed that the forest coverage decreased up to 351.9 km^2 between 1996 and 2006 and also 203.3km^2 between 2006 and 2016.

Table 4: MeanDecadalRainfallbetween 1987-2016

This table was derived from mean annual rainfall data for the three decades.

Year	Rainfall (cm)	Percentage (%)
1987-1996	167.9	32.1
1997-2006	173.7	33.1
2007-2016	182.5	34.8
Total	524.1	100

Source: NiMet Imo State, 2017

Table 4 shows the average decadal rainfall in Imo state during the last thirty years (1987-2016). This is a summary of the average decadal rainfall quantities during the relevant decades. This table shows how rainfall quantities changed during the three decades covered by this study. It was also discovered that the past decade (2007-2016) had the largest rainfall amount, with 182.5cm as the decade's mean, accounting for 34.8% of the total rainfall amount for the thirty years. Imo state, on the other hand, had the lowest mean decadal rainfall between 1987 and 1996, with 167.9cm, accounting for 32.1% of the total amount for the three decades. Also, rainfall rose by 5.8cm (1%) between the first and second decades and by 8.8cm (1.7%) between the second and third decades. The amount of rain falling is rising. Likewise, the increase in rainfall seen in this study agrees with Snyder et al (2010), Werth and Avissar (2005). Figure 4 depicts the pattern of increasing rainfall over the last three decades.

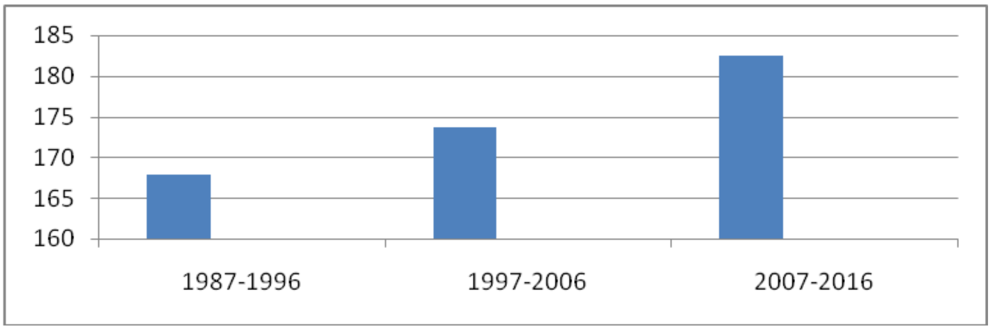


Fig.4.10: Mean Decadal Rainfall of Imo State between 1987-2016

4.2 Correlation of Forest Depletion with Rainfall

Using the Pearson Moment Correlation Coefficient model, the correlation of forest depletion with rainfall reveals the type of link and relationship that exists between forest depletion and rainfall in the research region. Because the computed value of 't' is bigger than the tabulated value, the study region has a substantial link between rainfall and forest loss.

Table 5: Mean Decadal Temperature of the Three Decades

This table was derived from the data on temperatures of the three decades. The data were further broken down to obtain the means of the various decades before presentation.

Year	Temperature (mm)	Percentage (%)
1987-1996	26.80	33.2
1997-2006	26.82	33.3
2007-2016	27.00	33.5
Total	80.62	100

Source: NiMet Imo State, 2017

This table have the records of the mean decadal temperatures of Imo state between 1987-2016. It as well captures the percentage contributions of each decade. Table 5 revealed rise in temperature. It shows that Imo state experienced the highest temperatures during the third decade which was the hottest with recorded mean of approximately 27^{0}C while the first decade was the coolest. The table further indicated increase in temperature by 0.02^{0}C (0.1%) between the first and second decades and further rose by 0.18^{0}C (0.2%) between the second and third decades. Therefore, temperature has risen by 0.2^{0}C during this three decades. This result conforms with the findings of Njoku et al (2009), Nogherotto et al (2013) and the suggestions of Snyder (2010). Fig.5 illustrates the temperature increase from the first (1987-1996) decade towards the last decade (2007-2016) of the study.

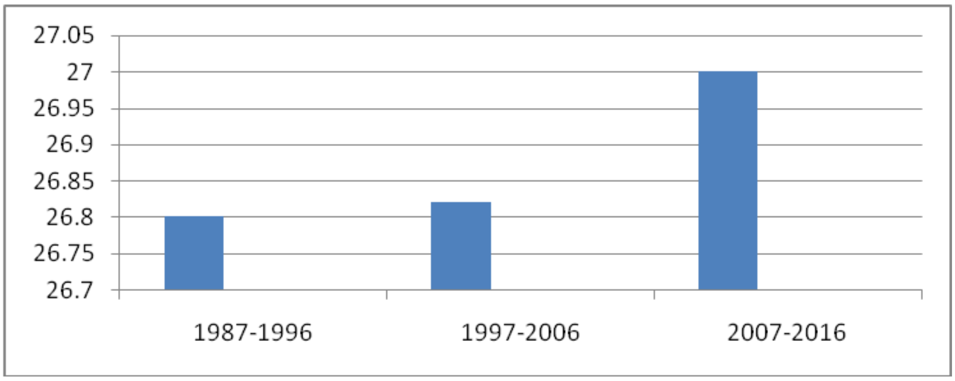


Fig.5: Mean Decadal Temperature of Imo State Between 1987-2016

4.3 Correlation of Forest Depletion with Temperature

The correlation model reveals the form of association and relationship that exist between forest depletion and temperature of the study area.Since the table value of 't'at 0.05 significant level is greater than the calculated value of 't' there is no significant relationship between forest depletion and temperature in the study area from 1987-2016.

On the other hand, Imo state experienced the lowest mean decadal rainfall between 1987-1996 with 167.9cm of rainfall which represents 32.1% of the total amount for the three decades. Also, rainfall increased by 5.8cm (1%) between the first and second decade and further increased by 8.8cm (1.7%) between the second and the third decades.There is an increasing trend in rainfall amounts. Again, the increase in rainfall as observed in this study conforms with the suggestions of Snyder et al (2010), Werth and Avissar (2005). Therefore, it is pertinent to state that Imo State temperature has risen by 0.20C from 1987-2016. This result conforms with the findingsof Njoku et al (2009) and Aigbe et al (2012).

V. CONCLUSION

The world's forests are rapidly disappearing at an alarming rate, contributing significantly to the global threat of climate change. Numerous studies in many parts of the world, including the Amazon, have found that forests play an important role in controlling climate factors like temperature and rainfall. Unfortunately, the world's forests are rapidly disappearing at an alarming rate, contributing significantly to the global threat of climate change. In the same spirit, a similar study was done in Imo State to demonstrate the impact of forest loss on rainfall and temperature. As a result, the study revealed an increase in rainfall amount in comparison to other deforested regions of the world. Likewise, the outcomes of this study demonstrated a rise in temperature, which is consistent with the majority of data in this area.

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