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THE POTENTIAL IMPACTS OF CLIMATE CHANGE ON TRANSPORTATION IN IMO STATE, NIGERIA

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ABSTRACT

Extreme weather events wreak havoc on transportation infrastructure and operations. The consequences of climate change on the transportation sector will vary by mode and region. The impacts on roadways and airports in Imo State, Nigeria, are examined in this study. Between 1999 and 2019, the Nigerian Meteorological Department collected monthly rainfall and monthly air temperature data (minimum and maximum) at the Owerri synoptic station and converted them to an annual average (tables 1 and 2). According to the data analyzed in this study, rainfall and temperature are critical climate variables. This study covers a 20-year climatic history, which allows for a more accurate assessment of climate fluctuation and change in the studied area. Each year's total rainfall was calculated, as well as the average rainfall for the year. The average temperature for each year, on the other hand, was calculated using the same time period as the total minimum and maximum temperatures (table 1 and 2). For the climatic period, the state's mean annual rainfall and temperature data were used to create rainfall and temperature charts (see figures. 3 and 4), which were then used to study the state's rainfall and temperature patterns and patterns of change. However,

this study determined that the fluctuations in temperature regimes and variations in rainfall across the state during the study period indicated some evidence of variability and change in the area's climate system, as demonstrated by the observed effects of observed shifts in climatic parameters on the environment and, in particular, transportation.

KEYWORDS: transportation infrastructure, temperature data, climate, imo state, transportation.

1.1 INTRODUCTION

Climate variation is now widely documented, and the ramifications are becoming evident as data and climate models get more complex. Climate variability and change affect all countries, but developing countries, particularly those in dry, semi-arid, and heavy rainfall regions, are particularly vulnerable. Due to its physical and socioeconomic qualities, Africa is considered the most sensitive continent on the planet to climatic changes and change. In Africa's Sahel region, warmer and drier weather have already resulted in a shorter growing season, which has a negative effect on agriculture.

In Nigeria, it is widely accepted that the climate has varied over time and space and will continue to do so in the future (Ojo, 1987). Numerous differences in rainfall, in particular, have occurred across Nigeria's various climatic regions and individual locales. In the south east, for example, Imo State, droughts have been considerably less persistent, while rainfall has increased and temperature has increased and decreased significantly over the years, in comparison to other northern states.

Extreme weather events have a detrimental effect on the transportation infrastructure and management. Even though infrastructures are constructed to withstand a variety of stressors across their useful lives, the increased frequency and intensity of extreme weather events accelerates their deterioration. Additionally, transportation services must be regulated to avoid disruptions and accidents that may become more frequent as a result of adverse weather. Climate change's effects on the transportation sector will differ by mode and region. Climate change model outputs indicate that repercussions will be extensive and costly. The consequences will necessitate considerable modifications in transportation system planning, design, construction, operation, and maintenance. Transport infrastructure and operations are more vulnerable to catastrophic occurrences – such as storm surges, flooding, and wind gusts than to small variations in temperature or

precipitation. Additionally, transportation operations are more vulnerable to climate change than infrastructure. Airports suffer a variety of climate-related dangers, including sea level rise and storm surge, while high winds pose a significant hazard, particularly during landing and takeoff. Sea level rise, storm surges, flooding, and strong winds all have the potential to interrupt seaport operations. This study examines the effects of climate change on highways and airports in Imo State, Nigeria.

1.2 AIMS OF THE STUDY

The study's ultimate goal was to investigate the effects of climate change on transportation in Nigeria's Imo state. The study's objectives were to:

1. Identify the impacts of rainfall and temperature on road networks in Imo State.
2. Identify the impacts of rainfall and temperature on airport in Imo State.

1.3 SIGNIFICANCE OF THE STUDY

The outcomes of this study will highlight the consequences of climate change on the transportation systems, attracting policymakers', and other stakeholders' attention to the threats that climate change poses to their environment and transport networks.

The findings of this study will be valuable to government and non-governmental organizations interested in improving the transportation conditions of the people in Imo area of Nigeria.

The study's findings will also open up new avenues for scholars who are interested in climate change impact on transportation.

3.1 STUDY AREA

With a land area of around 5,100 square kilometers, Imo State is located between latitudes 4°45'N and 7°15'N. It is located in the humid tropics and is characterized by a year-round high surface air temperature regime. The average minimum temperature is 23.5°C, while the average maximum temperature is 32.1°C. The year is divided into two seasons: rainy and dry. April is the start of the rainy season, which lasts until October.

The state contains 27 Local Government Councils and three major political zones: Okigwe, Orlu, and Owerri. Its administrative capital is Owerri, which is the most populous, commercialized, and industrialized city in the state. The state's population is estimated to be

around 4.8 million people (Imo State - Wikipedia 2021). Natural resources in the state include crude oil, natural gas, lead, zinc, and some economic flora.

Figure 1: Map of Nigeria showing Imo State.

Figure 2: Map of Imo State (Study Area).

3.2 METHODOLOGY

Between 1999 and 2019, the Nigerian Meteorological Department, gathered monthly rainfall and monthly air temperature (minimum and maximum) data from the Owerri synoptic station and converted it to an annual average (tables 1 and 2). The data used in this study shows that rainfall and temperature are important climate variables. One

climatic era of 20 years is covered in this study, which provides a better opportunity to evaluate climate fluctuation and change in the study area.

Each year's total rainfall was computed, along with the year's average rainfall. However, the average temperature for each year was determined over the same time period as the total minimum and maximum temperatures (table 1 and 2).

For the climatic period, the state's mean annual rainfall and temperature data were used to build rainfall and temperature charts (see figs. 3 & 4), and these charts were used to analyze the pattern and patterns of change in the state's rainfall and temperature.

Table 1: Rainfall Data for Imo State, 1999-2019 (Owerri SynopticStation).

Year	Total RF	Mean RF
1999	2515.4	209.6
2000	2337.2	195
2001	2304.3	192
2002	2053.7	171
2003	2327.8	194
2004	1762.3	147
2005	2236.6	186.4
2006	3209.1	267
2007	2361.6	197
2008	2470.2	205.9
2009	2092.8	174.4
2010	2106	175.5
2011	2812.3	234.4
2012	2030.4	169.2
2013	2445	203.7
2014	2014.4	167.8
2015	2247.2	187.3
2016	2163.9	180.3
2017	2128.8	177.4
2018	2007.6	167.3
2019	2895.6	241.3

Source of Data: NIMET, Nigeria

Table 2: Temperature Data for Imo State1999-2019.

Minimum ^{o}C			Maximum ^{o}C		
Year	**Total**	**Mean**	**Total**	**Mean**	**Average**
1999	283.8	23.65	382.1	31.84	28.0
2000	283.6	23.63	386.1	32.18	28.0
2001	285.7	23.81	388.1	32.34	28.1
2002	284.7	23.73	387.5	32.29	28.0
2003	289.6	24.13	388.4	32.37	28.3
2004	286.7	28.89	388.6	32.38	30.7
2005	289.6	24.1	393.6	32.8	28.5
2006	291.8	24.3	394.2	32.9	28.6
2007	265.8	22.15	380.6	31.72	27.0
2008	284.5	23.71	392.1	32.68	28.2
2009	271.8	22.65	378.4	31.53	27.1
2010	275.3	22.94	385.5	32. 13	27.5
2011	267.2	22.27	381.1	31.76	27.0
2012	266.2	22.18	378.5	31.54	26.8
2013	267	22.25	374.3	31.19	26.7
2014	270.2	22.52	379.9	31.66	27.1
2015	268.4	22.37	383.1	31.92	27.1
2016	275.6	22.97	391.3	32.61	27.8
2017	277.9	23.16	384	32	27.6
2018	250.9	20.91	375.2	31.27	26.1
2019	257.6	21.47	385.6	32.14	26.8

Source of Data: NIMET, Nigeria

4.1 RESULTS AND DISCUSSION

This research discovered that the weather and climate systems in Imo State and Southeastern Nigeria are unpredictable and evolving, as witnessed on a global scale. Figure 3 (ref. table 1) shows that the average mean rainfall in 1999 was 209.6mm; from 2000 to 2005, there was a dramatic decrease in rainfall, with 2004 being the most severe of this period with 147mm of rainfall. The year 2006 saw the most rainfall throughout this climatic era, with a total average rainfall of 267mm; nevertheless, the amount of rainfall decreased until 2011, when it increased dramatically. The years following 2011 likewise experienced a decrease in rainfall amount until 2019, when there was a significant increase.

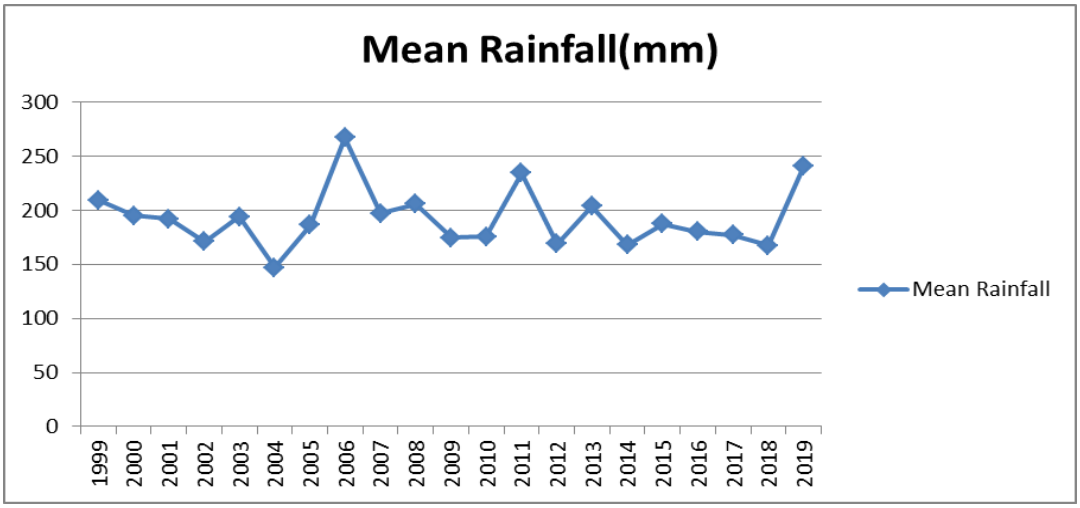

Fig. 3: 20 years (1999-2019) Rainfall Curve in Imo State.

On the subject of temperature, it was discovered that there were both spatial and temporal differences in temperature. Results from figure 4 (refer to table 2) show that the temperature remained nearly constant from 1999 to 2003, with a significant increase in 2004 when the temperature jumped to 30.7 degrees Celsius from 28.3 degrees Celsius. The temperature has been steadily declining since 2004, with 2018 and 2019 witnessing temperatures of 26.1 and 26.8 degrees Celsius, respectively, in the years following 2004. It was noted in 2018 that the lowest average temperature of this climatic era was recorded, and thatthe highest average temperature was recorded in 2004.

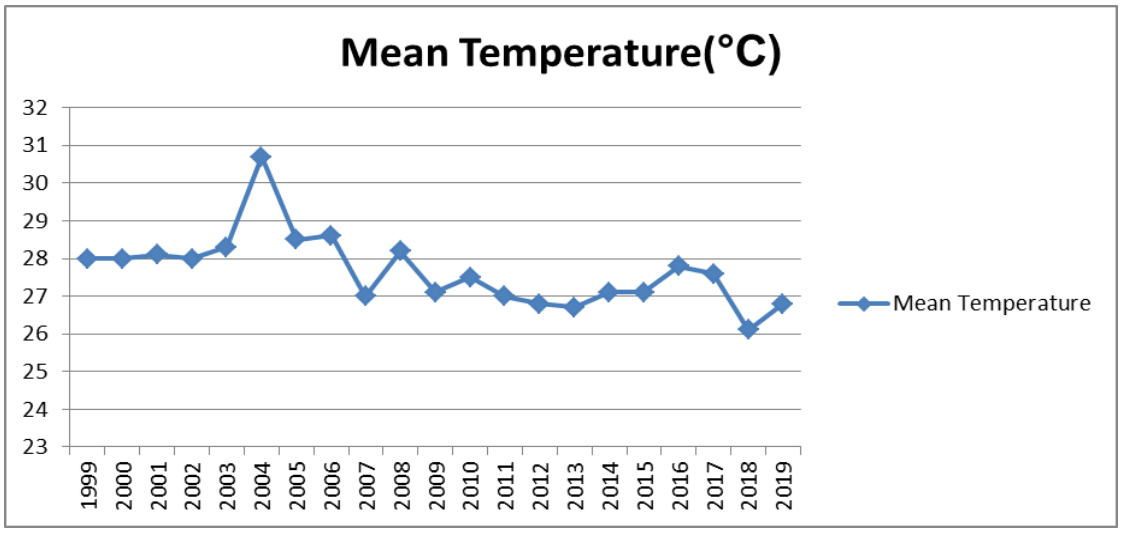

Figure 4: 20 years (1999-2019) Average Temperature trends in Imo State.

However, this study determined that, based on the findings, the fluctuations in temperature regimes and variations in rainfall across the state during the study period indicated some

evidences of variability and change in the area's climate system, as evidenced by the effects of the observed shifts in climatic parameters on the environment and, in particular, transportation.

Global warming and climate change phenomenon

Global warming is caused by the accumulation of Greenhouse gases (GHGs) such as Water vapor (H_2O), Carbon dioxide (CO_2), Methane (CH_4), Ozone (O_3), Nitrous oxide (NO_2) and the fluorinated gases –Chlorofluorocarbons (CFC) - Hydro fluorocarbon (HFC), Per-fluorocarbon (PFC) and Sulphur hexafluoride (SF_6) in the atmosphere. Ultra-violent solar radiation from the sun passing through the atmosphere is absorbed by the Earth's surface causing it to warm. Part of the absorbed energy is then re-radiated back to the atmosphere as thermal radiation (infrared radiation). The greenhouse gases in the atmosphere trap some of these radiations which are meant to go into outer space and re-emits (reflects) them back to the Earth's surface heating it and increasing its temperature. This is what is commonly known as "greenhouse effect". The increasing concentration of GHGs in the atmosphere through man-made emissions is the principal cause of global warming and climate change.

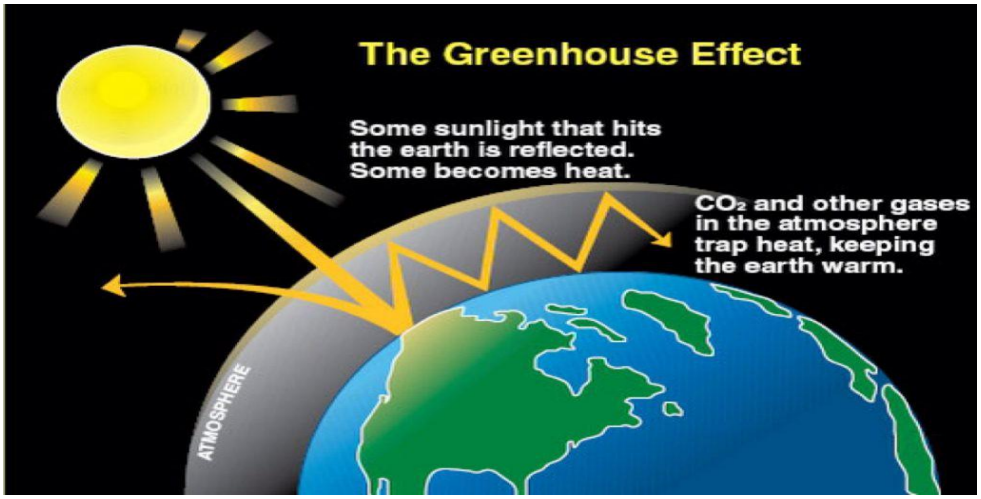

Figure 5: greenhouse effects on the earth.

Some evidence of climate change activities in Nigeria

Temperatures have risen across the country since the last century, with 1.20 degrees Celsius in the Niger Delta's coastal cities and 20 degrees Celsius in Nigeria's far north. Heat waves have been reported around the country as a result of a 1.70 C increase in mean air temperature. While rainfall in the semi-arid north has decreased, it has increased in the coastal states (Odjugo and Ikhuoria 2003; Adefolalu, 2007). Increased rainfall in coastal

towns may have contributed to the growing floods that have ravaged the cities of Warri, Lagos, Port Harcourt, and Calabar, as reported by (Ogundebi, 2004; Ikhile 2007; Nwafor, 2007; Umoh, 2007; Odjugo, 2010). Sea level rise (SLR) of 0.2m and salt water intrusion into coastal plains have been observed in the coastal region (NEST, 2003, Nyelong 2004; Nwafor 2006), producing severe socio-economic concerns in these places. Run-off from excessive precipitation and rising sea levels (SLRs) have accelerated the pace of sedimentation/siltation of our rivers, causing them to become shallow, necessitating extensive capital and maintenance dredging to keep them navigable all year.

Imo state's vulnerability to the impacts of climate change

Imo State significantly contributes to global warming through GHG emissions from industrial and domestic sources, gas flaring, oil/gas exploration and exploitation activities, and other activities, making it extremely vulnerable to climate change and related threats. Increased temperatures (heat waves) destroy her roads, highways, autos, and bridges; severe rainfall that floods the roadways and causes landslides is some of the effects of adverse weather on Imo State transportation facilities. Imo State has experienced series of floods at different points but was hit by an unprecedented flood in 2006, which flooded homes, halted economic activity, and forced some residents of the Orlu, Ikeduru, and Oguta neighborhoods to flee their homes.

Figure 6: Flood in Umuaka area of Imo State.

Climate change impacts on road infrastructure in Imo State

Road transportation is the movement of passengers and/or goods on roads from one place to another. Heat waves cause road surfaces to weaken and expand, resulting in rutting and

cracks, especially in high-traffic regions. Many types of vehicles are subject to overheating when the temperature rises. The thermal expansion/destruction of bridge and flyover joints in Imo State is also a result of high temperatures.

Rainfall increases traffic congestion and accidents in Imo State. Dissolved salt in flood water undermines asphalt pavements, which could result in potholes. Increased rainfall destroys road concrete, concrete culverts, and road embankments, resulting in higher maintenance expenses. Salinization of our flooded roads - impact of salt on automobiles, such as corrosion of vehicle body panels, undercarriages, fuel pipes, brakepipes and linings, shock absorbers, exhaust systems, bumper support systems, and so on.

Figure 7: Pot holed road.

Climate change impacts on air transport

Temperature rises, which leads to damage of airport roads, runways, and tarmacs, among other things. Increased temperature also affects aircraft 'lift' owing to less dense air, reducing the lift created by the wing and the push produced by the engines necessitating more energy, which translates to higher fuel consumption/cost.

Increased rainfall puts ground-level aviation infrastructure, such as runways, tarmacs, hangers, and buildings, at risk of flooding.

5.1 CONCLUSION

Transportation systems help any country's socioeconomic growth and development. The public transportation networks in Nigeria, whether federal or state run, are severely underdeveloped and poorly maintained. If nothing is done, the obvious (ongoing) and

forecasted catastrophic repercussions of climate change on themand other essential infrastructure could plunge the country into significant economic, social, and environmental disaster in the future. Unfortunately, the administration is currently making no significant attempt to address the devastating threats of climate change, which could signal doom for the country.

However, this study concludes that, based on the findings, changes in temperature and rainfall patterns across Imo State over the study period suggested some evidence of climate change in the area's climate system, which was reflected in environmental and transportation impacts.

5.2 RECOMMEDATION

More emphasis should be placed on empirical research into potential climate impacts on transportation and their probability, as well as adaptive transportation planning choices and how these adaption options might be mainstreamed into national transportation policies and practices.

I advocate for a greater commitment to incorporating concerns of potential climate impacts and adaptation choices into transportation planning, design, construction, maintenance, and operations.

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