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# Evidence of Climate Variability in Imo State of Southeastern Nigeria

Fidelis Chinazor Okorie[1], Ifeyinwa Okeke[2], Austine Nnaji[3], Christian Chibo[1] and Edith Pat-Mbano[4]

*1. Department of Geography and Environmental Management, Imo State University, Owerri, Nigeria*

*2. Department of Geography, University of Lagos, Lagos, Nigeria*

*3. Department of Environmental Technology, Federal University of Technology, Owerri, Nigeria*

*4. Department of Urban and Regional Planning, Imo State University, Owerri, Nigeria*

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**Abstract:** Climate variation generally occurs at local scale, regional scale, national scale and global scale. Having established that the global climate has varied slowly over the past millennia, centuries, and decades and it is expected to continue to vary in future. Like the climate change, variability may be due to, national internal processes within the climate (internal variability), or variations in natural or anthropogenic external forces (external variability). Evidence of climate variations is now well documented, and the implications are becoming increasingly clear as data accumulates and data and climate models become increasingly sophisticated. The fluctuations in rainfall and temperature regimes are the atmospheric driving forces that are responsible for the climate variations over the southeastern Nigeria including Imo State as the case in other parts of the world. It is on this premise that this study examined the evidence of climate variability in Imo State of the southeastern Nigeria. The study employed the holistic use of real meteorological data from Nigerian Meteorological Department on two weather parameters (temperature and rainfall), for 30 years (1980-2009). Results indicated fluctuations in temperature and rainfall regimes within the period under study, which were the reasons for the variations in climate of the region. Apparently, evidence of climate variability are indicated by increasing surface air temperature, increasing heat waves which enhances disease vectors, communicable diseases and epidemics, sea level rise and associated coastal erosion, flooding, increased evaporation that dry up streams and rivers etc..

**Key word:** Climate variation, meteorological data, Imo State, Nigeria.

## 1. Introduction

Climate Variability occurs generally at global, regional and local scales. No doubt, global climate has varied slowly over the past millennia, centuries and decades and will continue to vary in future. The variability in climate refers to changes in patterns, in the weather and climate, such as rainfall patterns and temperature. This variation is driven by the uneven distribution of solar heating, the individual responses of the atmosphere, oceans and land surface, the interactions between these and the physical and characteristics of the regions.

Evidence of climate variations is now well documented and the implications are becoming clear due to the facts that data and climate models in that regards are becoming increasingly sophisticated. All countries of the world are vulnerable to climatic variations and change, and developing countries especially, those in arid, semi-arid and high rainfall regions. Africa is considered the most vulnerable region in the world in terms of climate variations and change, due to its physical and socio-economic characteristics. In Sahel region of Africa, warmer and drier conditions have already led to a reduced length of growing season with detrimental effects on crops.

The earth's history has shown that climate variation

**Corresponding author:** Fidelis Chinazor Okorie, Ph.D., main research fields: climate variability and change, environment management. E-mail: chinazorfiddy@hotmail.com.

and change are components of inevitable planetary dynamics [1, 2]. The earth has experienced cycles of temperature and precipitation changes on a geological scale. As WMO (1979) [3-5] have observed, it is certain that climate must vary over time. The overlying mechanism for the various changes in weather and climate system is related to restless atmospheric processes, which are always in a delicate state of equilibrium. These processes determine the relationship between the atmospheric environment and components of the ecosystems.

Although some historical changes in climate have resulted from natural causes and variations, the strengths of the trends and the patterns of change that have emerged in recent decades indicate that human influences, resulting primarily from increased emission of $CO_2$ and other green house gases, have now become the dominant factor [6]. The rate and amount of these changes, their consequences on temporal and spatial patterns, are at present source of major concern to atmospheric scientists and allied researchers.

In Nigeria, it is well known that climate has varied in time and space, and that it will continue to vary in future [4]. Many variations in rainfall particularly have occurred for the different climatic regions and individual locations in Nigeria. In the south east, Imo State for example, droughts have been relatively less persistent, while rainfall is observed to be increasing and temperature increases and reduces moderately over the years compared with other states in the northern part of the country.

Also, studies show that the past and current climatic disasters and their disastrous consequences were not limited to or peculiar to Nigeria or Africa. As the Sahelian drought of the 1992/1993 causes the death of many animals and about 60% drop in crop yield over northern Nigeria [7, 8], the same year 1972 saw droughts in the Soviet Union and the occurrence of EL Nino off Peru. In 1974, monsoons reduced food production in India, while in 1975 cold waves in Brazil badly damaged coffee crops. In 1976, droughts in Europe caused widespread economic dislocations, while in the United States of America; Cold winters forced many industries and schools to close in the same year [4].

In August, 1988, 142 people died, 1,800 houses were destroyed and 14,000 farms were swept away when Baguda Dam in north eastern Nigeria collapsed following a flashed flood [9]. March-May of 2011, particularly April, brought extreme weather and climate events to many parts of the United States. Tornadoes, flooding, droughts and wildfires ravaged many parts of the country during the period and each of these extremes broke long standing records and have been compared to the "worst" such cases in history [10]. Also about 40 people died and in total, over one million people were impacted due to flood waters and mudslides in eight provinces of southern Thailand following unusual heavy spring rainfall between March 26th and 31st, 2011 [10].

Friday 26th August 2011, torrential rainfall triggered severe flooding in Ibadan, the state capital of Oyo province in southwestern Nigeria. The flood caused 30 deaths and displaced nearly 2000 people [11].

Precipitation has generally occurred and is predicted to continue to occur in bots of more intense, sudden events punctuated by seasonal droughts (IPCC, 2007). Likewise severe weather events and natural disasters are occurring more frequently and intensely than expected compare to historical records [12]. As global temperature continues to increase, these extreme events are predicted to occur more often and with greater severity [13].

It was assumed in this study that the fluctuations in rainfall and temperature regimes are basically, the atmospheric forces that are responsible for the climate variability and change over Imo State of Nigeria as the case in other parts of the world. It is on this premise therefore, that this paper focused on determination of shifts in rainfall and temperature over 30 years and their resultant effects as the evidence of climate variability in Imo State of Southeastern Nigeria.

## 2. Methods and Data

Mean monthly rainfall and monthly air temperatures (minimum and maximum) data from Owerri synoptic station between 1980 and 2009 converted to annual mean was collected from the Nigerian Meteorological Department, Lagos (Tables 1 and 2). Rainfall and temperature data used in this study indicates that the two parameters are key climatic variables. Also temperature was used because Afiesimama et al. [14] show that this climatic element actually determines the prospects as well as the ecological and socioeconomic problems of Nigeria. The research covers one climatic period of 30 years, which provides a better platform to investigate the variability and changes in the climate systems in the study area.

From the monthly rainfall data collected, total rainfall for each year, mean rainfall and percentage mean rainfall were calculated for the thirty years. On the other hand, total minimum temperature and total maximum temperature as well as the average temperature for each year were calculated for the same period (Tables 1 and 2). Finally, the data was further grouped into decades, such as D1 (1980-1989), D2 (1990-1999) and D3 (2000-2009), where the maximum mean rainfall and maximum mean temperature in each decade and decadal mean rainfall and average temperature were tabulated (Table 3).

**Table 1 Rainfall data for Imo State, 1980-2009 (Owerri Synoptic Station).**

| Year | Total RF | Mean RF | Mean RF (mm) |
|---|---|---|---|
| 1980 | 2398.2 | 199.9 | 3.4 |
| 1981 | 2432.7 | 202.7 | 3.4 |
| 1982 | 2404.3 | 200.4 | 3.4 |
| 1983 | 1557.9 | 129.8 | 2.2 |
| 1984 | 2153.2 | 179 | 3.0 |
| 1985 | 2396.1 | 199.7 | 3.4 |
| 1986 | 2482.9 | 206.9 | 3.5 |
| 1987 | 2075.5 | 173 | 2.9 |
| 1988 | 2563.7 | 213.6 | 3.6 |
| 1989 | 2581.5 | 215 | 3.6 |
| 1990 | 2961.3 | 246.8 | 4.2 |
| 1991 | 2567.4 | 210.6 | 3.5 |
| 1992 | 2424.1 | 202 | 3.4 |
| 1993 | 2182.8 | 181.9 | 3.1 |
| 1994 | 2626 | 219 | 3.7 |
| 1995 | 2622.3 | 219 | 3.7 |
| 1996 | 2705.5 | 225 | 3.8 |
| 1997 | 2891.4 | 241 | 4.1 |
| 1998 | 1640.1 | 136.7 | 2.3 |
| 1999 | 2515.4 | 209.6 | 3.5 |
| 2000 | 2337.2 | 195 | 3.3 |
| 2001 | 2304.3 | 192 | 3.2 |
| 2002 | 2053.7 | 171 | 2.9 |
| 2003 | 2327.8 | 194 | 3.3 |
| 2004 | 1762.3 | 147 | 2.5 |
| 2005 | 2236.6 | 186.4 | 3.1 |
| 2006 | 3209.1 | 267 | 4.5 |
| 2007 | 2361.6 | 197 | 3.3 |
| 2008 | 2470.2 | 205.9 | 3.5 |
| 2009 | 2092.8 | 174.4 | 2.9 |
| | | 6110.5 | |

Source of Data: NIMET 2011, Lagos, Nigeria.

**Table 2 Temperature data for Imo State 1980-2009.**

| | Minimum 0 °C | | Maximum 0 °C | | |
|---|---|---|---|---|---|
| Year | Total | Mean | Total | Mean | Average |
| 1980 | 279.7 | 23.31 | 378.8 | 31.57 | 27.4 |
| 1981 | 278.9 | 23.17 | 378.7 | 31.56 | 27.4 |
| 1982 | 277 | 23.08 | 378.3 | 31.53 | 27.3 |
| 1983 | 284.1 | 23.68 | 387.1 | 32.26 | 28.0 |
| 1984 | 276 | 23 | 385.8 | 32.15 | 27.6 |
| 1985 | 277.7 | 23.14 | 377.4 | 31.45 | 27.3 |
| 1986 | 276.9 | 23.08 | 378.5 | 31.54 | 27.3 |
| 1987 | 280.2 | 23.35 | 390.9 | 32.58 | 28.0 |
| 1988 | 282.5 | 23.54 | 381.8 | 31.82 | 27.7 |
| 1989 | 274.7 | 22.89 | 382.4 | 31.87 | 27.4 |
| 1990 | 284.6 | 23.72 | 381.7 | 31.81 | 27.8 |
| 1991 | 281.4 | 23.45 | 378.7 | 31.56 | 27.5 |
| 1992 | 274.9 | 22.91 | 380.6 | 31.72 | 27.3 |
| 1993 | 275.8 | 22.98 | 380.7 | 31.73 | 27.4 |
| 1994 | 267.1 | 22.26 | 381 | 31.75 | 27.1 |
| 1995 | 268.3 | 22.36 | 382.7 | 31.89 | 27.2 |
| 1996 | 276.5 | 23.04 | 389.6 | 32.47 | 27.8 |
| 1997 | 281.6 | 23.47 | 387.3 | 32.28 | 28.0 |
| 1998 | 283.7 | 23.64 | 397.5 | 33.13 | 28.4 |
| 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 |

Source of Data: NIMET 2011, Lagos, Nigeria.

**Table 3 Summary of the rainfall and temperature conditions in Imo State for the three Decades (1980-2009).**

| Decades | Maximum mean RF in each decade | Decadal mean RF (mm) | Maximum mean temp in each decade | Decadal average Temp. (°C) |
|---|---|---|---|---|
| D1 (1980-1989) | 215 mm | $R_1$-192 mm | 28.0 °C | $T_1$-27.5 °C |
| D2 (1990-1999) | 246.8 mm | $R_2$-209.2 mm | 28.4 °C | $T_2$-27.7 °C |
| D3 (2000-2009) | 267 mm | $R_3$-193 mm | 30.7 °C | $T_3$-28.3 °C |

Source: Field survey (Okorie, 2012)

The mean annual rainfall and temperature data were used to construct the rainfall and temperature charts of the state for the climatic period (Figs. 1-3), and with these charts, the analysis of the pattern and trends of rainfall and temperature changes in the state was carried out.

## 3. Background Information of the Study Area

Imo State is bounded on the east by Abia State, on west by Rives State, on the north by Anambra and Enugu States and on the south by Rivers State. The

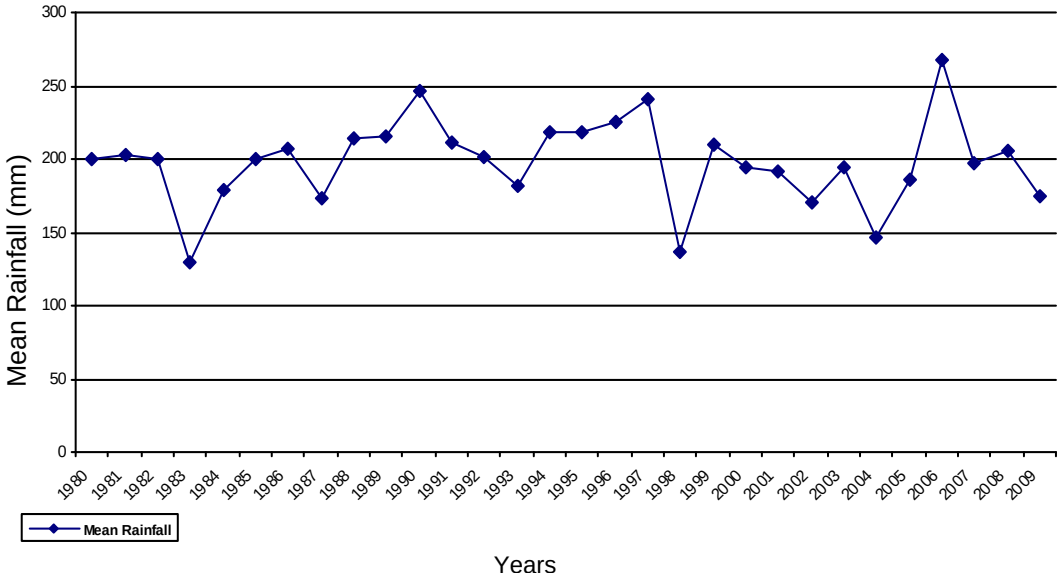


**Fig. 1 30 years (1980-2009) rainfall variability Curve in Imo State.**

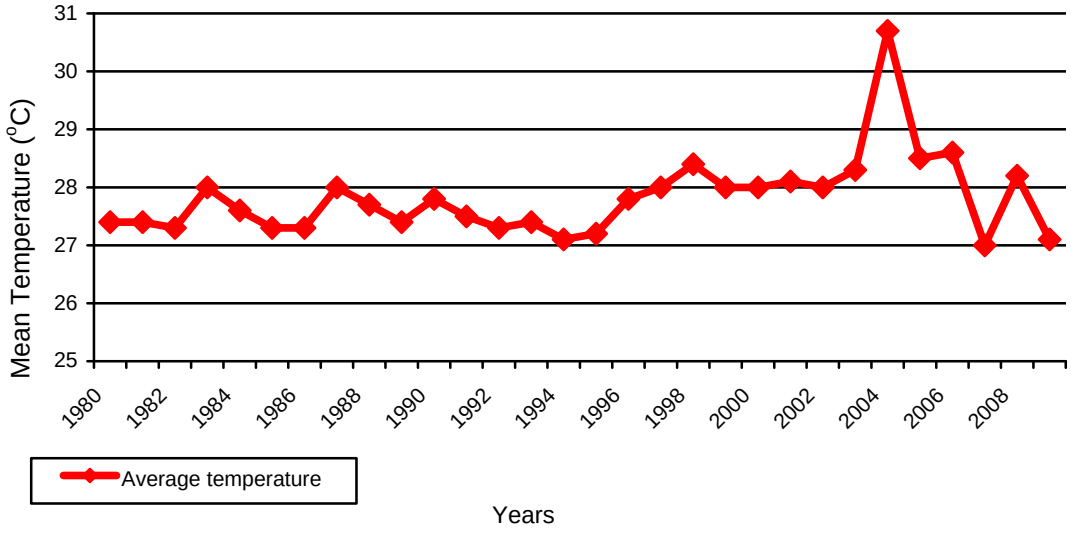


**Fig. 2 30 years (1980-2009) average temperature trends in Imo State.**

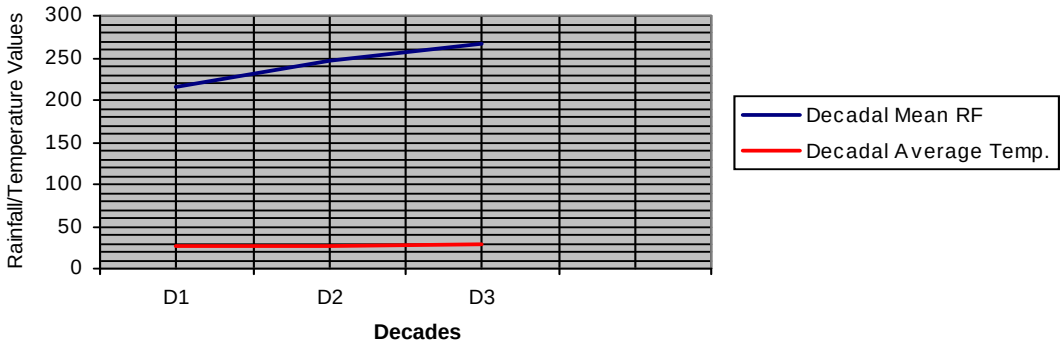


**Fig. 3 Decadal temperature and rainfall values.**

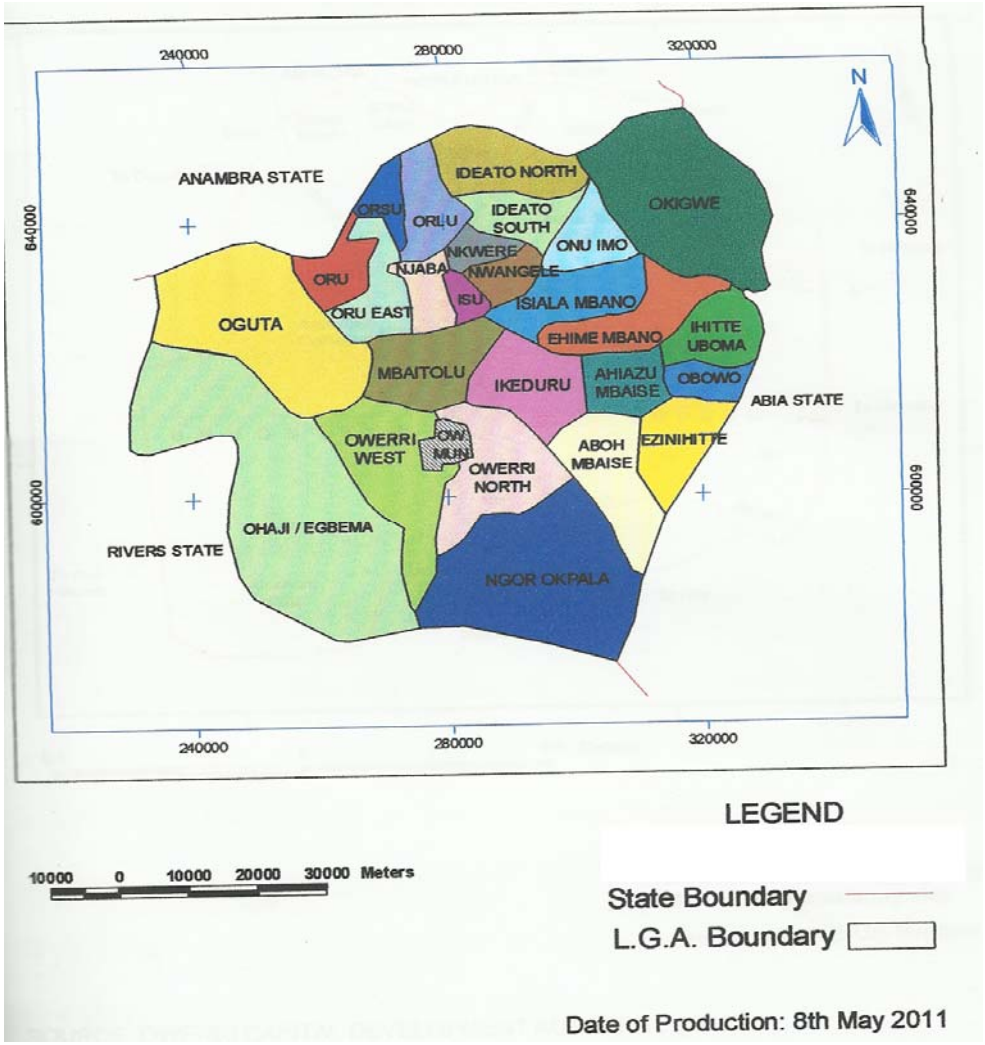


**Fig. 4 Map of Imo State, Southeastern Nigeria. Source: Owerri Capital Development Authority.**

State is located between latitude 4°45′ N and 7°15′ N, and longitude 6°50′ E and 7°25′ E with an area of about 5,100 km$^2$. With the current rising surface temperature and rainfall variability, the area is likely vulnerable to global warming consequences. Besides, there is mean annual rainfall and mean annual surface air temperature data of the area use in this study.

Imo State of the Southeastern Nigeria lies within the humid tropics and generally characterized by a high surface air temperature, regime year-round. Current mean maximum temperature is 32.1 °C while the current minimum temperature is 23.5 °C (Table 2). Two seasons, wet and dry are observed in the year. The rainy seasons begins in April and lasts till October. Double maxima, with the first maximum in June and the second in September also characterized the climate. There is thus a "little dry season" in-between known as "August Break" brought about by the seasonal north and southward movement of the ITCZ (Inter-Tropical Convergence Zone).

The state has 27 Local Government Councils with three major political zones namely, Okigwe (Imo North), Orlu (Imo West) and Owerri (Imo East). The administrative Capital of the state is at Owerri (Owerri municipal), which is the most populated, commercialized and industrialized city in the entire state (Fig. 4). The population of the state is about 3, 927, 563 with male, 1, 976, 471 and female 1, 951, 092 [15].

The state is rich in natural resources including, crude oil, natural gas, lead and zinc. Economically

exploitable flora like the iroko, mahogany, obeche, bamboo, rubber tree and oil palm predominate. However with a high population density and over farming the soil has been degraded and much of the native vegetation has disappeared.

## 4. Results and Discussion

This study established that there is a variability and change in the weather and climate system of Imo State and the entire Southeastern Nigeria as observed even at global scale. For example, the result from Fig. 1 (Table 1) shows that the percentage average mean rainfall from 1980, to 1982 was the same 3.4% but in 1983, there was sharp decline in rainfall with the mean 2.2% (129.8 mm), but in 1984, it increased to 3.0%, 3.4% and 3.5% in 1985 and 1986 respectively. In 1987, it dropped to 2.9% and rose to 3.6% in 1988/1989 .Then in 1990 it rained heavily with 4.2% (246.8 mm) and dropped to 3.5% in 1991, and remained high for 7 years till 1998 when it declined to 2.3% (136.7mm) and the next year 1999 it moved to 3.5% and remained high above 3.0% throughout, except in 2002 with 2.9%, 2004 with 2.5% (147 mm) and in 2009, 2.9% (174.4 mm).

Also on the temperature, there was spatial and temporal variability. The results from Fig. 2 show that, the air temperature was increasing gradually, and remained steadily high throughout the 30 years climatic period, which varied from 27 $^{o}$C to 30 $^{o}$C. Least average temperature of 27 0 $^{o}$C, recorded in 2007. Followed by 27.1 $^{o}$C average recorded in 1994 and in 2009, then, in 1995, the average temperature was 27.2 $^{o}$C. The rest years were very high in average air temperature but the highest was recorded in 2004 being 30.7 $^{o}$C (Fig. 2).

Also considering the results on a decadal level, both the temperature and rainfall has been increasing gradually. For example (Fig. 3), in the first decade (D1) being 1980-1989, the highest mean annual rainfall within the period was 215 mm and the decadal mean rainfall ($R_1$) was 192 mm while the highest average temperature was 28 $^{o}$C and the decadal average temperature ($T_1$) was 27.5 $^{o}$C. In the second decade (D2) being 1990-1999, the decadal rainfall ($R_2$) increased reasonably to 209.2 mm and decadal temperature ($T_2$) gradually increased to 27.7$^{o}$C. In addition, in the last decade (D3), $R_3$ reduced to 193 mm below the amount recorded in D2 but slightly above the amount recorded in D1. $T_3$ on the other hand increased sharply to 28.3 $^{o}$C above the recorded temperature in the first and second decades (Table 3 and Fig. 3)

However, this paper ascertained that based on the findings, the fluctuations in temperature regime and the variations in rainfall over the state within the period under study have shown some evidences of the variability and change in the climate system of the area, following the impacts that the observed shift in the climatic parameters has created on the environment.

### *4.1 Impact of Climate Variability in Imo State*

Climate variability can be resulted from both natural and anthropogenic factors. The degree of climate variability can be described by the differences between long-term statistics of meteorological elements calculated for different periods, (in this regard, the measure of climate variability is the same as the measure of climate change). Researches have shown that for the past few decades, anthropogenic factors like urbanization, deforestation, population explosion, industrialization and the releases of greenhouse gases are the major contributing factors to the depletion of the ozone layer and its associated global warming and climate change [16].

The evolving climate change coupled with increasing temperature had been observed to plunge some localities into experiencing extreme weather conditions [17]. Available evidences show that climate change will be global, likewise its impacts, but the biting effects will be felt more by the developing countries especially those in Africa due to their low level of coping capabilities [18]. Nigeria is one of such developing countries. Researchers have shown that Nigeria is already being plagued with diverse

ecological problems that have been linked directly to the on-going climate change [19].

In Imo State of Southeastern Nigeria, deforestation has triggered soil erosion, compounded by heavy seasonal rainfall that has led to the destruction of farmlands, houses and roads, coastal erosion, flooding and flash flood disasters (including, diseases and epidemics). Heat waves with communicable diseases and disease vectors due to increasing surface air temperature, increased evaporation that affects streams and rivers, landslides and land degradation and other climate related disasters are the evidence of climate variability and change in Nigeria, which are common place events in Imo State as established in this study. Example of the impacts is shown on the part of Ikenegbu road and works layout road in Owerri urban threatened and destroyed by gully due to excessive rainfall (Fig. 5). Hence, a recent study shows that about 16% of the erosion in Owerri Municipal of Imo State is caused by erosion [20].

Also this study reveals that some people are presently being displaced and having their abandoned buildings submerged in floodwaters since seven years ago in Umuna area of Orlu Local Government of the State due to flash floods following seasonal torrential rainfall (Fig. 6).

**Fig. 5 Ikenegbu road in Owerri destroyed by gully erosion.**

**Fig. 6 Abandoned building in Umuna Orlu due to seasonal floods.**

## 5. Conclusion

Climate variability is a global phenomenon and it occurs from region to region. Imo State of the Southeastern Nigeria has experienced climate variations and their consequences as experienced in other parts of the world [4, 21, 22, 23]. It has reported that variations in rainfall intensified for the different climatic regions and individual locations in Nigeria in the last three decades of the last century [24]. However, it is becoming increasingly clear that the global temperature rises steadily at rate unprecedented in the experience of modern society.

Obioh [21], in his study on other evidences of climate variations across Nigeria observed that steady rise in global surface air temperature trends and variable storm intensities are becoming regular feature of the climatic system. These cause distortions of local climate patterns and increase in evidence of weather-related disasters.

However, the study indicated that there have been variations in the climate of Imo State and the entire Southeastern region of Nigeria as well. The evidence of which is seen on steady increase in surface temperature, torrential rainfall which causes flash floods and flood disasters, increasing frequency and intensity of extreme weather events such as thunderstorms, sudden droughts, lightening, landslides, unpredicted rainfall patterns, drying up of rivers and lakes as well as other climate related disasters.

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