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An Assessment of Climate Change in Benin City, Edo State, Nigeria

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Abstract

This study sets out to assess the climate of Benin City to determine significant changes in its climatic variables. Benin is the capital city of Edo State a mid-western state in Nigeria. Data of average temperature, rainfall and relative humidity from 1981 – 2015 (35 years) were collected from the Nigerian Meteorological Agency (NIMET), airport station, Benin City. The data was analysed using ANOVA and Duncan multiple range. Findings from the study reveal that average temperature from 1981-2015 showed a significant trend as years 1981 through 1990 had the least temperature which increased with time as seen in the years 2001 through 2010. Duncan multiple range was adopted in testing the source of the significant differences across the variation year interval. The trend shown for the average annual rainfall also showed a significant trend. The average annual rainfall in the study increased with time as the trend rose from 153.66mm in years 1981 through 1990 to 211.57 in the years 2011 through 2015 when compared using one way of variance. Duncan multiple range was adopted in testing the source of the significant differences across the variation year interval. However in the case of average annual relative humidity results showed a positive trend but no significant difference across the year interval. Trend was compared using one way of variance. Duncan multiple ranges were adopted in testing the source of the significant differences across the variation year interval. Based on these findings, the study concludes that the climate in Benin City has significantly changed.

Keywords: Climate Change, Temperature, Rainfall, Humidity, Benin City

INTRODUCTION

Climate is defined as long-term averages and variations in weather measured over a period of several decades. It refers to the characteristic conditions of the earth's lower surface atmosphere at a specific location; weather refers to the day-to-day fluctuations in these conditions at the same location (IPCC, 2001). The variables that are commonly used by meteorologists to measure daily weather phenomena are air temperature, precipitation (e.g., rain, sleet, snow and hail), atmospheric pressure and humidity, wind, and sunshine and cloud cover (FAO, 2008: WMO, 2008). Asides anthropogenic activities, changes in climate is a normal part of earth's natural variability which is related to interactions among the atmosphere, ocean and land as well as changes in the amount of solar radiation reaching the earth (NOAA, 2007). The rate of present change in climate is faster than most of the past event making it more difficult for human societies and the natural world to adapt (NAS and The Royal Society, 2008). For instance, according to NOAA (2007) the last decade of the 20th century and the beginning of the 21st have been the warmest period in the entire global instrumental temperature record. Earth's average surface air temperature has increased by about 0.8^{0}C since 1900, with much of the increase taking place since the mid-1970's (NAS and The Royal Society, 2008). Climate change or global weather patterns or global warming can be described as the biggest environmental issue of our time. It

is global in its causes but its consequences are far more reaching in developing countries, particularly Nigeria. It is a topical issue worldwide because of its attendant problems that are threatening the sustenance of man and his environment. These are particularly becoming more severe in the under-developed and developing countries (IPCC, 2001:2007). Climate change has become the new reality of our time. It brings with it changes in weather patterns that can have serious repercussions for human beings, upsetting seasonal cycles, harming ecosystems and water supply, affecting agriculture and food production, causing sea-levels to rise (Nicholls, 2011). Climate change has a cumulative effect on natural resources and the balance of nature. Its effects are already visible in Nigeria (Ishaya and Abaje, 2008).

Nigeria, as a developing nation is particularly sensitive to the effects of climate change. A large part of the economy of the country depends on natural resources, which are particularly vulnerable to climate change. When those resources are affected, communities are implicated. Disease, loss of livelihoods and settlements can force entire communities into relocation or complete extinction and even refugee status. As critical as the effect of climate change is, it is not clear whether Nigerians are aware of what climate change is or its effects. Perhaps the biggest obstacle is the lack of awareness and knowledge as Ishaya and Abaje,(2008) had put it.

In Benin City essential climatic elements particularly rainfall, temperature, humidity are neither incorporated into its complex environmental planning processes nor utilized in its continuous urban development activities. The dynamic nature and characteristics of the climate in the study area have not been assessed from authentic scientific perspectives. These integrated weaknesses, have given rise to serious challenges on the physical environment which relate to floods, infrastructural damages, traffic delays, prevalence of water-borne diseases, poor commercial activities, and residents protests over dissatisfaction with the government performance. Hence, adequate and authentic climate information, no doubt, could be utilized for carrying out important urban activities which could be long-lasting and life-preserving.

Benin City is selected for a close assessment owing to important reasons. It has recognized characteristics of an urban settlement which include social infrastructures, dense human populations, complex urban canopy layers, and numerous small-scale firms and industries with lucrative financial and commercial institutions. It has one basic meteorological station which is currently operated by the Nigerian Meteorological Agency (NIMET) where recent and authentic climate data can be obtained for utilization in both theoretical studies and empirical planning activities. The city has experienced climatic changes because of increased urbanization over the years, and these include modifications in its dense vegetal and rich fauna species, geomorphic, atmospheric, thermal, and hydrological characteristics (Okhakhu, 2016).

Currently, the climate of Benin City has not been assessed adequately by environmentalist on beneficial scientific guidelines (Edema *et al.,* 2015). Specifically, the essence of rainfall in the development process of the city has not been considered by the planning authorities. Hence, the urgent need to bridge this development vacuum based on permanent recognizance, incorporation and utilization of climatic elements. The purpose of this study therefore is to determine if the climate of Benin City has significantly changed.

METHODOLOGY

Study area

Benin City is located at latitude 06° 19′00″ E to 6° 21′ 00″ E and longitude 5° 34′ 00″E to 5° 44′ 00″E with an average elevation of 77.8 m above sea-level. Benin City is a pre-colonial city, the capital of defunct Bendel State and the present day Edo State. Benin City is underlain by sedimentary formation of the Miocene-Pleistocene-age often referred to as the Benin formation (Odemerho, 1988). The city is located in the humid tropical rainforest belt of Nigeria with a population of 762,717 according to the 1991 national population census with a projected population of 1.3 million by 2010 at 2.9% growth rate. The rainy season in Benin begins in March/April and ends in October/November. Rainfalls are of high intensity and usually double maxima with a dry little spell in August usually referred to as 'August Break'.

Data Type and Data Source

The study relied primarily on secondary quantitative monthly temperature , rainfall and relative humidity data of Benin City for 35 years (1981-2015) collected from NIMET, Airport Station, Benin City. The mean values for temperature, rainfall and relative humidity were computed from their respective minimum and maximum values. The standardized anomalies of average temperatures, rainfall and relative humidity were computed using 1981-2015 normals.

Data Collection

At NIMET Station, observation is made at fixed observing hours. The main synoptic hours are 0000 (midnight), 0600 (6am), 1200 (noon) and 1800 (6pm) Greenwich mean time. Additional observations are made at other times between the four main times, often hourly or at three hours intervals. This procedure is in line with World Meteorological Organization (WMO) standards (WMO, 2008). Daily rainfall, humidity and temperature measurements were taken by NIMET meteorologists and averages drawn to give daily readings which were inputted as data into the computer for record keeping.

The temperature data of the study area was taken using a thermometer. The thermometer is usually needed to measure the temperature of the surrounding air. This is to ensure that the temperature data of the surrounding air is the same as the thermometer; it must be shaded from sunlight and be exposed to adequate ventilation.

The rainfall data of the study area was taken using rain gauge. The amount of rain that falls at a specified time is expressed as the depth of water it would produce on a large, level impermeable surface. Data was expressed in millimetres. Rainfall measurement is carried out daily. Before rainfall measurements, certain precautions are taken against the effects of obstructions, wind, splashing and evaporation for accurate data collection.

The relative humidity data of the study area was taken by using a hygrometer. The humidity of a packet of air is usually denoted by the mass of vapour contained within it, or the pressure that the water vapour exerts. Relative humidity is measured by comparing the actual mass of vapour in the air to the mass of vapour in saturated air at the same temperature.

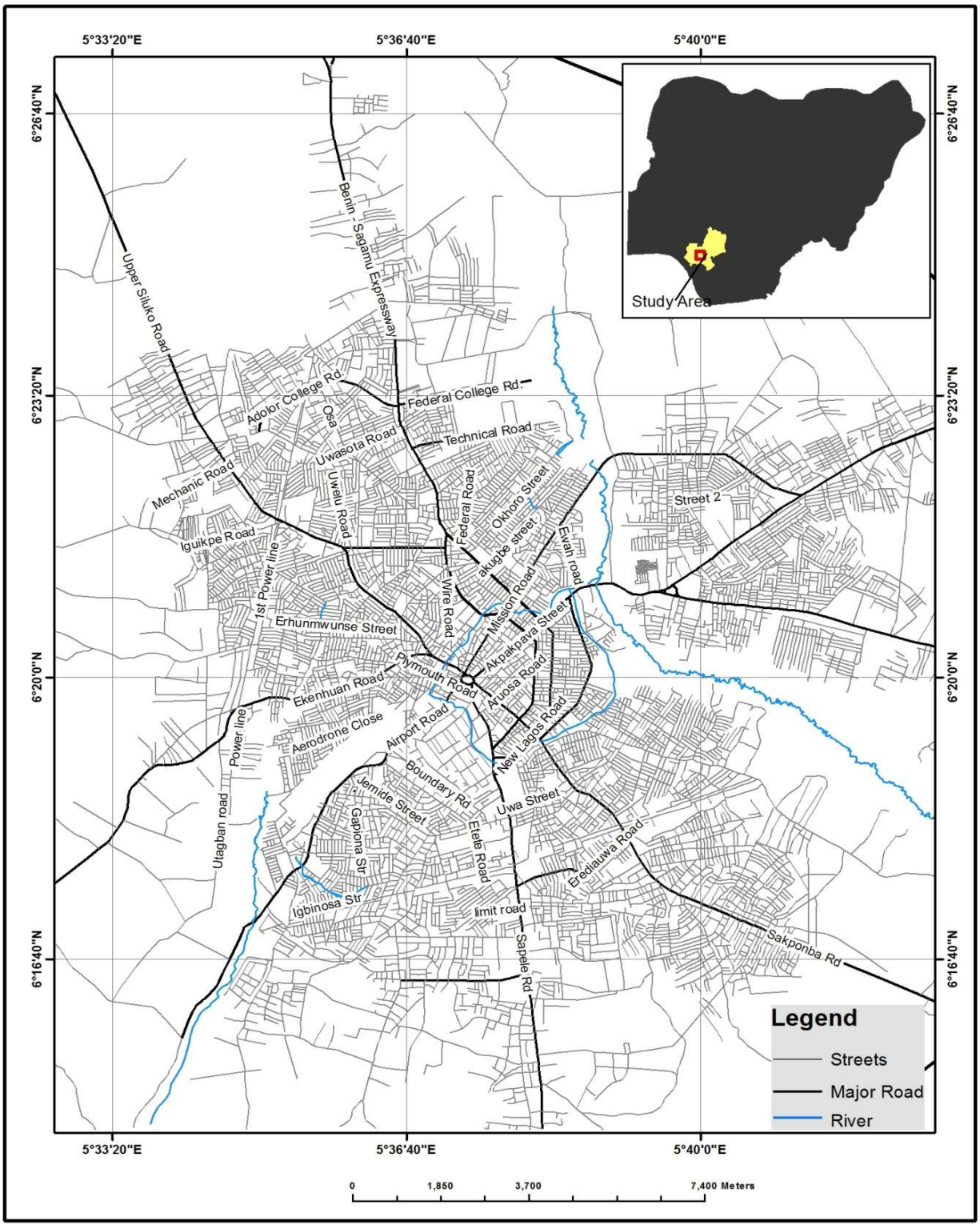

Figure 1: Map of Benin City.

Data Analysis

Mean and standard deviation were used to examine the individual climate parameters. Temporal comparisons were carried out to test for significant differences in the climatic parameters using

analysis of variance (ANOVA). If significant value ($P<0.05$) were obtained in the ANOVA, Duncan multiple range (DMR) test was performed to determine the location of significant differences. To assess the time series-climatic parameters relationship, regression analysis was adopted. The climatic parameters were taken as the dependent variable while the time series represented the independent variable. The ANOVA and regression were performed using SPSS excels respectively. All analyses were considered significant at 95% confidence level.

RESULTS AND DISCUSSION

The average temperature in the study area for the period under review is depicted graphically in figure 2. It shows that between the years 1981 to 1990, 1987 had the highest average temperature (28.12 ºC) while the lowest average temperature of 27.17 ºC was recorded in 1982. Furthermore, in the following decade the city experienced an increase in average temperature with the year 1998 recording the highest average temperature of 28.27ºC and the year 1999 observed as having the lowest average temperature (26.95 ºC). The pattern was quite similar for the years 2001 through 2010 where the decade experienced the highest temperature in 2010 (28.24 ºC) and its lowest temperature in 2002 (27.53 ºC). The City subsequently experienced a gradual decline in average temperature between the years 2011 to 2013 after which it started to soar again. Also, for the period under review the graphical representation depicts that the average temperature in Benin City had a positive trend with a regression value of $R^2 = 0.2284$.

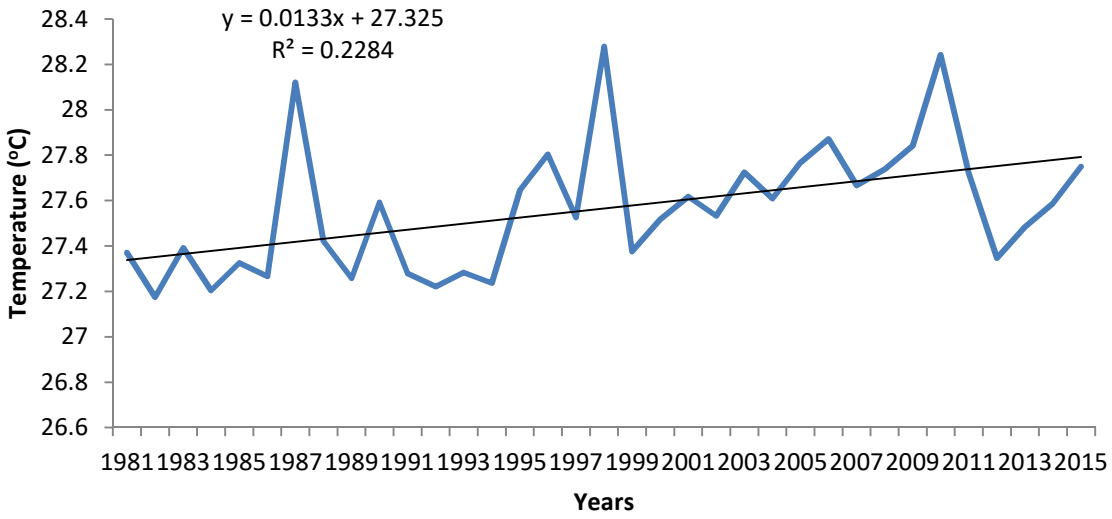

Figure 2: Average temperature in Benin City showing trend line in the last 35 years (1981-2015)

Similarly, the average rainfall in Benin City for the period under review was graphically represented in figure 3. It depicts the year 1990 to have had the highest average rainfall between the years 1981 to 1990. However, the year 1984 was recorded to have experienced the lowest average rainfall for the same decade. In examining the following decade, it was observed that the year 1995 recorded the highest rainfall while 1993 recorded the least rainfall amounts. Furthermore, the years 2001 through 2010 shows that an average of 235.16mm of rainfall was recorded in 2010 making it the year Benin City experienced the highest amount of rainfall; whilst on the other hand a total of 161.94mm of rainfall was recorded in 2003 making it the year with the least amount of rainfall all in the same decade. In the subsequent years, average rainfall amounts were observed to be on a gradual decline. However, the graphical representation shows that during the years under review the average rainfall trend was positive with a regression value of $R^2 = 0.3949$

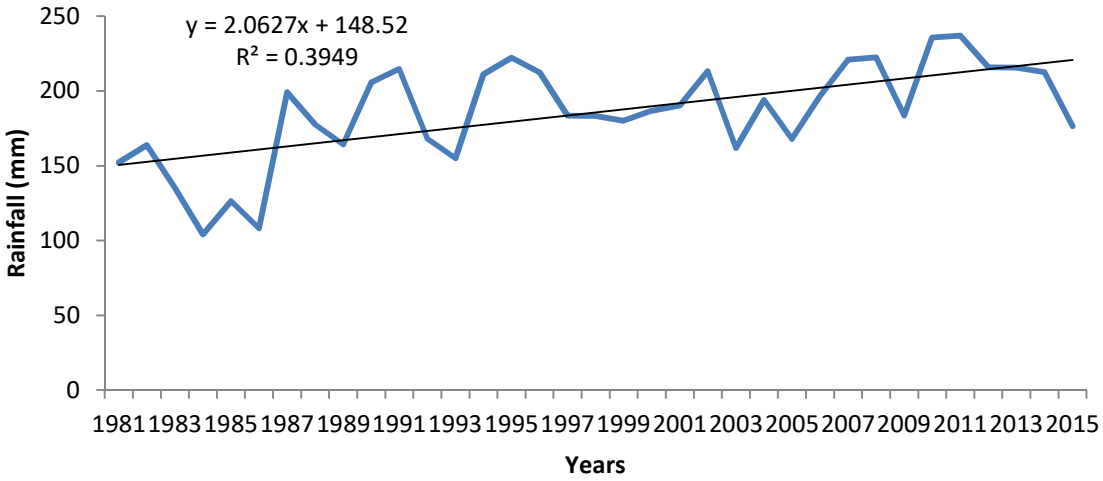

Figure 3: Average rainfall in Benin City showing trend line in the last 35 years (1981-2015)

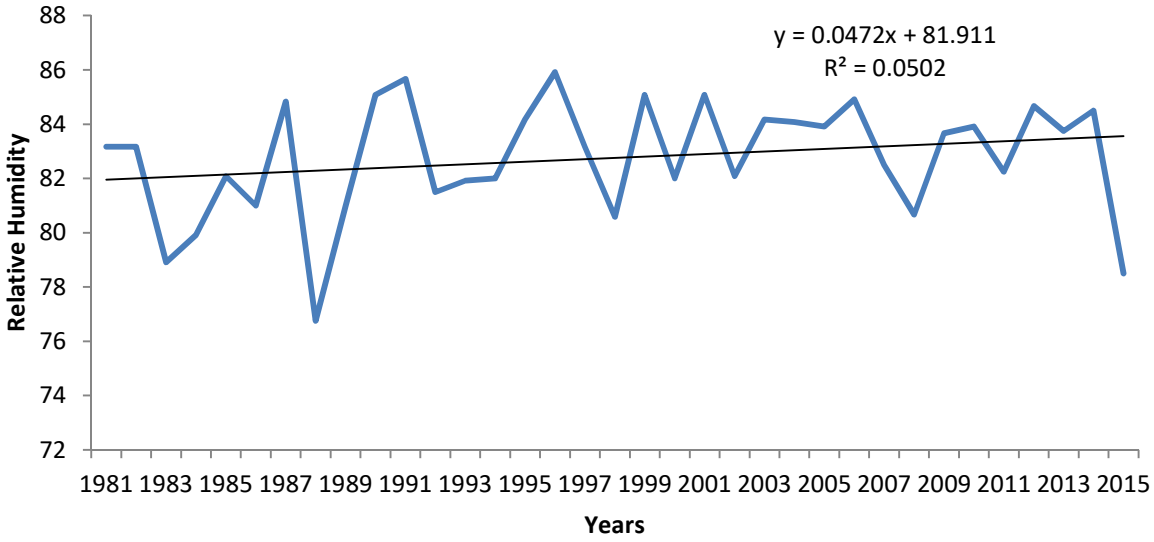

Figure 4: Average relative humidity in Benin City showing trend line in the last 35 years (1981-2015)

Table 1: Determination of significance of mean temperature, rainfall and relative humidity in Benin City in the last 35 years (1981-2015)

	1981-1990 $\bar{x}$±SD	1991-2000 $\bar{x}$±SD	2001-2010 $\bar{x}$±SD	2011-2015 $\bar{x}$±SD	p-Value
Temperature (°c)	27.41 ±0.28	27.52 ±0.33	27.76 ±0.20	27.58 ±0.17	p<0.05
Rainfall (mm)	153.66±35.24	191.70 ±22.29	198.67 ±24.19	211.50 ±21.86	p<0.05
Relative humidity (%)	81.59±2.62	83.20±1.89	83.50±1.36	82.73±2.55	p>0.05

Significant Difference: $p<0.05$; No Significant Difference: $p>0.05$

Furthermore, a graphical representation of average humidity for the study area for the period under review is depicted in figure 4. It shows that between the years 1981 to 1990, average humidity was highest in the year 1990 with a value of 85.08% and lowest in the year 1988 with a value of 76.75%. The figure also shows that on the following decade the highest humidity value of 85.66% was recorded in 1991 while the least humidity value of 80.58% was recorded in 1998. The years 2001

through 2010 shows that the year 2008 had the lowest value while 2001 had the highest value. The values for subsequent years were observed to be between 83% and 84%. However, in the year 2011 average humidity declined to an all-time low of 75%. The graphical representation also that for the period under review, average humidity had a positive trend with a regression value of $R^2 = 0.0502$.

On the other hand, Table 1 depicts significant difference for average temperature, rainfall and humidity for the period under review. It shows that there was significant difference ($p<0.05$) in average temperature and rainfall. However, in the case of relative humidity the table shows that even though there was a positive trend as shown in the graphical representation, it did not amount to any significant difference.

In summary, results from the study reveal a progressive (positive) trend of average temperature in Benin City, with the years 2001 through 2010 been the warmest decade. The implication of this would be felt in agriculture as this condition may be unfavourable for the cultivation of some food crops for example maize. Gerad, (1988) and Sowunmi *et. al,*. (2010) in their study conclude that maize requires temperature of between 21^0C and 30^0C for optimum production. If the current trend continues, the production of maize in Benin City will greatly reduce if not impossible. This trend would also give rise to the proliferation of pest which would eventually attack these food crops (Ishaya and Abaje, 2008). Another implication is that human comfort will be strongly affected by the present trend of temperature. On the other hand, the study reveals high levels of rainfall. The implication of this condition translates to soil erosion as well as flooding. The effects of these conditions are felt in agriculture, infrastructure as well as health. Furthermore, an insignificant but positive trend was also revealed in the case of relative humidity. The implication of this would be human discomfort

CONCLUSION AND RECOMMENDATIONS

Based on the foregoing, the study concludes that the climate of Benin City has significantly changed. The study further goes to recommend the following strategies to adapt to the changing climate in the City;

In terms of increasing temperature the researchers strongly recommend enhanced agricultural inputs such as improved seedlings as well as irrigation to replenish moisture loss resulting from rapid evaporation. Also there is need for pest resistant species of crops for planting. On the part human comfort the researchers suggest that individuals should wear light clothing, sleep in well ventilated rooms and avoid direct sunlight especially at peak periods of the day (11.30am – 3.30pm). This will help prevent or reduce the incidences of heat stroke as well as skin cancers.

Furthermore, with respect to the present trend of rainfall, the researchers recommend that government and private sector should discourage deforestation, encourage afforestation and seek sustainable alternatives. Deforestation leads to soil erosion as well as emission of sequestered carbon, which in turn leads to the continuous warming of the environment. The researchers also suggest that government should take this trend into cognisance in the urban planning process. This is paramount because the current trend of rainfall depicts high intensity and volumes of water, which would lead to very high probability of flooding and eventual destruction of lives and property.

Finally, relative humidity depends on temperature, pressure and water vapour. Results from the study reveal that relative humidity is on a progressive trend. Therefore, it can be deduced that this is as a result of the increased temperature and rainfall. With these findings, the researchers suggest that light clothing should be worn as human comfort would be affected due to slow evaporation of perspiration from the skin. Sleeping in a well-ventilated room is also encouraged; this is to reduce the incidence of respiratory infections and allergies (Arundel *et. al.,* 1996). The later statement should be taken into

cognisance by the housing development authority of government in the formulation of policy guidelines in the construction of buildings in the City.

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