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Impact of Climate Change on Temperature Trends, Implications on Agricultural Production and Mitigation Strategies

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Abstract

The state of the environment as a natural home for the habitation of humans, plants, animals and biotic elements cannot be over emphasized. The environment plays an essential role in life support and dictates the socio economic growth and survival and the livelihood opportunities that are available in an area. Nevertheless, this life support has been subjected to series of devastations caused by natural catastrophes that are mainly anthropogenically induced resulting in flood, drought, desertification, changes in temperature pattern, among others. This unhealthy situation has to be minimized or totally put to an end. The purpose of this study was to access data/information on temperature trends for period (1988 – 2002) and for the period (2018 – 2019). The data/information accessed were analyzed using descriptive statistics. The result shows that temperature values were high between the months of February and March and in the month of November for the period (2018 – 2019). The result also shows that the month of February often recorded highest temperature values in the same period (2018 – 2019) showing rising temperature trends than in the period (1988 – 2002). Recommendations, among others, include that: there should be shift in planting dates of some crops, edible cover crops to be cultivated as "must crops" during the planting seasons and construction of water channels for irrigation purposes.

Background to the Study

Global Carbon Project (GCP), 2015) refers to climate change as any change in climate over time whether due to natural variability or as a result of human activities. The United Nation Framework Convention on Climate Change (UNFCCC), 2018) defines climate change as change of climate which is attributed directly or indirectly to human activity that alter the composition of the global atmosphere and which is in addition to natural variability observed over a comparable time (Intergovernmental Panel on Climate Change (IPCC), 2017).

The trend of the change is on the increase. Idumah, Owombo and Adesina (2014), reported that the time period between 2005 – 2010 was the warmest since 1880 and 0.5^0C warmer that the mean for 1961 – 1990 era. The global surface temperature tied 2005 as the warmest on record, according to the National Oceanic and Atmospheric Administration (UNFCCC, 2017). The incessant increase and variation in the elements of weather are due to man's activities such as fossil fuel burning and land use changes which cause increasing emission of quantity of greenhouse gases (GHCs) into the Earth's atmosphere and the environment (UNFCCC, 2017). These greenhouse gases include carbon dioxide (CO_2), methane (CH_4) and Nitrogen dioxide (N_2O) and a rise in the amount of heat from the sun withheld in the Earth's atmosphere as well as heat that would be radiated back into space. It is the increase in heat that causes the greenhouse effect, resulting in global warming and subsequently climate change.

According to Idumah, Owombo and Adesina (2014), climate change is characterized by increase in average global temperature (global warming); changes in cloud cover and precipitation particularly over land; melting of ice caps and glaciers and reduced snow cover and ocean acidity – due to sea water absorbing heat and carbon dioxide from the atmosphere.

Global warming, otherwise known as climate change, has been increasingly recognized as the greatest threat of the century (UNFCCC, 2017). This position is in line with that of the (IPCC, 2018) and the (UNFCCC, 2017) which have identified climate change as the greatest threat of the century and reported that the earth's average temperature has risen by 0.74^0C. Furthermore, the present atmospheric concentration of carbon dioxide (CO_2) is 385ppm (parts per million) far more than any time in the last 650,000 years resulting in climate change or global warming. According to Pekin (2010) of all the holocausts that have afflicted mankind such as plaques, earthquakes, tsunami, smallpox, HIV/AIDs, etc, none has the greatest threat to wipe out lives on earth through either continuous flooding or permanent drought than climate change. It has been projected that about 9billion people will inhabit the earth by 2050, most of which live in developing countries. As a result, the world is confronted with the robust question over how can our planet sustain and feed this population consequent on climate change with its implications on food security, access to clean water and sanitation, population migration and the threat of an increased number of natural and man-made disasters (Awotoye and Matthew, 2010).

The projected future impact of climate change and variation are worrisome. According to UNESCAP (2011), the earth could warm by an additional 7.2degrees Fahrenheit during the 21st century if no action is taken to reduce emissions from burning fossil fuels, such as coal and oil. This rise in average temperature will have far-reaching effects on the earth's climate patterns and on living things. Expectedly, developing countries are the most vulnerable to climate change negative impacts due to lack of resources to adapt to or combat them socially, technologically and financially. With the foregoing, there is need to intensify efforts in charting more new paths to assisting in reducing the emissions of greenhouse gases (GHGs) or enhance their sinks and in these processes mitigate global warming and climate change negative impacts and this formed the basis of this study. Following this, the study tends to address the ensuing research questions; how was the temperature pattern for the period 1988 – 2002; what were the temperature values in the period 1988 – 2002; how was the temperature patterns for the period (2018 – 2019); what were the temperature values for the period (2018 – 2019).

The main objective of this study is to access data/information on temperature patterns for the period (1988 – 2002) and (2018 – 2019). The specific objectives included; to determine temperature patterns for the period (1988 – 2002); determine the month(s) of maximum temperature values for the period (1988 – 2002); determine the temperature patterns for the period (2018 – 2019) and determine the month(s) of maximum temperature values for the period (2018 – 2019).

Statement of the Problems

Climate change and variation constitutes a major threat to the environment and biodiversity. Climate change has adversely impacted natural resources, food security, human health, the environment, economic activity and physical infrastructures. The trend of the change is on the increase and the projected future impacts of climate change and variation are worrisome.

Globally, scientists have made efforts to divide the causes of global warming or climate change into two broad perspectives; natural and human causes. The efforts by researchers, scientists as well as potential international organizations to identify these factors are widely acknowledged. Although climate change has been recognized, studied and debated for decades but the recognition of the present high concentrations of greenhouse gases in the atmosphere growing at unprecedented rate and magnitudes with its apparent devastating effects is relatively recent and should demand intensified studies so as to come up with more adaptation and mitigation strategies. To this dimension, all hands must be on deck to combat global warming. At the international level, some mitigation strategies have been recommended and some already in action, among which are negative emission strategies. At the local level, there is need for some mitigation strategies as well and which this study tends to provide.

Materials and Method

Two sets of materials were used in this study. The first set was from literature. The second set was sourced from the Agromet Unit of the National Root Crops Research Institute (NRCRI), Umudike.

Umudike is located about 8km east of Umuahia Town along Umuahia – Ikot Ekpene road with latitude $05^0$29'N, longitude $07^0$33'E and at an altitude of 122m above the mean sea level (Emeka-Chris, 2011). Umudike is 140km North of Port Harcourt International Airport and 135km south of Enugu Airport and 80km east of Owerri Airport in Imo State. It is within the subequatorial climatic belt characterized by two major seasons; the wet and dry seasons. The wet season starts in April and ends in September with a peak in June and July, while the dry season lasts from October to March. However, recent global climatic change has affected the durations of these seasons. Rainfall is high in the area, with an annual average of about 2,217.86mm. Relative humidity is also high and generally over 70%, while mean annual temperature is about 27^0C.

Data Collection and Analysis

Data were collected from two major sources. Firstly, literature provided data/information on temperature trends for the period (1988 – 2002). The second source is the Agromet Unit of the National Root Crops Research Institute (NRCRI), Umudike which provided data/information on temperature patterns for the period (2018 - 2019). The data were analyzed using descriptive statistics.

Issues About Temperature in Relation to Agricultural Production (Exerts from Oga, 2014)

The environment of any crop or animal determines, to a large extent, its performance. As a result, some varieties of crops and certain breeds of animals perform better in the temperate region than in the tropics, whereas others perform better in the tropics than in the temperate region. Even within the tropics, certain varieties of crops and breeds of animals perform better in some areas than in others.

Temperature is one of the environmental factors that affect agricultural production. It is a very important element of weather and climate. Temperature is the degree of hotness or coldness of a body, be it living or non-living. The temperature of a body or an object depends on the amount of heat energy it receives from the sun or from a nearby hot object. The higher the heat energy absorbed by a body, the higher its temperature.

In Nigeria, temperature is not a limiting factor for agricultural production for it is general or even. The period of favourable temperature makes the tropics potentially more productive than temperate regions. Solar radiation is the major determinant of the ambient temperature (25^0C). Optimum temperature for plant establishment is within the neighbourhood of 30 – 35^0C. Different parts of plants, however respond differently to the same temperature conditions. Temperature fluctuation is only important for crop growth and yield when moisture supply is limiting. The words and related temperature

given in Table 1 refer to daily, monthly and annual mean temperatures. For example, a month which has a mean temperature of 25^0C is refer to as "a hot month" and if it is over 30^0C, it is referred to as "very hot"

Table 1: Words Related to Daily, Monthly, Annual Mean Temperatures

Temperature ^{0}C	Describing words
Below -10^0	Very cold
-10^0 - 0^0	Cold
0^0 -10^0	Cool
10^0 -21^0	Warm
21^0 -30^0	Hot
Over 30^0	Very hot

Source: Bunnet and Okunrotifa (1984) in Oga, (2014).

Temperature, no doubt, is a pronounced factor of physical weathering. Weathering breaks up the surface of parent rocks into smaller particles. Air and water enter the spaces between the particles and chemical changes take place which result in the production of chemical substances. When plant and animals die, they decay and produce a substance called *humus*. This is very important to soil fertility. Bacteria play a vital role in the decomposition of plant and animal remains. The end product of these mechanical, chemical and biological processes is "soil" which is one of the world's most important natural resources. It is important to note here that the above situation is possible under favourable temperatures (30 – 35^0C). All soils contain mineral matter, organic matter, water, air and living organisms, especially, bacteria. If any one of these is seriously reduced in amount or removed from a soil, then the soil deteriorates.

Despite the developments made in science and technology, farmers and their products (crops and livestock) are still at the mercy of weather and climate. Weather conditions such as temperature, rainfall, humidity and wind may encourage or discourage the production of crops. Crops and animals have optimum temperature levels of the range (30 – 35^0C) for optimum performance. Extreme cold or hot weather retards growth and development of living organisms. In extreme conditions, the animal or plant may not survive. Water stress or heat load is detrimental to man including his crops and livestock. High humidity promotes the growth of fungi and diseases which may be injurious to both man and his crops. In the same manner, winds of high velocities such as hurricane can cause serious crop failure by lodging, impairment of flowers and uprooting of crops.

Weather often controls man in his choice of activities in which to get involved. In other words, choice of agricultural activities is dependent on weather. There is no doubt that man and his activities are vulnerable to climate variations and as a result, the management of climatic resources should therefore involve the rational use of the beneficial effects of weather and climate and the prevention, avoidance or minimization of the hazardous effects.

Implications of Temperature on Agricultural Production

With the foregoing, in association with issues about temperature in relation to agricultural production, earlier discussed, results or information in Tables 3 and 4 show rising temperature trends and these have implications for agricultural production.

High temperatures are detrimental to the soil making it not supportive to crop production. This is because it will cause the reduction or removal of mineral matter, organic matter, water, air and living organisms, especially bacteria. This condition will affect soil fertility and making it impossible for the soil to adequately support crop production.

Another implication of high temperatures is that, it will cause crops not to grow and develop properly. For example, high temperatures will affect maize plants adversely because it will prevent the development of the silk leading to low or no grain production. Cotton plants may shed their boils and fruit trees will drop their fruits prematurely when temperatures become too high, while high temperatures coupled with long sunshine hours will scorch some fruits crops such as pineapples. Under high temperature regimes, temperate crops such as wheat, barley, apples and grapes may not be grown in many parts of Nigeria. They may, however, be grown on a very small scale in parts of Mambila plateau in Taraba State and Baga (near Lake Chad) in Borno State because the temperatures in these areas during the harmattan season are low and provide the chilling condition which is necessary for the development of flower buds and fruits.

Another implication here, concerns the development and performance of exotic breeds of livestock. Tropical breeds of livestock are adapted to the high temperatures in Nigeria but the imported (exotic) temperate breeds may not perform well. This is because the high temperature affects them adversely. Excessive heat as a result of high temperatures increases the animal's metabolism thereby making it dissipate heat by panting, and also reduces the period a temperate breed of cattle spends in grazing. The implication here is that it will lead to reduced growth rate and lowered milk yield because of the reduced feed intake. The animal also tends to consume a lot of water so as to replace that which is lost from the body through perspiration. Poultry birds will suffer heat stress during high temperatures resulting in death of the birds. Consequently, high temperatures which lead to global warming and subsequently climate change need to be mitigated.

Results and Discussion

Patterns of Temperature Average 14 years from (1988 – 2002)

Table 2: Summary of Monthly Distribution of Temperature

Maximum Air Temperature (^{0}C) Average 14 years (1988 – 2002)

Months	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec
Min	30	31.1	28.8	30.6	28.8	27.3	26.1	25.9	26.1	27.8	29.4	30
Max.	33	34.4	35.2	34.6	32	30	29	28	29.5	31.3	32	32
Mean	31.8	33.3	32.1	32.1	28.6	28.6	27.3	26.9	27.9	29.2	30.6	31

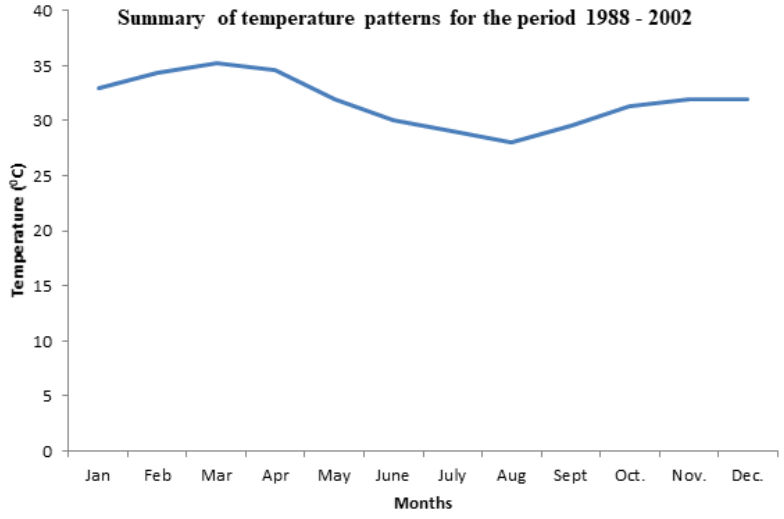
Source: Oguntola, (2007)

Table 2 shows temperature pattern for the period 1988 – 2002. The pattern of temperature shows a rising trend in this period. Seven (7) months in the period shows temperature values above 31^{0}C and five (5) months recorded temperature values of 30^{0}C and below. The first five (5) months recorded temperature values between 33^{0}C and 34.6^{0}C.

Determination of Month(s) of Maximum Temperature values for the Period (1988 - 2002)

The temperature patterns in Table 1 above, show rising temperature values between the months of January and April. The months of January, February, March and April recorded maximum temperature values of 33^{0}C, 34.4^{0}C, 35.2^{0}C and 34.6^{0}C respectively and the highest maximum temperature value of 35.2^{0}C was recorded in the month of March.

Figure 1: Designed with information on maximum temperature values in Table 2



Pattern of Temperature for the period (2018 – 2019)

Table 3: Summary of Monthly Distribution of Temperature (^{0}C) for the year, 2018 (Maximum Air Temperature) for the year, 2018

Months	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec
Min	22	24	24	23	22	21	21	22	23	23	24	20
Max.	34	35	34	34	33	31	30	30	30	31	31	33
Mean	28	29.5	29	28.5	27.5	26	25.5	26	26.5	27	27.5	26.5

Source: Agromet Unit of National Root Crops Research Institute (NRCRI), Umudike, Abia State

Table 4: Summary of Monthly Distribution of Air Temperature (^{0}C) for the year, 2019 (Maximum Air Temperature) for the year, 2019

Months	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec
Min	22	22	23	24	24	24	23	24	23	23	24	25
Max.	35	34	34	36	32	29	28	30	27	31	32	33
Mean	28.5	28	29	30	28	26.5	25.5	27	25	27	28	29

Source: Agromet Unit of National Root Crops Research Institute (NRCRI), Umudike, Abia State

Determination of the month(s) of Maximum Temperature Values for the Period (2018 – 2019)

Tables 2 and 3 show temperature patterns for the period 2018 – 2019. The patterns show a more increasing trend of temperature from the month of January to February in the year, 2018. In the year, 2019, the months of January and April recorded higher temperature values than in the year, 2018.

Tables 2 and 3 above show more rising temperature values compared to temperature values in Table 1. Table 2 shows that maximum temperature values of 34^{0}C, 35^{0}C, 34^{0}C and 34^{0}C were recorded in the months of January, February, March and April respectively in the year, 2018. This rising trend in temperature values is also evidenced in Table 3 which shows temperature values of 35^{0}C, 34^{0}C, 34^{0}C and 36^{0}C recorded for the months of January, February, March and April respectively in the year, 2019. The highest maximum temperature value recorded for the periods covered (2018 – 2019) was 36^{0}C as compared to the highest maximum temperature value of 35.2^{0}C average 14 years from 1988 – 2002 which is a difference of 1.2^{0}C. This trend in temperature for the periods covered shows rising temperature patterns, see figures 2 and 3. This temperature situation is in agreement with the position of Nwaiwu et al (2014), that the temperature of the planet earth is on the increase. This current temperature is also in agreement with a recent intergovernmental panel on climate change (IPCC), 2018) Report which demonstrated that anthropogenic activities so far have caused an estimated 1.00C of global warming above the pre-industrial level, specifying a likely range between 0.8 and 1.2^{0}C (United Nation Environment Programme (UNEP), 2019; You matter, 2020). It is stated that global warming is likely to increase up to 1.5^{0}C between 2020 and 2052, if the current emission rates of GHGs persist (IPCC, 2018) with the foregoing therefore, it is pertinent to state here that these rising temperature patterns have gone beyond the usual temperature patterns and values (30 – 35^{0}C) and as such, no longer encouraging to human livelihoods. For example, records have shown that the current temperature patterns are no longer favourable for agricultural production, especially in Tropical African countries.

To this regard, farmers have lost farm inputs and produce consequent on lack of or inadequate information or knowledge about these changes in temperature patterns and need to know about the changes in order to be adequately equipped and guided in the planning of their farming activities so as to forestall future farm losses. To this

perspective is where agricultural extension services or education is very relevant so as to provide farmers with information and knowledge on current weather conditions and smart agricultural practices. This will help to reposition them better in the face of the current weather/climate vagaries. This is where coping, adaptation or mitigation strategies are very necessary.

Figure 2: Designed with information on maximum temperature values in Table 3

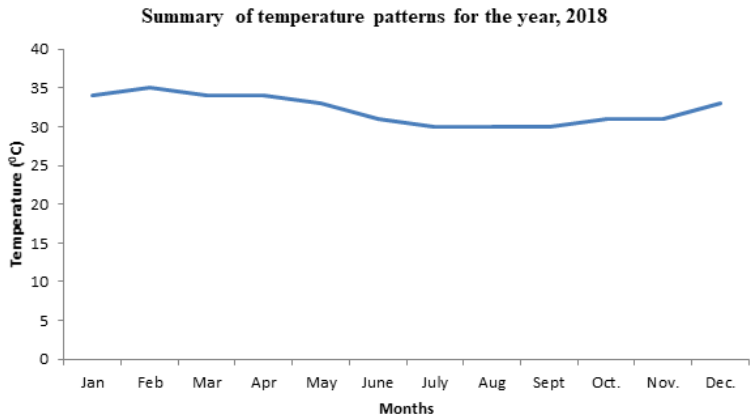
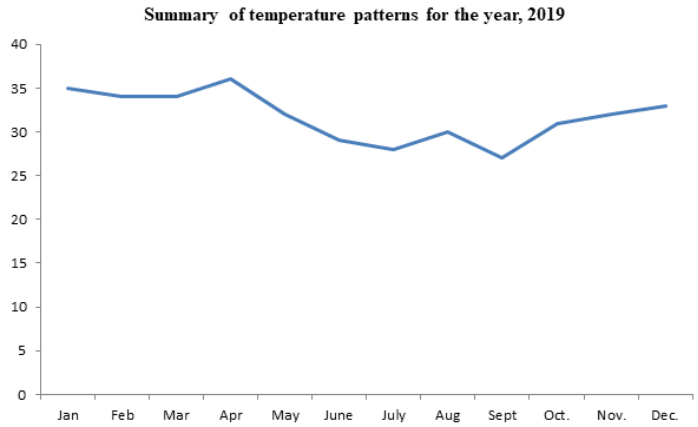


Figure 3: Designed with information on maximum temperature values in Table 4



Mitigation and Mitigation Strategies

According to National Aeronautics and Space Administration (NASA), 2018). Mitigation – reducing the flow of heat – trapping greenhouse gases into the atmosphere, either by reducing the sources of these gases or enhancing their "sinks" that accumulate and store these gases. Mitigation strategies, on the other hand, are measures created or established to help reduce the flow of heat-trapping greenhouse gases into the atmosphere either by reducing the sources of these gases or enhancing the "sinks" that accumulate and store

these gases. According to Recha, Kapukha, Wekesa, Shames and Heniner (2014), climate change mitigation can be achieved with the following measures:

Residue Management
This is the sound handling and utilization of plant and crop residues. It combines mulching, composting, integrative livestock and manure management and ideally leaves 30% or more of the soil covered with crop residues after harvest. This practice is helpful for mitigating climate change in that by avoiding burning of residues, avoids emissions of aerosols and greenhouse gases (GHGs) generated from fire. Burning of residues should be limited and carefully managed. A special form of residue management which is currently being promoted, especially, in the Kenyan context are "*trashlines*" which are made from crop residues, grasses and other organic materials collected from the field. They are constructed along the contour lines in order to slow down surface runoffs and in the process reduce soil erosion and gradually accumulate soil leading to the building of terraces along the contour.

Use of Improved Crop Varieties
These are crop varieties that have been developed through research and tested to have special qualities, such as fast-maturation rates, high yield, pests and diseases tolerant. These are helpful for climate change mitigation in that they can increase soil carbon or residues that can be managed to store carbon in the soil for a long period of time.

According to Oga (2015), climate change mitigation can be achieved by employing the following strategies:

Afforestation (Enhanced Tree Planting) This is the process of transplanting tree seedlings generally for forestry, land reclaiming purposes. Planting trees currently can provide immediate gains in productivity while also making the farm more resilient to a changing climate. Planting of trees for whatever purpose, will have some benefits in trapping atmospheric carbon. Native trees located around farm buildings can contribute toward the mitigation of air carbon pollutants including ammonia, a powerful GHG emitted from livestock units. Trees are able to intercept some of these emissions through dry deposition on the leaf and bark surfaces. Trees provide shade and minimize air temperature through evaporative cooling as a result of transpiration from leaves. In this wise, it should be noted that not any type of tree species should be planted. Recommended species in this regard are fast growing and maturing plant species such as Gmelina and leguminous shrubs and trees such as *Acacia, Gliricidia*, among others.

Establishment of Tree Shade and Shelter
Increasing summer temperatures will step up heat stress to housed are free – range livestock. Shade of trees minimizes air temperature through evaporative cooling as a result of transpiration from leaves. Using native deciduous frees provide very remarkable shading effect during the summer months, but allows available solar gain to benefit buildings and livestock during writer. In addition, shelter can have positive

impact on pasture growth and increase the food efficiency of outdoor and housed livestock through reduction in the wind child factor. A well designed shelter around the farm building and farms has the capability of reducing heating costs by 11 – 41 percent and lowering farm carbon emissions. The provision of shade and shelter for housing building and farm building can reduce energy consumption and GHG emissions.

Creation of Windbreaks (using fast growing leguminous plants and native deciduous plants or tree species)
Windbreaks are stripes of trees, shrubs and vines planted closely together along the edges of croplands perpendicular to winds. Fast growing leguminous plants e.g. *Gliricidiasepium*, can make fast or quick windbreaks while at the same time "store or sink" nitrogen in the soil. Plant materials removed as thinning from plantation or as coppice can be chipped and used to provide bedding for housed livestock. This can have cost advantages over straw and reduce the release of volatile nitrogen compounds into the air.

Creation of Farm Woodlands
A farm woodland can be referred to as a habitat where trees are not the dominant plant farms. It is made up of different plants of different species and of varying sizes and heights. A farm woodland is cultivated or planted and in some cases may be termed plantation. The plantation may be managed for a particular or various benefits among which are food, shelter and timber. Apart from these benefits, because of the varied structure of the farm woodland, it may act as a potential source of atmospheric carbon sequestration and in the process help to mitigating GHG emissions. The leguminous component of the farm woodland will help to store nitrogen in the soil thereby reducing N_2 emissions.

Conclusion
Climate change variation constitutes a major threat to the environment and biodiversity. It has adversely impacted natural resources, food security, human health, the environment, economic activity and physical infrastructure. The impacts are evident in the threats posed by drastic changes in temperature patterns among others. There is need to provide information and knowledge on these drastic changes in weather elements, especially on temperature patterns for guidance and encouragement in fashioning livelihood opportunities and even as it concerns agricultural production. The main objective of the study is to access data/information on temperature patterns and to accomplish some specific objectives. A major result of the study shows that there is rising temperature trend and this call for mitigation. Mitigation strategies among others include proper residue management through avoidance of burning, tree planting (afforestation), among others.

Recommendations
1. Creation of more awareness on the realities of global warming and climate change

2. Shifting of planting dates for some crops
3. Construction of water channels for irrigation activities during periods of droughts
4. Local weather stations should be established in rural localities to help produce information on current weather changes for farmers in support of NIMET other relevant stakeholders

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