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Climate Change Effect on Temperature Patterns and Implications for Agricultural Production

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Abstract

The Inter-government Panels on Climate Change (IPCC) and the United Nations Framework Convention on Climate Change (UNFCCC) have identified Climate Change as the greatest threat of the century and reported that earth's average temperature has risen by 0.74^{0}C. Furthermore, the present atmospheric concentration of carbon dioxide (CO_2) is 385 ppm (parts per million) far more than at any time in the last 650,000 years resulting in Climate Change or global warming. The purpose of this research was to access information/data on temperature patterns for the period (1988-2002) and for the period (2017-2018). The information/data accessed were analyzed using description statistics. The result shows that temperature values are high between the months of February and March and in the month of November. The result also shows that the month of February, often records the highest temperature values. Recommendations, among others, included those crops of short-day length should not be cultivated between the months of February and March and in the month of November and farmers as cooperatives, to construct water channels as source of irrigation during water scarcity.

Keywords: *Temperature patterns, Climate change, Agricultural production, Mitigation Strategies.*

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Background to the Study

Global warming, otherwise known as climate change, has been increasingly recognized as the greatest threat of the century (Pekins, 2010). This position is in line with that of the Intergovernmental Panel on Climate Change (IPCC) and the United Nations Framework Convention on Climate Change (UNFCCC) 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 carbondioxide (CO_2) is 385ppm (parts per million) for 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 plagues, 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 9 billion people will inhabit the earth by 2050, most of which live in developing countries (Perkins, 2010). As a result, the world is confronted with the roboust 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 (Onoja*, et al,* 2011)

Globally, Scientists have made efforts to divide the causes of global warming and climate change into two broad perspectives, natural and human causes. The natural causes are several including earth's orbital change, solar variations, volcanic eruptions and ocean currents. The human causes include burning of fossil fuels, land-use and deforestation (Onoje *et al.,* 2011). The effects of these causes manifest in rising sea levels, melting of ice caps, heat waves, violent downpours, animal metabolism, among others. The efforts by researchers, scientists as well as potential International Organization among which are (IPCC) and (UNFCCC) to identify these factors are widely acknowledged. The impacts of these varied factors, their interplay, synergy and tension on climate change, and the potential mitigation and adaptation strategies have widely been noted and discussed in several literatures. 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 an unprecedented rate and magnitudes with its apparent devastating effects. This calls for all hands to be on deck both at the international and local levels in order to come up with smart practices to help reduce GHGs emissions and subsequently mitigate global warming and climate change. Following this, the main objective of this research was to access data / information on temperature patterns for the periods (1988 – 2002) and (2017 – 2018) and to also accomplish some specific objectives and this informed the study.

Statement of the Problem

The Intergovernmental Panels on Climate Change (IPCC) and the United Nations Framework Convention on Climate Change (UNFCCC) 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 at any time in the last 650,000 years resulting in climate change or global warming. Both natural and human activities cause climate change.

These various causes have led to rising sea levels, melting of ice at the world's poles and on its mountains and violent downpours resulting in over flooding and submerging of coastal areas and consequent migration of animal species; heat waves resulting in desertification, depletion of water availability, reduced animal metabolism and agricultural food production, loss of biodiversity, food insecurity, decreased animal heat, among others. Some measures identified to have potentials to bring about climate change mitigation include the use of carbon capture and storage technology and trading plants for carbon as carbon tracking devises, breeding of fuzzy-leaved crops and irrigation as techniques for cooling the atmosphere. Strategies for climate change adaptation through a multi-dimensional and multi-sectoral approach have become imperative as a result of inequalities between developed and the developing nations in terms of limited capital resources and expertise.

The successes recorded so far through these efforts are encouraging but they have not been able to drastically reduce the rise in atmospheric temperature, hence the consequences abound, especially in the developing countries like Nigeria. Following this, there is need for conserted efforts to bring the atmospheric rise in temperature below 20^0C by 2050 in tandem with Copenhagen and Kyoto summits accord. It is also pertinent to adopt measures that would quickly help to reduced GHGs. The IPCC reported that the world average temperature has continued to rise but that the extent, duration and severity of its consequences will strongly depend on how quickly and effectively the greenhouse gases (GHGs) can be drastically reduced. This implies that all hands must be on deck both at the international and local levels to come up with quick more strategies to help reduced GHGs and subsequently mitigate global warming and climate change. The main objective of this research was to access information data on the temperature patterns for the periods (1988-2002) and (2017-2018).

Specific objectives include: to determine temperature pattern for the period (1988-2002); to determine the month(s) of maximum temperature values; to determine the temperature pattern for the period (2017-2018); to determine the month(s) of maximum temperature values for (2017-2018); to highlight temperature/light (sunlight or solar radiation) as Environmental factors that affect Agricultural production and to suggest mitigation strategies.

Materials and Method

Some materials used for this work National Root Crop Research Institute (NRCRI) Umudike. Umudike is located about 8km east of Umuahia town along Umuahia-Ikot, Ekpene road with latitude $05^0 29^1$N, longitude $07^0 33^1$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 only 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

The basic data required for this study include the temperature data for the period of (2017-2018) years. The data was from the Agromet Unit of the National Root Crop Research Institute Umudike Daily, month and yearly temperature patterns were collected from this unit for a period from 2017 to 2018. The other is data on temperature pattern for the period 1988 – 2002.

Temperature/Light (sunlight or solar radiation) as Environmental Factors that Affect Agricultural Production

According to Oga (2014), in Nigeria, temperature is not a limiting factor for agricultural production for it is general or even. For every crop there is an optimum temperature. The range is actually from 30-35^{0}C and the limit of tolerance to heat varies with crops and with their stages of growth. Nigeria is characterized by high temperatures. A low temperature is, therefore, not a limiting factor to crop growth and development. Some crops such as sorghum, millet or sisal are able to withstand high temperatures because they are resistant to drought. High temperatures and low humidity 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 bolls and fruit trees will drop their fruits prematurely when temperatures become too high, while high temperatures coupled with long sunshine hours will scorch pineapples. Tropical breeds of livestock are adapted to the high temperatures in Nigeria but the imported (exotic) temperature breeds usually do not perform well. This is because the high temperatures affect them adversely. Excessive heat 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. These results in 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. There are three aspects of light which are important to agricultural production and to the farmer, in particular. These are light *duration, light intensity* and *light quality.* Photo-periodism is the term used to refer to the response to light duration and timing of light and dark conditions. It is simply expressed as the response to light duration.

Light affects flowering in some plant species such plants are regarded as being photosensitive or periodic. Photosensitive plants have critical day length for flower production. Plants can be classified mainly as long day and short-day. Plants which are classified as long day plants require a period of long days for flowering and will not do well if the day length is always shorter than their critical day length. The long day plants are stimulated to flower when the day length is greater that the critical value which is about greater or less than (14 hours), as for example, African Spinach or Indian Spinach (green i.e. *Amaranthus*) and Irish Potato. When the days are short, these plants grow vegetative without flowering. Short-day plants, on the other hand, require a period of short days for flowering and will not do well if the day length is always longer than their critical day length. Short day plants are stimulated to flower when the day length is short, for instance, they are exposed to sunlight not exceeding or less than 10hours. Crops classified as short day plants include okra, corn, millet, sorghum, rice and some varieties of cowpea, soya beans, etc. When the days are long, vegetative growth, delayed flowering and leaf maturity will be enhanced. In other words, these crops mentioned above are photosensitive, they will grow vegetatively and will not produce flowers unless the critical day length is operative. As a result of this sensitivity to day lengths, attempts are usually made to grow varieties of crops that are day neutral. Day neutral crops are insensitive to day lengths. They can grow and thrive well when day lengths are long and when day lengths are short. Most tropical crops are however, day neutral. Examples here include cassava, banana, cocoa, rubber, cotton and sunflower.

Results and Discussion

Patterns of temperature average 14 years from (1988-2002).

Table 1: Summary of Monthly Distribution of Temperature

(Maximum air temperature(^{0}C) average over 14 years

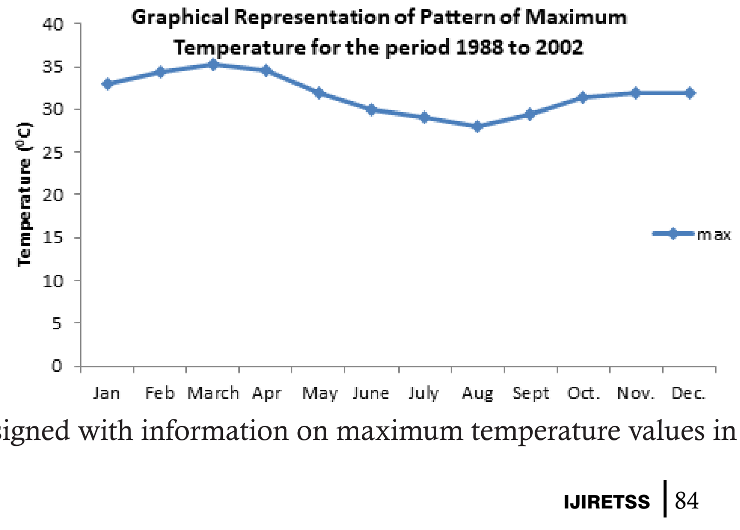
Months	Jan	Feb	March	Apr	May	June	July	Aug	Sept	Oct.	Nov.	Dec.
min	30	31.1	28.8	30.6	28.9	27.3	26.1	25.9	26.1	27.8	29.4	30
max	33	34.4	35.2	34.6	32	30	29	28	29.5	31.3	32	32
mean	31.8	33.3	32.1	32.1	28.6	28.6	27.3	26.9	27.9	29.2	30.6	31

Table 1 shows temperature trends for fourteen (14) years from 1088 – 2002. These trends in temperature show rising patterns from the month of January to the month of April after which it started to drop down to the month of August. After the month of August, it started to rise from the month of September to the month of December. These temperature pattern for the period is represented in Fig. 1.

Determination of the month(s) of maximum temperature values for the period (1988-2002).

Table 1 shows temperature values recorded for the period (1988 – 2002). Temperature values of 33^{0}C, 33.4^{0}C, 35.2^{0}C and 34.6^{0}C were recorded in the months of January, February, March and April respectively, see Figure 1. The maximum temperature value for this period was recorded at the value of 35.2^{0}C in the month of March and the mean temperature value of 31.8^{0}C.

Fig 1: Pattern of maximum temperatures for the period 1988-2002



Source: Designed with information on maximum temperature values in Table 1

Patterns of temperature for the period (2017 – 2018)

Table 2: Summary of Monthly Distribution of Temperature

(Maximum air temperature(^{0}C) for 2017

Months	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct.**	**Nov.**	**Dec.**
min	23.4	24.2	24.6	24.2	23.7	23.5	29.4	23.1	22.7	23.6	23.5	23.5
max	33.3	34.8	34.9	33.1	32	31.6	29.5	28.7	29.8	30.9	32	33.5
mean	28.5	29.5	29.5	28.5	28	27.5	29.5	26	26.5	27.5	28	29

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

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

(Maximum Air Temperature) for the year, 2018

Months	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**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

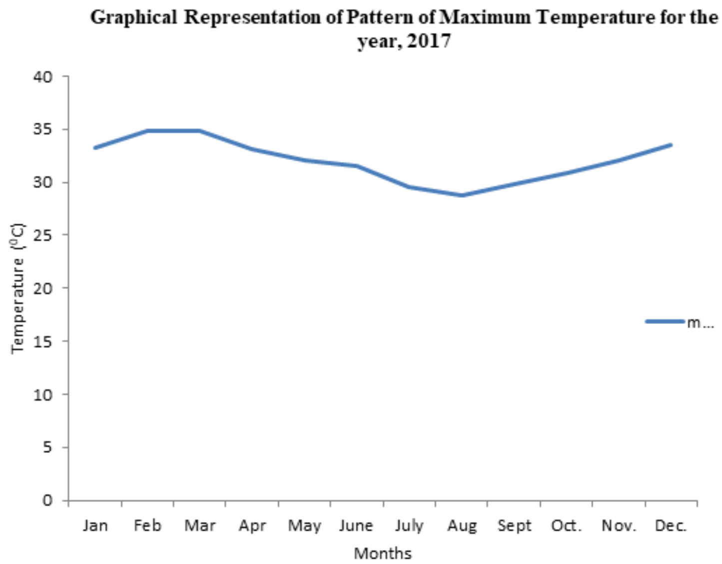
Source: Agromet Unit of National Root Crops Research Institute (NRCRI) Umudike, Abia State

Tables 2 and 3 show temperature patterns for the period 2017-2018. The patterns show a more rising nature of temperature values from the months of January to March and in the month of December in the year, 2017. In the year, 2018, the months of January, February, March, April and December recorded higher temperature values than in the year, 2017.

Determination of the month(s) of maximum temperature values for the period 2017-2018.

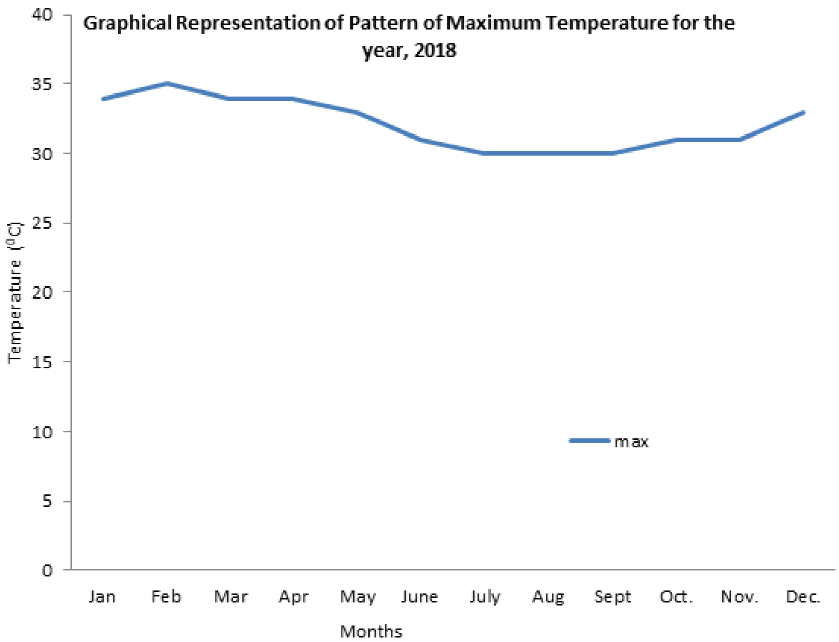
Tables 2 and 3 show more growing temperature values compared to temperature values in Table 1. Table 2 shows that high temperature values of 33.3^{0}C, 34.8^{0}C and 33.1^{0}C were recorded in the months of January, February and March respectively in the year, 2018. This growing trend in temperature is also observed in Table 3 where values of 34^{0}C, 35^{0}C and 34^{0}C were recorded for the months of January, February and March respectively in the year, 2018. The highest maximum temperature value recorded for the periods covered (2017-2018) was 35^{0}C as compared to maximum temperature value of 35.2^{0}C average from 1988-2002.Despite this very dismal difference in temperature values, the trend in temperature for the periods covered shows increasing temperature patterns. See Figures 2 and 3. These increasing temperature trends are in agreement with the position of Nwaiwu *et al.,* (2014), that the temperature of the planet earth is on the increase. These increasing trends in temperature are also in agreement with the position of (IPCC, 2018).With the foregoing therefore, it is pertinent to state here that these rising or growing patterns of temperature have gone beyond the usual temperature patterns which used to be favourable for most crops in depended of, whether they are long day or short day crop(s). Farmers have lost farm inputs and produce consequent on lack of information or knowledge about these changes in temperature patterns and need to know about the changes in order to be adequately equipped to forestall future farm losses. This is where agricultural extension education or services is very relevant so as to provide farmers with information and knowledge on smart agricultural practices. This will help guide them in the planning of farming activities in order to forestall future losses on the farm. This is where coping, adaptation or mitigation strategies are necessary.

Fig 2: Pattern of maximum temperatures for the year, 2017



Source: Designed with information on maximum temperature values in Table 2

Fig 3: Pattern of maximum temperatures for the year, 2018



Source: Designed with information on maximum temperature values in Table 3

Implications for Agricultural Production

Based on the two preceding scenarios, and with the information or results in Tables 1, 2 and 3, showing high temperature values in the months of January, February and March, the implication here is that crops classified as long day will perform favourably well and should be cultivated during this period. African Spinach, for example, a long day crop should be cultivated. If, for instance, the seed is required by the farmer for future propagation, the plant should be cultivated from the month of December to March for proper seed production consequent on critical day length and using irrigation sources. On the other hand, if the leafy part of the plant is required by the farmer, it should be cultivated after these months i.e., from the month of May up to the month of July. This leafy part of the plant is an important source of food, vitamins, etc., for both humans and livestock.

Another implication of this is that short day crops should not be cultivated during this period. Rather, day neutral crops may be cultivated, if there is adequate source of water or irrigation.

In the case of livestock, enterprises such as poultry, piggery, especially, and among others, should not be reared during this period of very high temperatures. This is because the high temperatures affect some of them adversely, resulting in heat stress and even death. This position is in agreement with Tasie *et al.,* (2014) that heat stress reduces human labour use on farms, lowers labour productivity, lowers livestock productivity and leads to rapid deterioration and waste of farm produce. Excessive heat as a result of high temperatures increase metabolism of some livestock, e.g., exotic temperate breed making it dissipate heat by panting and also reduces the period spent in grazing (Oga, 2014). The implication of this is that it will result in reduced growth rate and lowered milk yield because of the reduced feed intake. Another implication here is that, if these animals should be reared, there should be provision of adequate shade of trees or under heat proof roofs with adequate provision of water.

Mitigation/Mitigation Strategies

Mitigation refers to any activities that reduce the overall concentration of greenhouse gases (GHGs) in the atmosphere. Temesegen *et al.* (2014) and Shanaham *et al.,* (2013). Mitigation – reducing climate change-involves 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 (National Aeronautics and Space Administration (NASA, 2018). Mitigation strategies on the other hand, are measures put in place 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 Nwaiwu *et al.,* (2014), climate change mitigation strategies are as the following:

Agroforestry

This is a collective name for land use systems and practices in which woody perennials are deliberately integrated with crops and/or animals on the same land management unit. The integration can be either in a spatial mixture of or in a temporal sequence. Agroforestry is helpful for climate change mitigation in the following ways:

(i) Agroforestry trees store carbon.
(ii) The soils of agroforestry system contain significant quantities carbon. Generally the amount of carbon stored in a system's soil remains steady, increasing slowly with time.

Residue Management

This is the sound handling and utilization of plant and crop residues. It combines mulching, compositing, 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 mitigation of 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 that is currently being promoted, especially, in the Keyan context are "*trashline*", which are made from crop residues, grass and other organic materials collected from the field. They are constructed along the contour line in order to slow down surface runoff and reduce soil erosion and gradually accumulate soil leading to the building of terraces along the contour.

Farming on Already Cleared Farmland

This is associated with trading plants for carbon in order to prevent carbon emission which is a precursor of carbon dioxide CO_2.According to Pekins (2010), it has been advocated that in the tropics, a complex trade-off exists between expanding agriculture and keeping carbon locked up on the land. This position is in agreement with Pekins (2010) who advised that farmers particularly those in the tropics should focus on boosting crop yields on already cleared land to prevent carbon emissions. This is because in the tropics, farmers engage in bush-burning and other farming practices that boost carbon dioxide emissions.

Massive Irrigation System

This is associated with induced cooling through irrigation. According to Pekin (2010), research has demonstrated that through enhanced evaporation, irrigation cools the earth's surface and provides a counter balance to global warming, particularly in the higher latitudes but additional warming from the tropics, if not checkmated, is capable of throwing that balance off-kilter. According to Onoja *et al*., (2011) African countries particularly, Nigeria, should take advantage of their vast agricultural land to engage in massive irrigation system of agriculture so as to benefit from the irrigation-induced cooling. Accordingly, expansion of various River Basins and FADAMA projects in Nigeria are apt in this regard (Onoja *et al.,* 2011).

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 yields pests' diseases tolerance. 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.

Conclusion

Climate change has caused rising trend in global temperature and this has impacted various weather elements, among which is temperature and human endeavors and it calls for mitigation measures. Consequently, the main purpose of the research was to access data / information on temperature patterns for two distinct periods (1988 – 2002) and (2017 – 2018) and to also accomplish some specific objectives. The temperature pattern, to a large extent determines the scenario of agricultural production. Currently, the nature of temperature in relation to agricultural production is not encouraging due to the influence of global warming and climate change. In order that agriculture continues to play its role as the backbone of a nation's economy, global warming and subsequently climate change need to be mitigated and strategies to be employed in this regard include, among others, creating adequate awareness to the public and especially farmers on the realities of the current changing patterns of temperature, cultivating more of the day neutral crops, shifting planting dates of some crops and avoid setting fire on cut down vegetation or trashes on the farm to reduce the emission of $CO_2$to the atmosphere.

Recommendations

i. More awareness should be created on the realities global warming and climate change and on the current temperature patterns.
ii. Farmers should be advised to shift the planting dates of some crops following the current temperature patterns.
iii. Farmers should cultivate more of day neutral crops.
iv. Farmers should cultivate cover crops as "must crops" during the farming seasons.
v. Farmers through co-operative efforts should construct water channels (irrigation) for use on the farms during periods of high temperatures and water scarcity.
vi. Local weather stations should be established in rural localities to help provide information to farmers on current weather changes, especially, as it concerns temperature patterns.

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