



Science

THE EFFECTS OF CLIMATE CHANGE ON FOOD CROP PRODUCTION IN NORTHERN NIGERIA

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Abstract

The Earth's temperature is rising as a result of increased atmospheric concentrations of greenhouse gases. As the Earth warms, currently wet regions are expected to receive more rainfall, and currently dry regions receive less. Nigeria and indeed Northern Nigeria is not an exception. Crop production is one of the most vulnerable systems and heavily affected by climate change in Nigeria and more particularly in the Northern part of the country where the presence and prevalence of drought is mostly felt. Crops are mostly flooded and are rendered less productive by flood, in addition to extensive dependence on rainfed farming coupled with high poverty level of the people of the region. Major crops cultivated in the region include groundnuts, beans, cotton, soybeans, sesame, cashew nuts, mango, cassava, yam, gum arabic, maize (corn), melon, millet, , plantains, rice, sorghum, bananas, yams, pepper, coffee, carrots, sugarcane, soybeans, with major producing states of soybeans as Kaduna, Niger, Kebbi, Nasarawa, Kwara, Jigawa, Taraba, Borno, Benue, Bauchi, Sokoto, Plateau, Zamfara and Abuja FCT are now facing yield depreciation. Most of these crops are facing problems such as flower abortions, wrong flowering and fruiting time and generally low yields due to the effects of climate change. As rainfall becomes more variable, farmers no longer are able to rely on their knowledge of the seasonality of climatic variables. It is recommended that, series of awareness in terms of seminars, symposiums, farmers field days should be conducted to the farmers to enlighten them on the knowledge of modern techniques of crop production, such as the use of early maturing seeds, drought resistance varieties and more especially the use of irrigation in order to boost crop production in the region. Weather focused information should be made available to the farmers in the form of short message (SMS) in addition to informing them on weather both in print media.

Keywords: Climate Change; Northern Nigeria; Flood and Crops.

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1. Introduction

The Earth's temperature is rising as a result of increased atmospheric concentrations of greenhouse gases. If greenhouse gas (GHG) emissions continue increasing at a high rate (essentially business-as-usual), climate models predict that global warming could increase 4.7-8.6° F above 2005-2025 levels by the end of the century.

As the Earth warms, currently wet regions are expected to receive more rainfall, and currently dry regions receive less, although there will be exceptions and there is considerable uncertainty on how and how much climate change will affect specific locations. Nigeria and indeed Northern Nigeria is not an exception.

Crop production is one of the most vulnerable systems and heavily hit by climate change in Nigeria and more particularly in the Northern part of the country where the presence and prevalence of drought is mostly felt, crops are mostly flooded by flood, extensive dependence on rainfed farming coupled with high poverty level, the crop grown could not sustain the needs of the increasing population of people in the region. Agriculture is one of the most unique instruments of growth, development and poverty reduction if properly harnessed. It also contributes greatly to the development of the economy of nation, the livelihood of the citizens and other services; but it is now being treated by climate change. FAO, (2007), stated that, climate change is marked with increased intensity and frequency of storms, drought and flooding, altered hydrological cycles and precipitation variance which have implications on future food availability. These are what is now experiencing in the northern part of Nigeria.

Even though, climate change may actually benefit some plants by lengthening growing seasons and increasing carbon dioxide. Yet other effects of a warmer world, such as more pests, droughts, and flooding, will be less benign. Using an aggressive climate model known as HadGEM2, researchers at the International Food Policy Research Institute projected that by 2050, suitable croplands for four top commodities—corn, potatoes, rice, and wheat—will shift, in some cases pushing farmers to plant new crops. These are also the major crops produced in northern part of Nigeria facing low yield due to the desertification which is an impact of climate change in the region.

Climate alone doesn't dictate yields; political shifts, global demand, and agricultural practices will influence how farms fare in the future. Crop yield analysis, spatial analysis, and agricultural systems analysis are the three main approaches for studying the "Implications of a Global Climatic Warming for Agriculture," according to Bullock, *et al.* (1995). Crop yield analysis estimates the effects of altered environments on crop productivity levels and has been employed widely in climatic impact assessments. Spatial analysis examines the implications of climatic warming on the area and location of lands suitable for agricultural production. Agricultural systems analysis assesses the impacts of climatic change on multiple agricultural activities and on the functioning of the agri-food sector, including prices, trade pattern, and employment.

Climate change is a growing threat to the agriculture sectors. The negative effects on agricultural production and livelihoods of farmers, foresters and fisher folk are already being felt in many places, more especially under the area under study; they will only get worse overtime. Unless climate change is addressed, agricultural productivity will decline with serious implications for

food security. Millions of low-income people will be at risk of hunger and poverty. The agriculture sectors also contribute to climate change due to their emissions of greenhouse gases. In the Paris Agreement on climate change, which was concluded in December 2015, the international community has recognized the need for urgent action and the role of the agricultural sectors in addressing this challenge. It is essential that the country pledges that formed the basis of the 2015 Paris Agreement on climate change are turned now into action. West Africa's rich soil and abundant water may support more rice if action is taken on time. Parts of East Africa are also believed to have great potential to expand production.

The Sahel climate or tropical dry climate, is the predominant climate type in the northern part of Nigeria. Annual rainfall totals are lower compared to the southern and central part of Nigeria. The rainy season in the northern part of Nigeria last for only three to four months (June–September) and very erratic.

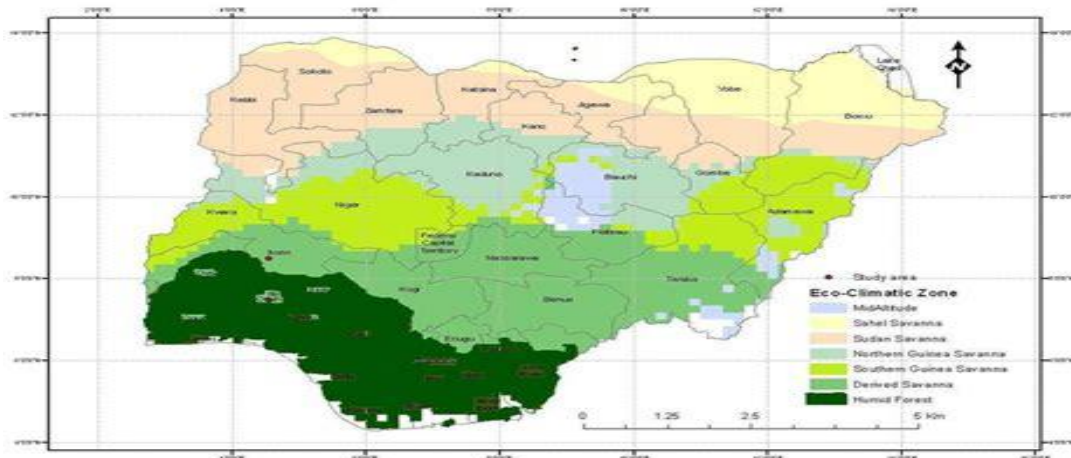
The tropical savanna climate or tropical wet and dry climate, is extensive in area and covers most of Western Nigeria to central Nigeria beginning from the Tropical rainforest climate boundary in southern Nigeria to the central part of Nigeria, where it exerts enormous influence on the region. This climate, the tropical savanna climate exhibits a well-marked rainy season and a dry season with a single peak known as the summer maximum due to its distance from the equator. Temperatures are above 18 °C (64 °F) throughout the year. Abuja, Nigeria's capital city found in central Nigeria, has a temperature range of 18.45 °C (65.21 °F) to 36.9 °C (98.4 °F), and an annual rainfall of about 1,500 mm (59.1 in) with a single rainfall maxima in September.

The single Dry season experienced in this climate, the tropical savanna climate in central Nigeria beginning from December to march, is hot and dry with the Harmattan wind, a continental tropical (CT) airmass laden with dust from the Sahara Desert prevailing throughout this period.

With the Intertropical Convergence Zone (ITCZ) swinging northward over West Africa from the Southern Hemisphere in April, heavy showers coming from pre-monsoonal convective clouds mainly in the form of squall lines also known as the north easterlies formed mainly as a result of the interactions of the two dominant airmasses in Nigeria known as the Maritime tropical (south westerlies) and the Continental tropical (north easterlies), begins in central Nigeria while the Monsoons from the south Atlantic ocean arrives in central Nigeria in July bringing with it high humidity, heavy cloud cover and heavy rainfall which can be daily occurrence lasting till September when the monsoons gradually begin retreating southward to the southern part of Nigeria. Rainfall totals in northern Nigeria varies from 1,100 mm (43.3 in) in the lowlands of the river Niger Benue trough to over 2,000 mm (78.7 in) along the south western escarpment of the Jos Plateau.

Climatic zones of Northern Nigeria: Major crops cultivated in the region include groundnuts, beans, cotton, soybeans, sesame, cashew nuts, mango, cassava, yam, gum arabic, maize (corn), melon, millet, , plantains, rice, sorghum, bananas, **yams, pepper, coffee, carrots, sugarcane and soybeans, with** major producing states of soybeans as Kaduna, Niger, Kebbi, Nasarawa, Kwara, Jigawa, Taraba, Borno, Benue, Bauchi, Sokoto, Plateau, Zamfara and Abuja FCT are facing problems of yield reductions. Most of these crops are facing problems such as flower abortions, wrong flowering and fruiting time and low yields due to the effects of climate change.

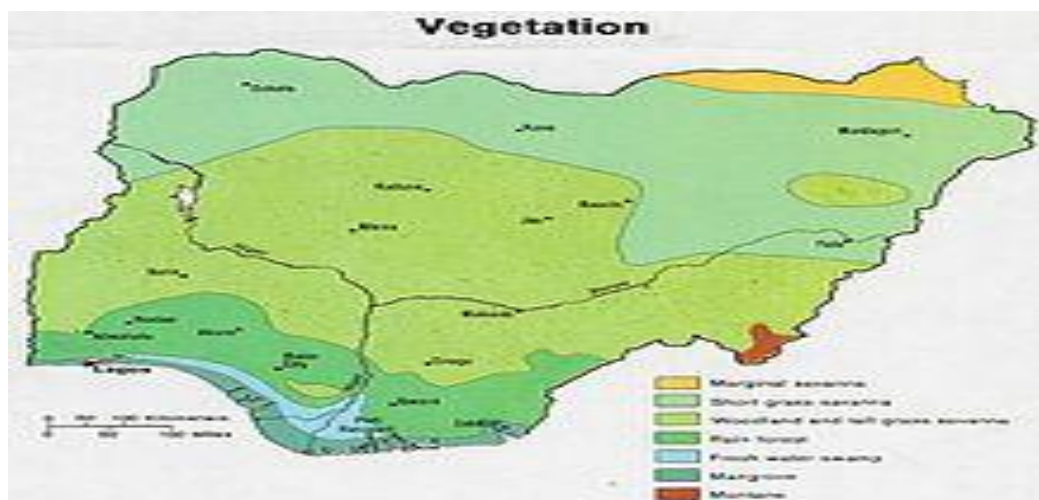
Map of climatic zones of Northern Nigeria.



Source: https://en.wikipedia.org/wiki/file-Nigeria_vegetation. Retrieved 24th September, 2018.

The Sahel climate or tropical dry climate, is the predominant climate type in the northern part of Nigeria. Annual rainfall totals are lower about 120 – 130 cm, compared to the southern and central part of Nigeria with 180cm – 430cm from the eastern to the coastal part of the country. The rainy season in the northern part of Nigeria last for only three to four months (June–September). Average rainfall about 120 – 130 cm. The rest of the year is hot and dry with temperatures climbing as high as 40 °C (104.0 °F) and also a dry season from November to March, with midday temperatures that rise above 38° Celsius (100° Fahrenheit) but relatively cool nights, dropping as low as 12° Celsius (54° Fahrenheit).

Vegetation in The Northern Part of Nigeria: Th vegetation of northern Nigeria is divided into three zones or categories thus: the three categories are divided into, Guinean forest-savanna mosaic, made up of plains of tall grass which are interrupted by trees, the most common across the country; Sudan savannah, similar but with shorter grasses and shorter trees; and Sahel savannah patches of grass and sand, found in the northeast.



Vegetation map of Nigeria.

Source: https://en.wikipedia.org/wiki/file-Nigeria_vegetation. Retrieved 24th September, 2018.

2. How Agriculture and Climate Change are Related: Causes and Effects.

Agriculture and climate change are deeply intertwined. The effects of global warming on food supply are dire, whilst world population is increasing. It's time to change the way agriculture affects the environment, and vice versa.

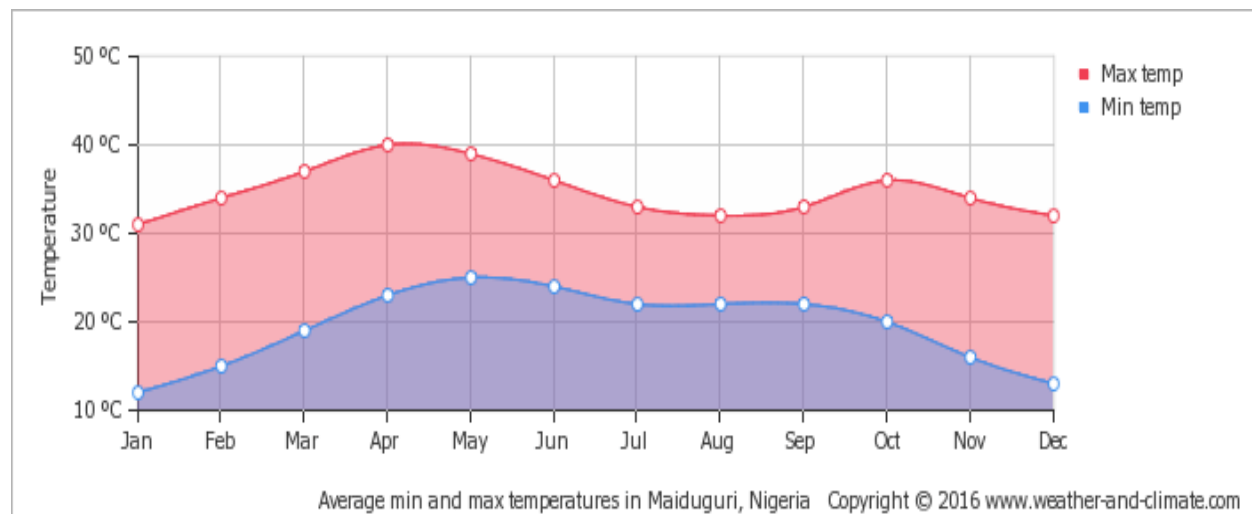
The relationship between agriculture and climate change is problematic to say the least, and it is putting food safety at risk. Using the “which came first, the chicken or the egg?” question as an analogy, it is difficult to understand exactly when this conflict began. Over time, has the effect of global warming on agriculture and food supply been to decrease crop production or has intensive agriculture contributed to climate change by causing average global temperatures to increase thus;

- 1) the world population is increasing,
- 2) the effect of climate change on crop production is also becoming glaring and,
- 3) the crops grown are not meeting the demands and needs of the increasing population growth.

Therefore, efforts has to be made in order to meet the demand of the increasing population, especially in the northern part of Nigeria.

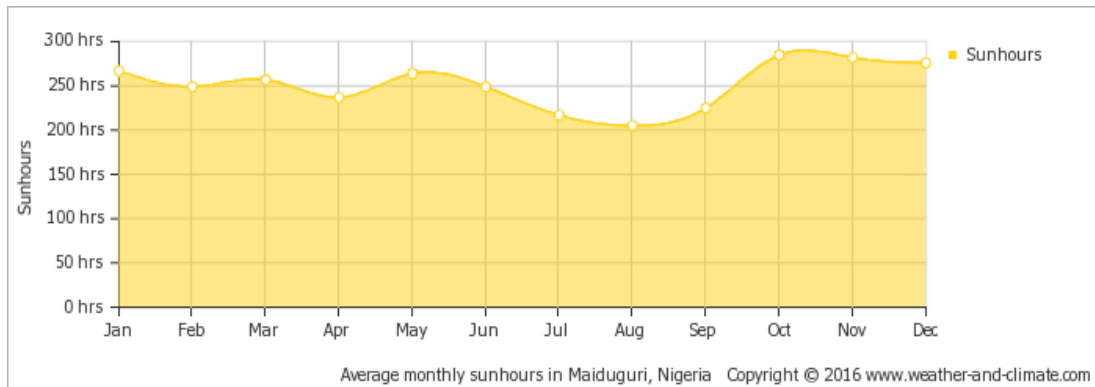
Average Monthly Weather in Maiduguri, Northern Nigeria: In Maiduguri, norther Nigeria, on the average, the temperatures are always high, most rainfall (rainy season) is seen in April, May and August. Dry periods are January and July and averagely, the warmest month is April and the coolest month is January. August is the wettest month while July is the driest month. These also has a serious effect on the type of crops grown in the area due to low rainfall, high sunshine and the vagaries of climate change.

Average Minimum and Maximum Temperature Over the Year: The monthly mean minimum and maximum daily temperature; in **Fahrenheit** are also presented below:



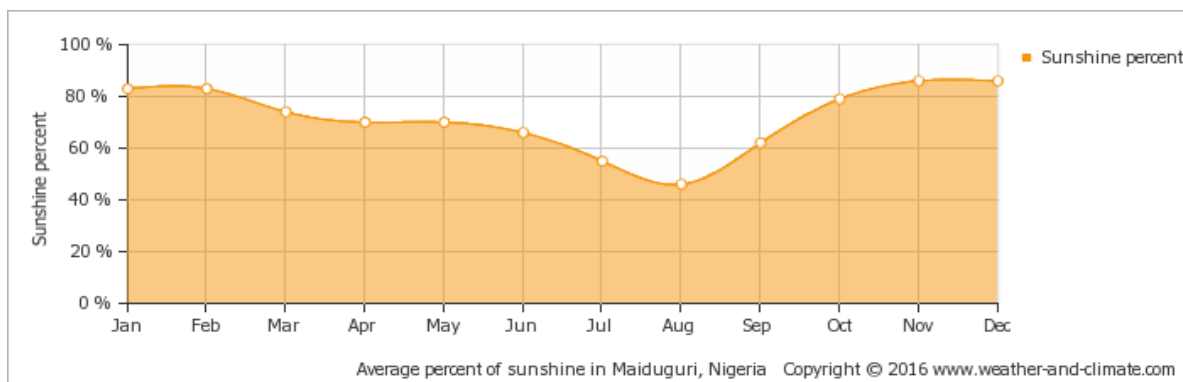
Source: <https://weahter -and- climate.com/average- monthly- rainfall-temperature-sunshine-Maiduguri-Nigeria>.

Average Monthly Hours of Sunshine Over the Year: This is the monthly total of sun hours



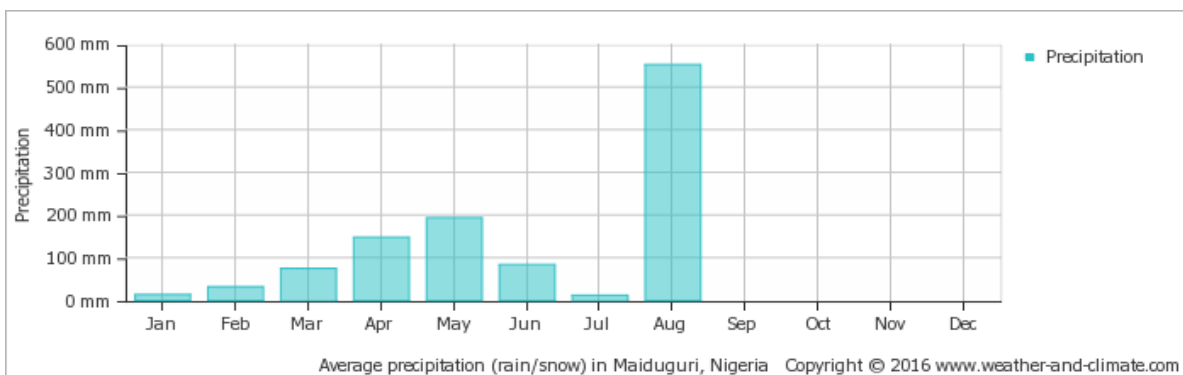
Source: <https://weather-and-climate.com/average-monthly-rainfall-temperature-sunshine-Maiduguri-Nigeria>.

Average Percent of Sunshine Over the Year: This is the mean percent of sun hours during the day



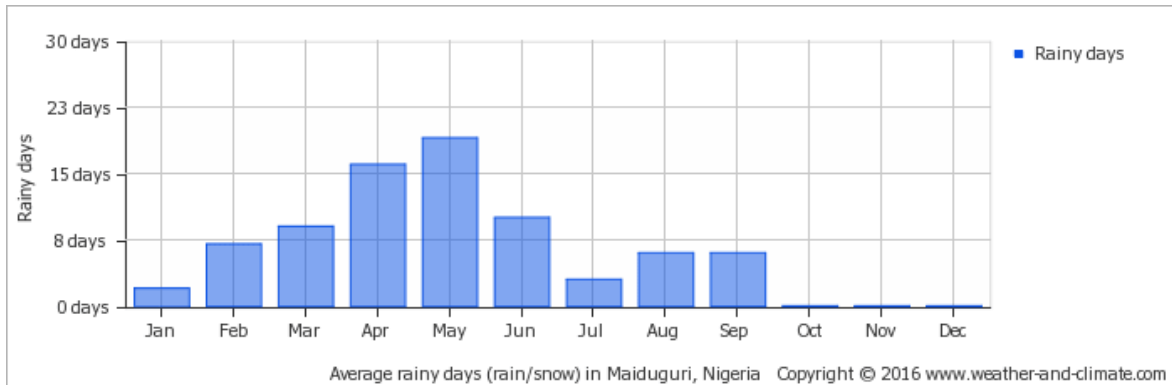
Source: <https://weather-and-climate.com/average-monthly-rainfall-temperature-sunshine-Maiduguri-Nigeria>.

Average Monthly Precipitation Over The Year (Rainfall, Snow): This is the mean monthly precipitation.



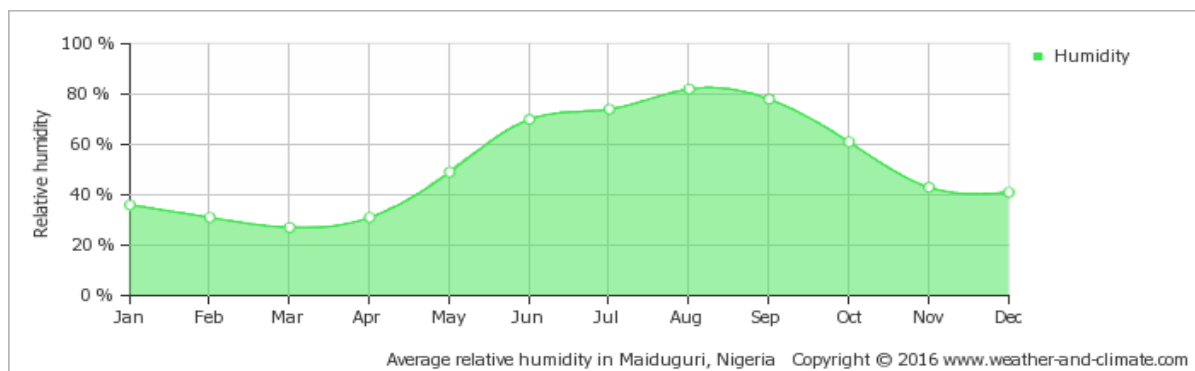
Source: <https://weather-and-climate.com/average-monthly-rainfall-temperature-sunshine-Maiduguri-Nigeria>.

Average Monthly Rainy Days Over the Year: This is the number of days each month with rain and snow.



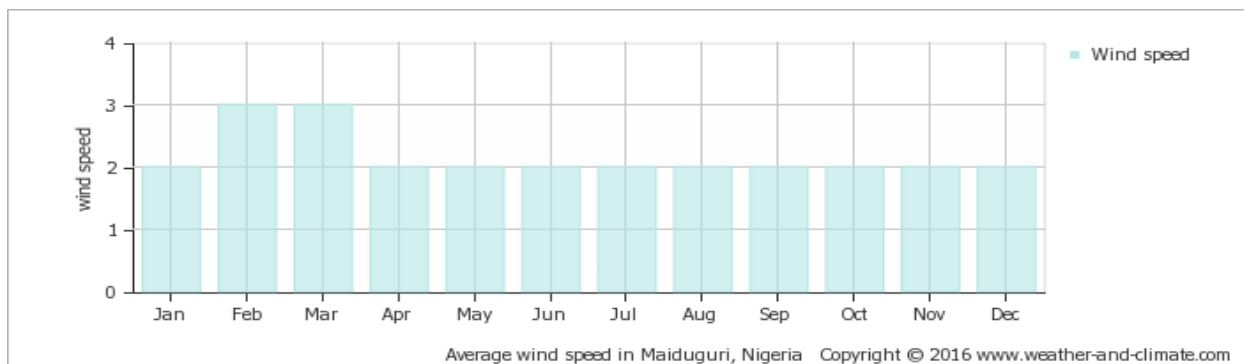
Source: <https://weather-and-climate.com/average-monthly-rainfall-temperature-sunshine-Maiduguri-Nigeria>.

Average Humidity Over the Year: This is The Mean Monthly Relative Humidity



Source: <https://weather-and-climate.com/average-monthly-rainfall-temperature-sunshine-Maiduguri-Nigeria>.

Average Wind Speed Over the Year: This Is the Mean Monthly Wind Speed (Meters Per Second)



Source: <https://weather-and-climate.com/average-monthly-rainfall-temperature-sunshine-Maiduguri-Nigeria>.

The World Population is Increasing: Population increase is a determining factor that must be immediately taken into consideration if we wish to gain a clearer picture of this dichotomy. The world population is in fact rapidly increasing and according to the United Nations Department of Economic and Social Affairs (UN/DESA) it could increase to 9.7 billion people by 2050, compared to today's 7.5 billion. At the same time, crop yields, mainly grain and corn, could decrease by 50 per cent over the next 35 years because of altered climatic conditions. A risk we must avoid and prevent, especially at this moment in history in which the number of people affected by famine is slightly decreasing. There are nearly 795 million people who regularly still don't have enough food to eat, The State Of Food Insecurity In The World 2015 report by the International Fund for Agricultural Development (IFAD) and World Food Programme (WFP) calculates. This number was 1 billion in 1990-1992. This is a serious indicator that needs to be addressed squarely especially in areas like the northern part of Nigeria.

3. The Effect of Climate Change on Crop Production: How is Climate Related to Agriculture.

“Climate change is acting as a brake. We need yields to grow to meet growing demand, but already climate change is slowing those yields,” Michael Oppenheimer, professor at Princeton University and co-author of the fifth report by the IPCC (Intergovernmental Panel on Climate Change, which brings together scientists from all around the world); reported that, the scientific community came together to point out that decrease in crop yields is already taking place due to global warming. Global climate change influences all aspects of our daily lives, and it will for many years to come. The challenge for each individual, institute, company and government is to not only identify the risks but also adapt and mitigate the effects to ensure a future for all on planet Earth. Although not all effects of climate change may turn out negative, most sectors will need to find ways to deal with the effects. Areas at high risk are agriculture and food security.

How Does Agriculture Contribute To Climate Change: At the same time, agriculture – especially intensive agriculture, characterized by monocultures and aimed at feeding farm animals – is one of the sectors that generates the highest amount of emissions of CO₂ (the main greenhouse gas). This quantity can be compared only to the sum total of the CO₂ emitted by all forms of transportation.

By looking deeper, we can observe that agriculture and the deforestation it causes were responsible for one fifth (21 per cent) of all CO₂ emissions in the decade from 2000 to 2010 (approximately 44 billion tons). This occurs because agriculture needs an increasing amount of space alongside massive amounts of chemical fertilizers now that the demand for meat and its products has increased dramatically in developing countries. This is damaging forests, which in turn would be able to absorb CO₂ and mitigate anthropic (man-made) emissions. A vicious cycle that makes agriculture both a victim (given the negative effects of global warming on food supply) and a perpetrator (one of the main causes of climate change).

Most of the time, when agriculture perpetrates its crimes, it isn't even contributing to feeding the ever-increasing world population. In fact, 95 per cent of the soy produced in the world is consumed by farm animals – mostly bovines – which demonstrates this conflict. Also, according to a study conducted by the Chalmers University of Technology in Goteborg, Sweden this means that

producing one kilograms of bovine meat require 200 kilos of CO₂ emissions. There are 700 million pigs in China alone, one for every two citizens, half of the global population of farm pigs. In order to feed these animals, forced to live in cages inside industrial warehouses, Beijing imports 80 million tons of soy, especially from Latin America and more specifically from the Brazilian Amazon where endless fields of soy are destroying one of the most biodiverse places in the world. One of the world's green lungs.

Agriculture and Climate Change: The Food and Agriculture Organization (FAO) 2016a, seems to have a clear idea of what should be done and is promoting sustainable practices in various countries through agroecology. This is a series of social and environmental measures aimed at creating a sustainable agricultural system that optimizes and stabilizes crop yields. These practices also tackle the effects of climate change, such as desertification and the rise in sea levels, and among them organic agriculture plays an essential role as it respects natural cycles, drastically reducing human impact.

According to the latest Eurostat data, from 2010 to today organic agriculture in Europe has grown by 2 million hectares, reaching a total of 11 million hectares of land (more than 6 per cent of the European total). If we want to continue the comparison with China – which was until recently one of the least evolved countries with regards to organic practices – this type of agriculture occupies 1.6 million hectares and generates 4.7 billion euros, according to data presented by Federbio, the Italian Federation of organic and biodynamic agriculture.

How Does Agriculture Affect the Environment? Eating Habits Matter, Especially in Europe
Agriculture and Climate Change. Concluding our world tour in the Old Continent, the aforementioned Chalmers University of Technology in Goteborg points us in a specific direction so that we can meet the CO₂ emission reduction targets set by the European Union: we must eat less bovine meat and dairy products. We can't protect the environment without changing our eating habits. Agricultural industries and intensive farming are in fact responsible for about one quarter of CO₂ emissions in Europe.

The Paris Agreement has set a clear objective: limiting the global temperature rise to “well below 2 degrees Celsius”, and to do everything in our power to “limit the temperature increase to 1.5 degrees”. In addition to the impact of energy (we of course can't ignore the terrible damage caused by fossil fuels combustion), making agriculture and all the activities connected to it sustainable is the answer to win the battle against global warming, as well as accelerate the transition to a healthier and more just society.

Impact of Climate Change on Crop Production: Crop production is highly sensitive to climate. It is affected by long-term trends in average rainfall and temperature, interannual climate variability, shocks during specific phenological stages, and extreme weather events (IPCC, 2012). Some crops are more tolerant than others to certain types of stresses, and at each phenological stage, different types of stresses affect each crop species in different ways (Simpson, 2017). The same trend is visible in the north.

Changes in Precipitation Regimes: Changes in precipitation regimes include changes in seasonal mean, the timing and intensity of individual rainfall events, and the frequency and length of

droughts. Each of these factors is critical to crop productivity. The impact of changes in precipitation will be particularly marked when they are combined with temperature alterations that affect the crop's evaporative demands. This may lead to different forms of moisture stress depending on the phenological stage the crop has reached.

As rainfall becomes more variable, farmers may no longer be able to rely on their knowledge of the seasonality of climatic variables. Shifting planting seasons and weather patterns will make it harder for farmers to plan and manage production. For example, a later start of the rainy season or an earlier end, or both, reduces the time that crops have to complete their growth cycle and, ultimately, causes yield losses (Linderholm, 2005). For photosensitive species, a change in the duration of the rainy season may cause a mismatch between their reproductive cycle, which is determined by day length, and the availability of sufficient soil moisture to produce good yields. Another expected impact of climate change is an increased occurrence of extreme weather events. Even where mean values for precipitation are not projected to change, there are likely to be more significant extreme weather events that will reduce crop yields. Heavy rain, hail storms and flooding can physically damage crops. Extremely wet conditions in the field can delay planting or harvesting. Prolonged droughts can cause complete crop failure (Tubiello and van der Velde, 2010).

The specific impacts of changes in precipitation regimes on crops vary significantly because around 80 percent of the cropped area is rainfed and produces 60 percent of world's food (Taub D., *et al.*, 2008).

Crop yield analysis, spatial analysis, and agricultural systems analysis are the three main approaches for studying the "Implications of a Global Climatic Warming for Agriculture," according to Lipiec, J; *et al* (2013). Crop yield analysis estimates the effects of altered environments on crop productivity levels and has been employed widely in climatic impact assessments. Spatial analysis examines the implications of climatic warming on the area and location of lands suitable for agricultural production. Agricultural systems analysis assesses the impacts of climatic change on multiple agricultural activities and on the functioning of the agri-food sector, including prices, trade pattern, and employment. These are directly related with the climatic trends in the northern part of Nigeria.

In *Climate Change and World Agriculture*, Parry L.M; (1990) sketches a broad picture of the effects of climate change in the "Effects on Plants, Soil, Pests and Diseases." He argues that the effects of carbon dioxide (CO₂) enrichment, without associated changes in climate, would probably be beneficial for agriculture. Higher temperatures, however, could increase the rate of microbial decomposition of organic matter, adversely affecting soil fertility in the long run. Also, studies analyzing the effects on pests and diseases suggest that temperature increases may extend the geographic range of some insect pests currently limited by temperature.

Rosenzweig, C and Hillel, D. (1998) compare temperate and tropical regions in "Predicted Effects of Climate Change on Agriculture." The regions differ significantly, both in the biophysical characteristics of their climate and soil and in the vulnerability of their agricultural systems and people to climate change. An analysis of the biophysical impact of climate changes associated with

global warming shows that higher temperatures generally hasten plant maturity in annual species, thus shortening the growth stages of crop plants.

The U.S. Environmental Protection Agency is expected to publish crop modeling studies conducted in 18 countries. These studies, which Rosenzweig *et al.* (1993). The effects of increased ultraviolet-B (UV-B) radiation are also of great concern. In Climate Change: The IPCC Response Strategies, the Intergovernmental Panel on Climate Change (1991) reports increases in UV-B radiation reduce yield in certain agricultural crops. The "Summary of Likely Impacts of Increased UV-B Radiation" provides a brief discussion of crop yields. Grandy, A.S *et al* (2006) discuss the potential for crop quality reduction due to the "Effects of UV-B and Global Climate Change on Rice Production" in the Environmental Protection Agency International Rice Research Institute (EPA/IRRI) cooperative research plan.

4. Conclusion and Recommendations

Crop production in the northern part of Nigeria is mostly rainfed dependant. Therefore, any unfavorable change in the climate will have a serious and negative effects on the yield of farmers in the region. The effect are multifold, such as flooding at the critical stage of crops maturity, erosion, long dry spell, decreases in soil fertility and prevalence of pests and diseases are the major bottle necks in the region. In general climate change has a devastating effect on crop output and yield more especially on cereals and tubers. aligning climate and development goals. Proper Managing natural resources especially in the extreme northern part of the country where the effect is mostly felt. Building institutions and policies for more resilient systems with lower emissions are pertinent. Addressing transboundary issues, Supporting and facilitating collective action and Managing risk should be taken with all the needed seriousness.

It is recommended that, series of awareness in terms of seminars, symposiums, farmers field days should be conducted to the farmers on the knowledge of modern techniques of crop production, such as the use of early maturing seeds, drought resistance varieties and more especially the use of irrigation in order to boost crop production in the region. Weather focused information should be made available to the farmers in a form of short messages through their mobile handsets in addition to always informing them on both through the print media and television sets.

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