IMPACT OF CLIMATE CHANGE, DESERTIFICATION ON AGRICULTURE AND FOOD SECURITY

BY

Dr. Aminu Zakari (MBBS) MD.
EXECUTIVE DIRECTOR, CENTRE FOR CLIMATE CHANGE AND ENVIRONMENTAL STUDIES. UNITED NATIONS OBSERVER ORGANIZATION TO UN FRAMEWORK CONVENTION ON CLIMATE CHANGE(UNFCCC). UN/ECOSOC STATUS.
Outline of presentation

• What is climate change?
• Green house effect and climate change
• Sources of green house gases emissions
• Factors leading to potential vulnerability to climate change
• Indicators of climate change
• Climate change and water resources
• Planning for future response to water resources and climate change
• Climate change and its impact on agricultural productivity
• Analysis of climate change impact on agriculture
• Application of GCM in Nigeria
• Adaptations to climate change
• Socio-economic factors and climate change
What is climate change?

A change in climate which is attributed directly or indirectly to human (anthropogenic) activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over a given or noticeable period of time.
INTRODUCTION

The greenhouse effect and climate change

• Estimates indicate that since 1991, the global atmosphere concentration of carbon dioxide has been increasing at a rate of about 1.8 parts per million or 0.018% per year.

• These trace gases in the atmosphere notably carbon dioxide, nitrous oxide and methane called “greenhouse gases” can absorb the heat radiated from the earth (i.e. Long wave radiation or infrared).

• The greenhouse gases prevent the heat radiated from the earth from being escaped into space.
INTRODUCTION

The greenhouse effect and climate change

• Human activities have led to an increase in the concentration of these greenhouse gases in the lower atmosphere, resulting in anthropogenic greenhouse effect which is resulting in global warming and its attendant “climate change”.

• The major greenhouse gases are carbon dioxide (CO$_2$), Methane (CH$_4$), Nitrous Oxide (N$_2$O), hydrofluorocarbons (H FCs), Perfluorocarbons (PFCs) and Sulphur hexafluoride (SF$_6$).
Sources of Anthropogenic Greenhouse Gases Emissions

The key sources of anthropogenic greenhouse gases emissions are:

• The energy sector
• Agricultural sector and
• Waste management sector
Sources of Anthropogenic Greenhouse Gases Emissions

The Energy Sector

• In the energy sector, greenhouse gases emissions emanate from fuel combustion through the energy, manufacturing and construction industries as well as vehicular emissions.

• Other sources are through fugitive emissions from fuels in the form of solid fuels (e.g. coal and oil and natural gas).
Sources of Anthropogenic Greenhouse Gases Emissions

The Energy Sector

• The industrial processes also contribute significantly to greenhouse gases emissions such as:
  – mineral production
  – chemical industries
  – cement production
  – metal production
  – production and use of halocarbons and sulphur hexafluoride, and the production and use of solvents
Sources of Anthropogenic Greenhouse Gases Emissions

The Agricultural Sector

The sources of emissions of greenhouse gases are:

• Enteric fermentation of ruminants (CH$_4$)
• manure management (anaerobic decomposition)
• rice cultivation (flooded rice fields)
• mineralization in agricultural soils (CO$_2$, N$_2$O)
• use of nitrogenous fertilizers (N$_2$O)
Sources of Anthropogenic Greenhouse Gases Emissions

Waste Management

- Sources of anthropogenic greenhouse gases emissions are through waste management.
- Anaerobic as well as aerobic decomposition of wastes results in the emissions of carbon dioxide, methane and nitrous oxide (or other nitrogen oxides NOx).
Indicators of climate change

• High solar radiation intensities and global warming
• Elevated air temperatures
• Reduced rainfall amounts and occurrence of droughts
• Unreliable and erratic rainfall events
• Poor rainfall distribution
• Extreme climate events – floods and storms
• Hurricanes and tornadoes
Sudan Savannah Zone

Mean annual Daily Temperature, 1951 to 2000 in the Sudan Savannah Region

Total annual Rainfall, 1951 to 2000 in the Sudan Savannah

Guinea Savannah Zone

Mean Annual Daily Temperature, 1951 to 2000 in the Guinea Savannah Zone

Total Annual Rainfall, 1951 to 2000 in the Guinea Savannah Zone
Factors Leading to potential vulnerability to climate change

- Unsustainable use of natural resources
- Lack of mitigation of greenhouse gas emissions in the industrial sector
- Weak waste management systems and poor environmental sanitation
- Imports of over-aged vehicles
Climate change and Water Resources

Sources of water resources

• natural precipitation
• groundwater resources
• freshwater rivers, streams, rivulets and lakes, dams and reservoirs and
• marine and estuarine water resources

Natural precipitation is the key source of water that feeds all the other water resources. Therefore a decrease in rainfall due to climate change will deleteriously affect all the other water resources.
Climate change and Water Resources

Runoff

- Runoff or overland flow is the major source of water feeding rivers, streams, rivulets, dams, lakes and reservoirs.
- It is estimated as amount of precipitation minus infiltration (i.e. the amount of precipitation that enters the soil).
- The current low levels of water in dams indicate the sensitivity of reservoirs storage to variations in runoff due to climate change and drought.
Groundwater Resource and Climate Change

Groundwater is an important source of global water requirements for:

- Domestic use
- Agricultural use and
- Industrial use

Groundwater is recharged through:

- Seepage from rainfall events
- Seepage from dams and reservoirs, and
- Seepage from rivers and lakes
Climate change and Water Resources

Marine and Estuarine Water Resources and Sea Level Rise due to climate change

Table 1. Expected sea level rise in Ghana due to climate change

<table>
<thead>
<tr>
<th>Year</th>
<th>Expected sea level rise (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>5.8</td>
</tr>
<tr>
<td>2050</td>
<td>16.5</td>
</tr>
<tr>
<td>2080</td>
<td>34.5</td>
</tr>
</tbody>
</table>
Marine and Estuarine Water Resources and Sea Level Rise due to climate change

Causes of sea level rise

• Volumetric expansion of sea water due to rise in sea water temperature
• Melting of polar ice due to rise in temperature
• Melting of ice-bergs due to rise in temperature
• Melting of mountain glaciers due to rise in temperature
Marine and Estuarine Water Resources and Sea Level Rise due to climate change

Effects of sea level rise

• Accelerated coastal erosion. For example, the annual coastal erosion in the Eastern area of Nigeria is estimated to be 3m.

• Inundation of low-lying coastal zones and

• Increased waves which favor further inland penetration of the sea water through internal lateral flow, which will increase salinization of coastal aquifer and streams.
Planning for the future response to water resources and climate change

• Climate change must be factored into water-resource planning and policies for the future on a contingency basis.

• A global climate change often results in linking of environmental factors that favour evaporative demand of the environment such as:

  • Increase in air temperature
  • Increase in net radiation
  • Decrease in atmospheric relative humidity, and increase in windiness
In planning for the future response to water resources and climate change, the following factors must be considered:

• A change in regional water resources must be considered holistically.

• The dynamic nature of water resource management must be fully considered physically and socially.

• Lessons from past development effects in connection with water resource management, especially past failures should be referred to and applied judiciously.

• The approaches should consider current water problems in the context of political and cultural perspectives.
Climate change and its impact on agricultural productivity

The adverse effects of climate change on agricultural productivity are due to:

• Increased temperatures (global warming)
• Decreased rainfall
Climate change and its impact on agricultural productivity

Stresses due to these two climatic variables result in reduced crop yields because of the following reasons:

• The plant tries to complete its life cycle more rapidly resulting in reduced storage of food product.

• Heat stress and reduced water availability could result in the death of the plant.

• Extreme climatic events such as storms and windiness can be devastating to plants through logging and flooding.
Climate change and its impact on agricultural productivity

- Higher temperatures increase the rate of water loss through evaporation and transpiration.
- With high temperatures, nutrient release through organic matter decomposition is not synchronized with the time when the plants nutrient requirement is at its peak.
- If climate change results in excessive rainfall, nutrient losses through leaching and erosion result in soil fertility decline.
- Higher temperatures with moisture favour the germination of spores and spread of bacteria, fungi and nematodes.
Climate change and its impact on agricultural productivity

Impact of climate change on Animal Production

Increased temperatures and animal physiology:

- High temperatures accelerate metabolic processes requiring high oxygen consumption, which if not met can reach final stage resulting in death.

- Higher surrounding temperatures could result intake of less food and more water and reduced gain-weight of the animal.
Impact of climate change on Animal Production

Increased temperatures and animal physiology:

• At high temperatures proteins and nucleic acids are denatured and protein synthesis in the animal is drastically reduced.

• High temperatures may change the membrane fluidity of the animal from gel phase to liquid crystalline phase leading to reduced performance and death.
Analysis of Climate Change Impacts on Agriculture

The analysis of future climate change impacts on agriculture demands multifaceted approaches involving:

• The study of biophysical processes
• Socioeconomic processes
The approaches employed include:

• Climate change Scenarios:
  These involve projections of what values climate parameters may assume in the future and how agriculture might fare in the new circumstances. This approach addresses the question: “What will agriculture be like in a given changed climate.

In this approach, chain of causalities from the biophysical responses of crops and livestock at the farm level to socio-economic effects are constructed.
There are different types of scenarios for the analysis of impacts of climate change on Agriculture. But the commonest ones are:

• Global circulation models (GCMs)
• Regional climate (Simulation) Models (Reg CMs)
Application of GCM in Nigeria

• GCMs are normally used to generate future climatic parameters based on current climatic parameters of a specified period. The generated future climatic parameters are fed into a given Dynamic Crop Growth Model to generate future crop responses to the changed future climatic parameters.

• This approach was used in Nigeria to simulate the impact of climate change on maize and roots and tubers production.
Model simulation (GCMs)

The GCMs used were the ‘Linked Model’ adopted from:

• The Hardly Centre Model 2 (HADCM 2)
• The U.K. Meteorological Office Transient Model (UKH 1)
Application of GCM in Nigeria

Dynamic Crop Growth models:

- **Maize:** IBSNAT Crop simulation models (DSSAT) (specifically CERES-Maize) was used.
- **Cassava/Cocoyam:** DSSATV4 (specifically) CROPSIM-Cassava/CROPGRO (ARGR 0980) were used.
Table 2. Expected average increase in temperature and decrease in rainfall

<table>
<thead>
<tr>
<th>Year</th>
<th>Increase in Temperature (°C)</th>
<th>Decrease in rainfall (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>0.6</td>
<td>2.8</td>
</tr>
<tr>
<td>2050</td>
<td>2.0</td>
<td>10.9</td>
</tr>
<tr>
<td>2080</td>
<td>3.9</td>
<td>18.6</td>
</tr>
</tbody>
</table>
Application of GCM in Nigeria

Simulated mean temperature and rainfall variations for all the agro-climatic zones of Nigeria up to the year 2080

As temperature increased, rainfall also decreased systematically.
Application of GCM in Nigeria

Using the 2020 data, average maize yield in Nigeria would decrease by 7%.

• National maize production in Nigeria declined by 30% in 1982 due to drought.

• Poor seed set in maize at temperatures above 38°C.
Application of GCM in Nigeria

Table 3. Projected yield Reduction of Cassava and Cocoyam

<table>
<thead>
<tr>
<th>YEAR</th>
<th>CASSAVA (%)</th>
<th>COCOYAM (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>13</td>
<td>11.8</td>
</tr>
<tr>
<td>2050</td>
<td>23</td>
<td>29.6</td>
</tr>
<tr>
<td>2080</td>
<td>58</td>
<td>68</td>
</tr>
</tbody>
</table>
Adaptations of Agriculture and Water Resources to climate change

• Altering the crops to be grown
• Early maturing and drought tolerant crops may be grown
  ✓ Change the methods of cultivation
  ✓ Conservation tillage may be used instead of conventional tillage systems
  ✓ Increased use of irrigation in areas prove to drought
• Altering timing of planting to make use of shifts in rainfall regimes
• Integrated soil fertility management
• Integrated pest and disease control measures
Socio-Economic Factors

These socio-economic factors should be tackled and resolved through government policy under changing climate conditions:

• Farm land values and tenure arrangements
• Crop produce market prices
• Cost of irrigation
• Cost of other inputs of production
• Government subsidy
• Improving the economic situation of farmers
CONCLUSION

Mitigation and adaptive measures are needed to offset any future impact of climate change on agriculture and water resources.
THANK YOU FOR YOUR ATTENTION