Agricultural Science

Year 1

SECTION

9

THREATS OF CLIMATE CHANGE AND MITIGATION MEASURES

Agriculture And Climate

Climate Variability, Adaptation and Mitigation Strategies

INTRODUCTION

Hello learner! You are welcome to section 9, and before we proceed to study what is in this section, it is important to appreciate that the knowledge and skills about the threats of climate change and its mitigation measures are crucial in agriculture and you need to pay much attention to it. This section deals with climate change – its causes, effects on crop growth and yield, as well as the conventional and indigenous strategies for combating climate change. You need to have a good understanding of how agricultural production might need to change because of the effects of climate change. This will help you to make better-informed decisions about what to grow and measures to put in place to ensure large yields and high productivity. You are expected to explain how both climate change and its mitigation measures affect agricultural production. Issues of climate change are inter-disciplinary in nature and may be studied in other areas like Geography, Science and even Social Studies.

At the end of this section, you will be able to:

- Explain the Causes of Climate Change and Current World Disasters.
- Discuss increasing drought, pestilence and decreasing crop yields.
- Explain indigenous and conventional strategies for dealing with climate change and climate variability.
- Discuss the effects of indigenous and conventional mitigation measures for combating climate change on agricultural production.

Key Ideas

- **Climate Variability**: It is the way aspects of climate (such as temperature and precipitation) differ from an average.
- **Climate adaptation:** This is the process of adjusting to the effects of climate change.
- **Climate Mitigation**: It is an action to limit the greenhouse gases in the atmosphere that cause climate change.
- **Greenhouse gases:** These are gases in the atmosphere that raise the surface temperature of the Earth.
- **Climate Mitigation Strategies**: They are measures taking to reduce the effects of climate change. E.g. Afforestation, carbon capture, conservation, renewable energy.
- **Conventional responses to climate change**: Conventional responses to climate

change refer to strategies and actions that are commonly pursued by governments, organisations, and individuals to address the challenges posed by global warming and to adapt to the impacts of climate change.

CAUSES OF CLIMATE CHANGE AND CURRENT WORLD DISASTERS

There is increasing evidence that the Earth's climate is changing due to human activities. Scientific evidence shows that life on our planet is in danger from climate change. The atmosphere and oceans have become warmer, accompanied by a rise in sea level, a strong decline in Arctic-sea ice and other climate-related changes. The impacts of climate change on people and nature include unprecedented flooding, heat waves, wildfires, and rising temperatures with accompanying damage costing billions of United States dollars. The way forward requires society to apply scientific information to make informed decisions about how to reduce the magnitude of climate change and how to adapt to its impacts.

Basics Of Climate Change: Greenhouse Gases Affect The Earth's Energy Balance And Climate.

The Sun serves as the primary energy source for Earth's climate. Some of the incoming sunlight is reflected directly back into space, especially by bright surfaces such as ice and clouds, and the rest is absorbed by the atmosphere and the Earth's surface. Much of the solar energy absorbed by the earth is re-emitted as heat in the form of longwave or infrared radiation. The atmosphere absorbs and re-radiates heat, some of which escapes to space. Any disturbance to this incoming and outgoing energy balance will affect the climate.

If all the heat energy emitted from the earth's surface passed through the atmosphere directly into space, the earth's average surface temperature would be tens of degrees colder than observed. Greenhouse gases in the atmosphere including, carbon dioxide, methane, and nitrous oxide plus water vapour, absorb and emit heat energy in all directions (including downwards), keeping the Earth's surface and lower atmosphere warm (Figure 9.10), supporting both plants and animal life on earth. Adding more greenhouse gases to the atmosphere enhances the effect, making the Earth's surface and lower atmosphere even warmer.

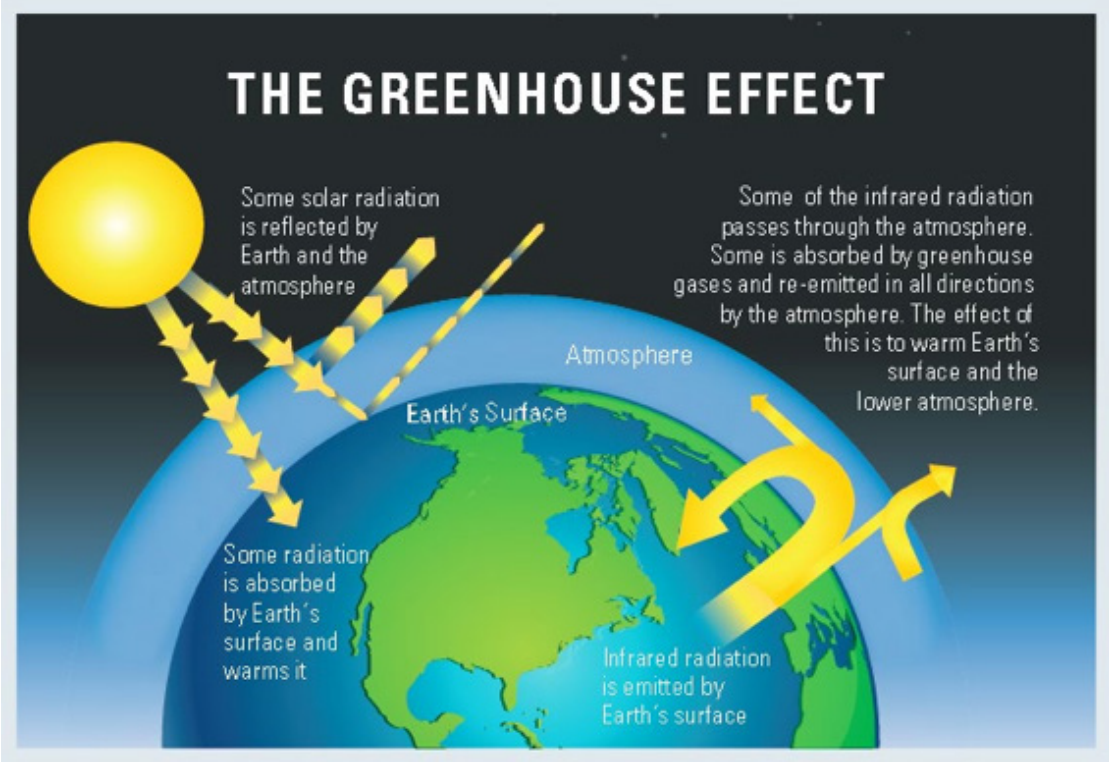

Figure 9.1: Greenhouse effect in the atmosphere.

Greenhouse gases such as carbon dioxide (CO_2) are emitted from the Earth's surface. Human activities – especially the burning of fossil fuels (coal and petroleum products) plus charcoal and wood, since the start of the Industrial Revolution, have increased atmospheric CO_2 concentrations by more than 40%. Other human activities such as clearing forests for farming and animal rearing, also contribute to global warming. Since 1900, the global average surface temperature has increased by about 1°C (1.8°F). The atmospheric concentrations of carbon dioxide, methane, and nitrous oxide have increased significantly. The concentration of CO_2 has since increased by over 40%, methane by more than 150% and nitrous oxide by roughly 20%. Increases in all three gases contribute to the Earth's warming with the increase in CO_2 playing the largest role. This has been accompanied by the warming of the ocean, a rise in sea level, a strong decline in Arctic Sea ice, widespread increases in the frequency and intensity of heat waves and many other associated climate effects. Much of this warming has occurred in the last five decades and is responsible for the observable climate change being experienced today.

Since 1958, there has been a steady annual increase in CO_2 concentration in the earth's atmosphere (Figure 9.2). The up-and-down saw-tooth pattern in Figure 9.2 reflects seasonal changes in the release and uptake of CO_2 by plants.

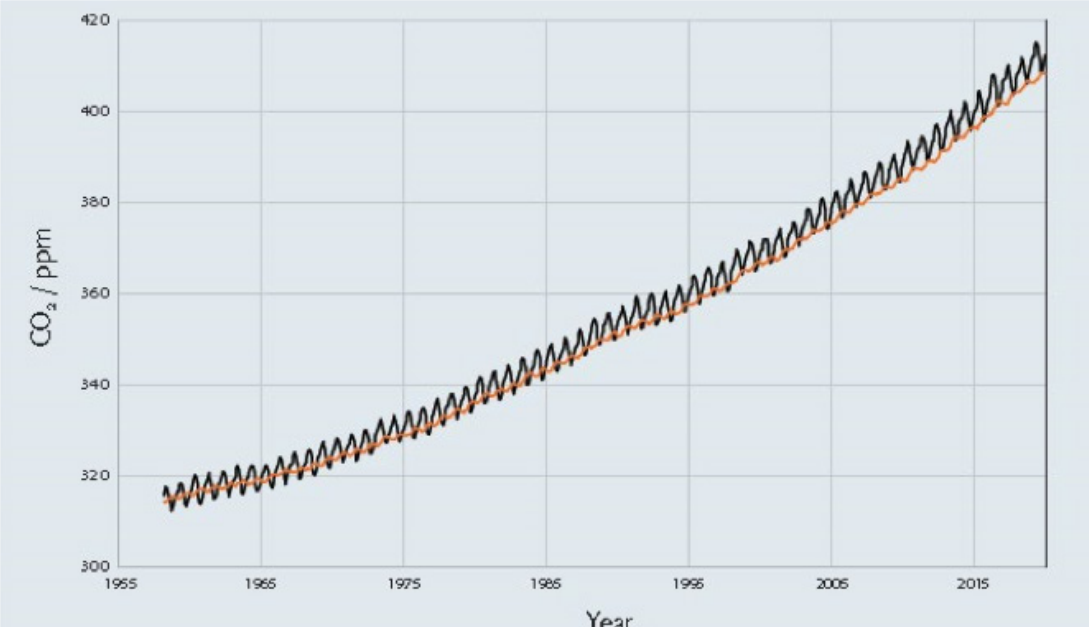

Figure 9.2: Atmospheric CO2 concentration since 1958 from the Mauna Loa Observatory in Hawaii (black) and from the South Pole (red).

Some key causes of current world disasters due to climate change

1. **Rising temperatures:** Global warming caused by the increased concentration of greenhouse gases in the atmosphere, primarily carbon dioxide from burning fossil fuels, leads to higher average temperatures. This contributes to heatwaves, droughts, and wildfires, which can have devastating impacts on ecosystems, agriculture, and human health.
2. **Changing rainfall patterns:** Climate change disrupts traditional precipitation patterns, causing shifts in rainfall distribution and intensity. This can result in both prolonged droughts and heavy rainfall events, leading to water scarcity or flooding and landslides.
3. **Melting of glaciers and polar ice:** The rising temperatures cause the glaciers and icebergs in the Arctic and Antarctic regions to melt, resulting in the rising of the sea level.
4. **Expansion of seawater:** Rising temperatures cause the expansion of seawater, further raising the sea level, and causing tremendous threats and damage to coastal communities. Actual damage inflicted includes coastal erosion, storm surges and flooding. This situation is being experienced along the coastal areas of Ghana, particularly in the Keta area in the Volta region and Nkotompo in the Western region.
5. **Extreme weather events:** Climate change intensifies the frequency and severity of extreme weather events such as hurricanes, cyclones, and typhoons, causing widespread devastation and loss of life and property.

6. **Ocean acidification:** Increased carbon dioxide levels do not only contribute to global warming, but also lead to ocean acidification. This impacts marine ecosystems, particularly coral reefs, and threatens the livelihoods of communities that depend on ocean resources.
7. **Biodiversity loss:** Climate change contributes to changes in ecosystems hence habitat loss, leading to shifts in species distribution and increased risks of species extinction.
8. **Economic and social inequities:** Vulnerable populations, particularly in developing countries, are disproportionately affected by climate change disasters due to their limited resources, inadequate infrastructure, and lack of adaptive capacity. This can increase existing economic and social disparities.
9. **Feedback loops:** Some climate change impacts trigger feedback loops that accelerate the process. For example, melting Arctic ice reduces the Earth's albedo (reflectivity), causing more sunlight to be absorbed by the darker ocean waters, leading to further warming and ice melting.

Addressing the causes of current world disasters due to climate change requires global efforts to

a. Reduce greenhouse gas emissions,
b. Promote the transition to renewable energy sources, and
c. Encourage enhanced adaptation and resilience measures, including promoting sustainable land and water management practices.

International cooperation and policy interventions are crucial to mitigating the impacts of climate change and minimising the occurrence and severity of climate-related disasters.

Great, well done! Having gone through the content successfully, do the following activities.

Activity 9.1

Browse through the Internet on the causes of climate change and their relationship with current world disasters. Discuss your findings with a friend or friends.

Steps:

a. Search online on the "causes of climate change and their relationship with current world disasters."
b. Read carefully and take down relevant notes.
c. Discuss your findings with your friend or friends.

Activity 9.2

Have a debate about the following statement "Human factors cause more climate change and disasters than natural factors".

Steps:

a. Look for a friend.

b. Read about human and natural factors that cause climate change and disasters.

c. Select an option to speak for or against the motion.

d. Debate between the two of you.

INCREASING DROUGHT, PESTILENCE, AND DECREASING CROP YIELDS

Increasing drought, pestilence, and decreasing crop yields are interconnected challenges in agriculture that have significant implications for food security and livelihoods. There are indigenous strategies for dealing with climate change and variability.

Indigenous communities have developed diverse strategies over generations to cope with climate change and variability. These strategies are often based on traditional knowledge, dependent on critical observation and deep understanding of local ecosystems, and the interconnectedness between nature and human well-being.

Major Consequences of Climate Change

1. **Increasing drought due to unreliable precipitation patterns and higher temperatures:**

   a. Unreliable precipitation patterns cause more frequent and prolonged droughts in certain regions or areas.

   b. Higher temperatures contribute to increased evaporation, drying up of water sources and soil moisture.

   These have serious consequences for agriculture, as crops and ornamental plants rely on adequate water availability to grow and thrive. Droughts lead to reduced crop yields, livestock losses and sometimes total crop failure, affecting food production and livelihoods.

2. **Increasing incidence and severity of pests and diseases:** Warmer temperatures and changing weather patterns create favourable conditions for the proliferation of pests and diseases that affect crops and livestock. Pests, such as insects and pathogens (e.g., bacteria, viruses, and fungi), thrive in warmer environments and expand their geographical range. Large infestations damage

crops and livestock, reduce yields, and can lead to increased pesticide use. In addition to crop and livestock losses, the reliance on pesticides can have negative environmental and health impacts.

3. **Declining crop yields:** The combination of droughts and increased pest pressure can collectively lead to a decline in crop yields. Changes in temperature and rainfall can disrupt plant growth cycles, affecting flowering, pollination, and fruiting. Extreme weather events such as heatwaves can damage crops and stress plants. All these factors interact to reduce agricultural productivity and can lead to food scarcity and higher prices.
4. **Food insecurity:** The consequences of increasing drought, pestilence and decreasing crop yields harm food security. With less water available for irrigation, reduced crop yields and losses due to pests, communities that rely heavily on agriculture face challenges in ensuring an adequate and nutritious food supply. Vulnerable populations, particularly in developing countries, are disproportionately affected by these climate-induced changes, leading to potential malnutrition and food insecurity.

Addressing these challenges requires adopting climate-resilient agricultural practices. Farmers can implement water-efficient irrigation systems, grow drought-tolerant crop varieties, and employ integrated pest management techniques. Early warning systems for pest outbreaks and weather events can help farmers take preventive measures. Improving soil health and implementing agroforestry practices can also enhance ecosystem resilience.

Well done! Now carry out the activities below.

Activity 9.3

Browse the Internet and read about the following topics 'The consequences of climate change on crop yields and food security' and "Effects of increasing drought and pestilences due to climate change and crop yield" before the lesson.

Follow the steps below to achieve activity 9.3.

Steps:

a. Search online using any preferred search engine. Make sure that your data is on.

b. Type "The consequences of climate change on crop yields".

c. Also type "Effects of increasing drought and pestilences due to climate change and crop yield."

d. Under each of them, read carefully about what you find and take down some important points.

e. Discuss the findings with your friend.

f. Discuss, also, the future of food security in Ghana in a changing climate.

Activity 9.4

Grow a vegetable crop on your school premises or at home. Subject them to different watering regimes for about three weeks and study the development patterns.

The steps below will guide you to grow a vegetable crop on your school premises or at home.

Materials needed: Empty milk or milo tin, plastic containers or sacs, soil, water, and viable vegetable seeds (such as cabbage, tomatoes, pepper, or carrots) and a suitable shade.

Steps:

a. Fill two containers or sacs with the soil, preferably loamy soil, or any other suitable substrate.

b. If metal or plastic containers are used, small holes must be created in them before they are filled with soil. These holes are called “drainage holes” that allow the excess water to drain away.

c. Sow some seeds of the selected vegetables in the two soil-filled containers or sacs.

d. Add the same amount of water to the soil in both containers immediately after sowing the seeds.

e. Place both containers with the sown seeds under a very good shade.

f. Subject the vegetable seedlings to different watering regimes for about three weeks and study the development patterns. For example, add twice the amount of water to one container and repeat this as necessary over the three-week period.

g. Observe what happens after one to three weeks and record your observations by recording changes in appearance, including height, number, and size of leaves.

h. Share your observation with your friends and let them also tell you what they have also done and observed.

Well done! I hope you and your friends have enjoyed this practical activity.

Project Work

Go to the website of the Ghana Meteorological Services to download temperature and rainfall data for any region or city over the last 10 years and plot graphs for the temperature and rainfall from the data.

Follow the steps below to perform the project work:

Steps:

a. Get data online on "temperature and rainfall data for any region or city over the last 10 years" from the Ghana Meteorological Services website.

b. Plot a graph of temperature against rainfall from the data obtained.

c. Discuss any trends that you have observed.

INDIGENOUS STRATEGIES FOR DEALING WITH CLIMATE CHANGE AND VARIABILITY

Climate variability is the annual or seasonal variation observed in the physical factors of weather such as temperature and precipitation. The long-term persistence of these variabilities leads to climate change.

Indigenous communities have developed diverse strategies over generations to cope with climate change and variability. These strategies are often based on traditional knowledge, dependent on critical observation and deep understanding of local ecosystems, and the interconnectedness between nature and human well-being.

Some Examples of Indigenous Strategies for Dealing with Climate Change and Variability Include

1. **Traditional Ecological Knowledge (TEK):** Indigenous communities possess a wealth of knowledge about their environment, including natural indicators for predicting seasonal weather patterns, many of which are based on the flowering of certain plants and the movement and presence of some animals, particularly birds. This knowledge is passed down through generations and helps predict and allows them to adapt to changing climatic conditions.
2. **Traditional farming and agriculture:** Indigenous farmers often employ traditional agricultural practices that are well-adapted to local climates and ecological conditions. This includes planting diverse crops on the same farm, using crop rotation and selecting resilient crop varieties that are suited to specific ecologies. Such farming practices ensure reduced damage by pests and diseases.
3. **Crop diversity/biodiversity conservation:** Indigenous farmers often practice agro biodiversity by cultivating a variety of crops with different growth requirements and resilience to various climatic conditions. This diversity ensures food security, even when some crops are affected by extreme weather conditions others survive and produce economic yields.
4. **Territorial management:** Many indigenous groups have developed intricate land management practices that promote sustainable resource use. These

practices involve rotational farming, controlled burning, and protection of critical ecosystems to maintain biodiversity and resilience in the face of climate change.

5. **Water management techniques:** Indigenous communities have developed efficient water management techniques, such as building terraces, canals, and reservoirs to capture and store water during rainy seasons for use during droughts and managing irrigation systems sustainably. These methods help ensure a steady water supply for agriculture and other needs. In some communities, forests are preserved around rivers and other water bodies to prevent drying up during the dry season. Farming close to these water bodies is prohibited thus preventing the cutting down of trees around the water bodies and also reducing silting.
6. **Cultural fire management:** Some indigenous communities use controlled burning practices to prevent larger wildfires and promote the growth of certain plants. Controlled burning reduces fuel loads, enhances soil fertility, and maintains the health of ecosystems.
7. **Nomadism:** Nomadic and semi-nomadic indigenous groups adjust their locations in response to changing climatic and environmental conditions by moving with their herds or crops. This mobility allows them to access different resources and adapt to shifts in vegetation and water availability.
8. **Resilient livelihoods:** Indigenous economies often incorporate a mix of activities, such as fishing, hunting, and other crafts with their farming. This diversity of livelihoods provides a buffer against the impacts of climate-related disruptions on any single activity.
9. **Cultural and spiritual practices:** Indigenous cultures often have rituals and ceremonies that are closely tied to natural phenomena. These practices reinforce the connection between humans and nature and can foster a sense of responsibility for environmental protection.
10. **Sustainable resource use:** Indigenous communities often adhere to principles of sustainable resource use, ensuring that the environment is not overexploited and that resources are managed in a way that allows for regeneration and continuity. Their land stewardship practices involve responsible management of land and natural resources to maintain ecological balance and ensure the well-being of current and future generations.
11. **Information sharing through storytelling:** Indigenous communities use oral traditions and storytelling to transmit knowledge about climate variability and adaptation strategies. This allows their wisdom to be shared across generations.

Acknowledging and respecting indigenous knowledge and practices are essential for developing effective and inclusive climate change adaptation strategies. Collaborating with indigenous communities, incorporating their perspectives and supporting their autonomy and rights are crucial steps in addressing climate change in a way that is both culturally sensitive and environmentally sustainable.

Congratulations! Now perform the activities below.

Activity 9.5

Where possible, organise a panel discussion featuring guest speakers from indigenous communities, researchers, and climate activists to share their expertise on the role of indigenous knowledge in climate adaptation, focusing on traditional practices, sustainable solutions, and the integration of indigenous wisdom in modern climate resilience strategies.

Steps for the panel discussion:

Pre-panel activities

a. Before the guest speakers arrive, carry out research about how indigenous communities use traditional methods to adapt to climate change.

b. Discuss findings with your group and prepare relevant questions for the guest speakers. You could include the following questions:

   i. What traditional practices have indigenous communities used to adapt to changing climate conditions in your locality?

   ii. How do indigenous farming techniques contribute to sustainable agriculture and water conservation in the face of climate change?

   iii. What are the challenges faced in preserving and passing down indigenous knowledge related to environmental sustainability?

   iv. How do indigenous communities build resilience against extreme weather events such as droughts or floods?

   v. What are the biggest challenges indigenous communities face due to climate change, and how do they overcome these obstacles?

   vi. How can young people from both indigenous and non-indigenous backgrounds become more involved in applying traditional knowledge to climate adaptation efforts?

Panel discussion

Listen carefully to the guest speakers, take notes, and ask questions during the discussion.

Post-panel discussion

a. Reflect on the key insights and analyse how indigenous knowledge can be applied to climate adaptation.

b. Write a report and present it to your teacher.

Activity 9.6

Design and carry out a project where you visit local communities to explore and learn about their indigenous strategies for combating climate change. Document these strategies, discuss their effectiveness, and promote awareness and respect for this traditional knowledge. Present your findings and insights through a group report to share what you have learned and how these practices can help address climate challenges.

Steps for the community engagement project:

a. Work in groups and plan a visit to the local communities and learn about their strategies for dealing with climate change.

b. Develop a list of questions to be asked during your community visit.

c. Arrange with local communities for the visit. Prepare necessary materials, such as notebooks and recording devices, for documenting information.

d. Visit the community, observe, and engage with members to learn about their climate adaptation strategies. Record detailed notes and gather insights.

e. Review and analyse the information collected. Discuss within your group how the indigenous strategies work and their impact on climate resilience.

f. Create a group report summarising your findings, including key strategies, their effectiveness, and any challenges faced. Highlight how these practices contribute to combating climate change.

g. Share stories or case studies from Indigenous communities that highlight specific strategies they employ to combat the negative effects of climate change.

h. Present your report to your class, explaining what you learned and how indigenous knowledge can be integrated into broader climate adaptation efforts.

CONVENTIONAL RESPONSES TO CLIMATE CHANGE

Conventional responses to climate change refer to strategies and actions that are commonly pursued by governments, organisations, and individuals to address the challenges posed by global warming and adapt to the impacts of climate change. These responses often involve technological, policy and behavioural approaches.

Some key conventional responses to climate change include:

1. **Renewable energy transition:** One of the primary conventional responses is transitioning from fossil fuels to renewable energy sources such as solar, wind, hydroelectric and geothermal power. This approach also involves adopting cleaner energy sources, improving energy efficiency, implementing emission reduction policies, and promoting renewable energy technologies. This shift aims to reduce greenhouse gas emissions and promote sustainable energy alternatives.
2. **Energy efficiency improvements:** Improving energy efficiency in various sectors such as transportation, buildings, and industries. This includes measures such as using energy-efficient appliances and implementing more efficient transportation systems.
3. **Afforestation and reforestation:** Planting trees (afforestation) and restoring degraded forests (reforestation) are important strategies for carbon trapping and usage. In Ghana, tree seedlings are planted every year in the Green Ghana Initiative to combat some aspects of climate change. Trees absorb carbon dioxide from the atmosphere thus helping to mitigate its effects on climate change.
4. **Policy frameworks and agreements:** Governments and international bodies work together to establish policies, regulations, and agreements to address climate change. The United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement, for example, aim to limit global warming to well below 2^0C above pre-industrial levels.
5. **Carbon pricing and market mechanisms:** Conventional responses include implementing carbon pricing mechanisms such as taxing carbon or emissions beyond a specified concentration. These measures force industries to reduce emissions and invest in cleaner technologies.
6. **Climate-resilient infrastructure:** Building infrastructure that can withstand the impacts of climate change, such as rising sea levels and extreme weather events, is a crucial response. This includes constructing flood barriers and sea defence walls, improving drainage systems, and designing more resilient buildings.

7. **Public awareness and education:** Raising awareness about climate change and its impacts involves educational campaigns and initiatives that inform the public, policymakers, and businesses about the importance of taking action.
8. **Adaptation and disaster preparedness:** This includes developing disaster preparedness plans and enhancing early warning systems.
9. **Sustainable agriculture and land use:** Implementing sustainable agricultural practices, such as no-till farming and agroforestry, can help reduce emissions from agricultural machines and increase resilience to climate change.
10. **Climate finance:** Climate finance involves funding projects focused on climate mitigation, adaptation, and technology transfer in developing countries.
11. **Research and innovation:** While conventional responses play a significant role, there is also growing recognition of the importance of incorporating indigenous knowledge in climate change strategies for a more holistic and effective approach. While conventional responses have made significant strides in addressing climate change, some critics argue that they may not be sufficient to achieve the necessary emission below catastrophic levels. Transitioning to more transformative approaches and exploring nature-based solutions are gaining prominence as complementary strategies to conventional responses.

Well done! Now carry out the activities below.

Activity 9.7

Identify conventional climate-related initiatives or projects within your community.

Steps for identifying and discussing climate initiatives:

a. Work with a friend or friends.
b. Carry out research to identify conventional climate-related initiatives or projects happening in your community. You could use online resources, community interviews, or local reports to gather information.
c. Organise your findings, noting key details such as the goals, methods, and impacts of each initiative.
d. Present your findings to the larger class.

Activity 9.8

Analyse conventional climate agreements and the challenges faced in implementing the agreements.

Steps to follow in analysing climate agreements and challenges:

a. Browse the Internet to find out conventional climate agreements like the Paris Agreement, Kyoto Protocol, or Africa's regional agreements.

b. State the main strategies outlined in these agreements for mitigating climate change, such as emission reduction targets, renewable energy adoption, or deforestation prevention.

c. State the challenges faced by countries in implementing these agreements, including financial, political, and social barriers.

d. Record your findings and share them with the rest of the class.

EFFECTS OF INDIGENOUS AND CONVENTIONAL MITIGATION MEASURES FOR COMBATING CLIMATE CHANGE ON AGRICULTURAL PRODUCTION

Both indigenous and conventional mitigation measures for combating climate change can have significant effects on agricultural production. However, their impacts differ in terms of approach, scale, and outcomes.

Summary of Indigenous Mitigation Measures and Their Effects on Agricultural Production

1. **Traditional farming practices**: Indigenous farming practices such as mulching, cover cropping, bush fallowing and growing drought-tolerant crops often prioritise sustainability, diversity, and resilience. This leads to better soil health, reduced erosion, and enhanced water retention, positively impacting agricultural productivity.
2. **Agroforestry and biodiversity**: Indigenous communities often practice agroforestry, integrating trees with crops, which enhances ecosystem stability, improves soil fertility, and provides additional income from non-timber forest products.
3. **Local seed varieties**: Indigenous farmers often maintain a rich diversity of traditional crop varieties adapted to local conditions. Seeds from locally adapted

crop varieties are more resilient to climate fluctuations and contribute to larger crop yields.

4. **Water management techniques**: Indigenous communities have developed innovative water management systems such as rainwater harvesting, cover cropping, crop selection and rotation, composting and mulching that optimise water use making agriculture more resilient to changing rainfall patterns, with a resultant yield assurance.
5. **Community-based adaptation**: Indigenous approaches emphasise collective decision-making and adaptive capacity, which fosters community cohesion and enhances resilience to climate-related challenges. These adaptation strategies are planned and executed together by the community members. Some of the community-based adaptation strategies are:
    a. Replanting forests and restoring damaged ecosystems.
    b. Diversifying crops so that they are better able to adapt to changing climates.
    c. Investigating and developing innovative solutions to prevent and manage natural catastrophes.

All these Indigenous mitigation measures enhance agricultural production by:

1. Promoting sustainable practices.
2. Conserving biodiversity.
3. Increasing resilience to climate variability.
4. Diversifying farming systems.
5. Reducing vulnerability to climate extremes,
6. Stabilising and increasing yields.

Summary of Conventional Mitigation Measures and Their Effects On Agricultural Production

1. **Renewable energy transition:** Conventional mitigation often focuses on transitioning from fossil fuels to renewable energy sources e.g. solar energy, wind energy, hydropower, and geothermal power. While this can reduce greenhouse gas emissions, it may have indirect negative effects on agriculture through changes in energy prices and land use for bioenergy crops.
2. **Intensive agriculture practices:** Some conventional mitigation strategies prioritise intensive agricultural practices including livestock rearing to increase food production. However, these approaches can lead to negative environmental impacts, such as soil degradation and loss of biodiversity.
3. **Afforestation and reforestation:** Planting trees to capture/trap carbon impacts agricultural land availability and positively affects the livelihoods of communities that depend on those lands.

4. **Carbon pricing:** The implementation of carbon pricing mechanisms may increase production costs which would be added to commodities such as equipment, tools, machinery, and fertilisers. This development will negatively impact agricultural production.
5. **Technological interventions:** Conventional mitigation often involves technological interventions, such as genetically modified organisms (GMOs) or precision agriculture. The effects of these technologies on agricultural production are the subject of ongoing debates.

Conventional mitigation measures, therefore, have mixed effects on agricultural production. As some strategies prioritise large yields, long-term sustainability and ecosystem health, some high-input practices increase vulnerability to climate shocks and disruptions in resource availability.

Congratulations! Now that you have studied the effects of Indigenous and conventional mitigation measures for combating climate change on agricultural production, do the following activities below.

Activity 9.9

Browse the Internet, list and discuss the indigenous and conventional mitigation measures for combating climate change. Present your findings to the rest of the class.

To be able to achieve activity 9.9, follow the steps below.

Steps:

a. Search online on the "indigenous and conventional mitigation measures for combating climate change" and read carefully.
b. Note down the most important points.
c. Discuss your findings with your friends.

Activity 9.10

Evaluate the impact of the indigenous and conventional mitigation measures for combating climate change on agricultural production.

Follow the steps below to achieve activity 9.10.

Materials:

Notebook, pen, tablet, Agricultural Science Learning Material, and online resources (FAO's Climate -Smart Agriculture Sourcebook, UNDP's Climate Change Adaptation Portal)

Steps:

a. Search online for some examples of indigenous and conventional mitigation measures and read and take down relevant notes.

b. Evaluate the effectiveness of the mitigation measures using the following criteria: environmental impact, economic feasibility, social acceptability, and agricultural productivity.

c. Create a table in your notebook to compare the advantages and disadvantages of indigenous and conventional mitigation measures.

d. Discuss your findings with a friend or friends.

REVIEW QUESTIONS

1. Describe the relationship between human activities and greenhouse gas emissions.
2. Discuss how greenhouse gases trap heat and cause global warming.
3. Outline and explain the major consequences of climate change on crop yield.
4. Discuss the relationship between rising temperatures and reduced water availability for agricultural activities.
5. Analyse the combined effects of increasing drought, pestilence, and decreasing crop yields on local communities and their food systems.
6. Explain the indigenous strategies for combating climate change.
7. Evaluate the significance of indigenous knowledge in adapting to climate change and variability.
8. Explain how renewable energy sources, such as solar and wind power, can be utilised in Ghana to reduce the impacts of climate change. Provide specific examples to support your explanation.
9. Evaluate the effectiveness of carbon pricing as a strategy to reduce greenhouse gas emissions.
10. Explain the impacts of indigenous and conventional mitigation measures for combating climate change on agricultural production.
11. How can traditional farming practices contribute to making crops more resilient in the face of changing weather patterns?

ANSWERS TO REVIEW QUESTIONS

1. Refer to the content on “greenhouse gases affect the earth’s energy balance and climate.”
2. How greenhouse gases trap heat and cause global warming

   Greenhouse gases act like a glass in the greenhouse. They absorb the sun’s heat that radiates from the Earth’s surface, trap it in the atmosphere and prevent it from escaping into space. The greenhouse effect then keeps the Earth’s temperature warmer than it would otherwise have been supporting life on Earth. Many greenhouse gases occur naturally in the atmosphere, but human activities contribute to their accumulation. As a result, the greenhouse effect in the atmosphere is boosted and it alters the Earth’s climate, leading to shifts in snow (temperate regions) and rainfall patterns, rise in temperatures and more extreme climate events such as heatwaves and floods.
3. Refer to the contents for the answers to the Q3.
4. Rising temperatures have a direct and profound impact on water availability for agricultural activities, creating a challenging environment for food production. This relationship manifests in several key ways:
   - Increased evaporation: Rising temperatures accelerate water loss through evaporation from soils and plants, reducing moisture available for crops.
   - Drought frequency and intensity: Higher temperatures lead to more frequent and severe droughts, limiting water supplies for irrigation.
   - Changes in precipitation patterns: Erratic weather patterns from warming disrupt rainfall distribution, reducing reliable water sources for agriculture.
   - Reduced snowmelt and glacier retreat: Warmer temperatures cause glaciers and snowpacks to shrink, decreasing essential water runoff for farming.
   - Groundwater depletion: Farmers increasingly rely on groundwater due to surface water scarcity, leading to long-term depletion of aquifers.
5. The combined effects of increasing drought, pestilence, and decreasing crop yields can severely destabilise local communities and their food systems. Here is an analysis of their impact:
   - **Food insecurity:** Drought and pest outbreaks reduce agricultural productivity, leading to food shortages, higher prices, and increased hunger in local communities.
   - **Economic strain on farmers:** Decreasing crop yields and rising production costs from drought and pest control push farmers into financial hardship, risking farm closures.

- **Migration and displacement:** Persistent crop failures force people to migrate from rural areas to cities, straining urban resources and infrastructure.
- **Collapse of local food systems:** Reduced agricultural output disrupts local food supply chains, leading to dependence on external food sources and weakening local food security.
- **Social and political unrest:** Widespread food shortages and economic hardship can lead to conflicts over resources, potentially destabilising social and political structures.

6. **Climate change adaptation strategies include:**
   - Growing climate-resistant crops: Develop and plant varieties tolerant of heat and drought.
   - Adopt water-saving technologies: Implement efficient irrigation systems and precision agriculture.
   - Adopt soil conservation practices: Use conservation tillage and cover crops to reduce erosion.
   - Adopt integrated water management: This may include promoting water reuse, recycling, and conservation.
7. **Significance of Indigenous knowledge in adapting to climate change and variability:**
   - **Sustainable resource management:**

     Indigenous knowledge provides sustainable methods for managing resources, such as water and land, crucial for adapting to climate change.
   - **Adaptability and flexibility:**

     Indigenous practices are adaptable, allowing communities to respond effectively to both short-term climate variability and long-term climate change.
   - **Biodiversity preservation:**

     Indigenous communities promote biodiversity through traditional farming and conservation techniques, enhancing the resilience of ecosystems to climate impacts.
   - **Local environmental understanding:**

     Indigenous knowledge offers a deep understanding of local ecosystems, enabling precise predictions and adjustments to weather and environmental changes.
   - **Complement to modern science:**

     Integrating indigenous knowledge with modern science creates a more comprehensive approach to addressing climate challenges.

8. Renewable energy sources, such as solar and wind power, can play a crucial role in reducing the impacts of climate change in Ghana by decreasing dependence on fossil fuels, which release large amounts of greenhouse gases into the atmosphere.

Explanation:

Solar energy utilisation:

Ghana receives significant sunlight throughout the year, making solar energy an ideal renewable resource. Solar panels are being installed in rural communities to power homes and schools, providing clean electricity without the carbon emissions associated with traditional generators. An example is the installation of solar systems in northern Ghana through government initiatives and private partnerships, helping communities access sustainable energy while reducing fossil fuel use.

Wind energy utilisation:

- Coastal areas in Ghana, such as Ada and Prampram, have strong wind potential. The government and private companies are exploring wind farm projects in these regions to harness wind power. Wind turbines generate electricity with zero emissions, reducing reliance on coal and gas power plants. For example, the planned development of wind energy in Ghana could generate significant renewable energy, contributing to national climate goals and reducing the overall carbon footprint.

9. **Evaluating the effectiveness of carbon pricing as a strategy to reduce greenhouse gas emissions**

Carbon pricing, through mechanisms like carbon taxes and cap-and-trade systems, is widely regarded as a powerful market-based approach to reducing greenhouse gas (GHG) emissions. Its effectiveness can be evaluated based on the following key factors:

The economic incentive for emission reductions

- ***Effectiveness*:** Carbon pricing creates a financial disincentive for emitting carbon dioxide (CO_2) and other greenhouse gases. By assigning a cost to emissions, it encourages businesses and individuals to seek out low-carbon alternatives, invest in cleaner technologies, and adopt more energy-efficient practices.

  Example: The European Union's Emissions Trading System (EU ETS) has led to a significant decrease in emissions within participating industries by setting a cap on emissions and allowing the trading of emission permits.

Flexibility and market efficiency

- **Effectiveness:** Carbon pricing offers flexibility, allowing emitters to determine how best to reduce their emissions. This market-based approach tends to be more economically efficient than prescriptive regulations, enabling companies to adopt the most cost-effective strategies for reducing their carbon footprint.

Example: In Sweden, the carbon tax on fossil fuels has resulted in significant reductions in emissions without stifling economic growth, as companies adjusted by investing in renewable energy and energy efficiency.

Innovation and clean energy investment

- ***Effectiveness:*** By making carbon-intensive activities more costly, carbon pricing fosters innovation in cleaner technologies and renewable energy sources. The revenue generated from carbon pricing can also be reinvested into green energy projects, thus accelerating the transition to a low-carbon economy.

  Example: Carbon pricing in British Columbia has helped fund clean energy projects, promoting the adoption of wind, solar, and hydroelectric power, which has contributed to long-term emissions reductions.

Emission reductions

- ***Effectiveness:*** Empirical evidence suggests that carbon pricing leads to measurable reductions in greenhouse gas emissions. A properly set price provides a strong enough signal for businesses and consumers to change their behaviour and invest in cleaner technologies.

  Example: In the UK, a carbon floor price (a minimum carbon price) has been instrumental in reducing emissions from coal-fired power plants, contributing to a national decline in carbon emissions.

Revenue generation and redistribution

- ***Effectiveness:*** Carbon pricing generates significant revenue for governments, which can be used to fund climate mitigation projects, and renewable energy initiatives, or be redistributed to offset any regressive impacts on lower-income households. This increases the policy's social acceptance and fairness.

  Example: In Canada, revenues from the federal carbon tax are returned to households through rebates, helping to offset the cost of the carbon price for lower-income families while still maintaining an incentive to reduce emissions.

Challenges and limitations

- **Uneven implementation:** Carbon pricing effectiveness can be limited by inconsistent global adoption. If only some regions or countries implement strong carbon pricing, it can lead to "carbon leakage," where companies relocate to jurisdictions with lower carbon costs, undermining the global impact of carbon pricing.
- **Setting the right price:** The effectiveness of carbon pricing depends heavily on the price level. If the carbon price is set too low, it may fail to drive significant emission reductions. Conversely, setting it too high may provoke economic resistance or create undue financial burden on industries and consumers.

- **Political and social resistance:** Carbon pricing faces political opposition, particularly from industries that are heavily dependent on fossil fuels, and from consumers concerned about higher energy prices. This resistance can slow the implementation or lead to the undermining of the policy's effectiveness through exemptions or subsidies.

10. Refer to content on "indigenous and conventional mitigation measures and their effects on agricultural production."

11. Traditional farming practices such as mulching, cover cropping, bush fallowing and growing drought-tolerant crops can contribute to making crops more resilient in the face of changing weather patterns.

- **Mulching:** Mulching helps to retain soil moisture, reduces evaporation, and regulates soil temperature. It also suppresses weeds, which compete for water and nutrients. By maintaining a stable environment for root growth, mulching enhances crop resilience during periods of drought.
- **Cover cropping:** Cover cropping protects the soil from erosion, improves soil structure, and enhances nutrient recycling. Cover crops such as legumes, can fix nitrogen into the soil, reducing the need for chemical fertilisers. They also improve soil organic matter, making it more resilient to heavy rainfall and drought conditions, thus supporting healthier main crops.
- **Bush fallowing:** This involves leaving land uncultivated for a period of time to allow it to regenerate itself naturally. Regrowth helps restore soil fertility and structure, enhances biodiversity, and improves water retention. By alternating between cultivation and fallowing, farmers can maintain soil health and reduce the risk of crop failure due to changing weather patterns.
- **Growing drought-tolerant crops:** Selecting and cultivating drought-resistant varieties can significantly enhance resilience to climate variability. Traditional knowledge often includes the use of local crop varieties that have adapted to specific environmental conditions. These crops typically require less water and can withstand prolonged dry spells (that is, prolonged periods of below-average precipitation which can lead to drought conditions), ensuring food security even in adverse weather scenarios.

EXTENDED READING

Click on the link below to read more about climate change.

- https://science.nasa.gov/climate-change/effects/ Effects - NASA Science
- https://www.researchgate.net/profile/Malcolm-Cresser/publication/238091112_The_Effects_of_Global_Climate_Change_on_Agriculture/links/02e7e532ca03f62d72000000/The-Effects-of-Global-Climate-Change-on-Agriculture.pdf

REFERENCES

1. STEM Agricultural Science Curriculum
2. https://www.fao.org
3. https://aielandcorp.com/#home
4. Understanding climate variability and climate change Food and Agriculture Organization

GLOSSARY

Climate: This refers to the average weather condition of an area over some time.

Climate change: Refers to the long-term shifts in temperatures and weather patterns.

Drought: This refers to a period of drier than normal conditions.

Pestilence: This refers to a contagious or infectious epidemic disease that spreads rapidly and widely.

Acknowledgements

Ghana Education Service (GES)

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