Republic of the Philippines
POLYTECHNIC UNIVERSITY OF THE PHILIPPINES
Taguig Campus
Science, Technology, and Society

MODULE 11
CLIMATE CHANGE AND ITS ENERGY CRISIS

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BACKGROUND AND RATIONALE

Climate change is one of the major issues facing humanity today and affects the environment, society and economy severely. These types of situations make it increasingly apparent that people need to learn more about the causes and consequences of this occurrence under conditions of climate change and unstable weather.

In the context of the Philippines, which is one of the countries most prone to climate-related threats, the consequences of climate change did not bypass it and are severe. These challenges involve more frequent and severe natural disasters, fluctuations in the yields in agricultural production, and concerns about the biological diversity and means of living. There is an ever-growing demand for education and creating awareness as well as collective commitment on climate change, climate resilience, and climate sustainability.

This module aims to equip the learners with basic information about climate change, more so, its importance, consequences and ways that citizens and groups can contribute towards bringing the change. In terms of the purpose of raising awareness and promoting well-informed decision-making, the module aims at preparing learners for assuming a proactive part in shaping a sustainable and climate change attracting future.

APPENDICES

Figure 1. The Greenhouse Effect

Chapter 12: Climate Change and its Energy Crisis

Learning Outcomes:

At the end of the module, students should be able to:

- Define climate change scientifically.
- Identify and describe the causes of climate change.
- Apply STS (Science, Technology, and Society) concepts on issues of climate change.

Learning Content:

Climate Change

Climate change itself is a very broad phenomenon which is characterized by deep changes in the environment, society and the economy on the international level. Knowledge of its causes, consequences, and implications for the future is therefore vital if lasting solutions are to be found and consistent progress achieved to support the creation of strong communities. This module teaches about climate change under the Science, Technology and Society perspective to enable a well informed and essentially skilled learner in tackling this global issue.

12.1. DEFINITION OF CLIMATE CHANGE?

What is Climate Change?

Climate change refers to the large-scale alterations of the climate of a particular geographical area or the whole world in particular years. In its simplest form, scientifically, it can be described as the rise in average global temperature that has been attributed to the burning of fossil fuels, deforestation, and other industrial activities. It is a series of changes that occur in the climate system all over the world, primarily due to human activities that cause an increase in the concentrations of greenhouse gases in the atmosphere. They include increased incidence and intensity of natural disasters, variations in the yields in agricultural productivity, biological diversity, and ways of life.

12.1.1. THE CAUSES OF CLIMATE CHANGE

The primary causes of climate change are related to natural and human activities:

1. Greenhouse Gases

- Water Vapor: The most abundant greenhouse gas, but because the warming ocean increases the amount of it in our atmosphere, it is not a direct cause of climate change.
- Carbon Dioxide (CO_2): A vital component of the atmosphere, carbon dioxide (CO2) is released through natural processes (like volcanic eruptions) and through human activities, such as burning fossil fuels and deforestation.
- Methane (CH_4): Methane is a more powerful greenhouse gas than CO_2 but has a shorter atmospheric lifetime. Emitted during agricultural processes, waste decomposition, and livestock activities.
- Nitrous Oxide (N_2O): It is a result from commercial and organic farming practices such as fertilizer manufacturing and application. It also originates from burning fossil fuels and burning of vegetation and has risen by 18% over the last one hundred years.

2. Human Activities

- Open Burning: Open burning is the largest global source of black carbon contributing 42% followed by residential biofuel burning at 38% and diesel transport at 14% (Bond et al., 2007). Although some emissions are due to wildfires, most of them are anthropogenic; they result from deliberate fires to cultivate stubbles, grassland, or low growing forest vegetation. When these fires become invasive, they also emit more black carbon, methane, CO, CO2, destroy ecosystems and even endanger human lives and buildings.
- Emission of Fossil Fuel: It refers to the burning of oil, natural gas, and coal to generate energy. It is the primary cause of current climate change, altering the Earth's ecosystems and causing human and environmental health problems.
- Emission of Gas from vehicles: Transport, being the main sub sector under energy, is marked by a high emission of

greenhouse gases particularly fueled by road vehicles through the combustion of gasoline. The contribution of emissions from ships and aircraft is also increasing. Transport accounts for slightly under a quarter of global energy-related CO_2 emissions, and its energy demand is projected to increase substantially.

- Chlorofluorocarbons (CFCs): These chemical compounds do not exist in nature – they are entirely of industrial origin. They were used as refrigerants, solvents (a substance that dissolves others), and spray can propellants.

THE GREENHOUSE EFFECT

The greenhouse effect occurs when gases in Earth's atmosphere trap the Sun's heat, keeping the planet warmer than it would be without an atmosphere. This process, similar to how a greenhouse works, makes Earth livable. A greenhouse traps heat through its glass walls and roof, warming the interior even in winter. Similarly, greenhouse gases like carbon dioxide trap heat in Earth's atmosphere. During the day, sunlight warms Earth's surface, and at night, some of the released heat is retained by these gases, maintaining an average temperature of 58°F (14°C).

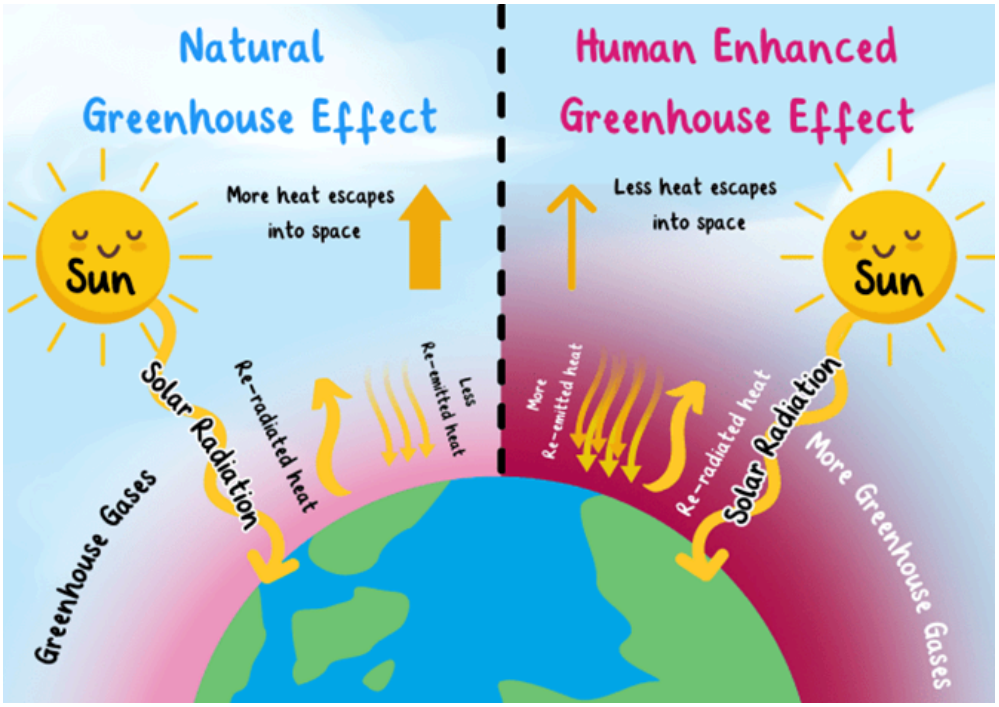

Figure 1. The Greenhouse Effect

12.1.2. THE EFFECTS OF CLIMATE CHANGE

- El Niño: It is when the tropical pacific temperature is above average. The dominant trade winds that flow from the east to the west along the equator are subdued or basically opposite. The story behind is that the central and eastern Pacific really has warm and moist air and hence, large storm clouds and frequent rainfall is observed.

- Sea Surface Temperatures to rise: The temperatures of world's oceans are increasingly rising through global warming and affecting ecosystems, natural patterns and economies. Global warming leads to sea level rise, coral reefs bleaching, more intense hurricanes and effect of carbon sequestration. As the biggest holding for carbon dioxide, oceans should do it through plankton that take away carbon deep in the sea after they die. But warming water slows down this process, meaning that a very important climate change buffer is

being lessened. Because oceans accumulate heat slower than the atmosphere due to their heat inertia, slight temperature rise critically affects ocean health and its capability to maintain stability caused by increasing levels of greenhouse gases.

- Ocean Acidification: It is emitted to the atmosphere through various human activities for warming of the climate system. Approximately one third to one half is taken up by oceans which mitigate the rate of atmospheric warming but cause ocean acidification. This process, as a result of fossil fuel emission, leads to increase in ‘pH’ of seawater making it acidic to marine life and the ecosystem including food supply, economy and tourism. Cutting down on CO2 emissions and handling other environmental pressures would go along way into decreasing ocean acidification.

- Sea level to rise: For the last one and a half century since 1880, the global sea levels have been rising at a rate of 8-9 inches (21-24 cm), caused by melting of glaciers, ice sheets, and by the expansion of the sea water as they have been warmed. Discovered that in the year 2023, sea level have raised to 101.4 mm (3.99 inch and this is the highest sea level recorded through satellite measurements as compared to the year 1993. Some ocean basins have increased by 6-8 inches (15-20cm) since 1993 due to regional wind and currents. The sea level increased by 3.6mm per year between 2006 and 2015 five times the increase of the 20th century. They could increase at least one foot (0.3 m) over 2000 levels by the year 2100 depending with emissions. Underlying soil conditions which lead to ground settlement and ocean currents, which are responsible for differences within regions, exist. Here in the United States, the fastest increase occurs in the Gulf of Mexico and mid-Atlantic, and Alaska and parts of the Pacific Northwest have already decreased but are expected to rise at a high rate with high emission.

- Tropical cyclones to intensify: It has been predicted that tropical cyclone-susceptible areas of the world will experience more powerful cyclones over the current century. Increasing trend in sea levels will worsen coastal floods hazard regardless of the cyclone intensity which may not increase. From future cyclones, increased rainfall gets predicted leading to more flooding. Greater, giant cyclones result in increased destruction so the projected trend toward intense cyclones is rather alarming. Though comparison of climate change impacts with other natural climate variability remains complex, data point more toward human consequences for some of these tendencies. Tropical cyclone data observes trends that are consistent with the expectations for a warming climate.

- Rainfall, River flow, and Flooding to intensify: The hydrological cycle is projected to intensify with global warming, leading to more extreme precipitation and flood risks. However, these changes often deviate from the expected atmospheric water-holding capacity increase, especially in regions with limited water availability. This study quantifies how spatial and seasonal water availability influences changes in extreme precipitation and flood intensities by the end of the 21st century. Results indicate a stronger intensification in wetter regions and seasons, with the relationship becoming more pronounced for less extreme events.

12.2. ECONOMIC IMPACTS OF CLIMATE CHANGE

- Altering Production Ecosystems: Global warming encompasses the major life-supporting ecosystem services on which society depends. For instance, low rainfall and high temperatures can be a factor in less food supplies, poor quality food and poor farmers yields. It also influences carbon sequestration, and the forest is one of nature's greatest absorbers for carbon monoxide and storage of the same in the soils and roots systems. Ecosystems cover plants,

animals and microorganisms which offer essentials like food, water, clean air and recreational services.

- Agriculture being an important sector depends on land and water and other natural resources which are influenced by weather. Though it might extend growing seasons or even introduce new crops to a location, climate change complicates farming elsewhere. New blights and pests have infected crops due to high temperatures. For rice the duration of cultivation may vary by climate zones and by rice types. Climate is the limiting factor in its growth and maturity; warmth favors sweet potatoes by shifting the latitudinal range of suitable environments upward and also changes in practices of cultivation. They may be cultivated in early maturing rice growing tracts which may be extended now into poorer tracts or at higher altitude.

- Food Security Delines: High temperatures and CO_2 are favorable to crops to some limit as they increase evapotranspiration rates and must have water for growth. For various climate change issues, such as water scarcity, extreme events, heat stress, and pests, agriculture production of water scarce areas will decline. In this case, it becomes difficult and expensive to adapt beyond 2°C of warming. In the hot areas such as Sahel or South Asian, any increase in the temperature may negatively affect the vulnerable produce say wheat. If no solutions are implemented, low crop yields will continue pushing more people into poverty.

- Malnutrition Increases: Climate change has worsened hunger and malnutrition, with extreme weather events like droughts, floods, and storms disrupting agriculture and reducing food availability. Vulnerable communities, especially those already facing food insecurity, are hit hardest as crop failures and livestock losses increase. Nearly half of deaths in children under 5 are linked to undernutrition, mainly in low- and middle-income countries,

according to the World Health Organization. Malnutrition has lasting developmental, economic, and social impacts, particularly on women and children, affecting immunity, organ development, and learning. Despite global recognition of nutrition's importance, malnutrition remains a critical global issue, contributing to child mortality.

12.3. ISSUES AND SOLUTIONS

What is the Energy Crisis?

Energy crisis is defined as the shortage of energy resources to meet the demand which gives rise to fluctuations of the economy, social upheavals and environmental problems. The possibilities for the shortage to appear vary from quickly, and it is a gradual process due to the influence of many circumstances, including the conflicts in the geopolitical region, the poor infrastructure of the country, high consumption rates, or the exhaustion of resources.

12.3.1. CAUSES OF ENERGY CRISIS

- Overconsumption: Today’s consumption model depends almost entirely on the non-renewable sources of energy such as oil, gas, coal and uranium. According to current trends of consumption, the first fossil fuel to run out of stock will be oil. Based on their availability, conventional oil can last for 40-60 years, natural gas approximately 70 years and coal will roughly take 200 years. These fuel sources exert pressure on the resource base by emitting pollutants and disturbing availability of water and oxygen.

- Overpopulation: World is growing beyond our imagination. In the latest development, the world’s population is growing by 60,000 people every eight hours, or two children every second somewhere in the world. At this rate of development, it would take fifty percent more energy to sustain mankind by

the year 2050, experts argue. Not only that, with people arise the need to feed them, water them, provide them shelter which strained our natural resources. The energy consumption in any given population is directly proportional to the size or the population in question. It has also be argued that number of energy resources define how many people the world can sustain in terms of population. Most of the conventional energy resources are at their peak and the search for renewable and manageable energy sources still goes on so knowing how the human population affects energy demand is important.

- Poor Infrastructure: A second reason that can be attributed to inadequate energy is the deterioration of power generation facilities equipment. Most energy producing organizations have aged plants and equipment, and this slows down energy production. Companies need to invest in improving and maintaining infrastructure and at the same time deliver optimal results. Changes are costly and require many more resources to be done. Though these resources contaminate the environment and are highly responsible for CO2 emissions, they are non renewable. Many energy producing companies continue to use old equipment that restrains output of energy production.

- Energy Waste: It is the uneconomical consumption of fuel and electricity that originates mainly from the ineffective utilization of energy resources. Therefore, waste reduction is a huge conservation of energy effort that requires everyone and society collectively to undertake. Energy conservation is not well understood by the population in most regions of the world.

- Natural Disasters or Major Accidents: Energy supplies are affected by harsh grievances such as severe line fault, or break, and natural disasters such as, drought, flood, cyclones, volcanic eruptions, and earthquakes. This has left energy as a natural resource with a highly fluctuating supply/demands ratio

and the same has the potential to increase the prices of essential commodities and therefore result in inflation.

12.3.2. SOLUTIONS TO ENERGY CRISIS

- Shift to Alternative or Renewable Energy Sources

  Renewable energy is energy from natural sources that can be replaced on man time scale, and they include solar energy, wind, water, hydro energy, tidal energy, geothermal energy. Renewable energy sources do not emit Greenhouse gases to the atmosphere and, therefore, are part of the solution to Climate change.

  - Wind Energy: It is derived from dynamic blowing of wind that uses wind turbines either on the land neighborhood (onshore) or in bodies of water (offshore). Wind energy has been utilized for thousands of years, but on and offshore wind energy has advanced during the past few years in terms of the electricity generated – through increased height of newer models and increased rotor diameter. Thus, total and average wind speeds differ significantly in different locations, but the technological opportunities in wind energy are higher than world electricity generation, and vast opportunities remain in most parts of the world to realise considerable wind energy capacity. Most regions of the world are characterized by high wind velocities but the best sites for wind energy are usually the most distant. There is enormous prospect for offshore wind power.

  - Geothermal Energy: Consists of the available thermal energy from the surface of the earth below this level. Heat is removed from the geothermal reservoirs either through wells or in other ways Some are these natural in the sense that they are hot and permeable and are called hydrothermal reservoirs while the others require to be made hot naturally and then have to be stimulated hydraulically and these are

knows as enhanced geothermal systems. Once fluids reach the surface, the fluids can be used to produce electricity from varying temperatures. Mature and reliable technology for generation of electricity from hydrothermal reservoirs has been existing; it is more than a century old.

- Solar Energy: Most abundant form of energy and it can however be captured even on a cloudy day. At a developmental level, solar energy at the top of the atmosphere is 10,000 times more available than the rate with which the world uses energy. SOLAR technologies can provide heat, cooling, natural light and power and fuels for a multitude of uses. Photovoltaic panels and solar power towers are the two most common technologies most used in capturing the solar energy to produce electricity. Even if the contribution of each country to the energy mix from direct solar energy is not proportional to the abundance of this source, every country might contribute in terms of utilizing direct solar energy. The cost of generating solar energy is low and has dropped significantly in the last decade and in fact in many instances is even cheaper than other forms of electricity. Solar panels have a durability of about three decades and are available in many shades depending on the sort of material that has been used during their production.

- Hydropower: Makes use of the power derived from water in the process where it flows from a higher position to a lower position. It can be produced from reservoirs and rivers. Reservoir developed hydropower plants freely use water stored in a reservoir storage while Run of river hydropower plants use the flow of the river. This is because the hydropower reservoirs are known to act as water supply sources for human and livestock consumption, for crop production and domestic use and for controlling floods and droughts, for harbors and other water transport services, and as sources of electricity. Hydropower overwhelmingly is the largest source of renewables in electricity production at the current time. It makes use of relatively

predictable rainfall regimes and may be affected by climate-related short-rages or changes in the ecosystem that affects rainfall. The same structures required for hydropower development may also have certain effects on ecosystems that are negative. That is why some people prefer small-scale hydro development calling it cheaper and friendlier to the environment, and especially suitable for countries with isolated rural areas.

- Bioenergy: It is derived from organic matter referred to as biomass which encompasses wood, charcoal, dung and other manures for heat and power generation, and crops for liquid Biofuels. Most biomass is consumed in the rural facilities for cooking, illumination and for heating facilities, which is normally done by the less privileged citizens mostly from the developing countries. Detailed biomass sources include dedicated energy crops as well as energy crop residues which include both agricultural residues and forestry residues and municipal and industrial organic wastes. Energy produced from burning biomass leads to production of greenhouse gas emissions but is slightly less than that produced when burning fossil fuels as in the case of coal, or oil or natural gas. Nonetheless, it is recommended that the application of bioenergy should be limited since there are many adverse environmental effects associated with the expansion of forest and bioenergy plantations that lead to deforestation and changes in land use.

- Biomass Energy: Biomass is defined as materials of organic origin from plants and animals, and this it covers crops, waste wood, and trees. Chemical energy that is within biomass can be in a form of heat and when it is ignited, electricity can be produced using turbine and steam. Unfortunately, biomass is frequently presented and marketed as a clean, renewable fuel complementary to electricity-generation coal, and a cleaner fuel. However, new science has established that many categories of biomass, particularly from forests emit more carbon than fossil fuels. Biological diversity suffers negative effects as well as

according to the source. Nevertheless, some types of biomass energy need to be considered as the low carbon source if certain conditions are met. For instance, saw dust or chips produced from sawmills, are a quickly decomposing feed that when used will release carbon.

QUIZ TIME!

1. Which greenhouse gas is considered the most abundant in the atmosphere but not a direct cause of climate change?

a. Carbon dioxide (CO_2)

b. Methane (CH_4)

c. Water vapor

d. Nitrous oxide (N_2O)

2 Which of the following is NOT a solution to the energy crisis?

a. Shift to renewable energy sources

b. Increased reliance on fossil fuels

c. Energy conservation

d. Improved infrastructure

3. Which renewable energy source harnesses heat from below the Earth's surface?

a. Solar energy

b. Geothermal energy

c. Wind energy

d. Bioenergy

4. Which sector contributes most to global energy-related CO_2 emissions?

a. Agriculture

b. Transport

c. Industry

d. Residential

5. What is a downside of biomass as a renewable energy source?

a. Low energy efficiency

b. High carbon emissions compared to fossil fuels

c. Potential deforestation and land use changes

d. Limited applications in rural areas

6. What is the most abundant source of renewable energy on Earth?

a. Wind energy

b. Solar energy

c. Hydropower

d. Bioenergy

7. Methane has a shorter atmospheric lifetime but is more potent than carbon dioxide.

8. Energy conservation requires collective effort and awareness among the population.

9. Geothermal energy relies on solar heat absorbed by the Earth's surface.

10. Renewable energy sources, such as wind and solar, do not emit greenhouse gases during operation.

ACTIVITY : CLIMATE ACTION PLEDGE

Address Climate Change and make actionable, personalized commitments to reduce environmental impact,

1. Identify High-Impact Areas in Your Life (Energy Usage, Consumption Habits, etc.).

2, Decide on a Specific Action to Take. Choose an achievable action to reduce your carbon footprint.

3. Set a Realistic Goal that motivates long-term change.

4. Share it to the class.

Quiz Answer Key!

1. B	5. B
2. B	4. A
3. C	9. A
7. D	8. C
6. D	10. A

Learning Resources

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