CLIMATE CHANGE EDUCATION IN NIGERIA: THE PROSPECTS AND CHALLENGES

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Foreword

I am very much delighted to write the foreword of this academic treatise titled "*Climate Change Education in Nigeria: The Prospects and Challenges*". When the request to foreword the book came to me, the very first thing I did was to go through the text with sense of diligence so as to understand the author's trend of thoughts. There are many books on climate change ed*ucation*. I have read some of them. I must admit that this book stands out in a class of its own. I make bold to assert therefore, that this is a masterpiece on contemporary issues that border on education in Nigeria and of course, outside the shores of Nigeria. I must also admit that this book is a timely and crucial contribution to one of the most pressing issues of our era. The reality of climate change is no longer a distant threat; it is a present-day crisis with profound implications for Nigeria and the global community. Nigeria, in particular, faces unique vulnerabilities, with its vast coastline, dependence on agriculture, and large population centers, all of which are increasingly susceptible to the adverse impacts of a changing climate.

This book arrives at a critical juncture. As the world grapples with the escalating consequences of global warming, including rising temperatures, extreme weather events, and sea-level rise, the need for informed action has never been more urgent. Education is paramount in this effort. By equipping individuals with the knowledge and understanding of climate change, we empower them to make informed decisions, adopt sustainable practices, and advocate for effective policies.

Climate Change Education in Nigeria: The Prospects and Challenges is a comprehensive and insightful resource that not only elucidates the complexities of climate science but also underscores its specific relevance to Nigeria. It meticulously examines the causes and consequences of climate change, analyzes its impact on Nigeria's unique ecosystems and communities, and highlights the importance of education in fostering resilience and adaptation.

In this highly commendable book, Dr. Chigbu lucidly presents the combined subject matter of education and climate change devoid of unnecessary technicalities. Having gone through this text, my conclusion is that, this book is more than an academic treatise; it is a call to action. It is a powerful reminder that every citizen has a role to play in addressing climate change issues. On this note therefore, every student and lecturer in education should have only one option: to follow Dr. Chigbu because she sells wise counsel at no cost. This book will be valuable to school managers and administrators at all levels of the education system, and even a ready tool for those who administer higher education in this country. I hope that this book will serve as a catalyst for change, inspiring educators, policymakers, and individuals to work collaboratively towards a sustainable and climate-resilient future for Nigeria. The book will also serve as a useful companion to students of educational administration and management at all levels, especially university students, NCE students in colleges of education, undergraduates, as well as postgraduate students of faculties of education. As a sincere advice, one cannot but avail oneself a copy or copies of this well-researched, easy-to-understand book on one of the very foundational courses of the Nigerian education system. I wish you happy reading.

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Preface

Climate change is one of the most pressing challenges of our time, with far-reaching consequences for the entire planet. No nation is immune to its effects, and Nigeria, with its large population, diverse ecosystems, and significant economic reliance on climate-sensitive sectors, is particularly vulnerable. Rising temperatures, altered rainfall patterns, sea-level rise, and increased frequency of extreme weather events are already impacting communities across the country, threatening livelihoods, exacerbating existing inequalities, and hindering sustainable development.

In the face of this complex and evolving crisis, education is a powerful tool. A well-informed and engaged citizenry is essential for building resilience, adapting to change, and mitigating future impacts. This book, *Climate Change Education in Nigeria*, is a comprehensive resource designed to equip educators, students, policymakers, and concerned citizens with the knowledge and understanding necessary to address this challenge effectively.

This book provides a thorough exploration of climate change science, impacts, and solutions, with a specific focus on the Nigerian context. It begins by establishing a strong foundation in climate science, defining key terms, and tracing the historical development of our understanding of climate change. It delves into the observed changes in climatic variables, the greenhouse effect, and the critical role of the ozone layer. It also examines the specific vulnerabilities and impacts faced by Nigeria, including environmental deterioration, acid rain, and other environmental hazards.

However, this book goes beyond simply describing the problem. It also explores the crucial role of education in fostering solutions. It provides an overview of environmental education, its classification, evolution, and development, and introduces the concept of environmental management. It is our firm belief that by increasing climate literacy and promoting environmental stewardship, we can empower individuals and communities to take meaningful action.

Climate Change Education in Nigeria is more than just a textbook; it is a call to action. It is a resource for anyone committed to creating a sustainable future for Nigeria and its people. We hope that this book will catalyse dialogue, inspire innovative solutions, and contribute to a more climate-resilient and environmentally conscious society.

B. C. Chigbu, PhD

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UNIT ONE:
CLIMATE CHANGE AND RELATED TERMINOLOGIES

CHAPTER 1. UNDERSTANDING CLIMATE CHANGE AND CLIMATE CHANGE TERMINOLOGIES

1.0. Introduction

Climate change is one of the most pressing issues of our time, with far-reaching consequences for our planet and its inhabitants. The scientific consensus is clear: human activities, particularly the emission of greenhouse gases, are significantly contributing to the warming of the Earth's atmosphere. These rising global temperatures are having devastating effects, from melting glaciers and sea level rise to extreme weather events and disruptions to the ecosystem. Climate change refers to the long-term warming of the planet due to an increase in average global temperature, primarily caused by human activities that release greenhouse gases, such as carbon dioxide and methane, into the atmosphere. In this unit, other related terminologies on climate change will be considered.

1.1. What is Climate Change?

Throughout the history of the Earth, the climate has been changing. What is happening now, however, is that we are hearing more and more about "the greenhouse effect". This greenhouse effect is a natural phenomenon, in which gases and small particles trap the sun`s heat and in that way maintain a temperature which is suitable for life. Concern now is that human activities have affected the atmosphere and are intensifying the greenhouse effect, leading to climate change more rapid than has been experienced before.

The effects of greenhouse gases upon the weather are complex and vary widely, depending upon where you are in the world. There has been (would be) more extreme weather events, from heat waves to hurricanes and from droughts to floods. For example, in Europe summers are hotter on average than they were. In 2003, 35000 people died in the summer heat wave which brought temperatures of over 40 degrees Celsius to some areas. In Africa, droughts are becoming more common. Japan is becoming warmer, and scientists are modifying the rice strains sown so that yields are not adversely affected. Hurricanes and typhoons are larger, stronger and more frequent and are now occurring in some areas where they have never been seen before. It is because of climate change.

Climate change occurs when the Earth’s average temperature changes dramatically over time. As little as one or two degrees can be considered a dramatic change because the Earth’s ecosystem depends on a very delicate balance, and even small shifts can have a far-reaching impact. A drop in average temperature can also be considered climate change, but in modern times, people using the term are usually talking about global warming. The average temperature of the Earth's surface has risen over the last century by 1 degree Celsius, and further rises are ongoing. Some experts predict that we may be causing damage which will lead to temperature rises of 6 degrees worldwide before the end of this century. If that were allowed to happen it would be catastrophic. The effects of climate change can already be seen, in the melting of permafrost near the North Pole and the rise of sea levels. Rising ocean levels ultimately cause concern about shrinking coastlines and island land masses.

Climate change refers to any significant change in measures of climate (e.g. temperature, precipitation or wind) lasting for an extended period (decades or longer). Climate change may result from:

• Natural factors, such as changes in the sun's intensity or slow changes in the Earth's orbit around the sun;

• Natural processes within the climate system (e.g. changes in ocean circulation); and,

• Human activities that change the atmosphere's composition (e.g. through burning fossil fuels) and the land surface (e.g. deforestation, reforestation, urbanisation, desertification, etc.)

1.2. Understanding Weather and Climate

To define 'climate', it is important to distinguish it from 'weather'. The weather that we experience on a day-to-day basis is a momentary atmospheric state characterised by temperature, precipitation, wind, and so on, and seems to vary irregularly, not following any particular pattern. When one considers longer time scales, weather can be seen to vary recurrently, be it on a global, regional or local scale. This is what we refer to as climate. In contrast to the instantaneous conditions described by weather, climate is described with average values (e.g. annual average, or mean, temperature), but also typical variability (e.g. seasonal maximum/minimum temperatures) and frequency of extremes such as monsoons/hurricanes/cyclones. The timescale upon which climate statistics are calculated is typically thirty years (e.g. 1981–2010).

1.2.1. Weather

Atmospheric conditions at any given time or place. It is measured in terms of such things as wind, temperature, humidity, atmospheric pressure, cloudiness, and precipitation. In most places, weather can change from hour-to-hour, day-to-day and season-to-season. Climate in a narrow sense is usually defined as the "average weather", or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period ranging from months to thousands or millions of years. The classical period is 30 years, as defined by the World Meteorological Organisation (WMO). These quantities are most often surface variables such as temperature, precipitation and wind.

1.2.2. Climate

Climate is usually defined as the "average weather", or more rigorously, as the statistical description of the weather in terms of the mean and variability of relevant quantities over periods of several decades (typically three decades as defined by WMO). These quantities are most often surface variables such as temperature, precipitation, and wind, but, in a wider sense, the "climate" is the description of the state of the climate system. Climate in a wider sense is the state, including a statistical description, of the climate system. A simple way of remembering the difference is that climate is what you expect (e.g. cold winters) and 'weather' is what you get (e.g. a blizzard).

1.3. Climate change terminologies

1.3.1. Climate variability

Climate variability refers to variations in the mean state and other statistics (e.g. standard deviations, occurrence of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or to variations unnatural or anthropogenic external forcing (external variability).

1.3.2. Deforestation

Deforestation is the natural or anthropogenic process that converts forest land to non-forest, i.e. those practices or processes that result in the conversion of forested lands for non-forest uses are termed deforestation. This is often cited as one of the major causes of the enhanced greenhouse effect for two reasons:

• The burning or decomposition of the wood releases CO_2, and,

• Trees that once removed CO_2 from the atmosphere in the process of photosynthesis are no longer present.

1.3.3. Desertification

It refers to land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities. The United Nations Convention to Combat Desertification (UNCCD) defines land degradation as a reduction or loss, in arid, semi-arid, and dry sub-humid areas, of the biological or economic productivity and complexity of rain-fed cropland, irrigated cropland, or range, pasture, forest and woodlands resulting from land uses or a process or combination of processes, including those arising from human activities and habitation patterns, e.g. soil erosion caused by wind and/or water, deterioration of the physical, chemical and biological or economic properties of soil and long-term loss of natural vegetation.

1.3.4. Emissions

It is the release of a substance (usually a gas when referring to the subject of climate change) into the atmosphere.

1.3.5. Global warming

Global warming is the average increase in the temperature of the atmosphere near the Earth’s surface and in the troposphere, which can contribute to changes in global climate patterns. Global warming can occur from a variety of causes, both natural and human-induced. In common usage, “global warming” often refers to the warming that can occur as a result of increased emissions of greenhouse gases from human activities.

1.3.6. Greenhouse effect

Greenhouse gases effectively absorb infrared radiation, emitted by the Earth’s surface, by the atmosphere itself due to the gases and by clouds. Atmospheric radiation is emitted in all directions, including downward to the Earth’s surface. Thus, greenhouse gases trap heat within the surface troposphere system. This is called the greenhouse effect.

1.3.7. Greenhouse gases (GHGs)

Greenhouse gases are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of infrared radiation emitted by the Earth’s surface, the atmosphere and clouds. Greenhouse gases include, but are not limited to, water vapour, carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), chlorofluorocarbons (CFCs), hydro chlorofluorocarbons (HCFCs), ozone (O3), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6). Besides water vapour (H_2O), the main GHGs are water carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and ozone (O_3) produced by the photo dissociation of N_2O. Other GHGs, produced exclusively by human activities, are fluorinated gases used in refrigeration and air conditioning systems, as well as in aerosol cans. According to the Intergovernmental Panel on Climate Change (IPCC, 2007), "most of the observed increase in global mean surface temperature from 1951 to 2010 is very likely due to the observed increase in anthropogenic greenhouse gas concentrations."

1.3.8. Greenhouse gas reduction potential

Possible reductions in emissions of greenhouse gases (quantified in terms of absolute reductions or in percentages of baseline emissions) that can be achieved through the use of technologies and measures are termed as greenhouse gas reduction potential.

1.3.9. Hydrological cycle

The cycle in which water evaporates from the oceans and the land surface, is carried over Earth in atmospheric circulation as water vapour condensates to form clouds, precipitates again as rain or snow, is intercepted by trees and vegetation, provides runoff on the land surface, infiltrates into soils, recharges groundwater, discharges into streams, and ultimately, flows out into the oceans, from which it will eventually evaporate again. The various systems involved in the cycle are usually referred to as hydrological systems.

1.3.10. Ozone layer

The stratosphere contains a layer in which the concentration of ozone is greatest, the so-called ozone layer. The layer extends from about 12 to 40 km. The ozone concentration reaches a maximum between about 20 and 25 km. This layer is being depleted by human emissions of chlorine and bromine compounds. Every year, during the Southern Hemisphere Spring, a very strong depletion of the ozone layer takes place over the Antarctic region, also caused by human-made chlorine and bromine.

1.3.11. Ozone Depleting Substance (ODS)

A family of man-made compounds that includes, but are not limited to, chlorofluorocarbons (CFCs), bromofluorocarbons (halons), methyl chloroform, carbon tetrachloride, methyl bromide, and hydrochlorofluorocarbons (HCFCs). These compounds have been shown to deplete stratospheric ozone, and therefore are typically referred to as ODSs.

1.3.12. Sequestration

It is the process of increasing the carbon content of a carbon pool other than the atmosphere, i.e. carbon storage in terrestrial or marine reservoirs. Biological sequestration includes direct removal of CO2 from the atmosphere through land-use change, afforestation, reforestation, carbon storage in landfills and practices that enhance soil carbon in agriculture.

1.3.13. Sinks

It is any process, activity or mechanism that removes a greenhouse gas or aerosol, or a precursor of a greenhouse gas or aerosol, from the atmosphere.

1.3.14. Adaptation

Initiatives and measures to reduce the vulnerability of natural and human systems against climate change. Various types of adaptation are, e.g. anticipatory and reactive, private and public, and autonomous and planned. Examples are raising river or coastal dikes, the substitution of more temperature shock-resistant plants for sensitive ones, etc.

1.3.15. Mitigation

Mitigation refers to efforts made to reduce the severity of climate change by decreasing greenhouse gas emissions or enhancing

1.4. Climate change indicators

2. The first indicator is the increase in the atmospheric temperature, which was noticed a long time ago. In addition, extreme heat episodes were observed worldwide with more intense and severe frequency
3. The ocean temperature increase, which has been measured since the 1950s by commercial ships or oceanographic vessels and more recently by the buoy system, showed a global average increase for a few decades.
4. The reduction of Arctic Ocean ice and sea ice area is another strong indicator of climate change acceleration: from 8.5 million km2 from 1950 to 1975, sea ice area fell very rapidly, reaching 5.5 million km2 in 2010.
5. The melting of continental glaciers has been observed almost universally for 3 to 4 decades, in the Himalayas and the European Alps. According to the IPCC, glaciers in northern Asia, central Europe, and Scandinavia will shrink by 80% in volume by 2100.
6. The reduction of the polar ice caps of Antarctica and Greenland, which was observed about ten years ago, has been attributed to the ocean water warming of these regions.

7. The rise of the ocean’s average level, monitored since 1990 by altimetric satellites, has shown a rise in the sea’s global average level by 3.4 mm/year over the period 1993-2016.
8. Biological indicators, such as the migration of earthly or marine animal populations and changes in the dates of seasonal agricultural activities, also showed the occurrence of global warming.

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CHAPTER TWO. UNDERSTANDING HISTORICAL PERSPECTIVES OF CLIMATE CHANGE SCIENCE

2.0. INTRODUCTION

Climate is conventionally defined as the long-term average of weather conditions, such as temperature, cloudiness, and precipitation; trends in these conditions for decades or longer are a primary measure of climate change. The climate is naturally variable. Evidence shows that throughout Earth's history, there have been numerous global climate changes that were much larger than those experienced in recent times. For most of the last 500 million years, the Earth was probably much warmer than it is today. Some data suggest that an increase has occurred in average temperatures at the Earth's surface of as much as 1°C since the mid-1800s, with continued trends of about one to two tenths of a degree per decade in recent years (IPCC, 2001). There are considerable uncertainties and ongoing scientific debate about the reasons for such changes and what they mean for the future. Computer-run climate models used by the IPCC assign most of the cause for this trend to increases in the atmospheric concentrations of greenhouse gases, due mainly to the burning of fossil fuels.

2.1. **Historical Overview of Climate Change Science**

A related term, "climatic change", was proposed by the World Meteorological Organisation

(WMO) in 1966 to encompass all forms of climatic variability on time-scales longer than 10 years, but regardless of cause. During the 1970s, the term climate change replaced climatic change to focus on anthropogenic causes, as it became clear that human activities had the potential to drastically alter the climate. Climate change was incorporated in the title of the Intergovernmental Panel on Climate Change (IPCC) and the UN Framework Convention on Climate Change (UNFCCC). Climate change is now used as both a technical description of the process, as well as a noun used to describe the problem.

The history of climate change discussion among people goes farther back in time than one might think. Weart (2007) notes that climate change was conceptualised in ancient times, with knowledge of the subject growing as the technology to study it improved over time. An important figure in climate science history who warned of possible problems was Guy Stewart Callendar, whose idea of carbon dioxide as a heat-trapping agent was indeed borne out by computer climate simulations in the 1970s- "Even subtle changes in the Earth's orbit could make a difference. To the surprise of many, studies of ancient climates showed that astronomical cycles had partly set the timing of the ice ages.

The climate was so delicately balanced that almost any small perturbation might set off a great shift" (Weart, 2007). More recently, Earth's climate has been studied by the Intergovernmental Panel on Climate Change, an organization made up of many scientists who specialize in climate studies. The IPCC has issued four reports over recent years that have studied the connections between human activity and climate change. One of the most recent report, "Climate Change 2007", declared that the consensus of the group is that there is 90% certainty that global warming is directly related to human greenhouse gas emissions.

2.2. Difference between climate change and global warming

Climate change and global warming are terms that are sometimes used synonymously, but they have different meanings in the sense that 'warming" is only one phase of the larger climate system on Earth that naturally features change. Physical evidence on Earth and in space has helped scientists understand that many factors can contribute to the changing of the planet's climate on a long-term basis. Examples of these factors are solar radiation levels, Earth's orbit around the sun, volcanic activity, ocean currents, and even plate tectonics. The periods of warming and cooling are referred to as interglacials and glacials, respectively, with the latter being partly characterised by enormous sheets of ice extending from the poles.

Global warming refers specifically to the long-term rise in the average surface temperature of the earth due to the increasing levels of greenhouse gases in the atmosphere. Global warming focuses primarily on the temperature increase aspect of climate change. Global warming is mainly caused by human activities that release greenhouse gases, such as carbon dioxide and methane, into the atmosphere. Whereas climate change refers to the broader range of changes that occur in the Earth's climate system, including temperature increases, precipitation changes, sea level rise, and shifts in weather patterns. Climate change encompasses not only rising temperatures but also other climate-related changes such as extreme weather events, ocean acidification, and changes in ecosystems. Climate change is caused by a combination of natural factors, e.g. volcanic eruptions, changes in Earth’s orbit, and human activities, e.g. greenhouse gas emissions, deforestation, land use changes, etc. The key difference therefore, is that global warming focuses on temperature increases, while climate change encompasses a broader range of climate-related change. Global warming is primarily caused by human activities, while climate change has both natural and human-induced causes.

2.3. Causes of Climate Change

The Earth's climate is dynamic and always changing through a natural cycle. What the world is more worried about is that the changes that are occurring today have been sped up because of human activities. These changes are being studied by scientists all over the world who are finding evidence from tree rings, pollen samples, ice cores, and sea sediments. There is a broad consensus amongst scientists that greenhouse gases released through human activity are the main factor causing climate change. The causes of climate change can be divided broadly into two categories

- Those that are due to natural causes and
- Those that are created by man.

2.3.1. Natural Causes

There are a number of natural factors responsible for climate change. Some of the more prominent ones are continental drift, variation in the Earth's orbit, changes in solar output, volcanic emissions, cosmic collisions, ocean currents, the Earth's tilt, and comets and meteorites. Let's look at them in a little detail.

2.3.1.1 Continental Drift

The discovery of fossils of tropical plants (in the form of coal deposits) in Antarctica has led to the conclusion that this frozen land, at some time in the past, must have been situated closer to the equator, where the climate was tropical, with swamps and plenty of lush vegetation. The continents that we are familiar with today were formed when the landmass began gradually drifting apart, millions of years ago. This drift also had an impact on the climate because it changed the physical features of the landmass, their position and the position of water bodies. The separation of the landmasses changed the flow of ocean currents and winds, which affected the climate. This drift of the continents continues even today; the Himalayan range is rising by about 1 mm (millimetre) every year because the Indian land mass is moving towards the Asian land mass, slowly but steadily.

2.3.1.2. Variation in Solar Output:

Many scientists thought that the sun`s output radiation only varied by a fraction of per cent over many years. However, measurements made by satellites equipped with radiometers in the 1980s and 1990s suggested that the sun`s energy output may be more variable than was once thought and showed a decrease of 0.1 per cent in the total amount of solar energy reaching the Earth over just in 18-month period. If this trend were to extend over several decades, it could influence global climate. Numerical climate models predict that a change I solar output of only 1 per cent per century would alter the Earth`s average temperature by between 0.5° to 1°C.The variation in sunspots (22 years cycle) also the effect on the variability of energy of the sun’s rays.

2.3.1.3 Volcanoes

When a volcano erupts, it throws out large volumes of Sulphur Dioxide (SO2), water vapour, dust, and ash into the atmosphere that can influence climatic patterns for years. There are many different types of volcanic eruptions and associated activities. Volcanoes affect people in a variety of ways, and at a variety of scales. Many more localised problems are sometimes posed by the release of toxic gases in volcanic eruptions. Fine ash from the 1883 explosion of Krakatoa, for example, was carried by the uprush of gas and vapours to a height of 27 km. It was blown around the world and caused exotic sunsets and other climatic effects. Generally, millions of tons of Sulphur Dioxide gas can reach the upper levels of the atmosphere from a major eruption. The gases and dust particles partially block the incoming rays of the sun, which ultimately effect on heat budget. Sulphur Dioxide combines with water to form tiny droplets of Sulphuric acid, which take the form of acid rain that is very harmful to ecosystem. These droplets are so small that many of them can stay aloft for several years. They are efficient reflectors of sunlight and screen the ground from some of the energy that it would ordinarily receive from the sun.

2.3.1.4. **Variation in the Earth’s Orbit & Axis**

The Earth's orbit is somewhat elliptical, which means that the distance between the Earth and the sun varies over the course of a year (perihelion, 147.1 million km & aphelion152.1 million km), which ultimately affects upon distribution of solar energy. This causes the solar radiation reaching the Earth to vary by about 3.5% above or below the average ‘solar constant’. The proximity to the equator also affects the climate of a place because equatorial regions receive maximum incoming solar radiation (energy) throughout the year. As one moves poleward ward the solar energy decreases. We usually think of the Earth's axis as being fixed. It is not quite constant: the axis does move, at the rate of a little more than a degree each century. This gradual change in the direction of the Earth's axis, called precession, is responsible for changes in the climate. The tilt of the Earth’s axis from the normal to the ecliptic itself varies, undergoing a slow oscillation, with a period of about 40,000 years, between 24°36′ and 21°59′. At present, the angle is 23°27′ and decreasing. Changes in the tilt of the Earth can affect the severity of the seasons - more tilt means warmer summers and colder winters; less tilt means cooler summers and milder winters.

2.3.1.5. Distance from the Oceans, Ocean Currents & El Nino

The oceans are a major component of the climate system. Scientists generally define the five components of Earth's climate system to include:

- i. Atmosphere,
- ii. Hydrosphere,
- iii. Cryosphere,
- iv. Lithosphere (restricted to the surface soils, rocks, and sediments), and
- v. Biosphere. Natural changes in the climate system result in internal "climate variability". Examples include the type and distribution of species, and changes in ocean-atmosphere circulations.

They cover about 71% of the Earth and absorb about twice as much of the sun's radiation as the atmosphere or the land surface. The oceans affect the climate of a place. Coastal areas are cooler and wetter than inland areas. Clouds form when warm air from inland areas meets cool air from the ocean. These clouds work as a barrier for heat and ultimately affect on climate. The centre of continents is subject to a large range of temperatures. In the summer, temperatures can be very hot and dry as moisture from the sea evaporates before it reaches the centre of the continent.

Certain parts of the world are influenced by ocean currents more than others. Ocean currents can increase or reduce temperatures. For example, the Gulf Stream is a warm ocean current which keeps the west coast of Europe free from ice in the winter and, in the summer, warmer than other places of similar latitude. Much of the heat that escapes from the oceans is in the form of water vapour, the most abundant greenhouse gas on Earth. Yet, water vapour also contributes to the formation of clouds, which shade the surface and have a net cooling effect. The El Niño event in the Pacific Ocean can affect climatic conditions all over the world. El Nino, which affects wind and rainfall patterns, has been blamed for droughts and floods in countries around the Pacific Rim. El Niño refers to the irregular warming of surface water in the Pacific. The warmer water pumps energy and moisture into the atmosphere, altering global wind and rainfall patterns.

2.3.2 Human Influence or Anthropogenic Causes

The factors above affect the climate naturally. However, we cannot forget the influence of humans on our climate. Anthropogenic is something/anything that is made by humans. An example of something that could be considered anthropogenic is excessive greenhouse gasses. The influence may be indirect or direct. We have been affecting the climate since we appeared on this earth millions of years ago. In those times, the effect on the climate was small because of the very low density of population. As the population increases, more and more land that was covered with vegetation has been cleared to make way for houses as well as for other uses which badly affect the composition of atmosphere spatially carbon dioxide and oxygen. Natural resources are being used extensively for construction, industries, transport, and consumption. Consumerism has increased by leaps and bounds due to increase in population to an incredible extent, creating mountains of waste that ultimately affect the environment.

The Industrial Revolution, starting at the end of the 19th century, has had a huge effect on the climate. The invention of the motor engine and the increased burning of Fossil fuels such as oil, coal and natural gas supply most of the energy needed to run vehicles, generate electricity for industries, households, etc. The energy sector is responsible for about 3/4 of the carbon dioxide emissions, 1/5 of the methane emissions and a large quantity of nitrous oxide. It also produces nitrogen oxides (NO_2) and carbon monoxide (CO), which are not greenhouse gases but do have an influence on the chemical cycles in the atmosphere that produce or destroy greenhouse gases.

The human impact on climate change is the most frequently misunderstood aspect of climate science. There are several possible reasons why students may resist the conclusion that humans are altering the climate. This concept may be uncomfortable to students due to feelings of guilt, political resistance, or a genuine lack of scientific understanding despite its overwhelming evidence.

Humans are largely responsible for climate change due to greenhouse gas emissions. Human activities result in emissions of four principal greenhouse gases:

- Carbon dioxide (CO_2),

- Methane (CH_4),
- Nitrous oxide (N_2O) and
- Halocarbons (a group of gases containing fluorine, chlorine and bromine). These gases accumulate in the atmosphere, causing concentrations to increase with time. Let us examine further human causes of climate change:

2.3.2.1 Emission of greenhouse gases from vehicles:

The main driver of climate change is the greenhouse effect. Greenhouse gases trap heat from the sun as it passes through Earth's atmosphere. There are some natural greenhouse gases, such as water vapour and carbon dioxide (CO_2). But over time, humans have added more to the atmosphere, creating a massive heat trap. The three largest greenhouse gases are carbon dioxide, methane, and nitrous oxide.

2.3.2.2 Burning of hydrocarbon products:

Burning fossil fuels aka, coal, oil, and natural gas, produces carbon dioxide and nitrous oxide. The problem with this is that, for more than a century, we've relied on burning these fuels to power our cars and travel across continents in a matter of hours. Fossil fuels also power our homes, keeping the lights on and our rooms warm. Our Internet habits are also responsible here. The largest known contribution comes from the burning of fossil fuels, which releases carbon dioxide gas into the atmosphere. Every email sent, movie streamed, or question Google adds carbon dioxide to the ecosystem. Although this is a tiny amount for each activity online, when added up for everyone who uses the internet.

2.3.2.3. Deforestation (cutting down forests):
Trees help to regulate the climate by absorbing CO_2 from the atmosphere. When they are cut down, that beneficial effect is lost, and the carbon stored in the trees is released into the atmosphere, thereby increasing the greenhouse effect.

2.3.2.4. Increasing livestock farming:
Cows and sheep produce large amounts of methane when they digest their food. Methane is a more powerful greenhouse gas than CO_2, but has a shorter atmospheric lifetime.

2.3.2.5. Agricultural activities:
The use of fertilisers containing nitrogen produces nitrous oxide emissions. Nitrous oxide, like CO_2, is a long-lived greenhouse gas that accumulates in the atmosphere over decades to centuries.

2.3.2.6. Industrial emissions:
Industrial emissions are one of the primary air pollutants. It presents a serious threat to natural ecosystems and human health at both global and regional levels. industrial emissions, apart from consequent odour issues, safety and occupational health of employees, and damaging the company's image in public, have become a significant concern. Industries such as petro-refineries, latex processing, bulk drug and pharmaceuticals, tanneries, waste treatment plants, poultry farms, and fish processing facilities release air that has both volatile organic compounds (VOCs) and volatile inorganic compounds (VICs). Therefore, air emission control is essential not only from

the public nuisance point of view but also for the removal of VOCs and VICs and for the general well-being of individuals and the environment.

2.4. How We All Contribute Every Day

All of us in our daily lives contribute our bit to this change in the climate. Give these points a good, serious thought:

- Electricity is the main source of power in urban areas: All our gadgets run on electricity generated mainly from thermal power plants. These thermal power plants are run on fossil fuels (mostly coal) and are responsible for the emission of huge amounts of greenhouse gases and other pollutants.
- Cars, buses, and trucks are the principal ways by which goods and people are transported in most of our cities: These are run mainly on petrol or diesel, both fossil fuels.
- We generate large quantities of waste in the form of plastics that remain in the environment for many years and cause damage.
- We use a huge quantity of paper in our work at schools and in offices. Have we ever thought about the number of trees that we use in a day?
- Timber is used in large quantities for the construction of houses, which means that large areas of forest have to be cut down.
- A growing population has meant more and more mouths to feed. Because the land area available for agriculture is limited (and in fact, is shrinking as a result of ecological degradation!), high-yielding varieties of crops are being grown to increase the agricultural output from a given area of land. However, such high-yielding varieties

of crops require large quantities of fertilisers, and more fertiliser means more emissions of nitrous oxide, both from the field into which it is put and the fertiliser industry that makes it. Pollution also results from the run-off of fertiliser into water bodies.

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UNIT TWO

OBSERVED CLIMATE CHANGE AND FUTURE PREDICTIONS

CHAPTER THREE: CHANGES IN CLIMATIC VARIABLES ON EARTH

3.0. INTRODUCTION

Climate generally refers to the average weather over long periods. The climate is affected by changes in solar energy, as well as complex interactions between the air, water, land, ice, and living world. Over billions of years, as the Earth has changed, so too has the climate. One feature of Earth's climate is the greenhouse effect. This effect causes the Earth's surface and lower atmosphere to be warmer than it would be otherwise. At the same time, the atmosphere also cools the surface through convection of heated air. The following chapters explore in more detail how human and natural factors affect the Earth's climate, and the changes that may occur over the next 100 years.

3.1. Observed Changes in Temperature

At any moment, temperatures on Earth range from about -40 °C to +40 °C, but local temperatures outside of this range are not uncommon. Current estimates obtained from thermometers at ground level, as well as weather balloons and satellite records, show that the Earth's average temperature has increased in recent decades, though they differ by exactly how much. Recent increases are on the scale of about one to two-tenths of a degree per decade.

The global average surface temperature is estimated by averaging thermometer measurements from thousands of land stations across the Earth, combined with those of sea-surface temperature from ships and buoys. Over the past 150 years, there have been many changes in the kinds of equipment used, where the monitoring takes place, how many places were sampled, and so forth. Data from over the oceans has been particularly difficult to obtain. Temperature data collected for climate analysis must be adjusted to remove all influences that arise due to urbanisation and other land-use changes, as well as changes in equipment, station location, and the number of operational stations over time. The resulting index indicates that the average temperature has increased about 1°C over the past 150 years.

The effect of GHG increase in the atmosphere has been proven to be the dominant cause of the observed global warming since the second half of the 20th century. An increase in surface temperature was estimated in 2017 around 1.0°C above pre-industrial levels, with a likely range between 0.8°C and 1.2°C (Allen et al. 2018) and a warming trend of about 0.2°C per decade. According to the National Oceanic and Atmospheric Administration (NOAA, 2021), the last decade

(2011-2020) was 0.82°C warmer than the 20th century (1901-2000) average, making it the warmest decade on record. This magnitude of warming is almost half of the 2°C warming that is compatible with the global climate stabilisation target of the EU and the ultimate objective of the UNFCCC. The warming is generally greater than average over land areas, while most ocean regions are warming at a slower rate. The NOAA (2021) ranked the year 2020 as the second warmest year on record (+0.98°C compared to the pre-industrial reference period), just behind the year 2016 (+1.00°C). This makes 2020 the 44th consecutive year since 1977 with global land and ocean temperatures above the 20th-century average. However, this warming was not uniform with differences from one continent to the other and between land and oceanic areas.

3.2. Observed changes in Precipitation

There is little evidence of a strong, long-term change in precipitation patterns, either globally or regionally. Precipitation has, however, changed abruptly in some areas, and it has increased slightly in many northern regions over the last 100 years. In many northern areas, rising temperatures have resulted in more wintertime precipitation falling as rain rather than snow. Precipitation patterns are shifting globally due to climate change, driven by increased moisture availability and shifts in atmospheric circulation patterns.

Despite uncertainties due to non-uniform data coverage, the majority of observation-based studies suggest that heavy precipitation events have become more intense and more frequent in Europe on average. However, there are large differences across regions and seasons. Studies generally agree that heavy precipitation has become more intense in northern and western Central

Europe, although changes are not always statistically significant. In southern Europe, there is only low confidence for an increasing trend of heavy precipitation, although sub-daily events are observed in regions where the mean precipitation decreases (Westra et al., 2014). Global warming is projected to lead to a higher intensity of precipitation and longer dry periods in Europe (Hartmann et al., 2013). Projections show an increase in heavy daily precipitation in most parts of Europe in winter during the 21st century, with increases of up to 30 % in North-eastern Europe

3.2.1. Changes in precipitation pattern

A. **Increases in extreme precipitation events:** there is a disproportionate increase in precipitation coming from intense rain events, leading to an increase in the frequency of prolonged periods without precipitation.
B. **Shifts in precipitation annual cycle:** Anthropogenic climate change is predicted to cause spatial and temporal shifts in precipitation patterns, including changes to the annual cycle of zonal mean precipitation.
C. **Regional variations:** observed changes in precipitation patterns vary by region, with some areas experiencing increases in annual precipitation and others experiencing decreases.

3.3. Observed Changes in the Frozen Parts of the Earth

The cryosphere is the frozen part of the Earth’s water system, and consists of snow, river and lake ice, glaciers and ice caps, ice shelves and ice sheets, and frozen ground. The cryosphere also provides an indirect way to see the effect of climate, but since it is affected by several factors, interpretation of changes is complex. For example, a local change in ice cover (for instance, the recession of a glacier) may be due to an increase in local average temperature, but it also may be the result of changes in precipitation, local sensitivity to changing solar radiation, or a combination of the above. Let's take them one after another.

3.3.1. Snow

Snow cover has decreased in most regions compared to the 1800s, especially in the spring and summer. Between 1966 and 2004, there was a decreasing trend in average Northern Hemisphere snow cover in spring and summer, but not substantially less in winter.

3.3.2. River and Lake Ice

Long-term (approximately 150-year) records show a general trend towards later freezing and earlier break-up of northern river and lake ice. There is, however, considerable variability in surveys of Canadian rivers since the late 1960s. The IPCC emphasises that river and lake ice data must be interpreted with care.

3.3.3. Sea Ice

Since satellite measurements began in 1978, the Arctic Sea ice area has steadily declined, with the rate of decrease greater in the summer than in the winter. The thickness of sea ice in the central Arctic has decreased since 1980, with most of the decrease occurring abruptly between the late 1980s and late 1990s. However, the IPCC notes that sea ice thickness is one of most difficult climate variables to measure. A study by NASA scientists, published after the IPCC report, concluded that cyclical patterns in the Arctic Ocean circulation, rather than global warming trends, explain many of the recent changes seen in the far North (Morison et al. 2007).

3.3.4. Glaciers

Glaciers are affected by changes in temperature, precipitation, and solar isolation (the amount of solar radiation received at the glacier). Data have been collected for relatively few glaciers worldwide, but of those sampled, most have been losing mass over the 20th century. The biggest losses have been in Patagonia, Alaska, the northwest USA, and the southwest of Canada. Regional patterns are complex, and there are places where glaciers have been advancing in the past decade. The thickness of the glacier on top of Mount Kilimanjaro has not changed much over the 20th century, although the ice is retreating at the vertical walls. Solar radiation has been identified by the IPCC as the main driver of this decrease.

CHAPTER FOUR:
OBSERVED CHANGES IN THE OCEANS AND SEA LEVELS

4.0. Introduction

The world's oceans play a vital role in regulating the Earth's climate, providing half of the oxygen we breathe, and serving as a primary source of food for billions of people. However, the oceans are undergoing significant changes due to climate change. We will look at these changes in this chapter.

4.1. **Observed Changes in the Oceans and Sea Levels**

The ocean plays an important role in climate variability. For example, ocean currents transfer heat from one location to another, and the ocean can hold about 1,000 times more heat than the atmosphere. It has proven difficult to thoroughly sample the ocean. Measurements only began in the 1950s, and trends are often impossible to identify due to variations in the datasets. Temperatures in some parts of the ocean are difficult to measure, and there are large regions in the Southern Hemisphere that are not well sampled. A worldwide network (www.argo.net) for sampling ocean temperatures, currents, and salinity was only completed in the fall of 2007.

4.1.1. **Heat Content.**

The average temperature of the global ocean between the surface and the top 700 meters is estimated to have risen by 0.10°C between 1961 and 2003. High rates of warming were observed between 1993 and 2003, but the IPCC notes that since 2003, the oceans have started to cool.

In response to carbon emissions from human activities, ocean heat content has increased at least since the 1950s. Oceanic warming represents approximately 93% of the Earth's warming, and it has been estimated that ocean heat uptake has doubled since the 1970s, with two-thirds of the observed increase occurring in the upper layer (0 – 700 m). Over the 1971-2010 period, the ocean warmed at a rate of 0.11 ± 0.02°C per decade by 75 m, decreasing to 0.015°C per decade by 700 m. There is also evidence for warming in deeper layers (700 – 2000 m), but warming trends below 3000 m are not statistically significant. In Europe, remote sensing observations (since 1979) indicate that sea surface temperatures (SST) in the North Atlantic and in the Baltic Sea have increased by 0.21°C and 0.40°C per decade.

4.1.2. **Salinity**

Ocean salinity can decrease if fresh meltwater from the cryosphere enters the oceans. Data on salinity are sparse in some areas, particularly in the Southern Hemisphere. However, salinity has decreased in the polar areas of the Pacific and increased in the tropical areas of the Atlantic and Indian oceans. Current observations do not provide a reliable estimate of a global average change in ocean salinity.

4.1.3. Carbon Absorption

The oceans absorb and store large quantities of carbon. The amount of carbon dioxide captured by the oceans decreased between 1970 and 1994, likely because the carbon content of the oceans themselves has increased, thus limiting their ability to absorb more carbon. This increase in carbon has led to an increase in surface water acidity, which can adversely affect some marine organisms.

4.1.4. Sea Level

Two major processes change the global mean (average) sea level: thermal expansion (the expansion of water as it warms) and the exchange of water between oceans, ice, the atmosphere, and other water reservoirs. Globally, sea levels are estimated to have risen on average by about 15 to 20 centimetres over the last 100 years, which is an increase of about 1.5 millimetres to 2 millimetres per year. Since the early 1990s, sea levels have been rising at a slightly higher rate of about 3 millimetres per year. Sea level changes are not the same globally. In some areas, the sea level is rising at several times the average rate, while in other areas, sea levels are falling. While scientific knowledge of sea level changes has improved significantly, there are still uncertainties which make it difficult to understand how each of the various processes has contributed to sea level rise over the last 100 years.

Changes in global sea level result from changes in the volume of the oceans and oceanic basins, as well as changes in the mass of water contained in the oceans. On time scales ranging from a few years to a few decades, variations in the mean sea level result from the increase of the ocean volume due to thermal expansion and from variations in the mass of water due to exchanges with continental reservoirs, such as rivers, lakes and inland seas, snowpack, ground water, but also mountain glaciers and polar ice sheets. While sea-level rise was primary due to the thermal expansion throughout the 20th century, the contribution from ice-sheet and glaciers has now become the dominant contribution. Altimetry observations provide estimates of the rate of sea level rise of 3.1 ± 0.3 mm/yr between 1993 and 2017 (WCRP Global Sea Level Budget Group, 2018) for a total sea level rise of 0.19 ± 0.02 m (IPCC, 2013).

4.1.5. Change in chemical properties

As GHG emissions increase, the dissolution of carbon in the ocean is more and more important, leading to an acidification of ~30%, which has affected ~95% of the near-surface ocean. Since the 1980s, the ph value has declined at a rate of 0.02-0.03 units per decade. Moreover, warmer oceans cause deoxygenation because oxygen is less soluble in warmer water and because of stratification (i.e. less mixing between surface and deep waters), which inhibits the production of oxygen from photosynthesis. The likely range of oxygen loss is estimated at 0.5-3.3% between 1970 and 2010 from the surface to 1000 m (IPCC, 2019).

4.1.6. Changes in the oceanic circulation

The Atlantic Meridional overturning circulation (AMOC) is an important component of the Earth's system as it is partly responsible (along with the atmosphere) of the heat transport from the tropics to the high latitude areas through a northward flow of warm and salty waters in the upper layer of the North Atlantic Ocean. Along its northward path, water cools down and becomes denser due to evaporation. In high latitude areas, cold and dense water sinks down to the deep Atlantic Ocean and a southward flow takes place feeding the bottom layers of the different oceanic basins before coming back to the surface. The Gulf stream, which originates in the Gulf of Mexico is a branch of the AMOC. It follows the Florida coasts, crosses the Atlantic and reaches the western European coasts. As a result, it has a great influence on the North Atlantic weather patterns and the western European climate. Global warming combined freshwater inputs from ice melting have the potential to reduce water density and thus, the strength of the AMOC, resulting in a cooling of western European areas.

4.2. Global Climate Projections

The IPCC report presents many specific forecasts of changes in the Earth's weather patterns over the next 100 years, based on the assumption of strong greenhouse gas-induced warming.

Global Climate Projections

4.2.1. Temperature

Depending on which of several scenarios of future global greenhouse gas concentrations is used, climate models project that average temperatures could increase from a minimum of 1.1°C to a maximum of 6.4°C. The same models also predict that greenhouse gases will cause warming in the tropical troposphere to be about double the warming at the surface. As of the present, this has not been observed. In most available data series, the troposphere appears to be warming less than the surface.

4.2.2. Precipitation

Evaporation and precipitation are expected to increase in a warmer climate. The models predict that precipitation will increase in the tropics and at the poles, and decrease in the subtropics and middle latitudes. The intensity of precipitation is projected to increase, particularly in tropical areas and at the poles.

4.2.3. Snow and ice

Current models show a wide range in the response of Northern Hemisphere Sea ice to temperature increases, from very little change to a strong accelerating reduction over the 21st century. Antarctic sea ice is projected to decrease more slowly than in the Arctic. Models project an overall decrease in glacier volume, but there is uncertainty in how to estimate future changes. In general, snow cover area and the total amount of snow are projected to decrease in the Northern Hemisphere, with increases in a few regions.

4.2.4. Sea levels

Depending on the emissions scenario, the average sea level is projected to rise between 18 cm and 59 cm. This will be due mostly to thermal expansion, though melting of glaciers, ice caps, and the Greenland ice sheet is also projected to contribute to the rise.

4.2.5. Tropical cyclones

Models that examine tropical cyclones on a large scale predict a decrease in the total number of tropical cyclones and little to no change in the intensity (strength) of individual cyclones on average. On the other hand, models that examines tropical cyclones at a higher resolution and on a smaller scale project that tropical cyclones will become more intense.

4.3. Climate change impact on the environment and ecosystems

4.3.1. Marine ecosystems

Changes in both the physical and chemical properties of the ocean alter the marine productivity and thus have substantial impacts on the health of marine ecosystems and the provision of seafood to society, such as through fisheries. First, ocean acidification exerts a strong threat to coral reefs, by reducing the concentration of carbonate ions and therefore the material that corals need to build their skeleton. As coral reefs host numerous organisms, this negatively impacts the entire ecosystem. Second, deoxygenation affects the metabolism of species by limiting biological activity. In recent decades, oxygen-depleted areas have rapidly expanded, leading to the so-called dead zones from which the organisms leave or in which they die. An outstanding example is the Baltic Sea, in which the expansion of dead zones has experienced a 10-fold increase since 1900, but oxygen-depleted areas have also been observed in other European seas in recent decades.

4.3.2. Coastal zones

European coastlines are expanded along more than 100,000 km with about 200 million people living in coastal areas, and host important economic activities, such as tourism, and various ecosystems. Therefore, growing attention is being paid to the evolution of the littoral owing to the risks posed by climate change. Among the most important risks are coastal floods, saltwater intrusions, coastal erosion and submergence of low-lying areas. Under global warming, low-lying European areas (e.g. Belgium, Netherlands, Denmark, southern and western France) could be permanently inundated in response to sea-level rise.

4.3.3. Coastal flooding

Coastal flooding results from a variety of causes, including storm surges produced by wind storms and sea-level rise. When surges coincide with high tidal levels, extensive flooding may occur, threatening ecosystems, infrastructures and human lives. As an example, the coastal flooding which occurred in 1953 in the North Sea destroyed 40,000 buildings and caused 2000 deaths in the Netherlands, Belgium and the United Kingdom. This kind of flooding event occurs every hundred years on average, but could happen annually by the end of the 21st century, unless appropriate protection measures are taken. A recent study (Vousdakas et al. 2017) estimate that the North Sea is projected to face the strongest increase in extreme sea level events (up to 1 m under the RCP8.5 scenario), followed by the Baltic Sea and the Atlantic coast, and 5 million Europeans could be affected by coastal flooding. Moreover, flood damages could increase by 2 to 3 orders of magnitude in the absence of adaptation (IPCC, 2019).

4.3.4. **Saltwater intrusions**

Saltwater intrusions into aquifers come from sea level rise and overexploitation of groundwater resources. These intrusions have the potential to threaten water supply, agriculture and ecosystems in coastal regions.

4.3.5. Coastal areas

Coastal erosion is due to the imbalance between the supply and export of sedimentary material to the coast. This results in the retreat of the coastline and threatens the sandy dunes, which are a significant protection for the littoral and for the hosted flora and fauna species. It may also have huge economic impacts because of the loss of land areas, and hence, because of the loss of properties and infrastructure. Coastal erosion is produced by strong winds, storm surges and high tidal levels and is amplified by sea level rise. It is also exacerbated by human activities because the natural flow of sediments in river basins is obstructed by various infrastructures. Hence, highly urbanised coastal zones are more exposed to possible damage. Currently, almost one-fifth of the European coastline is affected by coastal erosion with retreats of 0.5 to 2 m/yr on average. Adaptation solutions consisting of building natural or artificial barriers are therefore urgently needed. In the absence of appropriate adaptation measures, recent studies estimate that the coastline retreat could reach 65 m in southern Europe and 100 m in northern Europe (Athanasiou et al., 2019) for a 4°C warming but could be reduced by 50% if the warming was limited to 3°C (Vousdoukas et al., 2020).

4.3.6. Freshwater systems

In addition to changes in rainfall patterns, changes in the hydrological cycle induced by climate change also affect river flows, and may also increase the severity and frequency of droughts or river flooding.

4.3.7. River flows

River flows are not only influenced by rainfall and runoff, but also by other human interventions such as land use or morphological changes or river regulation. In addition, there is a substantial interannual and decadal variability. It is therefore difficult to detect long-term trends. However, according to recent studies (Blöschl et al. 2019), observations suggest that river flows have i/ increased in northwestern Europe due to increased rainfall in autumn and winter, ii/ decreased in southern Europe due to decreased precipitation and increase evaporation, iii/ decreased in eastern European regions as a result of a decline in snow cover and an increased snow melting. These regional differences reflect the seasonal trend of precipitation patterns. The seasonality is projected to change across Europe. Summer flows are projected to decrease in most of Europe, while winter and spring flows are expected to increase due to the risk of heavy rainfall (Beniston et al. 2018).

4.3.8. River flood

River flooding is caused by prolonged or heavy precipitation events, and they are the most important natural hazard in Europe in terms of economic losses. Direct economic impacts are related to damages to infrastructures (buildings, transport, roads) and agricultural areas. There are also indirect damages, such as production losses due to damaged transport or energy infrastructures. Flooding also has negative effects on the environment and human health. Almost 1500 floods have been reported in Europe since 1980 and more than half have occurred since 2000, but their occurrence result from several factors (land-use changes, expansion of urban areas, heavy precipitation), and it is therefore difficult to quantify the importance of each factor. As global warming is intensifying the hydrological cycle, more frequent heavy precipitation events are expected even in regions where the mean precipitation decreases. and more frequent flooding events could occur.

4.3.9. Droughts

Droughts are associated with rainfall deficits (meteorological droughts) or low-level water in lakes and natural reservoirs (hydrological droughts). The latter can be caused by prolonged rainfall deficit and by soil moisture deficit due to above- average evapotranspiration in response to high temperatures and hot extremes. They may have detrimental consequences on plant growth and crop yields, animal and vegetal ecosystems, water resource management (irrigation, power plant cooling) and on the availability of fresh water used for drinking. Since the second half of the 20th century, dry areas have expanded in Europe, and the frequency and severity of droughts have increased in the Mediterranean countries, Portugal and parts of central Europe. On the other hand, drought episodes have become less frequent in northern and parts of eastern Europe, but have become more severe in Scandinavia and south-eastern Europe.

4.3.10. Terrestrial ecosystems

Climate change also has many impacts on terrestrial ecosystems. Firstly, it greatly affects biodiversity by modifying the phenology of plants (with longer growing seasons and earlier pollen seasons) and the life cycle of animals (e.g. earlier arrival of migrant birds, earlier onset of reproduction and longer breeding season of many thermophilic insects). These trends, primarily due to increased temperatures, are projected to persist in the future. Secondly, global warming modifies the geographical range of flora and fauna species. This may induce changes in the species composition and can cause in turn a change in their mutual interactions (e.g. Montoya & Raffaelli 2010). Migration of some species towards higher latitudes and/or higher elevations is observed (Chen et al., 2011), but local and regional extinctions also occur for other species. The species which are expected to be the most affected are small populations, those with restricted climatic envelopes (i.e. range of favourable climatic conditions), such as those living in high latitudes or high elevations (Engler et al. 2011) or those whose ability to migrate is limited by human-made barriers, such as land use change and deforestation or expanded urbanization (Pereira et al. 2012).

4.3.11. Impact on human societies

Climate change and related changes in natural systems and have a strong influence on human societies, including water resources and food supplies, economic issues, health and wellbeing, energy production, migration of people and potentially geopolitical conflicts (Gemenne et al. 2014). There is a broad range of studies investigating the different aspects of these impacts and the potential adaptation strategies, synthesised in reports such as those provided by the IPCC (IPCC, 2014) or the European Environment Agency (EEA, 2017).

4.3.11.1. Human health

Climate change also causes impacts on human health through warming temperatures, changes in precipitation, extreme events, degradation of the air quality and rising sea levels. These impacts may directly affect the health of human beings (e.g. heat-related mortality or deaths and injuries from flooding or storms). There are also indirect effects from climate change, such as those acting on vector-borne diseases, food security and water quality. The severity of these risks is expected to increase in the future and will vary depending on where people live and to what extent they are exposed to climate risk, their economic status and how they are sensitive to health risks. It will also depend on the ability of public health and safety systems to address these new threats.

4.3.11.2. Extreme events

Extreme hot temperatures are associated with increases in mortality and morbidity. Exposure to extreme heat can lead to heat stroke and dehydration, as well as cardiovascular, respiratory, and cerebrovascular disease. In recent decades, the number of heat waves has increased across Europe and caused tens of thousands of premature deaths. An outstanding example is the heat wave in summer 2003, which caused at least 70,000 premature deaths (Robine et al. 2008). The most vulnerable populations include outdoor workers, homeless and low-income people, elderly persons, young children and people suffering from chronic diseases. In addition, people living in northern latitudes are more exposed because they are less prepared. Moreover, heat-related effects are exacerbated in urban areas because of the urban heat island effect, and adverse heat impacts are often more frequent in cities than in rural surroundings.

4.3.11.3. Vector-borne diseases

Changes in temperature and precipitation increase the geographic range of vector-borne diseases and can lead to illnesses occurring earlier in the year or can bring non-endemic illnesses in European areas. However, there are other factors favouring vector-borne diseases such as land use, travel and human behaviour, vector control and public health capacities. Lyme Borreliosis, transmitted by ticks, is the most common vector-borne disease in Europe, with more than 65,000 cases reported annually, despite no standard diagnosis of Lyme disease in Europe. Ticks can also transmit tick-borne encephalitis, and the mean annual cases reported in Europe have increased by ~400% over the past 30 years, although this can be due to a more robust detection. Global warming has increased the risk of tick-borne diseases in Europe by allowing ticks to survive at higher altitudes. The Asian tiger mosquito which transmits viral diseases (dengue, chikungunya, Zika) was first recorded in Europe (Italy) in the 1990s. Since then, it has expanded its geographical range in several European countries, and several cases of chikungunya have been reported in France and Italy (Rezza et al. 2007, Venturi et al 2017).

4.3.11.4. Food security and water quality

Warmer temperatures also favour the growth of bacteria in food, such as Salmonella, or the exposure to chemical contaminants stemming from human activities. In the oceans, seafood is also impacted by toxins produced by harmful algae. For example, higher sea surface temperatures will lead to higher mercury concentrations in seafood. Increases in extreme weather events, such as heavy precipitation, will introduce contaminants into the food chain through water runoff. Moreover, crop yields is also projected to decrease in southern Europe. While higher atmospheric CO2 concentrations can act as a "fertilizer" for some plants, they also lower the number of proteins and essential minerals in crops such as wheat, rice, and potatoes, making these foods less nutritious.

4.3.11.5. Agriculture and livestock

The agricultural sector is directly dependent on several climatic factors such as temperature, water availability and the occurrence of extreme climatic events. Crop yields and livestock production are therefore strongly influenced by climate change. On the other hand, increased CO2 emissions favour fertilisation and act therefore as a positive impact. It is generally accepted that the productivity of crops will be positively impacted in northern Europe due to increased temperatures leading to a lengthened growing season (more than 10 days since 1992) and to a shortening of the frost-free period. Conversely, southern and central Europe are negatively impacted as a result of warmer temperatures, the occurrence of more frequent hot extremes and a decrease in precipitation. Since 1995, the water deficit has increased in large parts of southern and eastern Europe. This impact is expected to be most acute in the future, which may lead to an expansion of the irrigation systems. However, this expansion may be constrained by projected reductions in water availability and increased demand from other sectors and for other uses.

The extent to which climate change affects crop yields depends on the crop and type, the ability of the soil to store moisture and the climatic conditions in the region. For example, in north-east Spain, grape yield has been declining due to water deficits since the 1960s. Yields of several rain-fed crops (e.g. wheat in France) are levelling off or decreasing (e.g. potato, wheat, maize and barley in Italy and southern-central Europe) because of increased temperatures. On the contrary, longer growing seasons have increased the yield of wheat, corn and sugar beet in parts of northern-central Europe and of the United Kingdom. As a result, climate change will induce a reallocation of agricultural practices between European countries.

4.3.11.6. Human migrations

Environmental changes have always been a key driver for population movements, even since the first hominids several million years ago. Today, climatic variations linked to human activities can occur on very short time scales (a few years to a few decades). The risk of climatic migrations is particularly exacerbated for populations already weakened by environmental conditions that are less favourable to the development of agriculture than in temperate latitudes, and by the fact that land use strategies do not always take into account all environmental risks. For example, in Africa and other parts of the world, there is a high population density around coastal areas, and the risk of rising sea levels is ignored. The current population movements related to the changing environmental conditions can be rapid in response to the occurrence of extreme events, or more gradual, such as those related to sea level rise. They can also be temporary or permanent.

4.3.12. Fisheries

The effects of climate change on marine ecosystems lead to a modification of the entire seafood chain, by changing the primary production, which affects the growth and survival of animals, by leading to the migration of certain species to higher latitudes, and by modifying the interactions between the different organisms. These effects have important socioeconomic consequences, particularly in countries where fishing is the main activity. In many regions, the composition of fishing catches has been radically transformed, and fish stocks have been reduced. For example, tropical areas experience the strongest decline, and by 2050, this decline is projected to be approximatelyf 40%. On the other hand, in regions at higher latitudes, such as the North Atlantic and North Pacific, there is an increase in the range of some fish species.

4.3.13. Energy

The energy sector is responsible directly or indirectly for the majority of anthropogenic greenhouse gas emissions. Both energy supply and energy demand are highly sensitive to changes in climate conditions. Temperature is one of the major drivers of energy demand in Europe, affecting summer cooling and winter heating for residential properties and business/industry. Heating and cooling are responsible for a large fraction of the European energy use and the electricity demand. Over the recent decades, heating has decreased, mainly in north-western Europe, and cooling has increased, particularly in southern and central Europe.

The increased frequency of extreme weather events, including heat waves, droughts and storms, poses additional challenges for energy systems. Increases in temperatures and the occurrence of droughts may limit the availability of cooling water for thermal power generation in summer. However, the impacts of climate change on energy production depend on the energy mix and the geographical location. In particular, impacts on renewable energy generation is subject to strong regional variations. Hydropower production may experience significant risks due to the retreat of glaciers and the subsequent decrease of water availability. On the contrary, conditions in Scandinavia are expected to improve because of more abundant precipitation.

4.3.14. Hot extremes

Observations indicate a continued increase in heat extremes for land areas over the last three decades. These extremes are characterised by more frequent warm days and nights and more frequent heat waves. They also have strong direct impacts on human health and well-being, as well as on society (e.g. through decreased labour productivity), ecosystems (e.g. through forest fires) and agriculture. In particular, heat waves exacerbated by the urban heat island effect and air pollution can have devastating impacts on human health in urban areas. In Europe, the maximum daily temperatures have shown significant upward trends, and the number of unusually warm days has increased by up to 10 days per decade since 1960 in most of southern Europe and Scandinavia. Large areas have experienced intense and long heat waves since 1950, most of which occurred after 2000 (in 2003, 2006, 2007, 2010, 2014, 2015, 2018 and 2019). The severity of a heat wave depends on its duration, its relative intensity (how much hotter than the mean temperature at a given location) and its amplitude. The most severe European heat waves have been characterised by the persistence of extremely high temperatures at night (Russo et al. 2015).

4.3.15. Permafrost

Permafrost is defined as soil that remains permanently frozen for at least two consecutive years. It is topped by a so-called 'active layer' that thaws each summer, and whose thickness can vary from a few centimetres to hundreds of meters, depending on altitude and latitude. At present, permafrost covers about 24% of the northern hemisphere continental areas. It is found mainly in polar and circumpolar areas and in mountain regions at lower latitudes (e.g. Chile, the Alps, the Himalayas). It can also be found in the seabed of the Arctic Ocean in the continental shelf areas.

In the Arctic region, measurements of ground temperatures indicate that permafrost temperatures have increased from the mid-1970s to 2010 from 0.15 ± 0.03 to 0.82 ± 0.07 °C per decade. Over the last decade, data from various boreholes extending from Svalbard to the Alps indicate a regional warming of permafrost of 0.5-1.0°C. Continuous monitoring over 5–7 years shows warming down to 60 m depth and current warming rates at the permafrost surface of 0.04–0.07 °C/year, with greatest warming in Svalbard and northern Sweden (EEA, 2017).

4.3.16. Wind storms

Storms may lead to significant damage on population, infrastructures and natural systems. In the North Atlantic and North Western Europe, the most severe storms occur primarily in winter. They are characterized by high wind speeds and may often be accompanied by extremes of precipitation.

In mid-latitudes, storms affecting large parts of land areas are referred to as extratropical cyclones. They develop from low-pressure weather systems that originate from the temperature gradient between the poles and the tropics. The storm tracks (i.e. the path of storms over time) depend on many factors such as land-sea contrasts, surface air temperature, topography and variability in the large-scale atmospheric circulation. The dominant mode of atmospheric variability in the North Atlantic is the North Atlantic Oscillation (NAO) defined as the pressure difference between the Icelandic low and the Azores high. When the pressure difference increases, more pronounced storms with high wind speeds are observed in northern Europe, while a weak pressure gradient leads to a displacement of the storms towards the Mediterranean basin. Wind measurements are often inhomogeneous. This is due for example to instrumental changes, environmental influences, changes in the frequency of measurements and various techniques of measurements. This leads to contradictory results and prevents drawing robust conclusions about the trends of the intensity and the frequency of storms until the middle of the 20th century. Most models neither indicate a clear trend for the storm activity in the mid-latitude regions, but agree on an increase in North-western Europe and the Baltic Sea (Hartmann et al., 2013; Feser et al., 2014). Despite large model uncertainties, it is now widely accepted that under global warming, the storm tracks shift poleward and eastwards (e.g. Ulbrich et al., 2009, Zappa et al., 2013, Yin et al., 2005). Moreover, modelling studies generally agree on increase in the intensity of storms in northern, north-western and Europe over the 21st century.

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UNIT THREE:

CLIMATE CHANGE: GREENHOUSE EFFECTS

CHAPTER FIVE: GREENHOUSE EFFECTS

5.0. INTRODUCTION

The greenhouse effect is a process that occurs when certain gases in the Earth's atmosphere, such as carbon dioxide and methane, trap heat from the sun. This process is essential for life on Earth, as it allows the planet to maintain a habitable temperature.

5.1. **How the greenhouse effect works**

Since the advent of the Industrial Revolution in the 1700s, humans have devised many inventions that burn fossil fuels such as coal, oil, and natural gas. Burning these fossil fuels, as well as other activities such as clearing land for agriculture or urban settlements, release some of the same gases that trap heat in the atmosphere, including carbon dioxide, methane, and nitrous oxide. These atmospheric gases have risen to levels higher than at any time in at least the last 650,000 years. As these gases build up in the atmosphere, they trap more heat near Earth's surface, causing Earth's climate to become warmer than it would naturally. Scientists call this unnatural heating effect global warming and blame it for an increase in Earth's surface temperature of about 0.60C (about 1 Fahrenheit degree) over the last 100 years.

The greenhouse effect results from the interaction between sunlight and the layer of greenhouse gases in the atmosphere that extends up to 100 km (60 miles) above the earth's surface. Sunlight is composed of a range of radiant energies known as the solar spectrum, which includes visible light, infrared light, gamma rays, X-rays, and ultraviolet light. When the sun's radiation reaches Earth's atmosphere, some 25 per cent of the energy is reflected into space by clouds and other atmospheric particles. About 20 per cent is absorbed in the atmosphere. For instance, gas molecules in the uppermost layers of the atmosphere absorb the sun's gamma rays and X-rays.

The sun's ultraviolet radiation is absorbed by the ozone layer, located 19 to 48 km (12 to 30 miles) above Earth's surface. About 50 per cent of the sun's energy, largely in the form of visible light, passes through the atmosphere to reach Earth's surface. Soils, plants, and oceans on Earth's surface absorb about 85 per cent of this heat energy, while the rest is reflected into the atmosphere, most effectively by reflective surfaces such as snow, ice, and sandy deserts. In addition, some of the sun's radiation that is absorbed by the Earth's surface becomes heat energy in the form of long-wave infrared radiation, and this energy is released back into the atmosphere.

The heat-trapping gases in the atmosphere behave like the glass of a greenhouse. They let much of the sun's rays in, but keep most of that heat from directly escaping. Because of this, they are called greenhouse gases. Without these gases, heat energy absorbed and reflected from the earth's surface would easily radiate back out to space, leaving the planet with an inhospitable temperature close to 19°C, instead of the present average surface temperature of 15°C (590F).

5.2. Types of Greenhouse Gases

Greenhouse gases occur naturally in the environment and also result from human activities. By far the most abundant greenhouse gas is water vapour, which reaches the atmosphere through evaporation from oceans, lakes, and rivers. The amount of water vapour in the atmosphere is not directly affected by human activities. Carbon dioxide, methane, nitrous oxide, and ozone all occur naturally in the environment, but they are being produced at record levels by human activities. Other greenhouse gases do not occur naturally at all and are produced only through industrial processes. Human activities also produce airborne particles called aerosols, which offset some of the warming influence of increasing greenhouse gases.

5.2.1. **Water Vapour**

Water vapour is the most common greenhouse gas in the atmosphere, accounting for about 60 to 70 per cent of the natural greenhouse effect. Humans do not have a significant direct impact on water vapour levels in the atmosphere. However, as human activities increase the concentration of other greenhouse gases in the atmosphere (producing warmer temperatures on Earth), the evaporation of oceans, lakes, and rivers, as well as water evaporation from plants, increases and raise the amount of water vapour in the atmosphere.

5.2.2. **Carbon dioxide**

Carbon dioxide constantly circulates in the environment through a variety of natural processes known as the carbon cycle. Volcanic eruptions and the decay of plant and animal matter both release carbon dioxide into the atmosphere. In respiration, animals break down food to release the energy required to build and maintain cellular activity. A byproduct of respiration is the formation of carbon dioxide, which is exhaled from animals into the environment. Oceans, lakes, and rivers absorb carbon dioxide from the atmosphere. Through photosynthesis, plants collect carbon dioxide and use it to make their own food in the process incorporating carbon into new plant tissue and releasing oxygen to the environment as a byproduct.

In order to provide energy to heat buildings, power automobiles, and fuel electricity-producing power plants, humans burn objects that contain carbon, such as the fossil fuels, oil, coal, and natural gas; wood or wood products; and some solid wastes. When these products are burned, they release carbon dioxide into the air. In addition, humans cut down huge tracts of trees for lumber or to clear land for farming or building. This process, known as deforestation, can both release the carbon stored in trees and significantly reduce the number of trees available to absorb carbon dioxide.

5.2.3. **Methane**

Many natural processes produce methane, also known as natural gas. Decomposition of carbon-containing substances found in oxygen-free environments, such as wastes in landfills, releases methane. Ruminating animals such as cattle and sheep belch methane into the air as a byproduct of digestion. Microorganisms that live in damp soils, such as rice fields, produce methane when they break down organic matter. Methane is also emitted during coal mining and the production and transport of other fossil fuels. Atmospheric concentrations of methane are far less than carbon dioxide, and methane only stays in the atmosphere for a decade or so. But methane is an extremely effective heat-trapping gas.

5.2.4. **Nitrous Oxide**

Nitrous oxide is released by the burning of fossil fuels, and automobile exhaust is a large source of this gas. In addition, many farmers use nitrogen-containing fertilisers to provide nutrients to their crops. When these fertilisers break down in the soil, they emit nitrous oxide into the air. Ploughing fields also releases nitrous oxide. Nitrous oxide traps heat about 300 times more effectively than carbon dioxide and can stay in the atmosphere for a century.

5.2.5. **Ozone**

Ozone is both a natural and human-made greenhouse gas. Ozone in the upper atmosphere is known as the ozone layer and shields life on earth from the sun’s harmful ultraviolet radiation, which can cause cancer and other damage to plants and animals. However, ozone in the lower atmosphere is a component of smog (a severe type of air pollution) and is considered a greenhouse gas. Unlike other greenhouse gases, which are well-mixed throughout the atmosphere, ozone in the lower atmosphere tends to be limited to industrialised regions.

5.2.6. **Synthetic Chemicals**

Manufacturing processes use or generate many synthetic chemicals that are powerful greenhouse gases. Although these gases are produced in relatively small quantities, they trap hundreds to thousands of times more heat in the atmosphere than an equal amount of carbon dioxide does. In addition, their chemical bonds make them exceptionally long-lived in the environment

5.2.7. **Chlorofluorocarbons**

Human-made greenhouse gases include chlorofluorocarbons (CFCs), a family of chlorine-containing gases that were widely used in the 20th century as refrigerants, aerosol spray propellants, and cleaning agents. Scientific studies showed that the chlorine released by CFCs into the upper atmosphere destroys the ozone layer. As a result, CFCs are being phased out of production under a 1987 international treaty, the Montréal Protocol on Substances that Deplete the Ozone Layer. CFCs were mostly banned in industrialised nations beginning in 1996 and will be phased out in developing countries after 2010. New chemicals have been developed to replace CFCs, but they are also potent greenhouse gases. The substitutes include hydrochlorofluorocarbons (HCFCs), hydro fluorocarbons (HFCs), and per fluorocarbons (PFCs).

5.2.8. **Aerosols**

Fuel combustion, and to a lesser extent, agricultural and industrial processes, produce not only gases but also tiny solid and liquid particles called aerosols that remain suspended in the atmosphere. Although aerosols are not considered greenhouse gases, they do affect global warming in several ways.

Diesel engines and some types of biomass burning produce black aerosols such as soot, which absorb the sun's energy and therefore, contribute to warming. Conversely, coal-fired power plants burning high-sulfur coal emit sulfate aerosols, which are light-coloured aerosols that reflect incoming solar energy to space. In this way, they have a cooling effect. Natural aerosols that also have a cooling effect are produced during volcanic eruptions and the evaporation of seawater. Aerosol particles also have an indirect cooling influence by acting as "seeds" for the condensation of water vapour into cloud masses. In general, the amount of solar energy reflected to space is greater on cloudy days.

Overall, aerosols may roughly offset the net warming influence of noncarbon dioxide greenhouse gases, half through their direct cooling effect and half through their indirect cooling effect. However, considerable uncertainty in aerosol processes means that their cooling influence could be much larger or much smaller. Aerosols are one of the least understood factors in climate change, and their effects are still being debated. Scientists are more certain, however, about the net effect of all greenhouse gas and aerosol emissions, which is estimated to be roughly equal to the warming influence of carbon dioxide alone.

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CHAPTER SIX: THE TEMPERATURE OF THE ATMOSPHERE

6.0. INTRODUCTION

The sun is the sole source of heat for the Earth's atmosphere. From the sun, whose diameter is more than a hundred times that of the Earth and whose surface is believed to have a temperature of about 6000 °c, there streams an immense quantity of radiant energy. Although only a small fraction of the energy emitted from the sun reaches the Earth, all life on the planet owes its existence to this radiation. Temperature decreases with increasing elevation at an average rate of about 6.5°C per km (about 19°F per mi). As a result, temperatures in the mountains are generally much lower than at sea level. Temperature continues to decrease throughout the atmosphere's lowest layer, the troposphere, where almost all weather occurs. The troposphere extends to a height of 16 km above sea level over the equator and about 8 km above sea level over the poles. Above the troposphere is the stratosphere, where temperature levels off and then begins to increase with height. Almost no weather occurs in the stratosphere.

6.1. Methods by which Air is Heated

The atmosphere is heated by radiation from the earth's surface, which retransmits the sun's radiation in the form of long or heat waves.

Consequently, the temperature of the atmosphere will vary with height above the earth's surface. Majorly, the atmosphere is heated by these three major processes.

6.1.1. Radiation

This is simply the direct heating of a body by the transmission of heat waves. The long waves from the Earth's surface heat the air near the ground. Earth is heated by short-wave energy from the sun. The air is heated by long-wave energy from the Earth.

6.1.2. Convection

Our convection currents are upward movements of warm air which, because it is at a higher temperature than its surroundings, is less dense and lighter and therefore tends to rise. By convectional heating of the atmosphere, air is heated by the earth, expands, and cold air flows in and is itself warmed by the earth.

6.1.3. Conduction

This is the process by which air is heated directly in the daytime by contact with the Earth's surface. Since the air tends to be heated in these three ways, the air near the surface, on the whole, attains the same temperature as the ground with which it is in contact. The ground temperature, however, depends upon the amount of solar radiation reaching the Earth's surface and upon the character of the surface which is receiving that radiation.

6.2. The Vertical and Horizontal Distribution of Air Temperature

6.2.1 **The Vertical Distribution of Temperature**

Experimental observation of air temperature at different altitudes has verified the assumption that air temperature decreases as height increases. Under normal conditions, while the rate of decrease is not uniform, the average is about 1.8 °C per 300 metres. This is called the 'lapse rate'; the steeper the lapse rate, the more rapid the decrease in temperature. The rate of temperature decrease naturally varies from place to place and from one part of the year to the next.

Dry air, when forced to rise, will expand and cool at a rate of 30°C per 300 metres. This is known as the 'dry adiabatic lapse rate' and is the rate at which rising dry air cools off; subsiding dry air warms when no heat is transferred from other surrounding sources. If the environmental lapse rate for a section of the atmosphere was 2.50C in 300 metres, and a portion of that air were made to rise, after 300 metres, the temperature of that dry air would be reduced by 30 °C

The portion of air would be 0.50 °C cooler than the surrounding air at the same level. The rate of decrease of temperature in ascending saturated air is known as the saturated adiabatic lapse rate, and for lower levels of the troposphere in temperate latitudes is of the order of 1.5 0C per 300 meters. The value is not constant and depends on the amount of moisture condensed. Cold air can contain less moisture than warm air, so the latent heat released in cold air will be less than in warm air.

6.2.2. The Horizontal Distribution of Temperature

The main features of surface air temperature over the Earth are largely decided by latitude. Temperature decreases gradually from the equator to the Polar Regions. These distributions, however, are largely modified by the position of land and sea surfaces and the seasonal changes in the sun's position relative to those surfaces. Surface air temperature can be shown on a map by a series of lines called Isotherms. An Isotherm is simply a line joining places having the same mean sea-level temperature.

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CHAPTER SEVEN: CLIMATE CHANGE CONCERN: OZONE LAYER

7.0. INTRODUCTION

The ozone layer is basically naturally occurring gas in the region of stratosphere where ozone particles are accumulated. The ozone layer is also naturally broken down, but there is a balance between its formation and natural depletion. As a result, the total amount of ozone remains constant. But ozone layer thickness varies with altitude and seasonal change. Ozone concentration is highest between 19-23 km. Most of the ozone is formed at the equator where there is maximum sunshine, but with winds it travels at high altitude and gets accumulated in the stratosphere. The ozone layer is a layer in Earth's atmosphere which contains relatively high concentrations of ozone (O_3).

7.2. **Health Risks Associated with the Ozone Layer**

7.2.1 **Eye Diseases**

UV (Ultraviolet) radiation also damages the eye 's outer tissues causing ―snow blindness‖, the ocular equivalent of sunburn. UVB's role in cataract formation is complex, but some subtypes appear to be associated with UV exposure. As a result, uncontrolled ozone depletion was projected to cause significant increases in cataracts.

7.2.2. Immune Suppression

UV exposure causes both local and whole-body immune suppression. Increased UV induced immune suppression due to uncontrolled ozone depletion could have influenced patterns of infectious disease, and the effectiveness of vaccination, but might also have decreased the occurrence of various autoimmune diseases.

7.2.3. Skin Cancer

UV radiation is a cause of skin cancer (melanoma and other types) in fair-skinned humans. Increases in UV radiation due to uncontrolled stratospheric ozone depletion would have led to more severe sunburn and large increases in skin cancer incidence (subject to changes in individual behaviour).

7.3. Ozone Layer Depletion

Ozone depletion describes two distinct, but related observations: a slow, steady decline of about 4 percent per decade in the total volume of ozone in Earth's stratosphere (ozone layer) since the late 1970s, and a much larger, but seasonal, decrease in stratospheric ozone over Earth's Polar Regions during the same period. The latter phenomenon is commonly referred to as the ozone hole. In addition to this well-known stratospheric ozone depletion, there are also tropospheric ozone depletion events, which occur near the surface in Polar Regions during spring. The most pronounced decrease in ozone has been in the lower stratosphere. However, the ozone hole is most usually measured not in terms of ozone concentrations at these levels (which are typically of a few parts per million) but by reduction in the total column ozone, above a point on the Earth's surface, which is normally expressed in Dobson units, abbreviated as "DU". Marked decreases in column ozone in the Antarctic spring and early summer compared to the early 1970s and before have been observed using instruments such as the Total Ozone Mapping Spectrometer (TOMS).

Reductions of up to 70% in the ozone column observed in the austral (southern hemispheric) spring over Antarctica and first reported in 1985 (Farman et al 1985) are continuing. Through the 1990s, total column ozone in September and October have continued to be 40–50% lower than pre-ozone-hole values. In the Arctic the amount lost is more variable year-to-year than in the Antarctic. The greatest declines, up to 30%, are in the winter and spring, when the stratosphere is colder.

7.4. Effects of Ozone Layer Depletion

Reduced ozone levels as a result of ozone depletion. A chemical destruction of the stratospheric ozone layer is beyond natural reactions. Stratospheric ozone is constantly being created and destroyed through natural cycles. Various ozone-depleting substances (ODS), however, accelerate the destruction processes, resulting in lower-than-normal ozone levels.

7.4.1 **Effects on Human Health**

Ozone layer depletion increases the amount of UVB that reaches the Earth's surface. Laboratory and epidemiological studies demonstrate that UVB causes non-melanoma skin cancer and plays a major role in malignant melanoma development. In addition, UVB has been linked to the development of cataracts, a clouding of the eye's lens.

7.4.2. Effects on Plants

UVB radiation affects the physiological and developmental processes of plants.
Despite mechanisms to reduce or repair these effects and an ability to adapt to increased levels of UVB, plant growth can be directly affected by UVB radiation. Indirect changes caused by UVB may be equally or sometimes more important than the damaging effects of UVB. These changes can have important implications for plant competitive balance, herbivores, plant diseases, and biogeochemical cycles.

7.4.3. **Effects on Marine Ecosystems**

UVB radiation has been found to cause damage to early developmental stages of fish, shrimp, crab, amphibians, and other marine animals. The most severe effects are decreased reproductive capacity and impaired larva development. Small increases in

UVB exposure could result in population reductions for small marine organisms, with implications for the whole marine food chain.

7.4.4. **Effects on Biogeochemical Cycles**

Increases in UVB radiation could affect terrestrial and aquatic biogeochemical cycles, thus altering both sources and sinks of greenhouse and chemically important trace gases (e.g., carbon dioxide, carbon monoxide, carbonyl sulfide, ozone, and possibly other gases). These potential changes would contribute to biosphere-atmosphere feedbacks that mitigate or amplify the atmospheric concentrations of these gases.

7.4.5. **Effects on Materials**

Synthetic polymers, naturally occurring biopolymers, as well as some other materials of commercial interest, are adversely affected by UVB radiation. Today's materials are somewhat protected from UVB by special additives. Yet, increases in UVB levels will accelerate their breakdown, limiting the length of time for which they are useful outdoors.

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CHAPTER EIGHT: VULNERABILITY TO AND IMPACT OF CLIMATE CHANGE

8.0. Introduction

Vulnerability is a critical component of the basic science of climate change because it comprises a set of conditions determined by physical, social, economic and environmental factors or processes, which increase the susceptibility of a community to the impact of hazards or to be hurt by an external stress. Impacts demonstrate the effect of climate change on different sectors from both natural and human systems. These impacts have serious implications for societies by aggravating vulnerabilities. To contain such adverse effects will require the development of adaptation mechanisms to the changing climate. This chapter will introduce learners to the concept of vulnerability, vulnerability of biodiversity to the impacts of climate change, vulnerability of infrastructure and settlement to climate change impacts, sectoral vulnerability to the impacts of climate change and strategies for reducing climate change disaster risks

8.1. Concept of vulnerability

Vulnerability is the extent to which a natural or social system is susceptible to sustaining damage from climate change, and is a function of the magnitude of change, the sensitivity of the system to changes and the ability to adapt the system to such changes. Hence, a highly vulnerable system is highly sensitive to modest changes in climate and one for which the ability to adapt is severely constrained

8.2. Vulnerability of biodiversity to the impacts of climate change

Biodiversity is the term given to the variety of life on Earth. It is the variety within and between all species of plants, animals and micro-organisms and the ecosystems in which they live and interact. Vulnerability of biodiversity to the impacts of climate change includes:

- Climate change results in the extinction of many plant and animal species and also causes a reduction in the diversity of terrestrial, freshwater and marine ecosystems. According to IPCC, 20-30% of plant and animal species are likely to be at increased risk of extinction if increases in global average temperature exceed 1.5-2.5°C.
- Vulnerability of ecosystems and species is partly a function of the expected rapid rate of climate change relative to the resilience of such systems. 1 million species may face an increased threat of extinction as a result of climate change,

according to the Millennium Ecosystem Assessment.

- Human development substantially reduces the resilience of ecosystems and makes many ecosystems and species more vulnerable to climate change through blocked migration routes, fragmented habitats, reduced populations, introduction of alien species and stresses related to pollution.
- Changes in species distributions, phenology and ecological interactions will have impacts, e.g. on pollination, invasions of agricultural systems by weed and locations of major marine fishing grounds.
- Climate change has already begun to affect the functioning, appearance, composition and structure of ecosystems (e.g. decreasing thickness of sea ice in the Arctic, wide-spread bleaching of corals, wetland salinisation and saltwater intrusion). Changes in the timing of natural events affect interactions between organisms, disrupting equilibria and ecosystems.

8.3. Vulnerability of infrastructure and settlement to climate change impacts

• Climate change could affect the sustainability of human settlements either by directly affecting the quality of life (e.g. by changing the probability of floods or the effects of air-pollution), by modifying the effects of the settlements on their surrounding environments (e.g. by changing the demand for water or changing the assimilation capacity of wetlands), or by changing the economic underpinnings (e.g. by changing the productivity of croplands, forests, or fisheries on which the settlement depends).

• Most of the impacts on human settlements from climate change are likely to be experienced indirectly through effects on other sectors (e.g. changes in water supply, agricultural productivity, and human migration).

• Many of the expected impacts in the developing world will occur because climate change may, by reducing natural resource productivity in rural areas, accelerate rural-to-urban migration, exacerbating already crowded conditions in the cities, and further depleting the labour force of the countryside.

- Climate change can be expected to affect the availability of water resources and biomass, both of which are major energy sources in many developing countries. Loss of water and biomass resources may jeopardise energy supply and materials essential for human habitation and energy production.
- In rural areas, particularly those in low-income countries, roads represent a lifeline for economic and agricultural livelihoods, as well as several indirect benefits, including access to healthcare, education, credit, political participation, and more.
- Roads may be sparse through geographic locations, making each road critical. Extreme events pose a costly hazard to roads in terms of degradation, necessary maintenance, and potential decrease in lifespan. Climate change poses costly impacts in terms of maintenance, repairs and lost connectivity.

8.4. Sectoral vulnerability to the impacts of climate change

Forest

• Forests are highly dependent on climate for their function (e.g. growth) and structure (e.g. species composition). Forest distribution is generally limited by either water availability or temperature.

• Concerning organisms and species, changes in temperature, rainfall, wind, and humidity are likely to affect many processes, including growth, reproduction, pollination, seed dispersal, phenology, pest and disease resistance and competitive ability.

• Climate change effects on species are likely to alter ecosystem balance and composition in unpredictable ways. For example, climate change may both disrupt and improve plant defences against pests and pathogens.

• Interactions among pests, pathogens and fire may cause either negative feedback loops or destabilising positive feedback loops. Fires can lead to outbreaks of pests and pathogens, and these can increase the probability and severity of fires. Sometimes, fires can reduce pest outbreaks, and fire suppression may increase the risk of epidemics.

• Habitat fragmentation and disturbance also create opportunities for invasive species and reduce the likelihood that native species will migrate within contiguous areas.

• The health and vitality of forests are threatened by stress factors such as uncontrolled logging, hunting and collection of NWFPs, fire, drought, invasive species and pests and diseases. These factors are likely to intensify in the future as the climate changes.

Agriculture and food security

• Agriculture is one of the most climate-sensitive sectors. Climate change affects all four dimensions of food security:

- ✓ food availability,
- ✓ food accessibility,
- ✓ food utilisation and
- ✓ Food systems stability.

• Climate change affects the health and productivity of crops, livestock, fish and forests and dependent rural livelihoods. This leads to hunger and malnutrition in such areas.

• A drop in water levels, drought, desertification and saltwater intrusion leads to more hunger and impoverishment. Water and food insecurity are exacerbated.

• While some mid-latitude and high-latitude areas will initially benefit from higher agricultural production, for many others at lower latitudes, especially in seasonally dry and tropical regions, the increases in temperature and the frequency of droughts and floods are likely to affect crop production negatively, which could increase the number of people at risk from hunger and increased levels of displacement and migration.

Water and coastal resources

• Climate change affects water resources through its impacts on the quantity, variability, timing, form and intensity of precipitation.

• Increased evaporation rates, a higher proportion of precipitation received as rain, increased water temperatures and decreased water quality in both inland and coastal areas. These tend to reduce water supplies to both the agricultural and municipal sectors.

• Drought-affected areas will likely become more widely distributed. Heavier precipitation events are very likely to increase in frequency, leading to higher flood risks.

• By mid-century, water availability will likely decrease in mid-latitudes, in the dry tropics and in other regions supplied by meltwater from mountain ranges. More than one-sixth of the world's population is currently dependent on meltwater from mountain ranges.

• The impacts of climate change on water and coastal resources affect ecosystems and communities, ranging from economic and social impacts to health and food insecurity, all of which threaten the continued existence of many regions in the world.

Health

• climate changes are likely to alter the health status of millions of people, including through increased deaths, disease and injury due to heat waves, rising sea levels, floods, storms, intense hurricanes, degraded air quality, fires and droughts.

• Changes in precipitation are creating changes in the availability and quality of water, as well as resulting in extreme weather events such as intense hurricanes and flooding.

• Climate change can be a driver of disease migration, as well as exacerbate health effects resulting from the release of toxic air pollutants in vulnerable populations such as children, the elderly, and those with asthma or cardiovascular disease.

• Increased malnutrition, diarrheal disease and malaria in some areas will increase vulnerability to public health and development goals, threatened by longer-term damage to health systems from disasters.

• Extreme and unprecedented cold spells and prolonged wet environments result in health problems, such as hypothermia, bronchitis and pneumonia, especially among old people and young children.

Transportation

• Higher temperatures can cause pavement to soften and expand. This can create rutting and potholes, particularly in high-traffic areas and can place stress on bridge joints. Massive floods, hurricanes, cyclones, typhoons, and storm surges lead to the destruction of houses, infrastructure (bridges, roads, electrical lines, dams, mine tailing ponds, etc.).

• Heat waves may limit construction activities, particularly in areas with high humidity. With these changes, it may become more costly to build and maintain roads. Heavy rains may result in flooding, which could disrupt traffic, delay construction activities and weaken or wash out the soil and culverts that support roads, tunnels and bridges.

• Exposure to flooding and extreme snow events also shortens the life expectancy of highways and roads. The stress of water and snow may cause damage, requiring more frequent maintenance, repair and rebuilding. Road infrastructure in coastal areas is particularly sensitive to more frequent and permanent flooding from sea level rise and storm surges.

8.5. Strategies for reducing climate change disaster risks

Disaster risk reduction refers to actions taken to reduce the risks of disasters and adverse impacts of natural hazards, through systematic efforts to analyse and manage the causes of disasters, including through avoidence of hazards, reduced social and economic vulnerability to hazards, and improved preparedness for adverse events. Strategies for reducing climate change disaster risks include:

•Ensure that disaster risk reduction is a national and local priority with a strong institutional basis for implementation.

• Identify, assess and monitor disaster risks and enhance early warning.

• Use knowledge, innovation and education to build a culture of safety and resilience at all levels.

• Reduce the underlying risk factors.

• Strengthen disaster preparedness for effective response at all levels.

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UNIT FOUR:
UNDERSTANDING THE ENVIRONMENT

CHAPTER NINE:
ENVIRONMENT AND THREAT

9.0. INTRODUCTION

Organisms and their environment constantly interact, and both are changed by this interaction. Like all other living creatures, humans have changed their environment, but they have done so generally on a grander scale than all other species. Some of these human-induced changes, such as the destruction of the world's tropical rainforests to create farms or grazing land for cattle, have led to altered climate patterns (see Global Warming). In turn, altered climate patterns have changed the way animals and plants are distributed in different ecosystems. Scientists study the long-term consequences of human actions on the environment, while environmentalists—professionals in various fields, as well as concerned citizens—advocate ways to lessen the impact of human activity on the natural world.

9.1. Understanding the Environment

Environment is derived from the French word Environ, which means encircle or surround. The environment encompasses all the living and non-living things that occur on Earth. The fate of the environment is tied to every life that inhabits the planet, including human beings. The industrialisation era brought about devastating impacts on the environment, and at the end of the nineteenth century, people started to apprehend the susceptibility of the environment and the gravity of the implications. nations gathered and issues regarding the environment were initiated on a priority with a hope to obtain and sustain a better future for our planet.

Environment is for the existence of entire mankind existing on earth and the generations to follow. Environment literally means surrounding, in which we are living. Environment includes all those things on which we are directly or indirectly dependent for our survival, whether it is living component like animals, plants or non-living component like soil, air water. According to Boring, a person's environment consists of the sum total of the stimulation which he receives from his conception until his death.' It can be concluded from the above definition that Environment comprises various types of forces such as physical, intellectual, economic, political, cultural, social, moral and emotional. Environment is the sum total of all the external forces, influences and conditions, which affect the life, nature, behaviour and the growth, development and maturation of living organisms.

According to Douglas and Holland: 'The term environment is used to describe, in the aggregate, all the external forces, influences and conditions, which affect the life, nature, behaviour and the growth, development and maturity of living organisms.' The Environmental Protection Act (1986) defined "Environment as the total of water, air and land, their interrelationship among themselves and with the human beings, other living beings and property."

The environment consists of three segments of the Earth, namely the atmosphere, hydrosphere and lithosphere:

Atmosphere:

The Atmosphere is a distinctive protective layer of about 100 km thickness around the earth. A blanket of gases known as atmosphere surrounds the earth and protects the surface of earth from the Sun's harmful, ultraviolet rays. It sustains life on the earth. It also regulates temperature, preventing the earth from becoming too hot or too cold and absorbs most of the cosmic rays and filter harmful ultra violet rays. The atmosphere has a marked effect on the energy balance at the surface of the Earth.

Hydrosphere:

The Hydrosphere comprises all types of water resources oceans, seas, lakes, rivers, streams, reservoirs, polar icecaps, glaciers, and ground water. Oceans represent 97 percent of the earth's water and about 2 percent of the water resources is locked in the polar icecaps and glaciers. Only about 1 percent is available as fresh water as surface water in rivers, lakes, streams, and as ground water for human use.

Lithosphere:

The lithosphere is the outer mantle of the solid Earth. It consists of minerals occurring in the Earth's crust and the soil, e.g. minerals, organic matter, air and water. Liveable components of the atmosphere, hydrosphere and lithosphere are called the Biosphere. The fate of every life that inhabits the planet, including that of human beings, is linked to environment. The industrialization brought about devastating impacts on the environment, and at the end of the nineteenth century, people started to apprehend the susceptibility of the environment and the gravity of the implications if the environment is not saved from it. Nations gathered and issues regarding the environment were initiated as priority, hoping to obtain and sustain a better future for our planet.

9.2. Factors Threatening the Environment

The problems facing the environment are vast and diverse. Global warming, the depletion of the ozone layer in the atmosphere, and the destruction of the world's rainforests are just some of the problems that many scientists believe will reach critical proportions in the coming decades. All of these problems will be directly affected by the size of the human population. Some of the factors threatening the environment include:

9.2.1. Population Growth

Human population growth is at the root of virtually all of the world's environmental problems. Although the growth rate of the world's population has slowed slightly since the 1990s, the world's population increases by about 77 million human beings each year. As the number of people increases, crowding generates pollution, destroys more habitats, and uses up additional natural resources. Although rates of population increase are now much slower in the developed world than in the developing world, it would be a mistake to assume that population growth is primarily a problem of developing countries. Because larger amounts of resources per person are used in developed nations, each individual from the developed world has a much greater environmental impact than does a person from a developing country. Conservation strategies that would not significantly alter lifestyles but that would greatly lessen environmental impact are essential in the developed world.

9.2.2. Global Warming

Like the glass panes in a greenhouse, certain gases in the earth's atmosphere permit the sun's radiation to heat earth. At the same time, these gases retard the escape into space of the infrared energy radiated back out by earth. This process is referred to as the greenhouse effect. These gases, primarily carbon dioxide, methane, nitrous oxide, and water vapour, insulate Earth's surface, helping to maintain warm temperatures. If the concentration of these gases rises, they trap more heat within the atmosphere, causing worldwide temperatures to rise. Within the last century, the amount of carbon dioxide in the atmosphere has increased dramatically, largely because people burn vast amounts of fossil fuels—coal and petroleum and their derivatives. Average global temperature has also increased by about 0.60 C (1 Fahrenheit degree) within the past century.

Atmospheric scientists have found that at least half of that temperature increase can be attributed to human activities. The consequences of such a modest increase in temperature may be devastating. Already, scientists have detected a 40 per cent reduction in the average thickness of Arctic ice. Other problems that may develop include a rise in sea levels that will completely inundate several low-lying island nations and flood many coastal cities, such as New York and Miami. Many plant and animal species will probably be driven into extinction; agriculture will be severely disrupted in many regions, and the frequency of severe hurricanes and droughts will likely increase.

9.2.3. Depletion of the Ozone Layer

The ozone layer, as a thin band in the stratosphere (layer of the upper atmosphere), serves to shield Earth from the sun's harmful ultraviolet rays. In the 1970s, scientists discovered that chlorofluorocarbons (CFCs)—chemicals used in refrigeration, air-conditioning systems, cleaning solvents, and aerosol sprays—destroy the ozone layer. CFCs release chlorine into the atmosphere; chlorine, in turn, breaks down ozone molecules. Because chlorine is not affected by its interaction with ozone, each chlorine molecule can destroy a large amount of ozone for an extended period. The consequences of continued depletion of theozone layer would be dramatic. Increased ultraviolet radiation would lead to a growing number of skin cancers and cataracts and also reduce the ability of immune systems to respond to infection. Additionally, the growth of the world's oceanic plankton, the base of most marine food chains, would decline.

9.2.4. Habitat Destruction and Species Extinction

Plant and animal species are dying out at an unprecedented rate. It was estimated that between 4,000 to as many as 50,000 species per year become extinct. The leading cause of extinction is habitat destruction, particularly of the world's richest ecosystems—tropical rain forests and coral reefs. If the world's rain forests continue to be cut down at the current rate, they may completely disappear by the year 2030. In addition, if the world's population continues to grow at its present rate and puts even more pressure on these habitats, they might well be destroyed sooner.

9.2.5. Air Pollution

A significant portion of industry and transportation burns fossil fuels, such as gasoline. When these fuels burn, chemicals and particulate matter are released into the atmosphere. Although a vast number of substances contribute to air pollution, the most common air pollutants contain carbon, sulphur, and nitrogen.

These chemicals interact with one another and with ultraviolet radiation in sunlight in dangerous ways. Smog is usually found in urban areas with large numbers of automobiles, forms when nitrogen oxides react with hydrocarbons in the air to produce aldehydes and ketones. Smog can cause serious health problems.

Acid rain forms when sulfur dioxide and nitrous oxide transform into sulfuric acid and nitric acid in the atmosphere and come back to earth in precipitation. Acid rain has made numerous lakes so acidic that they no longer support fish populations. Acid rain is also responsible for the decline of many forest ecosystems worldwide, including Germany's Black Forest.

9.2.6. Water Pollution

Estimates suggest that nearly 1.5 billion people worldwide lack safe drinking water and that at least 5 million deaths per year can be attributed to waterborne diseases. Water pollution may come from point sources or nonpoint sources. Point sources occur when discharge pollutants are from specific locations, such as factories, sewage treatment plants, and oil tankers. Pollution from nonpoint sources occurs when rainfall or snowmelt moves over and through the ground. As the run-off moves, it picks up and carries away pollutants, such as pesticides and fertilisers, depositing the pollutants into lakes, rivers, wetlands, coastal waters, and even underground sources of drinking water. Pollution arising from nonpoint sources accounts for a majority of the contaminants in streams and lakes. However, raw sewage, garbage, and oil spills have begun to overwhelm the diluting capabilities of the oceans, and most coastal waters are now polluted; threatening marine wildlife.

9.2.7. Groundwater Depletion and Contamination

Water that collects beneath the ground is called groundwater. Worldwide, groundwater is 40 times more abundant than fresh water in streams and lakes. Although groundwater is a renewable resource, reserves replenish relatively slowly. Agricultural practices depending on this source of water need to change within a generation in order to save this groundwater source. In addition to groundwater depletion, scientists worry about groundwater contamination, which arises from leaking underground storage tanks, poorly designed industrial waste ponds, and seepage from the deep-well injection of hazardous wastes into underground geologic formations. In addition to groundwater depletion, scientists worry about groundwater contamination, which arises from leaking underground storage tanks, poorly designed industrial waste ponds, and seepage from the deep-well injection of hazardous wastes into underground geologic formations.

9.3. Global Efforts to Protect the Environment

Most scientists agree that if pollution and other environmental deterrents continue at their present rates, the result will be irreversible damage to the ecological cycles and balances in nature upon which all life depends. Scientists warn that fundamental, and perhaps drastic, changes in human behaviour will be required to avert an ecological crisis.

To safeguard the healthful environment that is essential to life, humans must learn that earth does not have infinite resources. Earth’s limited resources must be conserved and, where possible, reused. Furthermore, humans must devise new strategies that mesh environmental progress with economic growth. The future growth of developing nations depends upon the development of sustainable conservation methods that protect the environment while also meeting the basic needs of citizens.

Many nations have acted to control or reduce environmental problems. For example, Great Britain has largely succeeded in cleaning up the waters of the Thames and other rivers, and London no longer suffers the heavy smogs caused by industrial pollutants. Japan has some of the world's strictest standards for the control of water and air pollution. In Canada, the Department of Commerce has developed comprehensive programmes covering environmental contaminants. In the United States, the Environmental Protection Agency (EPA) was established in 1970 to protect the nation's natural resources. In addition, the U.S. Congress has provided governmental agencies with legislation designed to protect the environment. Many U.S. states have also established environmental protection agencies. Citizen groups, such as the Sierra Club and the National Audubon Society, educate the public, support environment friendly legislation, and help ensure that federal and state laws are enforced by pointing out violations. Much still needs to be done in the area of environmental protection in Africa, with proper legislation to curb indiscriminate dumping of refuse and industrial waste.

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CHAPTER TEN: ENVIRONMENTAL DETERIORATION: ACID RAIN

10.0. Introduction

Acid rain became a household term in the 1980s when unchecked emissions from industry and motor vehicles were blamed for causing Environmental deterioration. Scientific evidence has linked acid rain to decreased fish and wildlife Populations, degraded lakes and streams, and human health hazards. Although the term has since faded from public consciousness, Acid rain is a complex and global problem that still exists today.

10.1. Understanding acid rain

Acid rain was identified in 1872 in Sweden and studied in the U.S. Beginning in the 1950s, acid rain is precipitation in the form of rain, Snow, hail, dew, or fog that transports sulfur and nitrogen compounds from the high atmosphere to the ground. Sulfur dioxide (SO2) and Nitrogen oxides (NO, NO2) are by-products from burning fuels in electric utilities and other industrial and natural sources. These chemicals react with water, oxygen, carbon dioxide, and sunlight in the atmosphere to form sulfuric and nitric acids.

The acids reach the ground and change the chemistry within the environment. The acidity of any solution is determined on a ph scale of 0 to 14. A ph level of 0 to 7 is considered acidic; 7 is neutral, and a level above 7 is alkaline. As the pH number decreases, acidity increases. Unopened bottled distilled water has a pH of 7, so it is neutral. In comparison, household ammonia is alkaline with a ph of 11.5. Milk is slightly acidic with a 6.5 pH, and soft drinks, which contain phosphoric acid, have a 3.1 ph. Although the ph scale may seem straightforward, determining the ph of "normal" rain is much more complex. When distilled water is exposed to air, interaction with carbon dioxide increases acidity through the formation of carbonic acid, H2CO3, and the pH level falls. Many scientists agree that the normal ph of rain is slightly acidic because of perpetual chemical interactions in the air.

Acid rain is linked to both natural and man-made sources. Nitrogen oxides are formed through the extreme heating of air when a thunderstorm produces lightning. Also, sulfurous gases are discharged from erupted volcanoes and rotting vegetation. However, most public attention has been focused on man-made sources of acid rain, which include the burning of any fuel that contains sulfur and nitrogen compounds, including public utilities, industrial boilers, motor vehicles, and chemical plants. Electric power generation accounted for 69 percent of total sulfur dioxide emissions in the U.S. in 2007 and 20 percent of nitrogen oxides, according to the U.S. Environmental Protection Agency (USEPA). Acid rain is not limited to the region where sources are located. Prevailing winds can blow chemicals in the atmosphere for hundreds or even thousands of miles before being deposited, regardless of state and country boundaries. For instance, compounds from industry in China can potentially be deposited in the U.S. Midwest. For this reason, acid rain is considered a global problem.

10.2. Effect of acid rain

Acid rain has been linked to detrimental effects on the environment and human health.

10.2.1 Forests, lakes, and streams

Acid rain can cause widespread damage to trees. This is especially true of trees at high elevations in various regions. Acidic deposition can damage leaves and also deplete nutrients in forest soils and trees so that trees become more vulnerable to disease and environmental stress. When lakes and streams become more acidic than normal, they cannot continue to support the same types of fish and aquatic life as in the past.

Fish communities dwindle due to high mortality, a reduced growth rate, skeletal deformities, and failed reproduction. Lakes ultimately become home only to species that can tolerate high-acid conditions. Game fish, such as trout, are particularly sensitive to acidic water conditions. A healthy lake has a ph of 6.5 or higher. Only a few fish species can survive at a ph of below 5; at a ph of 4, the lake is considered dead. A decrease in fish populations is often the first sign of an acidification problem. Not all lakes are equally vulnerable to acid rain, however. In some areas, such as in Illinois, the average pH of a freshwater lake is an alkaline 8 to 9 because soils and rocks in the bottom and sides of the lake contain high levels of calcium and magnesium, which neutralize the acidity of rain.

10.2.2. Plants and crops

Acid rain can potentially reduce agricultural production by changing the chemical properties of soil, slowing the rate of microbiological processes, and reducing soil nutrients. Roots of natural vegetation and crops can become damaged due to stunted growth.

10.2.3. Human effects

Acidic water moving through pipes causes lead and copper to leach into the water. Most public water suppliers remove such dangerous chemicals at the plant, but tainted water could be a problem for residents who don’t rely on public water supplies for their drinking water. Acidic fog can be more hazardous to health than acid rain, as small droplets can be inhaled. These atmospheric acids can cause respiratory problems in humans, such as throat, nose, and eye irritation, headache, and asthma. Acid fog is particularly dangerous for the elderly, those who are ill, and people who have chronic respiratory conditions.

10.2.3. Man-Made Materials

Although sunlight, heat, cold, and wind contribute to the deterioration of man-made structures and objects, acid deposition speeds up this process. Metal structures and vehicles become corroded, and limestone buildings, tombstones, statues, and monuments deteriorate faster when rain is acidic.

10.2.4 Soil

Each soil has a buffering capacity, which is the ability of the soil to neutralize acids. An alkaline soil, for example, has a high buffering capacity, because it can absorb high amounts of acidic precipitation without a ph change. Alkaline soil is less harmed by acid rain than sensitive soils with low buffering capacities are. Due to the concentration of industry, the soil quality, and the easterly winds, however, eastern Canada receives the majority of acid rain. With the drastic increase in the tar sands mining in northern Alberta, northern Saskatchewan, and Alberta could soon be at risk for acid rain.

10.2.5. Water

Slightly acidic Water should not be dangerous, as there is much food that has a low pH value; for example, lemon juice has a ph of 2.4. However, a low ph can indicate that there may be other contaminants in the water because if pollutants have been added to a water source, the ph typically will change. Water treatment facilities monitor the ph. level of the water while they are treating it for municipal use. Acidic or basic water is harder to disinfect than water with a ph. that is closer to 7.0. As well, if acidic water were sent through pipes and into homes, there would be a greater danger of pipe corrosion, which could allow metals to dissolve into the drinking water as it flows through the pipes. According to the World Health Organisation, a ph. less than 8.0 is necessary for effective chlorination. If the ph. is too high, water treatment facilities can decrease the acidity in some ways. One common method that is used to increase the ph is to send the water through a calcium carbonate filter, which neutralises the acid and increases the ph. of the water. Another common method is to inject a sodium carbonate solution into the water.

10.2.6. Vegetation

Acid rain can weaken trees by damaging the leaves and limiting the number of available nutrients. Acid rain dissolves nutrients and minerals and carries them away before the vegetation can use them to grow. Crops are not usually harmed by acid rain, because farmers use fertilizer, which includes the necessary nutrients or add crushed limestone to their fields. Limestone is an alkaline material, so it increases the buffering capacity of the soil to neutralize acids.

10.2.6. Buildings

Acid rain can corrode metals and deteriorate paint and stone. To see the effects of acid rain, try this experiment: Put a piece of chalk into a bowl of white sugar and another into a bowl of tap water. Leave them overnight and see which is more worn away in the morning. Vinegar is an acid with a pH of 2.8, and chalk is made of calcium carbonate, which is a compound of marble and limestone.

10.3. Solutions

There are several solutions to stopping manmade acid rain. Regulating the emissions coming from vehicles and buildings is an important step, according to the EPA. This can be done by restricting the use of fossil fuels and focusing on more sustainable energy sources such as solar and wind power. Also, each person can do their part by reducing their vehicle use. Using public transportation, walking, riding a bike, or carpooling is a good start, according to the EPA. People can also reduce their use of electricity, which is widely generated with fossil fuels, or switch to a solar plan.

UNIT FIVE:

ENVIRONMENTAL HAZARDS CAUSES: EFFECTS AND REMEDIES

CHAPTER ELEVEN: CONCEPT OF ENVIRONMENTAL HAZARDS

11.0. INTRODUCTION

It is a known fact that out of all the creatures present on our planet, only human beings have the higher thinking capacity and possess the ability to alter their environment. Our environment consists of physical, chemical and biological factors which are always in an interactive relationship with us, meaning that we affect our environment and consequently our environment affects us. These interactions may expose us to many environmental hazards. A hazard is something which is recognised to cause harm, that is, a source of danger. Initially hazards were known to have only natural origin and were believed to be the "act of God" or the result of some external powers. Later on it was found that there is no doubt that humans affect natural processes in many ways and so often lead to hazards. Many physical aspects of natural hazards, however, are out of their control. This does not imply that people are just passive in facing hazards; they can and do construct defences against and implement measures to mitigate the impacts of hazards. Here in this lesson we are going to learn about the causes and consequences of environmental hazards and will also highlight the role of man in originating, controlling and mitigating the environmental hazards.

11.1. Understanding Environmental Hazards

An environmental hazard is a threat posed by natural or built by the environment, to humans and the things that are valued in human society. Alexander (2000) defines environmental hazard as "an extreme geophysical event that is capable of causing a disaster." Burton and Kates (1964) maintain that natural hazards are those elements of the physical environment that are harmful to humans and caused by forces extraneous to them. Cutter (1993) defines hazards as the threats to people and the things they value such as their homes and belongings and environment. All these definitions are correct in the sense that hazards are harmful to people, but fails to acknowledge the role of humans in causing these hazards. There is no question that humans affect natural processes in many ways and thus often contribute to hazards. Keeping the anthropogenic role in mind United Nations define the hazard, as "A potentially damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation" (UNISDR, 2004). This definition directly acknowledges the role of humans in causing/exacerbating hazards. In the next section we are going to know about the classification of environmental hazards.

11.2. Types of Environmental Hazards

Many efforts have been made to classify the ever increasing list of hazards. Classifications of hazards usually provide us with a useful framework for identifying similarities, differences, making generalizations and setting up a sound management practice about the hazardous events. Most of the existing hazard typologies use the causes or origins of hazard events as the classifying principle. United Nations International Strategy for Disaster Reduction (UNISDR) classified the hazards into two families:

- Natural and
- Anthropogenic (man-made). The anthropogenic hazard family is sub-divided into three sub-families:
  - ✓ Technological Hazards (hazards, such as fire, explosion, and power outage, as well one location for a hazard, Mine Disaster, and a hazard entitled, Industrial Disaster),
  - ✓ Chemical and Radiological Hazards (Chemical Spill, Oil Spill, Radiation Contamination, Nuclear Incident) and
  - ✓ the Transportation Accident hazards (includes the media through which objects are transported, Rail Accident, Road Accident, Space Accident, Aviation Accident etc.

11.2.1. Natural Environmental Hazards

Natural hazards are those components of the physical environment, harmful to man and are induced by some extraneous forces. A natural hazard can be specified as an unexpected or uncontrollable phenomenon of rare magnitude that creates a threat to people, structure and economic assets caused by geological, seismic, hydrological and biological conditions. Earthquakes, volcanic eruptions, hurricanes, tsunamis, blizzards, and tornadoes that originate in the lithosphere, hydrosphere, or atmosphere are all natural hazards and are exclusively of natural origin. On the other hand, landslides, flood, droughts and fires are termed as socio-natural hazards, since their causes are natural as well as manmade e.g. landslides may cause flooding and in the same way groundwater extraction or drainage may contribute to droughts.

Tobin and Montz (1997) classified natural hazards into four categories:
(1) Meteorological (tropical cyclones/hurricanes, thunderstorms, tornadoes, lightning, hailstorms, windstorms, ice storms, snowstorms, blizzards, cold waves, heat waves, avalanches, fog, and frost),
(2) Geological (earthquakes, volcanoes, tsunamis, landslides, subsidence, mudflows, and sinkholes),
(3) Hydrological (floods, droughts, and wildfires), and
(4) Extraterrestrial (meteorites).

11.2.2. Anthropogenic Environmental Hazards

An Anthropogenic hazard (Man-made) also experienced as human induced disasters cover a broad range of events created largely due to accidents, negligence or sometimes even by human inventions, which result in huge loss of lives and property every year. These include road, rail, river, marine and aviation accidents, oil spill, building and bridge collapse, bomb blast, industrial and chemical accidents etc. These also include the threats of nuclear, biological and chemical disasters. This type of hazards may result from industrial accidents or deliberate as well as inadvertent action of individual or groups. India has experienced several man-made disasters. One among them is the 'Bhopal Gas Tragedy' it happened in the early hours of December 3, 1984, a highly toxic cloud of methyl isocyanate leaked from Tank

- E610 engulfing the city of Bhopal resulting as many as 10,000 deaths.

The anthropogenic hazards are further sub-divided into three sub-families:

- Technological Hazards
- Chemical and Radiological Hazards and
- The 'Transportation Accidents.

A. **Technological Hazards**

Technological hazards originate from the interaction of society, technology, and natural systems and constitute a relatively new form of threat. Technological hazards are the hazards which are caused due to mishandling, mismanagement or due to maladministration of technology. Technological hazards can affect localized or widespread areas. They are frequently unpredictable, can cause property damage, loss of life, and can significantly affect infrastructure. Hazards caused by incidents like dam failures (that cause downstream flooding), Fires, (burning in residential, commercial, industrial or other properties), uncontrolled releases of hazardous materials from fixed sites or during transport like uncontrolled releases of radioactive materials at commercial power plants or other nuclear reactor, power failures and telecommunications failures are some of the examples of technological hazards. One of the most devastating technological environmental hazards occurred in 1986, when a nuclear reactor in Ukraine, which at the time was part of the former Soviet Union, exploded. The explosion sent a huge cloud of radioactive particles into the air. The cloud drifted over Europe, contaminating millions of acres in Ukraine, Belarus, and Russia. Hundreds of thousands of people had to leave their homes. Many people suffered various illnesses because of their exposure to the radiation.

B. Chemical and Radiological Hazards:

Chemical and radiological hazards are those hazards that are caused by some chemical, biological, radiological or nuclear component, commonly known as CBRN. All these hazards agents (Chemical, biological, radiological or nuclear (CBRN)) are retained under this classification because there are distinct similarities in building some of the emergency preparedness and response measures for all of them. Chemical emergencies can happen in a number of different situations where hazardous chemicals are discharged into the environment. These chemicals can be in the form of gases, solids or liquids and can be either chemical elements, compounds in a natural or processed state or their by-products. Exposure by inhalation, ingestion or to the skin may result in illness or injury to human health depending on the chemical substance, the amount of the dose and the duration of exposure.

Biological hazards make up another type of environmental hazard; sources of biological hazards include pathogens like bacteria, viruses, parasites, insects, birds, and toxins or poisons that are produced by them. Animals and plants that appear in a place that is not their natural habitat can be environmental hazards.

Exposure in sufficient quantities and over a given duration may result in illness or injury to human health, and this can happen through natural exposure or release (intentional or unintentional) of these biological agents. For example, bacteria cause cholera, tuberculosis, leprosy, relapsing fever and many diarrhoeal diseases; viruses are responsible for hepatitis B and C, HIV, measles, polio, corona etc.; and there are many diseases caused by parasites like malaria, filarial, leishmaniasis, ascariasis, dracunculiasis (guinea worm), filariasis, onchocerciasis etc. Biological hazards arise from working with infected people or animals, or handling infectious waste and body fluids, as well as contact with unsafe water, food and waste.

Radioactive chemicals emit harmful radiations that have harmful impact on the environment. Nuclear and radiological hazards are related to ionizing radiation (the ability of particles to release ionizing radiation) from radioactive sources which in sufficiently high doses are hazardous to humans, animals and also cause an adverse impact on the surroundings. Nuclear emergencies involve or emerge from nuclear chain reactions while as radiological emergencies can affect all other situations involving radioactive sources, for instance, those employed in radiological devices for medical, industrial or research applications. Radioactive chemicals include: radioactive isotopes, radioactive elements, radionuclides, radioactive cesium, uranium, strontium etc. A radiation incident can create public panic and potentially result in a large displaced population seeking alternate shelter and health cover for possible exposure, which may produce an additional health care burden on the local mental health and public health resources. Long-term effects could include ecological damage, loss of food and agricultural output, and human resettlement.

C. Transportation Accidents:

The third sub-family of anthropogenic hazards is the Transportation Accidents, which occur along roads, railways, air, or water bodies. A transport accident is any accident or incident that happens during any type of transportation, including accidents occurring during road transport, rail transport, maritime transport and air transport. It can refer to a road traffic accident, including vehicle collision, pedestrian-bicycle collisions, pedestrian-pedestrian collisions and so on, a marine accident like a sailing ship accident, including man overboard, railroad accidents, including train wreck, an aviation accident and incident. Such risks may result from adverse weather conditions, human fault, and/or mechanical failure.

In other words accidents caused by the media of transportation like rail, road, space and aviation etc., Such risks may result from adverse weather conditions, human fault, and/or mechanical failure.om adverse weather conditions, human fault, and/or mechanical failure.om adverse weather conditions, human fault, and/or mechanical failure.om adverse weather conditions, human fault, and/or mechanical failure.om adverse weather conditions, human fault, and/or mechanical failure.om adverse weather conditions, human fault, and/or mechanical failure.om adverse weather conditions, human fault, and/or mechanical failure.om adverse weather conditions, human fault, and/ or mechanical failure.om adverse weather conditions, human fault, and/or mechanical failure. Transit arrangements are projected to displace people, commodities and services efficiently, economically and safely from one spot to some other.

Despite this broad goal, there are many environmental hazards that commonly disrupt or damage these systems in a variety of spatial and temporal scales. Referable to the potential for tragedy, various state and federal agencies have been established to regulate transportation methods and to minimize the number of automobile collisions, aeroplane accidents, train crashes and other types of transportation accidents. Safety boards and other agencies analyse and investigate accidents involving trains, planes and automobiles. Additionally, inspectors investigate trucking incidences and other transportation issues. However, industrial and transportation-related accidents and progressive or precipitous destruction of ecosystems reflect failures or side-effects of human-devised technologies, failures of judgment, or even flagrant human neglect.

11.3. CAUSES OF ENVIRONMENTAL HAZARDS

Most people dwell along the boundary of an environmental hazard-whether they recognise it or not. Some environmental hazards, such as a rising flood or a smoking volcano, are easy to recognize, while as others are not so easy to detect, whereas some environmental threats, such as earthquakes, can occur quickly, with short notice, other environmental hazards might take long time to become recognised, such as the influence of the pesticide DDT on wildlife and human tissue. Anything that affects the environmental health of humans, plants, and animals negatively is an environmental hazard. Air contamination, contaminated food, and water pollution are all examples of the environmental hazards Earth's population faces.

The United Nations International Strategy for Disaster Reduction (UNISDR) has divided hazards into two families: natural and anthropogenic. Natural hazards are naturally occurring physical phenomena having atmospheric, geologic or hydrologic origin like tornadoes, hurricanes, earthquakes, landslides, floods, droughts etc.

while as anthropogenic or man-made hazards are the hazards caused by human action or inaction like fire, explosion, Mine Disaster, Chemical Spill, Radiation Contamination, Nuclear Incident and even transportation accidents are all included in anthropogenic hazards. All these hazards may directly or indirectly bear on living organisms, biomes and ecosystems. The severities of these hazards are the key elements in the risk analysis.

These hazards affect the physical, mental and social welfare of people and may occur intentionally or unintentionally. Hazards lead to loss of life, damage of the economy, social disruptions and have adverse long-term effects. There are several environmental hazards that occur every year and hurt the human population and other components essential for their survival. Here we are going to discuss some important causes of the popular hazards.

11.3.1. Land Degradation

Land degradation generally signifies the temporary or permanent decline in the productive capacity of the land. It is also defined as the long-term loss of ecosystem function and productivity caused by disturbances from which the land cannot recover unaided. The most frequently recognised causes of land degradation include: overgrazing of rangeland; over-cultivation of cropland; water logging and salinisation of irrigated land; deforestation; pollution and industrial causes. Land degradation adversely affects people's livelihoods and occurs over 10 per cent of the Earth's land area. Land degradation affects humans in multiple ways, interacting with social, political, cultural and economic aspects, including marketing, technology, inequality and demographic change. Land degradation impacts extend beyond the land surface itself, affecting marine and freshwater systems, as well as people and ecosystems far away from the local sites of degradation. Land degradation is currently a huge challenge for sustainable development. This problem is more acute in the areas where the environment is intrinsically vulnerable and the population is losing control over its resources

11.3.2. Pollution

Any unfavourable alteration in the physical, chemical or biological characteristics of air, water, and land may or will adversely affect human life. Industrial life, industrial progress, living conditions and cultural assets are all classified as pollution, which is recognized toexerta negative stress on the positive health of the ecosystem. The substances that cause the undesirable changes in the air, water and land are referred to as the pollutants which can be a substance (e.g., dust, smoke), chemicals (e.g., SO2 or Methyl mercury) or factor (like heat, noise etc.) whose introduction into the environment has an actual or probable adverse effect on human interests. The rapid industrial growth and urbanisation has led to atmospheric pollution.

Industrial pollution is acute in areas where petroleum refineries, chemicals, iron and steel, non-metallic products, pulp and paper and textile industries are located. Dirt, dust, and solid waste propelled in the air are also harmful for humans, animals and plants. Acid rain destroys the forests and water bodies, gases like CFC's damage the ozone layer in the atmosphere, while as gases like carbon dioxide, which is directly poisonous, are all produced by anthropogenic activities. The primary sources of water pollution are flushing domestic and industrial seepages containing organic pollutants, wastes of chemicals, heavy metals etc., into lakes, canals, rivers, coastal areas and underground water sources. These pollutions can become one of the major reasons for both natural and man-made hazards.

11.3.3. Overpopulation or Overcrowding:

Overpopulation refers to a population which exceeds its sustainable size within a particular environment or habitat. Overpopulation is a consequence of various factors like increased birth rate, decreased death rate, better medical facilities, depletion of precious resources, immigration to a new ecological niche with fewer predators and so on. A sparsely populated area can become densely populated if it is not capable of sustaining life. Growth in population puts strain on natural resources, which results in environmental hazards. Overpopulation means more demand for food, clothes and shelter, more space to cultivate food and provide more homes to people, resulting in deforestation which is a prime factor that led to environmental hazards. Overcrowding is the major cause of many man-made hazards. The Tsunami in the Cuddalore district of Tamil Nadu occurred on 26 December 2004 causing massive loss of life and devastation of property Overcrowding was one great reasons of it. The untoward effect of overexploitation of resources due to huge population size was one big reason pointed out by geologists for the occurrence of this hazard.

11.3.4. Deforestation:

Deforestation is simply the conversion of forested tracts to barren lands, usually done by clear-cutting trees and removing the wood or vegetation for agricultural operations or to harvest wood as a fuel or for wooden products. The whole of Europe was once thickly forested, but the trees were cut down to provide wood and for agriculture. Today, rapid deforestation is taking place in the tropics, where rainforests in South America, Africa, and Asia are being cleared for agriculture. In India, some 3.4 million hectares of forest land were lost during the initial three decades of planning. Deforestation is still ongoing at a rapid rate in the name of river valley projects, urban settlement, industrialization, roads, communication etc. The issue of deforestation has reached to such a level that it has totally disturbed the ecological balance.

The process of deforestation results in many undesirable environmental impacts at multiple scales. Local impacts include decreasing soil stability, increasing erosion and transporting sediments into streams, reduction in biodiversity through loss of habitat, and alterations to microclimates that typically increase local temperatures because of loss of vegetation and increased numbers of heat islands. Deforestation can also produce impacts on a global scale. Research over the past decade has shown that the cutting and burning of large forest tracts is quickly liberating large amounts of carbon and increasing levels of the greenhouse gas, carbon dioxide, in the atmosphere. Removing forest vegetation further disrupts the global carbon balance by eliminating the living trees that served as a sink for carbon dioxide.

11.3.5. Ozone Depletion, Greenhouse effect and Global warming:

All three physical phenomena (Ozone Depletion, Greenhouse effect and Global warming) are connected to a major extent. Ozone depletion and global warming are linked with industrial development and energy use, especially fossil fuels. Near the Earth's surface, ozone is a troublesome pollutant, but its presence in the stratosphere is as important to life as oxygen. If the stratospheric layer of ozone disappears or thins, all terrestrial life will be annihilated. This depletion of ozone layer is linked to both 'greenhouse effect and global warming. The greenhouse effect occurs due to the emission of certain gaseous pollutants like methane, CFCs, water vapour and carbon dioxide in the air, which, after the warming of the atmosphere, causes the average global temperature to rise, known as global warming, which also imposes devastating and disturbing results on the biosphere. A rise of 5C temperature would affect all the components of the local, regional and global ecosystems. It results in the increase in the sea levels and ocean currents, prevailing winds, fresh water supplies, agriculture, forests, fisheries, industry, transport, urban planning, demographics, human health, etc. It also results in the melting of glaciers at the poles, which makes the cities that lie near the coasts or in low-lying areas prone to floods and landslides.

11.3.6. Faulty Mining Practice:

Mining is the extraction of economically valuable minerals or other geological materials from the surface of the earth (ore body, lode, vein, seam, reef or placer deposits). Mining is a hazardous operation and consists of considerable environmental, health and safety risks to miners. Unsafe conditions in mines lead to several accidents and cause loss and harm to human lives, damage to property, interruption in production, etc. Extraction of minerals on a large scale has created a grave problem in ruining the land, water, forest and air. Huge mining has resulted in the conversion of agricultural and forest land into roads, railway lines and the removal of vegetation and topsoil. Most of the people working in these industries suffer from several respiratory and skin diseases. The dust and various fumes inhaled by miners make them vulnerable to pulmonary diseases. The danger of collapsing mine roofs, inundation and fires in coal mines is a perpetual threat to miners. Dumping of waste and slurry leads to the degradation of land, soil and increases the water contamination in streams and rivers.

11.3.7. Disposal of Wastes:

Waste is any unusable or unwanted substance or material produced during manufacturing or as a consequence of a process. Waste products may be in the form of fruit and vegetable peels, leftover food, packing material, old and unwanted plastic objects, old clothes, etc. or the form of medicine, chemical or nuclear and radioactive substances. A hazardous waste is a waste with a chemical composition or other properties that make it capable of causing illness, death, or some other harm to humans and other life forms when mismanaged or released into the environment. Some hazardous substances show their toxic effects (humans or environment) after a single, episodic release, while others produce their toxic effects after extended exposure to the substance; the former is known as acute toxicity, while the latter is known as chronic toxicity.

There are many hazardous chemicals which are toxic in very small amounts, whereas others can have large volumes of exposure before there is a reaction. Having hazardous chemicals in the human body causes adverse reactions to fetuses, children, adolescents, adults and the elderly, but the reaction each may have varies. A fetus and young child are more susceptible to adverse reactions than an adult because their developing organs may be permanently damaged. Some potential health conditions in people of all ages include:

behavioural abnormalities, cancer, physiological malfunctions (e.g., kidney failure, reproductive impairment), genetic mutations, physical deformations, birth defects and so on.

11.4. EFFECTS OF ENVIRONMENTAL HAZARDS

The impacts of environmental hazards vary in their severity and are measured through analysis of the interaction between the hazard (natural or man-made) and the receptors (people, properties, infrastructure or environment). Different hazards affect different receptors to different extents. Hazards become less important when the receptors are other than humans or when humans are not directly impacted. The involvement of populations depend upon population density, magnitude of the hazard, frequency or how often the hazard occurs, development, preparations, accessibility, etc. The effects can be acute, meaning that the injury or harm can occur or be felt as soon as a person comes in contact with the hazardous agent, and sometimes it may be chronic or delayed. Once the hazard is removed or eliminated, the effects may be reversible or irreversible (permanent). Wealth and development play an important role in recovery from hazards, for example, an economically developed country can prepare for and predict hazards more effectively, and they have many resources to support a faster recovery than an underdeveloped country.

All types of environmental hazards can have primary, secondary, and tertiary effects. Primary Effects occur as a result of the process itself. For example, collapse of buildings during an earthquake, landslide, or hurricane. Secondary effects are originated from a primary effect. For example, fires ignited as a result of earthquakes, disruption of electrical power and water service as a result of an earthquake, flood, or hurricane, or flooding caused by a landslide into a lake or river. Tertiary Effects are long-term effects that are set forth as a result of a primary event. These include things like loss of habitat caused by a flood, permanent changes in the position of a river channel caused by flooding, and crop failure caused by a volcanic eruption, etc. Here we are going to discuss in brief some of the major effects of hazards:

11.4.1. Loss of life and property:

The loss of life and property due to natural disasters like tropical cyclones, floods, droughts, tornadoes, earthquakes, volcanic eruptions, etc, is enormous. Cities and towns are worst affected due to a large concentration of human population, commercial complexes and residential areas. Due to the collapse of large buildings, there is a greater loss of life and property. The worst damage a hazard can cause is the loss of human life as property loss can be engrossed with time, but a loss of life is irretrievable. Losing a family member has far more lasting impact than any other loss. Loss of a family member leads to social and psychological disturbance that affects the recovery phase and also lengthens the rehabilitation period. Another major effect of the environmental hazard is the loss of livelihood. The earning of a whole life is distracted in a moment, which can cause grief and other psychological traumas.

11.4.2. Social impact:

Man's social environment is developed in a family and family is the basic unit of a society. Natural or manmade hazard badly hampers the social life of the victim. Alteration or disturbance in the social life increases mental health issues, alcohol misuse, domestic violence, chronic disease, etc.

The acute impact of hazards is that people may be killed or injured, but the long-term effect is that diseases are spread; people are sheltered in refugee camps. Living in refugee camps or hospitals with temporary or permanent disability has several social ill effects. Upbringing in these camps is linked with social stigma, and adjustment in a community in a normal manner becomes very difficult.

11.4.3. Economic impact:

Hazards also have adverse longer-term consequences on economic growth, development and poverty reduction. Hazards deteriorate the economy badly by putting down the valuable assets such as buildings, equipment, human capital, etc., which consequently hamper their production capacity and sometimes lead to forced closure . The economy of these places would be affected by the devastation caused by these hazards, and the cost of restructuring settlements would be difficult. The focus and priority will shift from prosperity to recovery, and importance will be given to providing immediate assistance to victims. Japan's economy was jolted (cost $360 billion) by an earthquake and tsunami that hit the country on March 11, 2011. On an estimated 28,000 people died, and more than 500,000 people were displaced.

11.4.4. Health impact:

Health of all living organism, including humans might be at the receiving end as a result of the environmental hazards. Lack of basic necessities is a significant cause of human fatality rate. Environmental hazards increase the risk of cancer, heart disease, asthma, and many other illnesses. These hazards can be physical, such as pollution, toxic chemicals, and food contaminants, or they can be social, such as unsafe work, poor housing conditions, urban sprawl, and poverty. The basic infrastructure of health care is destroyed at the time of a natural hazard occupied with poor hygiene and lack of access to basic needs adversely affect the victim. Leakage of toxic chemicals from industries and accidents has both short-term and long-term effects on the health. Blindness, cancer, paralysis, heart trouble, gastric and respiratory abnormalities are the short-term effects of these hazards while as genetic imbalances in humans and its impact on future generations are the long-term consequences of the biological and chemical hazards. Radiation is a major health concern; humans exposed to diverse degrees of radiation can develop uncontrolled growth of malignant neoplastic cells. Radiations can also alter the hereditary composition of an organism.

11.4.5. Change in Temperature:

The global (Earth's surface, oceans and atmosphere) temperature is rising with every passing year due to human activities, primarily due to the combustion of fossil fuels that pump carbon dioxide (CO_2), methane and other greenhouse gases into the atmosphere. According to the National Oceanic and Atmospheric Administration (NOAA), the average global temperature has increased by about 1.4 degrees Fahrenheit (0.8 degrees Celsius) over the past 100 years, which leads to climate change and increases the likelihood of weather-related natural disasters. If global climate change causes the global average temperature to rise, frequencies of extreme weather events such as floods, droughts and heat waves are expected to increase in the future.

11.4.6. Loss of Tourism

The environmental hazards can be a huge setback for the tourism sector that relies on tourists for their daily livelihood. These hazards cause huge damage in the form of loss of green cover, loss of biodiversity, huge landfills, and increased air and water pollution can be a big turn off for most of the tourists.

11.5. REMEDIES OF ENVIRONMENTAL HAZARDS

Humans are subordinate to nature even though we have excelled in science and technology, these hazards do not recognise man-made borders and threaten the environment every time. Therefore, the hour demands that the international organisations and communities should operate together to diminish the danger of natural and manmade hazards. Some of the important measures to be taken by various stakeholders that can help us either in controlling or in minimising the damage caused by these hazards are:

11.5.1. Education and awareness

Widespread public awareness and education about the hazards will help in reducing the loss of life, personal injuries, and damage introduced by hazards. In today's world, with the help of technological advancement, acquiring knowledge and its application in the realm of action is regarded as the only effective means for preventing disasters or reducing their effects. People must be made aware of what natural hazards they are likely to face in their communities and should know in advance what specific preparations are to be made before the occurrence of a hazard. Media plays a significant role in educating the population about disasters and their management, without which we could not be aware people about disasters in remote areas of the country. Public officials and the media (television, radio, and newspapers) must be fully prepared to respond effectively, responsibly, and speedily to large-scale natural emergencies. Community-wide planning and education should be encouraged; schools, government organisations, community and church groups, business and neighbourhood organisations, hospital and medical groups, and the news media should all be involved.

11.5.2. Monitoring and control

Environmental Monitoring is a process of understanding the level of harmful pollutants present in the atmosphere and examining their effect on the environment, human life, animals and trees. The monitoring and control of environmental hazards involve a broad range of actions, each personalised to the particular hazard. Monitoring implies the use of routine measurements to observe changes in the environment, based on data from a wide diversity of sources, used to distinguish the critical agents, pathways and populations at risk. Such considerations will guide the methods to be utilised for monitoring and regular surveillance. Emissions inventories, Environmental data, bio monitoring data and health data are various measures that could be applied for examining the environmental hazards. Setting of guidelines and criteria pertaining to environmental levels may be implemented by voluntary agreement, a balance of penalties and benefits to encourage good practice and dissuade bad, legal mandate. Measures which entail licensing, emissions control, or health and safety protection can be enforced on individuals or individual companies violating the set protocol.

11.5.3. Environmentalism

This means building up good habits towards the environment and refraining from inappropriate acts against the environment. Some of the major safety measures include: cultivation of maximum number of tress, using ozone friendly motors, keeping toxic wastes separated, cleaning of water reservoirs from time to time, refraining from synthetic fertilizers, recycling of various materials, using bio degradable products, using cloth bags instead of plastic are few of the measures that could help in protecting the environment.

11.5.4. Use of Personal Protective Equipment

Monitoring and protection against harmful chemicals or radiation risks covers various significant areas. Workers in high radiation areas should have radiation monitoring tests carried out frequently. There are various technological solutions available to reduce radiation levels if found to be above the limit. Workers in the nuclear industry or in other fields where there is exposure to ionising radiations should wear radiation badges to monitor personal exposure. For non-ionising radiation sources, there are published guidelines on exposure limits from static magnetic fields, to time-varying electric, magnetic and electromagnetic fields. The guidelines advise basic restrictions to protect against the established adverse health effects of exposure, e.g. shielding or limiting frequent use.

11.5.5. Hazard Communication and Training Programme

A Successful hazard prevention and control programme should involve communication and training for workers, supervisors and all other persons working in hazardous areas or people living in places where hazards are prone. To make this programme effective, proper awareness and motivation should be integrated. Employees should be made aware of any sort of suspected or potential risk associated with their work.

People residing in flood-prone areas or earthquake-prone areas should be made aware of these hazards beforehand so that they either plan to migrate to other areas or are aware of basic precautions to be taken while living there. People should also be informed on the best available means for prevention and control, and on how they can contribute to their implementation. This information should be associated with the proper utilisation of any control system, be it based on engineering controls, employment patterns or personal security. Persons involved with prevention and control should have opportunities to continually update their knowledge, skills and should be alert to new guidelines and new standards which may be applicable.

11.5.6. Health Surveillance

Health surveillance of employees includes pre-employment, periodic and special health examinations, which include clinical observations, screening tests or investigations, and early detection of health impairment. Such surveillance should also be carried out in case of accidents, or those who have faced natural hazards, as people after survived through hazards also face various diseases, anxiety and depression, which deteriorate their health. Health surveillance can never be replaced by primary hazard prevention; however, it is an essential complement, as it contributes in many ways to preventive strategies. This health surveillance may serve as a useful indicator for controlling measures by detecting problems or failures in the system.

11.6. CONSERVATION AND PROTECTION OF THE ENVIRONMENT

The term 'conservation' of the environment relates to activities which can provide individual or commercial benefits, but at the same time, prevent excessive use leading to environmental damage. Conservation may be distinguished from preservation, which is considered to be "maintaining of nature as it is, or might have been before the intervention of either human beings or natural forces. We know that natural resources are getting depleted and environmental problems are increasing. It is, therefore, necessary to conserve and protect our environment. The following practices help in protecting our environment.

1. Rotation of crops.
2. Judicious use of fertilisers, intensive cropping, proper drainage and irrigation.
3. Treatment of sewage, so that it does not pollute the rivers and other water bodies.
4. Composting organic solid waste for use as manure.
5. Planting trees in place of those removed for various purposes.
6. National parks and conservation forests should be established by the government.
7. Harvesting of rainwater.

Some action points to protect or improve the environment

(i) Dispose of the waste after separating it into biodegradable and non-biodegradable waste material.
(ii) Start a compost heap or use a compost bin. This can be used to recycle waste food and other biodegradable materials.

(iii) Avoid unnecessary or wasteful packaging of products.

(iv) Reusable bags.

(v) Plant trees. They will help to absorb excess carbon dioxide.

(vi) Always observe World Environment Day on 5th June.

(vii) Never put any leftover chemicals, used oils down the drain, toilet or dump them on the ground or in water or burn them in the garden. If you do so, it will cause pollution.

(viii) Don't burn any waste, especially plastics, for the smoke may contain polluting gases.

(ix) Use unleaded petrol and alternate sources of energy, keep the engine properly tuned and serviced, and the tyres inflated to the right pressure, so that the vehicle runs efficiently.

(x) Avoid fast starts and sudden braking of automobiles.

(xi) Walk or cycle where it is safe to do so – walking is free; cycling can help to keep you fit.

(xii) Use public transport wherever you can, or form a car pool for everyday travel.

(xiii) Send your waste oil, old batteries and used tyres to a garage for recycling or safe disposal; all these can cause serious pollution.

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UNIT SIX:
THE CONCEPT OF ENVIRONMENTAL EDUCATION

CHAPTER TWELVE: AN OVERVIEW OF ENVIRONMENTAL EDUCATION

12.0. Introduction
12.1. Conceptualising environmental education

Environmental education (EE) refers to organised efforts to teach about how natural environments function and, particularly, how human beings can manage their behaviour and ecosystems to live sustainably. Environmental education describes the inter-relationships among organisms with their abiotic (Physical) environment. These include atmospheric conditions, food chains, the water cycle, etc. It is a basic science, which is an amalgamation of various subjects dealing with Earth and various activities taking place on it. Therefore, environmental science is important for one and all. Environmental education is a process that enables individuals to explore environmental issues, engage in problem solving and take action to improve the environment.

The environmental education inculcates a deeper understanding of environmental and environment-related issues amongst the people and offer individuals with the skills, experience and knowledge that are necessary to make them responsible decision-makers and community leaders. Environmental education is considered to be a global process which is a continuous and lifelong process.

The five important areas which should be given priority in environmental education are:

- Environmental education should be valued in a society.
- The emphasis on environmental education changes according to need through legislation, strategic documents and budgets.
- Acquiring and providing environmental education should comply with internationally accepted responsibilities, strategies and legislation.
- Every age group should be open to getting the environmental education needed and to developing the skills, attitudes and behaviour necessary for the development of a sustainable environment and lifestyle.
- Environment and sustainable development are an obligatory part of all levels of education.

Education that supports sustainable development is a system of knowledge, skills, attitudes and value orientations, which enables making people conscious of the relations of the natural, economic, and socio-cultural environment, focusing thereby on the idea of sustainable development.

Environmental education is directed towards shaping environmental awareness at local as well as global context. The educational system has the best possibilities for shaping people's value orientations, both through formal education, informal education and indirect shaping (from child to parent, etc).

12.2 objectives of environmental education

The objectives of environmental education are summarised by UNESCO/UNEP as Follows:

Awareness

Environmental education should foster an appreciation of the environment. It should help different groups and individuals to acquire awareness of and sensitivity to the overall environment and its allied problems. In Nigeria, the knowledge of the various ecological zones (from mangrove coastal vegetation, rainforest in the south, through derived savannah to Guinea, Sudan and Sahel savannah in the North is desirable. This will also enhance the appreciation of the type and quality of life (effects of each zone on human life) in these zones.

Knowledge

Environmental education should help social groups and individuals gain various experiences and a basic understanding of the environment and its associated problems. The people should he informed of their roles in causing environmental problems around them — deforestation, overgrazing, bush burning, desertification, erosion, loss of soil fertility, etc

Attitude

Environmental education should help acquire a set of values and feelings of concern for the environment and the motivation for active participation in environmental improvement and protection programmes. Individuals and groups need to adopt ethical values that awaken strong feelings for the environment and all its living and non-living components.

Skill

Environmental education should foster and assist in the acquisition of conservation practices and the skills needed to prevent environmental degradation, e.g. erosion control through the use of biological and mechanical methods. The people should be taught how to mobilise their human and natural resources to prevent ecological problems.

Evaluation
Environmental education should enable people to assess government programmes and land management practices that are being introduced.

Participation
Environmental education should provide opportunities for social groups and individuals to be actively involved at all levels involved in working towards the resolution of environmental problems.

The general objectives of environmental education include the following:

1. To develop the sense of awareness among the students about environment and its various problems.
2. To help the students in realizing the inter-relationship between man and environment.
3. To inform the students about the social norms that provides unity with environmental characteristics.
4. To create a positive attitude about the environment among student.
5. To develop proper skills required for the fulfilment of the aims of environmental education and educational evaluations.
6. To help the students realise the importance of taking proper steps to solve environmental problems.
7. To develop required curiosity among the students for the realisation of environmental problems so that they would be inspired to work for the solution of such problems.

8. To create appropriate situations for the students to participate in the process of decision-making about the environment.
9. To develop the capability of using skills to fulfil the required aims, to realise and solve environmental problems through social, political, cultural and educational processes.
10. To enlighten the people on the physical components of the environment. 11. To inform them about their dependence on the environmental resources.
12. To enlighten them about the changes in the environment in the last decade and the consequences of their present actions.
13. To alert them about the consequences of human actions on the environment, both on man himself and other forms of life.
14. To create concern for environmental quality and conservation and to foster understanding of man's relationship and interactions with the ecosphere.
15. To develop personal, community and national sanitation and conservation ethics.
16. To awaken appreciation of the aesthetic quality of nature to encourage its use for recreation.

12.2. Principles of Environmental Education

Environmental Education must involve everyone

By its very nature and importance, environmental education cannot be confined to any one group in our society.It is a responsibility for everyone, government, industry, the media, educational institutions and community groups, right down to the level of the individual at the grassroots.

Environmental Education must be lifelong

Information about environmental problems is forever improving as we learn from our past experiences and mistakes. As we develop and apply better environmental technologies, the ability of society and individuals to respond effectively also improves

Environmental Education must be practical

One of the most fundamental defining characteristics of effective environmental education is that it must lead to actions such as afforestation, good waste disposal, and avoidance of bush burning which will improve environmental sustainability and serve as the yardstick by which we can measure the effectiveness of our efforts in environmental education and creating awareness.

12.3. Roles of environmental education in addressing climate change

Environmental education plays a vital role in addressing climate change by raising awareness, promoting behaviour change, and inspiring individual and collective action.

Here are some of the roles of environmental education in addressing climate change:

Raising awareness

Environmental education raises awareness about climate change, its causes, consequences and potential solutions (UNESCO, 2017).

Promoting behaviour change

Environmental education promotes behaviour change by encouraging individuals to adopt sustainable lifestyles, reduce their carbon footprint, and conserve natural resources.

Supporting climate change mitigation and adaptation

Environmental education supports climate change mitigation and adaptation efforts by promoting the use of renewable energy sources, energy efficiency, and sustainable land use practices (IPCC, 2014).

Encouraging community engagement and participation
Environmental education encourages community engagement and participation in climate change decision-making processes, promoting a sense of ownership and responsibility.

Developing climate change leadership
Environmental education develops climate change leadership by inspiring individuals to take action, advocate for policy changes, and promote sustainable development.

Promoting sustainable consumption and production patterns
Environmental education promotes sustainable consumption and production patterns, reducing waste and pollution.

Supporting biodiversity conservation
Environmental education supports biodiversity conservation by promoting the importance of preserving ecosystems and species.

Promoting indigenous knowledge and perspectives
Environmental education promotes indigenous knowledge and perspectives, recognising the importance of traditional knowledge in addressing climate change.

Fostering international cooperation and collaboration

Environmental education fosters international cooperation and collaboration, promoting global solutions to climate change.

12.4. Scope of environmental education

The scope of Environmental Education is also called the content or subject matter of Environment Education. There are different aspects and components in the environment. The
scope of Environmental Education can be divided into biological, physical, and sociological aspects. They are described below:

Biological Aspect:

Biological aspects are one of the most important aspects of Environmental Education. A Human being, animals, birds, insects, micro-organisms, and plants are some of the examples of biological aspects.

Physical aspect

It can be further divided into natural aspects and human-made aspects. Air, water, land, climate, etc., are included in natural physical aspects. Likewise, Human-made physical aspects cover all human-made things such as roads, buildings, bridges, houses, etc..

Socio-cultural aspect:

Socio-cultural aspects are man-made social practices, rules and laws, and other religious places, etc. Human beings have created them with their effort. Thus, Environmental Education is related to science, economics, geography, technology, population and health education, etc. It helps to develop integrated knowledge and a feeling of co-operation in the students. As a result, Environmental Education becomes practical and contextual. EnvironmentalEducation can be implemented through formal and non-formal educational means.

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CHAPTER 13: CLASSIFYING ENVIRONMENTAL EDUCATION

Classification of environmental education

The concept of environmental education can be classified as:

Education for the Environment

Environmental education is a pragmatic response to the defacement of the environment. Environmental education is a kind of education which will seek to make pupils fully aware of the problems connected with their environment so that they will be able to tackle these problems with a sense of responsibility and with the technical skills which will enable them to contribute to their solutions along 'with other members of their community.

Education about the Environment:

Environmental Education includes conservation, outdoor and natural resource education, as well as nature study, but it also includes everything that relates to man and his environment. Environmental education is the study of man and how he shapes his total natural and cultural surroundings for good or ill. Man, not his technology, not the physical or biological world as a separate entity, not the arts or professions operating in segregated spheres, but all of these as they affect the quality of human life, becomes the pivotal concern. Man cannot be separated from the earth's ecosystem, for he 'is the only conscious manipulator of the environment, and his manipulation must be directed towards enhancing the quality of the environment.

Education through the Environment

Environmental education is not a separate subject. It is a multi-disciplinary approach both to education and to the problem of the environment. All the subjects in the existing curriculum do have some information about the environment, but in their present form, the subjects fail to relate to one another. Just as piecemeal attacks on environmental problems are ineffective, so is piecemeal education about the environment inadequate because it does not take into account the interdependence of the pieces. It must, therefore, be of wholes, not of parts, if the human race is to understand that the totality of environmental subject areas must collaborate, integrate and coordinate so that E.E. may prove effective in overcoming the environmental crisis. The multidisciplinary approach integrates environmental education into all learning, in all subjects in all grades, all year long and beyond the formal school years to a lifelong education.

13.2. Target population for environmental education

Three categories of audience have been identified for environmental education. These are

(a) General Public
(b) Specific occupational or Social Group
(c) Certain Professionals and Scientists
(1) General Public

There is a need for an environmental education programme which introduces awareness among the general public for its environment and the danger to which it may be exposed. This should involve adequate background knowledge and information about the environment, enables them to take part in decision making concerning their environment. It should include information on present or planned activities with major potential impact on the environment.

For the general public, environmental education should be provided at every age class and all levels of formal education for pupils and teachers and informal education for young people and adults, including the handicapped. There is a need for an environmental education programme which introduces awareness among the general public of its environment and dangers to which it may be exposed. Participants in the general public education should include the general public, especially non-governmental organisations.

(2) Specific Occupational or Social Group
These are those whose activities and influence have an important bearing on the environment. These include engineers, architects, administrators and planners, industrialists, trade unionists, policy makers and agriculturists. Their form of education should be both formal, through in-service training and short courses and non-formal, through seminars and workshops.

(3) Certain Professionals and Scientists: These groups include those working on specific problems of the environment, e.g. biologists, ecologists, hydrologists, taxonomists, sanitary engineers, etc.

Need and Significance of Environmental Education

The rationale for environmental education can be described as follows:

1. Knowledge about the changes that have altered the environment — land, water, weather, vegetation, social, cultural and political environment is an essential component of environmental education. Consequently, the

general populace should be equipped with all these to be able to solve the problems of the environment.

2. Land, water, forest and other mineral resources utilisation is the dominant feature of the rural economy, with agriculture the driving force. Uncontrolled and improper exploitation of these resources has implications on the environment, disrupting the living standard, causing starvation, displacement and human suffering. Environmental education is therefore necessary to create awareness of the causes and effects of these problems, viz: food and water scarcity, pollution, outbreak of epidemics and natural disasters such as floods, erosion and desert encroachment and of course, how to prevent them.
3. Environmental education is needed to foster international co-operation and understanding.
4. Public enlightenment on the impact of government policies on the local environment should be useful both to the government and the local people.
5. Awareness of such global environmental issues is an essential component of environmental education, which ordinary citizens should be aware of.
6. Environmental education for the overall social and economic emancipation of women and children. These form a substantial percentage of the utilisation of natural resources, especially in rural settings.
7. Environmental education is very essential for the lack of it. Environmental education is virtually a new thing in this part of the world.
8. Environmental education is also very essential for our survival on Earth. The

natural resources and cultural heritage need to be protected not only for this generation but for future generations.

9. To foster clear awareness and concern about economic, social, political and ecological interdependence in urban and rural areas.
10. To create new patterns of behaviours of individuals, groups and society as a whole towards the environment.
11. To provide every person with opportunities to acquire the knowledge, values, attitudes, commitment and skills needed to protect and improve the environment.

Importance of Environmental Education

Every individual needs to know about the functions in an environment. Only then will we become responsible for our environment. The points given below will help in understanding the importance of Environmental Education. When children study the environment and its functions, they develop a sense of understanding of the environment in the early stages of their lives. It is important to increase the awareness of individuals about the environment. With the help of Environmental Education, people's knowledge about the environment is instilled in the citizens of a state or a country. There are a lot of environmental issues that the world is facing. To avoid them in the future, people need to understand the environment and take proper care of it. It can only be done with the help of Environmental Education.

Environmental Education polishes various other skills of an individual. The ability to make decisions is strengthened with the study of Environmental Education, as people become more responsible and aware. Individuals can deal with any sort of environmental problem through Environmental Education. This, in turn, increases problem-solving skills. One develops sensitivity towards the environment because of all the environmental issues that have been happening for a long time. In this way, each individual takes any action by keeping in mind the harm it can cause to the environment. There is no particular viewpoint that is advocated through Environmental Education. All the aspects are taken into consideration to reach an informed decision. Just no one can solve the issues that arise in the environment. Environmental Education makes an individual rich in the knowledge of the environment so that the best possible solutions can be provided for even the smallest of situations the environment faces.

Strategies for Environmental Awareness

Various strategies have been proposed for the introduction of environmental education into school curricula and non-formal education. These include the following:

1. Introduction of environmental studies as a distinct and special subject, taught by specially trained teachers.
2. Introduction of environmental issues into the various traditional subjects
3. The re-orientation of the subject matter in the traditional schools to be in accord with the scope, aims, objectives, strategies and guiding principles of environmental education.
4. The re-evaluation and restructuring of the entire contents of various subjects to incorporate environmental education.
5. Integration of the contents of the various subjects within the framework that relates to the major environmental problems.

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UNIT SEVEN

THE GENESIS OF ENVIRONMENTAL EDUCATION

CHAPTER FOURTEEN: EVOLUTION AND DEVELOPMENT OF ENVIRONMENTAL EDUCATION

14.1. EVOLUTION OF ENVIRONMENTAL EDUCATION

The origin of the term 'Environmental Education' has always remained an issue, and it is claimed that it was used for the first time in

Paris in the year 1948. However, the formal beginning of the discipline of Environmental Education is marked by the organisation of the International Union for Conservation of Nature (IUCN) and Natural Resources Conference held in Paris in the year 1948, where the term was used widely as one of the central themes of the conference. After the conference, a formal body named, International Union for Conservation of Nature or IUCN was established in 1949.

Environmental education is not a contemporary subject matter. According to Palmer (1998), who is considered one of the prime advocates of environmentalism, the words 'environment' and 'education' were not used together until the mid-1960s. The evolution of environmental education can be credited to significant role of some of the great 18th and 19th century writers and educators, of which some of the notables are Dewey, Goethe, Rousseau, Haeckel, Humboldt, Froebel, and Montesson.

In the eighteenth century, Jean-Jacques Rousseau stressed the value of education that takes into consideration the environment. After that, the Swiss-born naturalist, Louis Agassiz, promoted Rousseau's philosophy. These influential pioneers contributed to the environmental thought and practice. In the UK, many writers attributed the founding of environmental education to a Scottish Professor of Botany, Sir Patrick Geddes (1854-1933), who was considered the originator of town and country planning. He was regarded as the first to establish an important link between the quality of the environment and the quality of education. Louis Agassiz and Sir Patrick Geddes were the two influential scholars of that time who laid the foundation for a real environmental education program, known as "the Nature Study", which took place between the late 19th century and early 20th century.

The School of Nature Study Union was formed in the year 1902. During the 1940s, the area of nature study broadened to rural studies with the formation of local associations. From this movement, the term 'environmental studies' evolved and was frequently in use, consisting of a mixture of teaching elements of geography, history and nature study. Simultaneously, the teaching of history, geography and biology also gained momentum with the establishment of the Council for the Promotion of Field Studies. The concept of Nature Conservation also played a significant role in the ongoing development of environmental teaching in 1949.

The first recorded use of the term environmental education in Britain is traced back to a conference held in 1965 at Keele University, Staffordshire, with the purpose of conservation of the countryside and its implications for education. This conference was significant for the UK, as it marked the first occasion where educationists and conservationists came together, and led to the establishment of the Council for Environmental Education (CEE), which met for the first time in July 1968. Since then, there has been a long history of the development of Environmental Education, accounting for more than seven decades.

14.2. **Development of Environmental Education**

The concept of environmental education emerged only in the seventies, and the period was called the decade of environmental education. During this period, the world realized that environmental concerns and awareness could be spread only through a mass environmental education program. The concept of environmental education emerged from the Stockholm Conference organised by the United

Nations in 1972. Recommendations of the conference emphasised the conduct of 'formal' and 'mass' environmental education programs. Educating the masses about the environment and its components is supposed to develop critical thinking, analytical and problem-solving skills in humans. It is also instrumental in developing knowledge and insights in human to improve their living quality on earth.

With the great efforts of many naturalists, April 22nd, 1970, was declared the first Earth Day. This event paved the way for the current environmental education movement. In the latter months, US President Nixon passed the National Environmental Education Act, which intended to incorporate environmental education into K-12 schools. In the years to follow, the North American Association for Environmental Education (NAAEE), formally known as the National Association for Environmental Education, was established to improve environmental literacy by providing resources to teachers to promote environmental education programs. The year was then declared by the European Council as the "Year of the Environment".

Efforts to define environmental education as a specific endeavour began in the 1960s. International support at the United Nations Conference on Human Environment, held in Stockholm in 1972, set the stage for the need to promote Environmental Education internationally. In the conference, participating governments recommended that environmental education be recognised and promoted on an international scale under the umbrella of the United Nations. The greatest landmark in the history to define the term 'environmental education' was an IUCN/UNESCO' International Working Meeting on Environmental Education in the School Curriculum' held m 1970 at the Foresta Institute, Carson City, Nevada, USA.

A classic definition of Environmental Education was formulated and adopted there: "Environmental education is the process of recognising values and clarifying concepts to develop skills and attitudes necessary to understand and appreciate the inter-relatedness among man, his culture and his biophysical surroundings. Environmental education also entails practice in decision-making and self-formulation of a code of behaviour about issues concerning environmental quality'' (IUCN, 1970)

14.3 Major declarations that guide the development of Environmental Education

Worldwide over the United Nations Educational, Scientific and Cultural Organisation (UNESCO) and the United Nations Environment Programme (UNEP) were credited with major declarations that have guided the development of environmental education. These are:

The Stockholm Declaration:

Environmental education was globally acknowledged when the UN Conference on the Human Environment was held in 1972, in Stockholm, Sweden, which affirmed that environmental education must be utilised as the key to address environmental issues all around the world. The Declaration of the United Nations Conference on the Human Environment took place between June 5th and June 16th of the year 1972. In this conference it was declared that-"Education in environmental matters for the younger generation as well as adults giving due consideration for the underprivileged is essential" The document, consisting of 7 proclamations and 26 principles, was created in order "to inspire and guide the people of the world in the preservation and enhancement of the human environment.

The International Workshop on Environmental Education (1975)

The International Workshop on Environmental Education, held in Belgrade, Yugoslavia, in October of 1975, resulted in what became known as The Belgrade Charter. The Belgrade Charter built on the framework of Stockholm and described the goals, objectives, audiences, and guiding principles of EE and proposed what has become the most widely accepted definition of Environmental Education which is "Environmental education is a process aimed at developing a world population that is aware of and concerned about the total environment and its associated problems, and which has the knowledge, attitudes, motivations, commitments, and skills to work individually and collectively toward solutions of current problems and the prevention of new ones". (UNESCO-UNEP 1976)

Intergovernmental Conference on Environmental Education held in Tbilisi

The definitive codification of Environmental Education as an international enterprise ultimately came out of the world's first Intergovernmental Conference on Environmental Education held in Tbilisi, Georgia, USSR, in October of 1977. The document known as The Tbilisi Declaration was formulated during this conference and in many quarters remains the definitive statement on what EE is and ought to be. These goals provide the foundation for much of what has been done in the field since 1978.

In 1987 UNESCO and UNEP jointly organised Educational Congress on Environmental Education and Training, called as ' Tbilisi Plus Ten Conference, was held m Moscow This was the tenth anniversary of the first ' Tbilisi Conference' Several major themes emerged from the deliberations of this event, including the vital importance of environmental education as summed up was "In the long run, nothing significant will happen to reduce local and international threats to the environment unless widespread public awareness is aroused concerning the essential links between environmental quality and the 51 continued satisfaction of human needs. Human action depends upon motivation, which depends upon widespread understanding. This is why we feel it is so important that everyone becomes environmentally conscious through proper environmental education" (UNESCO1987) (Palmer, 1998). The other endeavours followed for the development of Environmental Education were:

World Commission on Environment and Development (WCED)

The IUCN World Conservation Strategy (1980) suggested requirements for human survival and prosperity, putting forward the conservationist concept of sustainable development. The importance of sustainable development was established in the year 1987 when the World Commission on Environment and Development published the Brundtland Report. This report, also known as 'Our Common Future', enlightened the concept of sustainable development in which the protection of the environment and economic growth were regarded as interdependent notions, as well as the concept of social equity. According to the Brundtland Report, sustainable development implies "meeting the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987). Our Common Future (1988) was the name of the report published by the World Commission on Environment and Development, chaired by the Prime

Minister of Norway, Mrs Brundtland. It emphasised the relationship between the underdeveloped nature of parts of the world and existing social and environmental problems. The report is a survey of the planet's health, presenting the problems of atmospheric pollution, desertification, overpopulation, over-consumption, water shortages, poverty and underdevelopment.

United Nations Conference on Environment and Development (Earth Summit)

In 1992, the United Nations Conference on Environment and Development, which took place in Rio de Janeiro, Brazil, supported and embellished the goal of obtaining sustainability. This was achieved using international agreements made on climate change, woodland and biodiversity. One of the most significant aspects of the Rio Earth Summit was Chapter 36 of Agenda 21, the fulcrum of our current environmentally sustainable development. Agenda 21 focused on "reorienting education towards sustainable development, increasing public awareness, and promoting training.

Agenda 21 (1992)

The United Nations Conference on Environment and Development in Rio de Janeiro established further strategies for a sustainable future. Chapter 36 of the action plan adopted by the Conference, Agenda 21, focused on public education, awareness and training, which confirms the role of education and the importance of positioning environmental education in the perspective of sustainable development.

The UNESCO Thessaloniki Declaration (1997)

In UNESCO Thessaloniki Declaration (1997), 'Educating for a Viable Future', a multidisciplinary vision for concerted action was sought to further clarify the concept of education for sustainable development. It presented sustainability as an ethical and moral imperative and the objective to which education should devote itself as an instrument of choice. Education is considered as an ongoing process aimed at developing the capability of adapting to rapid changes in the world, but first and foremost as a process of transmitting knowledge and information to make the public understand the problems and to stimulate awareness. During the same period, individuals and groups, both within and outside formal education systems and agencies, began to generate new emphases in their educational work, finding and expressing different focal points and relationships as well as a new urgency in their treatment.

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CHAPTER FIFTEEN: INTRODUCTION TO ENVIRONMENTAL MANAGEMENT

15.0. INTRODUCTION

The word 'environment' is used in different ways. We talk of the 'home environment', the 'work environment', the 'social environment'. We use the word to describe our physical surroundings, made up of air, trees, and grass. Our concern must be for the world as a whole, its 'air, water, land, natural resources, flora, fauna, humans, and their inter-relations' By 'environmental management' we mean keeping control of our activities so that we do what we can to conserve these physical resources and to avoid polluting them. We can apply these controls in our life domestically, in what we buy and what we throw away, but it is usually in our work where the environmental impact of what we do is greatest. Such has been the impact of industrial activity that resources are becoming depleted and environmental damage is increasing (ISO, 2015).

15.1. Concept of Environmental Management

Environmental management can be defined as a goal or vision, an attempt to steer a process, the application of a set of tools, a more philosophical exercise seeking to identify and establish new outlooks, and much more. Individual environmental managers may have a problem-solving, sectoral, local, regional or global focus. They may be academics, regional or national decision makers and planners, nongovernmental organisation (NGO) staff, company executives, international civil servants, or all sorts of individuals or groups who are environmental stakeholders in some way using natural resources – herders, farmers, fishermen and so on (Barrow, 2005).

The International Organisation for Standardisation (ISO) in its document, ISO 14001 (2015) defined Environmental management as keeping control of our activities so that we do what we can to conserve these physical resources and to avoid polluting them. We can apply these controls in our life domestically, in what we buy and what we throw away, but it is usually in our work where the environmental impact of what we do is greatest. Such has been the impact of industrial activity that resources are becoming depleted, and environmental damage is increasing. Environmental management can be said to be the active management of the impact of society on the environment.

Environmental management is a subject that combines science, policy, and Socio-economic applications. It primarily stresses finding solutions to practical problems that people face in cohabitation with nature, resource exploitation, and waste production. In a purely anthropocentric sense, environmental management is all about dealing with the fundamental issue of how to innovate technology to evolve continuously while limiting the degree to which this process alters the natural environment. Thus, Environmental management is closely linked with issues regarding sustainable economic growth, ensuring fair and equitable distribution of resources, and conserving natural resources for future generations.

Environmental management is a response to human actions, considering the increasing seriousness and significance of today's disastrous human impact on natural ecosystems. It is comforting to know that with a smaller global population base and a less pervasive use of technology, the environment might be able to recuperate on its own from human misuse and abuse, but it is now widely recognised fact that in many cases positive intervention is necessary if the environment is to recover because people have bestowed more importance on economic growth than preservation of the natural ecosystems (NEC, 2011). Going through the various definitions, it will be observed that Environmental management has two major aspects:

- Socio-economic development
- Stability of the biosphere in general and stability of the various ecosystems in particular

15.2. The Principles of Environmental Management

According to Environmental Pollution (2017) and NEC (2011) there are some guiding principles of environmental management; these principles are helpful in environmental decision making.

Polluter Pays Principle (PPP)

For the last two decades, many economists have suggested that firms discharging polluting effluents to the environment should somehow be made to pay a price for such discharges related to the amount of environmental damage caused. The Organisation for Economic Co-operation and Development (OECD) has suggested the Polluter Pays principle (PPP) as a general basis for environmental policy. It states that if measures are adopted to reduce pollution, the costs should be borne by the polluters. According to the OECD Council, "The principle to be used for allocating costs of pollution prevention and control measures to encourage rational use of scarce environmental resources and to avoid distortions in international trade and investment is the so-called Polluter Pays Principle." The essential concern of this principle is that polluters should bear the costs of abatement without subsidy.

The Polluter Pays Principle means that the absolute liability for harm to the environment extends not only to compensate the victims of pollution, but also to cover the cost of restoring the environmental degradation. Thus, it includes environmental costs as well as direct costs to people or property. Remediation of the damaged environment is part of the process of sustainable development, and as such, the polluter is liable to pay the cost to the individual sufferers as well as the costs of reversing the damaged ecology.

The application of this principle depends upon the interpretations, particular cases and situations. This principle has brought more controversial discussions during the Rio Earth Summit 1992. The South has demanded more financial assistance from the North in combating environmental degradation in the South. There are practical implications for the allocation of economic obligations with environmentally damaging activities, particularly for liability and the use of economic instruments.

The User Pays Principle (UPP)

It is considered a part of the PPP. The principle states that all resource users should pay for the full long-run marginal cost of the use of a resource and related services, including any associated treatment costs. It is applied when resources are being used and consumed.

The Precautionary Principle (PP)

The main objective of the precautionary principle is to ensure that a substance or activity posing a threat to the environment is prevented from adversely affecting the environment, even if there is no conclusive scientific proof of linking that particular substance or activity to environmental damage. The words 'substance' and 'activity' are the result of human intervention.

The Rio Declaration in its Principle 15 emphasises this principle, wherein it is provided that where there are threats of serious or irreversible damage. Lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation. Therefore, the principle is essential for the protection of the environment and human health by being implemented in the field of the production and distribution of energy resources.

Principle of Effectiveness and Efficiency

It is essential that the efficiency of resource use may also be accomplished by the use of policy instruments that create incentives to minimise wasteful use. It also applies to various issues of environmental governance by streamlining processes and procedures to minimise environmental costs.

The Principle of Responsibility

It is the responsibility of all persons, corporations and states to maintain the ecological processes. Further, access to environmental resources carries attendant responsibilities to use them in an ecologically sustainable, economically efficient and socially fair manner.

The Principle of Participation

All the persons must participate in collective environmental decision-making activities. Some participation areas are related to the use of trees and other plants, minerals, soils, fish and wildlife for purposes such as materials and food as well as for consumptive and non-consumptive recreation. The second issue concerns solid waste, i.e. garbage, construction and demolition materials and chemically hazardous waste etc. The third issue of participation is related to pollution-generating activities.

The Principle of Proportionality

The principle of proportionality is based on the concept of balance. A balance is to be maintained between economic development on the one hand and environmental protection on the other hand. It cannot be disputed that no development is possible without some adverse effects on ecology. Therefore, it is essential to adjust the interests of the people as well as the necessity to maintain the environment. Moreover, comparative hardships have to be balanced and benefits to a larger section of the people have to be maintained.

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