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Review Article

Advance in Environmental Waste Management & Recycling

Case study of Global Warming

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Abstract

Many researchers, engineers and environmentalists are expressing deep concerns about changes in the overall climate of the planet. Fossil fuels are being continuously used to produce electricity. The burning of these fuels produces gases like carbon dioxide, methane and nitrous oxides which lead to global warming. Deforestation is also leading to warmer temperatures. The hazard of global warming is continuously causing major damage to the Earth's environment. Most people are still unaware of global warming and do not consider it to be a big problem in years to come. What most people do not understand is that global warming is currently happening, and we are already experiencing some of its withering effects. It is and will severely affect ecosystems and disturb ecological balance. Because of the treacherous effects of global warming, some solutions must be devised. The paper introduces global warming, elaborates its causes and hazards and presents some solutions to solve this hot issue. Above all, alternative energy sources (solar, wind, hydro, geothermal, bio mass) need to be seriously pursued. Finding and using renewable sources of energy is one of the methods to combat the ever increasing global warming effectively.
A greenhouse is a house made of glass that can be used to grow plants. The sun's radiations warm the plants and the air inside the greenhouse. The heat trapped inside can't escape out and warms the greenhouse which is essential for the growth of the plants. Same is the case in the earth's atmosphere. During the day the sun heats up the earth's atmosphere. At night, when the earth cools down the heat is radiated back into the atmosphere. During this process, the heat is absorbed by the greenhouse gases in the earth's atmosphere. This is what makes the surface of the earth warmer, that makes the survival of living beings on earth possible.

However, due to the increased levels of greenhouse gases, the temperature of the earth has increased considerably. This has led to several drastic effects.

Keywords: Life Cycle Assessment, Hot Mix Asphalt, Hot Mix Plant

Introduction

Many researchers, engineers and environmentalists are expressing deep concerns about changes in the overall climate of the planet. Fossil fuels are being continuously used to produce electricity. The burning of these fuels produces gases like carbon dioxide, methane and nitrous oxides which lead to global warming. Deforestation is also leading to warmer temperatures. The hazard of global warming is continuously causing major damage to the Earth's environment. Most people are still unaware of global warming and do not consider it to be a big problem in years to come. What most people do not understand is that global warming is currently happening, and we are already experiencing some of its withering effects. It is and will severely affect ecosystems and disturb ecological balance. Because of the treacherous effects of global warming, some solutions must be devised. The paper introduces global warming, elaborates its causes and hazards and presents some solutions to solve this hot issue. Above all, alternative energy sources (solar, wind, hydro, geothermal, bio mass) need to be seriously pursued. Finding and using renewable sources of energy is one of the methods to combat the ever increasing global warming effectively.

Material and Methods

Causes of Global Warming

Following are the major causes of global warming:

Man-made Causes of Global Warming

Deforestation

Plants are the main source of oxygen. They take in carbon dioxide and release oxygen thereby maintaining environmental balance. Forests are being depleted for many domestic and commercial purposes. This has led to an environmental imbalance, thereby giving rise to global warming.

Use of Vehicles

The use of vehicles, even for a very short distance results in various gaseous emissions. Vehicles burn fossil fuels which emit a large amount of carbon dioxide and other toxins into the atmosphere resulting in a temperature increase.

Chlorofluorocarbon

With the excessive use of air conditioners and refrigerators, humans have been adding CFCs into the environment which affects the atmospheric ozone layer. The ozone layer protects the earth surface from the harmful ultraviolet rays emitted by the sun. The CFCs has led to ozone layer depletion making way for the ultraviolet rays, thereby increasing the temperature of the earth.

Industrial Development

With the advent of industrialization, the temperature of the earth has been increasing rapidly. The harmful emissions from the factories add to the increasing temperature of the earth.

In 2013, the Intergovernmental Panel for Climate Change reported that the increase in the global temperature between 1880 and 2012 has been 0.9 degrees Celsius. The increase is 1.1 degrees Celsius when compared to the pre-industrial mean temperature.

Agriculture

Various farming activities produce carbon dioxide and methane gas. These add to the greenhouse gases in the atmosphere and increase the temperature of the earth.

Overpopulation

Increase in population means more people breathing. This leads to an increase in the level of carbon dioxide, the primary gas causing global warming, in the atmosphere.

Natural Causes of Global Warming

Volcanoes

Volcanoes are one of the largest natural contributors to global warming. The ash and smoke emitted during volcanic eruptions goes out into the atmosphere and affects the climate.

Water Vapor

Water vapor is a kind of greenhouse gas. Due to the increase in the earth's temperature more water gets evaporated from the water bodies and stays in the atmosphere adding to global warming.

Melting Permafrost

Permafrost is there where glaciers are present. It is a frozen soil that has environmental gases trapped in it for several years. As the permafrost melts, it releases the gases back into the atmosphere increasing the earth's temperature.

Forest Blazes

Forest blazes or forest fires emit a large amount of carbon-containing smoke. These gases are released into the atmosphere and

increase the earth's temperature resulting in global warming.

Causes of Greenhouse Effect

The major causes of the greenhouse effect are:

Burning of Fossil Fuels

Fossil fuels are an important part of our lives. They are widely used in transportation and to produce electricity. Burning of fossil fuels releases carbon dioxide. With the increase in population, the utilization of fossil fuels has increased. This has led to an increase in the release of greenhouse gases in the atmosphere.

Deforestation

Plants and trees take in carbon dioxide and release oxygen. Due to the cutting of trees, there is a considerable increase in the greenhouse gases which increases the earth's temperature.

Farming

Nitrous oxide used in fertilizers is one of the contributors to the greenhouse effect in the atmosphere.

Industrial Waste and Landfills

The industries and factories produce harmful gases which are released in the atmosphere.

Landfills also release carbon dioxide and methane that adds to the greenhouse gases.

Result

Global warming is the phenomenon of a gradual increase in the temperature near the earth's surface. This phenomenon has been observed over the past one or two centuries. This change has disturbed the climatic pattern of the earth. However, the concept of global warming is quite controversial but the scientists have provided relevant data in support of the fact that the temperature of the earth is rising constantly.

There are several causes of global warming, which have a negative effect on humans, plants and animals. These causes may be natural or might be the outcome of human activities. In order to curb the issues, it is very important to understand the negative impacts of global warming.

The greenhouse effect is the way in which heat is trapped close to Earth's surface by "greenhouse gases." These heat-trapping gases can be thought of as a blanket wrapped around Earth, keeping the planet toastier than it would be without them. Greenhouse gases include carbon dioxide, methane, and nitrous oxides. Scientists have determined that carbon dioxide's warming effect helps stabilize Earth's atmosphere. Remove carbon dioxide, and the terrestrial greenhouse effect would collapse. Without carbon dioxide, Earth's surface would be some 33 °C (59 °F) cooler.

Greenhouse gases occur naturally and are part of our atmosphere's makeup. For that reason, Earth is sometimes called the "Goldilocks" planet – its conditions are not too hot and not too cold, but just right to allow life (including us) to flourish. Part of what makes Earth so amenable is its natural greenhouse effect, which keeps the planet at a friendly 15 °C (59 °F) on average. But in the last century or so, humans have been interfering with the planet's energy balance, mainly through the burning of fossil fuels that add carbon dioxide to the air. The level of carbon dioxide in Earth's atmosphere has been rising consistently for decades and traps extra heat near Earth's surface, causing temperatures to rise.

Effects of Greenhouse Effect

The main effects of increased greenhouse gases are:

Global Warming

It is the phenomenon of a gradual increase in the average temperature of the Earth's atmosphere. The main cause for this environmental issue is the increased volumes of greenhouse gases such as carbon dioxide and methane released by the burning of fossil fuels, emissions from the vehicles, industries and other human activities.

Depletion of Ozone Layer

Ozone Layer protects the earth from harmful ultraviolet rays from the sun. It is found in the upper regions of the stratosphere. The depletion of the ozone layer results in the entry of the harmful UV rays to the earth's surface that might lead to skin cancer and can also change the climate drastically.

The major cause of this phenomenon is the accumulation of natural greenhouse gases including chlorofluorocarbons, carbon dioxide, methane, etc.

Smog and Air Pollution

Smog is formed by the combination of smoke and fog. It can be caused both by natural means and man-made activities.

In general, smog is generally formed by the accumulation of more greenhouse gases including nitrogen and sulfur oxides. The major contributors to the formation of smog are the automobile and industrial emissions, agricultural fires, natural forest fires and the reaction of these chemicals among themselves.

Acidification of Water Bodies

Increase in the total amount of greenhouse gases in the air has turned most of the world's water bodies acidic. The greenhouse gases mix with the rainwater and fall as acid rain. This leads to the acidification of water bodies.

Also, the rainwater carries the contaminants along with it and falls

into the river, streams and lakes thereby causing their acidification.

Runaway Greenhouse Effect

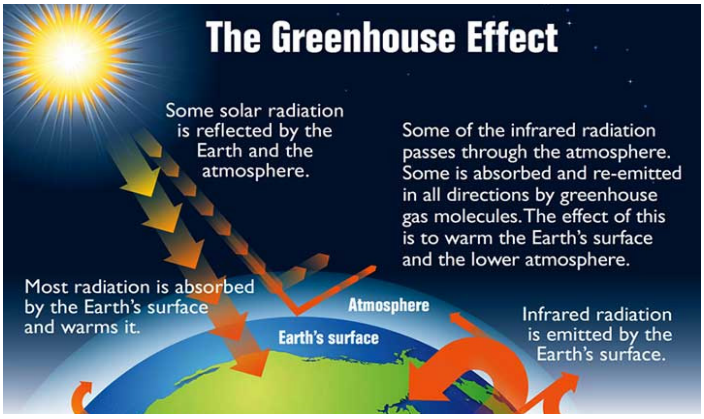
This phenomenon occurs when the planet absorbs more radiations than it can radiate back. Thus, the heat lost from the earth's surface is less and the temperature of the planet keeps rising. Scientists believe that this phenomenon took place on the surface of Venus billions of years ago.

This phenomenon is believed to have occurred in the following manner:

A runaway greenhouse effect arises when the temperature of a planet rises to a level of the boiling point of water. As a result, all the water from the oceans converts into water vapour, which traps more heat coming from the sun and further increases the planet's temperature. This eventually accelerates the greenhouse effect. This is also called the "positive feedback loop".

There is another scenario giving way to the runaway greenhouse effect. Suppose the temperature rise due to the above causes reaches such a high level that the chemical reactions begin to occur. These chemical reactions drive carbon dioxide from the rocks into the atmosphere. This would heat the surface of the planet which would further accelerate the transfer of carbon dioxide from the rocks to the atmosphere, giving rise to the runaway greenhouse effect.

In simple words, increasing the greenhouse effect gives rise to a runaway greenhouse effect that would increase the temperature of the earth to such an extent that no life will exist in the near future.



Greenhouse Gases

Many chemical compounds in the atmosphere act as greenhouse gases. These gases allow sunlight (short wave radiation) to freely pass through the Earth's atmosphere and heat the land and oceans. The warmed Earth releases this heat in the form of infrared light (long wave radiation), invisible to human eyes. Some infrared light released by the Earth passes through the atmosphere back into space. However, greenhouse gases will not let all the infrared light pass through the atmosphere. They absorb some and radiate it back down to the Earth. This phenomenon, called the greenhouse effect, is naturally occurring and keeps the Earth's surface warm. It is vital to our survival on Earth. Without the greenhouse effect, the Earth's average surface temperature would be about 60° Fahrenheit colder, and our current way of life would be impossible.

We know that several gases in the atmosphere can absorb heat. These greenhouse gases are produced both by natural processes and by human activities. The primary ones are:

Carbon dioxide (CO_2)
Methane (CH_4)
Nitrous oxide (N_2O)
Industrial Gases, including hydrofluorocarbons, per fluorocarbons, and sulphur hexafluoride.

Effects of Climate Change

A broad range of evidence shows that the climate system has warmed. Evidence of global warming is shown in the graphs (below right) from the US National Oceanic and Atmospheric Administration (NOAA). Some of the graphs show a positive trend, e.g., increasing temperature over land and the ocean, and sea level rise. Other graphs show a negative trend, such as decreased snow cover in the Northern Hemisphere, and declining Arctic sea ice, both of which are indicative of global warming. Evidence of warming is also apparent in living (biological) systems such as changes in distribution of flora and fauna towards the poles.

Human-induced warming could lead to large-scale, abrupt and/or irreversible changes in physical systems. An example of this is the melting of ice sheets, which contributes to sea level rise and will continue for thousands of years. The probability of warming having unforeseen consequences increases with the rate, magnitude, and duration of climate change.

Effects on weather

Global warming leads to an increase in extreme weather events such as heat waves, droughts, cyclones, blizzards and rainstorms. Such events will continue to occur more often and with greater intensity. Scientists have not only determined that climate change is responsible for trends in weather patterns, some individual extreme weather events have also directly be attributed to climate change.

Precipitation

Higher temperatures lead to increased evaporation and surface drying. As the air warms, its water-holding capacity also increases, particularly over the oceans. In general the air can hold about 7% more moisture for every 1 °C of temperature rise. In the tropics, there's more than a 10% increase in precipitation for a 1 °C increase in temperature. Changes have already been observed in the amount, intensity, frequency, and type of precipitation. Widespread increases in heavy precipitation have occurred even in places where total rain amounts have decreased.

Projections of future changes in precipitation show overall increases in the global average, but with substantial shifts in where and how precipitation falls. Projections suggest a reduction in rainfall in the subtropics, and an increase in precipitation in subpolar latitudes and some equatorial regions. In other words, regions which are dry at present will in general become even drier, while regions that are currently wet will in general become even wetter. Although increased rainfall will not occur everywhere, models

suggest most of the world will have a 16–24% increase in heavy precipitation intensity by 2100.

Temperatures

As described in the first section, global temperatures have risen by 1 °C and are expected to rise further in the future. Over most land areas since the 1950s, it is very likely that at all times of year both days and nights have become warmer due to human activities. Night-time temperatures have increased a faster rate than daytime temperatures. In the U.S. since 1999, two warm weather records have been set or broken for every cold one.

Future climate change will include more very hot days and fewer very cold days. The frequency, length and intensity of heat waves will very likely increase over most land areas. Higher growth in anthropogenic GHG emissions would cause more frequent and severe temperature extremes.

Heat waves

The IPCC Sixth Assessment Report (2021) projected multiplicative increases in the frequency of extreme events compared to the pre-industrial era for heat waves, droughts and heavy precipitation events, for various global warming scenarios.

Global warming boosts the probability of extreme weather events such as heat waves where the daily maximum temperature exceeds the average maximum temperature by 5 °C (9 °F) for more than five consecutive days.

In the last 30–40 years, heat waves with high humidity have become more frequent and severe. Extremely hot nights have doubled in frequency. The area in which extremely hot summers are observed has increased 50–100 fold. These changes are not explained by natural variability, and are attributed by climate scientists to the influence of anthropogenic climate change. Heat waves with high humidity pose a big risk to human health while heat waves with low humidity lead to dry conditions that increase wildfires. The mortality from extreme heat is larger than the mortality from hurricanes, lightning, tornadoes, floods, and earthquakes together.

Tropical cyclones

Global warming not only causes changes in tropical cyclones, it may also make some impacts from them worse via sea level rise. The intensity of tropical cyclones (hurricanes, typhoons, etc.) is projected to increase globally, with the proportion of Category 4 and 5 tropical cyclones increasing. Furthermore, the rate of rainfall is projected to increase, but trends in the future frequency on a global scale are not yet clear. Changes in tropical cyclones will probably vary by region.

On land

In the year 2019 the Intergovernmental Panel on Climate Change issued a Special Report on Climate Change and Land. The main statements of the report include:

Humans affect 70% of the ice free land, that play a key role in supplying the needs of humans and in the climate system.

The global food supply have raised what increased GHG emission, but 25% - 30% of the food is lost, 2 billion adults suffer from being overweight while 821 million people suffer from hunger.

The rate of soil erosion is 10 - 20 times higher than the rate of soil accumulation in agricultural areas that use no-till farming. In areas with tilling it is 100 times higher. Climate Change increases land degradation and desertification.
In the years 1960 - 2013 the area of drylands in drought, increased by 1% per year.

In the year 2015 around 500 million people lived in areas that was impacted by desertification in the years 1980s - 2000s.

People who live in the areas affected by land degradation and desertification are "increasingly negatively affected by climate change".

IPCC SRCCL 2019, pp. 7, 8 IPCC SRCCL Summary for Policymakers 2019, p. 7,8

Climate change will also cause soils to warm. In turn, this could cause the soil microbe population size to dramatically increase 40–150%. Warmer conditions would favor growth of certain bacteria species, shifting the bacterial community composition. Elevated carbon dioxide would increase the growth rates of plants and soil microbes, slowing the soil carbon cycle and favoring oligotrophs, which are slower-growing and more resource efficient than copiotrophs.

Flooding

High tides flooding is increasing due to sea level rise, land subsidence, and the loss of natural barriers.

Warmer air holds more water vapor. When this turns to rain, it tends to come in heavy downpours potentially leading to more floods. A 2017 study found that peak precipitation is increasing between 5 and 10% for every one degree Celsius increase. In the United States and many other parts of the world there has been a marked increase in intense rainfall events which have resulted in more severe flooding. Estimates of the number of people at risk of coastal flooding from climate-driven sea-level rise varies from 190 million, to 300 million or even 640 million in a worst-case scenario related to the instability of the Antarctic ice sheet. the Greenland ice sheet is estimated to have reached a point of no return, continuing to melt even if warming stopped. Over time that would submerge many of the world's coastal cities including low-lying islands, especially combined with storm surges and high tides.

Droughts

Climate change affects multiple factors associated with droughts, such as how much rain falls and how fast the rain evaporates again. It is set to increase the severity and frequency of droughts around much of the world. Due to limitations on how much data is available about drought in the past, it is often impossible to confidently attribute droughts to human-induced climate change. Some areas however, such as the Mediterranean and California, already show a clear human signature. Their impacts are aggravated because of increased water demand, population growth, urban expansion, and environmental protection efforts in many areas.

Wildfires

Warm and dry temperatures driven by climate change increase the chance of wildfires.

Prolonged periods of warmer temperatures typically cause soil and underbrush to be drier for longer periods, increasing the risk of wildfires. Hot, dry conditions increase the likelihood that wildfires will be more intense and burn for longer once they start. In California, summer air temperature have increased by over 3.5 °F such that the fire season has lengthened by 75 days over previous decades. As a result, since the 1980s, both the size and ferocity of fires in California have increased. Since the 1970s, the size of the area burned has increased fivefold.

In Australia, the annual number of hot days (above 35 °C) and very hot days (above 40 °C) has increased significantly in many areas of the country since 1950. The country has always had bushfires but in 2019, the extent and ferocity of these fires increased dramatically. For the first time catastrophic bushfire conditions were declared for Greater Sydney. New South Wales and Queensland declared a state of emergency but fires were also burning in South Australia and Western Australia.

Cryosphere

Earth lost 28 trillion tonnes of ice between 1994 and 2017, with melting grounded ice (ice sheets and glaciers) raising the global sea level by 34.6±3.1 mm.[91] The rate of ice loss has risen by 57% since the 1990s−from 0.8 to 1.2 trillion tonnes per year.

2012 Arctic sea ice extent

A map that shows ice concentration on 16 September 2012, along with the extent of the previous record low (yellow line) and the mid-September median extent (black line) setting a new record low that was 18 percent smaller than the previous record and nearly 50 percent smaller than the long-term (1979–2000) average.

The cryosphere is made up of those parts of the planet which are so cold, they are frozen and covered by snow or ice. This includes ice and snow on land such as the continental ice sheets in Greenland and Antarctica, as well as glaciers and areas of snow and permafrost; and ice found on water including frozen parts of the ocean, such as the waters surrounding Antarctica and the Arctic. The cryosphere, especially the polar regions, is extremely sensitive to changes in global climate.

The Intergovernmental Panel on Climate Change issued a Special Report on the Ocean and Cryosphere in a Changing Climate. According to the report climate change caused a massive melting of glaciers, ice sheets, snow and permafrost with generally negative effects on ecosystems and humans. Indigenous knowledge helped to adapt to those effects.

Arctic sea ice began to decline at the beginning of the twentieth century but the rate is accelerating. Since 1979, satellite records indicate the decline in summer sea ice coverage has been about 13% per decade. The thickness of sea ice has also decreased by 66% or 2.0 m over the last six decades with a shift from permanent ice to largely seasonal ice cover. While ice-free summers are expected to be rare at 1.5 °C degrees of warming, they are set to occur at least once every decade at a warming level of 2.0 °C.

Since the beginning of the twentieth century, there has also been a widespread retreat of alpine glaciers, and snow cover in the Northern Hemisphere. During the 21st century, glaciers and snow cover are projected to continue their retreat in almost all regions. The melting of the Greenland and West Antarctic ice sheets will continue to contribute to sea level rise over long time-scales.

Oceans

Global ocean heat content

Global ocean heat content from 1955 to 2019

Global warming is projected to have a number of effects on the oceans. Ongoing effects include rising sea levels due to thermal expansion and melting of glaciers and ice sheets, and warming of the ocean surface, leading to increased temperature stratification. Other possible effects include large-scale changes in ocean circulation. The oceans also serve as a sink for carbon dioxide, taking up much that would otherwise remain in the atmosphere, but increased levels of CO
2 have led to ocean acidification. Furthermore, as the temperature of the oceans increases, they become less able to absorb excess CO
2. The oceans have also acted as a sink in absorbing extra heat from the atmosphere.

According to a Special Report on the Ocean and Cryosphere in a Changing Climate published by the Intergovernmental Panel on Climate Change, climate change has different impacts on the oceans, including an increase in marine heatwaves, shift in species distribution, ocean deoxygenation.

The decline in mixing of the ocean layers piles up warm water near the surface while reducing cold, deep water circulation. The reduced up and down mixing enhanced global warming. Furthermore, energy available for tropical cyclones and other storms is expected to increase, nutrients for fish in the upper ocean layers are set to decrease, as well as the capacity of the oceans to store carbon.

Sea Ice

Sea ice reflects 50% to 70% of the incoming solar radiation, while 6% of the incoming solar engery is reflected by the ocean. With less solar energy, the sea ice absorbs and holds the surface colder, which can be a positive feedback toward climate change.

Oxygen depletion

Warmer water cannot contain as much oxygen as cold water, so heating is expected to lead to less oxygen in the ocean. Other processes also play a role: stratification may lead to increases in respiration rates of organic matter, further decreasing oxygen content. The ocean has already lost oxygen, throughout the entire water column and oxygen minimum zones are expanding worldwide. This has adverse consequences for ocean life.

Ocean heat uptake

Oceans have taken up over 90% of the excess heat accumulated on Earth due to global warming. The warming rate varies with depth: at a depth of a thousand metres the warming occurs at a rate of almost 0.4 °C per century (data from 1981 to 2019), whereas the

warming rate at two kilometres depth is only half. The increase in ocean heat content is much larger than any other store of energy in the Earth's heat balance and accounts for more than 90% of the increase in heat content of the Earth system, and has accelerated in the 1993–2017 period compared to 1969–1993. In 2019 a paper published in the journal Science found the oceans are heating 40% faster than the IPCC predicted just five years before.

As well as having effects on ecosystems (e.g. by melting sea ice affecting algae that grow on its underside), warming reduces the ocean's ability to absorb CO2. It is likely that the oceans warmed faster between 1993 and 2017 compared to the period starting in 1969.

Sea level rise

Historical sea level reconstruction and projections up to 2100 published in January 2017 by the U.S. Global Change Research Program. The IPCC's Special Report on the Ocean and Cryosphere concluded that global mean sea level rose by 0.16 metres between 1901 and 2016.The rate of sea level rise since the industrial revolution in the 19th century has been larger than the rate during the previous two thousand years.

Global sea level rise is accelerating, rising 2.5 times faster between 2006 and 2016 than it did during the 20th century. Two main factors contribute to the rise. The first is thermal expansion: as ocean water warms, it expands. The second is from the melting of land-based ice in glaciers and ice sheets due to global warming. Prior to 2007, thermal expansion was the largest component in these projections, contributing 70–75% of sea level rise. As the impact of global warming has accelerated, melting from glaciers and ice sheets has become the main contributor.

Even if emission of greenhouse gases stops overnight, sea level rise will continue for centuries to come. In 2015, a study by Professor James Hansen of Columbia University and 16 other climate scientists said a sea level rise of three metres could be a reality by the end of the century. Another study by scientists at the Royal Netherlands Meteorological Institute in 2017 using updated projections of Antarctic mass loss and a revised statistical method also concluded that, although it was a low probability, a three-metre rise was possible. Rising sea levels will put hundreds of millions of people at risk in low-lying coastal areas in countries such as China, Bangladesh, India and Vietnam.

Wildlife and nature

A vast array of physical and biological systems across the Earth are being affected by human-induced global warming. Recent warming has strongly affected natural biological systems. Species worldwide are moving poleward to colder areas. On land, species move to higher elevations, whereas marine species find colder water at greater depths. Of the drivers with the biggest global impact on nature, climate change ranks third over the five decades before 2020, with only change in land use and sea use, and direct exploitation of organisms having a greater impact.

The impacts of climate change in nature and nature's contributions to humans are projected to become more pronounced in the next few decades.Examples of climatic disruptions include fire, drought, pest infestation, invasion of species, storms, and coral bleaching events. The stresses caused by climate change, added to other stresses on ecological systems (e.g. land conversion, land degradation, harvesting, and pollution), threaten substantial damage to or complete loss of some unique ecosystems, and extinction of some critically endangered species. Key interactions between species within ecosystems are often disrupted because species from one location do not move to colder habitats at the same rate, giving rise to rapid changes in the functioning of the ecosystem. The Arctic is heating up twice as fast as the global mean. Seas are on track to rise one to four feet higher by 2100, threatening coastal habitats.

Terrestrial and wetland systems

Biodiversity

Climate change has been estimated to be a major driver of biodiversity loss in cool conifer forests, savannas, mediterranean-climate systems, tropical forests, and the Arctic tundra. In other ecosystems, land-use change may be a stronger driver of biodiversity loss, at least in the near-term. Beyond the year 2050, climate change may be the major driver for biodiversity loss globally. Climate change interacts with other pressures such as habitat modification, pollution and invasive species. Interacting with these pressures, climate change increases extinction risk for a large fraction of terrestrial and freshwater species. Between 1% and 50% of species in different groups were assessed to be at substantially higher risk of extinction due to climate change.

Ocean ecosystems

A part of the Great Barrier Reef in Australia in 2016 after a coral bleaching event

Warm water coral reefs are very sensitive to global warming and ocean acidification. Coral reefs provide a habitat for thousands of species and ecosystem services such as coastal protection and food. The resilience of reefs can be improved by curbing local pollution and overfishing, but 70–90% of today's warm water coral reefs will disappear even if warming is kept to 1.5 °C.Coral reefs are not the only framework organisms, organisms that build physical structures that form habitats for other sea creatures, affected by climate change: mangroves and seagrass are considered to be at moderate risk for lower levels of global warming according to a literature assessment in the Special Report on the Ocean and Cryosphere in a Changing Climate. Marine heatwaves have seen an increased frequency and have widespread impacts on life in the oceans, such as mass dying events. Harmful algae blooms have increased in response to warming waters, ocean deoxygenation and eutrophication. Between one-quarter and one-third of our fossil fuel emissions are consumed by the earth's oceans and are now 30 percent more acidic than they were in pre-industrial times. This acidification poses a serious threat to aquatic life, particularly creatures such as oysters, clams, and coral with calcified shells or skeletons.

Regional effects

Average global temperatures from 2010 to 2019 compared to a baseline average from 1951 to 1978. Source: NASA.

Regional effects of global warming vary in nature. Some are the result of a generalised global change, such as rising temperature,

resulting in local effects, such as melting ice. In other cases, a change may be related to a change in a particular ocean current or weather system. In such cases, the regional effect may be disproportionate and will not necessarily follow the global trend.

There are three major ways in which global warming will make changes to regional climate: melting or forming ice, changing the hydrological cycle (of evaporation and precipitation) and changing currents in the oceans and air flows in the atmosphere. The coast can also be considered a region, and will suffer severe impacts from sea level rise.

The Arctic, Africa, small islands, Asian megadeltas and the Middle East are regions that are likely to be especially affected by climate change. Low-latitude, less-developed regions are at most risk of experiencing negative impacts due to climate change. Developed countries are also vulnerable to climate change. For example, developed countries will be negatively affected by increases in the severity and frequency of some extreme weather events, such as heat waves. Already in 2021 climate change became "very obviously a rich-country problem,".

Projections of climate changes at the regional scale do not hold as high a level of scientific confidence as projections made at the global scale. It is, however, expected that future warming will follow a similar geographical pattern to that seen already, with the greatest warming over land and high northern latitudes, and least over the Southern Ocean and parts of the North Atlantic Ocean. Land areas warm faster than ocean, and this feature is even stronger for extreme temperatures. For hot extremes, regions with the most warming include Central and Southern Europe and Western and Central Asia.

The ten countries of the Association of Southeast Asian Nations (ASEAN) are among the most vulnerable in the world to the negative effects of climate change, however, ASEAN's climate mitigation efforts are not commensurate with the climate change threats the region faces.

On humans

The effects of climate change, in combination with the sustained increases in greenhouse gas emissions, have led scientists to characterize it as a climate emergency Some climate researchers and activists have called it an existential threat to civilization. Some areas may become too hot for humans to live in while people in some areas may experience displacement triggered by flooding and other climate change related disasters.

The vulnerability and exposure of humans to climate change varies from one economic sector to another and will have different impacts in different countries. Wealthy industrialised countries, which have emitted the most CO2, have more resources and so are the least vulnerable to global warming. Economic sectors that are likely to be affected include agriculture, human health, fisheries, forestry, energy, insurance, financial services, tourism, and recreation. The quality and quantity of freshwater will likely be affected almost everywhere. Some people may be particularly at risk from climate change, such as the poor, young children and the elderly. According to the World Health Organization, between 2030 and 2050, "climate change is expected to cause about 250,000 additional deaths per year." As global temperatures increase, so does the number of heat stress, heatstroke, and cardiovascular and kidney disease deaths and illnesses. Air pollution generated by fossil fuel combustion is both a major driver of global warming and – in parallel and for comparison – the cause of a large number of annual deaths with some estimates as high as 8.7 million[dubious – discuss] excess deaths during 2018.[164][165] It may be difficult to predict or attribute deaths to anthropogenic global warming or its particular drivers as many effects – such as possibly contributing to human conflict and socioeconomic disruptions – and their mortality impacts could be highly indirect or hard to evaluate.

Food security

Climate change will impact agriculture and food production around the world due to the effects of elevated CO2 in the atmosphere; higher temperatures; altered precipitation and transpiration regimes; increased frequency of extreme events; and modified weed, pest, and pathogen pressure.[166] Climate change is projected to negatively affect all four pillars of food security: not only how much food is available, but also how easy food is to access (prices), food quality and how stable the food system is.

Food availability

2011 projected changes in crop yields at different latitudes with global warming. This graph is based on several studies. 2011 projected changes in yields of selected crops with global warming. This graph is based on several studies.

As of 2019, negative impacts have been observed for some crops in low-latitudes (maize and wheat), while positive impacts of climate change have been observed in some crops in high-latitudes (maize, wheat, and sugar beets). Using different methods to project future crop yields, a consistent picture emerges of global decreases in yield. Maize and soybean decrease with any warming, whereas rice and wheat production might peak at 3 °C of warming.

In many areas, fisheries have already seen their catch decrease because of global warming and changes in biochemical cycles. In combination with overfishing, warming waters decrease the maximum catch potential. [Global catch potential is projected to reduce further in 2050 by less than 4% if emissions are reduced strongly, and by about 8% for very high future emissions, with growth in the Arctic Ocean.

Other aspects of food security

Climate change impacts depend strongly on projected future social and economic development. As of 2019, an estimated 831 million people are undernourished Under a high emission scenario (RCP6.0), cereals are projected to become 1-29% more expensive in 2050 depending on the socioeconomic pathway, particularly affecting low-income consumers. Compared to a no climate change scenario, this would put between 1-181 million extra people at risk of hunger.

While CO

2 is expected to be good for crop productivity at lower temperatures, it does reduce the nutritional values of crops, with for instance wheat having less protein and less of some minerals. It

is difficult to project the impact of climate change on utilization (protecting food against spoilage, being healthy enough to absorb nutrients, etc.) and on volatility of food prices. Most models projecting the future do indicate that prices will become more volatile.

Droughts result in crop failures and the loss of pasture for livestock.

Water security

A number of climate-related trends have been observed that affect water resources. These include changes in precipitation, the cryosphere and surface waters (e.g., changes in river flows). Observed and projected impacts of climate change on freshwater systems and their management are mainly due to changes in temperature, sea level and precipitation variability. Changes in temperature are correlated with variability in precipitation because the water cycle is reactive to temperature. Temperature increases change precipitation patterns. Excessive precipitation leads to excessive sediment deposition, nutrient pollution, and concentration of minerals in aquifers.

The rising global temperature will cause sea level rise and will extend areas of salinization of groundwater and estuaries, resulting in a decrease in freshwater availability for humans and ecosystems in coastal areas. The rising sea level will push the salt gradient into freshwater deposits and will eventually pollute freshwater sources. The 2014 fifth IPCC assessment report concluded that:

Water resources are projected to decrease in most dry subtropical regions and mid-latitudes, but increase in high latitudes. As streamflow becomes more variable, even regions with increased water resources can experience additional short-term shortages.

Per degree warming, a model[clarification needed] average of 7% of the world population is expected to have at least 20% less renewable water resource.

Climate change is projected to reduce water quality before treatment. Even after conventional treatments, risks remain. The quality reduction is a consequence of higher temperatures, more intense rainfall, droughts and disruption of treatment facilities during floods.

Droughts that stress water supply are expected to increase in southern Europe and the Mediterranean region, central Europe, central and southern North America, Central America, northeast Brazil, and southern Africa.

Health

Humans are exposed to climate change through changing weather patterns (temperature, precipitation, sea-level rise and more frequent extreme events) and indirectly through changes in water, air and food quality and changes in ecosystems, agriculture, industry and settlements and the economy. Air pollution, wildfires, and heat waves caused by global warming have significantly affected human health, and in 2007, the World Health Organization estimated 150,000 people were being killed by climate-change-related issues every year.

A study by the World Health Organization concluded that climate change was responsible for 3% of diarrhoea, 3% of malaria, and 3.8% of dengue fever deaths worldwide in 2004. Total attributable mortality was about 0.2% of deaths in 2004; of these, 85% were child deaths. The effects of more frequent and extreme storms were excluded from this study.

The human impacts include both the direct effects of extreme weather, leading to injury and loss of life, as well as indirect effects, such as undernutrition brought on by crop failures. Various infectious diseases are more easily transmitted in a warmer climate, such as dengue fever, which affects children most severely, and malaria. Young children are the most vulnerable to food shortages, and together with older people, to extreme heat.

According to a report from the United Nations Environment Programme and International Livestock Research Institute, climate change can facilitate outbreaks of Zoonosis, e.g. diseases that pass from animals to humans. One example of such outbreaks is the COVID-19 pandemic.
A minor further effect are increases of pollen season lengths and concentrations in some regions of the world.

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