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Climate Change, Effects

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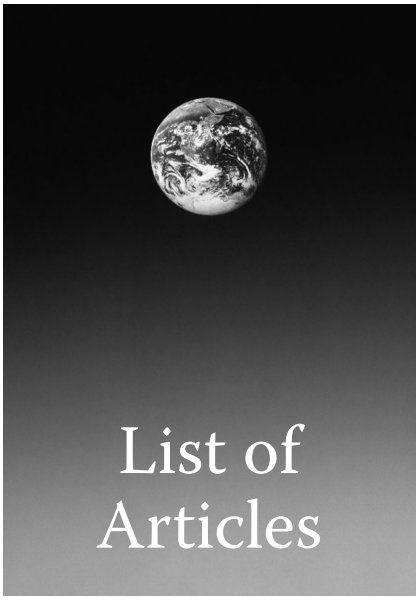

List of Articles

Climate Change, Effects

CLIMATE CHANGE IS commonly used to describe any systematic alteration or statistically significant variation in either the average state of the climate elements such as precipitation, temperature, winds, or pressure; or in its variability, sustained over a finite time period (decades or longer). It can be referred to as the long-term change in global weather patterns, associated especially with increases in temperature, precipitation, and storm activity.

These inconsistencies in climate systems are a potential consequence of the greenhouse effect by greenhouse gases (GHGs). Examples of greenhouse gases include: carbon dioxide (CO_2), methane (CH_4), dinitrogen monoxide or nitrous oxide (N_2O), halocarbon gases such as trichlorofluorocarbon ($CFCl_3$) and dichloroflurocarbon (CF_2Cl_2), water (H_2O), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). The atmospheric concentrations of these gases have been increasing, due to anthropogenic activities.

Climate change is attributed directly or indirectly to anthropogenic activities that impact the natural composition of the global climate elements. It may also be a result of natural external forcing, such as changes in Earth's orbital variables, or solar emission, and other natural internal processes of the Earth's climate system. The relative influences of external anthropogenic and natural factors on climate can be broadly compared, using the concept of radiative forcing. Radiative forcing simply refers to the process that disrupts the infrared radiation balance between incoming solar radiation from the Sun and the outgoing radiation from the Earth. A positive radiative forcing primarily results in the relative warming of the Earth's surface and is due to increasing levels of GHGs. A negative radiative forcing, which can arise from an increase in some types of aerosols, tends to bring about the cooling of the Earth's surface.

Changes in orbital variables, solar output, or explosive volcanic activity, are natural external factors that can also cause radiative forcing. The systematic account of these climate-forcing agents and their differences over a timescale is required to understand past climate changes in the context of natural variations, and to predict the nature of future climate changes.

The effects of climate change include variations in biospheric ambient temperature, which could lead to heat stress, change in rainfall patterns, sea-level rise, saltwater intrusion, loss of biodiversity, drought, habitat loss, and freshwater depletion and pollution. In most cases, climate change has been used interchangeably with global warming, and the greenhouse effect. However, in recent accepted usage, climate change only connotes any change or changes in modern climate systems, whether due to natural variability or as a result of human-caused activity, including an increase over a period of time of the average temperature of the Earth's atmosphere and oceans, known as global warming.

The United Nations Framework Convention on Climate Change (UNFCCC) has adopted the phrase *climate variability* for non-human mediated changes in climate elements. Climate variability is usually natural in origin, resulting primarily from slight variations in the complex processes that drive the movement of heat and mass between the atmosphere, the marine aquatic ecosystems, and the land surfaces. For example, the El Niño–Southern Oscillation (ENSO) is caused by weakening trade winds in the southern part of the Pacific Ocean, and has consistently affected regional variations of precipitation and temperature over much of the tropics, subtropics, and some mid-latitude areas, leading to warmer episodes in these areas. Trade winds carry warmer air west, which leads to rising sea temperatures and increased precipitation.

According to reports by the Intergovernmental Panel on Climate Change (IPCC), human beings are altering the Earth's natural climate system. Evidence indicates that human-induced climate change, if allowed to continue unabated, could have profound consequences for the economy and the quality of life of future generations. Fossil fuel consumption, which has been steadily increasing since the pre-industrial period, is causing an overall increase in concentrations of atmospheric GHGs, especially CO_2.

Current research indicates that radiative forcing driven by greenhouse gases is the primary cause of global warming. According to these studies, GHGs traps the Sun's heat energy and compels a redistribution of the trapped radiation available near the Earth's surface, thus regulating the Earth's temperature. GHGs, especially CO_2, are the major non-climate factors driving climate change. The continuous build-up of these gases is expected to cause

significant changes in climatic conditions over the next century.

WATER RESOURCES AND TEMPERATURE RISE

Researchers around the globe have found that climate change is likely to impact water resources depletion and pollution significantly. There have been observed changes in surface temperature, rainfall, evaporation, and extreme events since the beginning of the 20th century. The atmospheric concentration of CO_2 has increased from about 280 parts per million by volume (ppmv) to about 369 ppmv, and the global temperature of the Earth has increased by about 0.6 degrees C. The present CO_2 concentration has not been exceeded during the past 420,000 years and likely not during the past 20 million years. The current rate of atmospheric CO_2 level increase is unprecedented during at least the past 20,000 years. About 75 percent of the anthropogenic emissions of CO_2 to the atmosphere during the past 20 years is attributed to fossil fuel burning. The rest is predominantly due to land-use change, especially deforestation.

The globally averaged surface temperature is projected to increase by 1.4 to 5.8 degrees C 1990–2100. The global mean sea level has risen by 4–8 in. (10–20 cm.). The average global surface temperature is projected to increase by 1.4–3.0 degrees C 1990–2100 for low-emission scenarios, and 2.5–5.8 degrees C for higher emission scenarios of greenhouse gases in the atmosphere. Over the same period, associated rise in global mean sea level is projected between 1.3–13.6 sq. in. (9–88 sq. cm.).

A number of researchers have reported the impact of climate-change scenarios on hydrology of various basins and regions; they project that increasing temperature and decline in rainfall may reduce net recharge and affect freshwater resources. Human-caused influences are expected to follow a steady growth trend in the future; climate modifications caused by anthropogenic radiative forcing are considered to be more permanent than those caused by natural variability factors.

According to the Intergovernmental Panel on Climate Change (IPCC), since the Industrial Revolution began in the mid-16th century, CO_2 levels in the atmosphere have increased by 35 percent and the atmospheric concentration of CH_4 has increased by 1060 parts per billion (151 percent) and will continue to increase. The present CH_4 concentration has not been exceeded during the past 420,000 years. The inter-annual growth in CH_4 level slowed and became significantly variable in the 1990s, compared with the 1980s. It has been suggested that a significant ratio of the current CH_4 emissions are anthropogenic rather than natural. The anthropogenic sources of methane include the consumption of fossil fuels, cattle, paddy rice fields, and landfills. Recent studies have indicted carbon monoxide (CO) emissions as a cause of increasing atmospheric CH_4 concentration.

In addition, the emissions of persistent GHGs such as CO_2, N_2O, PFCs, and SF_6 could continue to have long-term impacts on atmospheric composition, radiative forcing, and climate elements. This could imply that anthropogenic climate change may persist for a long time to come. The enhanced atmospheric concentrations of GHGs are implicated as the primary cause of global warming.

Recent findings by the IPCC indicate that the atmospheric concentration of CO_2 in 2005 was 375 ppm compared to the pre-industrial levels of 280 ppm. This has contributed to the increase in the Earth's surface temperature by 0.6 degrees C (one degree F). Worldwide measurements of sea level have demonstrated a rise of about 0.56 ft. (0.17 m.) during the 20th century. The world's glaciers have, over time, receded steadily and Arctic sea ice extent has steadily shrunk by 2.7 percent per decade since 1978.

Glaciers are an intriguing part of the Earth's natural environment and have been identified as one of the significant and sensitive indicators of climate change. Their size, lifespan, and timescale information of accumulation and ablation, or growth and collapse (glacier retreat) are primarily attributed to change in climate elements such as temperature, precipitation, wind speed, humidity, and solar radiation.

Increased surface temperatures of the Earth are causing glaciers to melt faster than winter snows can replenish them. Melting sea ice may eventually lead to global changes in water resources and circulation, and melting ice could speed up warming of the Arctic because water absorbs much more heat than ice. Extreme and ongoing declines in the thickness and extent of Arctic sea ice will pose enormous consequences for the Arctic population, their ecosystems, and coastal evolution. As the glaciers shrink, a greater portion of the Earth's water will enter the liquid phase

and becomes available to the oceans and the atmosphere. This will ultimately result in a increased volume of water in the oceans, which could lead to a significant rise in sea level.

IMPACTS OF SEA-LEVEL RISE

During the 20th century, the sea level rose by 4–8 in. (10–20 cm.) primarily as a result of melting glacier ice and thermal expansion of warmer ocean water. It has been predicted that sea level rise will be even greater as the oceans warm along with the rest of the Earth. This is due to the fact that water expands as its temperature increases. Climate change models have predicted that a global mean sea level rise as much as 33 in. (85 cm.) is expected during the 21st century. Accelerated global sea-level rise is expected to have far-reaching and dramatic impacts in vulnerable regions of the Earth where subsidence and erosion challenges already exist. Rising seawaters are already submerging, for example, coastal wetlands and mangroves in southern Florida, and approximately one million acres of Louisiana wetlands have become open water since the mid 20th century.

Sea-level rise has the potential of causing increases in the intrusion of saltwater into coastal aquifers. Shallow islands, and coastal aquifers supporting human use (such as those in Long Island, New York, and central California) could be at greatest risk. Rising sea level has also contributed to increased mortality of trees in coastal areas of Louisiana and southern Florida, where saltwater has already intruded into the groundwater on which trees depend.

Other impacts associated with sea-level rise include changes in salinity distribution in estuaries, altered coastal circulation patterns, destruction of transportation infrastructure in low-lying areas, and increased pressure on coastal levee systems. Atlantic and Gulf Coast shorelines will be especially vulnerable to long-term sea-level rise, as well as any increase in the frequency of storm surges or hurricanes. Most erosion events on these coasts are the results of storms, and the slope of these areas is so vulnerable and gentle that a small rise in sea level may produce a large inland shift of the shoreline. This increases the threats to coastal development, transportation, freshwater aquifers, infrastructure, and fisheries. These impacts can adversely affect the quality of water resources. Moreover, the potential negative implications of climate change for water quality include reductions in stream flows, increased storm surges, and higher water temperatures. An increase in the number of intense precipitation days could lead to increases in the variety of agricultural and municipal polluting substances being washed into rivers, estuaries, streams, and lakes, and sea-level rise would contribute to saltwater intrusion into rivers, estuaries, and coastal aquifers.

FRESHWATER SUPPLY ISSUES

Global climate change will have major impacts on freshwater ecosystems. This will affect availability, as well as quality, distribution, and form. In certain regions, where stream flow and precipitation increase, flooding could threaten the structure and functions of aquatic systems, leading to increased pollution of freshwater ecosystems, especially in areas where human-mediated activities might have altered the landscape. The impacts of climate change on the Earth's freshwater resources have the potential of affecting international relations, especially at continental or country borders, where shared wetlands can generate local and international political and geographical disputes.

Impacts of climate change on water resources will have a wide range of consequences for coastal ecosystems. The health of the Earth's ecosystems will be affected by changes in the quality and quantity of freshwater runoff into coastal wetlands, higher water temperatures, extreme runoff rates or altered timing, and the ability of watersheds to assimilate pollutants and wastes.

Global climatic changes could pose a serious demand on the water supply. In most regions of the world where there are observed and projected declines in per capita average of annual freshwater availability, coupled with attendant population growth, the possibility of increased demand for water will likely lead to increased withdrawal of water, which will invariably reduce the recharging time of the water tables. These changes may influence a wide range of water-system components, including reservoir operations, water quality, hydroelectric generation, and navigation. In some regions, where large volumes of water are channeled for non-consumptive purposes such as agriculture demand, particularly for irrigation, water supply will be particularly sensitive to climate conditions;

Predicted mean sea-level rise of as much as 33 in. in the 21st century threatens fragile shorelines such as this one in Florida.

demand for irrigation water tends to increase as conditions become hotter and drier. A possible change in field-level climate may result in altering the timing of, and need for, irrigation.

In-stream water uses such as hydroelectric power generation, navigation, recreation, and ecosystem maintenance are also sensitive to changes in the quantity, quality, and timing of runoff stemming from greenhouse warming. Potential negative implications of climate change include reductions in dilution flows, increased storm surges, and higher water temperatures. Low flows in many rivers will lead to increases in salinity levels to downstream water users.

On the other hand, higher flows could help reduce some water quality concerns. Warmer water could threaten aquatic life directly, as cool-water habitats disappear, and indirectly, as dissolved oxygen levels decline with higher temperatures. An increase in days with more intense precipitation could increase the agricultural and urban pollutants washed into streams and lakes, further reducing oxygen levels. Heavy rainfall is primarily responsible for soil erosion, leaching of agricultural chemicals, and runoff of urban and livestock wastes and nutrients into water bodies.

CHANGING ECOSYSTEMS AND WEATHER

Another possible effect associated with climate change is the potential danger it holds for marine ecosystems. As the sea-level rises, coupled with increased warming of the ocean waters, marine biodiversity will be further threatened by the myriad impacts on all marine ecosystems, from tropical coral reefs (especially in the Maldives), to polar ecosystems. Coral reefs are already under severe stress from human activities, and have experienced unprecedented increases in the extent of coral bleaching, emergent coral diseases, and widespread die-offs. Damages to coral reefs lead to depletion of important habitat for fish food.

Changes in ocean temperatures, currents, and net productivity will affect the distribution, abundance, assemblages, and productivity of marine populations, with unpredictable consequences to marine ecosystems and fisheries. As the Earth's surface temperature warms, species may either migrate to a cooler, more suitable habitat, or die. Species that are particularly vulnerable to climate change effects include polar animals, such as seals, penguins, and polar bears, coral reefs, and many other endangered animal and plant species.

Climate change has the potential to alter the hydrologic cycle. In many regions of the world, global climate change will have significant effects on precipitation and evapotranspiration. Heavier rainfall could lead to flooding in many regions as warmer temperatures speed up the hydrologic cycle. Flood frequencies in some areas are likely to change. In northern latitudes and snowmelt-driven basins, floods may become more frequent, although the increase in flooding for any given climate scenario is uncertain and impacts will vary among basins.

Over the past century, it is estimated that there has been a 5–10 percent increase in precipitation. Climate-induced changes in hydrology will affect the magnitude, frequency, and cost of extreme events, which have the greatest economic and social impact on humans. Flooding, the most costly and destructive natural disaster, is becoming a common and extreme event as a result of climate-induced variations. Severe weather events are becoming more common and extreme, as well.

Climate change researchers have indicated that the number and strength of anthropogenic-induced climate extreme events such as storms, hurricanes, typhoons, floods, and tornadoes have increased over the past 10–20 years. For example, a record breaking 28 tropical storms hit the United States in 2005, alone. All these phenomena are traceable to variations in radiative forcing brought about by anthropogenic GHGs in the atmosphere. Increases in precipitation and runoff are likely to intensify the stresses

on streams, lakes, bays, estuaries, and rivers in some regions of the world by strengthening the transport of nutrients and contaminants loading to coastal ecosystems. Higher latitudes are more likely to receive increased precipitation and runoff, while lower latitudes are more likely to experience decreased runoff.

Regions with snowfall, such as the Rocky Mountains and Sierra Nevada, California, will experience seasonal shifts in runoff, with increases in winter and early spring runoff, decreases in late spring and summer runoff, and possible increased flood intensities. The frequency and severity of droughts could increase in some areas as a result of a decrease in total rainfall, more frequent dry spells, and greater evapotranspiration.

HEALTH ISSUES

Several health challenges can be linked to global climate change. According to IPCC scientists, a climate-induced warmer world could lead to a number of health problems. These health challenges include increased global distribution of tropical diseases, such as malaria and dengue, heat stress, hunger-related ailments, and injuries and drowning associated with increased storm frequency and intensity.

Africa, for example, is expected to be at risk from increased incidence of vectorborne diseases. A warmer Africa has the potential of opening up new areas for malaria, and altered temperature and rainfall patterns in the continent could lead to increased incidence of yellow fever, dengue fever, onchocerciasis, and trypanosomiasis. In the Middle East and Asia, heat stress, which will affect human comfort levels, and the possible spread of vectorborne diseases will likely result from climate-induced changes. In general, decreases in freshwater availability would lead to indirect impacts on human health.

SEE ALSO: Climate; Climate Models; Diseases; Floods; Health; Hurricanes and Typhoons; Salinity; Sea Level, Rising; Weather.

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Climate Change Knowledge Network

THE CLIMATE CHANGE Knowledge Network (CCKN) was established in 1998, to enhance cooperation between developed and developing countries on research related to climate change. The network aims to make knowledge about climate change available to all countries of the world. The collaborative efforts encouraged by the network strive to disseminate knowledge on climate change and to make such knowledge relevant for the international policy process. The network includes 12 core member institutions in Senegal, Zimbabwe, the United States, Canada, Brazil, Argentina, China, India, Norway, the Netherlands, and Sweden. The governments of Canada, the United States, and Norway support its activities.

The aims of the network are to promote more sustainable and equitable climate change management through research and communication on issues such as the Kyoto Protocol, to develop a dialogue between developed and developing countries for a better understanding of the global effects of climate change, and to help each member institution to increase its capacity to propose regional policies about climate change. The network promotes international negotiations that make explicit connections between

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