IMPACTS OF CLIMATE CHANGE ON INDIA

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Abstract

Climate change is not new, but these emissions significantly affect human employment. The geological record demonstrates that the Earth's climate has not been consistent and has fluctuated throughout time. It also demonstrates that previous climate change has affected the Earth's ecology and destroyed ecosystems. Understanding climate change is crucial since it has the potential to alter Earth's future sustainability. It poses a danger to India, the world's largest agricultural country. With a population of over 1.2 billion people, India is a vulnerable area. Climate experts estimate a 2.1° to 2.6°C temperature rise by 2050 and a 3.3° to 3.8°C temperature increase by 2080 in the rising Indian area. Further warming might endanger freshwater supplies. Change is expected to increase the frequency of severe weather events such as increased precipitation, droughts, rising sea levels, floods, and cyclones. Climate-induced migration from neighbouring nations may put a burden on its resources. Understanding climate change and its influence on natural resources are critical since it will affect millions of people. This article includes an overview of climate change research, potential effects on natural resources (in India), and mitigation methods.

Paper Identification

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1. Introduction-

Science and media research has shown in recent decades that the Earth's average temperature is increasing at an alarming rate. Global temperatures climbed 0.74 degrees Celsius during the industrial revolution. This rise is connected to an increase in the quantities of greenhouse gases in the lower atmosphere. Carbon dioxide is a significant contributor, with current levels at 380 ppm. An increase in the troposphere means the temperature has caused global warming, generating climate change, as in the past. Climate change is accurate, and the scientific community (e.g., the IPCC) believes that the global climate is rapidly changing. The IPCC anticipated global temperatures to rise by 1.4° to 5.8°C over the next 100 years based on existing climate change trends. Human actions such as burning fossil fuels and deforestation are responsible for most observed temperature increases since the mid-twentieth century. This message includes an overview of climate change research, climatic systems, and palaeoclimate, as well as future implications for India's natural resources and mitigation efforts.

2. Climate and greenhouse effect-

Climate means "average weather" Temperature, precipitation, humidity, wind speed, cloud cover, and other physical phenomena in the lower atmosphere are considered weather. The climate system is complex and dynamic. It includes solar radiation, the atmosphere, the lithosphere, the biosphere, the cryosphere, and the hydrosphere. It incorporates Earth's rotation and orbits around the Sun. Temperature and precipitation are unpredictable, as are their averages across months to centuries (a standard period is *30 years). The climate system develops throughout time due to internal and external effects, including solar radiation, volcanic eruptions, and human atmospheric changes. Without sun energy, the Earth would be dead. The atmosphere contributes to climate. The atmosphere is a gaseous envelope that surrounds the Earth and includes nitrogen, oxygen, carbon dioxide, ozone, methane, water vapour, and particle debris. It provides internal system fluctuations (temperature, precipitation, wind, cloud cover, solar radiation reflection and absorption) and life-sustaining gases. It protects the surface from UV rays and reduces overheating. Troposphere, stratosphere, mesosphere, and thermosphere are atmospheric layers. Its adequate thickness is between 16 and 29 thousand kilometres from sea level, although it thins out until it merges with space. Gravity traps 80% of atmospheric gases within 20 km of the Earth's surface. The Earth's surface absorbs solar radiation of visible or near-visible wavelengths. 70% of the incoming radiation is absorbed and warms the land, atmosphere, and oceans. As a result, the planet emits longer wavelengths of infrared light into the atmosphere. The atmosphere absorbs 90% of the land and sea's thermal radiation. Greenhouse gases, such as carbon dioxide and water vapour, reflect part of this to the Earth's surface, warming the lower troposphere and surface. The "Greenhouse Effect" recycles energy in the lower atmosphere to warm the Earth's surface and affects the climate. Almost all weather and climate events occur in the troposphere and stratosphere. The biosphere depends on this region. Greenhouse gases have influenced life's beginnings, evolution, extinction, variety, migration, and adaptation since Earth's genesis 4.6 billion years ago (Ba).

3. History of Climate Change Research

Kriesel (1968) noted in Montesquieu's works that he summarised the influences of the physical environment and non-physical social qualities (customs, manners, morals, traditions, and technology) on the evolution of complex biophysical, politico-economic, and socio-cultural systems [1]. Many ancient Greeks and other scientists speculated that people might influence temperature and rainfall patterns by clearing forests, irrigating deserts, ploughing fields, and overgrazing. In 1824, French physicist Joseph Fourier described the planet's inherent "greenhouse effect," saying that solar energy received by the Earth must be balanced by energy released by its surface. He also argued that the atmosphere should absorb some returning energy to keep the Earth warm. John Tyndall, an Irish scientist, discovered greenhouse gases in 1861, including water vapour, methane, and carbon dioxide. Jean Louis Rodolphe Agassiz, a notable Swiss-born American biologist and geologist, proposed the "Ice Age" idea in 1837. In the 1870s, geologists unanimously accepted the evidence of an ice age [2]. Adopting an ice age hypothesis sparked many questions, including what caused it, why and when it ended, if it would happen again, and whether the climate would change again. Svante Arrhenius, a Swedish scientist, postulated in 1896 that the ice age might have been caused by a drop in greenhouse gases, mainly carbon dioxide, which would have lowered temperature during the ice age. Industrial pollution might boost global temperatures in the following millennium, he said. Arrhenius' study explained historical climatic variations and helped develop the ideas of the greenhouse effect and climate change. In 1938, British engineer Guy Stewart

Calendar argued that land surface temperatures have increased in the past 50 years due to human activities. He also verified that carbon dioxide concentrations rose simultaneously, establishing the "Calendar effect" [3]. Climate change research began with ice age palaeoclimate investigations. Since most workers thought humans couldn't influence the environment, verification took a long time.

In the 1960s, evidence of human climate manipulation grew clearer [4]. In the 1950s, experts throughout the globe believed that carbon dioxide levels were rising and that global temperatures may climb by a few degrees Celsius by the end of the century. In the 1950s and 1960s, climate change research started. Hans Suess found in 1955, using carbon-14 isotopes, that marine waters did not quickly absorb carbon dioxide from burning fossil fuels. In 1958, Charles David Keeling started measuring carbon dioxide at Hawaii's Mauna Loa Observatory (USA). After four years, he proved that atmospheric carbon dioxide was growing [3]. The "Keeling Curve" presents annual carbon dioxide statistics.

Since the inaugural UN Conference on Human Environment (the Stockholm Conference) in the 1970s, worldwide interest in the environment has grown. This meeting sparked worldwide environmental politics by focusing on whale hunting, chemical pollution, and atomic bomb testing . Climate change wasn't a focus of the summit, but it led to the creation of the UNEP . In 1979, WMO sponsored the first World Climate Conference in Geneva. First, experts from throughout the globe outlined the fundamental implications of climate change on the Earth, which became the focus of national and international political disputes . UN Assembly Resolution No. 43/533 recognised climate change as a worldwide problem in 1988. The UN and WMO formed the Intergovernmental Panel on Climate Change (IPCC) in 1988 with cooperation from UNEP .The IPCC's main tasks are to document past climate (palaeoclimate) changes, the current climate and its environmental, social, and economic ramifications, and to anticipate future changes and provide recommendations for mitigating climate change. The United Nations Framework Convention on Climate Change (UNFCCC) was adopted in 1992 at the Rio Earth Summit. This international agreement aims to "stabilise greenhouse gas concentrations in the atmosphere at a level that will preclude harmful human influence with the climate system" [5]. UNFCCC subsidiary treaties Kyoto Protocol and Paris Agreement The Kyoto Protocol was formed in 1997 to control and reduce greenhouse gas emissions from industrialised/developed countries. The 2015 Paris Agreement intended to mitigate climate change and speed up and intensify low-carbon measures and investments. Its purpose is to facilitate global climate change reaction [5]. The Montreal Protocol and UNFCCC both contributed to climate change research.

4. Impacts of Climate Change

According to the IPCC, climate change threatens living and nonliving resources depending on location and latitude (IPCC Report 2007, 2019). Climate models show a few degrees of warming during the last century. Temperature rise has changed the world's climatic zones and ecosystems. This has changed many countries' environments, economies, and people's lives. Global warming and climate change cause glaciers and sea ice to melt, raising sea levels and low-lying flooding areas. They also increase the frequency and severity of extreme weather events. These causes lead to changing vegetation zones, extinction of animal species, the collapse of socioeconomic institutions, decreased agricultural yields and insecure food supply, fast spread of insect-borne illnesses, and increased severe weather and natural catastrophes. Climate change affects people and the planet. In 1998, the Yangtze River floods killed 4,000 and cost $30 million. [6] , Drought and wildfires in Florida, USA, destroyed 483,000 acres of forest and 356 houses, totalling $276 million [7]. A cloudburst hit the parched

Union Territory of Ladakh in August 2010. 600 missing, 130 dead, and 300 wounded (India Today 2010). Between 1900 and 1995, droughts worsened in Asia and Africa [8]. During the 2019-2020 Australian wildfire season, millions of acres of forest were burned, and 34 people died. Many animals were burned. When disasters strike almost simultaneously, people wonder whether climate change is to blame. Next, we'll discuss climate change's adverse effects.

4.1. Impacts on Himalayan Glaciers

10% of Earth's surface is ice, largely glaciers. In cold conditions, ice forms glaciers above the snowline. Arctic, Greenland, and Antarctica have plenty of ice now. The Rockies in North America, the Andes in South America, the Alps in Europe, the Himalayas in Asia, and Mount Kilimanjaro in Africa all have snow and ice (Africa). Snow and ice are minor, yet they offer fresh water for millions of people. Melting polar ice caps and retreating mountain glaciers in the Alps, Kilimanjaro, and the Himalayas are the most evident results of global warming [9]. The Himalayas are Asia's main supply of fresh water and contain the most glaciers outside the polar regions. So-called "Water Tower of Asia". Glaciers feed nine Asian river basins. This includes India's Indus, Ganga, and Brahmaputra. Fresh water from Himalayan glaciers flows into rivers that sustain one-third of the world's population. Climate change has altered glacier ecology. Himalayan glaciers are melting quickly, according to research [10]. Due to climate change, nearly 60% of Himalayan glaciers have melted in the past 20 years [11]. Chaturangi and Onglaktang, Rathong glaciers in Garhwal and Sikkim, have receded by 46 m per year. Kolhani and Machoi glaciers in Kashmir Himalaya have receded 16 and 8.1 metres yearly. Gangotri glacier in Garhwal Himalaya melts 23 metres per year on average. As temperatures increase, Himalayan glaciers melt, creating more and larger glacial lakes and increasing the danger of floods. Melting glaciers will first increase river flow to the ocean. Melting glaciers may cause dry times. Some major Himalayan rivers may become temporary, with peninsular India-style monsoons [12]. If present patterns of increasing temperatures continue, South Asia's ice and snow storms in Himalayan glaciers may vanish (WWF Report 2005). The region may witness more natural calamities like glacial lake floods and dam collapses as they go down. They will reduce the quantity of fresh water accessible for consumption, farming, and industry, reducing hydropower usage. Lack of water will have a long-term impact on human indices. Glaciers are susceptible to climate change and an excellent method to study the Himalayas.

4.2. Impacts on the Sea Level

Evidence shows that the global sea level has increased. The IPCC reports a 0.3 to 0.8 m rise in sea level over the last century. According to the IPCC special report on emission scenarios, the sea level would increase by 0.22 to 0.44 m by the century's end (2090–2099). The melting of land-based ice and snow cover due to global warming and the thermal expansion of the oceans are assumed to be the main reasons for the observed global rise in sea level. This is expected to cause the submergence of low-lying and deltaic regions, the loss of coastal ecosystems and wetlands, and the penetration of salty water into coastal aquifers. According to satellite data, sea-level rise has been strongest in the western Pacific and eastern Indian oceans since 1992. Krishnan et al. Humanity will face severe hurdles from the predicted rise. The expected rise in sea level will submerge the Indian subcontinent's coastline, with the most severe effects in rice-growing coastal areas of Myanmar, Bangladesh, Sri Lanka, India, and Pakistan. Dhaka (Bangladesh), Visakhapatnam, Mumbai, Kochi, Mangalore (India), and Karachi (Pakistan) will be at risk. Over 70 million in Bangladesh, 22 million in Vietnam, and 6 million in Lower Egypt will be at risk (UNDP Report 2008).

4.3. Impacts on Agricultural Productivity and Food Security

From Kharif to Rabi, India farms a range of crops. Kharif crops provide 78% of India's grain, while Rabi crops produce 72% of its food. Over 27% of India's GDP comes from agriculture. India will require a lot of food to feed its growing population soon. This requires more agricultural production. Weather and land resources, especially soil and water, affect Indian agricultural output. All the water needed for farming comes from the Himalayan, peninsular, and monsoon rivers. So, agricultural output is high. According to a 1996 IPCC report, the average temperature in India is expected to rise by 0.4° to 2.0°C in Kharif-growing regions and by 1.1° to 4.5°C in Rabi-growing regions by 2070. (IPCC). 1996 IPCC report The monsoon system may shift, causing more droughts and floods. In recent years, the country has been ravaged by floods, droughts, excessive rain, landslides, and cyclones. Himalayan glaciers, which feed many of India's rivers, have receded in recent decades, which may impair the water they give. These stats indicate climate change's influence on India's agriculture. Agriculture releases one-third of all greenhouse gases (nitrous oxide and methane) into the atmosphere. These changes may affect agricultural productivity positively and negatively, making crops more productive in specific locations and less productive in others. Rice and wheat, the primary dietary grains in India, don't perform well in hot weather. Their yields will fall when the temperature rises but climb with more rain. Apples and berries, which require winter cooling, would produce less if temperatures climbed. Climate change might cut agricultural productivity by 20% in developing countries by 2080. . Overall, increasing temperatures will affect the nutritional value and quality of grains, legumes, fruits, vegetables, cotton, tea, coffee, aromatic, and medicinal plants.

India has the most cattle to generate milk, recycle nutrients, and provide food. If temperatures rise, it will be harder for animals to conceive and more straightforward to spread illness [13]. Climate change is projected to make it harder to acquire food since it impacts to land, water, and biodiversity. Climate change has made it harder for farmers to grow crops, and global food costs have soared. Over 1 billion people are now "food insecure." This will make hunger and starvation worse in the following decades.

4.4. Impacts on Biodiversity

Biodiversity refers to Earth's various species. It's frequently measured by the number of genes, species, and communities and how much they vary. Ecosystems are crucial to biodiversity. It shows how living and nonliving earth components interact. Global warming will affect ecosystems via changes in temperature, sea level, rainfall, and extreme weather. Temperature affects biodiversity, and climate change may alter ecosystem organisation and productivity. Climate change threatens animals, plants, and bacteria. Due to a warming climate, ecosystems will alter size, shape, and location, and species will become extinct. Social and economic advantages will be harmed. Essential plant diversity. Herbs absorb carbon dioxide and lower its concentration. They also provide fuel, food, fodder, lumber, medicinal herbs, and fragrant plants. According to the IPCC's fourth assessment report (IPCC Report 2007), middle latitudes would receive less rain and endure more dryness. This would worsen wildfires. This will release organic carbon into the atmosphere, increasing global warming and reducing forest cover and carbon dioxide storage. Warm tropical rainforests may perish as cold temperate vegetation warms up. Global warming may drive lower-elevation woods to move higher.

Arctic, alpine, coastal, and island endemics that can't move will become extinct [14]. Tropical insects decompose organic detritus and pollinate flowers, enabling fruits and nuts to grow. Many insects need a small temperature range to live. A 1° to 2° C temperature rise might kill many. Tropical insects are expected to become extinct first due to global warming. Next are polar bears and Emperor penguins.

Global warming is destroying Arctic sea ice, making it harder for polar bears to find food. Some plant and animal species will flourish in a warmer climate. 20-30% of terrestrial species might become extinct if temperatures climb 3 degrees Celsius. Global warming will affect the planet's biodiversity.

4.5. Impacts on Human Health

Climate change is expected to affect water, air, food, and housing. Warmer temperatures may be good or bad for health. Where and how rapidly temperatures increase will influence the severity of these repercussions. Global warming may cause less rain in wet places and more rain in dry ones. This might boost food production and reduce hunger-related deaths. Extreme weather (heavy rain, droughts, landslides, floods, and forest fires), a water deficit, a loss of food production, and immigration may make people more susceptible to vector- and water-borne illnesses, insect-borne diseases, and starvation. Higher temperatures lessen the risk of mortality from cold in the winter and heat exhaustion in the summer.

5. Climate Change: The Indian Scenario

India is a growing nation whose fast expansion increases greenhouse gas emissions over time. The principal sources of emissions were expected to be agriculture, biomass burning, fossil fuel combustion, and tree cutting. From roughly 20 million metric tonnes in 1950 to more than 175 million in 1988, India's carbon dioxide emissions climbed at a pace of over 5.6% per year. By 2030, India is expected to be the world's third-largest carbon dioxide emitter. (2009 NIC Report). Brazil, South Africa, India, and China are expected to be the most significant greenhouse gas emitters. Within the next 20-30 years, China's emissions are expected to surpass those of the United States. India's population is around 1.2 billion people. And as one of the countries with the highest levels of greenhouse gas emissions, it is also one of the most susceptible to climate change. Climate change is already wreaking havoc on the country's natural resources, changing monsoon and rain patterns and increasing the chance of catastrophic weather events. Climate change, rapid population increase, industrialisation, urbanisation, and economic growth all pressure the country's social and economic development. More greenhouse gases are created when the industrial sector increases, causing the temperature to rise. Under the IPCC's A2 (740 ppm CO2, medium-high emissions, and a focus on economic problems) and B2 (575 ppm CO2, medium-low emissions, and a focus on environmental issues) scenarios, the average surface temperature is expected to rise by 3-4 °C by the end of the 21st century. Most of the warming is expected to occur in northern India, where temperatures are expected to rise the highest. Temperatures will rise during the day and at night, with higher latitudes increasing faster than lower latitudes and nights rising faster than days. Surface temperature rises are expected to elevate the snowline and enhance the possibility of flooding in northern India during the rainy season. Rain will pour heavily over the nation.

The west coast and western central India would be the worst, with Punjab, Rajasthan, and Tamil Nadu faring the best [15]. Tropical cyclones and floods will be more prevalent in the low-lying coastal areas of eastern India than on the west coast. A significant rise in sea level will flood various coastal areas of the country, notably the Gulf of Kutch and the West Bengal coast. This will jeopardise the lives of over 7 million people. As glaciers melt, the flows of glacier-fed Himalayan river systems surge momentarily before receding.

As a consequence, the country will struggle to get enough water for consumption, agriculture, and industry. Water stress will persist in the Indian region and intensify in the peninsula's south. Climate change will have a significant influence on Indian forests in the future. It is estimated that by 2085, every forest cover will have lost land and be replaced by a new kind of forest. Wetter forests will be found in the northeast,

whereas drier forests will be found in the northwest. Temperate conifer forests will replace warm mixed woodlands. The area inhabited by tropical evergreen forests is predicted to grow as tropical deciduous, and tropical semideciduous forests spread. However, the Western Ghats' evergreen, semi-evergreen, and mangrove forests will see little to no change [16].

Climate change may impact the spread of vector-borne diseases such as malaria, which is already a problem in India. Malaria and other ailments will be spread by climate change, affecting millions of Indians. This is because the country is already impoverished, and its public health services are insufficient. Malaria will become more common in the northern (Jammu and Kashmir, Ladakh, Himachal Pradesh, Punjab, Haryana, Uttarakhand, and Uttar Pradesh) and north-eastern provinces. (Arunachal Pradesh, Nagaland, Manipur, and Mizoram). Malaria will expand from central India to the southwestern coastal states of Maharashtra, Karnataka, and Kerala. However, it will remain a worry in places where malaria is already common, like Odisha, West Bengal, and Assam. Climate change is expected to spread diseases such as dengue, chikungunya, filariasis, Japanese encephalitis, leishmaniasis, and kala-azar. India is the most populated country in South Asia. Its borders are shared by Pakistan, Sri Lanka, Bangladesh, Myanmar, Bhutan, Nepal, Tibet, and China. India is more vulnerable to the effects of climate change on a local, national, and regional level due to its high population growth, low ability to adapt, high poverty, unique and valuable ecosystems, rich mineral wealth, vast productive agricultural regions, different water treaties, long international borders, and conflicts with some neighbouring countries. Many individuals are projected to cross India's borders in the following decades. Rising sea levels will cause flooding in the Maldives, Lakshadweep, parts of Sri Lanka, and Bangladesh and Myanmar low-lying areas. If glaciers melt and rain hard, flash floods and floods from glacial lakes threaten Bangladesh, Nepal, Bhutan, and Tibet. Consequently, millions of people will be compelled to move to India [17]. Between 12 and 17 million Bangladeshis have migrated to the Indian states of Assam and Tripura since the 1950s. This kind of mass immigration will increase demand for the country's natural and other resources and change the country's whole social and economic structure. Pakistan's agricultural output is mainly dependent on Indus River water. Already, India and Pakistan disagree on how the water of the Indus River should be distributed. If climate change limits the amount of accessible water, the two countries may go to war. Mass immigration and border conflicts must be seen as possible threats to national security. India may need to increase its diplomatic or military capabilities to solve these concerns.

6. Conclusions-

For a long time, scientists have been studying climate change. It began in the 1600s when the ancient Greeks realised that humans might influence the climate system. However, it accelerated in the second part of the twentieth century as it became more commonly understood that people impacted the climate system. Climate change is a significant issue that people must deal with right now. Most people now believe that human actions, such as using fossil fuels, increase carbon dioxide in the atmosphere. This, in turn, raises the temperature and is now the primary driver of climate change. Climate change significantly impacts living and nonliving natural resources, which varies from nation to country and latitude to latitude. Climate change is already affecting India. Changes in the nation are impacting natural resources and increasing the frequency of severe weather occurrences. In the long term, this will place a lot of pressure on the country's cultural and economic progress. Studies of geology and historical climates reveal that climate change is not a new phenomenon. The climate on Earth has changed several times in the past, including in glacial and

interglacial eras. During some of these instances, enormous quantities of biomass were destroyed. In the history of the world, there have been five major mass extinctions and numerous lesser ones. Some of them may have been caused or made worse by climate change, which significantly impacted selecting which species would survive or perish. Climate change is a significant danger to people and natural resources; to cope with it, we need solutions like mitigation and adaptation. Since we all live in and share the same environment, all nations, whether developing or developed, need to act rapidly collectively to avert climate change. No nation can win the battle against global warming if it acts alone, but the responsibility for decreasing it must be shared.

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