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Strategies for mitigating the effects of climate change

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Abstract

Climate change is defined as the alteration in climate patterns, primarily caused by greenhouse gas emissions from both natural systems and human activities. Human-induced global warming has already increased temperatures by approximately 1.0 degree celsius above pre-industrial levels. If current emission rates persist, this warming could reach 1.5 degrees celsius between 2023 and 2052. In 2018, there were 315 natural disasters worldwide, most of which were linked to climate change, resulting in economic losses totaling \$131.7 billion. Storms, hunger, wildfires, and droughts accounted for approximately 93% of the 68.5 million affected individuals. Alarming, the economic losses from wildfires in 2018 nearly equaled the total losses from wildfires over the previous decade.

Several strategies aim to reduce greenhouse gas emissions, improve energy efficiency, and shift to low-carbon alternatives. These include transitioning away from fossil fuels, increasing energy efficiency, and modifying agricultural techniques. Additionally, climate change may increase erosion rates, potentially decreasing agricultural production by 10-20% or more in extreme cases. Organic farming is a viable and sustainable option for adapting to climate change and variability, with potential for mitigation. By utilizing carbon sequestration, organic farming reduces reliance on non-renewable resources, offers a systematic approach to maintaining biodiversity, and adapts to climate change through crop management.

Various policies in India and globally also help mitigate climate change. This article reviews the three primary methods of reducing climate change: conventional mitigation, negative emissions, and radiative forcing geoengineering.

Keywords: Climate change, mitigation strategies, greenhouse gas, organic farming, policy

Introduction

The primary driver of climate change is the emission of greenhouse gases, which significantly alter climate patterns. Key contributors to these emissions are deforestation, transportation, and energy use in buildings. Global warming occurs as greenhouse gases trap heat in the Earth's atmosphere, with both human and natural activities contributing. Natural sources of emissions include forests, earthquakes, oceans, permafrost, wetlands, mud volcanoes, and volcanic activity ^[1]. On the other hand, human-induced emissions largely stem from energy production, industry, forestry, and land-use changes ^[2].

Human activities have already caused a rise in global temperatures by about 1.0°C above pre-industrial levels. If emissions continue unabated, the temperature increase is projected to reach 1.5°C between 2030 and 2052. In 2018, there were 315 natural disasters globally, most of which were climate-related, impacting approximately 68.5 million people and leading to \$131.7 billion in economic losses. Climate indicators like temperature, precipitation, sea level rise, ocean acidification, and extreme weather events have changed, according to the United Nations Climate Change Secretariat (UNCCS). Storms, hunger, wildfires, and droughts accounted for about 93% of these costs ^[3]. Documented climate hazards include droughts, floods, hurricanes, strong storms, heatwaves, wildfires, cold spells, and landslides ^[4].

Climate change is also likely to accelerate erosion rates, potentially decreasing agricultural production by 10 to 20% or more in extreme situations. Sectors such as infrastructure, food, health, and human habitats are particularly vulnerable to climate change impacts. In many countries, climate risks intensify vulnerabilities across various sectors due to factors such as temperature fluctuations, precipitation variability, changes in seasonal patterns, shifts in disease distribution, desertification, ocean effects, and soil and coastal degradation ^[5].

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A firm's strategy to reduce CO₂ emissions is known as a "climate change mitigation strategy" [6]. The proposed framework for mitigating climate change consists of 19 carbon-related activities and five methods to achieve three strategic objectives. Developing countries, particularly those in the BRIC group (Brazil, Russia, India, and China), will play a crucial role in shaping future emissions trends and climate negotiations. The success of climate policies will depend on progress toward sustainable development goals. Technological advancements and socioeconomic development plans will be vital in the ability to adapt to and mitigate climate change [7].

The literature identifies three main strategies for mitigating climate change. First, decarbonization technologies and techniques are used in conventional mitigation efforts to lower CO₂ emissions. According to several studies [8,9,10,11,12]. A second path consists of a fresh set of freshly suggested technologies and techniques [13,14,15,16,17,18,19,20,21,22]. Lastly, a third approach centers on the idea of controlling solar and terrestrial radiation to change the earth's radiation balances [23,24].

In addition to other factors like pressure and humidity levels in the surrounding environment, long-haul temperature and precipitation trends are used to characterize climate change. Prior to the industrial revolution, greenhouse gases (GHGs) such as CO₂, CH₄, N₂O, and H₂O were thought to have originated from natural sources such as volcanoes, forest fires, and seismic activity [25,26,27,28,29].

The two most important things to address the reaction to CC are adaptation and mitigation [30]. Mitigating greenhouse gas emissions can reduce or moderate them to some extent, and this makes the issue crucial from an economic and environmental standpoint [31,32,33,34,35]. The primary industries for policy adaptation and mitigation are forestry, land use, transportation, industry, and agriculture [36, 37].

1. Climate change status

The term "climate change" refers to a change in climate patterns that is mostly brought about by greenhouse gas emissions. Global warming is primarily caused by greenhouse gas emissions, which cause heat to be trapped by the earth's atmosphere. According to [38], natural systems include forest fires, earthquakes, seas, permafrost, wetlands, mud volcanoes, and volcanoes. Although the majority of human activity is focused on the generation of energy, industrial activity, forestry, land usage, and land-use change [39]. Groundwater is a crucial part of the climate system [40] but because the climate system is complicated and is made up of a web of intricate interactions and feedback, many possible effects of climate change are still completely unknown [41].

2. Causes of climate change

Climate change is one of the world's most urgent issues today, characterized by significant alterations in temperature, precipitation, snowfall, or wind patterns over several decades. Throughout Earth's history, its climate has undergone numerous changes. This serious issue is already affecting people and the environment globally. The speed and intensity of climate change are altering the suitable habitats for living organisms in freshwater, marine, and terrestrial environments. Significant changes on Earth include rising sea levels, extensive melting of snow and ice, and increasing air and ocean temperatures [42]. Most contemporary climate change is driven by human activities. Since the pre-industrial era, anthropogenic greenhouse gas emissions have increased, largely due to population growth and economic expansion.

Numerous artificial and natural factors contribute to climate change. With references, here are some major contributors to climate change:

Greenhouse gas emissions: by burning of fossil fuels, coal, oil & natural gas for energy and transportation is the main source of greenhouse gas emissions. Important greenhouse gases are methane (CH₄), Nitrous oxide (N₂O), and Carbon dioxide (CO₂) [43].

Deforestation: when forest are destroyed by fire or other natural means, they stored carbon is released back into atmosphere. Therefore, the planet's ability to absorb CO₂ from the atmosphere is diminished by deforestation [44].

Industrial processes: CO₂ and other greenhouse gases are released during industrial operation. This includes cement production, chemical manufacturing and metal smelting [45].

Agriculture: Methane emissions from rice cultivation and cattle digestion, along with nitrous oxide emissions from fertilized soils, are major contributors to climate change in agriculture [46]. Land Use Changes: Earth's capacity to absorb carbon dioxide is reduced and greenhouse gas emissions can rise due to land use changes like urbanization and agricultural conversion, which go beyond deforestation [47].

Natural factors: volcanic eruptions, fluctuations in solar radiation, and natural climate variability all play a role over longer time scales, even if human activities are the main cause of current climate change [48].

3. Climate change and agriculture

Global agriculture is the industry most responsible for 30-40% of greenhouse gas emissions, making it both a major contributor to and a major target of climate change [49,50,51]. Apart from all of these, the threat that climate change poses to Indian agriculture in general and food security in particular has given a new dimension to the difficulties already present [52]. The Indian summer monsoon, the main supply of water for the country's agricultural sector—has weakened since the latter part of the 20th century [53]. Farmers will bear the brunt of food security impacts, even though changes in the environment and agricultural production systems will have an impact [54]. Crop loss has a ripple effect on the economy, causing farmer hardship, inflation, and other issues. As of right now, the yearly average agricultural losses brought on by extreme weather events alone are projected to be worth 0.25 per cent of India's GDP [55]. Since 1750, there has been a 150% increase in the concentration of greenhouse gases such as methane (CH₄), carbon dioxide (CO₂), and nitrous oxide (N₂O), respectively [56]. Crop fertilization increases when atmospheric CO₂ levels rise, and warmer temperatures result in lower energy needs for crop growth. Climate change will become a serious issue in the twenty-first century, with detrimental externalities affecting both developed and developing nations [57].

Many crops will probably yield less as a result of their shorter growing seasons due to temperature rise [58]. A 2 °C increase in temperature in both the temperate and tropical zones is predicted to result in a drop in the combined production of wheat, rice, and maize [59].

4. Climate change risks and effects

The risks of climate change are immense, endangering the lives

and livelihoods of millions, if not billions, of people. Climate change poses various risks like rising temperature and heatwaves, melting of ice and sea level rise, impact on agriculture and food security, human health impacts, water scarcity etc. There is compelling evidence that the rising concentrations of greenhouse gases in the atmosphere pose significant risks and impacts, affecting nearly every aspect of human life and the environment, with the potential to be devastating^[60]. Weather patterns and climate have a wide range of effects on human physiology, health, and survival. Certain health effects, such as those from intense exposures like heat waves, are immediate. Climate change impacts differ in terms of where and when they occur. The Arctic has warmed more quickly than most other locations thus far as a result of feedback from climate change^[61]. Intense heat waves are the result of surface air temperatures rising over land at a rate that is almost twice as fast as it is over the ocean. In addition, deoxygenation, ocean stratification, marine heatwaves, and modifications to ocean currents are consequences of ocean warming^[62]. As carbon dioxide from the atmosphere is absorbed by the ocean, it is also becoming more acidic^[63]. Extreme weather events provide the greatest health concerns; these include heatwaves, storms, cyclones, fires, and floods. Hurricanes, heat waves, droughts, and heavy rainfall are among the extreme weather phenomena that are becoming more common and severe due to climate change. These occurrences have the potential to seriously harm ecosystems, infrastructure, and public health^[64]. This makes sea level rise a particularly serious long-term issue. In addition, deoxygenation, ocean stratification, marine heatwaves, and modifications to ocean currents are consequences of ocean warming^[65]. As carbon dioxide from the atmosphere is absorbed by the ocean, it is also becoming more acidic^[66].

5. Promoting reforestation and afforestation

Reforestation affects the climate biophysically, and depending on how much and in which direction it does so, it may help mitigate climate change. The process of establishing new forests by putting seeds or seedlings where there was previously no forest is known as afforestation. Reforestation and afforestation might increase the size of the world's forests by over one billion hectares, from 3.5 to 4.4 billion hectares, providing a significant new opportunity for atmospheric carbon sequestration^[67]. Even while forests are being planted and restored in many places of the world, and new plantations can efficiently absorb carbon^[68], creating new forests on a large scale could swiftly clash with other^[69,70,71]. Numerous negative effects of climate change have been linked, such as the spread of infectious diseases, decreased availability and quality of drinkable water, loss of biodiversity, infrastructure deterioration, and stress on public health^[72]. As a result, many consider it to be among the most important problems facing the contemporary world.

Policymakers and the scientific community have been focusing more on nature-based solutions in recent years as efforts to develop policies and strategies for reducing and adapting to climate change have intensified. These solutions represent a comprehensive framework of integrated ecosystem-based approaches designed to take into account social, economic, and environmental factors and interconnections while solving environmental and societal concerns. The conservation, rehabilitation, and sustainable management of natural ecosystems such as grasslands, wetlands, forests, and coastal areas—are all part of nature-based solutions^[73]. International research indicates that restoring damaged forest ecosystems

could significantly reduce CO₂ emissions brought on by deforestation and forest degradation brought on by manmade or natural disturbances^[74,75,76,77]. However, to guarantee that afforestation/reforestation is a fruitful nature-based solution (NBS), its effects on other domains, such as economic enhancement and biodiversity conservation/enhancement, must also be evaluated. For instance, the afforestation of wetlands, savannahs, grasslands, and peatlands helps remove carbon from the atmosphere, but it can also have disastrous effects on the biodiversity of the area^[78]. Additionally, by combining afforestation and reforestation with industrial carbon removal technologies like bioenergy with carbon capture and storage (BECCS), the benefits of these initiatives for mitigating climate change can be significantly increased. For lowering greenhouse gas emissions, BECCS is seen as one of the most promising technologies^[79,80].

Conclusion

It is vitally important to establish workable mitigation and adaptation measures as soon as possible given the current state of climate emergency. A change in climate patterns that is mostly brought about by greenhouse gas emissions from both natural systems and human activity is known as climate change. Future climate change is expected to have an impact on livelihoods, biodiversity, water availability, and food production.

There are various causes of climate changes like greenhouse gas emissions, deforestation, agriculture, natural factors and land use changes. Climate change causes various affects to agriculture like crop loss has a ripple effect on the economy, causing farmer hardship, inflation, and other issues. Many crops will probably yield less as a result of their shorter growing seasons due to temperature rise. Risks and effects of climate change endangering the lives and livelihoods of millions, of people. Like rising temperature and heatwaves, melting of ice and sea level rise, impact on agriculture and food security, human health impacts, water scarcity etc, are the various effects. But to mitigate the climate change there are various strategies also like conservation of forests, afforestation & reforestation, develop low carbon technologies. As a result, the issues associated with development align with attempts to mitigate climate change.

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