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CLIMATE CHANGE AND IT'S MULTIFACETED IMPACT ON INDIA: A COMPREHENSIVE REVIEW OF ENVIRONMENTAL, AND ECONOMIC DIMENSIONS

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ABSTRACT

In India, climate change represents one of the foremost issues that dramatic alteration of ecosystems and communities, especially those located at the rural periphery and at the coast, brings about. Focally, it is a problem for agriculture which supports almost fifty percent of the labor force since erratic climatic conditions and water deprivation reduce agricultural productivity, thus endangering food supply and aggravating rural poverty. Other areas likewise infrastructure, energy, and health are also not spared, with damages arising due to climate factors increasing the costs of repairs, and increase in temperature aggravating health-related concerns associated with heat and heat prone disorders and epidemics. India has also been implementing measures against climate change, and this has led to improvements in ranking, from 10th position in the Climate Change Performance Index of 2022 to the 7th position in the indices of 2024. When considering the years between 1901 and 2018, it was noted that there was an increase of 0.7°C (1.3°F) on the temperatures recorded in India. In the year 2024, however, New Delhi reached a temperature of 52.3 degrees Celsius (126 degrees Fahrenheit). Further projections assert that unless climate factors change significantly, droughts of even a more severe nature than at present will be frequent by the end of the century. It has also been projected that the health of mangroves will be put at risk by the increase in sea levels, the decrease in fresh water and the conversion of land to other uses. Cement production in India contributes around three gigatons of greenhouse gases every year. In order to fight these problems, the state formulated strategic measures and programs for the promotion of renewable energy, energy saving, and for the development of organic agriculture. However, these measures are complicated by the issues of financing and implementation.

Keywords: *Climate, Altered, Water, Issues, Recorded, Damage.*

Introduction

Climatic changes describe long-term shifts in temperature, precipitation, or other atmospheric parameters which are mainly caused by anthropogenic factors such as fossil fuel burning, deforestation, and industrialization (IPCC, 2021). It has been noted that climate change has led to increased temperatures, more natural disasters, decreasing biodiversity, and more, which has not affected all regions equally (United Nations, 2020). India is also prone to higher climatic vulnerability due to its

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geographical and monsoon dependency and further vulnerable agricultural, water and health resources (Rao et al., 2021). The frequency of extreme weather events such as cyclones and droughts have also intensified and shifted patterns, further impacting mainly coastal and agricultural regions (Patnaik & Sharma, 2019).

The climate sensitivity of India's topographical features is also determined by its geography. For example, the Himalayas buffer the climate, however, quickening rise in temperature has started to accelerate glacial melting which in effect diminishes the river water flow upon which millions of people downstream rely on (Patel & Chaturvedi, 2021). (Kumar et. al, 2020) Himalayan glaciers may lose up to 30-40 percent of their mass by 2050 worsening the water shortage, and increasing the siltation and flood occurrence. Furthermore, India's position near the Indian Ocean and dependence on the monsoon system which accounts for almost 80 percent of annual rainfall in the country is another factor that makes the country susceptible to changing rainfall distribution (Goswami & Ramesh, 2019). According to the Indian Institute of Tropical Meteorology (2019), lack of monsoon predictability has resulted in droughts in previously rain-fed fertile areas which put agriculture at high-risk. The coastal areas are also under the double threat from the: increase in sea level and the rise in the intensity and frequency of tropical storms, around 45 million people in flood-prone areas were affected in the last decades by the 11 % increase in cyclone intensity (Germanwatch, 2021). In many ways, it is true that India's latitudinal location gives it extreme seasonal fluctuation one of which is increased intensity of heatwaves which predications suggest could increase by 25 percent by 2030 leading to about $450 billion a year in foregone productivity.

India sustains additional risk even with climate-related fields like agriculture, water resources, and energy since it has an increasing population and expanding needs in those sectors. Such issues enhance the country's vulnerability to a number of climate issues such as shifting monsoons, water shortage, excessive heating, and extreme climatic events. This review takes into account India's vulnerabilities in these settings and focuses on the threats of climate change to the economy and the environment. There is increase in the frequency of weather-related events such as the one witnessed between 2000 and 2020 when Germany watches recorded more than 300 extreme temperature events with economic impacts over $87 billion (Germanwatch, 2021). Industry data show that about 58% of the India population practice agriculture which is quite susceptible to varying rainfall and drought affecting food security as well as the incomes of farmers (Gupta & Singh, 2019). (Shukla et al. 2020) Growth in temperature and climate change will irreversibly impact the Indian economy by worsening conditions for agriculture and reducing the crop area by 15-18% for the major crops by the year 2050. The immense population of India along with single dependence on construction activities sensitize the society for important strategy relating both manufacturing and construction for change (Kumar & Ramesh, 2018). These policies have aimed at national upgrades policies on climate change for sustainability and optimal solutions focusing on renewable options (Government of India, 2021).

Environmental Dimensions

In India, climate changes have resulted into increase in the temperature coupled with high variability of monsoons and increased frequency of extreme weather, which is a clear threat to the environment. Temperatures have been on steady rise of about 0.7°C from 1901 and anticipated to even increase to 4.4°C at the end of the century if high emissions are maintained (Kothawale et al. 2019). Monsoons have also become more unpredictable and uneven, with some areas experiencing 10% less precipitation over the last several decades. This variability has effects on agriculture, water resources and food security and is believed to be associated with the Indian Ocean's Sea Surface Temperatures (SST), which are warmer than normal, changing regular monsoons and causing droughts and floods at the same time (Roxy et al., 2017; Gupta & Ramesh, 2018).

Severe weather conditions like heavy downpour are common in India and such changes have been attributed to climate change as India suffers extreme rainfall resulting into widespread floods in both urban and rural areas. For instance, the Kerala floods of 2018, displaced over one million people and caused $4.4 billion in damages (Germanwatch, 2021). Another climatic abnormality bound to increase heatwaves which are predicted to increase by 25% by the year 2030 thus contributing to potential economic losses to the tune of about 450 billion dollars due to decreased productivity (Shukla et al., 2020). Further, cyclonic storms

India is experiencing intense destruction to its natural habitats, ecosystems, and resources owing to climate change. In India, there has been a triggered migration of certain species while others

face the threat of extinction due to shifts in ecosystems caused by temperature increase along with irregular patterns of rainfall. There are extreme areas of biodiversity hot spots such as the Western Ghats, and the Himalayas regions that have recorded that a quarter to a third of the Indian plant and animal species are likely to die out as their habitats are destroyed (Rao et al., 2020; Ghosh & Singh, 2021). The rivers such as Ganges, Brahamaputra, and Indus are also under threat due to the accelerated melting of glaciers in the Himalayas that will dry up the water source relied upon by over 600 million people for drinking and farming purposes (Patel & Chaturvedi, 2021).

Forests which occupy around 24% of the area in India are facing threats which lead to deforested areas as a result of increase in temperature and unsustained rainfall which establishes a negative loop to their ability to sequester carbon (Kumar et al., 2019). Coastal Ecosystems continue to be pessimistically impacted by the steady rise in sea levels, which has steadily increased at a rate of 1.3 mm, and tends to endanger wild mangroves, coral reefs, and over 45 million people's lives who live in regions that are prone to flooding (Germanwatch, 2021). Sundarbans, mangrove-shrouded paddy-growing regions that can thwart cyclones, are getting smaller as sea rises.

Climate change is impacting India in several ways and still this is present in one country alone have widespread impacts. Increasing sea levels coupled with increasing cyclones pose a threat to millions of people in the country. The Indian coastline is likely to experience 0.8-meter rise in sea levels by the end of the century which will lead to the forced migration of about 45 million people. The cities of Mumbai, Chennai and Sundarbans already face floods and saline intrusion at different intervals of time at different levels (Roxy & Sharma 2018). There has been a reduction in mangrove coverage of nearly 24% in Sundarbans in thirty years which essential for protection against storm surges (Germanwatch 2021). On the other hand, droughting regions like Maharashtra and Rajasthan are starting to face even more problems than ever; now about 40% of land in India is drought-prone along with of course water scarcity with consequential agricultural collapses and economic losses of up to two billion dollars annually (Goswami & Singh 2019; Kumar et al. 2019).

As a result of these differing effects of climate change which persists at times, there is a clear need for increased targeted measures of adaptation. India faces the threat of losing its biodiversity and undervaluing its resilience while providing decent livelihood for the people within an increasing number of climate threats with a projected cost for adaptation with $2.5 trillion by the year 2030 (Sharma 2021).

Economic Dimensions

Climate change is having an increasing impact on India with visible consequences on food security, cropping pattern, productivity, and economic sectors. About 17% was the contribution of agriculture to India's economy while it employed about 58 percent of its population, based on the second National Agriculture Census. As far as India is concerned, around 80% of total annual rainfall is concentrated on the monsoon (Gupta & Singh, 2019). However, irregular monsoon patterns due to climate change have caused imbalances in the distribution of rainfall which has in turn disrupted crop and planting calendars. Research suggests that a decrease in monsoon rainfall can be associated with losses in crop productivity of about 5-10% for staple crops such as rice and wheat (Roxy et al., 2017). Moreover, the changes in temperature as a result of climate change may push wheat production down further by around 5 million tons a year, increasing the already limited food security (Kothawale et al., 2019).

Farmers are beginning to abandon paddy farming and cultivating drought resistant crops such as millet in semi-arid zones, due to the changes in the cropping systems (Sharma & Patel, 2021). Farmers report a $9 billion annual economic loss from agriculture arising from climate-related risks, affecting their income levels and rural sectors as a whole (Shukla et al., 2020). These are most impacts are evident in the drought affected states like Maharashtra and Rajasthan, where rainfall deficits and depletion of groundwater resources have diminished derrota- paddy cultivation in these states.

Apart from agriculture, others Indian industries like fisheries, tourism and energy are also affected due to climate change all of them are of great economic importance. Fisheries are especially at risk from increased sea surface temperatures and ocean acidification as these alter fish population and breeding patterns. The warming Arabian sea has resulted in decreased population of Indian mackerel and other species, gravely, affecting nearly 3.9 million in the fishery sector (Gupta & Chaturvedi, 2020). It is believed India's fish stocks are expected to decrease by 10 to 30% by the year 2050 as the oceans keep warming and corals keep bleaching putting food sources and incomes of coastal communities at risk (Patel et al., 2019).

Tourism sector which accounts for around 9.2% of the Indian GDP and also provides employment for more than 42 million people is threatened by climate impacts like increase in temperatures, and extreme weather conditions (Ghosh & Singh, 2021). Major hotspots of tourism including the Himalayas and coastal regions have registered increases in mudslides and floods as well as loss of coral reefs which may reduce the tourist numbers and consequently economically disadvantage the host communities. If the current global warming trends continue and glaciers melt at the same rate, tourism in the Himalayas will decline by up to 20% by 2030 (Shukla & Ramesh, 2018).

The rising temperatures coupled with increased water scarcity due to climate change certainly poses a few challenges for the energy sector but at the same time it also opens up new arenas for energy production. Coal and for that matter even hydropower plants are predicted to see at least a 5-10 percent drop in energy output from water-scarce regions (Kumar et al., 2019).Therefore, in order to fulfill the growing energy needs of its people and curb further greenhouse emissions, India has quickly integrated itself into the renewable energy sector with plans to establish 450 GW of renewable capacity by 2030 (International Energy Agency, 2020).This change is vital since by 2030 urban areas could permanently be in a state of high electrical consumption demand reaching levels of 15% over its 2016 levels (Sharma, 2021).

The rural economies with basic agricultural practices stand to lose $9 Billion seeing that crops would cease to grow due to climate changes. Sharma et al. 2021. This brings about more debt to the indigenous farmers pushing a large number of people to instead move into urban centers shifting the population density to cities (Shukla et al., 2020). Floods and increased sea levels destroy the essential infrastructure for most economic activities of cities leading to increased $30 billion every year (Germanwatch, 2021). Mumbai and Kolkata are two coastal cities that will be particularly affected as both are under consistent risks of flooding

Government and Policy Response

The National Action Plan on Climate Change or NAPCC known to have a been adopted on June 30, 2008 is one of the phases of India's systematic and holistic response to climate change through eight National Missions which include solar energy, energy efficiency and sustainable agriculture among others. The objective of this plan is to cut back on greenhouse gas emissions, create climate resilient investments, and shift towards a low carbon economy. Policy measures aim at achieving 500 GW of renewable energy capacity and emission intensity of GDP reduced by 33-35% by the year 2030. Post the achievements owing to the reaching of more than 100 GW in active renewable capacity by 2021, hindrances like, coordination errors and finance gaps that have been approximated at $2.5 Trillion by the year 2030 has not evolved into deterring factors for bettering direction (Chandel et al., 2016). Based on the NAPCC, the GIM was established in order to deal with climate change through increasing carbon sinks in forests and increasing climate change adaptation of forest-dependent communities. The GIM supports bottom-up governance decentralization and citizen participation; however, it could also result in commercialization of the forest leading to change in how the communities interacted with the ecosystems. The GIM has cumulatively planted over over 155,130 hectares across 17 states and one Union Territory, with an allocation of Rs. 909.82 crore for its initiatives, thereby contributing to India's broader climate action objectives(Jha, S., 2012).

There are also efforts such as the National Electric Mobility Mission Plan (NEMMP-2020) that was launched on January 9, 2013, which envisages the promotion and sale of 6-7 million electric vehicles in 2020. This mission also targets the reduction of 2.2-2.5 million metric tonnes of liquid fuel while reducing CO2 emissions. Moreover, the NEMMP has been quite instrumental in increasing sales of electric two-wheelers, building up charging infrastructure, and enabling demand subsidies for electric vehicles including the approval of e-buses for intracity and intercity operation (Srikanth, R., 2018). Finally, the Jawaharlal Nehru National Solar Mission JNNSSM) further reinforces the above efforts by advocating for growth in clean energy to improve the energy security of the people of India. The focus of the mission includes the development of grid solar and off-grid solar with the success depending on adequate subsidy, organizational backing, and awareness of the public. That said, although India is ranked third with regards to the amount of solar energy produced, the country did not meet the target of 100 GW. The country faced challenges which included lack of financing, land acquisition constraints and dependence on foreign sourcing of solar components mostly from clients from China (Kaur, R., 2016).

Future Projections and Recommendations

The emphasis in future projections on climate change adaptation and the development of new technologies is on the increasing role of eco-bricks and Direct Air Capture (DAC) technologies. Eco-bricks made of waste PET bottles with combination of inorganic waste have been projected to gain in popularity as a cheap construction material in areas that have no industrial recycling (Antico et al, 2017). On the other hand, the increasing interest in DAC technologies globally will trigger considerable resources and creativity towards reduction of carbon dioxide in the atmosphere. The emergence of such supports as tax credits and policies will likely speed up the expansion of the already existing DAC companies as well as the formation of new companies. Furthermore, catalytic converters will remain essential in the transport sector in addressing emissions, allowing for the move towards green vehicles and assisting in global sustainable development objectives.

In order to fill the deficiencies of the Indian perspective of NAPCC, there are a number of recommendations which can increase effectiveness of climate action within the country. Such approaches include but are not limited to: improving finances and resources for the development and diffusion of clean technologies, improving coordination between climate policies which are implemented at the central and state levels, and establishing effective tracking and accountability frameworks. There should be public-private collaborations so that investment and know-how from the industry can be utilized while local populations through awareness and skills initiatives are critical for the success in the long run. Other areas of focus which are likely to be significant in reaching the desired climate change adaptation and sustainability targets will be the support for research and development in modifying current technologies and policy advocacy to support development of green technologies.

Conclusion

India faces serious challenges due to climate change. Extreme weather events are one of the many environmental impacts that have posed the need for action. Heatwaves have an economic effect as they increase vulnerabilities of productivity, and agriculture which employs a large proportion of the population is also at risk from changing rainfall regimes. Coastal areas are submerged by rising sea levels while the frequency of droughts is making the water supply limited. Solving all these interconnected problems will demand multifaceted approaches, sound and effective policies, and synergetic interactions among the state, the business community, and the society at large in order to create a relevant and durable future for India.

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