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Economic Burden of Climate Change in India: A Review

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ABSTRACT

The economic burden of climate change in India is a multifaceted challenge with wide-ranging implications across agriculture, health, infrastructure, water resources, and energy sectors. Rising temperatures, erratic monsoon patterns, and the increased frequency of extreme weather events—such as floods and droughts—are placing significant stress on the country's economy. Agriculture, which employs nearly 50% of India's workforce, is particularly vulnerable, with studies estimating a potential GDP loss of 1.5% to 2% annually due to declining yields and productivity. Health costs related to heat stress, vector-borne diseases, and malnutrition are also projected to rise, exacerbating social and economic inequalities. Coastal regions and megacities face mounting adaptation costs to protect infrastructure from sea-level rise, cyclone and flooding. The review highlights that the venerable populations, who contribute the least to greenhouse gas emissions—are disproportionately affected. The paper underscores the need for integrated economic modeling, region-specific adaptation strategies, and stronger climate finance mechanisms. It emphasizes the urgency of embedding climate resilience into development planning and highlights the long-term economic benefits of transitioning to low-carbon pathways.

Keywords : Climate change, economic burden, health, agriculture, food security, urban development, energy sector, social inequality, infrastructure, economic growth

INTRODUCTION

Climate change is widely recognized as the most significant threat to human security and global economic stability. Its impacts extend beyond environmental degradation, posing serious economic challenges across multiple sectors. The economic costs arise from extreme weather events—including heatwaves, floods, droughts, and cyclones—rising sea levels, biodiversity loss, declining agricultural productivity, and mounting healthcare expenses.

According to the Intergovernmental Panel on Climate Change (IPCC, 2021), without urgent global mitigation, climate change could result in economic losses amounting to trillions of dollars by the end of the 21st century. Developing countries, especially in Asia and Africa, are particularly vulnerable due to their high

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dependence on climate-sensitive sectors such as agriculture, fisheries, and natural resources, combined with limited adaptive capacity (World Bank, 2022).

One of the most immediate economic consequences of climate change is damage caused by extreme weather events. In 2023 alone, global climate-related disasters led to economic losses exceeding $313 billion, of which $119 billion were insured losses (Munich Re, 2024). The increasing frequency and intensity of such disasters not only strain national budgets but also impede long-term development and economic growth. Historical examples underscore the magnitude of these losses—Hurricane Katrina (2005) inflicted over $160 billion in damages to the U.S. economy, while the 2022 floods in Pakistan caused more than $30 billion in losses, displacing millions and intensifying poverty (UNDRR, 2023).

Beyond immediate destruction, climate change contributes to long-term economic disruptions through sea level rise, loss of biodiversity, and a decline in ecosystem services. Rising temperatures and erratic precipitation patterns adversely affect agricultural yields and water availability, threatening food security and increasing the risk of famine. These disruptions affect both developed and developing nations, but the economic toll is particularly severe for low- and middle-income countries due to their economic reliance on agriculture and tourism. According to the World Economic Forum (2021), the global economy could shrink by up to 18% by 2050 if no action is taken. Furthermore, the financial sector faces growing exposure to climate-related risks, with increasing insurance claims, unstable investment portfolios, and rising costs of climate adaptation (Bank of England, 2020).

India, one of the world's fastest-growing economies, is especially vulnerable to climate-induced economic shocks. Rising temperatures, unpredictable monsoons, sea level rise, and frequent natural disasters threaten India's infrastructure, livelihoods, and GDP growth. A report by the Reserve Bank of India (RBI, 2023) estimates that climate change could reduce the country's GDP by 2.5% to 4.5% annually by 2030 in the absence of mitigation strategies. Sharma et al. (2022) projected that even with global warming limited to 2°C, India's GDP could decline by 2.6% by 2100, escalating to a 13.4% loss under a 4°C increase, primarily due to adverse effects on labor productivity, precipitation, and temperature.

The economic cost of climate-related disasters in India is already evident. For instance, floods alone have caused losses of approximately $4.2 billion, with projected urban property damage ranging from $157 billion to $535 billion. The GDP impact could exceed $84 billion, demonstrating the magnitude of economic vulnerability (Ganesh et al., 2024).

Key sectors such as agriculture, infrastructure, energy, and healthcare are especially at risk. Crop failures, damage to transport and power systems, climate-sensitive diseases, and heat-related illnesses collectively threaten economic stability and exacerbate poverty. Millions of livelihoods, particularly among informal workers and rural populations, are at risk.

PUBLIC HEALTH

Climate change is emerging as one of the greatest public health challenges in India, significantly increasing mortality and morbidity rates, especially among vulnerable populations such as the elderly, children, women and those in low-income and informal labor sectors (Saunik& Shaw, 2024). The economic impact of climate-induced health crises is profound, with increasing healthcare costs, loss of productivity, and damage to livelihoods across sectors—particularly agriculture and urban informal employment.

The rise in extreme weather events—particularly heatwaves, floods, and droughts—has exacerbated health issues and overburdened India's healthcare infrastructure. Between 2014 and 2023, individuals over 65 experienced an average of 8.4 days of heatwave exposure annually, a 58% increase from the 1990s. In 2023 alone, heat-related productivity losses were estimated at $141 billion, with the agricultural sector accounting for $71.9 billion of these losses (The New Indian Express, 2024; Climate Connection, 2023). The Ministry of Health and Family Welfare (MoHFW) reported over 24,000 heatstroke cases and nearly 3,000 deaths due to extreme heat in 2022 (MoHFW, 2023).

Rising temperatures also correlate with an upsurge in cardiovascular diseases and other heat-related illnesses. According to The Lancet Countdown (2021), more than 25,000 deaths occurred due to extreme heat between 1990 and 2020. These health emergencies are not only causing human suffering but are placing a severe financial burden on the healthcare system.

Vector-borne diseases like malaria and dengue are expanding their geographic and seasonal range due to

warmer and wetter conditions. The transmission potential of dengue-carrying mosquitoes has risen by 85% since the 1950s, escalating healthcare demands (CAG, 2023). Treating these diseases now adds approximately $3 billion annually to India's healthcare expenditures (WHO, 2022). In 2023, over 90% of India was at risk from extreme heat, further compounding public health and vector-borne disease threats (Debnath et al., 2023).

Air pollution, intensified by climate change, remains a major contributor to premature deaths and economic losses. In 2019, air pollution caused approximately 1.67 million deaths, accounting for 17.8% of India's total deaths (Vohra et al., 2021). WHO (2023) estimates that air pollution contributes to over 1.6 million premature deaths annually, resulting in economic losses of ₹ 7 lakh crore (approximately $85 billion) each year.

Furthermore, climate change indirectly affects health by increasing food and beverage costs. Droughts in Vietnam and Brazil have caused coffee prices to hit 50-year highs, and similar climatic shocks have raised the prices of tea, cocoa, and rice (The Times, 2024). These price increases strain household budgets, especially among the poor, leading to undernutrition and long-term health consequences.

A Duke University study showed that India lost 259 billion labor hours annually between 2001 and 2020 due to global warming, costing the economy $624 billion (CAG, 2023). Without urgent mitigation and adaptation strategies, cumulative climate-related damages could reach $35 trillion over the next 50 years (CAG, 2023).

AGRICULTURE AND FOOD SECURITY

Climate change poses a severe and escalating threat to agriculture and food security in India, where over 50% of the population relies on agriculture for their livelihoods. Being one of the most climate-sensitive sectors, agriculture is vulnerable to rising temperatures, erratic rainfall, frequent extreme weather events, and the growing unpredictability of the monsoon season. These changes have led to decreased crop productivity, increased economic burden on farmers, and greater stress on national food security systems.

India's agricultural output is critically dependent on the southwest monsoon, which contributes nearly 75% of the country's annual rainfall. However, due to climate change, this monsoon pattern has become increasingly erratic. According to the Ministry of Earth Sciences (2020), there has been a 6% decline in monsoon rainfall over the last 60 years. This decline, coupled with rising temperatures, affects major crops like wheat, rice, pulses, and oilseeds. A study by ICRIER (2022) revealed that a 1°C rise in temperature could reduce wheat yields by up to 6%, significantly impacting national food production and rural incomes.

Extreme weather events have further compounded the challenges. Floods, droughts, and cyclones are becoming more intense and frequent, damaging standing crops and disrupting supply chains. For example, in 2023, unseasonal rainfall and floods caused crop losses across Maharashtra, Punjab, and Odisha, with estimated damages exceeding ₹ 25,000 crore (~$3 billion) (MoAFW, 2023). These losses force farmers to invest in costly adaptive measures such as irrigation systems, resilient seed varieties, and insurance coverage—expenses that most small and marginal farmers cannot afford.

Food inflation is another major consequence. Reduced agricultural output due to climate anomalies results in supply shortages, leading to higher food prices. The Reserve Bank of India (2023) noted that climate variability is a major driver of food inflation in fruits, vegetables, and cereals. This not only affects purchasing power among the poor but also worsens malnutrition, especially among children and women. According to ICAR (2023), wheat and rice yields could drop by 6–12% by 2050, leading to further food insecurity and economic stress.

The impact extends to allied sectors like livestock and fisheries. Rising temperatures reduce milk yields and increase the incidence of livestock diseases, while warmer oceans disrupt fish breeding, reducing fish catches. These combined effects weaken rural food diversity and income stability, adding to the economic burden.

Furthermore, studies show that climate change has already caused a loss of 259 billion labor hours annually between 2001 and 2020 due to heat-related stress, costing India approximately $624 billion (World Bank, 2019). Heat stress is projected to significantly reduce labor productivity in agriculture and outdoor sectors, contributing up to 50% of future GDP loss in high-emission scenarios.

Overall, agriculture, which contributes around 18% to India's GDP and employs nearly 43% of its workforce,

faces an existential threat from climate change. Without urgent adaptive measures, India could witness a 16% drop in agricultural output and a GDP decline of 2.8% by 2030 (Sharma et al., 2022). Strengthening climate resilience in agriculture is thus vital for economic stability, food security, and rural livelihoods.

INFRASTRUCTURE AND ECONOMIC GROWTH

Climate change has emerged as a formidable threat to India's infrastructure and economic growth, imposing a growing financial burden on both public and private sectors. As India urbanizes rapidly and pursues ambitious development goals, the country's critical infrastructure—including transportation networks, energy systems, urban housing, and water management—is increasingly vulnerable to climate-induced stresses. The rising frequency and intensity of extreme weather events such as floods, heatwaves, cyclones, and sea-level rise are already causing significant damage to physical assets and disrupting key economic activities.

According to the National Disaster Management Authority (NDMA, 2022), India suffers average annual losses of around $10 billion due to climate-related disasters, with infrastructure damage accounting for a major portion of these losses. Events like Cyclone Amphan (2020), the 2023 Mumbai floods, and the Chennai deluge have caused widespread destruction to roads, railways, power grids, housing, and water systems, resulting in significant reconstruction costs. In 2023 alone, urban flooding in India's metropolitan regions caused economic losses estimated at ₹ 35,000 crore (~$4.2 billion), severely impacting both livelihoods and regional productivity (Ganesh et al., 2024).

Urban centers such as Mumbai, Chennai, and Kolkata are particularly at risk due to their coastal locations and high population density. The World Bank (2020) estimates that by 2050, over 36 million people living in Indian coastal cities could be exposed to sea-level rise, necessitating over $200 billion in investment to protect critical infrastructure. Moreover, increased rainfall intensity overwhelms outdated drainage systems, contributing to recurrent flooding, property damage, and transportation paralysis. The National Institute of Disaster Management (NIDM, 2023) projects that sea-level rise alone could lead to annual infrastructure losses exceeding ₹ 1.5 lakh crore ($18 billion) by 2050 if adaptation measures are not scaled up.

Heatwaves also pose a serious challenge. The structural integrity of roads, railway tracks, and buildings is compromised under high temperatures, while energy demand for cooling surges. This leads to grid stress and outages, especially in regions dependent on hydropower, which is itself affected by erratic rainfall and glacial melt. According to Debnath et al. (2023), the life span of key infrastructure assets is expected to decline due to extreme heat, escalating maintenance and replacement costs. The Council on Energy, Environment and Water (CEEW, 2021) warns that disruptions in power supply from climate impacts could reduce India's GDP by up to 1.2% by 2050.

The broader macroeconomic implications are alarming. Climate-related damage to infrastructure and disruptions to production and trade reduce long-term growth and increase economic inequality. The Reserve Bank of India (2023) estimates that India could experience an annual GDP loss of 2.5–4.5% by 2030 due to cascading climate impacts. A long-term projection by Sharma et al. (2022) warns that in a high-emissions scenario, India's GDP could shrink by up to 13.4% by 2100.

Furthermore, adapting to climate change comes at a high cost. The Ministry of Finance (2021) estimates that India needs over $200 billion annually until 2030 to build climate-resilient infrastructure. However, the financing gap remains significant, straining public budgets and diverting resources from essential development initiatives. Unless robust investments in climate-resilient infrastructure are prioritized, India's economic growth and sustainable development goals will remain critically undermined.

URBAN DEVELOPMENT

Urban development in India faces mounting economic challenges due to the intensifying impacts of climate change. With over 35% of its population living in urban areas and this figure projected to rise to 40% by 2030, India's cities are at the frontline of climate-related risks such as floods, heatwaves, water scarcity, and sea-level rise (UN-Habitat, 2022). These climate-induced stresses impose a severe economic burden on urban infrastructure, housing, utilities, public health, and service delivery, threatening the long-term sustainability of urban growth.

One of the most direct impacts of climate change on urban areas is flooding, which severely damages roads, drainage systems, housing, and livelihoods. The

increased frequency and intensity of heavy rainfall events, coupled with poor urban planning and inadequate drainage systems, make Indian cities like Mumbai, Bengaluru, and Chennai highly vulnerable. In 2023, urban flooding alone caused economic losses estimated at ₹ 35,000 crore (~$4.2 billion) in major metropolitan regions, disrupting businesses, displacing residents, and damaging infrastructure (Ganesh et al., 2024). According to the National Institute of Disaster Management (NIDM, 2023), such incidents are expected to increase in frequency, with potential economic losses in urban areas exceeding ₹ 1.5 lakh crore ($18 billion) annually by 2050 without significant mitigation.

Heatwaves are another growing challenge, particularly in densely populated cities. The India Meteorological Department (IMD, 2022) reported a significant increase in the frequency and duration of heatwaves in urban areas. These conditions increase energy demand for cooling, strain water resources, reduce labor productivity, and elevate public health costs. According to a study by Singh et al. (2022), heat stress could reduce labor productivity in cities by up to 25%, especially in outdoor sectors like construction, waste management, and transport, directly impacting urban economic output.

Urban housing, particularly in low-income and informal settlements, is disproportionately affected by climate change. Slum areas are often located in flood-prone zones or heat islands, where exposure to environmental hazards is high. Climate events exacerbate housing insecurity, displacement, and public health issues, leading to increased demand for state-led rehabilitation, public health interventions, and emergency services (Bharadwaj & Pandey, 2023). According to the Ministry of Housing and Urban Affairs (2022), over 68 million urban residents live in vulnerable housing, and the cost of climate-proofing slum housing could exceed ₹ 2 lakh crore ($24 billion) by 2030.

Water scarcity, exacerbated by erratic rainfall and groundwater depletion, further strains urban development. Cities like Delhi and Bengaluru are already facing periodic water crises that impact domestic consumption, sanitation, and industrial production. A NITI Aayog (2021) report estimated that 21 major cities in India could run out of groundwater by 2030, with urban water demand projected to double by then. The economic cost of addressing urban water insecurity through desalination, water recycling, and infrastructure upgrades is substantial, putting pressure on municipal finances.

The World Bank (2020) estimates that climate-related impacts could cost Indian cities $1.5 trillion by 2050 if adaptive infrastructure and planning are not implemented. Despite growing awareness, many urban local bodies lack the financial and technical capacity to invest in climate-resilient infrastructure. This results in delayed development projects, cost overruns, and increased dependence on state and central government support.

SOCIO-ECONOMIC INEQUALITY

Climate change has increasingly become a catalyst for deepening socio-economic inequalities in India, disproportionately affecting marginalized populations who possess limited adaptive capacity and economic resilience. As one of the most climate-vulnerable nations, India's existing disparities in income, education, access to health care, and housing are magnified by the adverse effects of a warming planet. Climate-induced challenges such as extreme heat, floods, droughts, and erratic rainfall have intensified the vulnerability of rural communities, informal sector workers, and socially disadvantaged groups, thereby perpetuating and widening existing social and economic divides.

According to the Intergovernmental Panel on Climate Change (IPCC, 2022), climate change acts as a "threat multiplier" by exacerbating poverty, inequality, and social tensions. In India, this is evident as climate impacts are more pronounced among people who rely heavily on climate-sensitive sectors like agriculture, fisheries, and construction. A study by CEEW (2021) found that over 80% of India's poor live in districts that are highly vulnerable to climate extremes. These populations often lack insurance, savings, and access to quality infrastructure, making recovery from climate shocks far more difficult and slower compared to wealthier counterparts.

Rural populations, particularly smallholder farmers, are among the most affected. Frequent crop failures due to droughts, floods, and heatwaves have led to increased indebtedness and migration to urban areas, where informal jobs offer little social protection. Sharma et al. (2022) noted that these climate-induced displacements are largely unplanned and often result in migrants living in substandard conditions with limited access to water,

sanitation, and health services. Consequently, not only does climate change affect income security, but it also fuels urban poverty and puts additional pressure on public infrastructure.

Urban areas, too, are not immune. Climate impacts are unevenly distributed across cities. Informal settlements, often located in low-lying, flood-prone, or heat-prone areas, are at high risk. During heatwaves, for instance, residents in slums suffer higher exposure due to poor housing quality, lack of ventilation, and limited access to cooling systems. A report by the National Institute of Urban Affairs (NIUA, 2023) highlighted that the poorest urban households in cities like Delhi and Ahmedabad face higher mortality rates during heatwaves compared to wealthier areas, underscoring how infrastructure inequality amplifies climate risk.

Health inequality is another dimension of this burden. The Lancet Countdown Report (2022) pointed out that climate-related diseases such as vector-borne infections and respiratory issues from air pollution are more prevalent among the poor, who have limited access to healthcare facilities and insurance coverage. Climate change thus not only reduces their income and food security but also increases their health expenditures.

Additionally, gender inequality is reinforced under climate stress. Women, particularly in rural India, bear the brunt of water and food insecurity, as they are primarily responsible for household water collection and subsistence agriculture. UN Women India (2021) reported that climate stress increases women's unpaid labor and reduces their opportunities for education and income-generating activities.

ENERGY SECTOR

Climate change poses a significant economic burden on India's energy sector, which is both a major contributor to greenhouse gas emissions and a critical victim of climate-induced disruptions. As energy demand continues to rise alongside economic growth and urbanization, climate-related challenges such as extreme temperatures, erratic rainfall, and glacial retreat increasingly threaten energy supply, infrastructure, and affordability. These disruptions affect both fossil fuel-based and renewable energy systems, resulting in higher production costs, reduced efficiency, and compromised energy security.

One of the most immediate impacts of climate change on the energy sector is the increased frequency and intensity of heatwaves. High temperatures raise electricity demand for cooling, particularly in urban areas, placing stress on power generation and distribution systems. According to the International Energy Agency (IEA, 2021), India's peak electricity demand could increase by 45% by 2040 due to rising temperatures alone. This results in higher operational costs, frequent blackouts, and overloading of grids, particularly during summer months. In 2022, India experienced record-breaking heatwaves that led to severe power shortages in several states, affecting industrial productivity and household welfare (Ministry of Power, 2023).

Thermal power plants, which account for over 60% of India's electricity generation, are particularly vulnerable to climate change. Rising temperatures reduce their efficiency, while water scarcity—exacerbated by erratic rainfall and declining groundwater levels—limits their cooling capacity. A study by the World Resources Institute (WRI, 2020) found that nearly 40% of India's thermal power plants are located in water-stressed areas, making them increasingly vulnerable to shutdowns. These disruptions translate into financial losses and reduce the reliability of energy supply across sectors.

Hydropower, another key component of India's energy mix, faces risks due to changing rainfall patterns, glacial retreat in the Himalayas, and increased sedimentation caused by extreme weather events. Irregular monsoon rains and flash floods can lead to either water shortages or dam overflows, destabilizing hydropower output. According to the Central Electricity Authority (CEA, 2022), hydroelectric generation in India declined by over 5% in 2021 due to erratic rainfall, resulting in a shift back to coal-based generation, which increased costs and emissions.

The renewable energy sector, despite being essential for climate mitigation, is not immune to climate variability. Solar photovoltaic (PV) systems may experience reduced efficiency during prolonged heatwaves or dusty conditions, while wind energy output is affected by changing wind patterns. Moreover, extreme weather events such as cyclones damage infrastructure, as seen during Cyclone Tauktae in 2021, which affected wind farms and transmission lines along the western coast, causing power outages and infrastructure losses exceeding $2 billion (NDMA, 2021).

The economic burden is further compounded by the financial requirements for climate adaptation in the

energy sector. According to the Ministry of Finance (2021), India needs over $30 billion annually by 2030 to climate-proof its energy infrastructure. This includes investments in grid modernization, resilient transmission systems, decentralized renewable energy, and disaster-proofing generation plants. Without these investments, climate change will continue to erode the reliability and affordability of energy, ultimately hampering India's growth and development goals.

CONCLUSION

Climate change presents a profound and multidimensional economic challenge for India, affecting key sectors such as agriculture, infrastructure, energy, urban development, and public health. The economic burden is not limited to immediate physical damages from extreme weather events like floods, droughts, heatwaves, and cyclones, but extends to long-term losses in productivity, GDP, and human development. According to the Network of Central Banks and Supervisors for Greening the Financial System (NGFS), if current global climate policies remain unchanged, India could face a GDP loss of up to 19% by 2050, significantly higher than the projected global average of 15%. By 2100, this could worsen to a staggering 30%, underlining the urgency of transformative action.

Acute physical risks—particularly droughts and heatwaves—are responsible for more than 75% of total losses in NGFS scenarios, further exacerbating India's vulnerabilities in agriculture, energy supply, and labor productivity. These cascading impacts fuel food insecurity, increase urban infrastructure strain, deepen socio-economic inequalities, and threaten national economic stability. Without effective mitigation and adaptation measures, India's aspirations for inclusive growth, poverty reduction, and sustainable development may remain unattainable.

However, this looming crisis also presents a strategic opportunity. The economic burden of climate change can serve as a catalyst for change—driving investment in green technologies, climate-resilient infrastructure, sustainable urban planning, and inclusive policy reforms. Strengthening early warning systems, promoting low-carbon energy, and building institutional capacity for climate governance can not only reduce climate-related losses but also foster innovation and generate green jobs.

Mitigation efforts, such as carbon pricing and transitioning to a net-zero economy by 2070, will be critical in reducing long-term damage. Simultaneously, adaptation strategies—like climate-resilient farming, water resource management, improved public health systems, and targeted support for vulnerable communities—must be accelerated to enhance resilience. These initiatives should be guided by integrated, multi-sectoral policies that align climate action with India's development goals.

Ultimately, the fight against climate change must be viewed not just as an environmental imperative but as an economic necessity. A globally coordinated response, supported by climate finance, technology transfer, and capacity building, is vital to mitigate the risks and secure a sustainable, equitable future. For India, the path forward lies in embracing a climate-smart development model that prioritizes both economic growth and ecological balance—ensuring prosperity for current and future generation.

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