Climate-Economic Country Risk Profile

India

The current pace of climate change has impacts that range from rising sea levels to extreme weather patterns, forcing governments around the world to grapple with two distinct types of risk: The physical risks of climate change include the potential destruction of land and infrastructure, lost productivity in the agriculture sector and the health impacts of heat stress and natural disasters. Minimising future impacts through decarbonisation, however, creates a set of transition risks as the economy adjusts to new regulations, energy systems and consumer sentiment. Managing these risks will entail mitigation measures that tackle the root causes of climate change – chiefly by reducing carbon emissions – and adaptation measures that build resilience to the impacts that cannot be avoided, such as investments in protective infrastructure.

The impacts of climate change pose a particular threat to emerging economies by eroding economic growth, jeopardising the security and freedom from want that underpin peaceful development. Mitigating the progress of climate change requires national policies to limit greenhouse gas (GHG) emissions, but these require substantial near-term investment, altering relative prices, patterns of trade, competitiveness and industrial development.

Successes and failures in this nexus also affect geopolitical, geoeconomic and security risks, not least due to their capacity to shape socioeconomic fortunes. This profile focuses on India as a country that faces high transition and physical risks simultaneously. This is the basis for India's double cost crunch – climate damages raise adaptation needs and can weaken revenues, while transition needs increase financing requirements precisely when capital remains expensive and public resources are under pressure. The result is a compression of near-term policy space at a critical stage of structural transformation. This profile highlights the geopolitical, geoeconomic and security dimensions of this predicament and offers recommendations.

BACKGROUND

The **GeoClimRisk** (The Geopolitics of Climate Risks) project examines how climate change, its economic impacts, and their interaction with geopolitics shape emerging security risks, with a focus on countries facing an intense "double cost crunch". It aims to inform international cooperation, policymakers and risk-management strategies.

The "**double cost crunch**" refers to the simultaneous economic pressure from climate damages and the low-carbon transition. Investments in green and decarbonised energy are widely recognised as a key engine of economic development, especially in energy-poor regions. However, substantial up-front investments demand scarce financial means with high financing costs.

The urgent need for **climate action** in India – in terms of both mitigation and adaptation – has been recognised, but success will depend on simultaneously diversifying energy, enhancing adaptation and resilient infrastructure, and implementing development and social protection.

Climate change amplifies **geopolitical tensions, humanitarian challenges and resource strain** in India and the wider region. Increasing biophysical and economic impacts further undermine the adaptive capacity to cope with these risks. To address these demands will require major investment, international cooperation and updated security planning.

PROJECT RESULTS

Higher financing costs and capital scarcity make India's **energy transition** slower and more expensive, especially because renewables need high up-front investment. As a result, coal and gas remain more competitive in the near term, which can raise electricity prices, reduce renewables deployment, and increase import dependency and emissions.

Climate change is projected to cause very large **GDP losses** in India under current policies, with substantial uncertainty around how long-lasting the damages will be. These losses would fall unevenly across society, hitting poorer households harder, and could also weaken the capital base needed for the green transition and other development goals.

An **ambitious climate policy** yields long-term benefits that far exceed near-term costs. Delayed mitigation, on the other hand, intensifies the double cost crunch as accumulated damages erode fiscal capacity precisely when financing is expensive and large up-front investments are needed. Disentangling these trade-offs improves investment timing and avoids misallocation, and allows the costs of swift mitigation to be viewed against the savings in future adaptation requirements.

Rising energy demand will increase India's reliance on imported oil and gas in the short to medium term, creating **geopolitical vulnerability**. Expanding electrification and renewables can reduce this dependence and strengthen resilience, but requires affordable finance for technologies, grids and storage. At the same time, severe climate impacts impose high damage and adaptation costs, burdening the economy and potentially limiting response capacity.

PIK
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A bustling street scene in Varanasi.

1. Country context

1.1. CLIMATE AND TRANSITION RISKS

India's population is projected to peak near 1.7 billion mid-century [1], compounding the challenge of sustainably fuelling a growing economy while managing escalating adaptation demands and loss and damage realities [2]. Due to its demographics, geographic exposure and heavy reliance on monsoon rains, South Asia has been designated a global climate vulnerability hotspot [3].

Core climate hazards and impacts

Extreme heat and public health: The rising frequency of extreme heatwaves and dangerous wet-bulb temperatures pose direct threats to human survivability. It also severely impacts labour productivity, particularly for India's vast informal outdoor workforce in agriculture and construction [3].

Water security and glacial melt: Glacier recession in the Hindu Kush Himalaya is altering seasonal freshwater availability. This destabilises major river systems like the Ganges and Brahmaputra, threatening downstream agricultural systems and long-term water security [4].

Agriculture and food security: The agricultural sector – which employs nearly half of India's population – remains highly sensitive to climate deviations. Shifting monsoon patterns, temperature anomalies and extreme weather events directly threaten crop yields and food supply chains [3].

Coastal and urban vulnerability: Rapidly growing coastal mega-cities face compounding risks from sea level rise, intense tropical cyclones and storm surges, which trigger severe urban flooding and threaten critical economic infrastructure [3].

Socioeconomic realities and adaptation

Climate disruptions act as a major macroeconomic drag, directly lowering potential GDP and altering demographic stability [5; 6]. Adverse weather shocks increasingly drive both distress migration toward prosperous urban centres [3] and stagnant localised rural mobility due to depleted household resources [7].

Mitigating these systemic risks and protecting vulnerable populations will require massive, coordinated public and private capital flows into climate-resilient infrastructure and adaptive agricultural practices.

1.2. ENERGY

Adaptation: Climate change affects both energy demand and supply in India. Rising temperatures increased the demand for electricity for space cooling [8] by 21% between 2019 and 2022. Peak demand has nearly doubled since 2010 [9]. This strains the national grid, especially during heatwaves, and many businesses and consumers regularly resort to diesel-based generators to cope with power outages.

Water stress can also suppress energy supply by affecting the performance of coal and nuclear power plants. Hydropower generation [10], a secondary but significant energy source, suffers as river flows become less predictable and high flow events challenge operations in the Himalayan basins. Further systemic stress arises from bottlenecks in coal transport due to flooding, compounded by the concentration of coal production in a few states and constrained transport infrastructure.

Grid modernisation to manage peak loads will need to be part of the adaptation response [11], alongside infrastructure adjustments to cope with water stress, extreme weather impacts and internal supply chain congestion.

Mitigation: The transport sector [12] continues to rely on high-emission fuels and over 70% of total power generation still depends on coal [13]. Coal remains central to India's development strategy and is often framed as a source of national wealth. An additional 90GW [14] of coal-fired capacity is planned to meet growing energy demand, but the sector faces structural inefficiencies [15]: the low quality of domestic coal results in relatively high costs, low efficiency and high air pollution, and is unsuitable for steel production. Coal production also suffers from low labour productivity and places significant pressure on transport infrastructure. In June 2026, India had an installed power generation capacity of 549GW, of which 52.5% came from renewable energy sources (solar, wind, biomass and hydropower). However, renewables accounted for only around 25% of the country's actual electricity generation mix.

Policy and regulatory frameworks further reinforce coal dependence. Long-term power purchase agreements with coal power generators, alongside relaxed air pollution regulations [17] merits coal power over renewables. When combined with transmission bottlenecks, this leads to high curtailment rates of variable renewable energy [16].

Mitigation efforts therefore require a transition towards diversified and low-carbon energy generation, including a decentralised renewable energy supply [11]. This will require reforms to the design of electricity markets and regulatory frameworks to enable greater integration of renewables. However, these investments must be made in a context where climate impacts are already constraining fiscal space by increasing sovereign risk and the cost of capital, while simultaneously raising public spending needs for social programmes and services.

1.3. POLICY

India's climate-linked risks are significant and require careful management. The National Action Plan on Climate Change (NAPCC) [18] provides an approach for both mitigation and adaptation, including policies on energy efficiency, water management and sustainable agriculture. Mitigation efforts focus on renewable energy, particularly supported by the National Solar Mission [19]. The National Nuclear Mission [20], Green Hydrogen Mission [21] and Bio Energy Programme [22] also support other low-emission energy sources. A bill to further support civil nuclear power generation by the private sector passed in late 2025 [23].

India has committed to achieving net-zero emissions by 2070 [24]. Its 2022 nationally determined contribution (NDC) and subsequent 2031–2035 NDC [25] pathways include a target of 50% non-fossil installed electric power capacity by 2030 – which has already been exceeded, reaching 52.57% by February 2026. While the updated 2035 contribution raises the target to 60%, the newer contribution [26] sets a 47% emissions-intensity reduction relative to 2005 by 2035. It also commits to creating an additional carbon sink of 3.5–4Gt of carbon dioxide equivalent (CO_2e) through additional forest and tree cover by 2035.

In 2025, India also adopted the Carbon Credit Trading Scheme (CCTS) [27], alongside mandatory compliance and voluntary offset approaches, and has set GHG intensity targets for nine energy-intensive sectors. However, the current level of near-term mitigation ambition remains limited relative to long-term net-zero objectives and projected growth in energy demand. Although India has overachieved part of its earlier [28] non-fossil installed-capacity target ahead of schedule, progress in installed capacity does not by itself resolve the slower decarbonisation of actual electricity generation, industry, freight, and end-use demand.

Domestic political economy dynamics still favour a carbon-intensive development pathway in important segments of the economy, slowing the scale-up of low-carbon alternatives and reinforcing policy bias toward incumbent energy systems. An Indian model assessment [29] finds that emission neutrality could still be achieved, but would require a massive ramp-up of climate policies following a phase of coal-based economic growth. This sequencing strategy is risky because it postpones mitigation action to a time when physical climate damages, infrastructure lock-in and adjustment costs may all be higher.

This is where the double cost crunch becomes policy-relevant: delaying the transition may protect near-term growth in carbon-intensive sectors, but it will increase the cumulative adjustments needed later. All the while, physical climate impacts are already raising adaptation costs and straining fiscal capacity. On the adaptation side, separate national missions under the NAPCC are being implemented to address sustainable agriculture, water, afforestation, sustainable habitat and Himalayan ecosystems. Initiatives such as the National Adaptation Fund for Climate Change [30] have prioritised water conservation, disaster management and climate-resilient agriculture at the state level. The Indian government is furthermore facilitating the preparation and implementation of Heat Action Plans (HAPs) across the country, integrating early warning systems, health sector preparedness, inter-departmental coordination and public outreach, albeit with mixed success [31].

Taken together, adaptation efforts remain insufficient relative to growing need, especially where repeated heat stress, water insecurity, urban exposure and agricultural sensitivity compound over time. Expectations also lie with the Union Budget on these fronts, and heatwaves are still not fully eligible for disaster relief funding [32] under the national framework. Overall, India's policy challenge is no longer the balance between adaptation and mitigation, but how to finance both under tightening development constraints.

1.4. SECURITY AND GEOPOLITICAL CONSIDERATIONS

Climate impacts can be categorised into short-term acute risks and long-term deterioration. Acute risks are related to extreme events or crises, whereas chronic risks result from recurring, intensifying conditions and structural changes with long-lasting effects. Gradually increasing impacts – especially those affecting economic growth – lower the capacity to recover from acute extremes, turning them into chronic problems.

Climate risks interact with geopolitical and security risks to pose new or more difficult challenges. India's security and geopolitical risks arise predominantly from border disputes, cross-border terrorism, illegal migration and regional competition (particularly with China). Economic asymmetry (including a large trade deficit with China), sea lane protection and relations with other powers (including Western partners) are also complicating factors.

Internally, more frequent or severe weather events put a strain on India's disaster response systems [33], with the more disaster-prone states struggling to generate revenue and manage post-disaster liabilities. Food insecurity and crop yield reductions affect livelihoods and can contribute to internal migration, local unrest [34] and urban strain [35]. In addition, extreme weather affects fuel supply chains, power generation, peak load pressures and transmission losses, putting additional strain on both energy and economic security. Extreme weather also disrupts mining, transport and port facilities that are integral to India's power system. Finally, a sustainable energy transition also depends on access to a range of critical resources, including minerals [36], some of which India has to compete for on the global market.

Climate impacts directly on security at India's borders, as changing weather patterns and melting glaciers affect coastal and mountain military [37] bases, and contribute [38] to miscalculation and patrolling issues with China. There is greater water conflict [39] with both China and Pakistan over scarcity in transboundary river systems. Furthermore, extreme weather impacts habitability in both India and neighbouring Bangladesh, which may contribute to bilateral migration flows [40] and additional strain in some regions [41]. In the Indian Ocean Region [42], maritime security is challenged by climate-linked stress on sea routes, fisheries and coastal infrastructure, which interacts with China's expanding presence in the region.

Chronic deterioration is reflected in statistics and estimations that relate economic data to climate variables and identify systematic relationships between variations in climate and economic variables. This econometric approach reveals substantial effects on today's GDP. Another way to estimate the chronic deterioration is to quantify the impact of climate change on productivities of various production sectors and then combine these effects in a general equilibrium model. This methodology also estimates the impacts of global warming on economic activity. Both methodologies are subject to uncertainties, which also means that the deteriorating effect of climate change on economic activity can be very strong.

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2. Results

Our research[1] explores how climate damages, the transition to a low-carbon economy, and their interaction in the double cost crunch might impact the geopolitics of India. It sheds light on some previously downplayed, yet critical, components of climate pressure, including various climate change impacts and their long-term persistence, the effect of capital market frictions on the total cost of the transition, and technological choices within the energy sector.

India is committed to moving to a low-carbon economy in the long term and has pledged to become emission-neutral[2] by 2070. In 2024–25, the majority of its additional energy needs were met for the first time by non-fossil fuel sources [43], especially renewables and nuclear. In pursuing these commitments, India faces several interlinked structural challenges [44], including the challenge of successfully integrating high shares of variable renewable energy into the grid, fragmented governance and land acquisition hurdles, just transition considerations, import dependence and limited storage deployment at scale. Finally, the structural legacy of coal [45] – including coal-based employment and sunk infrastructure – contribute to political and economic resistance to its phase out [46]. The high financing cost [47] of the transition to net zero demands high investment – USD 22.7 trillion by 2070 [24] according to NITI Aayog (the National Institution for Transforming India) – can increase fossil fuel import dependency and reduce the capital available for investment in renewables, storage and transmission. It also leaves India with a financing gap of over USD 6 trillion after accounting for aggregate flows from domestic and external sources available under normal circumstances.

Heatwave in Prayagraj.

2.1. IMPLICATIONS OF THE COST OF CAPITAL FOR THE ENERGY TRANSITION

India's energy sector – especially electricity generation – is dominated by fossil fuels, and demand is increasing steeply to power the country's economic development and eradicate poverty. The investment required to meet this demand will have to be drawn from the overall budget, thereby competing with broader economic interests. India also faces regulatory uncertainties and is cautious about opening its capital market.

These factors drive risk mark-ups that further exacerbate the general scarcity of capital. India's financing costs are therefore higher than in developed economies. This especially affects the development of renewable energy sources due to their high capital intensities, even though renewables are competitive. This can have significant geopolitical implications, as a slower deployment of renewables will prolong the use of fossil fuels, thereby increasing CO_2 emissions and import dependency.

Against this background, Figure 1 presents the annual electricity investments (left-hand panel) and total investments (right-hand panel) required for the electricity sector and the overall economy over the period 2025–2060 under a current climate policy scenario. The blue bars represent absolute investment levels, while the red lines (right axis) reflect their relative share of projected Indian GDP during this period under SSP2[3] assumptions.

As shown, substantial investments are required in the power sector, even under a current climate policy scenario. Absolute investment levels increase over time, but decrease as a share of GDP, reflecting higher projected GDP growth relative to the growth in electricity investment requirements. This pattern reflects the scarcity of capital in the short-term and, thus, its high economic value due to strong investment demand during this period. A similar pattern is observed for total investment

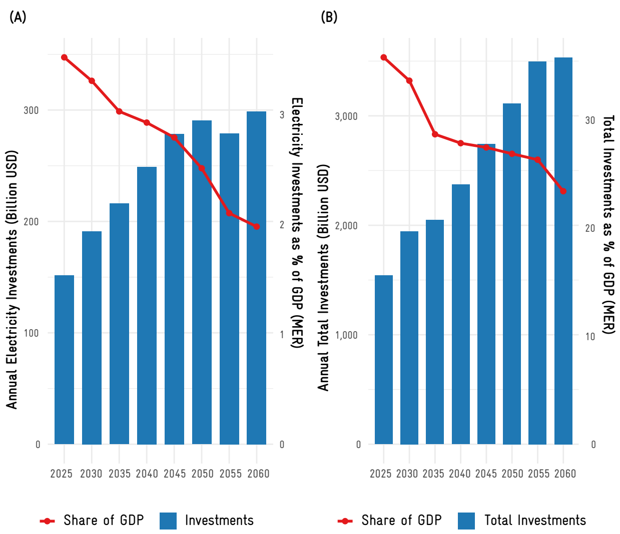

Figure 1. Annual electricity investments (panel A) and total investments (panel B) over the 2025–2060 period under a current climate policy scenario. Blue bars represent absolute investment levels on the left axis, while the red lines show their share relative to GDP (MER) on the right axis.

needs, although they are significantly larger (by a factor of approximately 10) in both absolute and relative terms, as they encompass investments across the entire economy beyond the energy sector.

To leverage the required investments, additional costs of capital arise as reflected by the weighted average cost of capital (WACC). These costs are incurred on top of transition requirements, increasing the overall cost of transforming both the energy system and the broader economy. Since WACC is applied to investment volumes, the resulting capital costs for economy-wide investments significantly exceed those for energy technologies alone. These additional costs can dampen economic growth and reduce energy demand. Moreover, their cumulative effect increases over time as capital stock accumulates, since financing costs apply to both current and past investments that remain within their lifetime.

Although much smaller in magnitude, WACC-related costs for energy investments can significantly influence technological dynamics in the power sector, as illustrated in Figure 3. This figure presents the cost-optimal power mix under scenarios with perfect (circles) and imperfect (triangles) capital markets up to mid-century. Both scenarios assume current climate policy ambition and SSP2 socioeconomic conditions for India. In the imperfect capital market scenario, heterogeneous risk premia are applied on top of the risk-free rate, whereas a uniform interest rate applies across the whole economy in the perfect capital market scenario. In other words, no additional capital cost is considered for low-carbon investments in the perfect capital market setting.

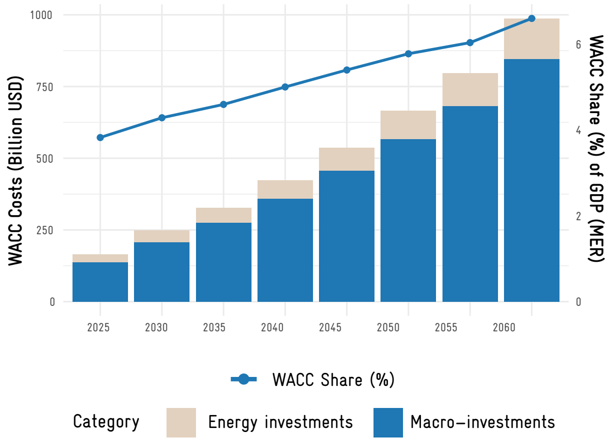

Figure 2. Annual cost of capital requirements over the period 2025–2060 for financing investments in the energy sector and the overall economy under a current climate policy scenario. Bars represent absolute values (left axis), while the blue line shows their share relative to Indian GDP (MER; right axis).

The results indicate that higher costs of capital reduce the deployment of wind and solar technologies, relying instead on coal and, to a lesser extent, gas. This is because renewable technologies are more capital-intensive, requiring higher up-front investment compared to fossil fuel technologies. The inclusion of capital costs therefore leads to a relatively higher levelised cost of electricity for renewables compared to fossil fuels, lowering the share of renewables in the power mix, lowering overall electricity production, and raising electricity prices. The increased use of fossil fuels can also increase import dependency by 5% in the imperfect market setting in 2050 compared to the perfect capital market scenario (from 40% to 42%).

These results should not be interpreted as forecasts of India's future power mix, as outcomes will depend on the level of climate policy ambition – renewable technologies would dominate the power mix under more ambitious climate scenarios. Instead, these results reflect the impact that capital markets may have on the technological choices within the power sector.

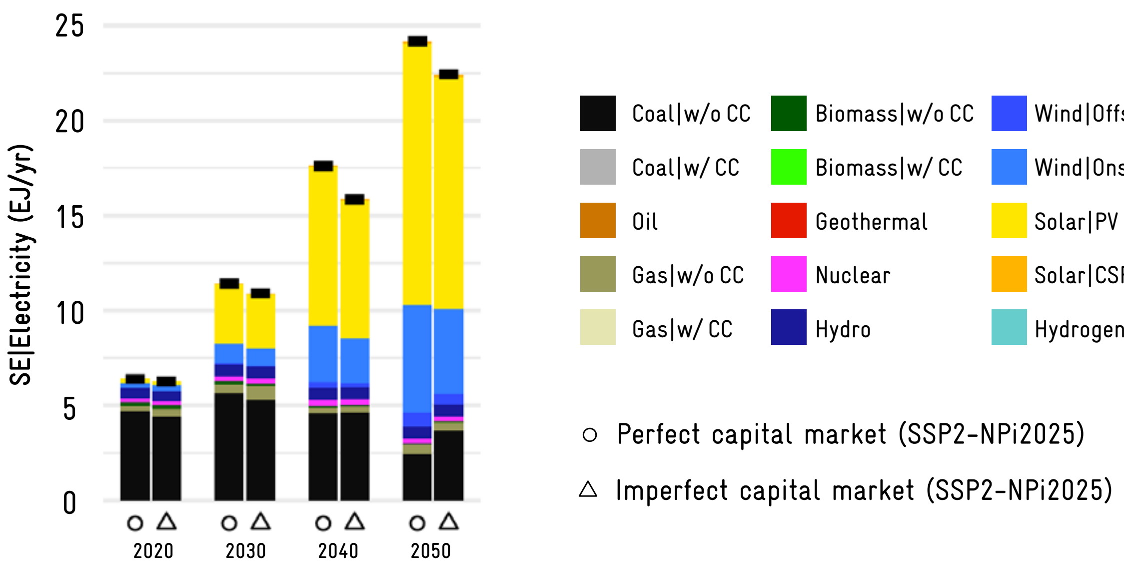

Figure 3. Cost-optimal Indian power mix up to the middle of the century under perfect and imperfect capital market scenarios, assuming current climate policy ambition and SSP2 socioeconomic conditions.

2.2. ECONOMIC DEVELOPMENT AND CLIMATE IMPACTS

Climate change affects economies and socioeconomic systems, for example through impacts on labour productivity, food security and health. Extreme weather events linked to climate change can also destroy property and infrastructure and exacerbate migration trends. The impact of changing climate conditions [39] and weather extremes [40] on economic growth in India [50] has already been assessed. We further highlight the economic impacts of (i) changes in terrestrial water storage linked to climate change and (ii) the effects on capital and labour. Finally, we integrate a published economic damage function into the integrated assessment model REMIND and derive the double cost crunch: the impact of climate effects and mitigation efforts on GDP (Sec 2.2.3). Note that the three economic impact channels are estimated using independent approaches (econometric estimates, bottom-up modelling, aggregate damage functions). While the first two illustrate the importance of looking at specific channels in detail, the latter combines more comprehensive damage estimates with mitigation.

2.2.1 Changes in terrestrial water storage

Terrestrial water storage (TWS) encompasses all freshwater resources on, above and below land. This includes groundwater, root zone soil moisture, surface water, snow, glacier ice and permafrost, as well as vegetation water [51]. TWS is an essential climate variable as defined by the World Meteorological Organization (WMO) and an important natural resource for food and energy production, manufacturing and ecosystem health. Satellite gravimetry-based methods have revealed substantial TWS changes over the past two decades, particularly in northern India [52]. The National Capital Territory (NCT) of Delhi and the state of Haryana have seen especially extensive TWS depletion [53].

Following the expansion of pumps during the Green Revolution in the 1970s [54], India has become the world's largest user of groundwater [53]. The Indus delta relies primarily on mountain snow and glacier melt for irrigation during the pre-monsoon season [55], but groundwater pumping for drinking water and irrigation is a main driver of TWS depletion in the northwest of the country [56]. Other key drivers of TWS depletion are climate factors such as droughts and declines in monsoon precipitation,[4] which decrease soil moisture [54] and increase pressure on groundwater resources through irrigation use [55].

To date, there has been no quantitative assessment of the economic impact of TWS changes, hampering the development of sustainable water management and adaptation strategies. Yet, such an assessment is needed to estimate the costs and benefits of sustainable water management decisions, in particular under future climate change. It also undermines any comprehensive estimate of the total cost of climate change. In a global analysis, we statistically evaluate Gross Regional Product per capita (GRPpc) data from more than 1,600 subnational regions worldwide [57], and map these to changes in TWS between 2004 and 2018 [58]. Using a fixed-effects panel regression model, we assess the effect of year-to-year changes in TWS on GRPpc growth[5] and arrive at heterogeneous results, with the highest negative economic impacts around the Caspian Sea and in northern India. Furthermore, a heterogeneity analysis based on machine learning suggests that regions with a high share of agricultural area, or low-income per capita, are economically more vulnerable to declining TWS [59].

This analysis informs preliminary estimates of the cumulative economic impacts of TWS changes in India at the subnational level, depicted in Figure 4. According to these estimates, Haryana, Punjab and the NCT of Delhi experienced the highest reductions in economic growth due to TWS decline (relative to a hypothetical scenario with constant annual mean TWS). While TWS reduction occurred in most regions, some experienced slight increases in TWS and are therefore estimated to have benefitted; these include Madhya Pradesh, Maharashtra, Chhattisgarh, Manipur and Mizoram [63]. Since these results build on a global average impact estimation, they should be complemented by local analyses; nonetheless, these estimations highlight the link between sustainable water management and economic costs and benefits in India.

With future climate change, India's water gap[7] is projected to increase dramatically, even for moderate warming scenarios [63]. This corresponds to increased pressure on TWS supply, potentially reaching the limits of possible groundwater extraction [64]. Hence, climate change has the potential to exacerbate the depletion of TWS by the very economic sectors that rely on it.

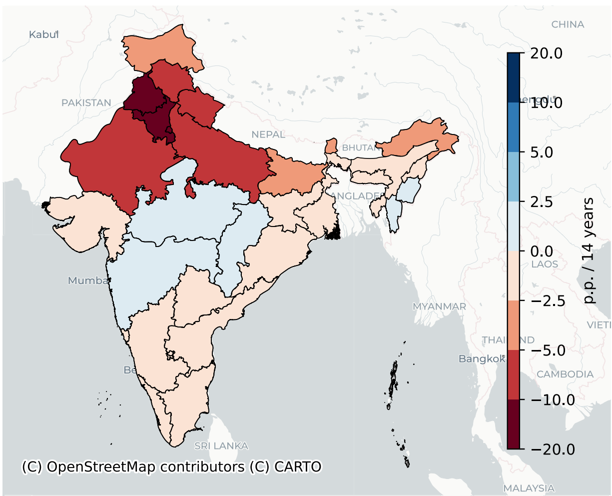

Figure 4. Preliminary cumulative difference in economic growth, relative to a counterfactual scenario with no TWS change, in percentage points (p.p.) (2004 to 2018).[6] Regions coloured in blue have likely benefitted from more TWS while red regions have experienced overall TWS decline, and therefore negative economic impacts (not necessarily implying negative growth rates).

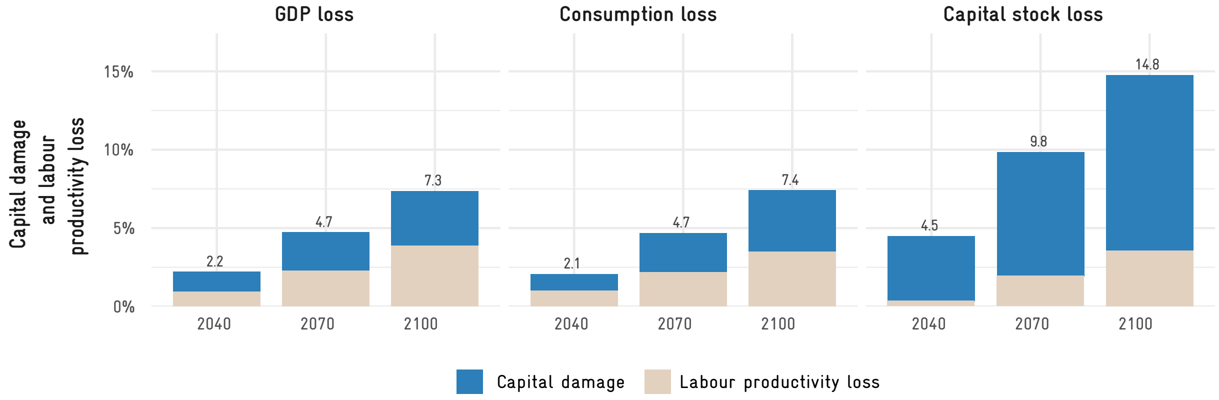

Figure 5. Economic losses due to climate change in India projected by the MOSAIC multi-sector growth model under the SSP2 current policy scenario. Bars represent additional losses on top of today's climate baseline (% deviation from counterfactual run without additional climate change).[9]

2.2.2 Capital and labour channels

Having established the economic impact of TWS as a function of climate change, we next examine the potential extent of climate impacts through two key economic channels: capital and labour productivity. Climate change damages productive capital (buildings, machinery, infrastructure) through a range of physical impacts, while rising heat stress reduces worker productivity, especially in outdoor sectors such as agriculture, construction and fisheries.[8]

Cumulatively, these two channels could produce GDP losses of around 2% for Europe and the USA, around 4–5% for China, Japan and Southeast Asia, and around 7% for India by 2100 (see Figure 5). This makes India one of the most exposed regions in the world. Note that these are damages from further warming after 2025, not the total cumulative impact of climate change. To put this into context, climate change could mean an average household in India consumes 7% fewer goods and services by the end of the century than they would in a world without further warming.

India's higher exposure reflects a combination of demographics (a much larger share of the workforce is employed outdoors, mainly in agriculture and construction), climate (higher baseline temperatures and humidity push more workdays into the dangerous wet-bulb range), and limited adaptive capacity (less widespread access to air-conditioned and shaded workplaces, and less reserve capital available to fund reconstruction without crowding out new productive investment).

By 2100 the combined damages lead to a drop of 15% in capital stock in India, relative to the counterfactual scenario (Figure 5, right-hand column) – roughly twice the GDP loss for the same year. This reflects direct destruction by extreme weather events (orders of magnitude for India: river flooding 45%, wildfire 35%, coastal flood 12%, tropical cyclone 5% of capital-damage exposure) and the diversion of investment toward reconstruction rather than productive expansion. This highlights the importance of disentangling the channels of economic loss: an aggregate estimate conceals how much investment is diverted to repair, and understates the drag on long-run capital accumulation on which durable productivity and consumption gains depend.

These damages translate into concrete macro-financial risks. The adaptation investment they imply – sea defences, flood-resilient infrastructure, irrigation and cooled workplaces – could be large, recurring and hard to defer. The increased frequency and severity of extreme weather events could strain public finances and raise sovereign borrowing costs – an effect amplified for India by central government debt of around 56% of GDP, low investment-grade sovereign ratings, and non-life insurance penetration of only around 1% of GDP – pushing unhedged climate losses onto the public balance sheet [67; 68]. The cumulative picture also weighs on foreign direct investment: market-seeking flows face a smaller and less affluent target market as household consumption is depressed, efficiency-seeking flows lose part of their productivity advantage as heat stress weighs on outdoor sectors, and asset-seeking flows face a higher country-risk premium. For an emerging economy that still relies on capital deepening, the diversion of investment towards reconstruction undermines the growth agenda as well as the energy transition.

2.2.3 Overall economic impacts of climate change

To assess the costs of inaction and the benefits of mitigation policy more comprehensively, we need to quantify the overall effects of climate change on GDP. However, the persistence of the effects on GDP or GDP growth are highly uncertain, and the longer impacts last, the higher the overall burden. To reflect this uncertainty, we provide a medium and a high estimate for GDP losses.[10]

For a current policy pathway, global mean temperatures increase from about 1.4°C above preindustrial levels at present day to 2.6°C by 2100. This leads to GDP losses in India of 5–9% in 2050, and up to 13–23% by the end of the century (Figure 6). These are additional losses over and above those already incurred by 2025. These aggregate GDP effects are larger in India than for its trading partners, and are likely understated as they do not include the impact of water depletion. This dynamic precisely underpins the double cost crunch: climate impacts erode the capital base on which the green transition depends, consumption losses constrain domestic savings, and capital losses raise the marginal cost of low-carbon investment with long-term repercussions on development. It should also be noted that economic estimates overlook losses to ecosystems or reductions in health and wellbeing, and aggregate numbers hide the distributional consequences of climate change, with the poor likely to suffer the greatest impact.

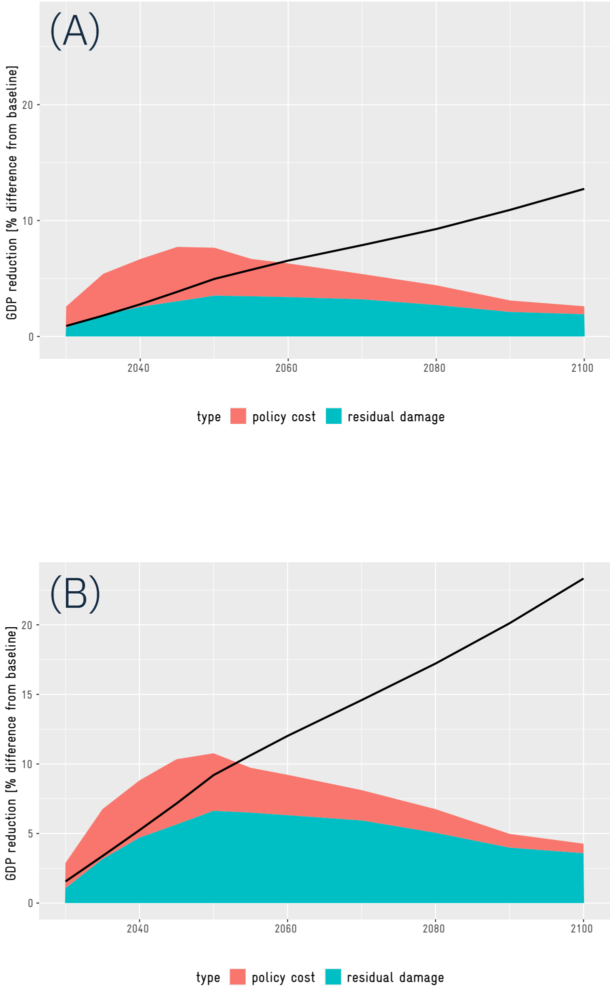

Figure 6: The double cost crunch for India: policy costs and residual damages under a Paris-compatible mitigation scenario for a medium (Scenario A) and high (Scenario B) damage specification. The black line illustrates the damages expected under the current level of policy ambition.

2.3 THE BENEFITS OF AMBITIOUS CLIMATE POLICY

Ambitious international climate policy efforts in line with the Paris Agreement would mitigate global mean temperature increases to about 1.45°C by 2100, relative to preindustrial levels. This would lower the economic damages substantially from the before-mentioned 13% in 2100 to about 3% (see Figure 6). On top of these residual damages, the mitigation costs for India need to be considered. These are growing and peak around 2050 as a percentage of GDP, before declining after the transition has been achieved. A main reason for the substantial increase in the near-term is the need to limit the temporary overshoot of global mean temperature to about 1.75°C before it decreases and falls below the 1.5°C threshold level. This peak and decline behaviour is also reflected in the time profile of the residual damages. To limit the overshoot and bring global temperatures below 1.5°C again, global CO_2 emissions need to achieve net-zero and turn net-negative thereafter. Net zero will likely require some carbon dioxide capture and storage, with the level (and therefore cost) of removals determined by the degree and speed of near-term emission reductions. Delayed emission reductions will also be more costly because they will have to be more ambitious and achieved over a shorter period of time. The benefits of ambitious climate action therefore far outweigh the costs in the long run.

Failing to meet the goals of the Paris Agreement will also result in substantial residual damages, and not all climate impacts will be reversible once they have been incurred. These will feed into the double cost crunch (Figure 7), complicated by near-term fossil fuel dependence, demographic shifts and distributional effects. While delays in climate policy reduce near-term transition costs, they allow climate damages to accumulate, eroding the fiscal capacity to transition and adapt to climate change. In India, this interaction is especially pronounced because high physical climate exposure, rising energy demand, continued coal dependence and elevated capital costs coincide with a development strategy that still requires rapid infrastructure build-out and broad-based welfare gains.

Taken together, governments need to navigate the trade-off between early ambition, which increases near-term investment costs but minimises long-term climate damages, and delayed ambition, which reduces near-term costs but increases damages through (potentially irreversible) over-shoot consequences. The double cost crunch – combining residual damages and transformation costs – thereby intensifies with postponement of mitigation.

The message is clear: immediate action is economically rational because long-term benefits exceed costs, post-ponement worsens the double cost crunch, and unavoided damages can reduce the fiscal capacity needed for both adaptation and transition. Nonetheless, making both burdens visible simultaneously enables better timing of investments and avoids costly misallocations.

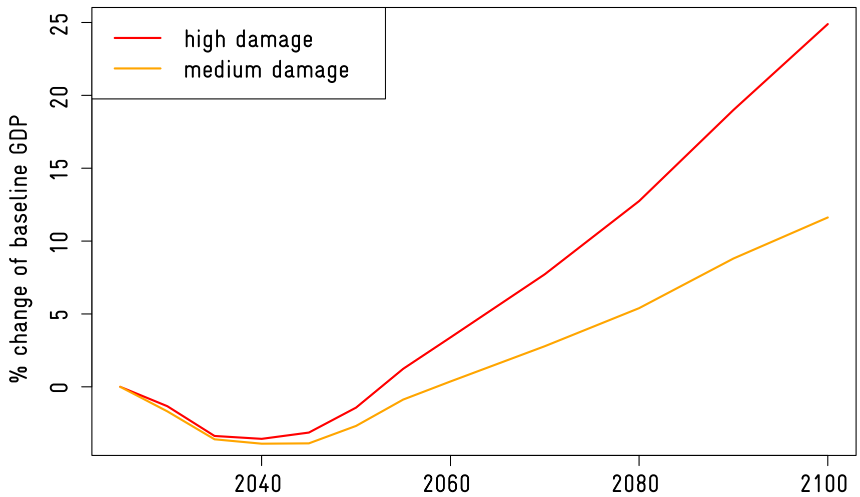

Figure 7: India's net benefits compared to a baseline with climate damages for a Paris-compatible mitigation scenario. The baseline is represented by the case with no additional climate impacts on the economy compared to 2025 and continuation of the climate policies that are already implemented.

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Map of India and its neighbouring countries.

3. Conclusion in a geopolitical and security context

India faces a complex energy–geopolitics landscape that will affect its long-term positioning:

On the one hand, India's fossil fuel imports are set to further increase in the short- and medium-term, given its economic development and growing energy demand. Already the world's second largest net importer of crude oil, India is projected to become the largest source of global oil demand growth until 2030, despite electrification of key sectors [71]. Moreover, natural gas demand is expected to grow by 60% by 2030 [72]. These dynamics could further increase the existing dependence on crude oil and natural gas [73] – with exposure to potential future price volatility and supply shocks. The significant effects of the recent global energy crisis on India illustrate the associated geopolitical risks.

On the other hand, the ongoing rollout of solar PV and wind technologies could form the basis of a cost-effective power sector transformation with long-term geopolitical benefits: it not only bears potential for green growth, but also helps build energy self-sufficiency. Strong policy support, falling prices for renewable energy technologies and growing private investments have already contributed to an ambitious rollout of renewables and made them a pillar of green development [73]. Simultaneously, energy security and affordability remain key considerations. Against this backdrop, the relatively high up-front costs for greening the energy sector constitute a challenge, especially as private sector investments hinge on favourable funding. Lowering the cost of capital is key to incentivising investments, thus preventing the slow-down in renewable rollout and a lock-in of fossil dependencies [74]. Further investments could bring co-benefits for affordability, sustainability and energy resilience, but grid development, modernisation and energy storage become the next frontier in the energy transition.

As renewable penetration rises, battery storage and power electronics become system-critical infrastructure. The resulting dependence on external supply chains for crucial minerals and components creates a new form of vulnerability, linking energy security with (industrial) geopolitics. However, in contrast to fossil fuel imports, technology and material dependencies can be reduced through investments in domestic manufacturing, recycling and supply chain diversification.

Our research adds further evidence to the growing literature on physical risks in India. Freshwater scarcity, reduced labour productivity and destruction of capital stock could dampen economic growth at a time when adaptation needs continue to rise. Extreme weather events may also threaten agricultural sectors and critical infrastructure in the energy and industrial sectors [75].

Finally, our findings complement and intersect with existing insights on the implications of climate change for human health and wellbeing. According to the 2026 Climate Risk Index, India is among the ten most at-risk countries, with many people affected in both absolute and relative terms, as well as in high economic costs and absolute fatalities [76]. This provides a human security lens for understanding the complexity of climate risks: heatwaves not only affect labour productivity, but also occupational health and safety, and prolonged and repeated heat waves not only affect economic growth, but also morbidity and mortality. These impacts are exacerbated when vulnerability is high and adaptive capacities are lacking [75]. Floods arising from unpredictable precipitation patterns, sea-level rise and tropical cyclones also constitute a key risk to livelihoods, especially in urban environments [77; 75]. From a sectoral perspective, agriculture is highly exposed, directly impacting those who depend on it for their livelihoods as well as contributing to wider food insecurity [77; 75]. This underlines the fact that economic and human security challenges should be considered jointly in future adaptation planning. India's climate adaptation planning at national and local levels provides a valuable entry point for further engagement, including for international partnerships.

ENDNOTES

1 The reported climate impact numbers are based on structural economic and econometric models, and should be understood as broad orders of magnitude rather than exact forecasts. Because the underlying assumptions, input data and transmission channels from climate signals to economic damages are subject to uncertainty, the results are best used for comparing scenarios and regions within the model framework; our deliberate simplifications, such as smooth damage functions, a limited set of impact channels, and frictionless reconstruction help isolate these comparative patterns.
2 So far, the government has not officially defined emission neutrality – it could be either carbon neutrality or GHG-neutrality. The latter definition is much more challenging to achieve, as it also includes methane and nitrous oxide which are hard to abate, as considerable quantities originate from the agricultural sector.
3 This projection is based on the second Shared Socioeconomic Pathway (SSP2) as defined in the IPCC Sixth Assessment. Although SSP2 represents "middle-of-the-road" assumptions for India and the global economy, there is considerable heterogeneity across alternative SSP scenarios.
4 While overall monsoon rainfall is projected to increase under future climate change, so is its interannual variability [60]; even slight deviations in monsoon timing can lead to drastic droughts or flooding [65]. In the most severe case, a climate change-induced tipping (abrupt shift) of the monsoon circulation could lead to strongly altered spatial rainfall patterns [61].
5 To account for possible reverse causality – economic activity causing changes in TWS – this approach controls for human water consumption using the output of the WaterGAP v2.2d model [62].
6 The results are based on a linear time-trend fit of the year-to-year mean TWS changes and the coefficient of the fixed effects panel regression model.
7 The amount by which water demand exceeds water supply.
8 We use MOSAIC, a multi-region growth model that tracks the structural transformation of the economy across three sectors (agriculture, manufacturing, services) and 12 macro-regions, calibrated to historical national accounts and the SSP2 current-policy scenario. The capital-damage channel is calibrated on Mandel et al. [65], with endogenous reconstruction investment. The labour productivity channel uses sectoral ISO heat-stress dose-response estimates at the median percentile (vulnerability mapped to sector: agriculture = high, manufacturing = medium, services = low) [66]. The capital and labour contributions visible in the figure are derived from two standalone runs that isolate each channel, attributed proportionally so they sum to the joint-run total.
9 Capital damage from Mandel et al. (2025); labour productivity loss from sectoral ISO heat-stress dose-response (García-León et al. 2021), with vulnerability tiers mapped to sectors.
10 Damages are calculated based on an aggregate damage function by van der Wijst et al. (2023) [69]. It reflects floods, sea level rise and other climate impacts on agriculture, forestry, fisheries, energy demand and supply, labour and infrastructure. The range is broadly in line with the recent meta study by Howard and Sterner (2025) [70].

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