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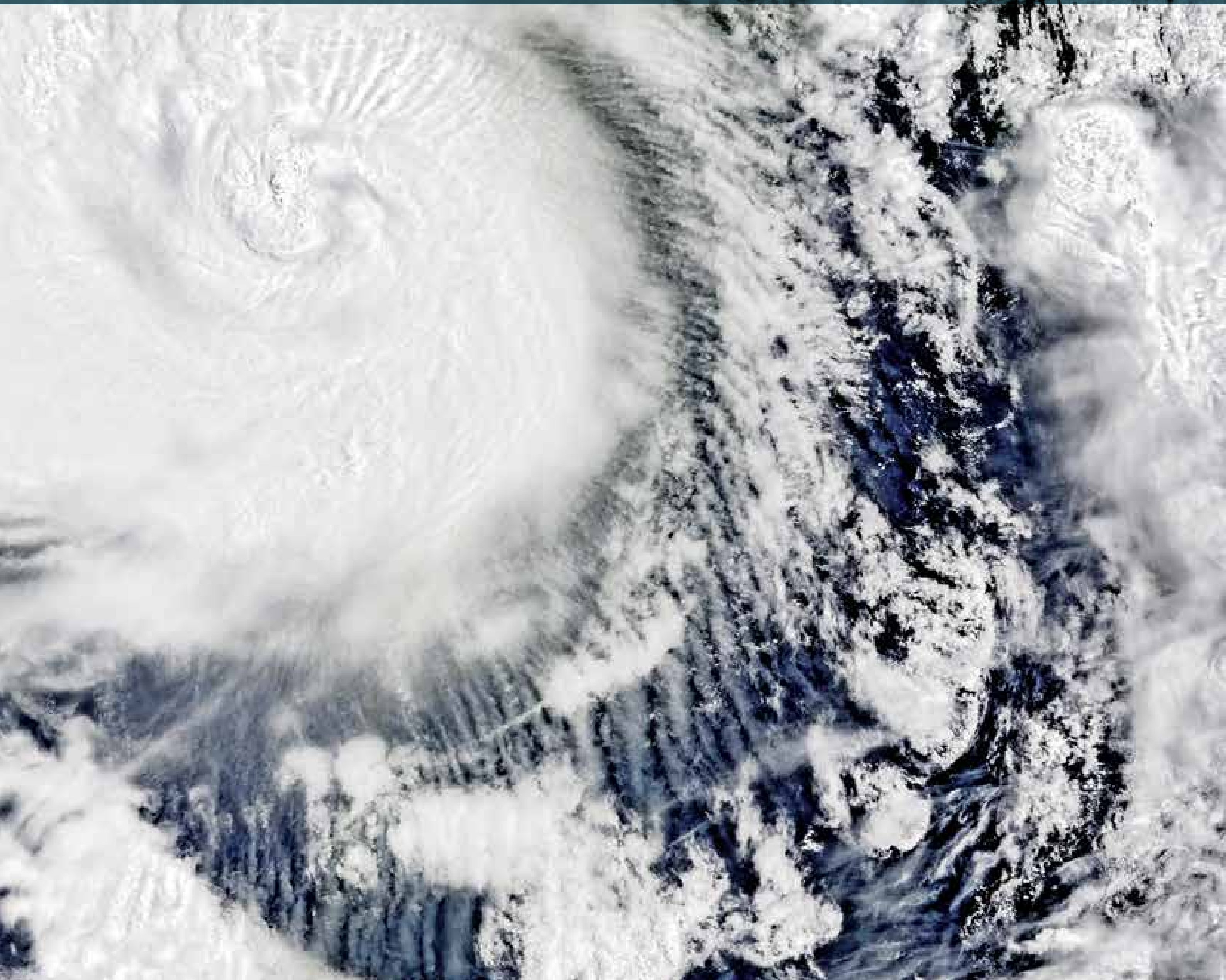

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CLIMATE FINANCE IN INDIA 2023

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EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

This report takes stock of the current climate finance landscape in India, along with the estimated financing requirements, enabling conditions and macro policy instruments to achieve national 1.5°C and 2°C goals.

Climate change will negatively affect India's economy leading to annual Gross Domestic Product (GDP) loss of 3 per cent to 10 per cent by 2100 (Kompas et al., 2018; RBI, 2023). In a business-as-usual scenario, India is estimated to face GDP per capita loss of 2.6 per cent, 6.7 per cent and 16.9 per cent in 2030, 2050, and 2100 respectively (Kahn, 2019). The impacts of climate change are projected across regions and key sectors like health, agriculture, labour productivity, and infrastructure. Beyond a certain warming threshold, climate impacts could be irreversible, potentially catalysing the collapse of ecological, social and economic system, as the space for adaptation rapidly contracts. It is hence crucial to limit warming to 1.5 °C and transition to a low-carbon economy in the coming decades. **However, meeting the global 1.5°C target will require investments of 7 to 18 per cent of India's GDP_{2019}.**

An estimated annualised investment of USD 167 billion from 2016-2030 or around 8 per cent of India's GDP2015 (MoEFCC, 2015) is required to achieve India's Nationally Determined Contribution (NDC) targets. Low-carbon emissions pathways require significantly higher investments for a rapid energy transition. To achieve the 2°C goal annualised energy investments, 4 to 16 per cent of India's GDP_{2019} is needed; while meeting the 1.5°C target will require 7 to 18 per cent of GDP_{2019} over 2016-2050 (McCollum et al., 2018). Assuming equal annual investments till 2050, around 2.2 per cent and 2.8 per cent of GDP_{2015} is required in low-carbon sectors (see Table below). The transition to these low-carbon pathways will need a dramatic overhaul of India's economic investment and incentives and development priorities.

India: Annualised climate investment needs (% GDP 2016-50)

Scenario	Total Investments	Low-carbon Investments
NDC	1.5% (0.5 to 4.3)	0.8% (0.1 to 3.0)
2°C	2.6% (1.1 to 6.0)	2.2% (0.8 to 5.0)
1.5°C	3.2% (1.2 to 6.9)	2.8% (1.0 to 5.9)

Source: McCollum et al., 2018

Indian climate finance flows have increased annually between 2017-2019 by 150 per cent to reach USD 44 billion by 2020 but remain grossly inadequate, and are concentrated in the power sector (CPI, 2022). Climate finance is also skewed in favour of mitigation (~90 per cent) compared to adaptation (~10 per cent). Domestic commercial finance is the most prominent source, followed by budgetary commitments. Private investments have grown but are largely limited to renewable energy. The total climate finance from MDBs to India was USD 1.9 billion in 2015, which increased to USD 3.7 billion by 2022 (European Investment Bank, 2023).

The costs of decoupling India's economic growth from coal-based energy will have significant short-run macroeconomic impacts. These costs could be limited in the long term by appropriate policy choices, but deep distributional concerns will need to be addressed at scale. The GDP differential between business-as-usual and low-carbon scenarios is 0.7 per cent in 2050 (Gupta et al., 2020), implying that the medium-run impacts will be limited. Yet, there are deep concerns over distributional impacts of this decoupling, which will need to be addressed through the implementation of a just transition for and within India, and appropriate incentives and redirected investments. Nearly 57 per cent of India's total installed electricity generation capacity comes from coal and other fossil energy sources (CEA, 2023). The share of coal-based energy will reduce substantially in the transition to a 2°C and 1.5°C world. For India, this comes along with serious energy security concerns, job losses for millions of coal-dependent workers, and revenue loss for states dependent on coal royalties.

Over 7 million workers are employed in India's coal mines and more are employed in related sectors (Blankenship et al., 2022). A 'just transition' will need to address the social risks of stranded jobs, its differential impacts on communities, the cost of adaptation and building resilience and making up for losses and damages. India's coal sector is dominated by multiple national and state government-owned enterprises involved in mining and power generation. It is difficult for India to transition away from coal because of energy security and the political economy of livelihood concerns, but doing so is crucial for a just and sustainable energy transition. Significant additional funds and appropriate policies are required, to ensure that the transition does not disproportionately affect vulnerable communities and industries. Workers need to be compensated for loss of livelihoods and supported with skill development and re-employment. Affected communities need alternative livelihoods and re-settlement, if necessary and appropriate (Pai et al., 2020).

India's energy transition is leading to the stranding of carbon-intensive assets and revenue losses. Over 40 GW in 34 coal power plants (concentrated in the public sector) were classified as 'stressed' in 2018, with USD 25 million in outstanding loans (Standing Committee on Energy, 2018; ODI, 2019). Yet, about USD 90 billion was invested in coal-based power plants over 2006-2014, with 50 per cent via public investment (Viswanathan and Garg, 2020). The government's short-run support for coal is a barrier to, and will delay the energy transition by dampening market signals on the cost-effectiveness of renewable energy.

India's energy transition risks could be hedged if both Central and State governments follow an orderly, coordinated set of policies with low uncertainty. The stability of India's financial systems is closely linked to climate mitigation because of the significant burden it bears for the import of oil and gas. Financial sector risks can be addressed if financial stakeholders (governments, RBI, financial regulators, commercial bankers, and investors) internalise climate risks into their decision-making to limit further carbon lock-ins and stranded assets. Simultaneously, RBI and central government policy needs to function in tandem to attract significant private investment in the energy transition. Many banks are starting to review their exposure to climate-related risks, which along with appropriate nudges like green bonds, interest subventions and subsidies can accelerate the energy transition.

India's adaptation costs were estimated at INR 29 trillion in 2020 and INR 86 trillion in 2030, calculated at 2012 constant prices (DEA, 2020). The total tracked green finance for adaptation in 2020 was INR 370 billion per annum, falling woefully short of the required costs (CPI, 2022). The largest source of funds for adaptation is public budgetary support, which is limited because of the high levels of India's current fiscal deficit and budgetary constraints. The COVID-19 pandemic exacerbated existing inequalities and development deficits, increasing adaptation needs. In addition, many Indian states do not have the institutional capacity to plan, invest, implement and mainstream climate action into their development programmes and investments.

Some progress has been seen in government investment in building adaptive capacity in vulnerable sectors like agriculture, water and urban areas. Yet, this is not commensurate with India's rapidly expanding adaptation needs. Convergence between SDG implementation and resilience-building adaptation actions can provide a fillip to domestic adaptation investment.

Private sector investment in adaptation in India is negligible due to many structural barriers. As new adaptation opportunities emerge, there is scope to expand this. Financial and policy interventions by governments, donors, development banks and financial institutions are necessary to incentivise private adaptation finance.

India needs to redirect investment away from fossil fuel and carbon-intensive sectors into low-carbon and resilient development via coordinated climate adaptation and mitigation action. India's climate mitigation investments should focus on the energy transition and its climate adaptation investments should focus on filling the resilient infrastructure and sustainable land use and ecosystem services investment gap, to move towards a 1.5°C goal. Both public and private investments should be redirected and incentivised to have high synergies with climate action and the SDGs. Within this, expanding the flow of private investment in the energy transition is critical. To enable this, the government should create a special facility to de-risk the financial sector from transition risks. The macro-mismatch between India's savings, capital flows and resilient infrastructure investment needs can be addressed through increased international climate finance.

1.

LINKS BETWEEN CLIMATE CHANGE AND FINANCIAL SYSTEMS

1. LINKS BETWEEN CLIMATE CHANGE AND FINANCIAL SYSTEMS

Climate change is intensifying across the globe rapidly. Many of its impacts are unprecedented and some, like sea level rise, may even be irreversible over the next hundred to thousand years (IPCC, 2021). 2022 was the eighth consecutive year in which the annual global temperature reached at least 1°C above pre-industrial revolution levels (RBI, 2023). There is a 66 per cent likelihood that annual average surface global temperature will be more than 1.5° C above pre-industrial levels, for at least one year from 2023 to 2027 (WMO, 2023).

India has observed significant changes in mean and extreme climate since the 1950s (Garg et al., 2015; Kahn et al., 2019 ; RBI, 2020). There has been an increase in mean annual temperature, night-time temperatures and hot days, increased variability in monsoon precipitation, including its decline in many regions (Sanjay et.al, 2020). The frequency and severity of droughts has also increased, posing challenges to food security and water availability (Garg et al., 2015). The changing weather patterns and climate anomalies are increasingly more intense and frequent. India faced its hottest February in 2023, in over a century (IMD, 2023). The rise in annual average temperature in India has also been significantly sharper in the last two decades than any other 20-year interval (RBI, 2023). Such changes in weather patterns have macroeconomic implications for the country.

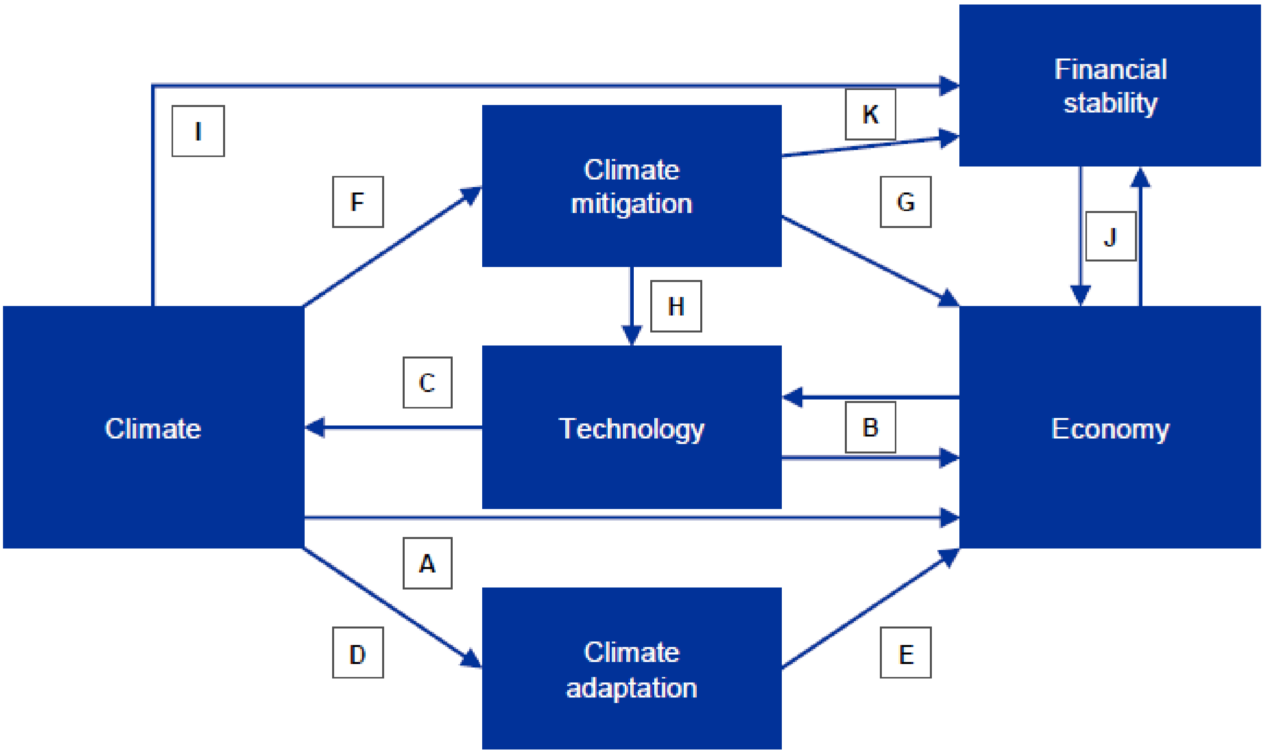
Existing literature recognises a long run negative relationship between economic growth and climate change (Kahn et al., 2019 ; Dell et al., 2012; Mejia et al., 2018). A sustained increase of 0.04°C in average global temperature, in the absence of mitigation policies, is estimated to reduce world real GDP per capita by over 7 per cent by 2100 (Kahn et al., 2019). With a business-as-usual approach (under the RCP 8.5 scenario), India is estimated to face GDP per capita loss of 2.62 per cent, 6.70 per cent and 16.92 per cent in 2030, 2050 and 2100 respectively. However, by limiting temperature increase to 0.01°C per annum, in line with the Paris Agreement, global GDP loss can be restricted to 1 per cent. Climate change is expected to reduce GDP through various channels, including reduced labour productivity, increased health issues, drought-induced food shortages, infrastructure damages and disrupted supply chains.

The impacts of climate change are expected to be far-reaching in breadth and magnitude, affecting a wide range of industries, sectors and regions in a correlated manner. Beyond a threshold, these impacts can force social and economic systems to collapse, with limited room for adaptation. As climate change affects the economy through various feedback loops (Figure 1.1), climate adaptation can help the economy to adjust to the changes (to some extent) and climate mitigation can reduce GHGs. There are two potential mitigation pathways: restricting economic growth to reduce impact; and adopting new technology so that economic growth continues but with lower emissions. Economic costs are associated with both these pathways, mitigation in the form of investments in new technologies and absence of mitigation in the form of transition costs and physical damages respectively.

1.1. Climate Change, the Economy and the Financial Sector

Climate change impacts in the financial sector are categorised into transition risks and physical risks. Transition risks refer to financial losses caused by the transition to a low-carbon economy. Physical risks are the result of disruptions to economic activity and the corresponding impact on asset performance from climate change shocks and stresses (Climate-Related Market Risk Subcommittee, 2020).

Figure 1.1: Linkages between climate and economy



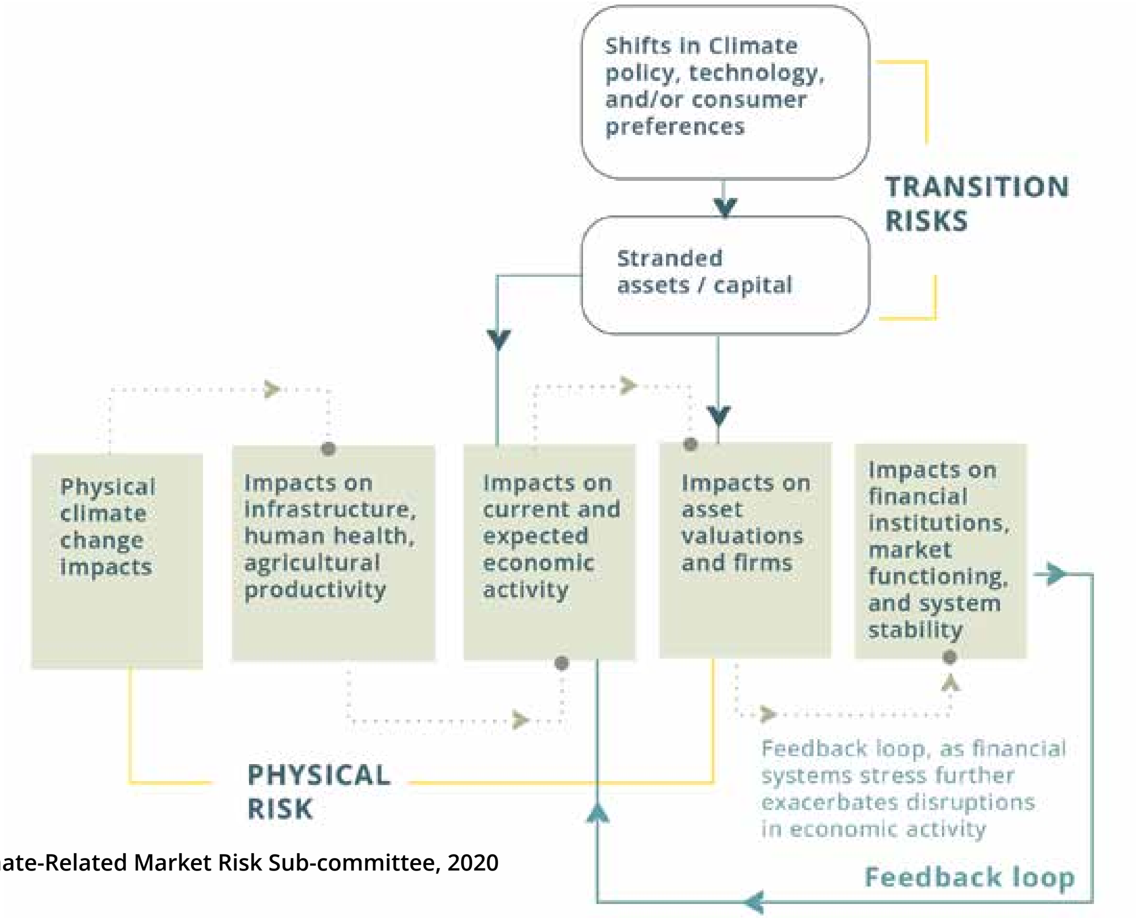
Note: A: Effects of changing climate on economic activity; B: Effect of technological advancements on economic growth; C: Effect of technological growth (and subsequent economic growth) on climate; D: Climate adaptation responses; E: Costs of climate adaptation; F: Climate mitigation policies; G: Climate mitigation through restriction of economic activity; H: Climate mitigation through technological advancements while maintaining economic growth; I: Physical risks from climate change; J: Feedback loops between the impacts of climate change and climate change policies on the economy and the financial sector; and K: Stranded assets as a result of climate mitigation measures.

Source: Andersson et al., 2020

Climate change mitigation carries risks of financial losses due to abrupt policy changes and can also have a destabilising effect on the financial system (FSB, 2020). For example, the clean energy transition via an unexpected change in policy could render some fossil fuel assets like coal unviable. Stranded coal assets could impact the financial sector and the economy through feedback loops. Climate-change-driven changes in projected earnings and expenses in certain sectors can affect the debt repayment capacity, the collateral of borrowers and increase credit risk for banks.

The speed of asset repricing is uncertain due to the uncertainties in technological progress and rollout of climate policies. If Central Banks fail to internalise carbon pricing impacts, inflation can increase due to mitigation measures. However, in the medium-to-long term, falling renewable energy prices and increased energy efficiency can offset these efforts (Andersson et al., 2020).

Figure 1.2: Relation between physical risks and transition risks



Source: Climate-Related Market Risk Sub-committee, 2020

Inadequate mitigation can lead to higher level of physical risks as extreme weather events can damage physical assets, lead to loss of life, increase defaults, damage balance sheets of households and firms, and cause potential financial sector distress (Ens and Johnston, 2020). Physical risks can affect both banking and insurance sectors. The interactions between physical and transition risks is complex as climate responses can affect the balance between the two. For instance, dedicating more resources to accelerate climate transition can divert resources from adaptation measures, thereby amplifying physical risks. Conversely, adaptation investments without carbon management will increase transition risks. The Climate-Related Market Risk Subcommittee (2020) (See Figure 1.2), shows the causal chains between the two risks, demonstrating their impact on economic activity and the financial system through asset devaluation and other feedback channels.

The physical risks of climate change will lead to frequent and severe negative supply and demand shocks. The supply shocks include capital destruction, labour supply and other supply chain disruptions due to infrastructure damage, while demand shocks include reduced consumption and investment due to damage to household and corporate balance sheets. Central Banks face a trade-off between stabilising inflation and output fluctuations due to such shocks (Ens and Johnston, 2020).

Increase in negative supply shocks makes it more difficult for Central Banks to accurately forecast output gaps and, by extension, inflation. The increase in the volatility of inflation and output has implications on the monetary policy regime (e.g., inflation targeting, price-level targeting or nominal income/GDP targeting).

Box 1.1: Potential physical risks from climate change in India

Various macroeconomic climate change studies indicate a bidirectional causality between temperature and GDP per capita, with warmer countries like India experiencing more pronounced short-and medium-term macroeconomic effects. Climate risks are particularly intensive for emerging markets, where climate impacts are in tandem with other macro-financial vulnerabilities (Burke et al., 2015, Mejia et al., 2018, FSB, 2020). The Reserve Bank of India's (RBI) analysis of macroeconomic impacts of climate change shows that increasing temperature, precipitation volatility and extreme events can impact supply by reducing the economy's aggregate output across agriculture, manufacturing and service sectors, and raising prices. This has adverse implications for India's trade balance, income and potential economic growth. Changing weather patterns and events also impact consumer behaviour and preferences, thereby influencing demand conditions (RBI 2020, 2023).

Effect on consumption expenditure

Climate change can influence consumption expenditure through diverse pathways like agriculture, migration, health and labour productivity (Mani et al., 2018). Variability in precipitation level affects future consumption expenditure patterns, while increasing temperatures and wet conditions contribute to incidence of vector- borne and other infectious diseases, resulting in productivity and income losses (Akutsu and Koike, 2019). Extreme heat days are correlated with declining worker productivity, and changing climate patterns can force people out of their traditional professions into less suitable occupations, resulting in lower incomes. Extreme events majorly disrupt consumption and savings and have a disproportionate impact on low-income groups. A study using household-level data from NSSO shows that climate shocks via rise in temperature and precipitation adversely impacts bottom 70 per cent individuals, with median consumption falling by 16 per cent (Aggarwal, 2019).

Effect on labour productivity

High temperatures can reduce labour productivity vis-à-vis task productivity, labour supply (hours worked) and labour effort. Indian agriculture, construction and industry are particularly vulnerable to labour productivity losses due to heat stress (RBI, 2023). Indian manufacturing worker efficiency at the plant level declines on hotter days, with a magnitude of roughly minus 2.8 per cent per °C temperature elevation, an effect driven primarily by on-the-job task productivity decline as opposed to increased missed days of work or absenteeism (Adhvaryu et al., 2014; Sudarshan and Tiwari, 2014). The World Bank (2022) estimates that India could account for 34 million of the projected 80 million global job losses from heat stress linked productivity decline. An estimated 4.5 per cent of the country's GDP could be at risk by 2030 owing to lost labour hours (RBI, 2023). Productivity loss can also manifest through lower agricultural yield (IMF, 2020), or indirectly manifest through health impacts. In the long run, this will have a direct negative impact on national output, individual income, poverty reduction and other development goals (Hallegatte and Rozenberg, 2017).

Impact on agriculture productivity and food security

Agriculture faces severe poverty and developmental impacts of climate change (Hallegatte, 2016). Crop production and food security is expected to be negatively affected in the long term and in lowlatitude countries (IPCC, 2014). Estimates from India show that high temperatures in the top 20 percentile of temperature distribution in a district leads to kharif crop loss of 4 per cent and rabi crop loss of 4.7 per cent (GOI, 2018 in RBI 2023). Similarly, when a district receives significantly less rainfall (bottom 20 percentile), there is 12.8 per cent reduction in kharif crop and decline of 6.7 per cent in rabi crop (ibid). Extreme weather patterns can reduce farm incomes in the range of 15 per cent to 18 per cent on average, and up to 20–25 per cent in non-irrigated areas (MOF, 2018). Decreased agricultural output influences food inflation. The RBI noted that in the last six decades, three major global food inflations (the 1970s, 2007–08 and 2010–14) were triggered by adverse weather shocks, which were followed by an increase in oil prices and adverse trade policy interventions (RBI, 2020). In the long run, frequency of extreme events and changing weather has implications for agricultural yield, farm incomes and food inflation.

Impact on health

Climate change has a significant impact on health and influences mortality and morbidity rates. Infectious diseases, air pollution, and heat stress are major concerns for human health due to climate change (Patz et.al., 2005). Heatwaves increase infant mortality rates and affect vulnerable populations disproportionately. The incidence of more than 100 deaths in heat-related events is expected to increase by 146 per cent in India in the future (Mazdiyasni et al., 2017). Incidence and spread of infectious diseases are determined by changing climatic conditions, which also aggravates mental health and well-being. Rising temperatures have led to loss of around 153 billion hours of labour in 2017, with 80 per cent of these losses occurring in the agricultural sector due to high exposure to heat.

Impact of extreme events

Extreme events such as floods and tropical cyclones have significant impacts on India’s economy. The Global Assessment Report on Disaster Risk Reduction (UNISDR, 2015) estimates India’s average annual economic loss from disasters at USD 9.8 billion, with floods causing over USD 7 billion losses. Poor and marginalised communities suffer disproportionate risks like loss of assets, livelihoods and forced migration due to such extreme events. Floods in 2019 impacted 14 states, displacing 1.8 million people and causing 1,800 deaths (RBI, 2023). Study of key extreme events like floods, cyclones and droughts over the last 10 years in nine states of India shows that natural disasters adversely impact economic activity by shrinking output and raising inflation (ibid).

By 2050, 35 million people in India could face annual coastal flooding, with 40–45 million at risk by the end of this century (World Bank, 2021). A cross-country analysis of 136 coastal cities shows that a 50 cm rise in global sea level by 2070 can triple the exposure of population and increase asset exposure by tenfold (Hanson et al., 2011). Inadequate socio-economic development can escalate flood-related losses from USD 6 billion to USD 52 billion by 2050 for these cities (Hallegatte et al., 2013). Cities like Kolkata, Mumbai and Chennai are very susceptible to coastal flooding. Potential damages to property and livelihood could exceed USD 100 billion, USD 328 billion and USD 734 billion by 2050, 2070 and 2100 respectively in Mumbai, without effective adaptation and mitigation efforts (Abadie et al., 2020).

Apart from the systemic risks, climate change can lead to 'sub-systemic' shocks, which can potentially impact particular sectors, assets and regions, without destabilising the entire financial system. These can impact community and agriculture banks, local insurance markets, and other localised financial systems and hinder financial inclusion efforts, affecting small businesses, farmers, and poor and marginalised households. Climate change can also be a threat multiplier for poverty as climate shocks can push vulnerable populations, including those who are not poor currently, into poverty (Hallegate, 2016). Consequently, it can be argued that climate change can hamper the poverty reduction and development agenda.

Central Banks and governments need to assess both, the direct impacts of physical and transition risks and the indirect effects, given the interconnectedness in the economic and the financial systems (Ens and Johnston, 2020). The indirect second-order impacts refer to the transmission of shocks through financial linkages, the production chain and in feedback loops between the two systems ('J' in Figure 1.1).

Physical risks are being observed and the mitigation-focused climate transition is still evolving; as such it is likely that physical risks and transition risks may unfold in parallel (Climate-Related Market Risk Subcommittee, 2020). As the severity and frequency of physical damages increases, there could be faster introduction and implementation of mitigation policies, which may cause disorderly transition, compounding financial challenges for banks, investors and governments (FSB, 2020). The two interrelated challenges for the financial systems include safeguarding the stability of the financial system from physical risks and facilitating a transition to a low-carbon, climate-resilient economy (Climate-Related Market Risk Subcommittee, 2020).

1.2. Conclusions

- Climate change will have long-term macroeconomic impacts on the Indian economy. This will lead to nationwide impacts, with GDP per capita loss of 2.6 per cent, 6.7 per cent and 16.9 per cent in 2030, 2050, and 2100 respectively, as climate change affects key economic sectors, including agriculture, health, labour productivity, buildings, and infrastructure.

- Accelerating climate change impacts on physical structures and socio-economic systems are not only leading to direct economic costs but are also increasing systemic risks to the financial sector.

- Physical risks include adverse effects on agricultural output, labour productivity, human health, investments, damages and losses to buildings, infrastructure, services, and the economy from extreme events, which can worsen with increasing warming.

- Transition risks include financial impacts of transitioning to a low-carbon economy, urban and infrastructure systems, built environment, agricultural and land use, and industrial systems. This can worsen with unplanned mitigation. The socio-technical energy transition will result in asset stranding and losses from carbon lock-in.

- The interconnected nature of economic and financial systems gives rise to sub-systemic risks, as physical and transition risks can cascade and amplify each other, increasing overall impact.

2.

FINANCING CLIMATE ACTION IN INDIA

2. FINANCING CLIMATE ACTION IN INDIA

Climate action finance in India is gaining momentum, but the available funds remain inadequate for a smooth low-carbon transition. Broad trends of climate finance flows show that government budgets, domestic banks, and financial institutions fund the majority of climate action in the country. To meet climate goals, it is critical to mobilise large-scale private sector investments that also have synergies with developmental action. This chapter lays out the broad trends in the sources and direction of climate financing over the last decade, the split between support for mitigation and adaptation, and outlines India's institutional framework to deliver climate finance and support climate action.

2.1. Trends in Climate Finance

Analysis of climate finance flows in this chapter shows a lower proportion of low-carbon investments in sectors outside power. Nevertheless, clean transportation investments, particularly in electric vehicles have increased in recent years, stimulating a transition in this sector. The sustainable building sector has also seen some improved investment, but land use sectors, including agriculture received limited low-carbon investment despite being significant contributors to global carbon emissions.

National banks and development finance institutions (DFIs) have played important roles in increasing climate finance in power and urban infrastructure sectors since 2010. They have facilitated financial structuring of markets, co-invested with private actors, and partnered with national and international policymakers to promote favourable policies. Private finance has been invested in equity and debt with attractive risk-adjusted returns emerging, particularly in the energy sector.

In recent years, there has also been a growing interest in sustainable finance, which has helped raise funding for green projects. An estimated USD 43 billion has been raised in labelled and unlabelled green bonds in India between 2014 and 2023, with domestic power producers accounting for 80 per cent of these bonds (CNBC-TV 18, 2023; ETenergyworld, 2023). Aware of this growing interest in sustainable finance, the Indian government in 2023 issued the first two tranches of sovereign green bonds worth INR 80 billion each (totalling approximately USD 2 billion), joining 43 other governments that have raised such debt (Hussain and Dill, 2023; Kumar, 2023; Manglunia, 2023).

2.1.1. Domestic sources of climate finance

Domestic public finance is the most prominent source of climate finance in India. The government finances climate action through direct budgetary allocations, taxes, subsidies, market mechanisms to leverage private finance, and by facilitating and supplementing climate funds. Climate funds are usually associated with national climate missions and receive finances from cess collections besides direct budgetary allocations. In 2017–18, 85 per cent of total green finance in India came from domestic sources, with budgetary outlays forming 18 per cent and Public Sector Undertakings (PSUs) funding accounting for 12 per cent of the total tracked green finance (Sinha et al., 2020). In 2019 and 2020, green finance tracked across three sectors – clean energy, energy efficiency and clean transport - was USD 44 billion per annum (CPI, 2022). Around 87 per cent and 83 per cent of this finance was raised domestically in 2019 and 2020, respectively (ibid). Of this 60 per cent came from private finance and 40 per cent from public finance through budgetary allocations and PSUs. Trends in government climate finance flows from 2014 onwards show a steady focus on climate mitigation through renewable energy and rural electrification (Singh, 2017) as shown in the Table 2.1 below. Climate adaptation has been supported through interventions in agriculture and water sectors, through increased allocation to the Ministry of Environment, Forests, and Climate Change (MoEFCC).

Table 2.1: Budgetary response to climate change (2014 – 23)

Year	Mitigation	Adaptation	Others
2014-15	Renewable energy, infrastructure	NAFCC was created with USD 14 million.	Long-term credit fund with NABARD with initial corpus of USD 714 million.
2015-16	Reduction in funds for the MNRE	Funding for agriculture adaptation	Clearer division of responsibilities and resources between Centre and States
2016-17	MNRE funds increased, support to off-grid renewables, USD 428 million for nuclear power	Increased funds to MoEFCC Agriculture adaptation through crop insurance programs, food security	
2017-18	MNRE allocations decreased by 33 %. Support to rural electrification	Minor increase in allocations for MoEFCC and climate adaptation.	Budget allocations specific to NDCs rolled out.
2018-2019	MNRE budget rises by 8.5%, while allocation for decentralised renewable power decreases by 7.5%.	MoEFCC allocation remains unchanged. Increase of USD0.2 million for NAFCC.	Special scheme on air pollution control. Subsidised machinery for in-situ management of crop residue
2019-20	Allocation for CPCB - USD 14 million, reduced by USD 2 million.	MoEFCC budget - USD 422 million (10.4% increase).	Fiscal measures to promote EVs. Statutory and regulatory bodies' budget cut by 13%.
2020-21	Allocation for MNRE increased by 9.48 %	MoEFCC budget increased by 4.91 %	~ 297 million USD for power and RE. DisCom reforms. Phaseout thermal power plants.
2021-22	Allocation for MNRE remained unchanged	MoEFCC budget allocation decreased by 7.42 %	USD 29.9 million for urban air pollution.
2022-23	MNRE allocation rise by 19.94 %	MoEFCC allocation increase by 5.57 %	USD 1.61 billion for PLI - solar modules, Financial support to SC and ST farmers for agro-forestry.
2023-24	MNRE allocation increase by 48.15%	Slight increase in allocation for MoEFCC (1.63%)	Green Credit Programme, 25% budgetary allocation of MoEFCC for pollution control.

Source: Based on Singh, 2017 and union budget documents[1]

1 Increase or decrease is relative to the budget of the previous year. NAFCC: National Adaptation Fund for Climate Change; MoEFCC: Ministry of Environment, Forest and Climate Change; MNRE: Ministry of New and Renewable Energy; NABARD: National Bank for Agriculture and Rural Development; CPCB: Central Pollution Control Board.

The government's efforts to finance climate action began in 2010 with a coal cess as a form of carbon pricing. The cess increased from USD 0.71 per tonne in 2010 to USD 5.71 per tonne in 2016. A new Clean Energy Cess was introduced in 2015 after India announced its commitments towards the Paris Agreement. This cess was aimed at funding research and development in clean energy. Between 2010 and 2018, about USD 12.35 billion of cess was collected, but only 24 per cent of it was transferred to the National Clean Energy and Environment Fund (NCEEF) in 2015–16 and utilisation rate of the finance was even lower (DoE, 2018). With the introduction of the Goods and Services Tax[22] (GST) Compensation Cess in 2017, the Clean Energy Cess was replaced but utilisation of the new cess was further diluted. The GST Compensation Cess has been used to fill state budgetary deficits and fund regional development needs rather than clean energy initiatives. The unspent balance from the NCEEF is also being transferred to the State GST Compensation Fund to compensate the states for loss of revenue.

Apart from direct budgetary allocations, the government also finances climate action through market-based mechanisms, which have facilitated large-scale renewable energy deployment. Regulatory schemes like the Perform Achieve and Trade (PAT), Renewable Energy Certificates (REC), Renewable Purchase Obligations (RPO) and Feed-in-Tariffs (FIT) have improved energy efficiency and supported investments in low-carbon generation. Despite some drawbacks, the PAT mechanism (Bhandari and Shrimali, 2018) has helped to reduce energy intensity in energy-intensive industries like cement and fertilisers (Oak et al., 2019). In India, FITs are set by the State Electricity Regulatory Commissions (SERCs) and use long-term agreements and guaranteed pricing tied to costs of production to protect producers from risks and sustain their interest in the renewable energy market. Other financial instruments include the tax-free infrastructure bonds of USD 794 million, introduced in 2015 to support renewable energy projects. Such market-based policies have reduced tariffs of solar and wind energy, and improved the competitiveness of renewable energy.

Domestic commercial banks contributed nearly 40 per cent of the total tracked finance in 2017–18. Private climate finance includes loans, private equity finance, venture capital, partial risk guarantees and green bonds (Singh, 2017; Jha, 2014). Sinha et al., (2020) found that the majority of private finance in 2017–18 consisted of debt, followed by equity. Non-Banking Financial Companies (NBFCs) provide debt financing mainly for the renewable energy generation sector, and Indian banks are increasingly supporting low-carbon transition projects. In 2017, SBI availed a USD 625 million loan from the World Bank to support grid-connected solar capacity (World Bank, 2017). Many banks like Yes Bank, Exim Bank and SBI have also issued green bonds, but most money raised through this instrument is by government companies like IREDA and NTPC, followed by domestic power producers. Majority of the proceeds of the green bonds in the country are being utilised in the renewable energy sector. The country's first sovereign bond issued this year in INR, oversubscribed by four times, signals the potential of sustainable finance to mobilise large-scale accessible climate finance (Hussain & Dill, 2023; Kumar, 2023).

2 The Goods and Services Tax is an indirect tax used in India on the supply of goods and services. It is a comprehensive, multistage, destination-based tax. Under GST, the centre (CGST) and the states (SGST) simultaneously levy tax on a common base. An Integrated GST (IGST) is levied for an inter-state supply of goods or services. This shall be levied and collected by the Government of India and such tax shall be apportioned between the Union and the states.

2.1.2. International sources of climate finance

Multilateral development banks (MDBs) like the Asian Development Bank (ADB), World Bank, Asian Infrastructure Investment Bank (AIIB), European Investment Bank (EIB) and bilateral agencies like the United States Agency for International Development (USAID), Japan International Cooperation Agency (JICA), and the Department for International Development (DFID) (now Foreign, Commonwealth & Development Office (FCDO) provide international funding for climate action. Other organisations like GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit), ADB, and the United Nations Development Programme (UNDP) provide technical assistance and capacity building.

Specialised bodies created by the United Nations Framework Convention on Climate Change (UNFCCC) like the Global Environment Facility (GEF) and the Green Climate Fund (GCF), also channel climate action funds. GEF administers the Special Climate Change Fund (SCCF) and Adaptation Fund, providing grants, concessional loans and public–private partnership opportunities. India has accessed USD 9.86 million from the Adaptation Fund since 2014, with USD 6.68 million used for five projects in 2015–16. India has also used USD 774.37 million from Climate Investment Funds (CIFs), operated by the World Bank since 2008. Clean Technology Fund (CTF), one of the two components of CIF supports the majority of the projects in India, including supporting development of over 3 GW of new installed solar power capacity and associated transmission infrastructure. CTF concessional financing helps to offset the high upfront costs of large-scale solar park projects and de-risk investments in rooftop solar photovoltaics.

GEF Funds, the largest contributor of global financial flows in India, had funded 97 projects with funding of USD 816.47 million and an additional co-financing of USD 7.08 billion until 2017. However, the funding data from GEF cycle shows that the grant component from GEF is only 12 per cent of the co-financing component. MDBs like the World Bank and ADB contributed to over 50 per cent of the total GEF-funded projects in India. Along with other GEF agencies, such as the Food and Agriculture Organization (FAO), United Nations Environment Programme (UNEP) and UNDP develop and execute these projects.

Table 2.2: GEF projects in India GEF cycles from 1991-2026 (million USD)

GEF Cycle	Focus Area			
	Climate Change	Biodiversity	Land Degradation	Persistent Organic Pollutants
Pilot Phase (1991-94)	41	-	-	-
GEF-1 (1994-98)	56	75	-	-
GEF-2 (1998-02)	11	27	-	-
GEF-3 (2002-06)	381	55	-	-
GEF-4 (2006-10)	861	58	31	94
GEF-5 (2010-14)	700	210	21	53
GEF-6 (2014-18)	2,396	72	-	-
GEF-7 (2018-22)	125	15	76	-
GEF-8 (2022-26)	42	44	4	-
Total	4,613	557	133	147

Source: Global Environment Facility, 2023 [3, 4]

Across all GEF funding cycles, climate change projects received five times more funding than others. Though India as a climate-vulnerable country requires more adaptation actions, the majority of GEF-funded climate change projects focused on mitigation on the principle of incremental reasoning and cost5 (MoEFCC, 2018a).

The GCF, another operating entity of the UNFCCC's financing mechanism, plays a crucial role in the post-2020 Paris Agreement framework as it supports developing countries to meet their NDC ambitions and fund the shift towards climate-resilient and low-carbon development through a country-driven approach.[55] The GCF emphasises equal allocation to adaptation and mitigation projects and supports early-stage project development and policy, and technological and financial innovation to catalyse climate finance. During the initial resource mobilisation period, around USD 10.3 billion was pledged to the GCF. India has four GCF projects with a total finance of around USD 314 million as of 2021 (Table 2.3). Three projects are medium-sized, while the Green Growth Equity Fund project is large in scale.

In 2018, the GCF signed a joint declaration with the International Solar Alliance (ISA) to strengthen collaboration on renewable energy, and to promote solar energy solutions.

3 Global Environment Facility. Retrieved November 22, 2023, from https://www.thegef.org/country/india

4 For projects that have multiple focus areas, the first mentioned area is taken as the focus area category. Hence, the theme-wise financial flows are only indicative. The amount includes both the GEF grant component and the co-financing component. Incremental cost funding is the fundamental operational principle of the GEF.

5 The country-driven approach is a core principle of the GCF. It implies that developing countries lead GCF programming and implementation. Country ownership of GCF financing decisions enables developing countries to turn NDC ambitions into climate action.

Table 2.3: Ongoing GCF projects in India (value in million USD)

Funding from	Theme	Project value	Investment Portfolio	
Enhancing climate resilience of coastal communities	Cross-cutting	130	Co-financing (Grant)	62%
			Co-financing (In kind)	5%
			GCF Grant	33%
			Co-financing by public sector	
Green Growth Equity Fund	Mitigation	945	Co-financing (Equity)	6%
			GCF Equity	14%
			GCF Grant	1%
			Co-financing by private sector	
Line of Credit for solar rooftops - commercial, industrial and residential	Mitigation	250	Co-financing (Loan)	40%
			Co-financing (Equity)	20%
			GCF Loan	40%
			Co-financing by private sector	
Groundwater recharge, solar micro-irrigation in Vulnerable Tribal Areas of Odisha	Adaptation	166	Co-financing (Grant)	67%
			Co-financing (In kind)	9%
			Co-financing (Loan)	4%
			GCF Grant	21%
			Co-financing by public sector	

Source: Global Climate Fund [66]

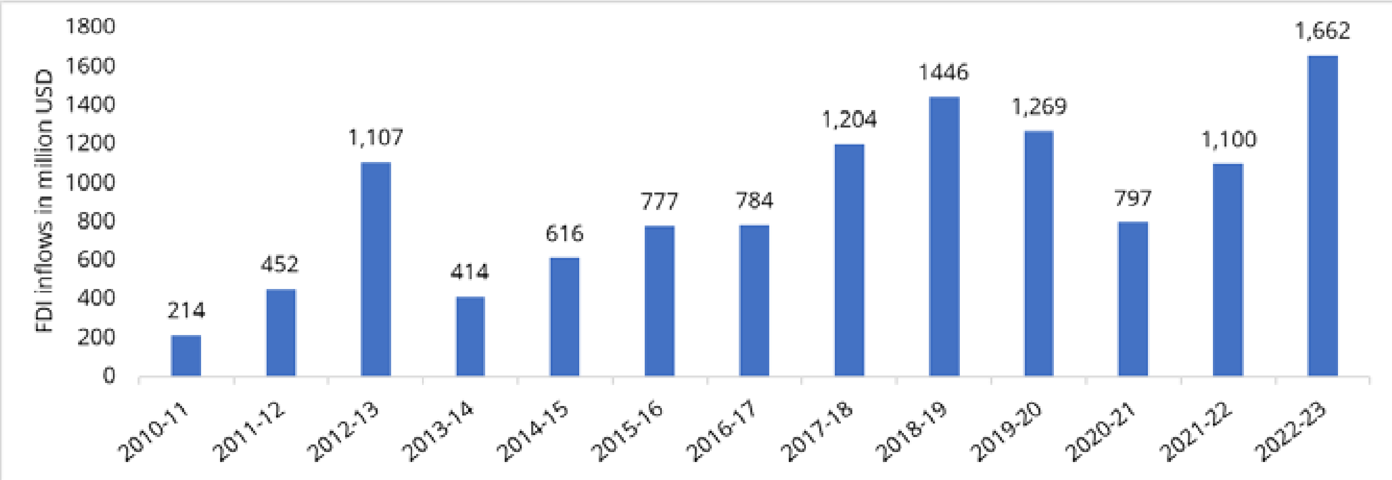
MDBs often provide direct funding to project developers or route the funds through development financial institutions such as Small Industrial Development Bank of India (SIDBI), both public- and private-funded NBFCs such as Indian Renewable Energy Development Agency Limited (IREDA) and Power Trading Corporation (PTC), and nationalised banks such as SBI. Some of the big institutional investors also receive MDB funds to support project implementation agencies. Investors can also mobilise money from the market for investments in climate-aligned projects like clean energy.

International private sources of climate finance also include investments through the Clean Development Mechanism (CDM), Foreign Direct Investments (FDI) and philanthropy. India is one of the largest recipients of CDM projects, accounting for over 20 per cent of these projects worldwide (Singh, 2017). The National Clean Development Mechanism Authority (NCDMA) was set up in 2003 to review CDM proposals.

Until August 2018, 12.6 per cent of the total Certified Emission Reductions (CERs) were issued to Indian projects, across sectors like energy efficiency, fuel switching, industrial processes, municipal solid waste, renewable energy and forestry (MoEFCC, 2018a). FDI in renewable energy has been increasing (Figure 2.1) thanks to India's liberal foreign investment policy in this sector, allowing up to 100 per cent investments with no prior government approvals. In June 2020, the MNRE announced the formation of an FDI cell to process the FDI proposals.

6 Accessible at https://www.greenclimate.fund/projects

Figure 2.1: Foreign Direct Investments (in million USD) to Non-conventional Energy in India (2010–22)



Source: Ministry of Commerce and Industry

Sinha et al., (2020) conducted a study tracking green finance flows in India during 2017–18 from domestic and international, and public and private sources (Figure 2.2). Key findings include:

- Public domestic sources are the major contributors to climate finance in India, with commercial banks playing an important role. The share of international sources is smaller, at around 12 per cent of the total. Bilateral agencies provide 75 per cent and multilateral agencies contribute 25 per cent of the international finance.

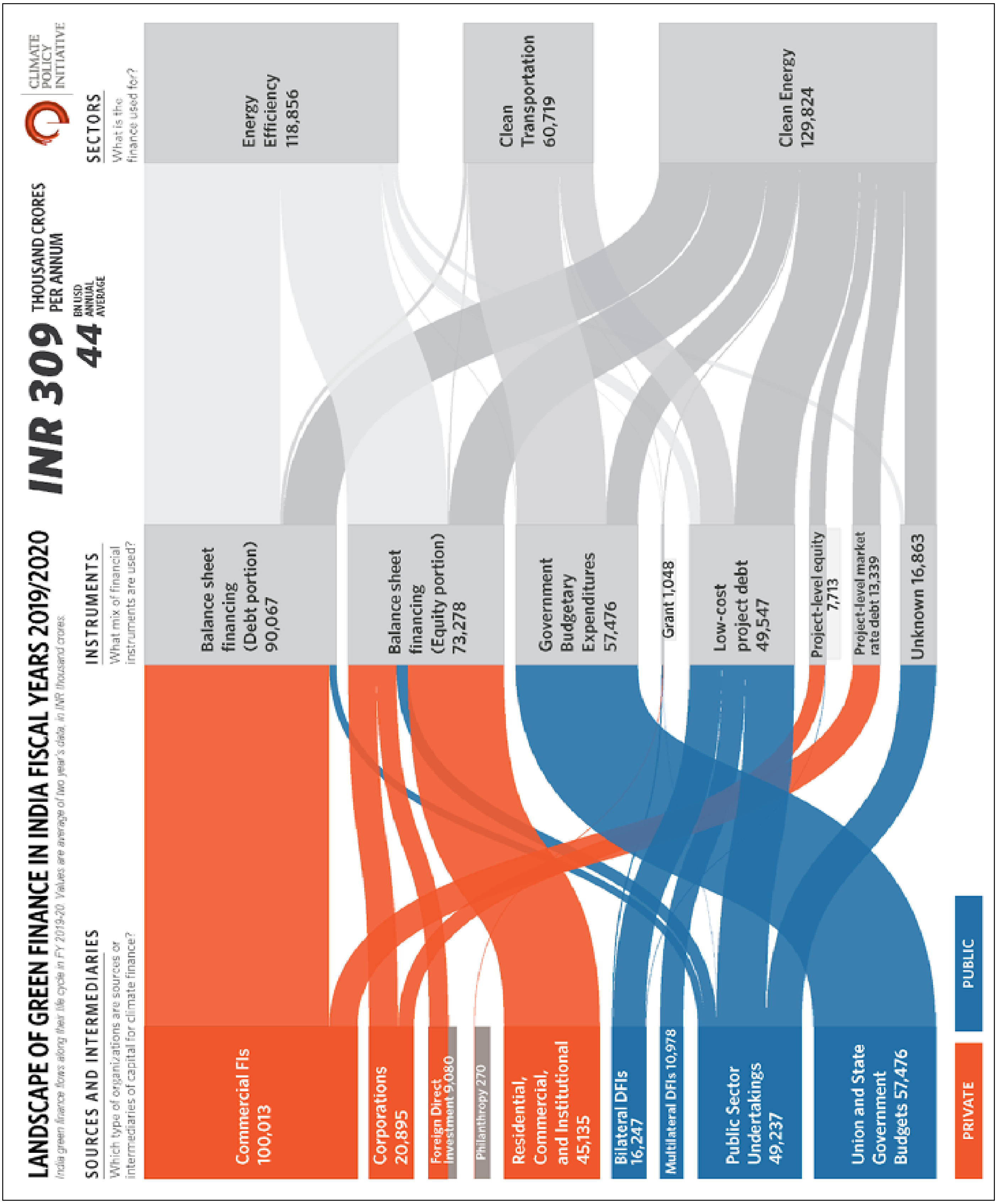
- PSUs disburse funds for the Central and State governments, bond markets, and international development agencies. PSUs, which received budgetary support and government investments, used more than half of the funds for research, development and capacity building. The remaining funds were directly leveraged in the market to finance projects through debt.

- Private and international public finance rely on debt, while domestic public finance is mainly in the form of grants-in-aid and budgetary allocations.

- Tracked green finance for mitigation in 2017–18 is an average USD 19 billion per year, falling short of the required amount.

- The power generation sector accounts for 80 per cent of the annual tracked green finance, with solar PV and onshore wind power accounting for 80 per cent of the total power generation sector finance. Solar power received the most investments out of all the other renewables combined.

Figure 2.2: Landscape of mitigation finance in India (2019–20)



Note: It does not include adaptation finance[7]

Source: (Khanna et al., 2022)

7 Landscape of Green Finance in India 2022. Climate Policy Initiative.

BOX 2.1: Sustainable finance in emerging economies

Sustainable finance consists of incorporating environmental, social, and governance criteria in business and investment decisions, and economic development (IMF, 2022). IPCC (2020) takes a broader view of sustainable finance as including environmental (including climate but also water, biodiversity objectives), socio-economic, and governance priorities in such a way that leads to investments and financing of multiple Sustainable Development Goals (SDGs). Within sustainable finance, climate finance is crucial for the transition to a low-carbon economy, especially for developing countries. This section draws largely from the IMF working paper, 'Sustainable Finance in Emerging Markets : Evolution, Challenges and Policy Priorities' by Goel et al. (2022), to trace the trends and evolution of sustainable finance in emerging market economies.

The global sustainable finance market is dominated by advanced economies (AEs). However, more recently, emerging markets (EM) have experienced a surge in sustainable finance with an increased market share and growing investor appetite for ESG products. An IMF paper (2022) notes that in 2021, EMs turned a corner with sustainable finance, as total flows in ESG-related bonds touched USD 200 bn against USD 60 bn in 2020. Sustainability equity flows reached USD 25 bn bringing the total cumulative assets under management to USD 150 bn. 2021 marked the first year that EMs gained market share in sustainable finance over AEs.

Excluding China, ESG investments now make for 18 per cent of foreign financing for emerging markets. The IMF authors link this surge to post-pandemic financing needs in emerging markets, Latin America's increased climate borrowing and a good performance of ESG assets over broader indices. ESG debt finance instruments are categorised in two broad ways, based on use of proceeds and based on behaviour, on key performance indicators (KPIs). Sustainability-linked instruments used behaviour-based instruments that define targets and KPIs linked to sustainability (ibid). Among the EMs, China is a clear front runner in the ESG ecosystem (on par with advanced economies like US, Germany, and France) followed by Latin American countries like Chile, Peru and Mexico. Chile has invested 12 per cent of its GDP in sustainable debt, followed by Peru and Mexico that have invested 2 per cent of their GDP each in sustainable debt (ibid). Excluding China, two-thirds of the 2021 issues came from the corporate sector (ibid).

Green bonds are the most popular sustainable finance instrument in emerging markets, but other social and sustainability-linked instruments are also growing. In 2021, emerging markets raised USD 103 bn in green bonds, a significant portion of this came from China. Chile, India, Mexico and Brazil have the largest share of cumulative green bonds, outside of China. Non-green bond instruments that are doing well include social, sustainability-linked and sustainable bonds. While the financial sector has been a dominant issuer of green bonds, the proportion of issues from other sectors like utilities, energy and industrials has increased since 2019 in all emerging markets excluding China (IMF, 2022). Overall, 60 per cent of bonds issued in emerging markets in 2021 were owned by the government (largely because of China) but there is an increase in private sector participation. Excluding China, two-thirds of the 2021 issues came from the corporate sector (ibid).

Box 2.2 : India and sustainable finance

Sustainable finance instruments can play a key role in mobilising private sector investments for climate action in India. However, so far the finances raised through green bonds in India have been limited. Aware of the growing traction of sustainable finance, the Indian government has been putting in place the framework to win the confidence of investors. The issue of sovereign green bonds this year is a step in this direction. The securities regulator, SEBI also strengthened its framework for green bonds in 2022, in line with the updated Green Bond Principles recognised by International Organisation of Securities Commission (IOSCO) (GOI, 2023a). The watchdog enhanced the scope of green debt securities to include two new modes of sustainable finance, yellow bonds (solar energy) and blue bonds (water sector) (ibid).

The proceeds from the bonds are meant to finance green projects that address mitigation or adaptation, and aim to reduce carbon intensity of the economy or make it more climate resilient (DEA, 2022). Projects that can receive funding include renewable energy, sustainable water and waste management, green buildings, climate change adaptation, biodiversity etc. These proceeds cannot be used for extraction, distribution of fossil fuels or for projects that depend majorly on fossil fuel energy (ibid). SEBI has also issued new sustainability reporting requirements under the Business Responsibility and Sustainability Report (BRSR) with more quantifiable metrics that will be made mandatory for top 1,000 listed firms to re- port ESG risks, financial implications (ibid).

However, India's bid to develop a mature sustainable finance market faces several challenges, many of them common to emerging markets. This includes lack of clear taxonomy of sustainable finance, information asymmetry leading to poor investor awareness about the instruments, poor ESG ratings of firms and data disclosures, inadequate tax incentives to promote sustainable projects, strong pipeline of qualified green projects etc (Goel et al., 2022; Manglunia, 2023). The biggest challenge for emerging economies lies in strengthening the climate information architecture to enable global data comparability, promote transparency to avoid green washing and incentivise correct pricing for the risks (IMF 2022, 2021). One of the financial stability risks of sustainable finance products is that it has an investor base sensitive to global financial conditions. This can have repercussions for developing countries (ibid). For instance, tightening of monetary policy in advanced economies led to a fall in the green bonds market in 2022.

2.1.3. The scope of India's carbon market for climate mitigation

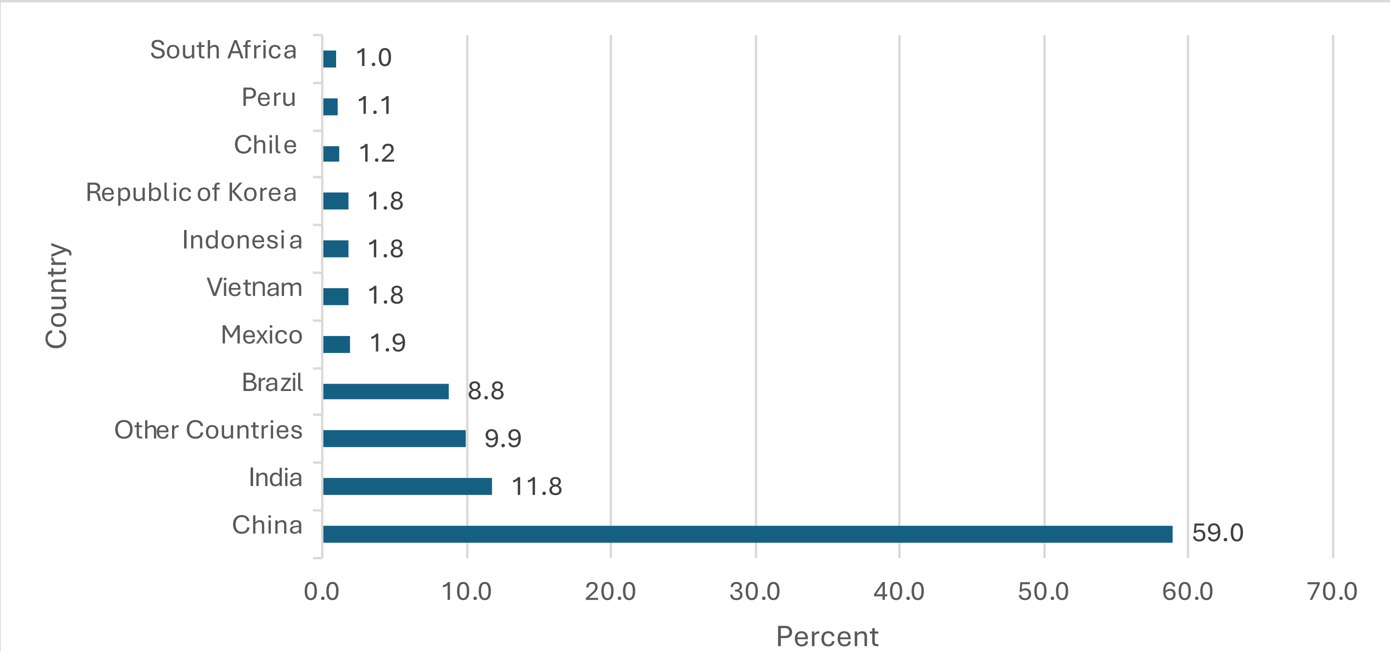
The development of carbon markets gained traction post the Kyoto Protocol, when specific instruments such as the European Union Emission Trading System (EU-ETS) and Clean Development Mechanism (CDM) were launched. India first embraced CDM and subsequently the development of a local carbon market. The emphasis of India's carbon markets was on reducing specific energy consumption (the Perform, Achieve and Trade scheme) and improving renewable energy offtake (Renewable Energy Certification and Renewable Portfolio Standards).

The Clean Development Mechanism, as defined under Article 12 of the Kyoto Protocol, was set up to help developing countries access finance and technology and enhance their institutional capacity for climate mitigation. It provides developed countries with an opportunity to reduce their emissions by purchasing Certified Emission Reductions (CERs) in developing countries. These CERs are generated through mitigation projects with each CER equivalent to the mitigation of 1 tonne of CO_2.

A total of 7,842 projects were registered worldwide under the CDM in December 2023. Out of these, more than 70 per cent of projects are from India and China. India accounts for 22 per cent of the overall projects registered in the UNFCCC CDM division. In India, the National CDM Authority (NCDMA) under the Ministry of Environment, Forest, and Climate Change (MoEFCC) is the implementing agency for CDM.

Although countries are free to decide the location, type and size of projects, around 60 per cent of these projects are large-scale projects, with the energy sector accounting for more than 75 per cent of the total, followed by waste management, with a 10 per cent share. These projects have helped large-scale renewable energy technologies deployment in India.

Figure 2.3: Distribution of registered projects worldwide in the UNFCC CDM division



Source: UNFCCC, December 2023

Of the total certified emission reductions (CERs) generated of nearly 1 billion tonnes of CO_2 equivalent, China received the highest share, of about 60 per cent, followed by India with 11 per cent. India's share in the total CERs issued has declined over time. In 2004, India's share was around 46 per cent, which dropped to 11 per cent in 2022.

In 2012 the CDM market collapsed due to insufficient demand for CERs, leading to a drastic fall in the price of CERs from USD 20 to less than USD 0.5 per CER. This laid the foundation for the growth of an unregulated voluntary carbon market (VCM) (p. 4, Bureau of Energy Efficiency, 2022). India is a leading VCM players having issued 278 million carbon credits over 2010 and 2022, accounting for 17 per cent of the global carbon supply chain.

While there is no concrete data available to predict the future market size of India' carbon market in India, an estimated 295 million tonnes of CO_2 emissions can be avoided across eight major sectors by 2030, as compared to Business-As-Usual (BAU) scenario, through a well-developed ICM (Bureau of Energy Efficiency, 2022).

Research conducted by Lin and Huang (2022) illustrates the significant impact of carbon markets in countries like China, underscoring the potential for similar reductions in carbon emissions in India. India's lucrative carbon market is estimated to be worth over $1.2 billion in 2021 (Down To Earth, 2023). In 2020, Indian firms accounted for one-fifth or 298 million issued carbon credits, or 10 per cent of the country's annual GHG emissions in the year 2020 (Down To Earth, 2023). In May 2023, India hosted 1,450 of the listed 6,481 projects in the world's two leading carbon registries, Verra and Global Standard, which hold more than 90 per cent of the non-governmental/voluntary carbon credits across the world. Most of these carbon credits are for projects that shift energy sources from fossil fuels to renewable energy, enable carbon capture through afforestation and plantations and agriculture.

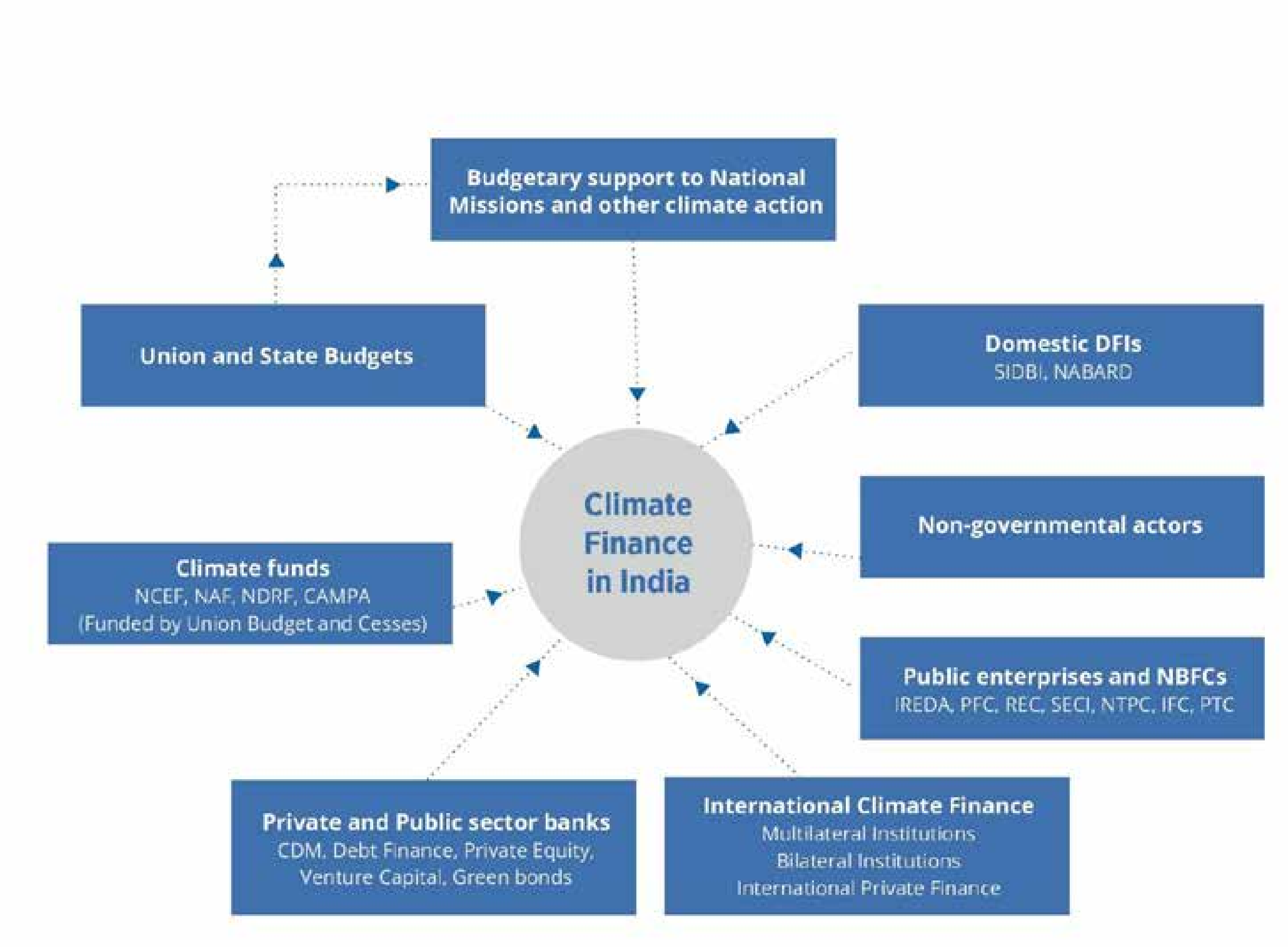
India has an opportunity to leverage its carbon credit market to achieve its NDC goals along with its development needs. An assessment of 500 registered CDM projects between 2013–2020 shows that it was able to generate 90 million CERs, equivalent to a reduction of 90 million tonnes of CO_2 emissions. The first two cycles of the PAT mechanism helped in reducing around 100 million tonnes of CO_2 equivalent, although this was not identified as an explicit program goal.

A concrete, robust carbon market in India has the potential to contribute to tackling the twin challenges of decarbonisation and development, but this hinges on robust design and related mechanisms. Realising this potential, MoEFCC released a notification in May 2023 regarding the development of the Indian Carbon Market (ICM) (MoEFCC, 2023). The Bureau of Energy Efficiency, along with the Ministry of Power and MoEFCC, are responsible for developing the ICM. The Ministry of Power notified the Carbon Credit Trading Scheme, 2023, to help provide incentives to a robust ICM based on a cap-and- trade mechanism (Ministry of Power, 2023).

2.2. Key Institutions and Funds

The climate finance architecture in India includes various institutional players at different levels of governance (Figure 2.3). International multilateral and bilateral institutions provide technical and financial support, while ministries and national agencies liaison with major international funds to secure project funding. Indian development finance institutions and NBFCs also engage with international agencies through government channels. These financial bodies further support banks and NGOs in climate action.

Figure 2.4: Climate finance architecture in India



Source: Authors' compilation

The National Action Plan for Climate Change (NAPCC), set up in 2008, with the objective to formulate and implement climate action, was among the earliest government initiatives. It was formalised with eight core missions. The MoEFCC is the nodal agency for the NAPCC, with each mission having its own nodal ministry. Strategies and interventions for each mission are determined by the respective ministries, shaping India's climate response.

Following NAPCC, the Climate Change Finance Unit (CCFU) was set up in 2011, under the Department of Economic Affairs in the Ministry of Finance. CCFU represents the ministry in national and international climate finance forums, inspects UNFCCC commitments, and assists MoEFCC on financial issues.

Additionally, finances have also been allocated to different climate funds, including National Clean Energy Fund (NCEF), National Adaptation Fund for Climate Change (NAFCC), the National Disaster Response Fund (NDRF) and Compensatory Afforestation Fund Management and Planning Authority (CAMPA). NCEF, created in 2010–11 out of the coal cess, finances clean energy initiatives, including research, NAPCC mission projects, and technological improvements.

NAFCC, established in 2015, aims to finance climate adaptation measures in vulnerable states and fill gaps in existing schemes. Initially allocated USD 50 million from 2015–17, it required USD 26 million in 2017–18. The NAFCC primarily funds schemes under the NAPCC, implemented by state governments and nodal departments. States also compete to secure international funding from GCF and other sources under UNFCCC. States like Andhra Pradesh, Haryana, Kerala, Odisha, and Tamil Nadu have submitted proposals to MoEFCC for accessing GCF funds. GCF's limited annual approvals per country and funding requirements prompts states to innovate and build technical capacity (Prasad and Sud, 2018).

State nodal departments for climate change play a critical role in coordinating climate activities within the state and between the Central and the State governments (Stiller & Meijerink, 2016). Their functions include providing technical and advisory support to line departments, organising State Steering Committee on Climate Change (SCCC) meetings, and facilitating access to domestic and international climate finance sources (Prasad and Sud, 2018). Nodal departments also actively engage in climate change project preparation, implementation, monitoring, research and capacity building workshops.

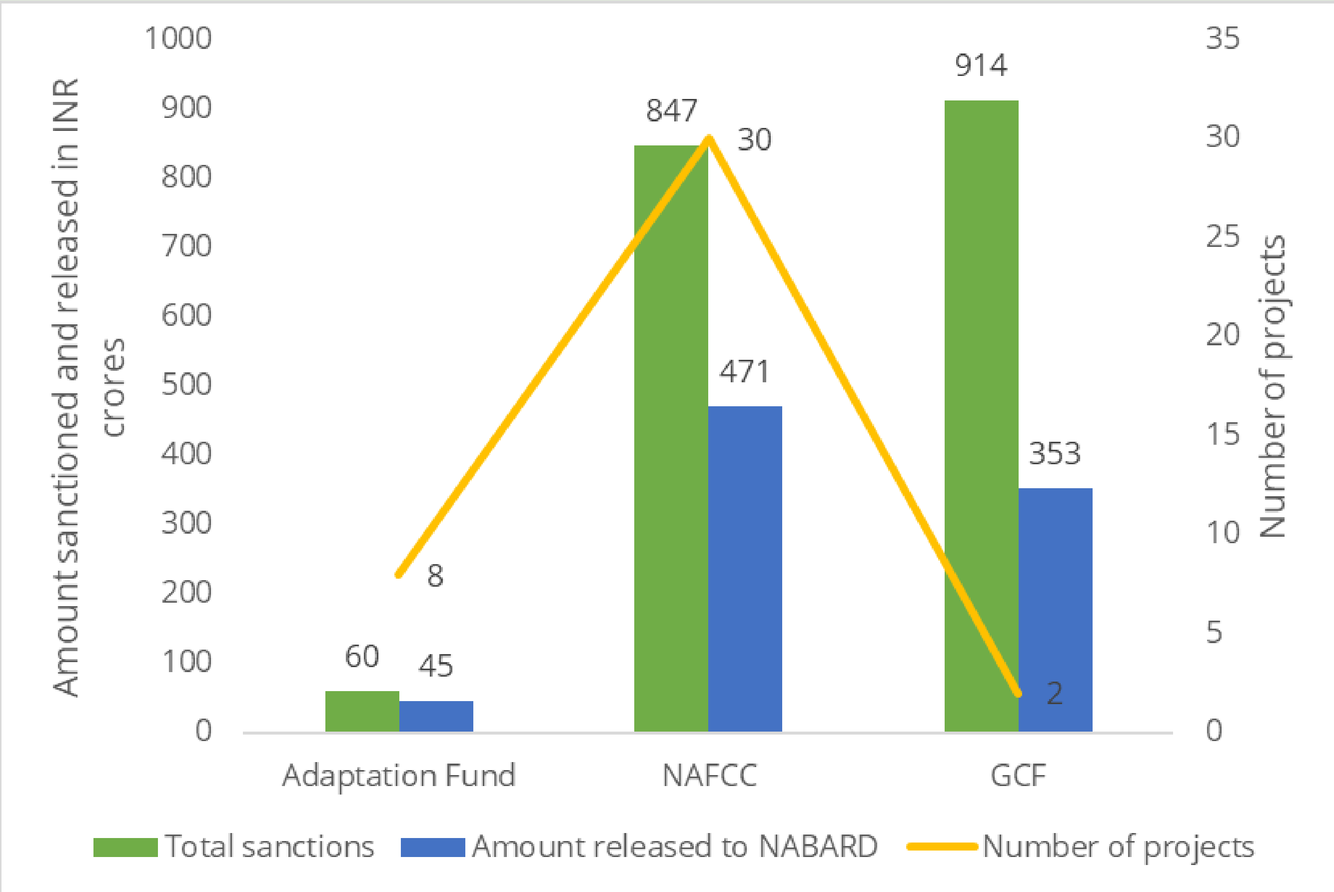
Through the Climate Change Action Programme (CCAP) set up in 2014, the government made efforts to advance scientific research and assessment of climate change. With an initial allocation of USD 42 million for five years, CCAP aims at building institutional and analytical capacity for climate change research and supporting domestic climate action programmes at the national and state level (Planning Commission, 2013). CCAP was allocated USD 24.6 million from 2017–2021 (MoEFCC, 2021).

PSUs like IREDA, National Thermal Power Corporation (NTPC) and Solar Energy Corporation of India (SECI) have also facilitated flow of public funds into renewables and other mitigation activities. IREDA provides long-term loans to investors for renewable energy and energy efficiency projects (Jha, 2014). SECI aids implementation of the National Solar Mission. Additionally, NABARD acts as the nodal implementing agency for managing various domestic and international adaptation funds. The institutional framework to assist climate action has strengthened since the launch of NAPCC, with NABARD playing a crucial role.

Box 2.3: Role of NABARD: A case of institutional response to climate action in India

NABARD, a leading development finance institution and an accredited National Implementing Entity (NIE) in India, plays a pivotal role in the deployment of climate funds. It is the NIE for the UNFCCC Adaptation Fund and National Adaptation Fund for Climate Change (NAFCC) and the Direct Access Entity (DAE) for GCF. NABARD also helps state governments, civil society organisations, and other agencies to source resources from international and national funds. As of March 2020, NABARD was assisting 40 projects, with a total value of INR 1,820.58 crore, under various funding mechanisms (NABARD, 2021).

Projects under NABARD in INR crores



Note: Total number of GCF projects in India is four. Two recent projects (Enhancing climate resilience of India's coastal communities and Green Growth Equity Funds projects) are not included here.

Source: NABARD, 2021

NABARD and Adaptation Fund: As the NIE for Adaptation Fund (AF) since 2012, NABARD is responsible for the overall management, monitoring and reporting of all AF projects. NABARD can access AF from the Adaptation Fund Board (AFB) to implement climate adaptation projects proposed by central or state governments, NGOs and research institutions. In 2021–22, three new projects were submitted through NABARD to AF. Some of the prominent AF projects in India are: the climate proofing of watersheds in Tamil Nadu and Rajasthan, enhancing adaptive capacity of small and medium farmers in West Bengal, and of small inland fishermen in Madhya Pradesh.

NABARD and NAFCC: As the NIE for implementation of adaptation projects under NAFCC, NABARD identifies project ideas from the State Action Plan for Climate Change (SAPCC), formulates projects, appraises, sanctions and disburses funds, monitors and evaluates, and undertakes capacity building of stakeholders.

Sectoral investments through NABARD from Adaptation Fund and NAFCC

Sector	Adaptation Fund (%)	NAFCC (%)
Agriculture	26	36
Food Security	28	-
Livestock	-	16
Water Management	14	28
Coastal Resource Management	7	13
Ecosystem Conservation and Livelihoods	25	7

Source: Adaptation Fund Portfolio Highlights[8] and NAFCC Portfolio Highlights[9]

NABARD and GCF: Projects supporting low-emission pathways are financed by the GCF through NABARD. There is a focus on projects aimed at developing resilient livelihoods and promoting climate smart agricultural practices.

Apart from providing national and regional entities direct access to climate finance, NABARD also operates a Climate Change Fund, created out of its profits during 2016–17, to foster sustainable development and address climate change impacts. It implements developmental projects like watershed development and sustainable livelihood initiatives for tribal communities through its Natural Resource Management (NRM) programme. Over 28 per cent of NABARD's funds are for climate change adaptation and mitigation with thematic focus on forestry, agriculture, animal husbandry, land development and minor irrigation. Some of NABARD's climate change oriented programmes include:

- Rural Infrastructure Development Fund (RIDF): The fund was created in 1995–96 with a focus on three broad objectives: agriculture and allied sectors, social sector, and rural connectivity. Its cumulative allocations until 2020–21 were USD 54 billion.

- Umbrella Programme on Natural Resource Management (UPNRM): This programme, aimed at supporting ecologically sustainable business models, was implemented in 2015 in collaboration with GIZ and KfW Development Bank. With its initial budget, it provided financial (EUR 52 million) and technical assistance (EUR 5.3 million) for the implementation of selected projects.

- NABARD Infrastructure Development Assistance (NIDA): NIDA offers credit support to rural infrastructure projects. From its inception in 2010–11 until January 2021, NIDA approved loans worth USD 8.25 billion to support 110 projects focused on power transmission improvement, renewable energy generation, provision of sanitation, irrigation, etc.

8 Accessible at: https://www.nabard.org/demo/auth/writereaddata/File/Overall%20AFB%20Project%20Flyers.pdf
9 Accessible at: https://www.nabard.org/demo/auth/writereaddata/File/Overall%20NAFCC%20Project%20Flyer.pdf

2.2.1. India's climate vision

India's climate vision, linked to its development agenda, centres on meeting sustainable development challenges like ending poverty and protecting vulnerable sections of society, along with reducing emission intensity and improving energy efficiency (GOI, 2023a). India's updated NDC and Long-term Low Emissions Development Strategy (LT-LEDS), submitted in 2022, outline the country's climate vision for an extended period. These affirm India's commitment to global agreements to reduce emissions within the framework of 'common but differentiated responsibilities and respective capabilities' (PIB, 2022). The updated NDC has upped climate ambitions from the 2015 NDC, by targeting reduction in emission intensity of its GDP by 45 per cent instead of 35 per cent and setting up 50 per cent of its cumulative power capacity from non-fossil fuels instead of 40 per cent, by 2030 (GOI, 2022, 2023).

Other commitments made in the NDC include promoting sustainable lifestyles to reduce carbon footprint (Mission LIFE), creating additional carbon sink of 2.5 to 3 billion tonnes, increasing investments for better adaptation in sectors and regions vulnerable to climate change, mobilising funds from developing countries and so on (ibid). LT- LEDS envisages a just transition to a low-carbon economy with a focus on increasing renewable energy capacity, setting up and expanding green hydrogen capacity as a critical source of alternative energy (to decarbonise hard- to-abate sectors like steel and heavy industries), transitioning to low-carbon transport and promoting climate resilient development in cities (MoEFCC, 2022).

Policy measures adopted so far reflect the country's climate priorities, with mitigation strategies largely focused on energy and urban infrastructure sectors. Some of the low-carbon transportation policy targets include electrifying transport through a comprehensive package for electric vehicles, 20 per cent ethanol blending in fuel by 2025, net-zero Indian Railways by 2030, developing mass transit systems, fuel efficiency and promoting alternative fuels (ibid). Policy measures and targets under low-carbon energy include policy and financial support for renewables to increase its capacity to 50 per cent, green energy corridors in eight renewable-energy-rich states, smoother grid integration for renewable energy and threefold increase in nuclear power. Indian budgets increasingly are backing climate action priorities.

The Union budget of 2023–24 similarly makes an effort to expand non-fossil fuel electricity. This included announcing the National Green Hydrogen Mission, decarbonising transport and using green bonds to fund this new infrastructure (Deb et al., 2023). For instance, solar power has a hike of 54 per cent in this budget, as compared to 2022–23; allocation to Faster Adoption and Manufacturing of Electric Vehicles (FAME), which provides subsidies to electric vehicles, has doubled from last year; import duties on equipment for manufacturing lithium batteries has been slashed; and an outlay of USD 1 billion is proposed for the electrification of the Indian Railways (ibid).

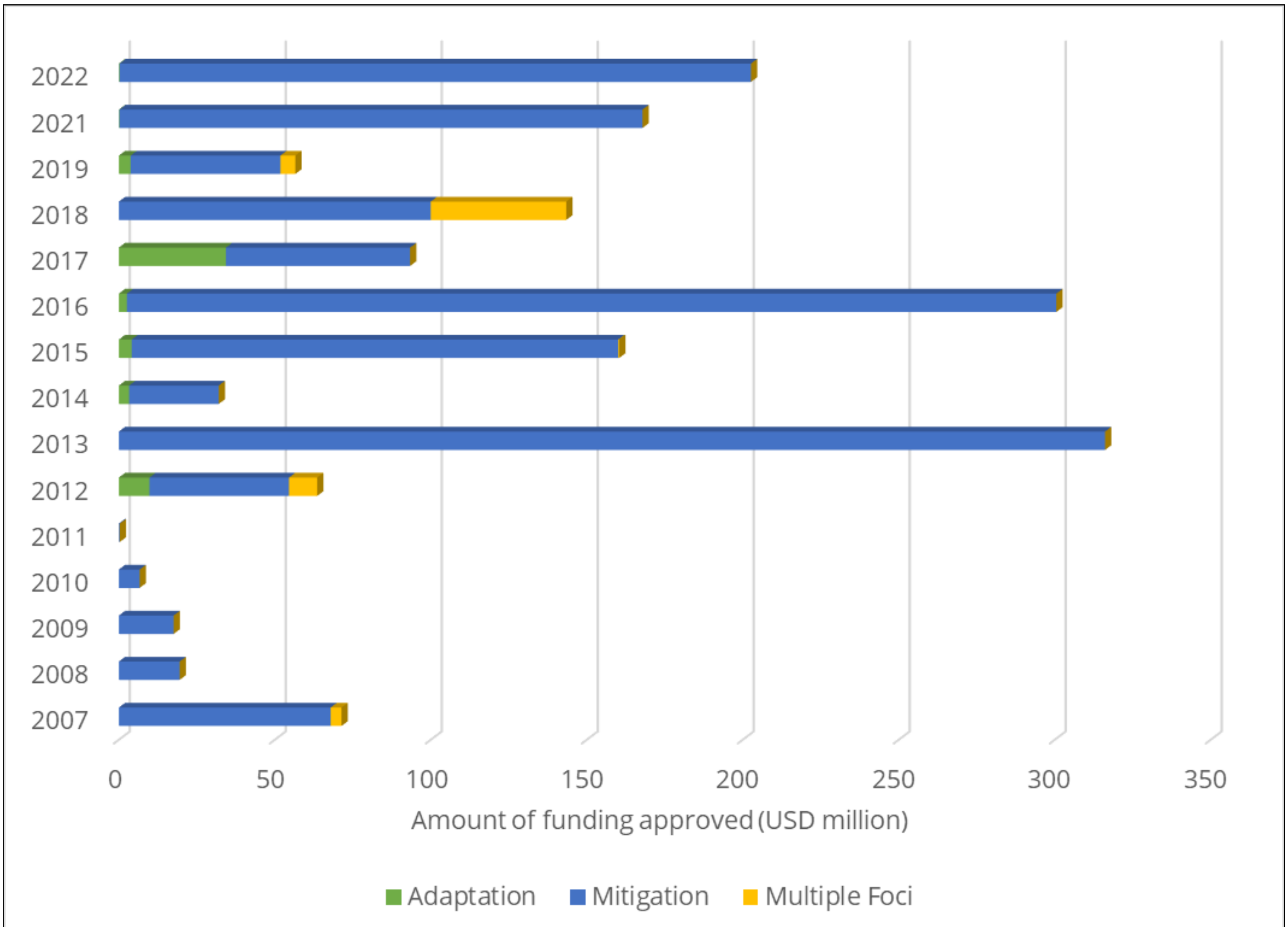
Climate adaptation policy measures are being also addressed and financed through budgetary allocations for the country's flagship schemes, like AMRUT, PMAY, Jal Jeevan Mission and Swachh Bharat Mission, which aim to upgrade existing water, housing and sanitation infrastructure and ensure its universal access, thereby reducing climate vulnerability. Various estimates, as discussed in Chapter 3, suggest that India's climate goals will require trillions of US dollars. Achieving many of these climate policy targets and goals is contingent on access to adequate climate finance, which remains woefully short.

2.3. What is being Financed?

Climate action finance flows have been increasing over the last decade, but globally they are skewed in favour of mitigation. Mitigation finance is monitored and tracked better than adaptation, sustainable development, and biodiversity conservation finance, potentially exaggerating the observed tilt towards mitigation. The lack of uniform classification of climate financial support themes or sectors further complicates the analysis. This section analyses whether and to what extent climate finance favours mitigation. It examines climate finance flows from different sources like GEF and bilateral flows tracked by the Organisation for Economic Co-operation and Development (OECD) and domestic funding recipients and priorities.

Besides direct climate mitigation, GEF funds environmental conservation with prevention of land degradation and biodiversity projects, accounting for about 32 per cent of its total funding in India. While GEF also supports projects with multiple benefits, in most such cases, the primary focus is on climate change mitigation. Data from multilateral climate change funds,[10] on the total pledges, deposits and project approvals, tracked by Climate Funds Update, shows similar trends. Mitigation funds significantly dominate the total multilateral climate funds received in India from 2007 to 2018 (Figure 2.5).

Figure 2.5: Multilateral climate finance by the objective of investments (2007–22)



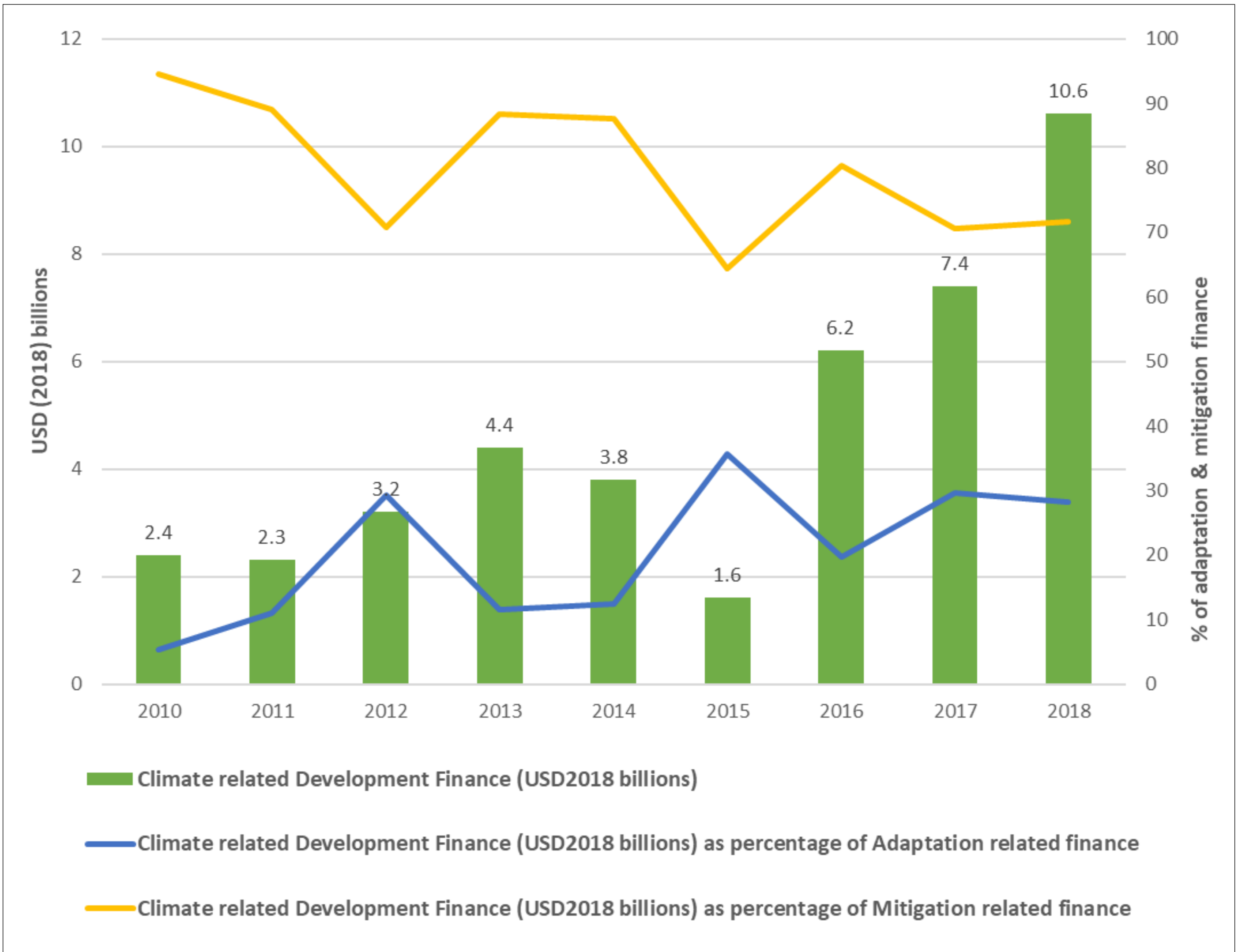
Source: Climate Funds Update[11]

10 This includes GEF, GCF, Adaptation Fund and SCCF, among many other climate funds
11 Climate Funds Update. Accessed at https://climatefundsupdate.org/data-dashboard/ on 24th November 2023

The primary focus of mitigation actions is on the energy sector with allocations of USD 943 million, with other mitigation activities getting USD 479 million. Since 2014, there has been a slow uptake of adaptation finance. Bilateral climate development finance to India from OECD Development Assistance Committee (DAC) countries from 2010 to 2018 (Table 2.4) also reflects the skewed allocation towards mitigation. The share of adaptation, however, is found to be increasing over the years.

Bilateral flows towards the transport sector have been increasing as metro rail projects are being implemented across various cities in India. Fifty-five per cent of the international bilateral flows were for sustainable transport in 2017–18 (Sinha et al. 2020), followed by 21 per cent for the power generation sector and 23 per cent for energy efficiency measures. Climate-related development finance data tracked by the OECD shows similar trends.

Figure 2.6: OECD-tracked climate-related development finance by sectors of focus (2010– 18)



Source: Authors' compilation (OECD DAC External Development Finance Statistics)

Domestically, the power generation sector attracts most investments in climate mitigation finance. Almost 80 per cent of the total tracked domestic climate finance flows were directed towards the power sector in 2017–18. Solar energy gained the most public and private funds among the different renewables. Between 2010 and 2018, investments in solar PV projects and wind energy have been gradually increasing (IEA, 2020). Sinha et al. (2020), however, caution of a bias towards power generation investments due to the relative ease of reporting data in this sector, and that there could be potential underestimation of finance flows towards the non-energy mitigation actions.

Domestic transport sector investments have also been increasing. The private sector has invested in electric vehicles like three-wheeler rickshaws, while spending of individual households on electric vehicles has also increased (Sinha et al., 2020). Funds for improving energy transmission and end-use energy efficiency have been increasing with INR 20,000 crore directed for such activities between 2016 and 2018 (Sinha et al., 2020). The energy and transport sectors attract investments because of the reducing costs of renewable energy technology as well as subsidies and government support.

2.3.1. MDB linked climate finance for the urban and infrastructure transition

Urban India is estimated to generate 87 per cent of national GHG emissions (Albrecht et al., 2011). It also concentrates much of India's climate risk, potentially undermining the transition towards climate resilient development. Multilateral development banks (MDB) have played a key role in financing climate related interventions in urban India. Their contribution has increased from USD 57 billion in FY 2017-2018 to USD 93 billion in FY 2021-2022 (CPI, 2023). The quantum of climate finance flowing into climate aligned urban interventions is in the range of 0.07-0.12 per cent of India's GDP.

The minimum level of urban infrastructure investment should be close to 1.14 per cent of India's GDP, to meet the country' development aspirations and the SDGs (HPEC, 2011). The current budgetary allocation for all capital investments in urban areas ranges between 0.1-0.2 per cent of GDP, which is far short of this. Municipal expenditures themselves are less than 1 percent of India's GDP, which is much lower than comparable norms in middle-income countries (Revi et al., 2022). Annual MDB-led climate finance averages 10 per cent of aggregate municipal revenue. This is skewed towards metropolitan and million+ cities, with smaller and medium sized cities unable to attract climate finance to manage local climate risks.

It is clear that current climate finance allocations are highly inadequate to institutionalise a climate-aligned urban and infrastructure transition in India. A dramatic scale-up of investments is imperative, to effectively address India's climate challenges.

On average, 70 per cent of the urban-centric projects funded by MDBs in 2022 are in the transport sector. These include support to metro rail systems, ecosystem development for electric vehicles, and other transport infrastructure. Water-related projects addressing flood management and water supply that could be seen as climate-adaptation aligned are the second large cluster. The third major investment cluster is in energy infrastructure e.g. the ADB-funded Delhi Power Distribution Project.

Approximately 89 per cent of these investments are allocated to mitigation related mitigation , while only 11 per cent are directed towards adaptation and resilience building. This imbalance contributes to the steady expansion of climate-related physical risks in Indian cities. The redirection of climate finance in a balanced form to address both adaptation and mitigation needs to be carefully operationalised. There is a clear need to accelerate adaptation investments recognising that cities are on the frontline in responding to climate-related shocks and stress (2023, CPI).

2.4. How is Energy Transition being Financed ?

India's NDC commitment to achieve 500 GW RE capacity by 2030 will require around USD 2.5 trillion of investment between 2015-2030, or USD 170 billion annually. India's revised NDC targets, of achieving net-zero by 2070, will need a cumulative investment of USD 10 trillion by 2070 (IFSCA, 2022).

India however, managed to raise only USD 44 billion over 2019-20. This is only a quarter cent of the required annual investment needed for a green transition (Khanna et al., 2022). This section tracks how the supply side of transition finance is being raised in India.

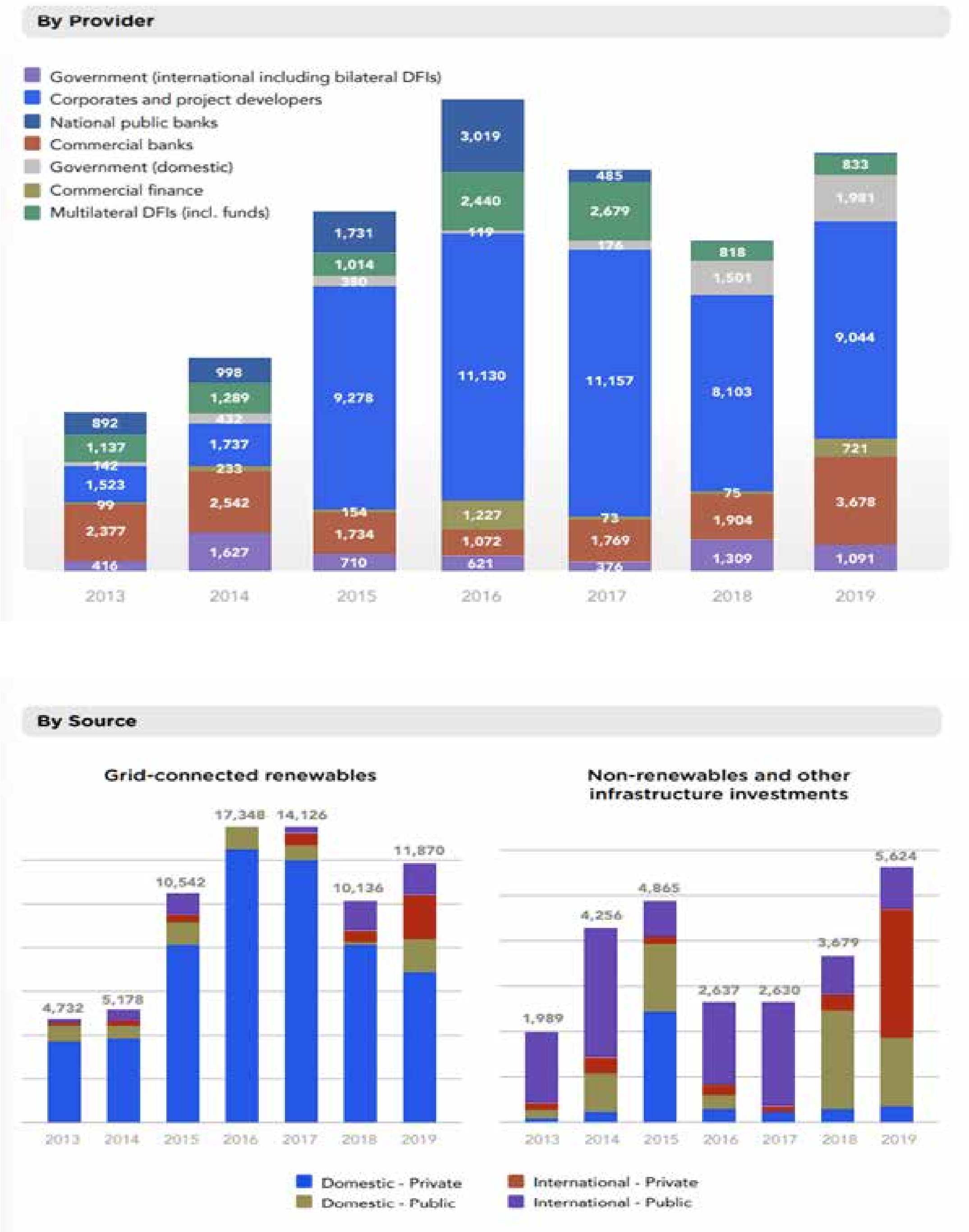
A bulk of climate finance in India is raised domestically. International finance has grown, but contributed only 13 and 17 per cent of the total climate finance in India in 2019 and 2020. Most international private capital flows lean towards established low-risk industries like renewables. Grid-connected utility-scale RE projects dominate power finance commitments in India (Coldret et al., 2022). Financial transfers from global North to South are still plagued with structural impediments (Khanna et al., 2022) such as underdeveloped financial markets, deficient domestic market policy frameworks and weak regulations for adaptation and climate risk response, apart from inflexible and opaque international credit and risk assessment practices (Saran, 2019).

Like other infrastructure, RE in India is mostly debt financed, typically around 75 per cent (Dutt et al., 2021). The Parliamentary Standing Committee on Energy and MNRE estimated annual investments of USD 19-25 billion for India to meet its 2030 RE targets in 2022 (MNRE, 2022). However, only USD 9 billion of investment was mobilised annually in recent years, resulting in a significant financing gap of over 50 percent (Sindhu & Shah, 2023). India allocated over USD 73.4 billion to support the energy sector in FY 2021, including nearly USD 29.6 billion in subsidies (IISD, CEEW, 2022). While fossil fuel subsidies decreased by 72 percent to ~USD 9.55 billion over 2014-21 (Aggarwal et al., 2022), these subsidies in FY 2021 were still 9 times higher than RE subsidies, providing a strong disincentive to the penetration of RE.

RE development in India is driven by large domestic actors, particularly public sector enterprises and private developers, amid a supportive policy environment. Between 2013-2019, domestic finance from the private and public sector represented was 75 per cent of all tracked finance, with international finance contributing the remainder. Private finance constituted 59 per cent of total finance, primarily directed towards utility-scale wind and solar projects. Lower corporate taxes, robust auction designs, public investment in transmission infrastructure, and regulatory interventions have attracted private capital to RE projects.

In FY 2021-22, the composition of the RE sector shifted significantly, with five domestic and international investors — Adani Green Energy Limited, Reliance New Energy Solar, a consortium of banks (ANZ, Credit Agricole, DBS Bank, MUFG and HSBC), RMG and Global Power Synergy Public company contributing 43 per cent of the total RE investment in installation capacity. Out of the total USD 14.5 billion in RE generation investment deals in FY 2021-22, the largest portion was raised through bonds (USD 4 billion) (Garg, 2022).

Figure 2.7: Power sector financing in India (2013-19) in USD million



Source: Couldrey et al., 2022

Between 2015 and 2019, debt and balance sheet financing were the major energy transition financing instruments used in India. Domestic debt financing, driven by commercial banks, constituted 19 per cent of total tracked finance during this period. The limited share of commercial bank may be due to RBI's prescribed debt limits of 20-25 per cent across infrastructure sectors that includes power, to limit the concentration of credit risks. Despite the risk of stranded assets, investments in coal power projects accounted for 16 per cent of total tracked energy commitments in 2019, with commercial bank financing contributing 35 per cent to coal projects (see Figure 2.7). A reduction in financing for existing coal-fired power projects, could create opportunities to redirect financing to RE projects.

Figure 2.8: Power sector financing in India by instrument (2013-19) in USD million

Source: Couldrey et al., 2022

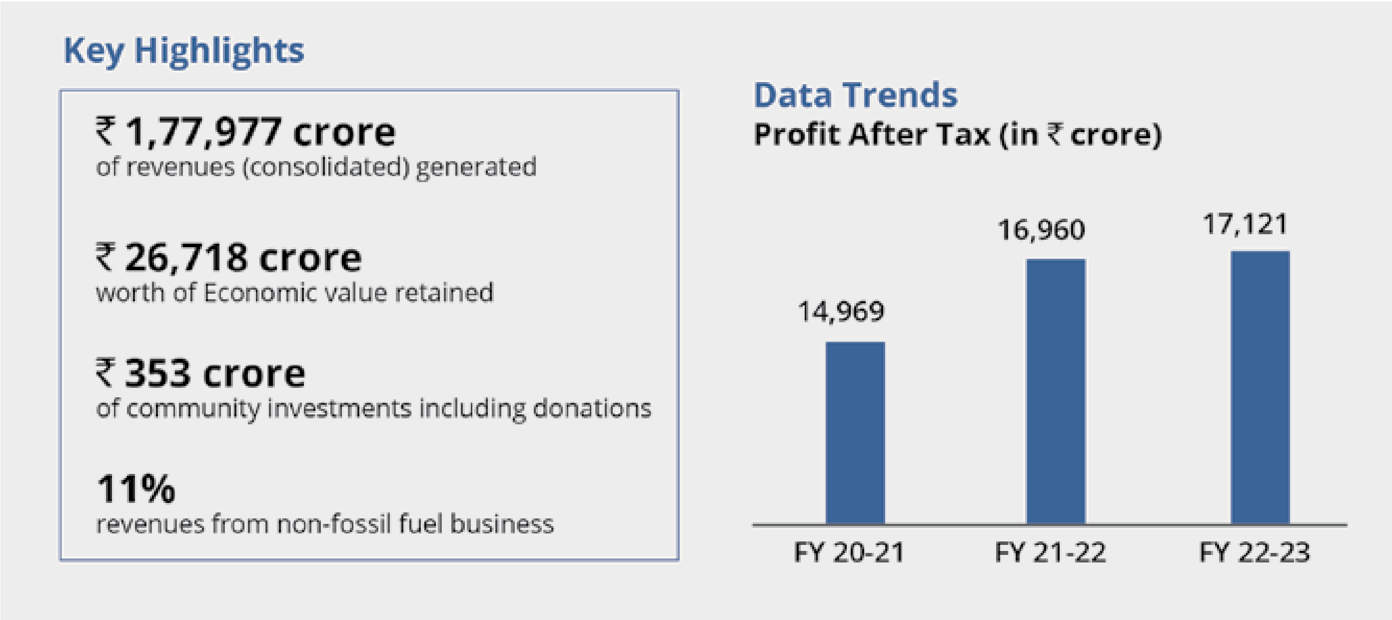
Public budgetary allocations, PSUs and commercial banks contribute about 70 per cent of the tracked climate mitigation finance in India. Renewable energy assets align seamlessly with the investment preferences of long-term institutional investors, particularly pension funds and life insurers. Notably, in the Indian context, Life Insurance Corporation of India (LIC) and the Employee Provident Fund Organization (EPFO) stand out. LIC manages around 70 per cent of the industry's total assets under management (AUM), nearly USD 510 billion as of March 2022, while EPFO, the largest pension fund in India, holds assets worth around USD 196 billion as of March 2021 (Srivastava, 2023). These entities represent a substantial portion of domestic institutional capital, influencing capital allocation across various sectors of the economy.

However, historically restrictive investment guidelines from sector regulators like the Insurance Regulatory and Development Authority of India (IRDAI) and the Pension Fund Regulatory and Development Authority (PFRDA) have limited LIC and EPFO's investments in renewable energy. Addressing these regulatory constraints could unlock substantial potential for increased institutional investment in India's RE sector.

2.4.1. Public enterprise financing of India's energy transition

The National Thermal Power Corporation (NTPC), Solar Energy Corporation of India (SECI) and Rural Electrification Corporation (REC) are three prominent domestic institutions that facilitate energy transition investments. NTPC, India's largest power conglomerate, has adopted a strategic approach to transition away from fossil fuels. First, it is diversifying by increasing investments in RE projects. In FY 22-23, NTPC and its subsidiaries added around 4 GW of commercial capacity including RE. It also plans to invest approximately USD 12 billion to install 16 GW of RE capacity (Mathew, 2023). Despite economic challenges, NTPC reported its highest ever net profit of USD 21.4 billion in FY 22-23. Non-fossil business made for 11 per cent of NTPC's total revenue of USD 2.15 billion in the same period.

Figure 2.9: NTPC key financial highlights (FY 2022-23)



Source : NTPC, 2023

Energy trading (approximately 48 per cent) followed by hydro power generation contributed the largest chunk of NTPC's non-fossil fuel sources revenue in FY 22-23.

Second, its subsidiary, NTPC Green Energy Ltd aims to achieve 60 GW RE capacity, or 45 per cent of its cumulative generation capacity by 2032. The estimated investment requirements for this are over USD 30 billion, with strategic investments coming from pension funds, equity investors, and some big private corporations (Press Trust of India, 2022). NTPC Green Energy Ltd plans to raise USD 24 to 36 million for RE projects by March 2023.

Third, NTPC green bonds and equity investments are used to mobilise funds to achieve the RE targets. In the FY 2023, NTPC Ltd. raised USD 366 million and USD 60 million through two bonds issues, the first with 7.35 per cent coupon rate and maturity period of three years and the second with 7.44 percent coupon rate and maturity period of ten years (Reuters, 2022). NTPC also facilitates RE projects by serving as a guarantor for projects between RE producers and DISCOMS.

SECI, another key federal institution driving India's energy transition, primarily executes initiatives sponsored by the MNRE. Its focus lies in implementing Viability Gap Funding (VGF) schemes for large-scale, grid-connected solar power projects under the Jawaharlal Nehru National Solar Mission (JNNSM). The company's operations extend to wind power projects, solar park schemes, and grid-connected solar rooftop schemes, etc. Actively involved in the auctioning of solar, wind, hybrid, and floating power projects, SECI holds a power trading license, and engages in the trade of renewable power derived from projects established under its ongoing initiatives. (SECI, 2023).

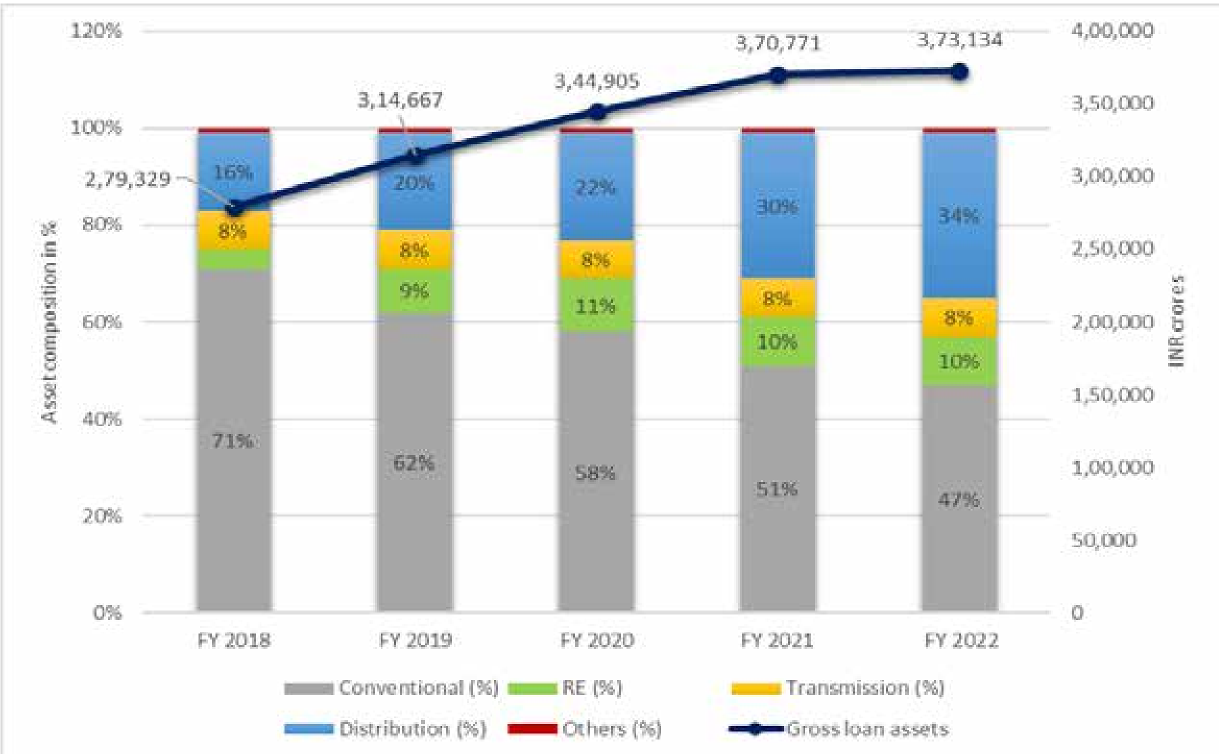
There are two potential supply side risks associated with the increasing share of intermittent renewables in India's energy mix: grid instability and stricter forecasting and scheduling rules. These are more pronounced for Independent Power Producers (IPPs). Federal agencies such as NTPC and SECI address these supply side risks by inviting tenders for standalone energy storage projects, facilitating grid balance without the need for curtailment. With federal agencies handling land mobilisation and grid connectivity, two critical elements of IPP project implementation are effectively de-risked. Government-owned enterprises commonly leverage relationships with State governments to secure land owned by them. For example, NTPC is developing a 0.93 GW project with the support from the Rajasthan Solar Park Development Corporation and has also acquired land in Gujarat for a 4.75 GW solar park.

Identifying off-takers before auctions is crucial for IPPs to mitigate risks. IPPs prefer SECI auctions over those organised by State Discoms, due to SECI's prompt payment history. However, SECI faces delays in securing DISCOM buyers post-auction. SECI addresses this by proactively identifying DISCOM buyers before auctions, like in the auctioning of 4.2GW solar capacity in Rajasthan (Jaiswal & Gadre, 2022). In this case, the State DISCOMs were predetermined as committed buyers in the tender, which rekindled IPPs' interest in participating in the 2021 wind auctions.

Besides NTPC and SECI, REC Ltd. and Power Finance Corporation (PFC) are crucial NBFCs under the Ministry of Power. Recent statistics reveal a misalignment in these NBFCs with India's energy transition in the absence of sufficient diversification into new energy technologies like RE, EV, and battery storage, as their coal lending tapers off. Coal lending for PFC has declined from 71 per cent to 47 per cent, and for REC from 45 percent to 40 per since FY 18 to FY 21. But, the proportion of renewable energy in PFC loan assets increased from only 4 per cent to 11 per cent, and for REC this remained stable at 3 to 4 per cent in the same period. PFC and REC need approximately 142 per cent and 156 per cent CAGR growth in their renewable energy loan assets to register 10 per cent net CAGR profits.

They need to disburse approximately INR 497,315 crore over the next three years to meet debt capital requirement of about 89 GW of solar and 38 GW of wind capacity. Without course correction, PFC and REC's net profits are expected to grow at merely 0.2 and 2.5 percent CAGR respectively from FY2022-25 (Raj & Fernandes, 2023).

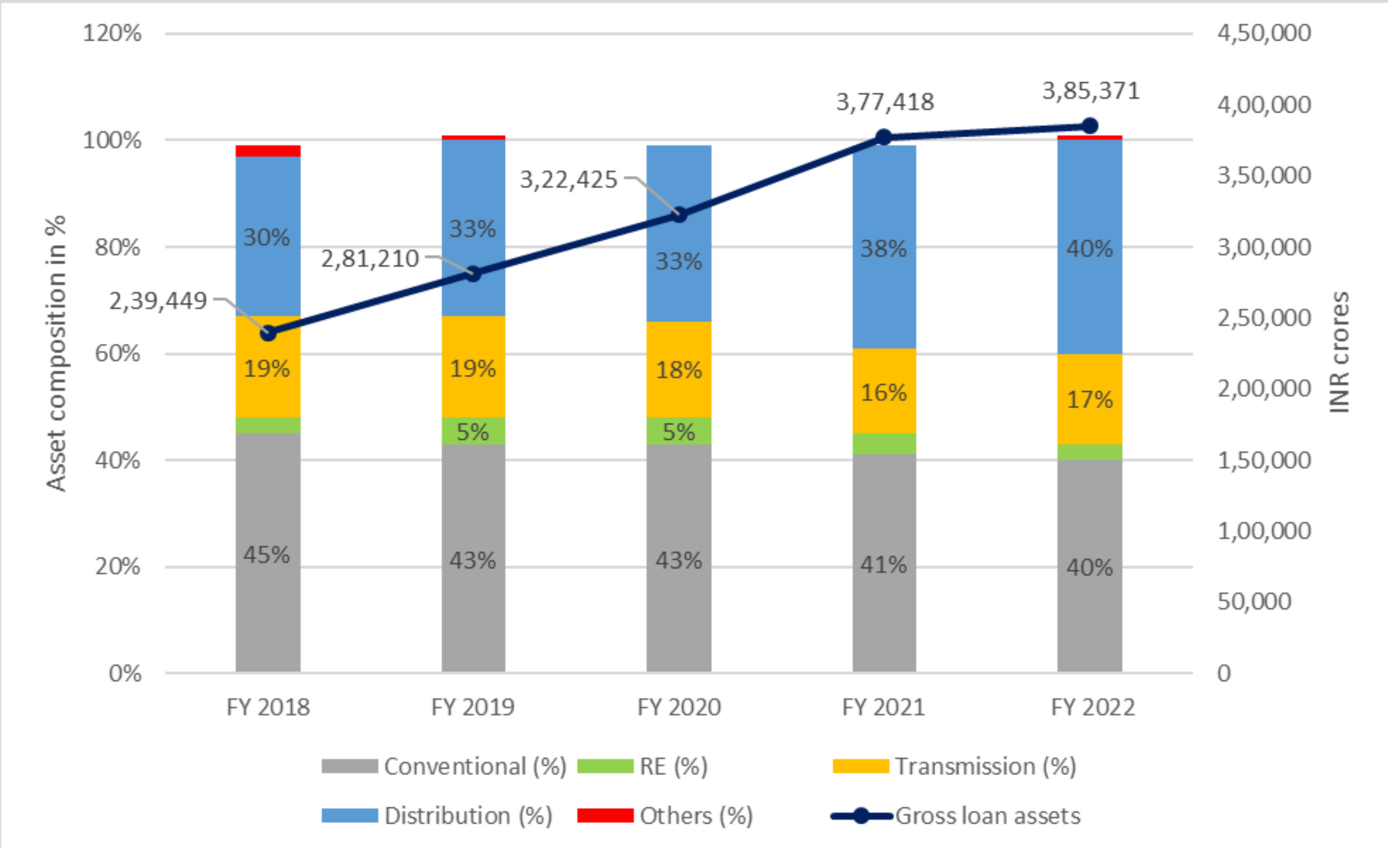
Figure 2.10 : PFC asset composition (INR crores)



Source: Authors' composition (Raj and Fernandes, 2023)

During FY18-22, PFC's loan book was predominantly led by the distribution sector, with a slight growth in RE, as the share of conventional power dropped consistently (see Table 2.4) REC's loan book composition remained relatively stable from FY 18-22 (see Table 2.5). With a marginal decrease in conventional power (45 to 40 per cent), the distribution sector drove loan book growth from 30 per cent in FY 18 to 40 per cent in FY22. The share of RE and transmission investments did not change significantly.

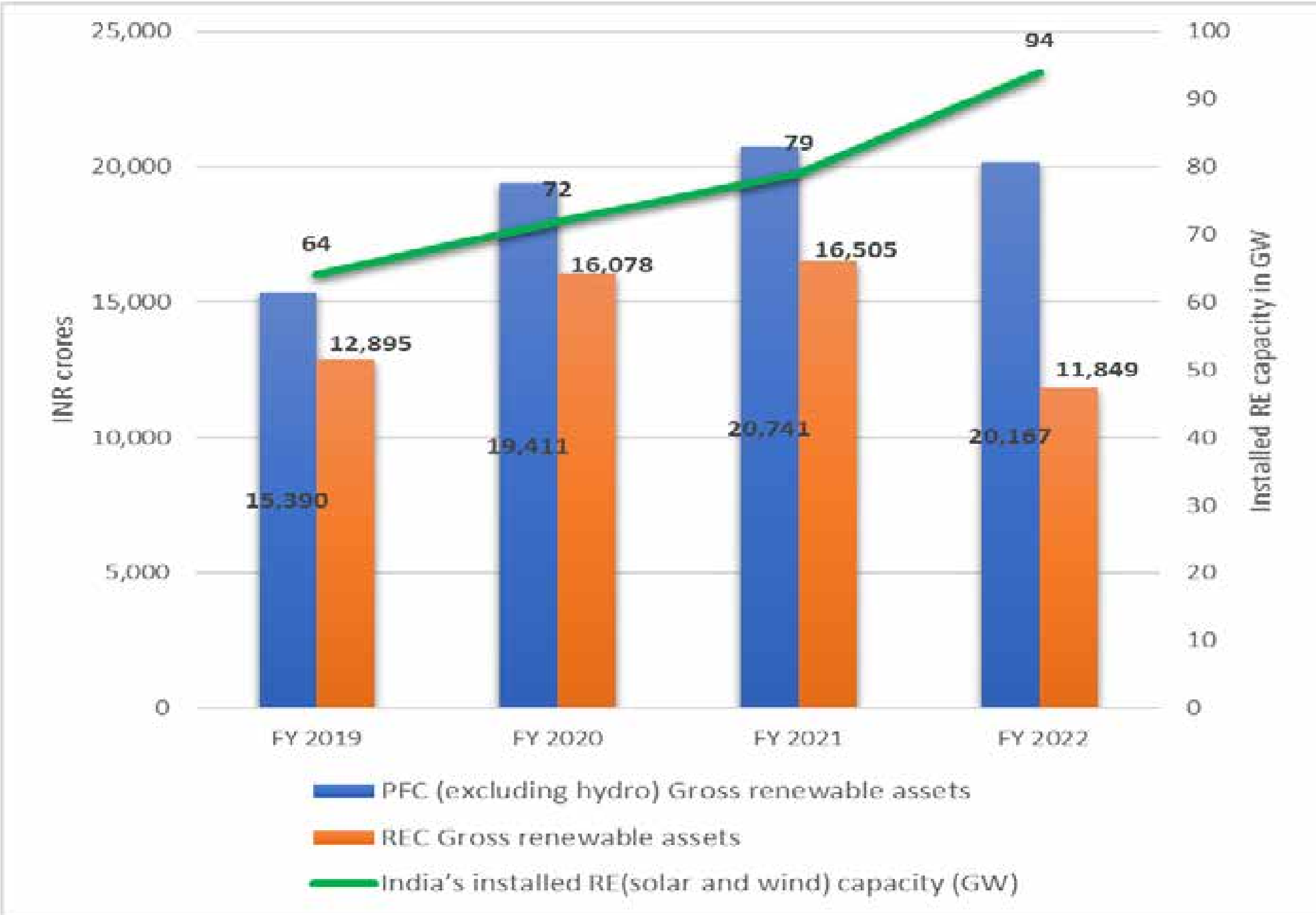
Figure 2.11: REC asset composition (INR crores)



Source: Authors' composition (Raj and Fernandes, 2023)

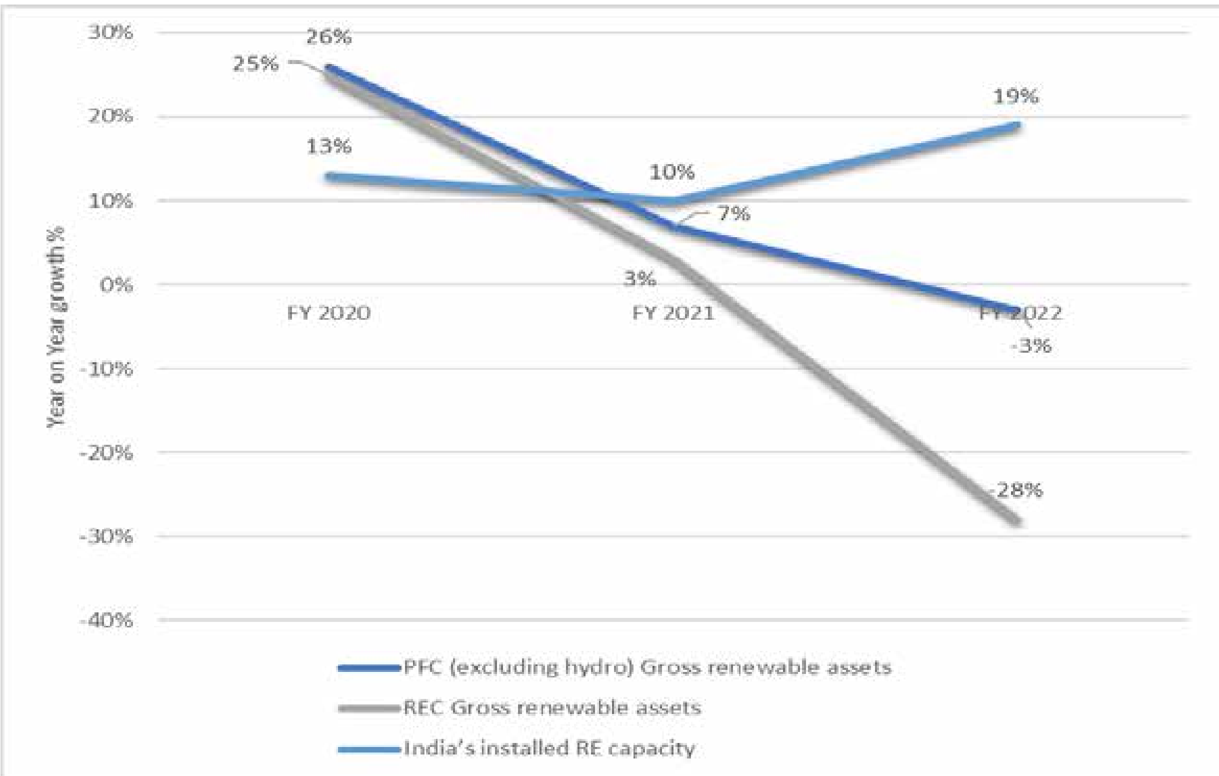
Even though India's RE targets mandate substantial investments, PFC and REC, country's largest power sector lenders, failed to capitalise on the potential in renewable financing. Their RE loan books grew at a 8.3 per cent and 8.11 per cent compound annual growth rate (CAGR), respectively, from FY 2019–202, falling behind India's capacity addition rate. PFC's claimed 32 per cent CAGR growth in its renewables loan book over the last 5 years can be primarily attributed to the reclassification of large hydro projects from conventional to the renewable category starting from FY 2020.

Figure 2.12 : PFC and REC gross RE loans assets and India's RE capacity



Source: Authors' composition (Raj and Fernandes, 2023)

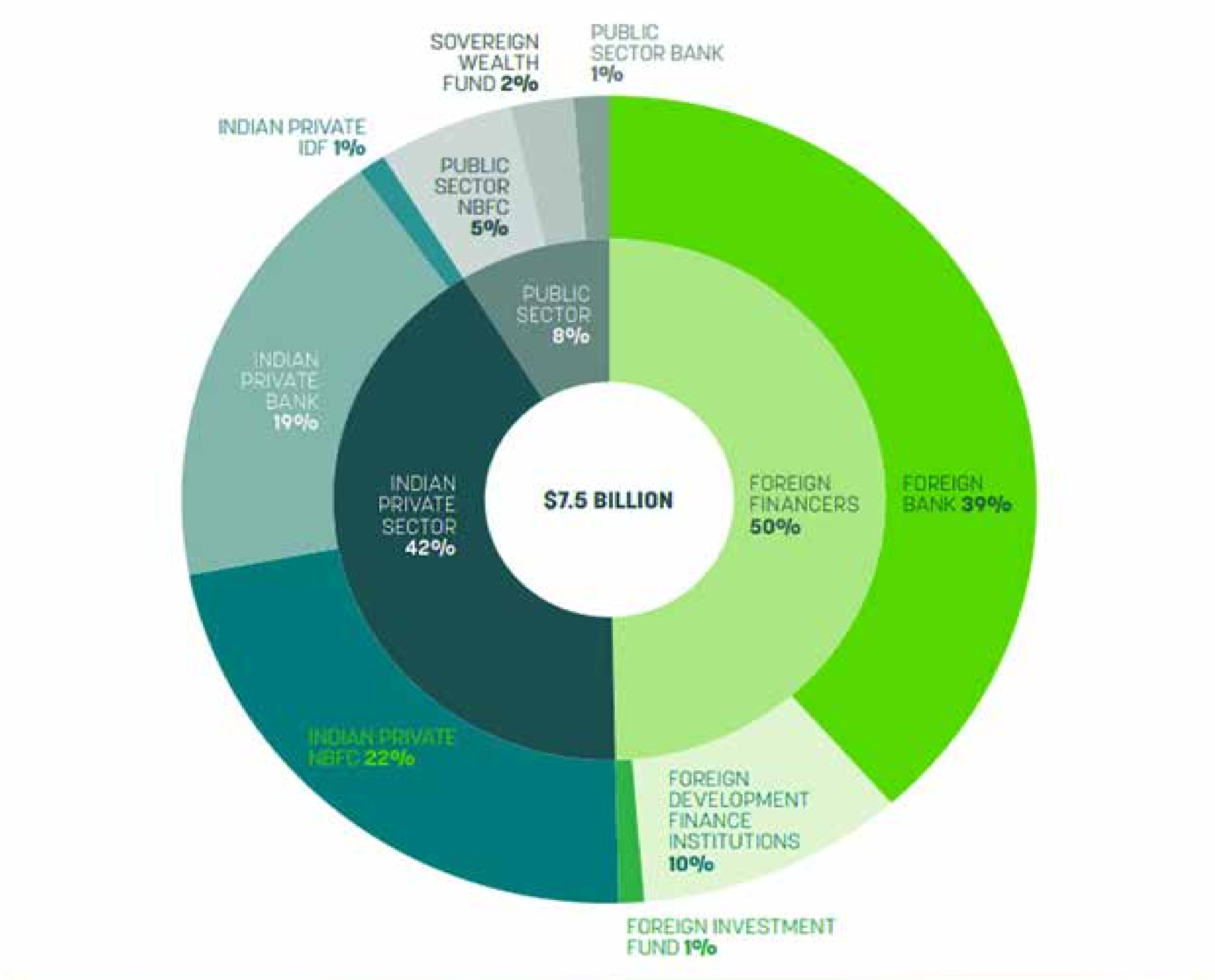
Figure 2.13: PFC and REC Gross renewable assets and India's installed RE capacity year on year growth percentage



Source: Authors' composition (Raj and Fernandes, 2023)

PFC and REC's foray into RE finance has been lacklustre despite unprecedented expansion of this sector. With access to low-cost Current and Savings Account (CASA) deposits, banks outshine NBFCs in securing favourable financing. To foster robust growth in their RE loan portfolio, PFC and REC must now navigate the competitive terrain by providing loans at rates that match industry standards.

Figure 2.14: Sources of debt new-build RE projects in India (2019-21)



Note:Chart shows deals captured in the BNEF database by date of financing. NBFC – Non Banking Finance Company, IDF – Infrastructure Debt Fund

Source: BloombergNEF, 2022

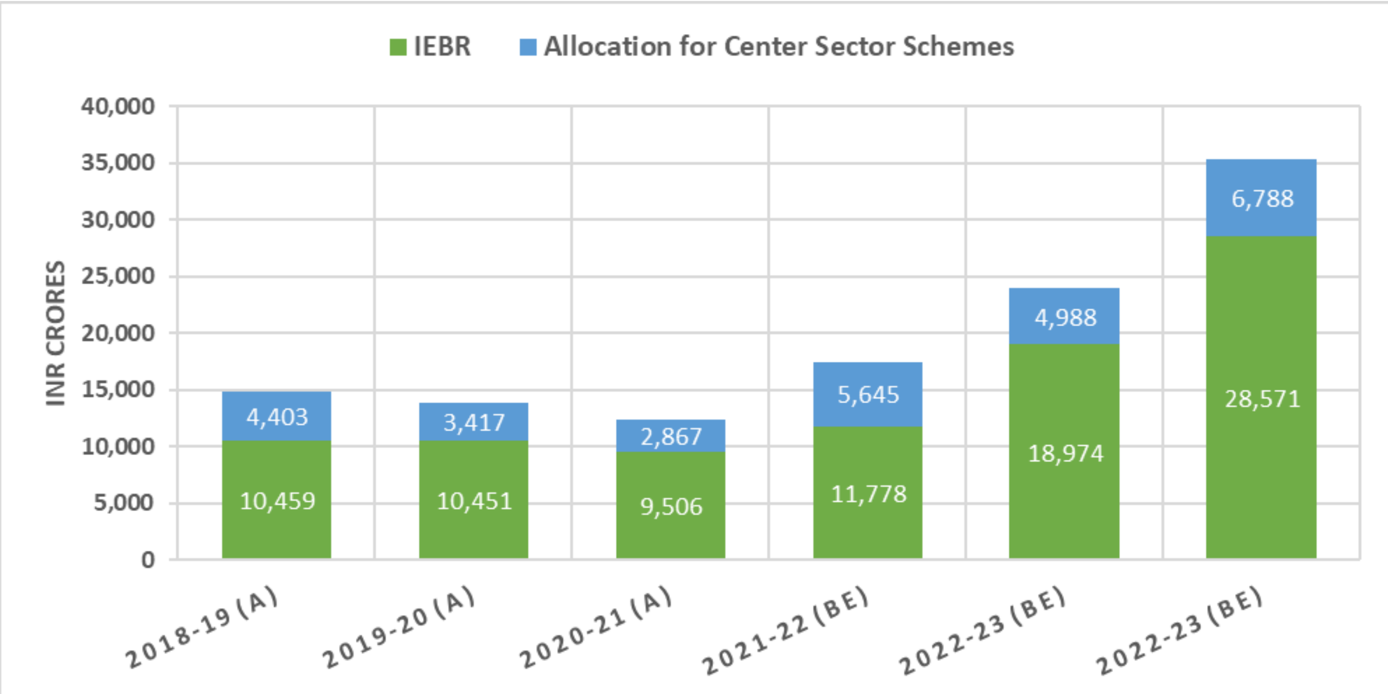
2.4.2. MNRE budgetary allocations for climate mitigation and support for climate mitigation

In India, multiple ministries are responsible for India's net-zero target, however the Ministry of New and Renewable Energy (MNRE) and the Ministry of Environment, Forests and Climate Change (MoEFCC) play a key role.

The MNRE financing for renewable energy is through two broad categories - financing for central government schemes and programmes (gross budgetary support) and financing through PSUs that is outside the purview of the Union budget, accounted as Internal and External Budgetary Resources (IEBR) (CBGA, 2020).
In the FY 2022-23 budget allocation Rs. 6,788 crore was allocated to MNRE as gross budgetary support through various central government schemes and programmes. The Central sector scheme allocation under MNRE ministry increased almost 20 per cent from FY 2021-2022 BE and 136 per cent from the FY 2020-21 actual spend.

The IEBR component supports PSUs like SECI, IREDA through financial instruments like Viability Gap Funding (VGF) to increase private investments to the sector. The IEBR component is much larger than the gross budgetary support, more than four times in FY 2022-23 and it has increased significantly over the last three years (see Figure 2.15). This is likely to be linked to the government's push for private sector participation in large-scale renewable projects (CBGA, 2020).

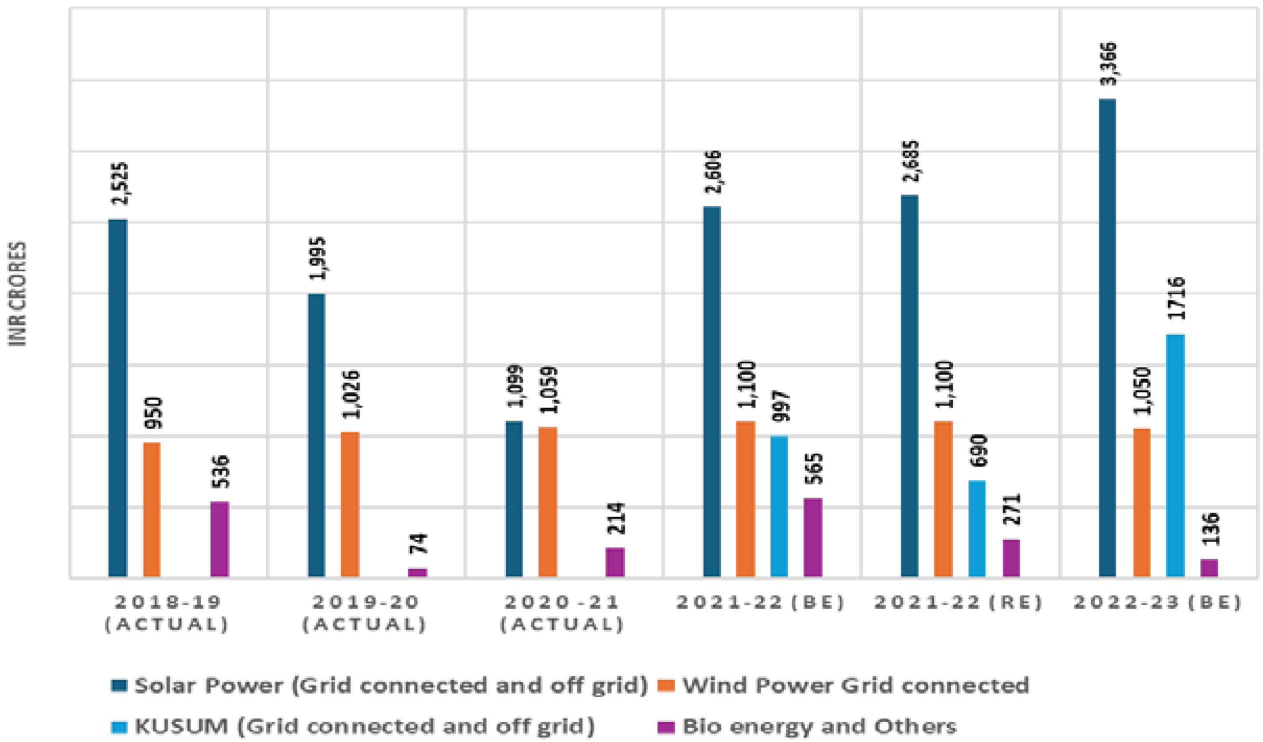
Figure 2.15: Trends in MNRE budgetary allocation and IEBR funding



Notes: i) IEBR = Internal and Extra Budgetary Resources. They constitute resources raised by PSUs through profits, loans and equity; ii) Central sector schemes include grid connected RE, off-grid RE power, R&D programmes and other supporting programmes.

Source: Compiled by CBGA from Union Budget documents, 2018-2023

Figure 2.16 : Budget allocation for major MNRE programmes (Rs crore)



Note: Others comprise allocation for R&D and International cooperation, National Green Hydrogen Mission, HRD and Training, and Green Energy Corridors.

Source: CBGA An Analysis of Union Budgets, 2022-23

Among the major MNRE programmes (see Figure 2.16), the highest allocation of Rs. 3,304 crore in the BE of FY 2022-23 went for grid interactive solar power projects. This is 40 per cent more than the budget allocation of FY 2021-22 and almost 240 per cent more than the actual spent in the FY 2020-2021.

Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM-KUSUM) got the second largest allocation of Rs. 1,716 crore among the major MNRE programmes, over FY 2022-23[AR1] . PM-KUSUM was launched in 2019, with an objective of ensuring energy security for farmers by helping them set up 10,000 MW of Decentralised Grid Connected Renewable Energy Power Plants on barren land, 17.50 lakh stand-alone solar agriculture pumps and solarisation of 10 Lakh Grid Connected Agriculture Pumps. Grid connected wind power got the next major allocation of Rs. 1,050 crore in MNRE's FY 20222-23 budget.

2.5. Conclusions

- Climate finance in India comes primarily from domestic sources. Public budgetary allocations, PSUs, public banks, NBFCs, private sector, and commercial banks contribute about 70 per cent of the tracked climate mitigation finance in India.

- The primary focus of climate finance in India is on mitigation, with adaptation gaining slow traction. The energy sector gets most of this, followed by end-use sectors like transportation and manufacturing.

- MDB and multilateral climate funds like GCF and GEF are the main sources for international climate finance to India. MDBs' climate finance contributions have increased from USD 57 billion in 2017-18 to USD 93 billion in 2021-22.

- MDB-linked climate finance for urban interventions in terms of aggregate municipal revenue averages 10 per cent yearly but is skewed towards big cities, with 70 per cent of projects funding the transport sector. Overall, climate finance required for institutionalising urban and infrastructure transition in India is significantly inadequate.

- Indian firms accounted for one-fifth or 298 million issued carbon credits, or 10 per cent of the country's annual GHG emissions in the year 2020. A concrete carbon market in India has the potential to contribute to the twin challenges of decarbonisation and development, but this hinges on robust designs and policy mechanisms.

- Between 2013-2019, domestic finance from the private and public sector represented around 74 per cent of all tracked finance for energy transition, with international finance contributing the remainder. Private domestic finance contribution was 59 per cent of total finance, primarily directed towards utility-scale wind and solar projects.

3.

ASSESSING FINANCING NEEDS

3. ASSESSING FINANCING NEEDS

Despite many uncertainties linked to different climate change scenarios and subsequent responses, it is necessary to assess the magnitude of investments for climate action. A systematic valuation of financing requirements to reach climate goals like 1.5°C and below 2°C, can provide governments and international organisations direction and clarity to provide sectoral support priorities, climate-aligned policies and measures to redirect investments to accelerate the low-carbon transition.

The low-carbon emissions pathways require a fast and radical change across systems - energy, industries, urban and infrastructure, land, freshwater and ocean, and societal choices around behaviour and consumption (IPCC, 2023). These changes need to be backed by robust investments across public, private, domestic and international sources.

However, tracked global finance flows for both mitigation and adaptation fall short of the requirements to achieve climate goals, with this gap being the largest in developing countries. Global mitigation investment requirement to limit warming to 2°C or 1.5°C up to 2030 is three to six times more than the current level (ibid).

Given the size of the global financial system, there is sufficient global capital to close these investment gaps but there are several barriers to re-directing finances towards climate action including perceived political, regulatory and economic risks of investments in developing countries. Nearly three-quarters of the global climate finance remains in high-income countries (Hourcade, J.C et al., 2021). Reducing barriers to climate finance requires clear policy signalling by governments and alignment of public finances to address these perceived risks and improve returns on low-emissions investments.

In India, there is a growing concern whether available climate finance can meet the country's NDCs. Current investments are insufficient to incentivise system-level changes in the energy investment portfolio, necessary to reach low-emissions targets (McCollum et al., 2018). Energy systems transition is challenging, given that the upscaling of supply-side investments has to complement demand-side investments to improve energy efficiency and induce behaviour change to reduce electricity demand. The energy mix in low-carbon scenarios is drastically different from the scenarios compatible with current climate policies. There is also a substantial difference in the requirements for 1.5°C and 2°C targets.

Additional finances might also be required to support vulnerable populations from increased energy prices. Carbon Dioxide Removal (CDR) technologies like Carbon Capture and Storage (CCS) and carbon sequestration are also advocated to achieve negative emissions to align with the available carbon budget. Mittal et al., (2018) and Vishwanathan and Garg (2020) estimate that CCS would play a crucial role in long-term mitigation plans of India. Investments in CDR, including CCS, have so far been a low priority and do not figure in the present NDCs. The existing economic incentives focus on emissions reduction and renewable energy. The support needed for CDR and CCS in terms of R&D and deployment depends on the implementation of other mitigation policies and socio-political concerns (Vishwanathan and Garg, 2020).[12]

Besides the quantum, the timing of the investments play a crucial role in determining whether lower temperature targets are possible. Delayed or inadequate mitigation will increase economic losses from climate change, leading to financial instability, making it more difficult to mobilise climate action finance.

12 Vishwanathan and Garg (2020) further note that the need to install and scale up CCS is higher if mitigation measures are taken only after 2030 to achieve the deep decarbonisation scenarios. Early investments in renewable energy and systems transition are associated with a lower share of CCS in the energy mix. Late action will require more CCS because (a) there is less time frame for CO2 emission reduc- tion and (b) of the presence of coal and gas in the primary energy mix.

For India, the economic costs of late mitigation of about 3 to 5.8 per cent of GDP is comparable to costs of emissions pathways of 1.5°C or a well below 2°C scenario (Mittal et al., 2018). Delayed and inadequate mitigation will also make it difficult for the government to balance mitigation and adaptation expenses and lead to trade-offs between mitigation and development objectives.

Box 3.1: Enhancing institutional capacity, strengthening policy instruments and enabling climate finance: Key insights from the IPCC Special Report on 1.5°C

De-risking low-emission investments and carbon pricing: Distributive impacts, Challenges and Regulatory measures

To stay below 2°C, substantial annual mitigation investments in the power sector are required, necessitating approximately 0.36 per cent of the global GDP from 2015 to 2025. These investments can be funded from reduced consumption or redirected savings towards climate-aligned investments, prioritising low-emission infrastructure over existing carbon-intensive infrastructure. However, scaling climate finance to meet targets faces hurdles, with both public and private sectors encountering resource constraints.

While market mechanisms like carbon pricing are proposed, implementing a universal carbon price is hindered due to the adverse distributional impacts of higher energy prices. Climate pricing also poses challenges of stranded assets and requires changes in capital stock and re-skilling of workers. Overcoming these obstacles require robust policy measures and collaborative efforts among institutions to ensure equitable outcomes.

The pace of low-emission energy technology is also a factor in climate financing. The energy systems transition faces challenges like decommissioning costs of existing infrastructure, market structures inertia, cultural habits, and risk-averse behaviour by end users. To increase investments in low-emission infrastructure, it is crucial to reduce risk-weighted capital costs with public budget support, including tax cuts, subsidies, loans and revolving funds.

Integrated Policy Packages and Financial Cooperation

Policy instruments, regulatory measures, economic incentives and de-risking investments must work synergistically to align financial flows with emission reduction. Hence, integrated policy packages that also consider social and political contexts of the region are essential. International coordination through specific institutions is also necessary to address equity in climate action and differential responsibilities of different countries. Such institutions can improve financial access to developing countries through loans, business models or by nudging financial markets. Non-state actors also play a major role in infrastructure investments and climate-aligned transitions, by supporting resource mobilisation and governance improvements. Financial institutions like Central Banks, financial regulatory authorities and MDBs need to collaborate with other actors. Involving microfinance institutions is important for social resilience and local-level climate resilience. Interaction and coordination between these different types of institutions and stakeholders is crucial to manage expectations, accelerate emission costs reduction and maximise co-benefits.

Box 3.2: Climate scenarios

Four broad scenarios used in most integrated assessment studies are described below. These scenarios are based on population and socio-economic development assumptions in line with the 'middle-of-the-road' storyline of the Shared Socioeconomic Pathway (SSP2). The SSP2 poses moderate challenges to mitigation and adaptation, with global social, economic and technological trends not deviating markedly from historical patterns. Development and income growth is uneven, environmental systems face degradation, global population is projected to peak at 9.5 billion between 2070–2080.

The 'Current Policies' (CPol) scenario serves as a baseline and considers energy- and climate-related policies already implemented as of 2015. Vishwanathan and Garg's (2020) 'Business-as-usual' (BAU) scenario assumes the continuation of current policy and economic dynamics, incorporating ongoing mitigation and adaptation strategies outlined in India's National Environmental Policy (2006), NAPCC and SAPCCs, extending them until 2050. Three other mitigation scenarios are the Nationally Determined Contributions (NDC), 'Well Below 2 Degrees' (2°C) and 'Toward 1.5 Degrees' (1.5°C), which progressively tighten policies for low-carbon energy, energy efficiency and climate change mitigation. The NDC scenario assumes the implementation of NDCs by 2030 and aims for an overall emission reduction of 33-35 per cent from the 2005 level between 2005 and 2030, with 40 per cent of electricity generation from non-fossil fuels. It does not consider carbon budget constraints (Vishwanathan and Garg, 2020).

The 'Well Below 2°C' scenario aims to limit maximum global average temperature increase to 2°C with more than 66 per cent likelihood. It follows policies of the NDC scenario to meet carbon budget constraints. The projected carbon constraints are in the range of 115-130 Bt-CO2 (during 2011-2050) compared to 165 Bt-CO2 for the BAU scenario. The scenario includes retiring low-efficiency coal-based thermal power plants, enhancing energy efficient technologies, extending India's renewable potential, and introducing storage technologies. The 2°C scenario focuses on low-carbon mobility, infrastructure and other policies to support large and small cities, towns and rural centres to grow sustainably (Vishwanathan and Garg, 2020).

The 1.5°C scenario assumes a high stringency of mitigation policies, to limit the temperature increase to 1.5°C in 2100 with more than 50 per cent likelihood. It requires less than 115 Bt-CO2 during 2011-2050. To prevent technology and behavioural lock-ins, this scenario promotes early transitions to low-carbon pathways, relying on aggressive PAT to improve energy efficiency standards and switch-over to cleaner fuels. Dematerialisation, recycling and reuse are promoted in all sectors of the economy to make development more sustainable in the long- run.

Apart from these emission-target-based scenarios, some studies are based on alternative growth or development scenarios (Shukla et al., 2015; Gupta et al., 2020; Shukla and Chaturvedi, 2013). A conventional scenario relies on market-efficient instruments like carbon tax to decouple carbon emissions from the economy. Unlike this, the 'sustainable' decarbonisation pathways follows a 'development first' framework wherein the CO2 mitigation actions are back-casted from the national sustainability goals set at the end- time horizon. The driving factors in the sustainability scenario are the co-benefits between the two goals: development and climate.

3.1. Investment Needs for India's NDC

Prior to the NDC commitments in 2015, the estimated costs to achieve the NAPCC objectives from 2012 to 2020 were about USD 240 billion (1 USD equivalent to 60 INR) (MoF, 2012). In its NDC, India has committed to reduce the emissions intensity of its GDP by 33 to 35 per cent from 2005 levels, by 2030, and by 40 per cent of its cumulative installed power capacity from clean energy in its NDC. To achieve these targets, India requires an estimated total outlay of USD 2.5 trillion (at 2014–15 prices) from 2016 to 2030 (MoEFCC, 2015). This translates to about USD 167 billion per year, nearly 8 per cent of India's GDP in 2014–15. The NITI Aayog estimates that the mitigation costs for a moderately low-carbon strategy would be USD 834 billion (at 2011 prices) from 2010 to 2030, taking into account associated costs like technological transition, R&D, intellectual property rights and capacity building. India needs to scale up its current annual investments from 2018 by nine times to realise its NDC goals (Jena and Purkayastha, 2020; Sinha et al., 2020).

Kanitkar et al. (2018) compare investments, energy and economic factors under the BAU scenario with an emissions restrictions[13] scenario aligned with the NDC targets. The BAU scenario considers two possible growth pathways driven by the industrial sector or the service sector. The per capita electricity demand, total installed capacity and annual power sector investment are higher in the industry-based scenario than the services-based scenario. When there are emission constraints, fuel supply requirements change, thus necessitating additional investments. This study finds that total additional investments are higher in the emission constraint scenario. While per capita emissions reduce by 19 per cent in the emissions constraint scenario compared to the BAU scenario, this comes at the cost of a 41 per cent increase in the total power sector investments. The deployment of renewable energy is also more at 32 per cent in the low emissions scenario, as compared to 10 per cent in the BAU scenario (table 3.1).

Table 3.1: Electricity capacity, demand and investment requirements under different climate scenarios

Scenario	Total Installed Capacity (GW)	Annual Investment in Electricity Sector (USD billions)	Installed Capacity of Renewable Energy sources as% of total Installed capacity	Per Capita Electricity Demand (kWh/ person/ year)
2003-04 (base year)	168	-	13%	634
Growth driven by sector with no emission constraints (2030-31)				
Industrial sector	729	19	-	2,318
Service Sector	603	15	10%	1,919
Service sector with emissions constraints	723	21	32%	1,848

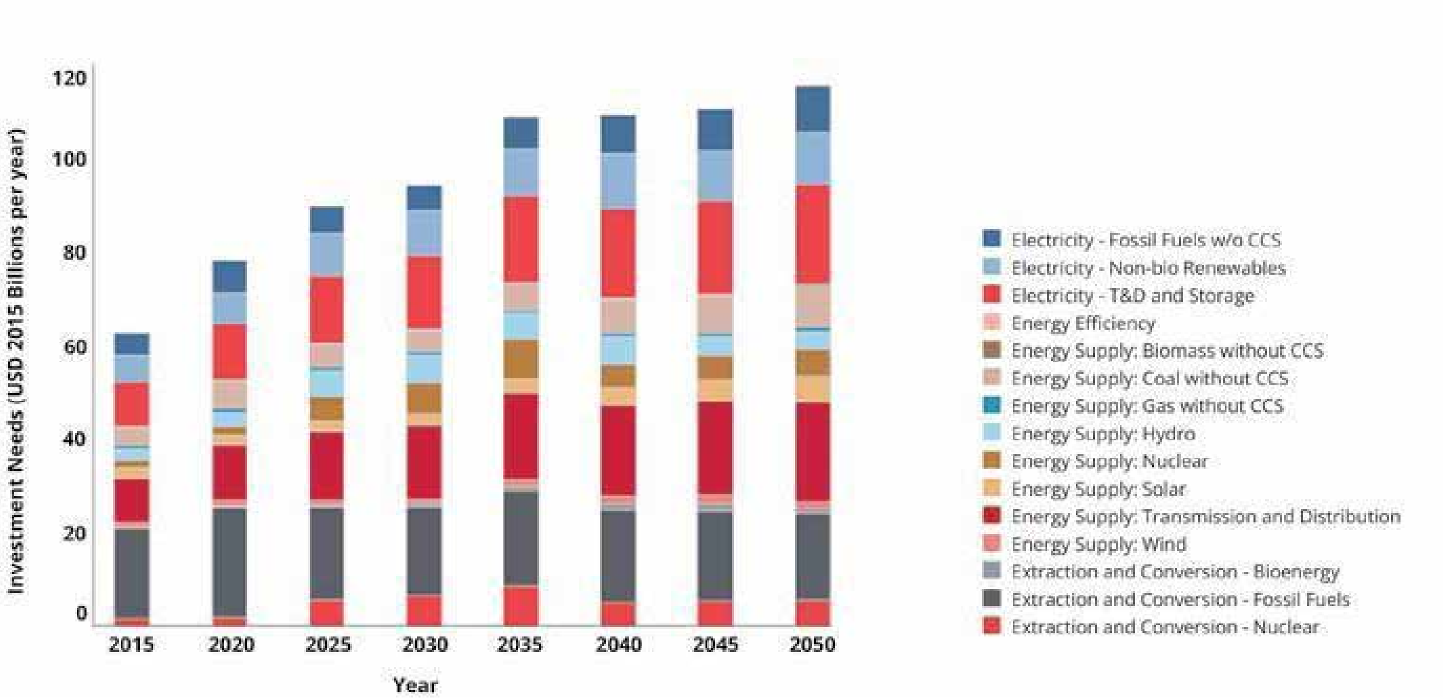
Source: Kanitkar et al., 2018

13 It is assumed that India's NDCs will result in total allowable cumulative emissions of 18 GtC between 2005 and 2030 when there is a GDP growth rate of 7.1 percent. Keeping the fraction of emissions attributable to the power sector constant between 2005 and 2030, a constraint of 6 GtC for emissions for the power sector is considered.

McCollum et al. (2018) estimate global investment of USD 130 billion per year (till 2030) in low-carbon energy and improved energy efficiency to meet the NDC targets (Figure 3.1). This analysis identifies transmission, distribution and electricity storage as essential for achieving NDCs. Fossil fuels funding is not projected to decrease, but there is a gradual increase in the funding for nuclear energy production.

Vishwanathan and Garg (2020) estimate a cumulative investment of USD 2.37 trillion, averaging around USD 120 billion per year in power sector investments under the NDC scenario in India. This includes 24 per cent of the investments each for coal and solar power, 12 per cent on gas, and around 8 per cent each on modern bioenergy and nuclear. This estimate excludes other investments needed for demand-side transitions, like energy efficiency improvement or energy transmission and distribution. The various NDC-consistent investment estimates are presented in Table 3.2. Two recent estimates (INDC, 2015; Vishwanathan and Garg, 2020) suggest that USD 2.4 trillion worth of total investments are required between 2016 and 2030 for India to achieve its NDC targets.

Figure 3.1: Annual investment needs for NDC in India (2015–50)



Source: McCollum et al., 2018[14]

The realisation of NDC targets requires significant cumulative investments, as indicated by various academic and government sources. The Ministry of Finance, Government of India estimated that an investment of USD 240 billion, (conversion rate of 1 USD to 60 INR) is necessary for the period spanning 2012 to 2020 (MoF, 2012). NITI Aayog projected a more extensive financial commitment, proposing USD 834 billion (2011 prices) for the duration from 2010 to 2030 (NITI Aayog, 2014). Furthermore, the Intended Nationally Determined Contributions (INDC) of 2015 advocated for a substantial investment of USD 2.5 trillion (2014–15 prices) from 2016 to 2030 (INDC, 2015).

14 The NDC scenario assumes implementation of all countries' NDCs by 2030. Post 2030, an assumption of equivalent effort in carbon emissions development is assumed with no intensification. Represents a continuation of fragmented and highly diversified climate action worldwide.

In alignment with this, Vishwanathan and Garg (2020) estimated an investment of USD 2.37 trillion (2014– 2015 prices) for the timeframe 2015 to 2030. This collective data underscores the substantial fiscal commitments imperative for meeting NDC targets over varying temporal scopes, as articulated by diverse scientific assessments.

3.2. Financing the 1.5ºC or 2ºC Targets

A 1.5ºC or 2ºC world can be a reality only with a dramatic increase in investments. For the global emissions level to be in line with these targets, annual investments in low-carbon energy will have to surpass fossil fuel investments by 2050 or earlier. Clean investments should be more than fossil fuel investments in the entire supply chain, and not just in the power generation sector (McCollum et al., 2018). This study estimates a global investment gap of approximately USD 320 billion (USD 480 billion) per year, till 2030, to achieve a 2ºC world. India needs half of these total energy investments, unforeseen in the baseline scenario.[15] This suggests India should increase its low- carbon energy and energy efficiency investments by 50 per cent from the current levels, while simultaneously withdrawing financial support to carbon-intensive sectors.

Table 3.2: Energy investment requirements under different climate scenarios for India (in billion USD)

Climate Scenario	Time Period	Annual Energy Investments	Annual Demand-side Energy Investments	Source
CPol	2016-2050	153 (51 to 299)[16]	0	McCollum et al., (2018)
	2016-2030	132.41	0	Zhou et al., (2020)
NDC	2016-2050	160 (58 to 328)	0 (-1 to 4)	McCollum et al., (2018)
	2016-2030	181.63	0	Zhou et al., (2020)
	2016-2030	120	-	Vishwanathan and Garg (2020)
2ºC early action[17]	2016-2030	270	-	Vishwanathan and Garg (2020)
Well below 2ºC	2016-2050	235 (120 to 453)	35 (16 to 71)	McCollum et al., (2018)
	2016-2030	189.82	22.88	Zhou et al., (2020)
	2016-2030	160	-	Vishwanathan and Garg (2020)
Towards 1.5ºC	2016-2050	288 (190 to 526)	60 (33 to 109)	McCollum et al., (2018)
	2016-2030	191.13	25.9	Zhou et al., (2020)

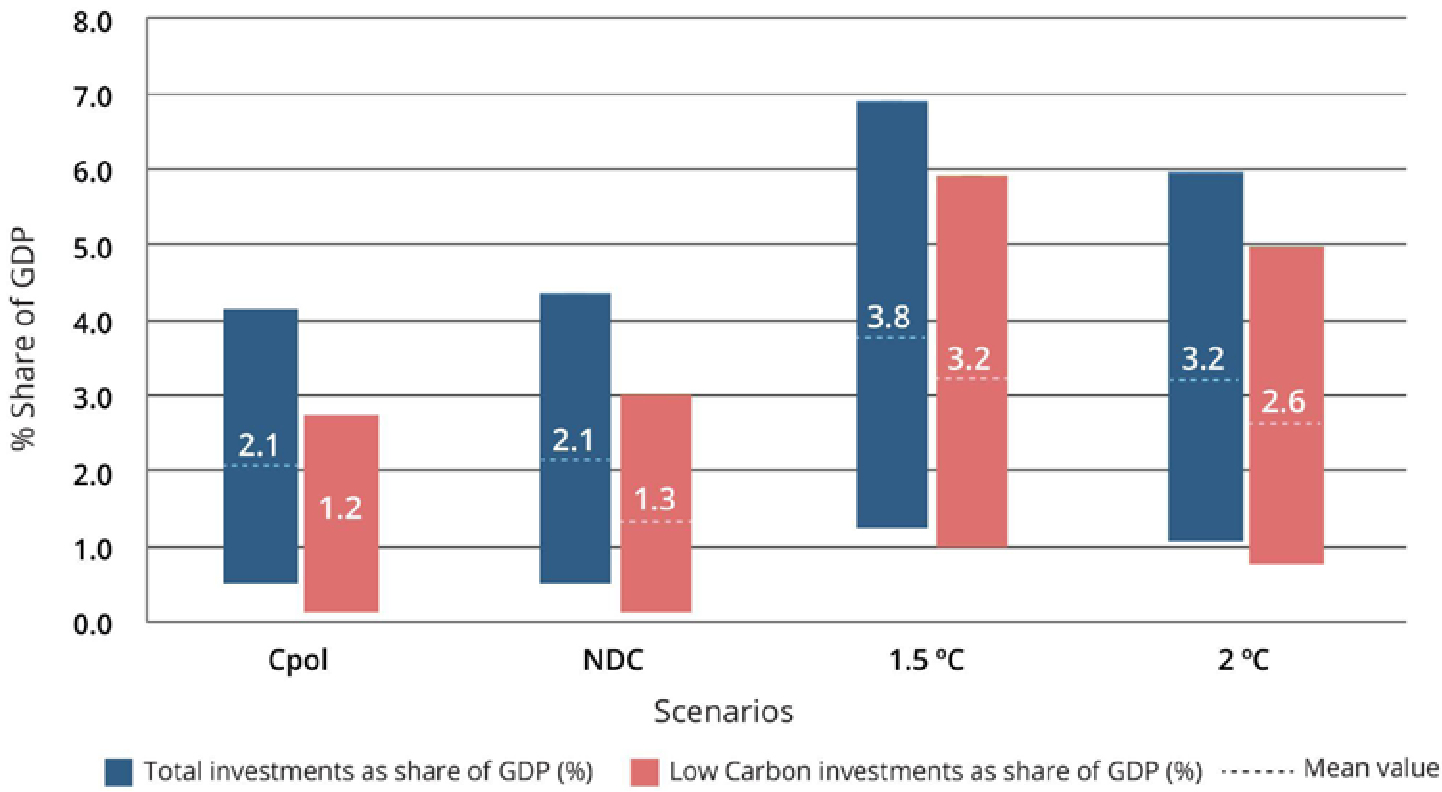
Note: Current Policies (CPol) denotes a climate scenario with policies of 2015.

Annual energy investments estimates are inclusive of demand-side energy investments.

15 The baseline scenario takes into account those energy- and climate-related policies that were already 'on the books' of countries as of 2015.
16 McCollum et al. (2018) use six different IAMs to estimate the investment requirements. The range of investments is given in the parentheses.
17 In the early action 2ºC scenario, the budget constraint was not anticipated in intertemporal optimisation models until 2020 (it is 2030 in the late action 2ºC scenario). Post 2020, the budget is fully anticipated via an explicit bound on cumulative emissions by ratcheting up BAU and NDC policy measures

Apart from the direct costs (captured as investment needs) incurred in the transition, there are also indirect transitional costs for the economy. Deep decarbonisation requires installing CCS technologies, scaling up of energy storage facilities, phasing out of inefficient power plants, shifting towards cleaner fuels and installing energy efficient technologies. Energy sector transformation of this scale requires investments worth USD 6–8 trillion between 2015 and 2030 (Vishwanathan and Garg, 2020).

Figure 3.2: Annual investments as a percentage of GDP in India as estimated by different Integrated Assessment Models (2016–50)



Source: McCollum et al., 2018[18]

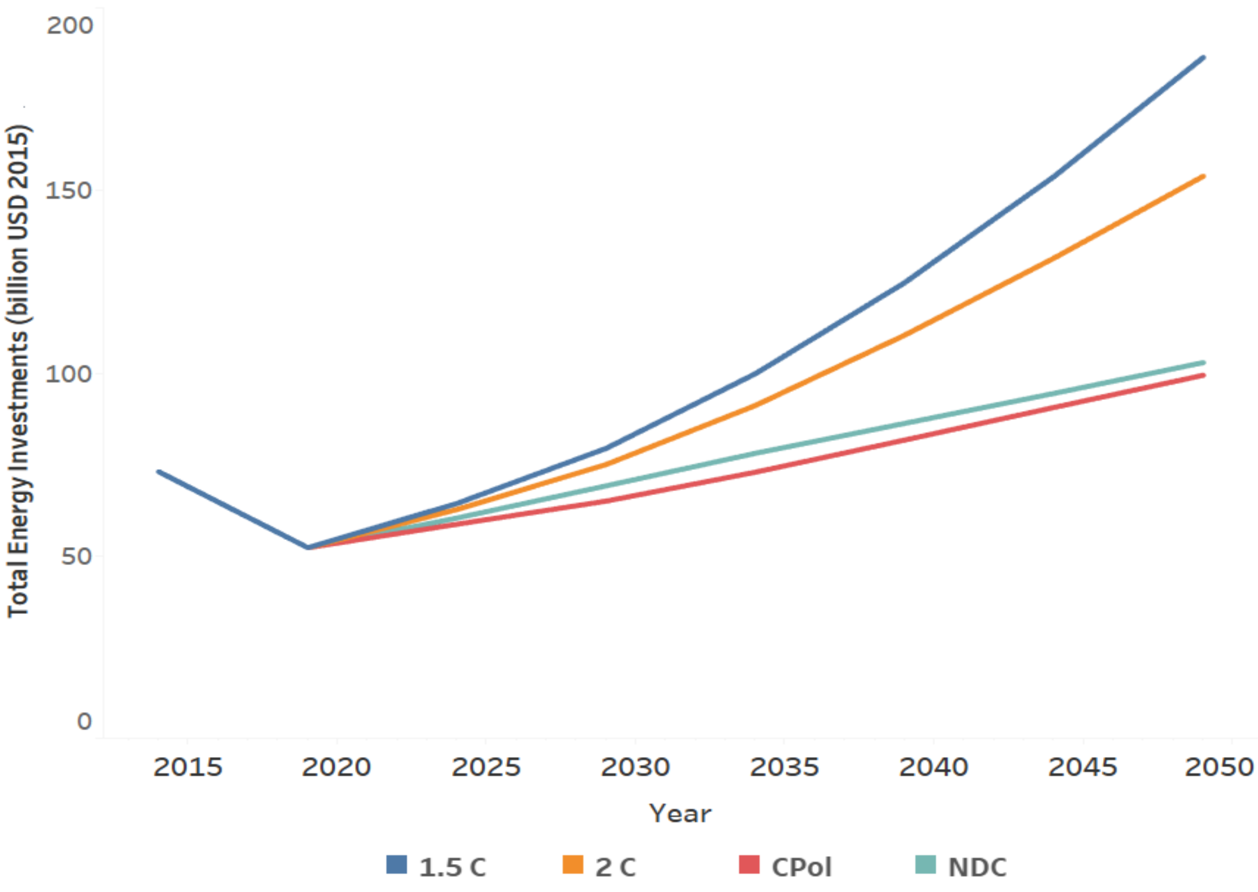
McCollum et al. (2018), using six different Integrated Assessment Models[19] estimate the need for USD 120 billion to USD 453 billion of energy investments between 2016 to 2050 in the 2°C scenario, representing around 4 per cent to 16 per cent of India's GDP in 2019. For the 1.5ºC scenario, higher investments of USD 190 billion to USD 526 billion (around 7 per cent to 18 per cent of GDP in 2019) are required. The authors identify a link between investments and emissions, noting an inflection point around the emissions abatement level targeted by the 2ºC scenario. Such an inflection point is observed across all models, suggesting that beyond a threshold, even a marginal increase in CO2 abatement would require a disproportionately higher increase in investments.

18 Average of estimates from six different IAMs are presented with the range of estimates.
19 The six models are AIM/CGE, IMAGE, POLES, MESSAGEix-GLOBIOM, REMIND-MAgPIE and WITCH-GLOBIOM

The study finds that transition from CPol to NDC, NDC to 2°C, and 2°C to 1.5°C requires an increase in investments at each level. To go beyond the 2°C target to 1.5°C, incremental low-carbon energy and efficiency investments need change in capital invested per tonne of CO2 avoided, relative to the energy system transformation efforts up to that point. Marginal emissions abatement costs keep increasing with the stringency of climate targets. In the NDC scenario, marginal abatement cost is lower as the low-cost options are first availed in emissions reduction. Once these options are exhausted, further emission reduction comes at additional expenses.

Zhou et al. (2020) estimate that between 2016 and 2030, average annual investments in renewable electricity (mainly solar and wind) need to increase from a baseline of USD_{2015} 77.42 billion in the CPol scenario to USD_{2015}131.76 billion in the 2ºC scenario, and to USD2015 136.44 billion in the 1.5ºC scenario (Figure 3.3). These results show that the investment needs intensify after 2030, once an emissions abatement threshold is reached. It is reported that from 2031–2050, investments on renewables must grow from the baseline of USD2015 179.88 billion to USD2015 377.24 billion in 2ºC and USD2015 457.83 billion in 1.5ºC. As current mitigation efforts are not sufficient to keep global temperature at expected levels, higher amounts of abatement at faster pace is required post 2030s. Meeting investment needs early helps to gradually increase and stabilise emissions reduction in a cost-effective manner (Mittal et al., 2018).

Figure 3.3: Total energy investments needed for different climate pathways in India (2015–2050)



Source: Zhou et al., 2020[20]

20 Current Policies (CPol) denotes a climate scenario with policies of 2015.

Currently, a major proportion of the investments are directed towards energy supply-side transition with less focus on the energy demand. However, demand-side energy efficiency investments are as important, as modification or retrofitting along the entire supply chain determines the desired level of energy transition. End-use sectors like buildings, industrial machinery and transportation must be capable of operating with newer technology, and storage and transmission facilities need to be remodelled. The transport sector has great potential for emissions reduction with the newer clean vehicular technologies. Additionally, demand-side actions also include lifestyle and behavioural changes. Climate education, information technology and sharing economy can encourage such individual actions (Dhar et al., 2018).

Mittal et al. (2018) predict the shadow carbon price, which captures the marginal mitigation costs using several IAMs[21]. For the 2ºC pathway, the carbon price is predicted to increase from USD 74 in 2030 to USD 187 in 2050 per tonne of CO2. For a 1.5ºC scenario, the corresponding values are USD 328 and USD 860 respectively. Until the 2040s, the NDC scenario has the lowest carbon price, but it overshoots the 2ºC scenario around the early 2040s. In 2050, the NDC pathway is expected to result in a carbon price of USD 551. A steady emission reduction rate ought to be followed now to ensure optimal future costs.

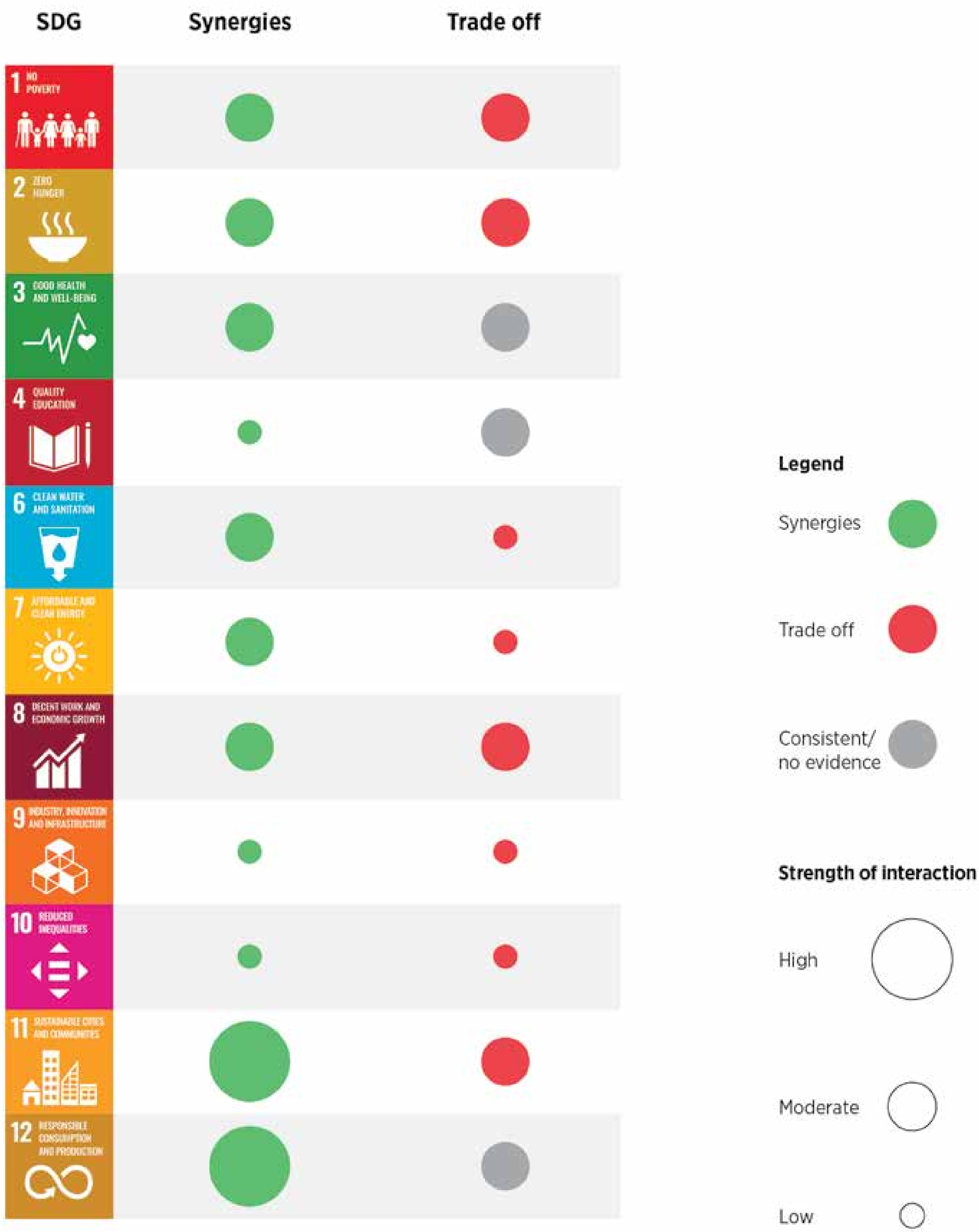
3.3. Funding for Sustainable Development

With a large proportion of its population poor and unemployed, India faces a development deficit. Consequently, increased financial allocations for development policies have to be met along with high climate finance requirements. The transition to a low-carbon world demands investments in both mitigation and socio-economic development. These investments are also linked through their macroeconomic implications and outcomes. Given budgetary resource constraints, policymakers need to consider the possible trade-offs between sustainable development and climate mitigation. This section looks at the synergies and trade-offs between SDGs and climate action (mitigation in particular) using peer-reviewed literature. It also examines the scale of investments required for mitigation in comparison to adaptation and SDGs. Investing in SDGs can contribute to building of adaptive capacity and social security (IPCC, 2014). While some SDG investments may increase with energy transitions, in the long run, climate mitigation helps to achieve these goals by recognising climate change as a key risk for sustainable development.

There are synergies and trade-offs between climate mitigation actions and the target indicators of SDGs (Fujimori et al., 2020, Liu et al., 2020). There are still knowledge gaps regarding the interactions between the energy SDG targets and the non-energy-focused SDGs in different contexts. Nerini et al. (2019) studied these interactions by ranking their direction and magnitude (Figure 3.4). The analysis shows more synergies than trade-offs. Globally, the number of trade-offs were four times fewer than the number of synergies between climate action and SDG achievement. McCollum et al. (2018) analysis of energy interlinkages of SDGs also found that positive interactions between SDG 7 (affordable and clean energy) and the other SGDs outweighed the negative linkages, both in magnitude and number. However, it is crucial to address these trade-offs as they can potentially block climate action (Nerini et al., 2019).

21 The carbon price is computed from the general equilibrium model: Asia-Pacific Integrated Model/Computable General Equilibrium (AIM/CGE). The carbon price from the global model is taken as an input in the model for India under the assumption that there is equal marginal mitigation cost across nations.

Figure 3.4: Synergies and trade-offs between climate action and the SDGs

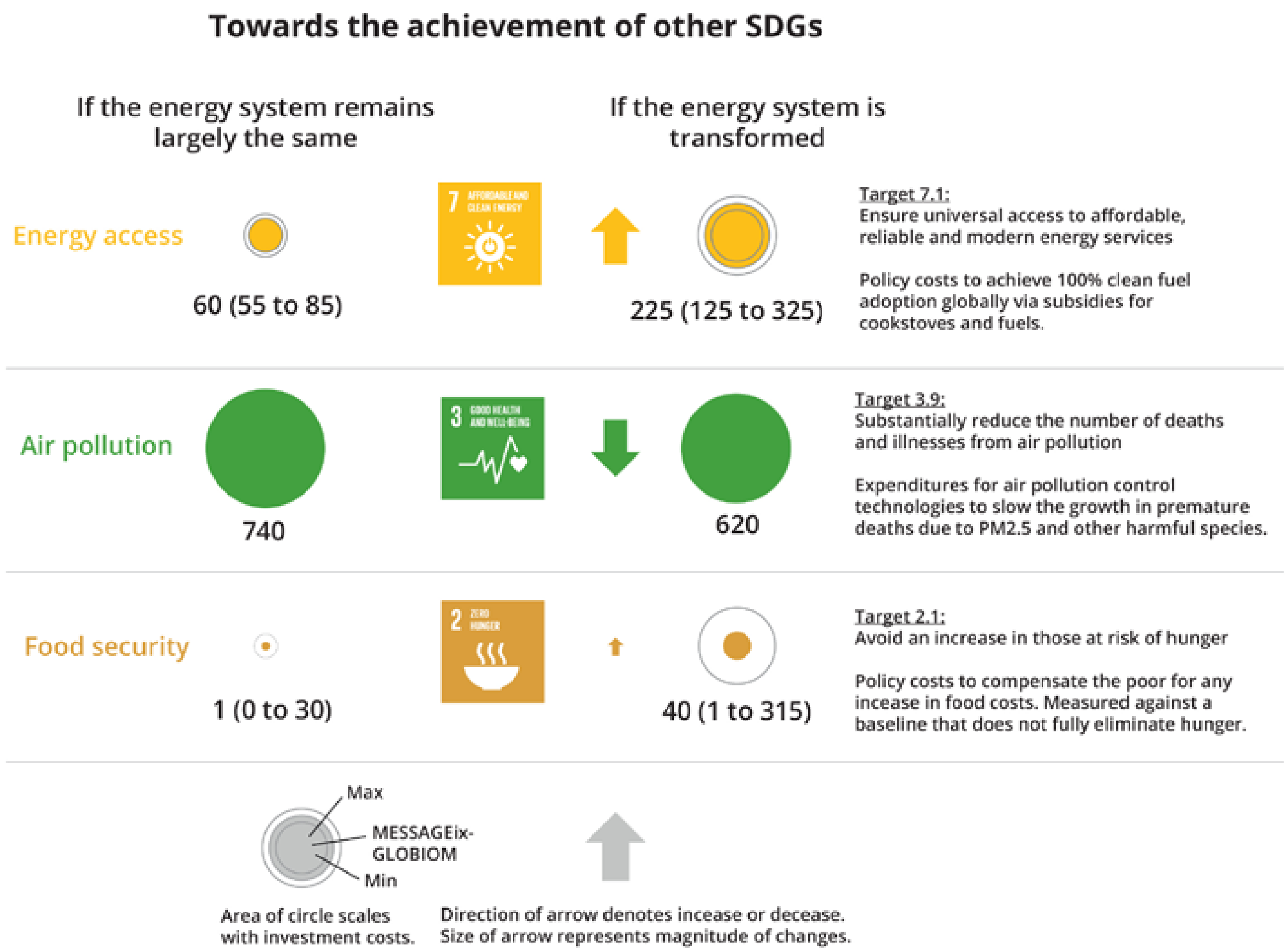


Source: Authors' computation (Nerini et al., 2019)[22]

22 Strength of interaction has been computed using weighted means across SDG (sub) categories based on Nerini et al., 2019

Climate action investments specifically for the energy systems transition are higher than the investment requirements for SDGs. McCollum et al. (2018) find that the total capital needs consistent with a transformed energy system (consistent with a 1.5°C or 2°C scenario by 2030) are larger than that for most other SDG targets (Figure 3.5) like food security, education and sanitation. The total energy investments are roughly a couple of trillion dollars, against a few hundred billion dollars for the latter. Zhou et al. (2020) also estimated that the investment needs for SDG 7 are much larger than the other SDGs.

Figure 3.5: Projected investments for making progress on a subset of SDG targets relevant for energy systems planning (till 2030)



Source: McCollum et al., 2018

Despite several synergies between SDG 7 and other SDGs, investing in SDG-7 also has negative implications on some of these goals. A transformed energy system, in line with the long-term climate goals may increase the investments needed to achieve some SDGs. For example, climate mitigation for SDG 7 can impact food security (SDG 2) through effects on prices, supplies of agricultural inputs and commodities. The investments needed for SDG 2 would increase by 40 times (between 2016 and 2030) if the energy system transforms (McCollum et al., 2018). Similarly, Fujimori et al. (2020) predict a trade-off between mitigation and food security. In their baseline scenario, the population at risk of hunger in Asia continuously decreases from 500 million in 2010 to 7.4 million in 2100. But, with mitigation policies (based on a carbon tax), the risk of hunger increases as a direct consequence of increased food prices.

India, in particular, faces higher risk of hunger under a decarbonisation scenario due to increased land rent. One per cent CO_2 emission reduction compared with the baseline scenario leads to the marginal adverse effects (in Asia) on food security (0.94 per cent), agricultural price (0.26 per cent), GDP (0.034 per cent) and biodiversity (0.026 per cent) (Fujimori et al., 2020).

Climate action can also enable and reinforce building prosperous, equal and peaceful societies (Nerini et al., 2019) as achieving some goals becomes cheaper with a low-carbon transition due to co-benefits. For instance, reducing air pollution (SDG 3) is easier with a low-carbon system (Tibrewal and Venkataraman, 2021). Investments in renewables and energy efficiency have reduced SO_2 by 25 per cent, NOX by 30 per cent and PM2.5 by 20 per cent (IEA, 2020). Shifting from a baseline scenario to a 2ºC scenario reduces investments for air quality improvement from USD2015 42.29 billion to USD2015 38.41 billion (Zhou et al.,2020).

Six SDG indicators show co-beneficial relationships with climate change mitigation, including premature deaths due to air pollution (SDG 3), air pollution mortality due to people under water stress (SDG 6),share of renewable energy and energy intensity (SDG 7), unemployment rate (SDG 8), food waste (SDG 12) and forests area (SDG 15) (Fujimori et al.,2020). For instance, health improvements are substantial as climate change mitigation is associated with a 30 per cent reduction in air pollution-related mortality (SDG 3) (ibid). Similarly, climate policy has a positive impact on forest area because the carbon tax raises the value of forests (Liu et al., 2020). Air quality, renewable energy share, energy intensity, unemployment and forest area have shown marginal improvement of 0.58 per cent, 0.23 per cent, 2.6 per cent,0.02 per cent and 0.34 per cent, respectively, with a 1 per cent CO_2 emission reduction compared with the baseline scenario (Fujimori et al., 2020).

However, SDGs with minimal linkages with energy transitions, like SDG 6 (clean water and sanitation) do not see a substantial change in the investments across different climate scenarios. Compared to the baseline scenario, only a USD2015 2.07 billion increase would be incurred in either of the low-carbon scenarios (Zhou et al., 2020). Government-supported strategies need to maximise positive interactions and minimise negative ones between the SDGs and climate action.

3.4. Conclusions

- Increasing climate investment flows towards mitigation will accelerate the low-carbon transition. The scale of investment requirements will increase as climate impacts increase, and targets get more stringent.

- An annual investment of USD 190 to 526 billion (around 7–18 per cent of GDP in 2019) is needed till 2050 for India to meet its 1.5ºC goals.

- Climate action investments in the energy systems transition are higher than investments needed to meet most other SDGs.

- Investments are required across the energy supply chain to deploy renewable energy generation, transmission, distribution, and electricity storage. Investment in CDR technologies is essential in low-carbon pathways, but the priority to invest in this in India's NDCs is low.

- The timing of climate change investments plays a crucial role in limiting warming as delayed mitigation can increase losses from climate change. Delay also increases the cost of abatement, leading to a disproportionately high increase in investments.

4.

MACROECONOMIC IMPACTS OF LONG-TERM MITIGATION

4. MACROECONOMIC IMPACTS OF LONG-TERM MITIGATION

The impact of climate action on economic growth is a major concern for governments and policymakers. There have been various attempts to conceptualise the relationship between economic growth and climate mitigation. Until the early 1990s, the 'limits to growth' idea suggested a trade-off between growth and sustainability, with climate action negatively impacting growth. Since the 1990s, there has been a shift in the narrative, with global institutions portraying climate change as a win-win situation (Tobin, 2020). More arguments now suggest a 'strong complementarity' between economic growth and climate action.

The recent narratives around 'green growth' are supported by two schools of thought: demand driven and technology driven. The Keynesian approach suggests that a 'green growth' scenario would lead to an increased demand for environmental products. The Schumpeterian approach advocates for growth by incentivising innovative new technologies that disrupt the economy's fossil fuels reliance. These evolving narratives influence policy options and guide policymakers in designing climate action interventions.

These narratives are particularly relevant for developing countries like India facing severe developmental challenges, where economic growth has to be prioritised along with climate action. India is currently undergoing a rapid economic and social transition, with increasing energy needs. The country faces the challenge of meeting its energy security goals while simultaneously reducing global emissions in line with a low-carbon pathway. Decoupling growth from coal-based energy has significant macroeconomic impacts. At the same time, decoupling is essential as the damages of not complying with at least the 2ºC target is severe for countries like India (Kompas et al., 2018). India's climate action policy and its proposed carbon emission trajectory will have to consider the impacts of climate change on the economy across various sectors and vis-à-vis GDP, consumption and trade to deliver the net-zero agenda without compromising economic development.

4.1. Impact of Physical and Transition Risks on Inflation and GDP

India is among the top ten countries that are most vulnerable to climate events. Literature has documented in detail the ways in which climatic change, manifested as heatwaves, floods, cyclones and erratic monsoons, has impacted lives and livelihoods, and destroyed infrastructure and property in India (Kompas et al., 2018; Mazdiyasni et al., 2017; Picciariello et al., 2021; Roxy et al., 2017) . These physical risks of climate change adversely impact supply and increase inflationary pressures that reverberate through the economy (see Box 1.1 in Chapter 1) (RBI, 2023).

The uncertainty post extreme events can also increase volatility of supply and prices and even alter demand due to changes in consumer behaviour (ibid). For example, an impact analysis of key extreme weather events in India from 2012 to 2022 in nine coastal states showed that such events reduce aggregate production in an economy and increase prices (ibid).

Similarly, a study on the economic impact of Cyclone Amphan, one of the biggest such disasters in recent years that impacted 13 million people after its landfall, shows that such events increase the debt level of firms and households, reduce consumption and employment due to potential displacement, and divert the government's budgetary allocations (RBI, 2023; ODI, 2021). Physical risks include acute risks and chronic risks, with the former referring to extreme events and the latter to gradual shifts in precipitation and temperature.

Transition risks for the GDP are equally significant, though its impacts are often more indirect than physical risks. These impacts reflect changes across the economy and depend on various factors, including government policies, technologies, investments, and consumer preference and so on (RBI, 2023). These changes can lead to inflationary shocks and increase risks to financial stability in the medium term due to higher investment costs of renewable energy or green technology, hike in fossil fuel prices (legacy cost of dependence on fossil fuels), and other factors.

Box 4.1: Landscape of infrastructure risks in South Asian economies and LMICs

Upper-middle-income and lower-middle-income countries hold 25 per cent and 7 per cent of the global infrastructure assets respectively. 67 per cent of the global infrastructure assets are concentrated in high- income countries. Notably, low-income countries account for a mere 0.6 per cent. However, it is evident that the countries grappling with significant infrastructure deficits are also susceptible to the highest relative risks. This is particularly evident in Low- and Middle-Income Countries (LMICs), including those in South Asia. Their relative Average Annual Loss (AAL) ranges from 0.31 per cent to 0.41 per cent of infrastructure value, whilst AAL in high- income countries is 0.14 percent (CDRI, 2023).

In the context of geographical delineation, the regions of South and East Asia manifest the most pronounced relative risk, denoted by a cumulative infrastructure AAL of 0.45 per cent. High-income nations and territories, along with economically robust middle-income counterparts, exhibit heightened absolute risk but simultaneously display low relative risk. High absolute risks depict only a small proportion of their capital stock, hence posing a lower threat to their infrastructure resilience. South Asian countries grapple with pronounced levels of both absolute and relative risk. This dual vulnerability underscores their susceptibility to large-scale losses, posing substantial challenges to resilience. There is a need to fortify resilience in South Asian countries, particularly those with high relative risks and constrained economic scale.

Climate change contributes to 70 per cent of the global AAL. LMICs with extensive infrastructure deficits, weak infrastructure governance, limited private investment and low fiscal capacity are more vulnerable to climate change impacts. High-income nations may experience an 11 per cent rise in their total infrastructure AAL. In contrast, middle-income countries could encounter an increase between 12 and 22 per cent, while low- income countries may face a more substantial 33 per cent elevation (Cardona et al., 2023).

Climate impacts could significantly shift the absolute and relative AAL of hydropower infrastructure. This is true for South Asian nations that rely heavily on hydroelectric power as their primary source of energy.

Infrastructure risks are concentrated in roads and railways, power, water and watershed, telecommunications, oil and gas, and ports and airports. As these sectors are crucial infrastructure assets, high relative and absolute AAL in these sectors poses profound challenges to resilience across most nations, specifically for LMICs with infrastructure and resource constraints. For instance, in South and East Asia, critical infrastructure resilience challenges include the power sector, telecommunications, and water and watershed. All of these internalise high levels of absolute and relative risks.

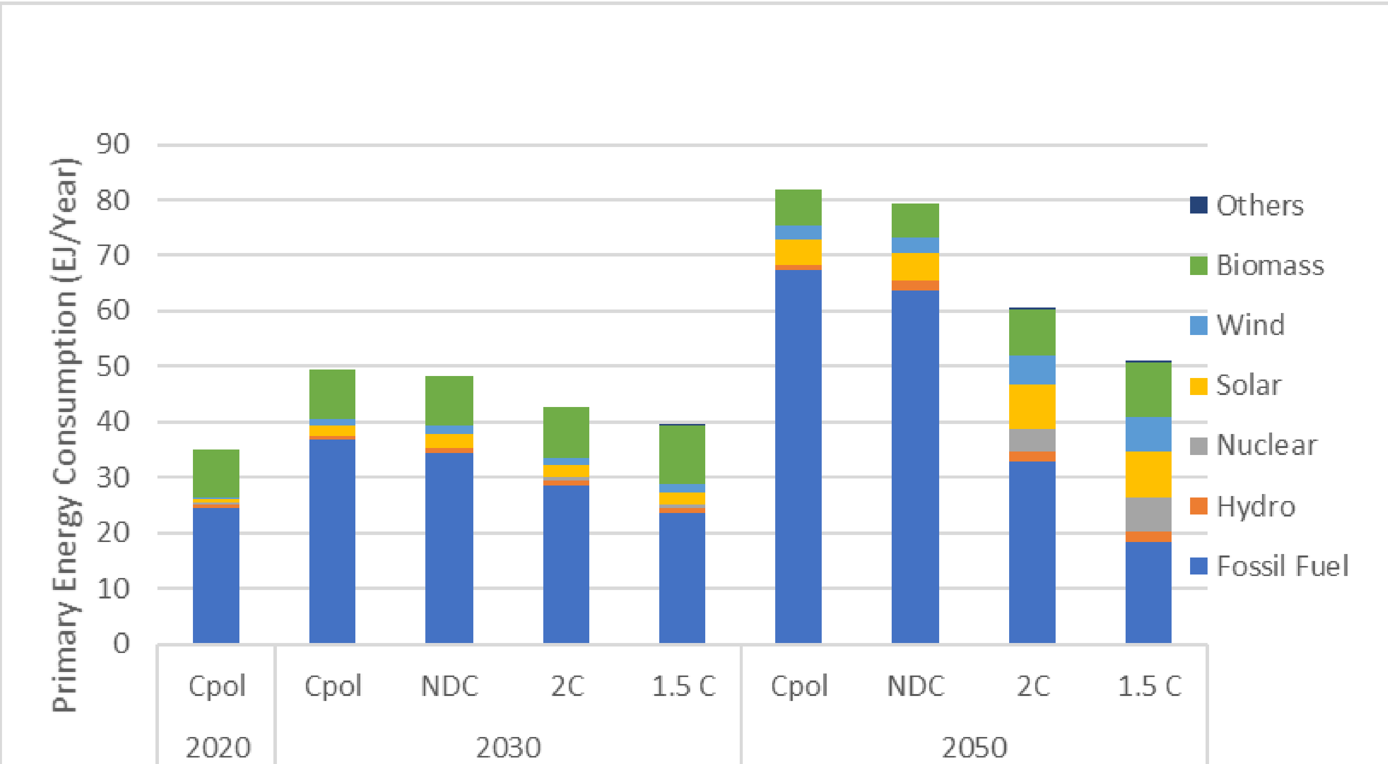
When AAL represents a high proportion of capital investments, this significantly reduces a nation's capacity for new investments. This means resources must be diverted to repair and cover rehabilitation costs of infrastructure damage. This also strains the nation's capacity to reduce the infrastructure deficit. Hence, countries with low domestic savings and weak reserves like those in South Asia are unlikely to cover their AAL without straining their fiscal stability and future investments. High levels of AAL as a proportion of social expenditure represent unfeasibility of progress towards SDGs. For instance, the AAL/Gross Fixed Capital Formation (GFCF) ratio is between 10 and 20 per cent in certain South Asian countries, indicating large infrastructure deficits and low resilience (Cardona et al., 2023).

4.1.1. Macroeconomic impacts of the climate transition

Climate transitions impact the GDP, consumption patterns, energy exports and imports, trade balances, employment, and lead to structural changes in various sectors of the economy. For instance, scenarios limiting warming to 1.5°C will require large reductions in energy demand, increasing energy efficiency, significant deployment of renewables, reduced material intensity and heavy reliance on negative emissions technologies, principally bioengineering and CCS, which come at higher costs and environmental risks. Low-carbon pathways also require substantial investments to transform energy systems. The costs associated with these mitigation efforts affect the GDP through system-wide changes in production, consumption process and trade patterns.

A well below 2°C scenario or a 1.5°C scenario requires an overhaul in investment patterns across the economy. Both scenarios require an additional 3 per cent investment in the energy sector in 2030 compared to the BAU scenario (Gupta et al., 2020). In 2050, the 2°C scenario needs additional investment of 15 per cent, considering the increased cost of clean energy in the later years. The 1.5°C scenario needs only 7 per cent more investments over BAU. The lower investments in the 1.5 °C scenario is due to decreasing energy demand with energy efficiency and consumer behavioural changes compensating investment costs.

Figure 4.1: Primary energy mix in India under four scenarios



Source: Zhou et al., 2020[23]

The underlying energy structure that would drive the need for capital investment is best captured by Zhou et al. (2020), indicating a significant decrease in energy demand (aligned to the 1.5°C scenario) and a change in the energy supply structure (less of coal and more of low-carbon supplies).

23 Current Policies (CPol) denotes a climate scenario with policies of 2015.

Achieving 1.5°C or well below 2°C will also require fiscal measures like carbon pricing, which have adverse distributional impacts for low-income groups and require revenue recycling. Carbon pricing implies placing an external price on carbon pollution as a means to reduce emissions and using this money for cleaner technology and mitigation. Energy systems model estimates indicate that the global carbon price of USD 85/tCO2 (in 2005 prices) would be required by as early as 2020 (Dietz et al., 2018). (This is approximately three times higher than the carbon price necessary to limit warming to 2°C.)

For the 1.5ºC scenario, the median carbon price rises to USD 145/tCO2 in 2030, and by 2100 it is almost USD 4,500/tCO2 (in 2005 prices). In the 2ºC scenario, the carbon price is estimated to be USD 74/tCO2 in 2030 and USD 187/tCO2 in 2050 (Mittal et al., 2018). Since carbon pricing is yet to be used in many sectors of the country, its policy and implementation will also lead to several macroeconomic impacts. At the same time, delay in implementing carbon pricing makes the 1.5°C target unattainable by conventional means.

4.1.2. Impact on GDP and consumption

India's climate action policy will have to consider the combined impacts of physical and transition risks on inflation and GDP to finalise a carbon emission trajectory. A comparative assessment considering both physical risks and transition risks shows that India's economy would take a significant hit in the long term if a lenient mitigation policy is followed (RBI, 2023). This is mainly because of the higher impact of physical risks of climate change. The table below referenced in the RBI report using the Network of Central Banks and Supervisors for Greening the Financial System (NGFS) assessment shows that India's GDP growth is negatively impacted most in the current policies scenario (BAU approach) and the NDC scenario by 2050. India's GDP is slashed by 9.87 per cent and 9.08 per cent in the current policies scenario and NDC by mid-century, respectively. This is considering a baseline GDP growth of 6.6 per cent by 2030. In other scenarios, the impact on India is not widely different from the US (an advanced economy) and the world average. The best policy option for India going by this assessment is to pursue aggressive climate action to reach the well below 2°C goal by 2030 as the costs of this on GDP are the least across all scenarios considered.

Table 4.1: Comparative Impact on GDP Under Different Climate Scenarios (% GDP Growth Rate)

Scenarios	Impact on GDP (USA)	Impact on GDP (World)	Impact on GDP (India)
Below 2 °C in 2030	-2	-2	-2
Below 2°C in 2050	-2	-3	-4
NDC in 2030	-3	-2	-3
NDC in 2050	-6	-6	-9
Current policies in 2030	-2	-2	-3
Current policies in 2050	-5	-6	-10

Source : RBI report, 2023

RBI's analysis (2023) using NGFS data further shows that current NDCs are not enough to meet India's net-zero agenda by 2070. This assessment also indicates that the country's aspiration to be an advanced economy by 2047, which requires a GDP growth rate of 9.6 per cent, increases challenges for its net-zero goal. A growth rate of 9.6 per cent in the absence of accelerated policy action would increase GHG emissions from 5.5 gigatonnes in 2030– 31 to 15.5 gigatonnes in 2047–48 and 32.4 gigatonnes in 2070–71 (ibid). In such a case, to achieve net-zero as an advanced economy by 2070, India will require 5.6 per cent decline in energy intensity from 2031–32, increase in green energy share in primary energy consumption from 9.1 per cent by 2030–31 to 28.7 per cent in 2047–48, and 82 per cent in 2070–71 (ibid). Overall, the RBI assessment shows that net-zero strategy by 2050, instead of the 2070, will be beneficial for the country as it will result in the least loss of output, by 2.2 per cent from the baseline in 2030 and 3.2 per cent in 2047.

Various other assessments focused on the costs of climate mitigation find that GDP growth falls in low-carbon scenarios (in some assessments steeply) in the initial years, depending on the stringency of the climate goals. However, assessments also conclude that these costs are largely recovered vis-à-vis gains in the long term. Globally, the mitigation costs of achieving the 1.5ºC scenario are estimated to be 150 per cent higher than the 2ºC scenario from 2010 to 2030, and about 50 per cent higher over the long term (2010 to 2100). This higher cost difference reduces annual GDP growth by an average of around 0.04 percentage points per year between 2010 and 2100, compared to the 2ºC scenario, which has an average growth of 2.20 per cent per year (Dietz et al., 2018).

In India, Kanitkar et al. (2018) find that the overall growth rate of GDP and household incomes remains similar in both BAU and low-carbon scenarios, with only distributional impacts. According to Gupta et al. (2020), the GDP variations are within 0.7 per cent in 2050 and are barely noticeable if expressed as variations of the average annual growth rate (Table 4.1). This suggests that climate action costs diminish in the long term.

Until mid-century, low-carbon scenarios show higher GDP than BAU because of energy efficiency improvements, their capital costs and the stability of investment measures (Gupta et al., 2020).

Table 4.2: GDP and annual growth rate under different climate scenarios, 2030 and 2050

GDP and Growth Indicators	Year	BAU	2˚C SUS	2˚C	1.5˚C
Real GDP (USD 2012 trillion)	2030	5.2	5.5	5.5	5.5
	2050	14.7	15.1	15.0	15.0
Average annual growth rate (%)	2030	6.3	6.6	6.6	6.6
	2050	5.8	5.8	5.8	5.8
CO_2 intensity of GDP (tCO_2/10^3 USD)	2030	0.8	0.8	0.6	0.6
	2050	0.4	0.2	0.2	0.2
Household consumption (GDP share)	2030	70.6	66.2	65.6	65.6
	2050	66.4	64.5	64.8	64.6

Source: Gupta et al., 2020[24]

24 2C SUS denotes a sustainable emissions pathway consistent with the 2ºC scenario.

The IMF (2020) estimates that after 15 years, the global GDP will reduce by up to about 1 per cent, relative to its baseline level under unchanged policies. However, when a green fiscal stimulus policy along with carbon pricing (consistent with a net-zero scenario) is implemented, the estimated transitional GDP costs in the next 30 years are 'moderate'. Carbon pricing lowers real GDP by increasing the cost of energy, while the green fiscal stimulus boosts it through higher investment spending. Additionally, it indirectly reduces the output costs of transitioning to a low- carbon economy by lowering future carbon emissions and the level of carbon taxes needed to meet the emission reduction targets. In the long term, the benefits of avoided damages from reducing emissions outweigh the negative effects of the transition.

Estimates by Mittal et al. (2018), however, indicate that aligning India's emissions pathways with the 2ºC or 1.5ºC scenarios could come at a substantial cost of GDP loss in 2035, of 3 per cent and 6.4 per cent respectively, with the losses to GDP going up to 3.2 per cent in 2050 under the 2ºC scenario, and 5.8 per cent in the 1.5ºC scenario. Shukla et al. (2017) estimate the GDP losses to be 0.7 per cent in 2020, 2.4 per cent in 2025 and 5 per cent in 2030 under the 2ºC scenario. But, these estimates do not capture the perceived benefits from mitigations–direct benefits of additional jobs, output gains, avoided loss and damages, and reduced adaptation investments.

CCS is projected to play a crucial role in India's efforts to meet the global carbon budget for 2ºC or 1.5ºC scenarios. Marginal cost curve estimates by Vishwanathan et al. (2018) for 2ºC and 1.5º show that CCS will be adopted at USD 40-60/t-CO_2 for gas and at USD 60–100/t-CO_2 for coal power plants. These costs can be covered by increased financial flows for R&D and technology transfer to low-carbon technologies. Incremental finance and effective technology transfer regimes for low-carbon technologies are vital for India's decarbonisation agenda and an optimal global response to achieving low-carbon targets (Shukla et al., 2017).

In India, mitigation efforts backing the 1.5ºC scenario show slightly higher annual GDP growth, indicating potential synergies between deep environmental performance and economic growth (Gupta et al., 2020). Therefore, tightening decarbonisation targets may have a positive impact on economic growth, provided there is a sustained investment effort. Further, there could be additional savings from mitigation efforts as renewable energy generation becomes increasingly cheaper. Gadre et al. (2020) estimate that India could save USD 78 billion cumulatively in electricity generation costs from 2020 to 2030 by following the least-cost path to meeting electricity demand, which involves increasing use of solar and wind energy.

The assessments on the impact of climate mitigation on consumption show that total per capita consumption is slightly higher in scenarios with higher energy efficiency (in the 1.5ºC scenario), or in a scenario with implementation of policies and modest technical progress compared to the BAU scenario (Parikh et al., 2018). In the 1.5ºC scenario, per capita consumption is around 6 per cent higher in 2045 and around 1 per cent higher in 2050, compared to per capita consumption in the BAU scenario. These results suggest that low-carbon scenarios do not impose any cost on human well-being, as reflected in per capita consumption (Parikh et al., 2018).

The low-carbon scenarios affect the share of household consumption in GDP in ways that reflect the impact on GDP. In low-carbon scenarios, household consumption as a share of the GDP decreases by 4.4 to 5.0 percentage points in 2030 and by 1.6 to 1.9 percentage points in 2050, when compared to BAU (Gupta et al., 2019). This is an effect of the increased trade balance as energy imports fall. Improved trade balance reduces the government's foreign debt at the consumption cost of 1 per cent of GDP.

Box 4.2: Effect of the energy transition on low-income households

The energy transition is likely to impact low-income households significantly through changed consumption patterns, jobs and government spending. Electricity tariffs and increase in prices can impact their consumption patterns. In some cases, the transition may also affect their employment status, and transfer in government spending from development to mitigation can impact their incomes. Using an integrated modelling framework, Kanitkar et al. (2018) find that the public expenditure to transform the power sector would reduce the government's investment in other sectors. The foregone development is found to reduce low-income households earnings from 2003 to 2031. The study assumes that the government and the private sector will finance climate mitigation equally. The government is assumed to source this additional investment in the power sector from all other sectors, in proportion to their contribution to GDP in 2003–04. Results from this modelling exercise show that the per capita income of the population in 2030–31 is lower under the emissions constraint scenario (of 6 GtC in the power sector between 2003–04 and 2030–31) in contrast to a scenario with no mitigation (ibid).

Table: Comparison of per capita income for different classes of households under different climate scenarios

Yearly Per Capita Income (USD)	Growth driven service sector scenarios			% Difference in Per Capita Income between scenarios
	2003-04 (base year)	No emissions (2030-31 constraint)	With emissions (2030-31 constraint)	
All households	338	1,354	1,308	3.4%
Rural households (quintile class)				
Lowest consumption	62	185	154	16.8%
Second highest consumption	354	1,662	1,600	3.7%
Urban households (quintile class)				
Lowest consumption	77	108	92	14.8%
Middle consumption	323	1,231	1,185	3.7%

Source : Authors' computation based on results of Kanitkar et al., 2018[25]

Rural low-income households face a 16.8 per cent reduction in their per capita income, while urban low-income households see 14.8 per cent reduction. The middle- and high-income households face only 3.7 per cent income loss when capital is redirected towards mitigation. Since the additional investment in the power sector is covered by potential reduced investments in other sectors, the output, employment and income in the other sectors is reduced, thereby adversely affecting low-income households (Carley and Konisky, 2020). Generally, increasing energy costs have a regressive impact on income distribution because energy expenditure forms a larger share of the budget of poorer households (Luciani, 2020). Households are also expected to minimise the added cost by insulating their homes or buying new electric vehicles, but a vast majority of low-income households have very little savings and patchy access to credit (Brown et al., 2020).

25 The effect of the transition on equity remains when economic growth is driven by the industrial sector as well. An emissions constraint of 6 GtC in the power sector between 2003–04 and 2030–31 is assumed.

4.2. Sectoral Composition of India's GDP and Systems Transitions

India is the third-largest emitter of global CO2 despite its low per capita emission intensity. A country's economic structure, nature of economic activities (services, industries or agrarian) and dependence on fossil fuels for energy requirements to a large extent dictate its carbon intensity (On the Road to COP 26, 2021). The carbon intensity of an economy is a measure of CO2 emissions per unit of GDP.

In India, the long-term shift in economic structure has been from agriculture towards a manufacturing and service- based economy. Post liberalisation, the services sector has dominated both the economic structure and growth rates in India. The share of the services sector to the GDP increased from 43.2 per cent in the 1980s to 60.9 per cent in 2010 (RBI, 2023). In 2021–22, the sector contributed around 63.5 per cent to the country's GVA, followed by the industries sector (manufacturing and mining) at 21 per cent, and the agriculture and allied sector at 15.6 per cent (GOI, 2023b). Globally, the service sector has not been seen as emission intensive and even in India, services- led growth has been linked to lower emission intensity trajectory post the 1980s (RBI, 2023).

However, the services sector includes two of the highest emissions-contributing services in the country: electricity and transport. The country's sectoral break-up shows that electricity, followed by the metal industries and transport, have the highest emission intensity. In 2018–19, these three sectors contributed around 9 per cent to the GVA and reported the highest emission intensity of nearly 13,348 metric tonnes of CO2 emissions per USD 1 million of output (GOI, 2023b). Their contribution to GVA increased to 11 per cent or INR 16.21 lakh crore (i.e.,INR 16.21 trillion) in 2021–22 at 2011–12 constant prices (ibid).

The industries sector is also very energy intensive in nature and difficult to decarbonise, given its substantially high fixed investments and longer lifetime of assets. The sector accounted for nearly INR 29 lakh crore (i.e., INR 26 trillion) of GVA in 2021–22 (at 2011–12 constant prices) (GOI, 2023b). Decarbonisation of the industrial sector requires change in production processes, expensive retrofitting, and adoption of new technologies. While the agriculture sector has less CO2 emission intensity than the industries and services sector, it also contributes to other GHG emissions like methane and nitrous oxide. Around 14 per cent of GHG emissions come from agriculture in India (RBI, 2023). Agriculture also accounts for 17 per cent of electricity consumption, besides 5.9 lakh tonnes of diesel used to energise agriculture pumps (ibid). As such, even its energy intensity (use of electric pumps for agriculture) is more than industries like textiles and construction.

Given the scale and intensity of climate change, a climate mitigation strategy needs to target the sectors that have high levels of emissions holistically (considering their interdependencies), instead of pursuing siloed sub-sectoral or industry/activity-specific actions. The IPCC (2021) pegs transformational change on simultaneous systems transitions in key areas, including energy, urban and infrastructure, land, freshwater and ocean ecosystems, and industry and societal choices around behaviour and consumption. These transitions, 'unprecedented in scale", imply decarbonisation across all carbon-emitting sectors (ibid). India's high-emission economic sectors can similarly be reframed broadly into energy, urban (transportation, infrastructure and construction), industry and agriculture systems. Systems transitions in these four broad areas afford the best opportunities to mitigate climate change.

Energy systems: Overall, the energy sector contributes to nearly 90 per cent of the CO2 emissions in India and its transition is crucial to achieving net-zero (RBI, 2023). Fossil fuel-based energy sources, including coal, oil and natural gas, dominate current energy consumption in the country. Currently, 70 per cent of India's electricity is produced from thermal power plants, making the country's electricity grids highly carbon intensive among major economies (ibid). Electricity contributes to over 40 per cent of the country's CO2 emissions.

Transitioning from fossil fuel energy to cleaner energy will require substantial capital investments in renewables. India's power sector is already decarbonising and the updated NDC target of 500 GW renewable energy capacity by 2030 is achievable. The falling production costs of renewable energy like solar and wind also make the energy transition viable, but more policy support is required, including to integrate variable renewable energy in existing grid and interstate transmission systems. Besides investments in renewables, energy transition in India requires a clear policy vision to ensure an orderly transition, given the dependence of jobs, states revenues, economies and investments in the coal industry (see Chapter 5 on Energy Transition).

Urban and infrastructure: With 70 per cent of the built environment yet to take shape and 40 per cent of our population estimated to be urban by 2030, the urban transition is pivotal for India. The urban transition offers several effective mitigation actions to reduce emissions and develop low-carbon pathways in transport, energy and building sectors in cities. Of these, the transport sector accounts for around 14 per cent of India's GHG emissions, with road transport contributing the most to CO2 emissions (RBI, 2023).

Existing policies are pursuing low-carbon pathways in transport through emphasis on electrification of transport by promoting electric vehicles, electrification of railways, building metro rail systems in cities, mandating energy efficiency standards for vehicles and buildings, promoting alternative fuels, and blending of ethanol in petrol. The government's more recent Gati Shakti plan that focuses on multimodal transportation to integrate waterways, highways and railways projects has the potential to improve logistics and reduce vehicular emissions due to road freight.

Industries: The Indian manufacturing sector relies on 45 per cent of coal for its energy requirements and 23 per cent on electricity. Energy consumption by the sector has been reduced in recent decades because of improvement in energy efficiency and shift in industries towards less energy intensive industries (RBI, 2023). However, certain hard- to-abate industries that contribute to nearly half of CO2 emissions of this sector, like steel, cement and ammonia, are poised to grow in India. India is the second-largest producer of steel and cement in the world and among the top five producers of ammonia. There is an urgent need to diversify into low-carbon intensive production for such hard-to-abate sectors. Besides the increasing share of renewables, India is looking at setting up an ecosystem for green hydrogen production to slowly replace coking coal and natural gas in iron and steel production and act as chemical feedstock in production of fertilisers and chemicals. The Union budget announced a Green Hydrogen Mission in 2023 with an outlay of INR 19,744 crore from 2023–24 to 2029–30 to make India a global hub for hydrogen production (GOI, 2023a). It is expected that green hydrogen capacity will reach 5 mmt per annum but so far, the production and supply chain of green hydrogen is yet to take any kind of concrete shape.

India will have to also incorporate carbon pricing to reduce emissions up to 80 per cent from these difficult sectors by 2050 (RBI 2023). The Energy Conservation Act 2023 envisages setting up of a carbon market or ETS to make the shift in policy from energy efficiency to emissions reduction (ibid). With the

EU's Carbon Border Adjustment Mechanism (CBAM) to be put into effect from 2026, there is also a transnational compulsion for doing so. CBAM extends carbon pricing to international trade, with carbon intensive imports like iron, steel, cement, fertilisers, aluminium etc. mandated to declare emissions during production and pay a levy on it, equivalent to domestic charges under EU ETS (World Bank, 2023).

Agriculture, forestry and land use: Agriculture emissions in India are primarily from the livestock sector (54.6 per cent) in the form of methane emissions due to enteric fermentation, use of nitrogenous fertilisers in agricultural soils (19 per cent), rice cultivation (17.5 per cent), livestock management (6.9 per cent) and burning of crop residues (2.1 per cent) (Gulati & Thangaraj, 2021). Decarbonising agriculture will require better livestock feeding and management, diversifying away from rice cultivation to other less water intensive crops like maize, promoting and subsidising soluble fertilisers (ibid).

Another option to decarbonise energy use in agriculture would be to run the feeder system for agriculture solely on renewables as is being currently explored by some states (RBI, 2023). India in its NDCs has pledged to create a carbon sink of 2.5 to 3 billion tonnes of CO2 by 2030. To deliver on this target, the government intends to implement the Green India Mission, create 140,000 km tree line on both sides of highways, along the Ganga River and reduce consumption of biomass and wood. Funds from CAMPA and NAP would be utilised for the same (Deshpande, 2021). However, there are several challenges to achieve this goal, including financial resources, confusion over the term 'forests cover' and overestimation of how much carbon is being sequestered in Indian forests (Mathur et al., 2021; Deshpande, 2021).

The structure of economic activity is sensitive to climate scenarios (Gupta et. al, 2020). Long-term mitigation strategy will have an impact on the country's economic structure and output. The assessment by Gupta et al. (2020) shows that in the long term, the share of agriculture in GVA will continue to fall and that of industries and services will increase. In low-carbon scenarios, the services share is projected to increase the most in 2030, but by 2050 the industry sector picks up, and ends 5.6–6.9 percentage points above its 2012 share. Initially, low-carbon scenarios reduce the GVA of industries and also raise the share of energy in GVA between the BAU and low- carbon scenarios, particularly in longer horizons. The main reason for this is the much higher capital intensity of renewables. This study suggests that energy supply investment of USD 131 billion/year would be required from 2012 to 2050 to achieve low-carbon energy (ibid).

An analysis by McKinsey predicts savings of USD 1.7 trillion in fuel imports, cheaper power tariffs, USD 36 billion fuel tax revenue loss, six million lost jobs, increased pressure on land systems to create carbon sinks, renewable power projects and reduced consumption as some of the impacts of the low-carbon transition (Gupta et al., 2022).

4.2.1. Impact on trade balance

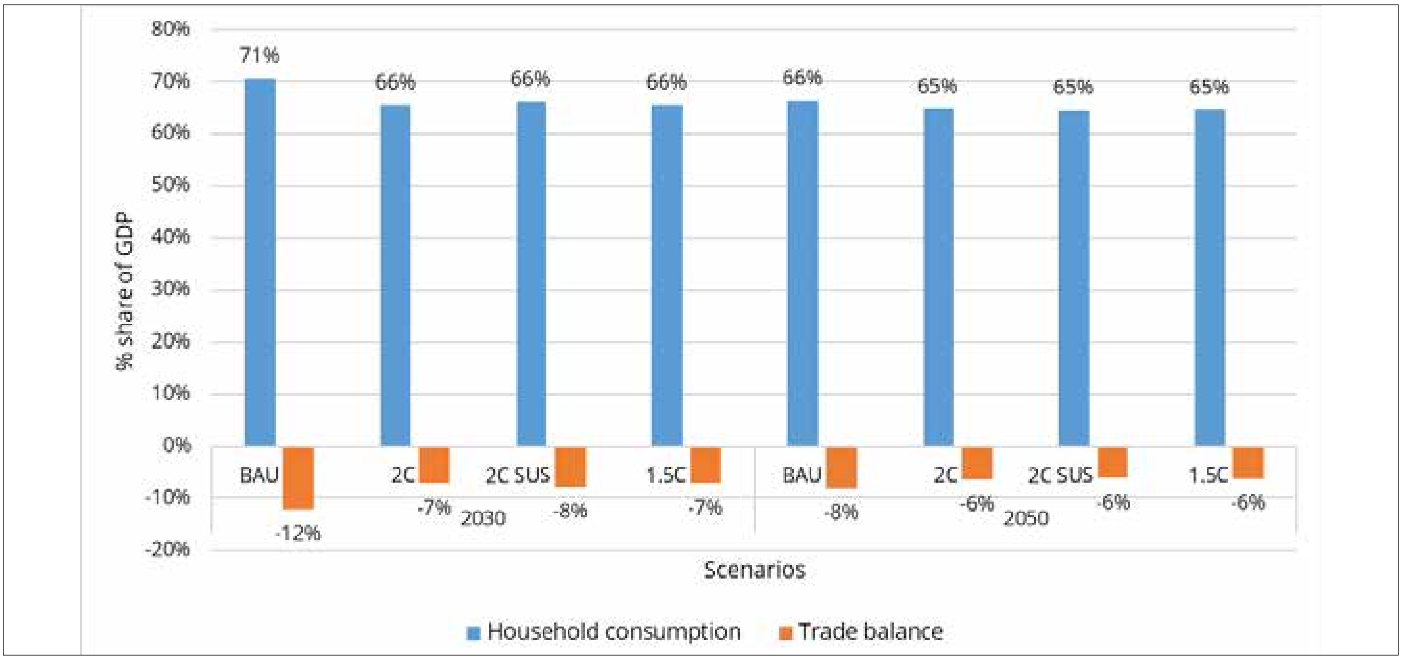
India imported nearly 80 per cent of its petroleum products consumption (Parikh, 2020) and 50 per cent of its domestic natural gas requirement in 2019–20. Despite having an abundance of coal, nearly 24 per cent of the country's coal consumption was imported in 2019–20. Domestic coal production has struggled to keep up with the high demand from coal-intensive industries like steel, cement and aluminium. Moreover, domestic coal often has lower quality with higher impurities, making industries prefer better quality coal from international markets.

India's high import dependency on oil and gas poses macroeconomic vulnerability. Net energy imports have averaged about 4 per cent of GDP, and peaked at 7–8 per cent of GDP in some years (Spencer et al., 2018). During periods of high international energy prices or rupee weakness, net energy imports can exert significant pressure on the current account deficit, currency valuation, inflation and interest rates.

The energy transition is expected to have a minimal negative impact on India's trade balance as it would reduce reliance on fossil fuels imports. It is estimated that the import of crude oil and other refined fuel would decline from a 26 per cent share of total imports in 2012 to 15 per cent share in 2050, under a 1.5ºC scenario (Gupta et al., 2020). Mitigation strategies could limit India's foreign debt to below or slightly above current levels by 2030 and 2050. Low-carbon policies can reduce energy imports, leading to an improved trade balance and reduced foreign debt (Gupta et al., 2019).

Mitigation has a strong impact on the trade balance as the deficit recedes by up to 5 percentage points in 2030 and 1.8 percentage points in 2050, compared to BAU (ibid). In 2050, the share of energy imports as a percentage of GDP declines from 7.3 per cent in the BAU scenario to 5.4 per cent in the 2ºC scenario and 5 per cent in the 1.5 scenario.

Figure 4.2: Trade Balance and household consumption under four climate scenarios, 2030 and 2050



Source: Gupta et al., 2020[26]

The reduction is highest under the sustainable 2ºC scenario (4.7 per cent of GDP) as a result of the decline in fossil fuel energy uses like oil fuels in the transport sector, natural gas in industry and of high-grade coal in steel production. India is estimated to have a foreign exchange savings of USD 620 billion, over 2012–2030, from a reduction in just oil imports in the 2ºC scenario compared to BAU (Gupta et al., 2020), and the savings is close to USD 1 trillion from 2012 to 2050. This has strong implications for India's energy security.

26 2C SUS denotes a sustainable emissions pathway consistent with the 2ºC scenario.

4.3. Conclusions

- India's climate action policy and its carbon emissions trajectory will have to consider the combined impacts of physical and transition risks on various sectors, and vis-à-vis GDP, consumption, and trade to deliver the net-zero agenda without compromising economic development.

- A comparative assessment of physical risks and transition risks shows that India's economy would take a significant hit in the long term if a lenient mitigation policy is followed, given the higher impact of physical risks in the country.

- A net-zero strategy by 2050, instead of 2070, will be beneficial for the country as it will result in the least loss of output, by 2.2 per cent from the baseline in 2030 and 3.2 per cent in 2047.

- India's climate mitigation strategy needs to target sectors that have high levels of emissions holistically, instead of pursuing siloed sub-sectoral or industry actions. The country's sectoral break-up shows that electricity, followed by the metal industries and transport, have the highest emission intensity.

- The Indian energy system transition impacts GDP, consumption patterns, energy exports and imports, trade balances, and employment. The transition brings structural changes within the various sectors of the economy that are closely connected. Its impact on low-income households is significant through changed consumption patterns, jobs, and government spending.

- The 1.5ºC scenario requires an overhaul of India's investment pattern in the economy. Compared to the BAU scenario, the 1.5ºC scenario requires 3 per cent additional energy investment in 2030 and 7 per cent in 2050.

- In the long run, the impact of the energy transition on GDP is less than moderate. Carbon pricing lowers real GDP by increasing the cost of energy, while green fiscal stimulus boosts GDP.

- Low-carbon energy policies will contribute to a reduction in fossil fuels imports in India, which relies on large coal, oil, and gas imports. Mitigation strategies will have a positive impact on India's energy security and foreign debt over the 2030 and 2050 horizons.

5.

ENERGY SYSTEMS TRANSITION

5. ENERGY SYSTEMS TRANSITION

Energy transition is pivotal in defining decarbonisation and India's net-zero pathways. Mapping India's primary energy mix under different climate scenarios, examining energy trends in end-usage demand sectors, and understanding drivers of this transition to renewables provide insights into how the energy transition is panning out in the country. The analysis in this chapter focuses on key research on the energy transition under various climate scenarios and how to accelerate low-carbon pathways over the next decade.

5.1. Primary Energy Mix

The primary energy mix under different climate scenarios is analysed below based on shortlisted peer-reviewed papers.[27] The key findings from the literature show that:

- Overall energy demand is expected to increase under all scenarios.
- Coal remains the largest energy source in the primary energy mix in all scenarios, but its demand is expected to significantly reduce in the 2°C and 1.5°C scenarios.
- The share of renewables in the primary energy mix increases in the 2°C and 1.5°C scenarios due to decoupling of emissions and growth.

Compared to the BAU scenario, the 2°C scenario exhibits a 13 per cent reduction in overall energy demand by 2020 and a 43 per cent reduction by 2030 (Shukla et al., 2017). In the NDC scenario, the energy demand is marginally lower (3 per cent) than the reference scenario in 2030. Coal dominates the energy mix in India, with power generation constituting the highest proportion.

Under the BAU scenario, the share of coal increases from 42 per cent in 2005 to 68 per cent in 2030 (Shukla et al., 2017). In the NDC scenario, there are no major changes in the primary energy mix compared to the BAU scenario (Mittal et al., 2018). Coal demand falls to a third in the 2°C scenario compared to the reference scenario in 2030. Low-carbon scenarios exhibit a strong decoupling between economic growth, energy use and emissions, due to a significant deployment of renewable energy. In the 1.5°C scenario, renewables like solar PV and hydro gain a significant share in the energy mix by 2050 compared to the 2°C scenario (Mittal et al., 2018).

27 The peer-reviewed papers include Shukla et. al, 2015, 2017; Mittal et. al 2018; Vishwanath and Garg, 2020; Zhou et.al., 2020; Gupta et. al, 2020.

Table 5.1: Composition of primary energy under baseline scenario, NDC and 1.5°C scenarios

Scenarios	BAU			NDC		1.5°C	
Years	2016	2030	2050	2030	2050	2030	2050
Coal (%)	45-***47***	***38***-40	40-***47***	31-***37***	31-***45***	***19***-33	***18***-33
Oil (%)	***24***-25	23-***24***	23-***25***	22	22-***26***	22-***29***	22-***23***
Bioenergy (%)	22	18	***8***-18	10-***19***	***8***-10	13-***21***	10-***14***
Gas (%)	5	10-***13***	10	***13***-19	***9***-19	18	***13***-18
Renewables (%)	***0.4*** - 1	6	***6***-9	***8***-15	***10***-15	***9***-12	12-***22***
Others (hydro, nuclear) (%)	***2***-3	***1***-3	***1***-3	***2***-3	3	***3***-4	4-***10***
Total Energy (EJ/yr)	***29***-36	***50***-55	***82***-84	***48***-51	73-***80***	***40***-53	54-75

Note : Figures in bold and italics are taken from Zhou et al., (2020)

Source: Vishwanathan and Garg (2020), Zhou et al., (2020)[28].

5.2. Electricity Generation Mix

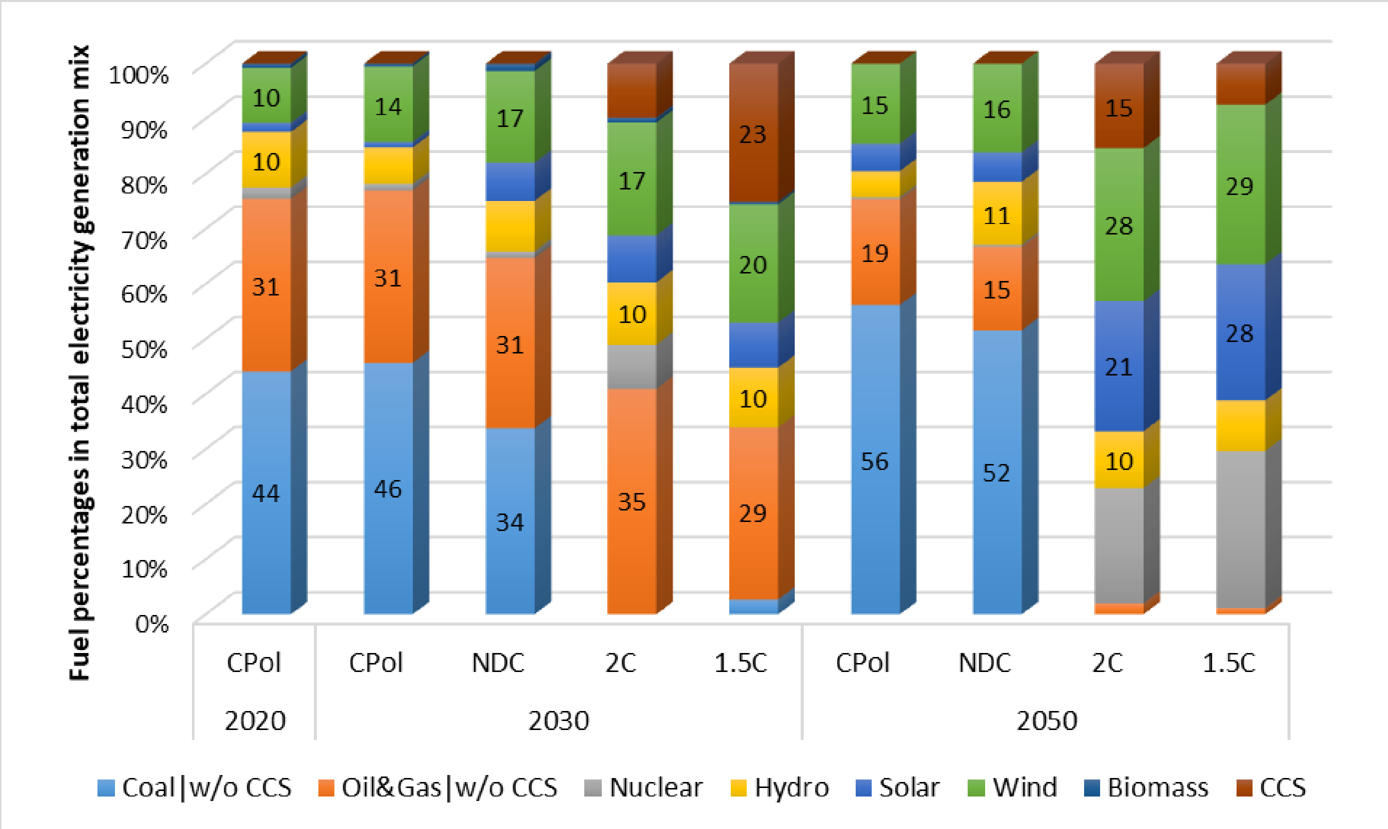
Demand for electricity is estimated to increase in India due to rising incomes, universal electrification, and the electrification of transport, residential and industry sectors. The key findings based on the analysis of the electricity generation composition through a review of selected studies include:

- Electricity generation increases in all scenarios but is lower in the low-carbon scenarios.
- The trend in the use of coal might reappear once CCS is established in the power generation sector.
- Sustainable low-carbon scenarios do not rely on CCS or nuclear energy. They are estimated to have lower energy demand.

Electricity generation is estimated to rise sevenfold between 2010 and 2050 (Shukla et al., 2015). Higher penetration of intermittent renewables leads to marginal rise in energy consumption by the power sector in the NDC scenario by 2025 due to network losses (Shukla et al., 2017). Coal is the main source of electricity generation in India, accounting for 78 per cent of the power generation mix, followed by 4 per cent each for gas and hydro, 2 per cent oil, 3 per cent nuclear, 7 per cent bioenergy, and the remaining 2 per cent from other renewables in 2016 (Vishwanathan et al., 2018). However, low-carbon scenarios indicate limited growth in coal-based power generation, with a shift to renewable energy. In low-carbon scenarios, the share of renewables surpasses 30 per cent, reaching even 50 per cent in the 2°C sustainable scenario (Gupta et al., 2020).

28 For Vishwanathan and Garg (2020), the 'Well below 2°C' scenario is taken as equivalent to the 1.5°C scenario. The range presented denotes the estimates for early action 2°C, late action 2°C, and well below 2°C scenarios.

Figure 5.1: Electricity generation mix in India under four scenarios



Source: Zhou et al., 2020[29]

In the 2°C scenario, the electricity demand is projected to decrease by 42 per cent by 2030 compared to the BAU scenario due to increase in the electricity prices resulting from the internalisation of high carbon prices (Shukla et al., 2017). Coal power peaks much earlier in the 2°C sustainable scenario compared to 2°C scenario (Gupta et al., 2020), due to the reduced demand for electricity. Sustainable low-carbon pathways (like the SE4ALL plus 2°C scenario in Dhar et al., 2018) exhibit the lowest electricity generation and the lowest CO2 intensity of electricity generation, demonstrating the fastest decoupling of electricity generation from CO2 emissions. Shukla et al. (2015) estimate that renewable energy accounts for 58 per cent of electricity generation capacity in 2050 in the conventional 2°C scenario and 71 per cent in the sustainable 2°C scenario. The conventional scenario has a higher share of nuclear energy, coal and biomass with CCS. There may also be a resurgence of coal-based power generation post-2030 with implementation of CCS.

Within renewables, the composition of electricity generation is expected to change over time due to varying price trends among different renewable energy sources. Until 2030, the renewable capacity will primarily consist of hydro, wind, solar and biomass (Shukla et al., 2015). Beyond 2030, solar power capacity is expected to dominate the mix. The composition of electricity generation under the different climate scenarios is shown in Figure 5.1. Shukla et al. (2015) estimate an increase in the share of nuclear energy in power generation in both conventional and sustainable 2°C scenarios, with higher proportion in the conventional scenario. Similar trend of increased nuclear energy use in the 2°C and 1.5°C scenarios, compared to the NDC is seen in the figure above (Zhou et al., 2020). But, this is not consistent with projections of Vishwanathan et al. (2018).

29 CPol stands for 'Current Policies', it denotes a climate scenario with policies of 2015.

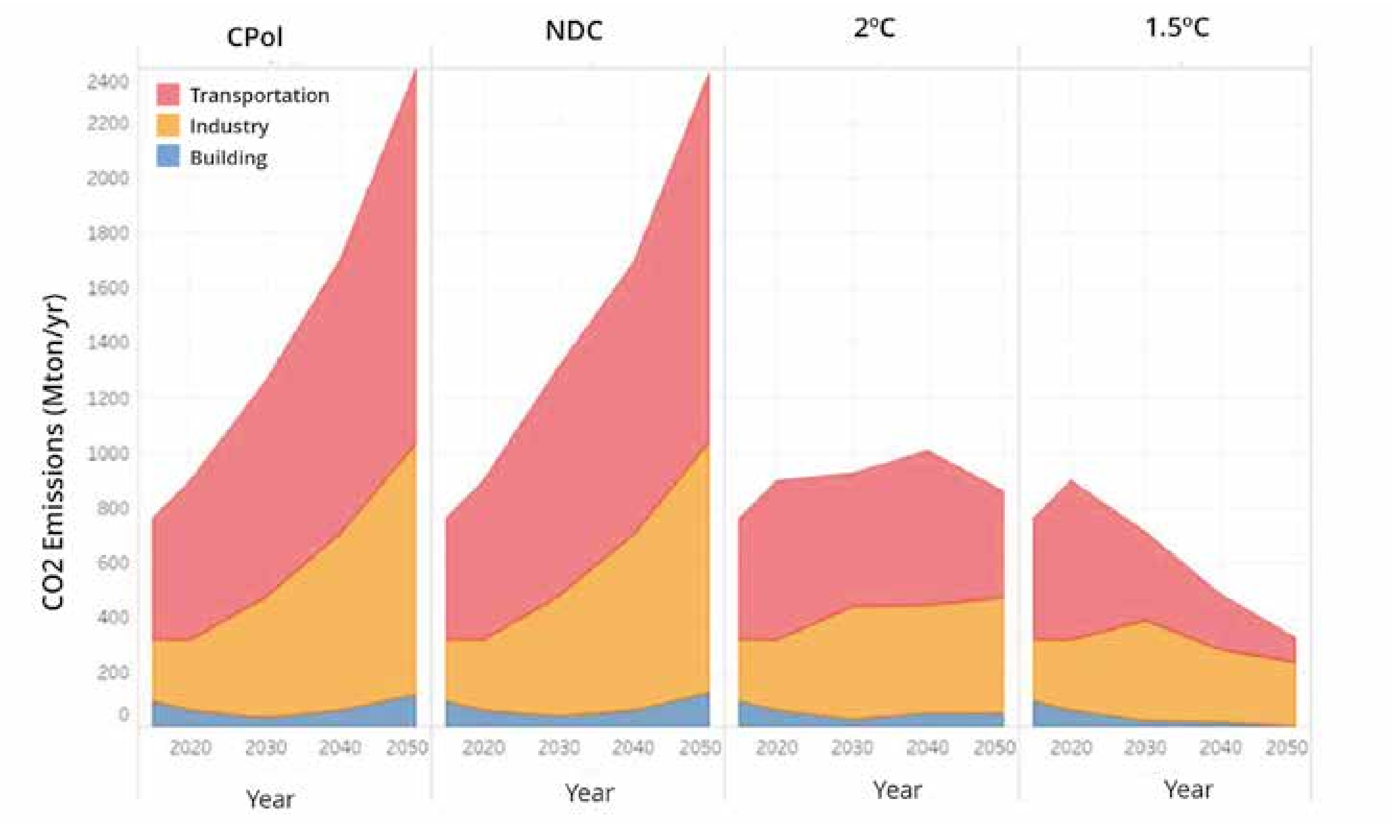
In the optimal cost 2°C scenario (conventional scenario), the share of coal-based electricity generation declines to 35 per cent, whereas the share of non-fossil-based power generation increases to 39 per cent in 2030 compared to the BAU scenario (Shukla et al., 2017).

5.3. End-Use Demand Sectors

An analysis of the projected energy transition in various end-use demand sectors like transportation, industry and buildings based on peer-reviewed literature shows the following broad results:

- Under the BAU or NDC scenarios, emissions from the end-use demand sectors do not peak until the 2050s (see Figure 5.2.). However, low-carbon scenarios demonstrate a substantial reduction in the forecast emissions.
- The transport and industries sector are anticipated to experience a faster pace of emissions growth.
- The decarbonisation scenarios highlight the highest emission reduction potential in the transport and industries sectors. The transport sector in particular offers climate change mitigation opportunities through increased adoption of cleaner fuels and electric vehicles. The growing use of electric appliances in the building sector, however, may increase energy demand in the building sector.

Figure 5.2: CO2 emissions of final energy sectors in India under four scenarios



Source: Zhou et al., 2020

5.3.1. Transport sector

The demand for passenger and freight transport is expected to increase as incomes rise. The transport energy demand increases from 1.7 EJ in 2010 to 12 EJ in 2050 in the NDC scenario (Dhar et al., 2018). The conventional scenario forecasts an increase from 2.6 EJ in 2010 to 15.3 EJ in 2050, while the sustainable scenario shows a smaller increase to 8.1 EJ in 2050 (Shukla et al., 2015). The sustainable coupled scenario (like in Dhar et al., 2018; Shukla et al., 2015) indicates a relatively lower transport demand.

The sustainable scenario is projected to see a three-fold increase in transport energy between 2010 and 2050, whereas the conventional scenario is projected to see a 5.8-fold increase in the same time period (Shukla et al., 2015). The transport sector targets would imply an 84 per cent share of electric cars, 79 per cent electric trucks, and an 84 per cent biofuel blend in oil by 2070 to achieve net-zero. Interventions that promote walking and cycling, increase public transport, support EVs, improve vehicle efficiency along with demand-side policies are expected to reduce transport demand. The shift towards renewables in the sustainability scenario also helps reduce the energy intensity for passenger transport and overall energy demand.

In the medium to long-term, the transport sector is projected to mop up a growing share of energy. The share of the transport sector in the final energy mix is estimated to increase from about 15 per cent in 2010 to about 20 per cent in 2050 in the NDC and 2°C scenario (Dhar et al., 2018). Transport energy intensity is also expected to increase in these scenarios. In the 1.5°C scenario, final energy demand reduces by 47 per cent in 2050 compared to the NDC scenario. Low-carbon scenarios help reduce CO2 intensity of transport energy use through the shift towards gas, electricity and biofuels (Shukla et al., 2015, Mittal et al., 2018). But, oil remains the largest transportation fuel source between 2010 and 2050 in both conventional and sustainable pathways to achieve 2°C (Shukla et al., 2015), while biomass becomes prominent in the 1.5°C and NDC 2°C (Mittal et al., 2018).

The transport sector accounted for about 11 per cent of total carbon emissions in 2010, which is projected to increase to 12 per cent in 2050 under BAU and 14 per cent under NDC scenarios. However, the emissions from the transport sector decrease to almost 9 per cent of the total carbon emission in the 1.5°C scenario. This reduction is attributed to a combination of policy measures like technological changes (EVs), modal shifts to low-carbon modes (metro rails) and behavioural changes affecting mobility demand (telecommuting).

India has set a sales target of 6–7 million EVs year on year from 2020 in its National Electric Mobility Mission, around 2 to 4 per cent of the total vehicle stock. This target has so far not been met. India's targets for 2030 include options like phasing out fossil fuel combustion engines and mandating a 30 per cent electric vehicle in the total automobile mix (Fekete et al., 2021).

Decarbonisation of the electricity sector along with electrification of transport in 1.5°C can help reduce overall carbon emissions (Mittal et al., 2018). By 2050, electricity in the transport energy mix is projected to be 18 per cent in the 2°C scenario and 24 per cent in the 1.5°C scenario. However, low-carbon policies alone will not improve the energy efficiency in this sector. The sustainable scenario shows a significant reduction in the share of transport sector CO2 emissions (16 per cent in 2050) compared to the conventional scenario (28 per cent) (Shukla et al., 2015). Demand side policies clearly hold potential in shaping the transport sector (Creutzig et al., 2016).

5.3.2. Industries sector

Industry is the second-largest contributor to GHG emissions in India accounting for 25 per cent of the total emissions. Three sub-sectors—steel, cement and chemicals—dominate industrial emissions, accounting for nearly 80 per cent of net industrial direct emissions (Busby and Shidore, 2017). Industrial energy consumption is estimated to increase by 4.3 per cent annually due to a huge increase in cement, brick manufacturing, iron and steel demand (Vishwanathan et al., 2017). Rising urbanisation, demand for residential and commercial buildings and construction of infrastructure are the key drivers for the demand for steel, cement and aluminium.

Dhar et al. (2018) estimate the energy demand of the industrial sector to increase steadily under all climate scenarios – NDC, 2°C and a sustainable 2°C (SE4ALL plus 2°C). But, the sustainable low-carbon scenario has a 22 per cent lower energy demand compared to the conventional scenario (Shukla et al., 2015). The final energy demand from industry in the sustainable low-carbon scenario will go up six times in 2050 relative to 2010, but the energy intensity of the sector is projected to improve over the same time period. CO_2 intensity also reduces from 3.92 tCO_2 per toe in 2010 to 1.49 tCO_2 per toe in 2050, under low-carbon scenarios (Shukla et al., 2015). There are various reasons for this, including reduced share of coal in the fuel mix in low-carbon scenarios, increased future deployment of CCS in steel and cement industries and increased share of gas in the fuel mix for industries. The rising share of electricity also contributes, as electricity itself gets increasingly decarbonised.

Apart from reducing energy supply side emissions, it is important to introduce demand-side interventions that link manufacturing and construction industries. National and subnational building codes that mandate low energy usage, urban building by-laws that specify waste management policies such as the use of fly ash from power plants for the brick and cement manufacturing industry can help reduce industrial emissions.

5.3.3. Buildings Sector

Residential and commercial buildings contribute to about 12 per cent of the country's GHG emissions (Busby and Shidore, 2017), accounting for 37 per cent of India's final energy consumption in 2015. In urban residential areas, LPG is the primary source for cooking while low-income populations use kerosene and biomass. Rural households still use traditional biomass though there is a shift towards gas and electricity pushed by government initiatives. This reduces local air pollution but increases CO_2 emissions. The building sector emissions tend to increase as the reliance on biomass declines (Vishwanathan et al., 2018). Under a deep decarbonisation scenario, the CO_2 intensity of energy use is projected to decline from 3.92 tCO_2 per toe in 2010 to 1.49 tCO_2 per toe in 2050 (Shukla et al., 2015). Direct electricity consumption is the major source of emissions in commercial buildings.

The electricity consumption in both residential and commercial buildings is projected to increase due to rapid scale-up of air-conditioning in Indian homes and offices (Phadke et al., 2014; Chaturvedi and Shukla, 2014). With nearly 70 per cent of buildings in 2030 yet to be built, there is a residential housing gap of approximately 19 million units in urban areas (NBO, 2013) and at least 43 million in rural areas (MoRD, 2011). This has huge implications for climate mitigation, as the choice of technology, design and materials, and the skilled expertise for implementing energy-saving options can greatly impact the cost and CO_2 emissions of future buildings (Khosla and Janda, 2019). To contribute to decarbonisation targets, the Indian building sector must reduce final energy demand by 40 per cent compared with business as usual. The current interventions are inadequate and there is scope to scale up efforts in this sector. The International Energy Agency (IEA) notes that India has access to cooling technologies with efficiencies greater than 400 per cent and that improving residential energy cooling equipment performance could save 3.5 EJ of energy by 2025 – nearly equivalent to India's total electricity use in 2015 (IEA, 2017).

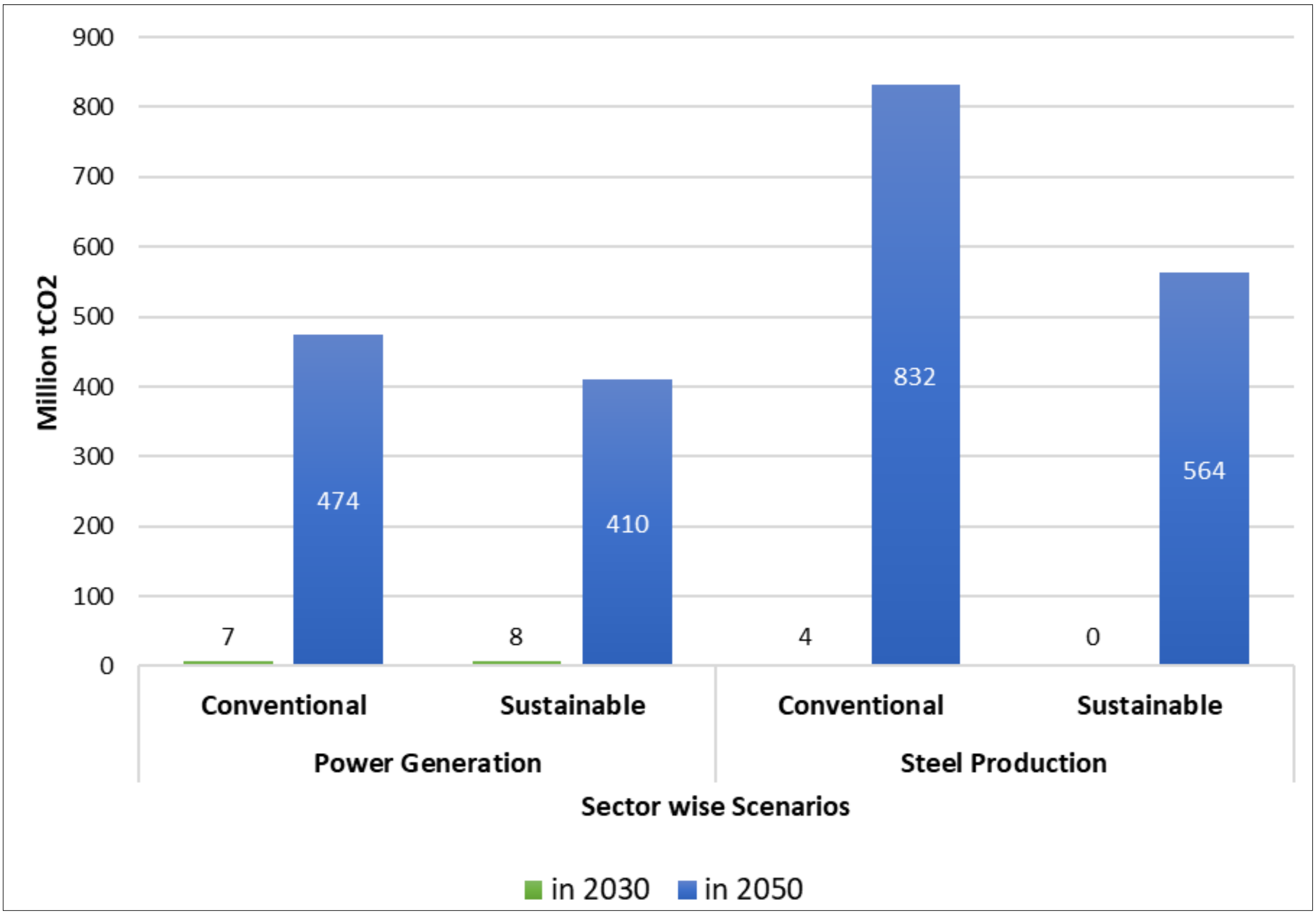
Mitigation efforts in the buildings sector focus on reducing demand. While some fuel is burnt onsite for cooking, and diesel generators supply electricity demand during power blackouts in high-end buildings, the majority of energy consumption comes from the centralised electricity from the grid. Demand reduction actions include measures that avoid the need for additional floor area, reduce energy consumption for heating/cooling, lighting, cooking and use of appliances (Creutzig et al., 2016). India is taking initiatives such as upgrading the Energy Conservation Building Code (ECBC), promoting green building rating and energy certification, and stimulating markets for low- carbon technologies but much more needs to be done. The National Electricity Policy of 2017 (NITI Aayog, 2017), suggests that strengthening and periodic revisions of the ECBC, its adoption, improved urban planning, adoption of high-efficiency lighting technologies can drive energy efficiency in both commercial and residential buildings.

5.4. Carbon Capture and Storage

Low-carbon scenarios with sustainable development pathways have lower usage of CCS, due to its increasing costs (Shukla et al., 2008, Shukla and Chaturvedi, 2013). Initial stored carbon reservoirs are cost-effective but after low-cost potential is exhausted, CCS costs for power plants are expected to rise post 2050. CCS cost in India is expected to rise unlike continued cost reduction for wind and solar energy (Vishwanathan et al.,2018, IRENA 2018). Therefore, renewables are preferred to CCS or alternatives like CCS with coal or biomass.

However, CCS is a crucial component to achieve emissions targets in a conventional climate pathway (Shukla et al., 2008, Shukla et al., 2015). Decoupling of economic growth and GHG emissions by reducing emissions intensity of energy becomes possible through CCS and fuel substitution. The cumulativeCO_2 sequestered by CCS between 2010 and 2050 is 9,929 million tCO_2 in the conventional mitigation scenario, compared to 7,099 million tCO_2 in the sustainable scenario (Shukla et al., 2015). The cumulative CO_2 sequestered is much higher in the conventional scenario due to the higher energy demand.

Figure 5.3: Amount of carbon sequestered (in million tCO_2)



Source: Shukla et al., 2015

CCS becomes economically viable at sites with high storage potential, low transportation and sequestration costs, such as depleted oil and gas wells. Carbon price is a crucial determinant for CCS deployment and its price is expected to increase steadily. The availability of low-cost CCS storage, primarily in depleted oil, gas wells and coal mines is limited to around 5 billion tCO2. Beyond this level, the supply curve of CCS steepens due to uncertainties in storage availability and integration of large point sources with CCS storages.

Anandarajah and Gambhir (2014) suggest that India can meet its emission reductions target without CCS technology with a greater reliance on renewables. However, CCS technologies can lower long-term mitigation costs as the absence of CCS technologies triples the marginal abatement cost in 2050, compared to scenarios with and without CCS. CCS is also important to achieve the carbon budget for the 2°C and 1.5°C scenarios in case of delayed mitigation. When the carbon price is in the range of USD 60 to 100/tCO2 , CCS is likely to be used (Vishwanathan et al., 2018). Analysis based on marginal abatement costs shows that CCS will be used at USD 40 to 60/tCO2 for gas and USD 60 to100 for coal power plants.

5.4.1. Green hydrogen in India's low-carbon transition

There is growing global interest in green hydrogen to accelerate the low-carbon transition, especially in hard-to-abate sectors such as iron and steel, cement, fertilisers, and refining, which emit substantial CO_2. Hydrogen is also seen as an option to replace liquid fossil fuels in other high-emission sectors like aviation, shipping and road freight.
Nearly 43 countries, including India, have outlined plans to achieve a hydrogen economy to accelerate the low-carbon transition. India aims to leverage green hydrogen in its energy transition to achieve net-zero while addressing its energy security and economic development goals.

Green hydrogen is an important component of India's Long Term Low Emissions Development Strategy (LT-LEDS) and finds explicit mention in its updated NDCs. As part of LT-LEDS, India aspires to establish a green hydrogen hub and increase its electrolyser manufacturing capacity to enable a production capacity of 5 MMT (million metric tonnes) of green hydrogen per annum by 2030 (MoEFCC, 2022). In 2023, the government approved the National Green Hydrogen Mission with an initial outlay of INR 19,744 crore. The mission is expected to facilitate the production, utilisation, and export of green hydrogen, mobilising an investment of INR 8 lakh crore by 2030. Adoption of green hydrogen is estimated to reduce 3.6 GT of cumulative CO_2 emissions, save energy imports worth USD 246 billion to 358 billion between 2020 and 2050, and create 0.6 million jobs (NitiAyog, 2022; RBI, 2023).

It is anticipated that global hydrogen demand could surge by 400 per cent by 2050, given the global imperative to decarbonise. In India, hydrogen demand is expected to increase by more than four times, reaching 29 MT, nearly 10 per cent of the global hydrogen demand. Presently, India consumes 6 MT of hydrogen annually, with the majority being grey hydrogen for the refinery and fertiliser sectors (RBI, 2023). Estimates by NITI Ayog (2022) suggest that the demand growth will initially come from sectors like refinery and ammonia, followed by steel and heavy-duty trucking in the longer term, which could account for 52 per cent of the total demand by 2050 (ibid).

The outlook for green hydrogen demand hinges on low-carbon policy certainty to enable its use in end-use sectors like steel, road freight, and electrofuels. Despite the optimistic demand forecasts, several challenges hinder the realisation of a hydrogen economy, including high production costs, technical difficulties in storage and transmission, and the absence of supportive policies and regulations.

Challenges to achieve green hydrogen economy

While hydrogen is abundant, it is not naturally found in its elemental form and has to be extracted from other compounds. The carbon neutrality of the energy source used for extraction defines the extent to which hydrogen can be green. Based on sources and extraction methods, hydrogen is classified into black/ brown (produced from coal or lignite gasification), grey (produced from steam methane reformation of natural gas or methane), blue (produced from natural gas or coal gasification combined with CCS or CCU technologies), and green (via electrolysis of water).

The current cost of producing green hydrogen ranges between USD 4.1 to USD 7/kg, more than double the cost of brown or grey hydrogen, rendering its production cost ineffective (NITI Ayog, 2022). To establish a domestic and international market for hydrogen, India must produce price-competitive hydrogen. Apart from production costs, the storage and transportation of hydrogen pose challenges due to its low density, gas flammability, and easy dispersion (ibid).

While storage tanks are the easiest way to store hydrogen, hydrogen's low density requires tanks that are over ten times larger than those used to store liquid fossil fuels, leading to increased costs. Similarly, transporting hydrogen will require substantial investment in laying of pipelines or re-purposing existing natural gas pipelines for hydrogen. However, pipelines will become cost effective only after hydrogen demand exceeds a critical threshold. Until then, transportation through compressed hydrogen trucks will be inevitable, making a case for having consumption closer to sites of production.

Estimates suggest that the levelised cost of green hydrogen can be made competitive with grey hydrogen by 2030. In a best-case scenario, considering the low levelised cost of renewables like solar and wind in India, reduced manufacturing costs of electrolysers, supportive policy interventions, could bring down the cost of green hydrogen to USD 1.60/kg by 2030 and USD 0.70 by 2050. (NITI Ayog, 2022).

Establishing a clean hydrogen economy also requires clear standards, regulations, and significant financing, which are yet to be fully defined. While several big private and public companies have shown initial interest in green hydrogen and electrolyser manufacturing following the government's intent to set up India as a green hydrogen hub, this transition is still in its nascent stage.

Significant challenges in hydrogen transition necessitate policy support from both the demand as well as the supply side. Industry and market players, policy makers, and financial institutions need to collaborate to enable this critical transition.

5.5. Drivers of the Energy Transition

India's energy management is crucial for global emissions reduction as the country is projected to have the fastest- growing energy requirement and consumption by 2040 (IEA, 2018). Providing clean cooking fuels to 500 million and electricity to 304 million is a priority by 2022 (IRENA, 2018; NEP, 2017). India's final energy demand is expected to double from nearly 600 Mtoe in 2017 to about 1200 Mtoe in 2042, at the rate of 8 per cent per annum (Thambi et al., 2018). Rapid urbanisation and demographic shifts in India are projected to increase energy demand driven by higher household incomes, higher household energy consumption and material-intensive urban development (IEA, 2021). Democratising electricity access while transitioning to clean energy is a dual challenge for India.

India's NDC for the Paris Agreement acknowledges that coal will continue to dominate power generation, and oil and coal are expected to be the major components of India's energy mix until at least 2040 (Soman et al., 2018). Although India has committed to installing 175 GW of renewable energy capacity by 2022 and reducing its emissions intensity by 2030, much remains to be done (Government of India, 2015). Some of the obstacles include outdated transmission grid systems and limited energy storage that hinder rapid adoption of renewable energy, which is intermittent and variable. Mixed signals from the government on reducing thermal power capacity further complicate the transition. However, recent investments in solar power (more than in all fossil fuels sources taken together in 2018) and increasing pace of transition to renewables, point to a concrete path towards India's NDCs.

As of March 2018, coal-based electricity accounted for 57 per cent of India's installed capacity (Malik et al., 2020). To meet its emissions reductions goals, newer coal plants should operate at only 65 per cent of their estimated capacity (Shearer et al., 2017). Transitioning to renewable energy is limited only to power generation with the transport and industrial sector still relying on conventional energy sources. Reducing costs of renewables vis-à-vis coal is primarily driving the transition to renewables. The average cost gaps between solar and wind, and coal is expected to increase three to five times between 2020 and 2030 (Spencer et al., 2018).

During this period, renewables are estimated to replace about a quarter to half of the existing coal capacity. Variable costs of half of India's existing coal fleets were found to be higher (INR 2.5–3 per kWh) than renewables making the substitution cost-effective (Spencer et al., 2018). The levelised cost of electricity (LCOE) renewables are now significantly cheaper than coal because of technology innovation and economies of scale in manufacturing.

India's levelised auction tariffs[30] for both wind and solar are among the lowest in the world due to intense competition between independent power producers (IPPs) during auctions and project optimisation. For instance, the 2019 average auction tariffs for solar are less than half of their 2015 levels. The decline has been less steep for wind, but for both technologies, the average tariff in 2019 was below INR 3/kWh. And, unlike coal, which is primarily government owned, private IPPs have built 90 per cent of the wind and solar power projects in the past five years.

Federal agencies like the Solar Energy Corporation of India (SECI) have substantially reduced risks of the renewable IPPs. SECI acts as an intermediate procurer, enabling IPPs to avoid direct contact with the DISCOMs, safeguarding them from payment delays. Despite decreasing LCOE for renewables, high grid integration costs remain a concern. Solar power production is concentrated during the day, necessitating storage and dynamic demand response to meet nighttime energy demands. Estimates indicate that a 15 per cent solar penetration rate could increase solar costs by 30 to 50 per cent (Hirth, 2013). India is expected to reach 15 per cent solar penetration rate by mid-to late 2020s. (Spencer et al., 2018).

In pursuit of a net-zero by 2070 with no CCS and commercially available hydrogen[31], India must adopt transformative policies across key sectors. The power sector necessitates a 99 per cent reduction in coal-based generation from its 2040 peak, coupled with ambitious expansions in solar, wind, and nuclear capacities. Resource constraints are a crucial driver in the transition away from coal. The scarcity of coal and water, essential inputs for coal power plants, is a major concern.

Indian thermal utilities' fresh water consumption increased by 43 per cent from 2011 to 2016, with 39 per cent of installed thermal capacity located in high water-stress regions (Lou et al., 2018). Water scarcity has caused thermal plants to cease operations, resulting in loss of tens of terawatt-hours of electricity generation in recent years (Luo, 2017). India's largest thermal power companies suffered losses of more than USD 1.4 billion between 2013 and 2016 because of production disruptions due to water. To mitigate future losses due to water scarcity and address air pollution concerns, shift towards renewables is speeding up in India.

30 The levelised tariff calculation converts a local currency structured tariff to a common USD/MWh base after accounting for inflation, currency of payment, project life and expected date of commercial operation. This enables like-for-like comparison between auctions over time and different geographical location.

31 Vaibhav Chaturvedi, Ankur Malyan, Implications of a net-zero target for India's sectoral energy transitions and climate policy, Oxford Open Climate Change, Volume 2, Issue 1, 2022, kgac001, https://doi.org/10.1093/oxfclm/kgac001

Box 5.1: Clean energy technology transition – LED lighting in India

Clean-energy technology transitions in emerging economies require innovative approaches and co-ordinated policies. One successful example is the widespread adoption of light emitting diodes (LEDs) in India. LED bulbs, offering lower energy use, longer lifespan, and reduced life cycle costs have replaced incandescent bulbs and compact fluorescent lamps (CFLs) in the country. From 2014 to 2018, annual LED bulbs sales increased over 130 times to 650 million bulbs resulting in over 30 billion kWh of estimated annual energy savings (Kamat et al., 2020). By 2018, LEDs dominated the market with 46 per cent share, making India one of its largest markets. However, LED manufacturing in India is limited, with major production coming from countries like China, Taiwan, and South Korea.

This LED transition was a result of a government-led market formation programme in 2014. The Energy Efficiency Services Ltd. (EESL), a joint venture between four public-sector utility companies, served as an interface between the government, private players and the consumers. LED bulbs were procured through a competitive bidding process and the prices dropped significantly over the years from USD 17 in 2009 and USD 6 in 2014 (Kamat et al., 2020) and USD 0.6 in 2016. The reducing prices complemented ambitious targets set by the government for LED street lamps and residential bulbs. The programme's success was also driven by China's overcapacity and low-cost LED manufacturing.

However, LED transition faces challenges like quality issues due to inadequate regulation and overdependence on LED bulb imports. Lack of coordination and linkages within the innovation system such as R&D by universities, labs, industry, and market initiatives by the government and private sector has hindered leveraging of technological capabilities. To achieve successful technology transitions, consistent strategic actions across the innovation system spanning knowledge development, diffusion, entrepreneurial experimentation, policy guidance, resource mobilisation, and technology legitimation is essential. LED adoption in India illustrates many of the complexities of an energy transition driven by technology.

5.6. Conclusions

- Coal and oil constitute the largest share in India's current primary energy mix and are projected to do so under all climate scenarios till 2050.

- Electricity generation is primarily driven through coal-based power generation. However, in the low-carbon scenarios, the share of renewable energy is expected to increase significantly to help phase out coal for power generation by 2050.

- The transition towards clean energy sources is primarily driven by the reducing costs of renewables. Between 2020 and 2030, the average gap in costs between solar and wind, and coal is expected to increase three to five times, due to technological innovations and economies of scale in manufacturing.

- India's emissions from the transport and industrial sectors are projected to accelerate in the business-as-usual climate scenarios. In decarbonisation scenarios, emission reduction is also the highest in transport and industrial sectors.

- The use of CCS for mitigation in India is conditional on its cost effectiveness, and the projected cost of carbon emissions in business-as-usual climate scenarios. In sustainable decarbonisation scenarios, CCS deployment is relatively low.

- While green hydrogen is crucial in decarbonising hard-to-abate sectors, India's plans to set up a green hydrogen hub are at a nascent stage. There are significant challenges in achieving a clean hydrogen economy, including making its production price competitive, and dealing with high costs of storage and transmission.

- In pursuit of a net-zero scenario by 2070 with no CCS and commercially available hydrogen, India must adopt transformative policies across key sectors. The power sector necessitates a 99 per cent reduction in coal-based generation from its 2040 peak, coupled with ambitious expansions in solar, wind, and nuclear capacities.

6.

CLIMATE RISKS AND THE FINANCIAL SYSTEM

6. CLIMATE RISKS AND THE FINANCIAL SYSTEM

Climate risks can destabilise the financial sector. Unchecked climate change can lead to severe disruptions including increased extreme weather events that cause physical damages and directly impact insurers. If insurance does not cover these physical risks, then affected corporations' and households' balance sheets face adverse impacts, potentially resulting in losses for the banking system. While this makes climate mitigation essential, transitioning to a low-carbon economy also involves financial risks due to stranded assets, investments, uncertainties in technological innovations, abrupt policy changes, and loss of jobs and revenues. As discussed in chapter 1, many of the physical risks are materialising, even as climate mitigation is evolving. As these risks unfold in parallel, they can threaten the financial systems, challenge monetary and fiscal policies. India is most vulnerable to physical risks among advanced economies and BRICs countries; it is also the least resilient to transition risks among BRICs countries (RBI, 2023). Thus, it is essential for Indian banks and financial authorities to play a more proactive role in the low-carbon transition. This calls for identifying, disclosing and reviewing climate risks and managing these risks in a way as to reduce their exposure to domestic financial systems to ensure a smoother transition.

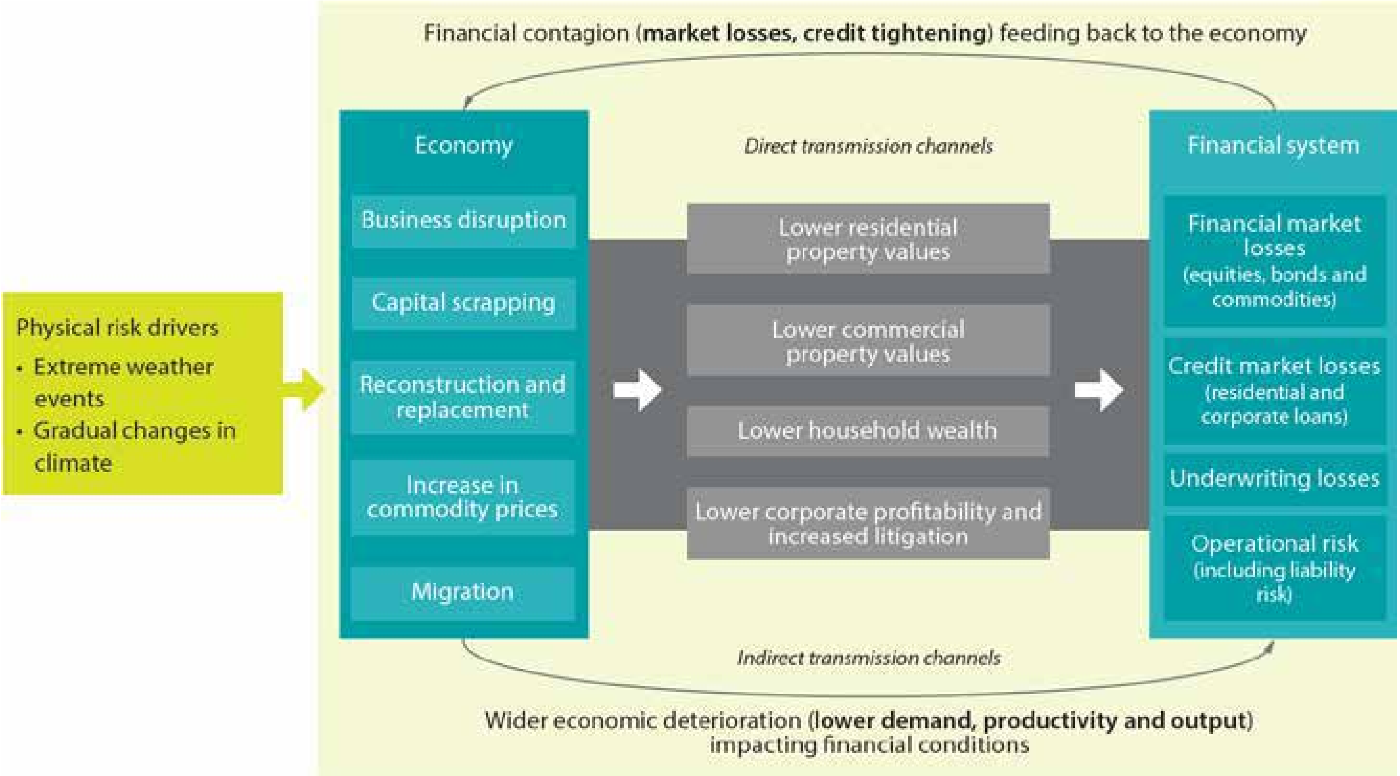
This chapter conceptualises links between climate risks and financial system, frames the broad risks faced by the financial sector, reviews the exposure of Indian banks to these risks and current state of risk management in the country.

6.1. Climate Risks and Financial Stability

The Central Bank of Netherlands study showed that climate risks exposure to carbon-intensive sectors was significant enough to pose potential systemic risks to the financial system (Campiglio et al., 2018; Regelink et al., 2017), with some risks already materialising. Many Central Banks are assessing climate-related risks, their impact on respective economies and exploring new methodologies including climate stress testing to capture exposure of diverse financial actors to climate risks. A climate stress testing of firms in the EU and the US showed that direct exposures via equity holdings to the fossil fuel sector is small (4 to 13 per cent) across all financial actors (Kriegler et al., 2013). But, the combined exposure to all other climate policy-relevant sectors is large (36 to 48 per cent of financial actors) (Battiston et al., 2017), especially for investment and pension funds. European financial institutions have direct 'high carbon exposure' (Weyzig et al., 2014). Relative to their total assets, banks have around 1.3 per cent, pension funds have 5 per cent, and insurance companies' 4.4 per cent exposure. Besides, banks' loan portfolios exposed to these sectors are comparable to the banks' capital stock.

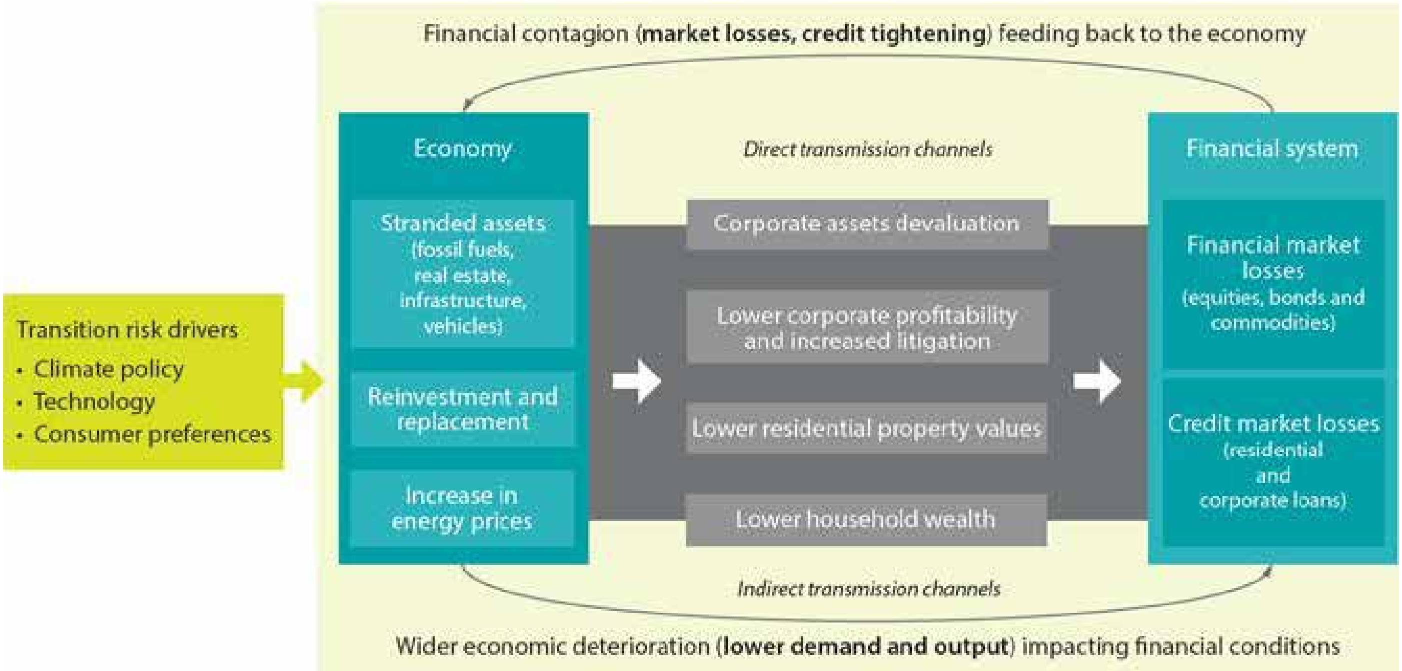
The interplay between physical risks, economy and the financial system creates feedback loops, amplifying and spreading impacts. For instance, damages to assets serving as collateral restricts lending, reduces financing for reconstruction, weakens household wealth and hampers consumption. Household losses can be significant, if they are uninsured. Financial sector can also be impacted indirectly by changes in investment-savings behaviour, lower productivity and economic slowdown. The increasing risks of tipping points like critical ecosystems and their potential acceleration in the near-term are not yet fully captured in risk models (NGFS, 2019).

Figure 6.1: Impact of physical risks on financial stability



Source: NGFS, 2019

Figure 6.2 : Impact of transition risks on financial stability



Source: NGFS, 2019

In India, RBI (2020, 2023) studied the macroeconomic impacts of climate change and found that some indicators of real economic activity are significantly impacted. The report (2020) shows that weather conditions have a significant impact on some key economic indicators like Purchasing Managers Index (PMI), Index of Industrial Production (IIP), demand for electricity, trade, tourist arrivals, and tractor and automobile sales. The 2023 RBI report as discussed in chapter 1 and 4 has shown how physical risks impact supply and demand and increase inflation and lower consumption. Given the economic and financial implications of climate change, Central Banks and financial regulators have a strong rationale to be involved in the low-carbon transition.

While climate mitigation is essential, transitioning to a cleaner, low-carbon energy also involves various financial risks, known as transition risks (Figure 6.2). These risks arise from the nature of assets and resources held by investors and financial actors. Stranded assets not only lead to economic losses and lost revenues but also affects the market valuation of the owning companies, negatively impacting investors, leading to cascading effects throughout the interconnected financial system. Initially, mitigation strategies like Carbon-Capture and Storage (CCS) and other geo-engineering techniques were expected to reduce the pressure on fossil fuels phase-out. But, delayed global action has intensified the threat of stranded assets. Gray et al., (2018) observed that the operational costs of 35 per cent of the existing coal capacity is greater than building new renewables; this value is expected to increase to around 96 per cent by 2030.

Transitioning to cleaner energy requires adapting transportation systems, power transmission and distribution networks, and expanding power storage capacities to accommodate variability in renewable energy availability. The government faces the challenge of financing these provisions and paying compensation to those who lose from the transition. This includes financial investors, workers in coal-intensive sectors and communities affected by deployment of renewable energy.

Box 6.1: Banks' perspectives on systematic climate risks and transition risks

The members of UNEP-FI's Principles for Responsible Banking[32] and some of the world's largest commercial banks have started integrating Integrated Assessment Models (IAMs) into their risk modelling and regulatory reporting work, and the purview of climate modelling is rapidly evolving in the banking sector. Along with the bank's usage of IAMs, prudential regulator engagement with banks on climate risk reporting is also expected to help in regulatory reporting and internal risk monitoring purposes.

The bankers and insurers of UNEP-FI acknowledge that there are various issues involved in modelling the interactions between the climate scenarios and credit methodologies. Bankers and insurers may need to consider the extent to which past data reflect the effects of climate change to date and how it can be used as a basis for predicting the future. They may consider a range of climate change risks and the degree to which they are considered to calibrate financial risk models. Practitioners may also need to develop leading indicators of potential future losses that can inform underwriting and pricing decision-making.

CICERO (2021) systematically analyses the methodologies used in the banking system. Some examples are discussed below:

CaixaBank: CaixaBank has applied the transition risk methodology provided by UNEP-FI to assess the change in 'Expected Loss in the Oil & Gas and Power Utilities sectors'. The methodology involves several steps like portfolio segmentation, developing a qualitative risk analysis, gathering internal risk data and making an estimate of the evolution of credit ratings for the different companies in the sample. The bank considered the following drivers of transition risk in the energy sector—evolution of carbon prices, future energy mix, business transformation, existence and valuation of stranded assets and evolution of new technologies. The bank developed a special-purpose tool that translates the qualitative assessment of transition risk into financial figures for the different companies in the sample. The tool uses the different 'Risk Factor Pathways (RFPs)' derived from modelling exercises under different scenario articulations. These modified RFPs are then translated into changes in the main credit risk factors that can be introduced in the bank's internal rating system in order to obtain a transition risk-adjusted rating for the companies, given their decarbonisation and transition strategies. The bank acknowledges that there are many gaps in their methodology:

- Further enhancement of the scenarios is needed to support the requirements of financial risk assessments, specifically greater detail on sectoral and regional factors.
- To fully integrate scenario outputs into decision-making, institutions must go further in translating climate variables into financially relevant factors.
- There is a need for additional clarity on how to evaluate specific borrowers under the different scenarios.

32 The Principles for Responsible Banking are a framework for ensuring that signatory banks' strategy and practice align with the vision society has set out for its future in the Sustainable Development Goals and the Paris Climate Agreement.

Mitsubishi UFJ Financial Group (MUFG): Many banks in the UNEP-FI expressed concerns about whether the balance sheet would survive a disruptive energy transition scenario. MUFG's own modelling pilot produced similar results, confirming that the bank would be resilient to the type of disruptive transition implied by a transition scenario. In the scenario analysis, centring on companies in developed countries where high economic growth cannot be expected and companies whose renewable energy ratio is extremely low, their capital efficiency gradually deteriorates as investment in renewable energy increases. Their credit ratings are also gradually downgraded as their financial strength weakens. Some challenges faced by MUFG are:

- The lack of standardised scenarios.
- Difficulty in calculating climate related risks in some companies with insufficient disclosure and lack of standardised climate risk database to calculate risks in a more systematic and transparent manner.
- Given the range of possible real-world outcomes, the ability to carry out climate risk assessments for several scenarios is important. While several different scenarios are being published by different institutions, there are still variations in the direction, coverage and granularity of models.

6.2. Types of Financial Risks

Climate risk management is possible when risks can be identified, measured and integrated in business decisions, and modelled to gauge impacts on clients and portfolios. The impacts of climate risk drivers (both physical and transition) can be observed through traditional risk categories, mainly credit, market liquidity and operational risks (Basel Committee on Banking Supervision, 2021; RBI, 2023).

Credit risks increase when climate risk drivers reduce borrower's ability to repay or service their loans and lenders ability to recover the loan due to default (ibid). Credit risks can impact households, firms, sovereigns and sub national institutions. For example, banks that are more exposed to fossil fuel linked industries like petrochemicals, oil refinery, thermal power plants vis-à-vis loans face higher transition risks. Households impacted by extreme weather events like floods face physical risks that reduce their capacity to repay loans.

Market risks refer to the changes in the value of financial assets including negative price adjustments where climate risk is not incorporated. This can lead to breakdown in correlations between assets, change market liquidity for certain assets, and reduce effectiveness of hedges (Basel Committee on Banking Supervision, 2021). For instance, investors can increase risk premiums from fossil fuel industry borrowers or reward borrowers they believe will stand to gain from green transitions like renewables.

Liquidity risks arise when climate risk drivers impact banks' ability to raise funds, liquidate assets to meet their obligations or reduce their access to stable funding sources (ibid). Liquidity risks get transmitted generally through the credit channel. During crisis or natural disasters for instance there can be competing claims on liquidity in banks from corporates, households with the former then restricting drawdowns of credit lines.

Operational or reputational risks arise due to inadequate or failed internal processes, people and systems due to external events. This includes increased regulatory and legal compliances and increased litigation and liability costs due to climate sensitive investments (Basel Committee on Banking Supervision, 2021). For instance, climate related lawsuits or actions could be sought against corporates, banks for past environmental actions.

Information and evidence on how climate risk drivers get manifested as different types of financial risks is limited, with that on regulatory risks being the most scarce. However, studies have looked at the impact of climate risk drivers, both physical and transition on wealth, income of households, firms and nations. There is empirical evidence that extreme events reduce property value (increasing credit risks where property is collateral), income, overall output and firms profitability, thereby increasing probability of defaults, non-performing assets ratios, and lower bank equity ratios. The physical risk drivers also increase borrowing costs and lower access to debt markets (for sovereigns) (Basel Committee on Banking Supervision, 2021).

Similarly, studies and scenario analysis have looked at the impact of transition risk drivers and shown how changes in government policy, consumer sentiment, technological advancement increases credit costs and risks for banks, adversely impacts corporate balance sheets due to stranded assets and reduced incomes (ibid).

6.3. Indian Banks' Exposure to Climate Risks

An analysis of Indian banks and financial institutions' exposure to transition risks is difficult given the scarcity of granular data in the absence of climate disclosure norms. Indian banks do not have to disclose emission intensity of their lending portfolios. There is also no common assessment or reporting framework that is followed to capture climate risks (Colenbrander et al., 2023).

While Indian financial regulators have engaged with climate change since 2007, when RBI first issued advice on sustainable development, non-financial reporting and corporate social responsibility, Indian banks are yet to engage actively with climate risks assessment and the low-carbon transition (ibid). Several initiatives have been taken over the years including SEBI's mandatory Business Responsibility Reporting and more recently the setting up of a Task Force on Sustainable Finance by the Ministry of Finance in 2021. In 2021-22, SEBI also issued new sustainability reporting requirements under the Business Responsibility and Sustainability Report (BRSR) with more quantifiable metrics that will be made mandatory for top 1,000 listed firms to report ESG risks and its financial implications in phases (Atre et al., 2023; GOI, 2023a). From this year, the ESG reporting framework will be applicable to top 150 firms by market capitalisation (Atre et al., 2023).

RBI (2023) has undertaken exercises to assess climate risks impact on Indian banks by classifying industries as green or brown depending on their energy intensity, by measuring the ratio of energy usage cost to gross output or value. A higher ratio points to greater energy intensity and relatively less green activity. Another method is to look at the sectoral energy consumption to its GVA (ibid). This assessment of Indian banks' transition risk, mapping energy intensities with sectoral bank debt shows higher exposure of banks to high emission industries and services like utilities, metal industries, transport.

A further spatial analysis shows that public sector banks (PSB) are more exposed to the conventional energy sector while private sector banks (PVB) have greater exposure to the transport sector. Both PSBs and PVBs have exposure to metal industries. Metal and utilities have higher gross non-performing assets ratio (GNPA) and their higher transition risks can pose greater credit risks for the Indian banking system in the future (RBI, 2023).

A more detailed study by Colenbrander et. al (2023) for ODI, on the transition risks faced by Indian banks in low-carbon scenarios, considered various data entry points, including national-level emissions data, GVA, and borrowings, and transactional-level data within sectors, in what they term as a 'top-down and bottoms-up approach' (ibid, p.3). Below, we consider the main inferences from this study to understand the extent to which India's financial sector is exposed to climate risk drivers. Their analysis of outstanding debt in India shows high leverage to high emission sectors across mining, manufacturing and services sectors. For instance, three-fifths of the total loans and bonds lent to the mining sector were for oil and gas extraction, one-fifth of the manufacturing debt was for petroleum refining and aligned industry. Electricity production accounted for 5.2 per cent of outstanding credit but only 17.5 per cent of this was for renewables (ibid).

The study mapped 70 per cent of the outstanding debt to India's emissions inventory, about INR 76 trillion out of total INR 108.6 trillion in 2021 and considered around 90 per cent of the country's emissions.

The sector-wide data shown in four ways vis-à-vis GHG emissions, outstanding debt, emissions intensity and debt intensity showed that nearly 12 per cent of outstanding debt is to energy intensive sectors. In comparison, 8 per cent of domestic bank lending to non-financial corporations in the European Union, is to energy intensive sectors (ibid). Among all the sectors, electricity production is the largest source of emissions and as mentioned above, accounts for 5.2 per cent of the outstanding credit lent by Indian banks (see table below). This is followed by other energy intensive sectors like cement, iron, steel and chemicals, which also have high levels of debt. These sectors (especially electricity) face transition risks and transfer these risks on their creditors as well as Indian financial markets.

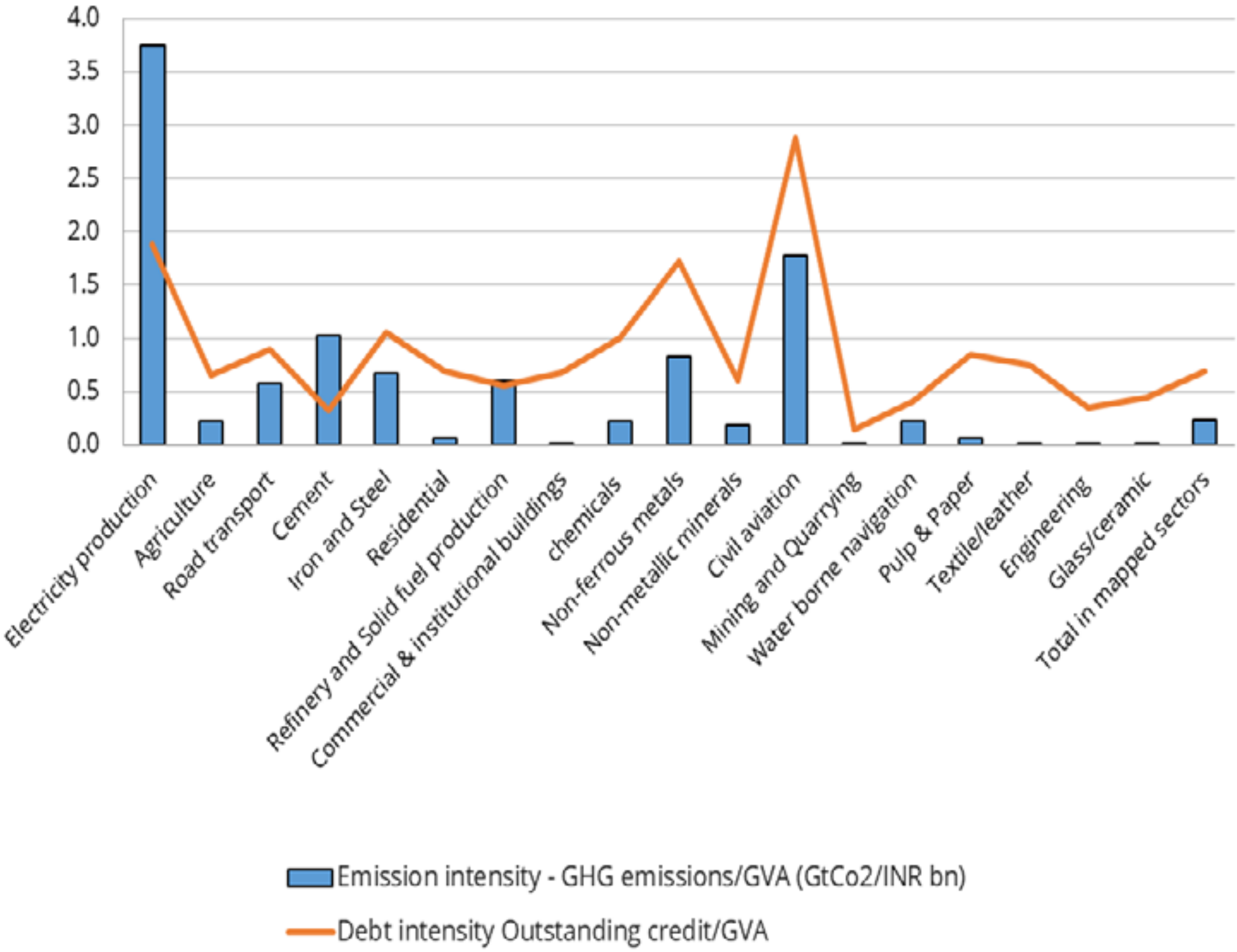
Table 6.1: Greenhouse gas emissions and gross outstanding debt by sector in India

UNFCCC sectors	GHG emissions (2016) GtCO2e	Gross outstanding debt (2021) INR billion
Electricity production	1,127,732	5,666
Agriculture and mining	429,149	13,356
Road transport	247,594	3,864
Civil Aviation	16,284	263
Water-borne navigation	2,944	54
Cement	160,249	502
Iron and Steel	138,116	2,169
Buildings	196,258	40,220
Manufacturing	131,509	8,009
Metals and Minerals	74,302	1,894

Source: Colenbender et. al (2023)[33]

33 Buildings include residential, commercial and institutional buildings. Manufacturing sector includes refinery and solid fuels pro- duction, chemicals, paper and pulp, textile, engineering, glass/ceramics.

Figure 6.3: Emission intensity and debt intensity by sector in India

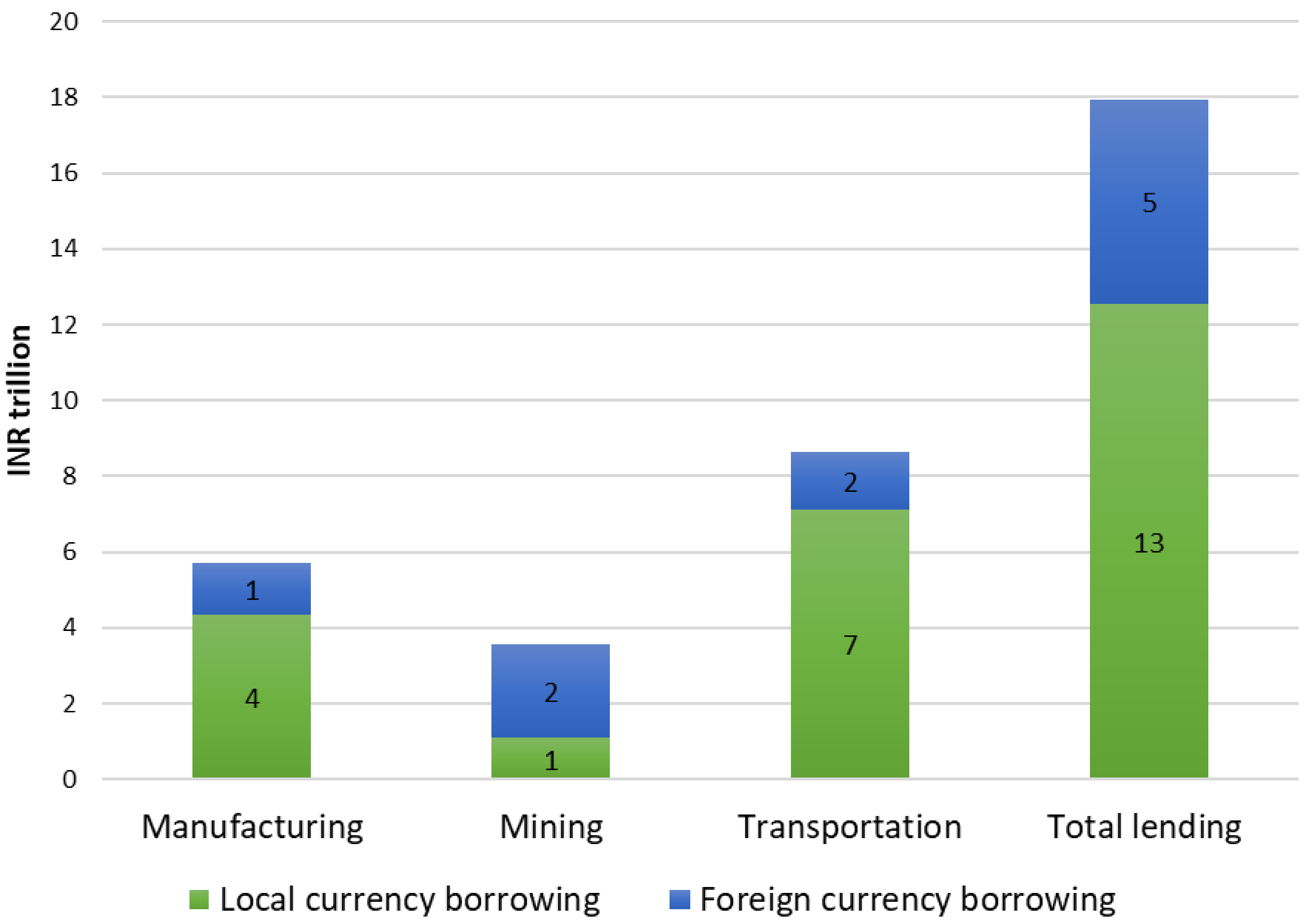


Source: Colenbrander et. al (2023)

While agriculture, road transport, residential and commercial buildings all account for a significant share of India's GHG emissions, the transition risks for these sectors is relatively low. Agriculture has moderate transition risk because its emission intensity and indebtedness is low compared to its gross value add. In the case of other sectors like transport, the transition risks get dispersed across millions of other vehicles, buildings, appliances and hence does not pose a systemic risk.

The break-up of the total borrowing in domestic currency and foreign currency further reveals nearly 82 per cent of funding to electricity, gas and sanitary services is in domestic currency. This indicates that transition risks of this sector can get transferred directly to the domestic financial systems (see Figure 6.4). Beyond power generation, 6 per cent of outstanding domestic is to other hard-to-abate sectors like cement, chemicals, iron, steel, gas extraction, and petroleum. But, this also includes heavy borrowings in foreign currency, which means some of the transition risks are transferred to foreign investors. While this reduces risks for the Indian financial sector, it increases exposure for the Indian borrowers and exposes Indian firms to currency risks.

Figure 6.4: Total borrowing by carbon-intensive sectors in 2021 (INR trillion)



Source : Colenbrander et. al (2023)

This paper also found that banks largely neglect climate risks; there is poor climate risk awareness and absence of processes and systems to identify, disclose and manage transition risks. Overall, the study reveals that India's financial sector is not ready or prepared for a low-carbon transition to meet 1.5°C or below 2°C target. Currently, lending for fossil fuel power generation and production far outstrips loans for renewables and such trends will result in investment lock-in that can jeopardise the financial sector. Similarly, lack of awareness and neglect of climate risks by banks threatens behavioural and institutional lock-ins that can increase the impact of transition risks.

Colenbrander et. al (2023) conclude that India's financial sector is heavily exposed to transition risks, and banks and financial institutions currently lack capacity, requisite skill, and knowledge to undertake climate risk management or engage actively in a low-carbon transition.

A recent report by Climate Risks Horizon (2023) that surveyed 34 of the largest Indian scheduled commercial banks by market capitalisation also revealed significant gaps in measuring and managing climate risks by these banks. For instance, the report notes that eight banks were at an advanced stage of scope emission disclosures, only two banks had a coal exclusion policy, and only one bank had measured its financed emissions (emissions of bank's investments and loan portfolio) (Atre et al., 2023). Seven banks had started planning for scenario analysis to calibrate climate risks, 10 had started the process of disclosing some of its GHG emissions and four had set a target of net-zero by 2030 (ibid).

The report also noted that the top 10 Indian banks are significantly exposed to high emission sectors like energy, chemicals and chemical products, basic metal and metal products, engineering, petroleum, coal products, construction, and vehicles. Three banks that stand out in their exposure levels include SBI, HDFC and ICICI, which are also categorised as Domestic Systematically Important Banks (D-SIBs) by RBI in 2023, which means they are too big to fail. 'None of these three banks have calculated their financed emissions or undertaken climate scenario analysis on their portfolios' (ibid, p.58).

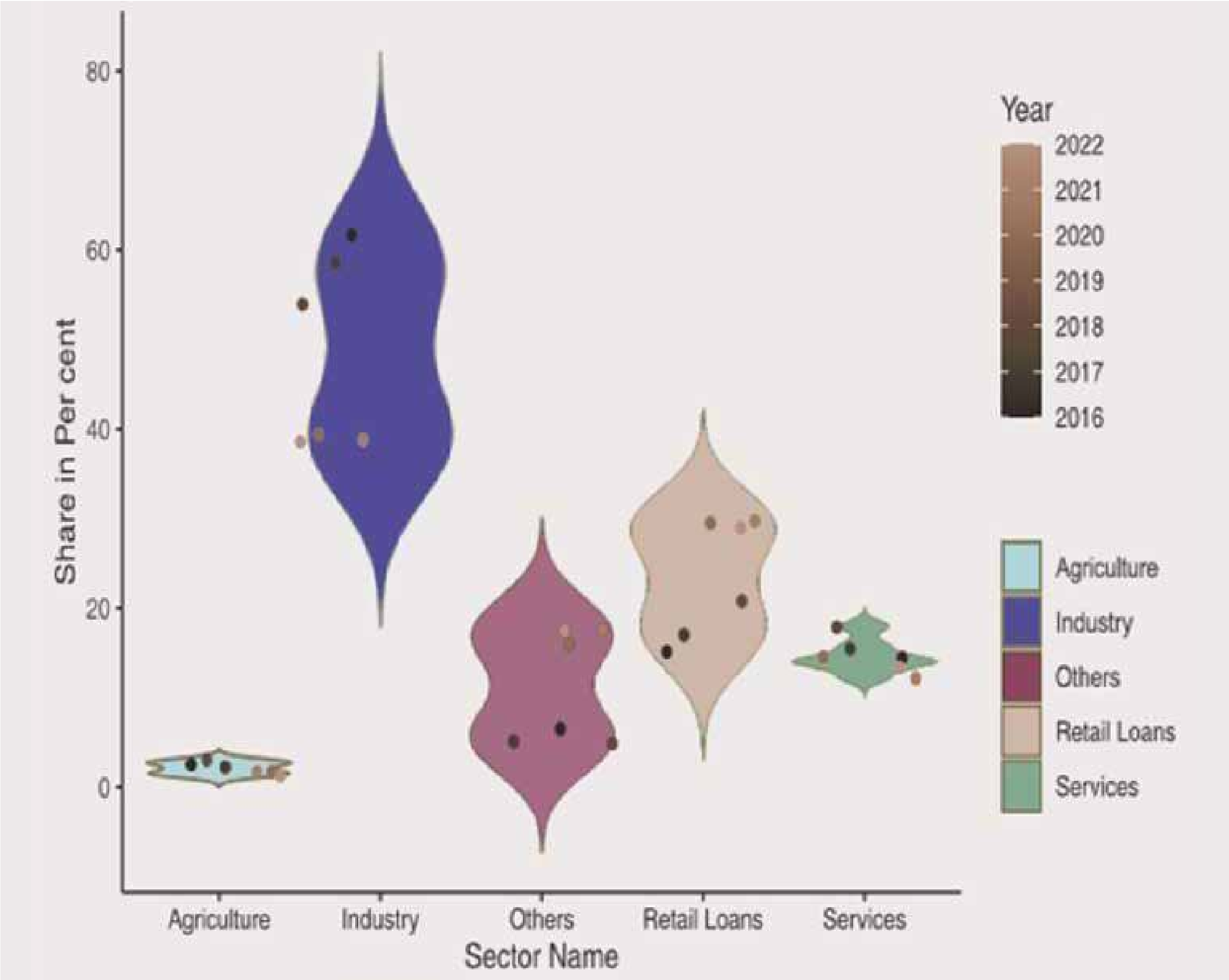
6.4. Role of NBFCs and Climate Risks

Besides the scheduled commercial banks, the role of NBFCs is crucial in India, in supplementing banking facilities at the grassroots level, including medium and small industries, businesses, retail finance, services and agriculture. There are several NBFCs registered with the RBI that operate through many branches to supply credit facilities to end consumers, who may find borrowing from banks too stringent or inaccessible. NBFCs categorised as systematically important with assets more than INR 500 crore dominate this segment in India (Ghosh & Mazumder, 2021).

They are well capitalised but bank lending forms a big part of their liabilities, and on the assets side their largest lending is for the industrial sector, which forms about 60 per cent of its advances (Ghosh & Mazumder, 2021; RBI, 2023) (see figure below). They also finance the retail and services sector and to a smaller extent the agricultural sector. Within retail and services, they finance automobile loans, commercial real estate, trade and transportation, and in the industry sector they are the key source of finance for medium, small and micro enterprises (ibid). The MSMEs rely on conventional fuel to operate and are vulnerable to transition risk via changes in government policy or technological advancements.

On the liabilities side, besides banks, they get their funds through debentures and issue of commercial papers. The NBFCs are closely interlinked with insurance companies, mutual funds, PSBs and PVBs, which also means any kind of a negative impact on the former can have a ripple effect on the financial system (ibid). As such, it becomes important to monitor their exposure to transition risks.

Figure 6.5: Sectoral distribution of NBFC credit



Source: Ghosh and Mazumder, 2021

Ghosh and Mazumder (2021) assess how the impact of structural, sectoral shocks, wherein NBFCs operate, can have a spillover impact on the economy through banking channels and other feedback loops. Their paper finds that sectoral shocks can increase banking interest rates by SCBs and thereby increase unemployment, reduce real wages and per capita capital formation in the country. Inversely, they find that increase in average failed firms and defaults among NBFCs' loanees increases their rate of interest by the latter. This discourages firms, small enterprises from entering the market, dampens the loans sector and leads to interest rate cuts by SCBs.

Using the same partial equilibrium model, RBI (2023) looked at the role of NBFCs in propagating climate risks (also causing shocks to sectors and structures) due to its interlinkages between the banking channels. RBI exercise shows that climate change impact on MSMEs leading to greater defaults gets transferred from NBFCs unto scheduled banks, even if the banks' lending to NBFCs is small or limited. 'When climate shock first increases the riskiness of a small firm and then gets transmitted to a large firm, economy wide delinquency increases' (RBI, 2023, p. 81). Given the backward and forward linkages with NBFCs, the report states any significant default in loans to NBFCs due to weather events can amplify financial delinquencies. To minimise impact of climate risk drivers on the financial system, NBFCs need to be evaluated for climate risks. There also needs to be greater data diffusion and transparency in information about the NBFC ecosystem.

Overall, the Indian banking sector along with shadow banks and intermediaries like NBFCs stand significantly exposed to climate risks. The government can hedge financial risks by enabling a non-disruptive transition by redirecting capital and introducing policy measures like carbon tax in an orderly fashion. Indian financial regulators and policymakers have to play on the front foot in this transition. Central Banks across the world are looking at ways to manage climate risks and enable low-carbon transition. The RBI has similarly started engaging with climate risk analysis, while SEBI has put in place new disclosure norms. However, these regulatory processes need to be brought up to speed. Indian banks independently also need to put in place climate risk management processes, to de-risk their portfolios and act proactively to enable a green transition.

Some studies argue that the economic costs of the transition can be offset by a positive 'green growth' effect, and the short-term costs are justified considering the long-term benefits. Ambitious climate policies aimed at structural reforms are suggested to promote innovation, job creation and lower production costs (ESRB, 2016). However, enabling and financing such a transition is challenging due to the path dependency in various sectors including energy systems. In the short-term, the government may face revenue losses from the transition as coal generated income reduces. Agricultural output and food security may also be impacted as input costs will rise due to policy uncertainty and higher capital costs. India's energy transition is significant as the country has to meet decarbonisation goals along with energy security and access targets. India has a potential to transition to low- carbon systems by meeting new demands only through renewables. To facilitate this transition, the government must carefully plan and respond to the different elements that define transition risks.

6.5. Conclusions

- Physical and transition risks from climate change can destabilise financial systems and disrupt established monetary and fiscal policy. They can reduce corporate profits, devalue assets, reduce residential and commercial property values, household wealth, and consequently increase litigation.

- Indian banks are highly exposed to transition risks through their lending portfolios, which are tilted heavily in favour of high-carbon emitting industries and services. Their investments in fossil fuel-based power continue to be higher than renewables in lending portfolios. Additionally, Indian banks lack processes, systems, and human resources to manage climate risks and support the low-carbon energy, urban and industrial transitions.

- Indian NBFCs have a strong grassroots presence and forward and backward linkages with carbon-intensive economic sectors, and more recently, renewable energy. NBFCs provide significant advances to MSMEs, reliant on fossil fuels for operation. An adverse climate impact on NBFCs' borrowers can have a spillover effect on India's banking sector. Their role in propagating climate risks in India's financial sector needs scrutiny.

- Both physical and transition risks are unfolding in parallel across traditional risk categories in India—credit, market, liquidity, and operations. These are expected to increase defaults, non-performing assets, market volatility, and lower bank equity ratios in the banking and finance sector. Hence, how climate risks manifest as financial risks needs careful consideration.

7.

TRANSITION RISKS

7. TRANSITION RISKS

Oil and gas infrastructure have economic value for around 75 to 85 years, while fossil fuel-based power plants have an average lifetime of 35 to 40 years (Bos and Gupta, 2017; Bos and Gupta, 2019). Climate policies required to meet warming targets of 1.5°C and (well below) 2°C for a safe world render these assets obsolete before their full life usage, leading to stranded assets. Stranded assets pose risks for investors and have diverse implications for the economy including for financial institutions, insurers, governments, workers and end consumers. Financial institutions and insurers may face debt defaults, devaluation or loss of assets from the balance sheet. Governments may have to incur additional expenses in the form of compensation to the investors or face legal consequences, besides loss of coal revenue and decline in economic activity in coal-dependent industries. Workers may suffer loss of jobs and be forced to migrate to other sectors and regions. And, the end consumers may also be affected through price hikes, the need for retrofitting housing and transport infrastructure. It is crucial to address these transition risks strategically to avoid financial crises and frame a holistic strategy for a timely and just climate transition in India.

7.1. Framework of Transition Risks

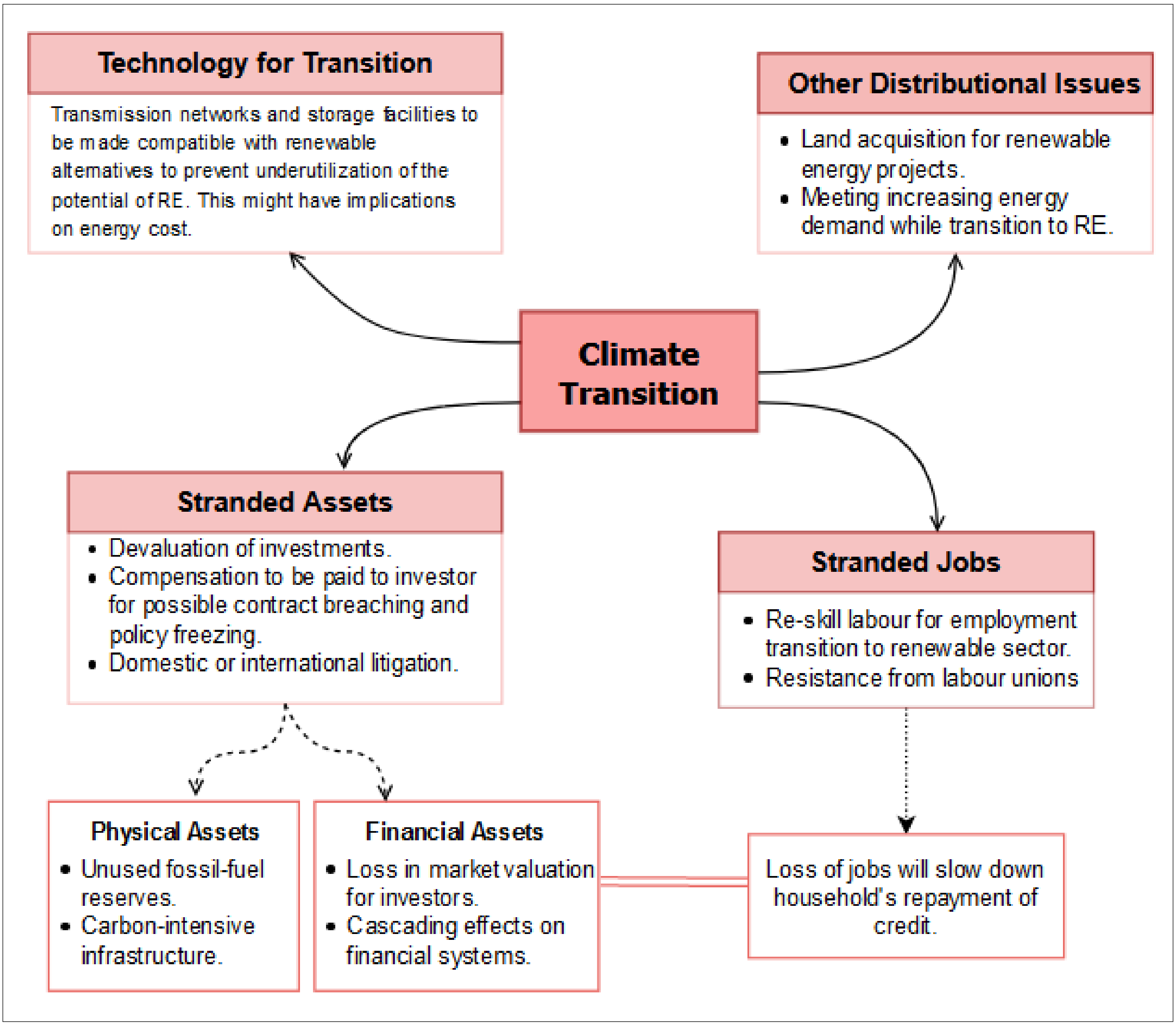
Stranded assets encompass physical assets like unburnt coal, carbon-intensive infrastructure as well as financial assets in the form of investments in carbon-intensive sectors. Bos and Gupta (2017) classify the transition risks faced by developing countries into economic, political, legal, ecological, and social risks, influenced by the type, pace of climate policies, including the intent to implement the Paris goals. Neglecting Paris targets reduces short-term economic and political risks but intensifies long-term economic and ecological risks.

Economic risks involve managing loss of value related to stranded assets. This risk is heightened when new investments are made in carbon-intensive energy as they will have to be stranded before the expected returns on them materialise. The cost of dismantling oil infrastructure and the carbon lock-in[34] also poses a huge burden on taxpayers and impacts firms and households cash flows and wealth. Figure 7.1 shows the interconnected impacts of the transition, including losses from stranded assets in physical and financial systems and job losses.

Developing countries like India continue to invest in coal to meet growing energy demand, which can create new stranded assets in the near-medium term. Without timely action, many of the 12-year-old operational plants in India, can continue to emit for the rest of their lifetime.

34 A carbon lock-in is a situation in which the inertia induced by fossil fuel related capital and infrastructure reduces the prospects of alternatives to emerge and grow.

Figure 7.1: Transition risks



Source: Authors' compilation

Carbon Tracker Initiative (2018) study shows that fossil fuel companies risk wasting USD 1.6 trillion of expenditure by 2025 if they follow the 'business as usual' path instead of meeting international climate goals. Private investors are at greater risk than state-owned companies as they are exposed to 88 per cent of the spending on unneeded oil and gas projects. Coal faces a potential USD 62 billion risk, with no coal mines viable except in India to replace imports. The private sector capital spending in a 1.75ºC world (midpoint of Paris Agreement) is estimated to be half the level under 2.7ºC.

For oil, USD 1.3 trillion of future spending is at risk, rendering new oil sands investments uneconomic and only a minority of potential heavy oil investment profitable. Countries like the US, Canada and China face higher risks for oil investments. In gas, USD 228 billion of future investment is at risk with half of the potential of European gas development spending and no requirement for new liquefied natural gas (LNG) capacity for a decade. Russia and the US are most exposed.

Economic risks also arise in the form of compensation to be paid to investors in return for stranded assets. Companies involved in the fossil fuel extraction, distribution and investors in related technologies expect compensation on their investments. Multinational investments carry additional risks of litigation for contract breaching or policy freezing. Bilateral investments usually protect the foreign investors, obliging states to compensate them, leading to double loss of stranded resources and the compensation. By preventing or reducing investments in carbon-intensive sectors, costs can be reduced to only stranded resources.

Potential legal risks can keep investors away from carbon investments. Some countries employ 'risk service contracts' placing burden of all costs on investors and making compensation for exploration conditional to discoveries. Inadequate compensation raises questions of who bears the risk of devaluation. In such cases, companies are likely to safeguard their investors and pass the costs along the supply chain to workers and consumers (Huxham et al., 2019).

The reduction of investments in coal is a natural consequence of increasing marginal extraction costs. Risky and resource intensive extraction methods (using water for extraction) can further increase production costs and reduce returns on investments. At the same time, demand-side concerns also influence transition risks. Before scaling up solar or wind capacities, suitable storage and transmission facilities have to be installed. Inadequate adaptation of transmission grid networks to the evolving renewable energy technologies can expose the country to energy supply deficit.

7.2. Just Climate Transitions

Energy transitions will lead to economy-wide transformation, resulting in implicit risk transfers from companies and investors to workers, end-consumers and local governments. Hence, climate transition policies and discourse should actively consider these consequences. A 'just transition' recognises the social risks of displaced jobs and its varied impacts on different communities (McCauley & Heffron, 2018). The preamble to the Paris Agreement also states the need for 'just transition of the workforce and the creation of decent work and quality jobs in accordance with nationally defined development priorities' (UNFCCC, 2016). The EU's Green New Deal conceptualises Just Transition Mechanism (JTM) aimed at ensuring a fair transition towards a climate-neutral economy without leaving anyone behind.

India has a significant coal footprint; it is the third largest coal producer in the world and the eight largest importer. Shifting away from coal-based energy will lead to the closure or restructuring of many associated industries. Over 7 million workers are employed in coal mining (Pai et al., 2020) with many more employed in other related sectors. In India, in 2012, around 3,58,500 people were directly employed in coal mining jobs (MOSPI, 2016). Nearly one million are employed along the entire coal-based energy production chain (Spencer et al., 2018). The coal mining and coal power sectors provide direct revenues to all levels of government and railways and engage in CSR. Coal is also a source of cheap or free fuel for households and industry. The International Labour Organization (ILO) estimates a loss of 6 million jobs globally by 2030 due to climate policies, partly due to increased labour productivity in the coal mining sector (ILO, 2018).

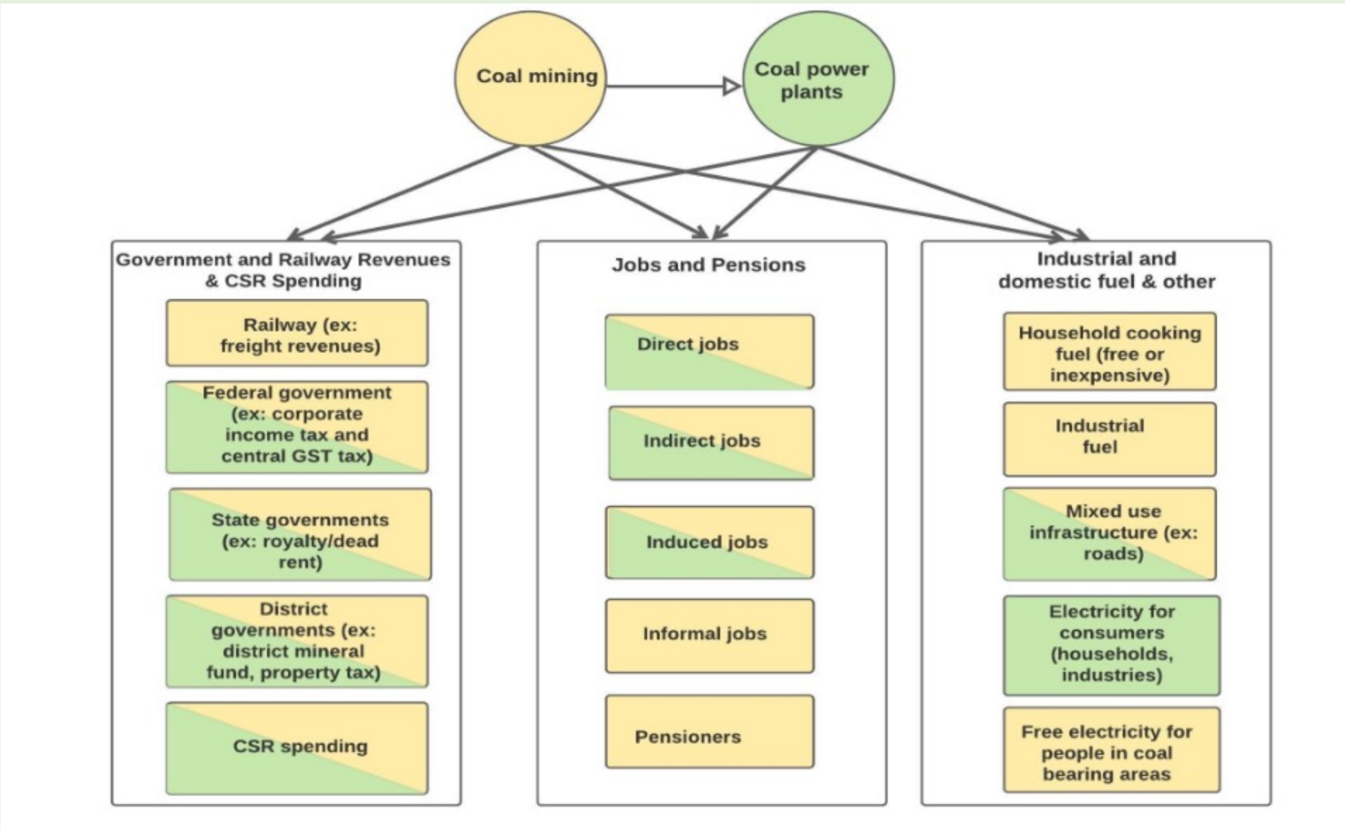
In India, labour productivity of the sector increased by around 6.6 per cent between 2000 and 2014, while employment decreased by 1.8 per cent (Spencer et al., 2018). A just transition is essential considering labour intensity of India's coal-mining sector is higher than the global average.

Box 7.1: Socio-economic dimensions of coal transitions in India

Most studies on coal transitions in India do not examine socio-economic impacts of coal plant closures on workers, their communities and regions. Pai and Zerriffi, (2021) address this gap by examining the scale of socio-economic dependency on coal at the subnational level. India's coal sector is largely controlled by Central and State government-owned enterprises involved in coal mining and coal power generation.

Three government-owned coal mining companies, Coal India Limited (CIL), Singareni Collieries Company Limited (SCCL) and Neyveli Lignite Corporation (NLC) accounted for 93 per cent of the country's total coal production in 2018-2019. The remaining share was produced by a small number of government-owned or private coal producers. Federal government-owned CIL, the largest coal mining company produced around 81 per cent during this period. Indian Railways, another federal-government owned entity, transports nearly 60 per cent of produced coal (Kamboj and Tongia, 2018).

Figure: Socio-economic contribution of coal sector



Note: The colour yellow, below, indicates coal mining's socio-economic contribution; green indicates coal power plants' socio-economic contribution; and half green, half yellow indicates contributions made by both coal mining and coal power plants.

Source: Pai and Zerriffi, 2021

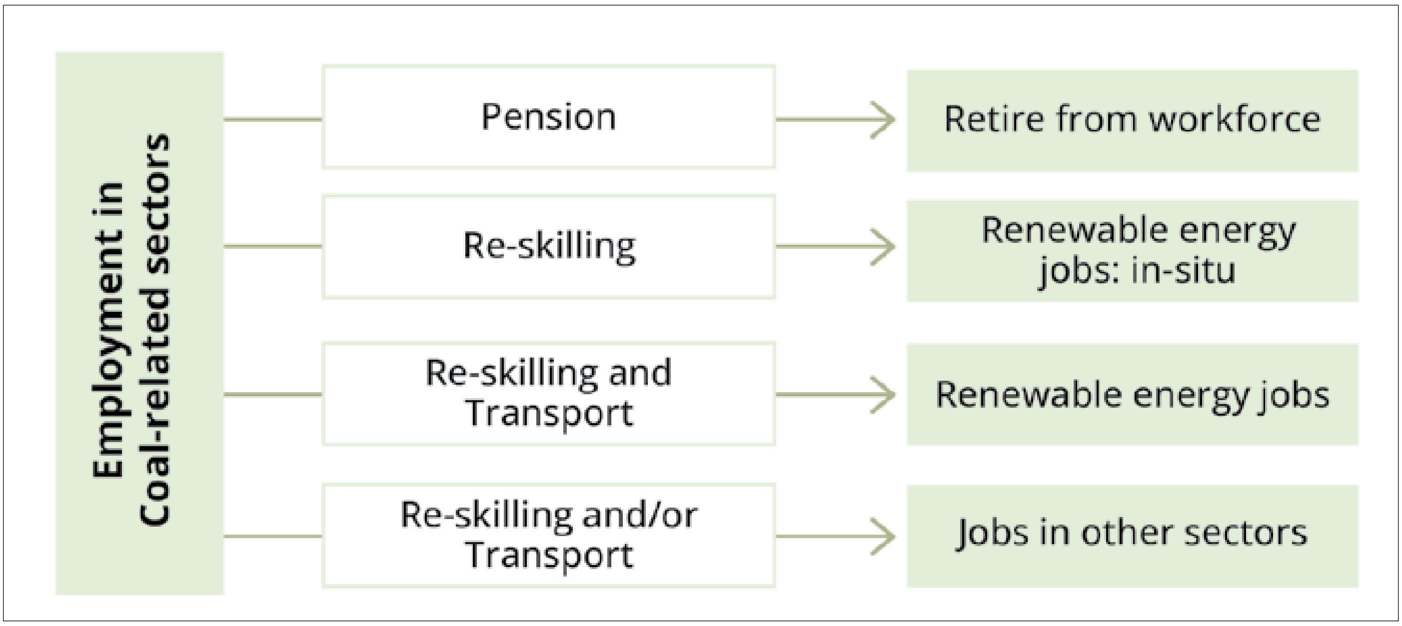
CIL directly employs 2,70,000 people (CIL, 2020) but the number of indirect and induced jobs common in all coal producing regions like contractors, people working in local retail industries are not quantified (Chandra, 2018; Pai and Carr- Wilson, 2018). There is also a large and unquantified informal sector, including extracting or scavenging of coal for domestic fuel or commercial sale.

Besides the numerous jobs tied to the Indian coal industry, there are nearly half a million coal mining industry pensioners, whose pensions depend on the continuity of coal mining. The Coal Mines Provident Fund Organisation (CMPFO, 2020), a government organisation, manages the pension fund by collecting equal contributions from coal mining companies and workers and disbursing pensions to retired workers. Any coal contraction will have consequences for coal industry pensioners (CMPFO, 2020).

Pai and Zerriffi (2021) find 284 districts with some form of coal dependency, including direct and indirect employment in coal mines or power plant jobs, coal pensioners, district revenue contributions, and/or CSR spending. Coal is mined in 51 districts in 13 states with large variations in employment numbers among these districts. These 51 districts have 80 per cent of all coal jobs. While Korba district in Chhattisgarh has the highest coal production, Dhanbad district in Jharkhand has the highest number of coal mining workers. Coal power plants are spread around 140 districts but represent only 20 per cent of all jobs.

Addressing challenges go beyond re-employment to ensuring the labour force has the right skills for the transition. Different phases of renewable energy will require workers with different skill-sets. While it is unsure whether jobs created in the renewable sector can absorb all coal workers, studies suggest that solar power has the most potential for reemploying coal workers after skill adjustment (Louie & Pearce, 2016; European Commission, 2018; IRENA, 2019). It is recommended to convert closed coal mining sites into solar and wind parks to create corresponding jobs but installation and retrofitting of available infrastructure is labour-intensive and provides short-term employment. Figure 7.2 illustrates the possible employment transitions for current coal sector workers, along with required action to reach the end goals.

Figure 7.2: Employment transition



Source: Authors' compilation

Creating local jobs for unemployed workers is crucial as all workers, especially the old and unskilled, cannot migrate for employment (Gore and Hollywood, 2009). Unlike professionals, coal miners generally become unemployed after lay-offs. If existing coal power plants retain workers for re-employment in renewables, duration of unemployment can be minimised. However, suitability of such conversions depends on the natural geographic endowments in each region.

A techno-economic resource suitability study by Pai et al., (2020) found that solar energy has a strong potential to provide jobs in India since 99 per cent of coal mining areas in India are suitable for solar power. Each local coal mining area needs around 1.96 GWe of installed solar power for all the workers to have solar jobs. Employment potential is also relatively high in the liquid biofuel and biomass sector (IRENA, 2019; CEEW, 2019). Distributed renewables like small-scale hydro, rooftop solar and biomass generate maximum employment for every MW of installed capacity. For example, one MW solar rooftop plant can employ 24.71 persons, while hydro and biomass employs 13.84 persons and 16.24 persons respectively (CEEW, 2019).

Neglecting the question of jobs will delay the energy transition as labour unions and coal-related industries' representatives would lobby against transition policies (Vona, 2019; Barca, 2019). Past coal transitions in some European countries show that the scale of impacts of the transition on the local communities and the speed of the withdrawal from coal was not well anticipated. In addition to the utilitarian motives, the feasibility of a transition may depend on it being 'just'.

Unemployment is just one of the socio-economic challenges arising from the transition. JTM aims to also address energy-efficient housing and energy poverty. This is especially relevant in developing countries like India, where universal power provisioning, its affordability and reliability continue to pose serious challenges despite the progress made in the last decade.

Besides this, land acquisition for renewable energy installations poses another challenge in the country. The lack of systematic assessment of the land-use impacts and social resistance against major projects hinders the transition. Transitioning to renewable energy also brings up the issue of spatial justice with vulnerable communities facing threat to livelihoods because of loss of commons (Yenneti et al., 2016). Large-scale solar, hydro and wind energy projects lead to land submergence, biodiversity destruction, human displacement, and human rights issues (Mohan, 2017). Hydropower, which often faces strong resistance, employs nearly 50 per cent of the workers in the energy sector in India (IRENA, 2019).

To avoid compounding problems, the loss of employment and the other social challenges in adopting renewables and ushering power reforms, must be handled simultaneously. Abrupt, unplanned transitions can increase inequality and hinder development (Spencer et al., 2018). The effectiveness of a transition depends on factors like project anticipation, its implementation, and comprehensive long-term impact analysis. In the next two subsections, we look at two case studies that showcase the multidimensionality and complexity of achieving 'just' transition.

The first case study of Pavagada Solar Park (PSP) in Karnataka looks at a new experimental model of land acquisition that aims at linking large-scale renewable power projects with development and equity outcomes. The second case focusses on Mumbai's power reforms through privatisation of supply amidst contesting demands for the right to affordable power from the city's informal settlements.

7.2.1. Pavagada Solar Park: navigating a just transition

The Pavagada Solar Park (PSP) in Karnataka, located in the Pavagada taluka of Tumkur district, spans 53 square kilometres, making it the world's third-largest solar park with an installed power capacity of 2.05 GW and an investment of approximately USD 2.2 billion (Tumkuru District, n.d.). This large-scale RE infrastructure reflects India's ambition to lead the global clean energy transitions, aligning at the state level with economic growth and local area development.

The Pavagada case is significant as it illustrates how policy rules were recoded, incorporating an innovative land mobilisation model to enhance justice outcomes for local communities. Historically, land disputes have plagued RE parks, hydropower projects, and thermal power plants (Singh, 2014; Kamra, 2020; Chari, 2020; Mahanta, 2010). In the context of energy transitions, justice concerns related to infrastructure development emerge from land dispossession, livelihood losses, gendered impacts, disruption of local ecosystems, and conflicts with locals that deter private investor interests.

To address these concerns, Karnataka's nodal agency for RE, Karnataka Renewable Energy Development Ltd. (KREDL), proposed the establishment of a special purpose vehicle, Karnataka Solar Power Development Corporation Ltd. (KSPDCL). KSPDCL acted as a bridge between DISCOMs, local communities, and private power developers to facilitate private investments in the PSP while safeguarding local communities' interests.

Recognising Pavagada's drought-prone status and poor agricultural productivity, the Karnataka government leveraged private capital investment for the solar park to contribute to a Local Area Development (LAD) fund, amounting to about USD 1.65 billion. This fund aimed to foster better justice outcomes through local infrastructure development, such as schools, roads and hospitals along with generating employment at the PSP (MNRE, 2015). An innovative land leasing model, spanning 28 years, was finalised, ensuring farmers retained land ownership while receiving a fixed annual income, thereby minimising land disputes. These justice elements were embedded in the development following consultations with local farmers.

In addition to the leasing policy, substantial policy recalibration was implemented to expedite PSP development. This involved coordinated efforts across various administrative departments, including the KSPDCL, Discoms, the electricity board, revenue office, and local civic bodies. Exempting solar parks from Environmental Impact Assessment (EIA) reduced delays, and the Revenue Department played a pivotal role in reclassifying the entire area from agricultural to commercial/ non-agricultural land (GOK, 2014; MNRE, 2017). Negotiating leasing conditions, ensuring local employment, and overseeing LAD fund utilisation were managed by a LAD committee comprising local administration and the Shakti Sthala Farmers' Welfare Association. This association empowered farmers to voice their concerns and monitored the transparent and efficient use of the LAD funds.

Despite general satisfaction among local communities with the project, PSP also led to certain injustices. For instance, employment opportunities generated were mainly unskilled, including jobs like those of security guards, grass cutters, panel washers. Many women, formerly engaged in agriculture, were left without any means of income. Restricted mobility for women is also a concern due large, fenced spaces that make transport difficult through previous farmlands. While certain natural features like water conservation infrastructure and natural boulders were preserved within the park, levelling of land for installation of panels destroyed natural vegetation, impacting the local ecosystem. Landless farmers and cattle rearers were among the worst affected by the project. They lost their livelihoods without getting adequate compensation in terms of job security or monetary assistance.

The PSP case highlights improvements in justice outcomes over previous energy infrastructure projects but also underscores the need for further exploration of the long-term and macro impacts of such projects. Innovative policy instruments need to align with appropriate institutional safeguards to effectively address energy-justice issues. The lack of comprehensive knowledge about localised institutional safeguards, their underlying principles, and functionality remains a gap in current scholarship and policy.

7.2.2. Balancing power: Mumbai's electricity reforms and contesting justice imaginaries

Mumbai's complex electricity provisioning offers an interesting justice dimension that brings together demand and supply-side dynamics. At the centre of this narrative is a city challenged by the tensions between its ambitions to develop as a global megapolis and the reality of hosting one of the world's largest slum populations (approximately 9 million people). This dual reality adds layers of complexity to the political economy of electricity infrastructure, a domain mediated by diverse institutional actors and a state-mandated regulatory framework. While Mumbai was being reimagined by the State and city authorities as a world-class city, with massive infrastructure upgrades, almost 40 per cent of the city living in informal settlements and slums were struggling for formal access to the electricity grid.

Mumbai's electricity landscape presents a unique mix of state-owned, municipal corporation-owned, and privately-owned distribution utilities, allowing for a multifaceted exploration of institutional work (IW) dynamics. The city's journey towards electricity reforms, initiated in the early 2000s, unfolded in three distinct phases: first, emphasising supply augmentation through privatisation; second, addressing demand side market dynamics through the Electricity Act 2003 and its amendment in 2010, and the parallel licensing arrangement in 2009; and third, a focus on greening the grid post the National Solar Mission in 2010.

The transition toward privatisation, aimed at enhancing competition and efficiency, was not without its controversies. The city's political landscape, historically intertwined with the Brihanmumbai Electric Supply and Transport (BEST), saw vocal opposition to privatisation from the ruling political party at the Municipal Corporation and politically aligned labour unions. Employment and affordable access to power were major justice concerns amid the shifting political focus towards unbundling and privatisation of power distribution.

On the demand side, slum communities and civil service organisations advocated for access to services through collective action. Their focus included formal access to the electricity grid, affordable tariffs, and service reliability. The struggle for electricity in these slum communities often transcends the utility of power as a service, becoming a lever for legal tenancy rights and access to other basic amenities.

The privatisation of Mumbai's electricity sector unfolded gradually, driven by efficiency concerns and a national mandate to increase RE capacity. The Maharashtra Electricity Regulatory Commission (MERC) emerged as the key change agent in the State's vision of reform through privatisation. Tasked with regulating distribution companies (DISCOMs) in the state, MERC plays a crucial role in tariff setting, monitoring Power Purchase Agreements (PPAs), dispute resolution, and consumer protection.

Despite the state positioning privatisation as a solution to inefficiencies, public utilities like BEST and MSDCL contested this narrative through litigation, pushing for tariff revisions. The entry of private players like Tata Power and Adani, following a Supreme Court judgement allowing private licensing in 2009, heightened tensions with existing utilities. This led to prolonged litigation and regulatory interventions, keeping tariff matters sub-judice for an extended period. Notably, private DISCOMs often faced legal challenges from BEST, specifically regarding the selective targeting of high-paying industrial and commercial consumers, shifting the responsibility for equitable power supply distribution onto the municipal corporation owned Discom. Unresolved cases from MERC often escalated to the Appellate Tribunal and the Supreme Court, turning legislation and regulation into pivotal arenas for navigating electricity infrastructure reconfiguration.

At the micro-level, prices and the right to electricity become grounds for contestation and struggle, primarily driven by demand-side actors. This struggle gained momentum due to the exclusionary nature of infrastructure provisioning in Mumbai, which labels slums as problematic and infrastructure disruptions (Graham, 2010). These struggles are manifested as organised bottom-up movements and community funding initiatives on the demand side, leveraging social audit reports, information campaigns, and grassroots initiatives to advocate for equitable access to electricity. At the same time, cyclical politics of slum regularisation also continues as the Municipal Corporation periodically revises cut-off dates, leaving a portion of the population outside the purview of legal electricity connections. Electricity is a crucial electoral agenda, and deprivation often leads to mobilisation of support for the next elections.

The establishment of MERC in 1999, followed by Public-Private Partnership agreements, marked a turning point. This led to changes of land use rules, financial sector regulations, and environmental clearances, reflecting the interlinkages between energy and tenancy rights, identity, water, land, and other infrastructure and justice elements, given the evolving landscape of private participation in the power sector.

The various articulations of energy justice around emerging configurations in the power sector have both material and non-material components. Private sector participation, net-metering, Renewable Energy Certificates (RECs), energy storage solutions, and smart grid technologies are reshaping the energy landscape. In slum electrification, community-led micro-grids, prepaid metering, government subsidies, NGO partnerships, and RE interventions have emerged as transformative elements.

While structural inefficiencies of distribution systems and financial constraints prompted increased private participation and a focus on renewables, Mumbai continues to heavily rely on imported fossil fuels, particularly coal. Overall, Mumbai's electricity provisioning evolves as a complex interplay of multiple actors, institutions, and socio-economic factors. Slum electrification emerges as a microcosm of this contest, as challenges of access, affordability, and reliability of electricity are magnified in these informal urban spaces.

The struggle for legitimate access to the electricity grid is interlinked with multiple justice considerations, including tenancy rights, identity, housing justice and access to other basic amenities. This intricate balance between demand and supply side forces necessitates nuanced solutions, recognising the symbiotic relationship between economic viability and social justice in the city's quest for an electrified future. The role of institutional capacity building and intermediaries (e.g., civil societies) become central to ensuring equitable arrangements in this new public-private regime in the city.

7.3. Transition Risks in India

7.3.1. Stranded assets in India

Over 40 GW of commissioned and under construction coal power capacity in 34 coal power plants is already 'stressed'[35] as of 2018 with USD 25 million in outstanding loans (Standing Committee on Energy, 2018). 16 GW of the 40 GW capacity is still under construction, mostly belonging to independent power producers (HLEC, 2018). The Central Electricity Authority, in June 2018, estimated that stranded assets capacity may be as high as 70 GW (ODI, 2019). Buckley et al., (2019) suggest that the actual amount of stranded assets in India exceeds 40 GW from 34 plants. Additionally, there are 14 GW of gas-fired power plants stranded due to inadequate domestic gas supply and increasing prices of imported gas.

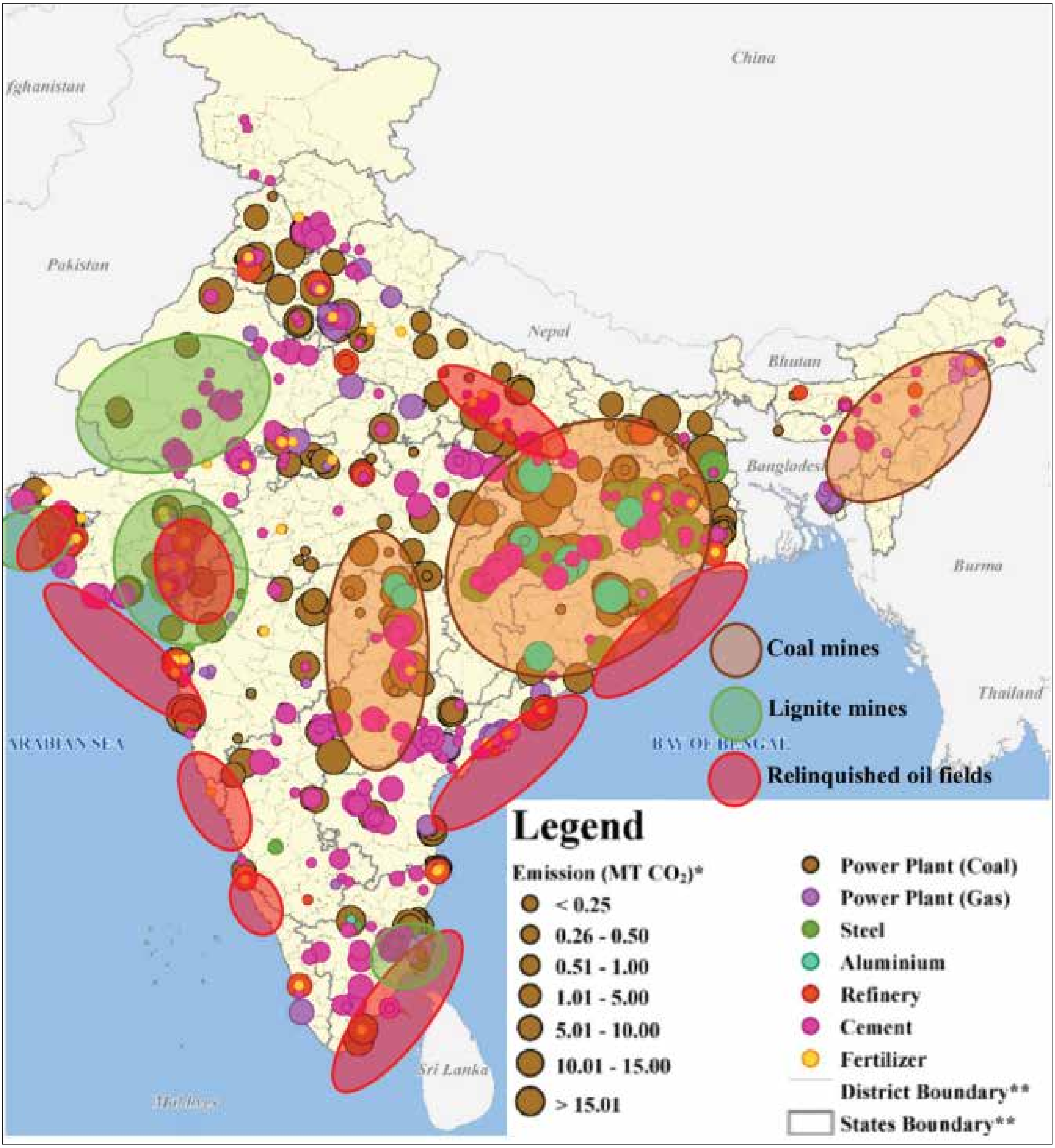
The power plants are stressed due to various reasons including unsteady coal supply necessitating expensive imports, uncertain power sales, regulatory, contractual issues and rising transportation costs due to increased freight charges. Financially stressed DISCOMs delay payments, affecting the project owner's ability to service their debts and acquire fresh equity. The failure of the DISCOMs perpetuates risks for energy generators and investors.

Chhattisgarh, Odisha and Jharkhand have the highest proportion of stressed assets with 58 per cent, 55 per cent and 27 per cent of their total capacity declared as stressed, respectively. Except for one, all of these plants are privately owned (Worrall et al., 2019). Together, these three states account for 22 per cent of all the power plants in India. Coal production is concentrated in certain districts with the most coal mines or plants and dominates the local economy. For example, coal mining in Dhanbad district of Jharkhand drives the district economy, contributing 41 per cent of Jharkhand's state mining sector value-add. Dhanbad's per capita District Domestic Product is 146 per cent higher than Jharkhand's per capita State Domestic Product (Spencer et al., 2018).

Figure 7.3 illustrates that Jharkhand, Odisha and Chhattisgarh are the primary emissions sources from large point sources (LPS). Carbon emissions (Mt CO2) are also concentrated in these regions due to the high number of steel, aluminium and cement production units. Garg et al., (2017) found that the CO_2 emissions from LPS are growing much faster than India's overall CO2 emissions. Since coal mining and carbon-intensive industries are concentrated in the same region, the impacts and opportunities of the transition here are significant. Stranded assets in these regions encompass ongoing investments in coal-based power plants as well as coal-based machinery/technology investments in these industries. Investments in coal specific demand-supply links may also be stranded, if it is limited to coal use. A successful climate transition requires a shift in primary energy sources along with changes in production structures of major industries.

35 As per RBI's definition.

Figure 7.3: Large point source CO2 emissions in India (2020)



Source: Garg et al. (2017)[36]

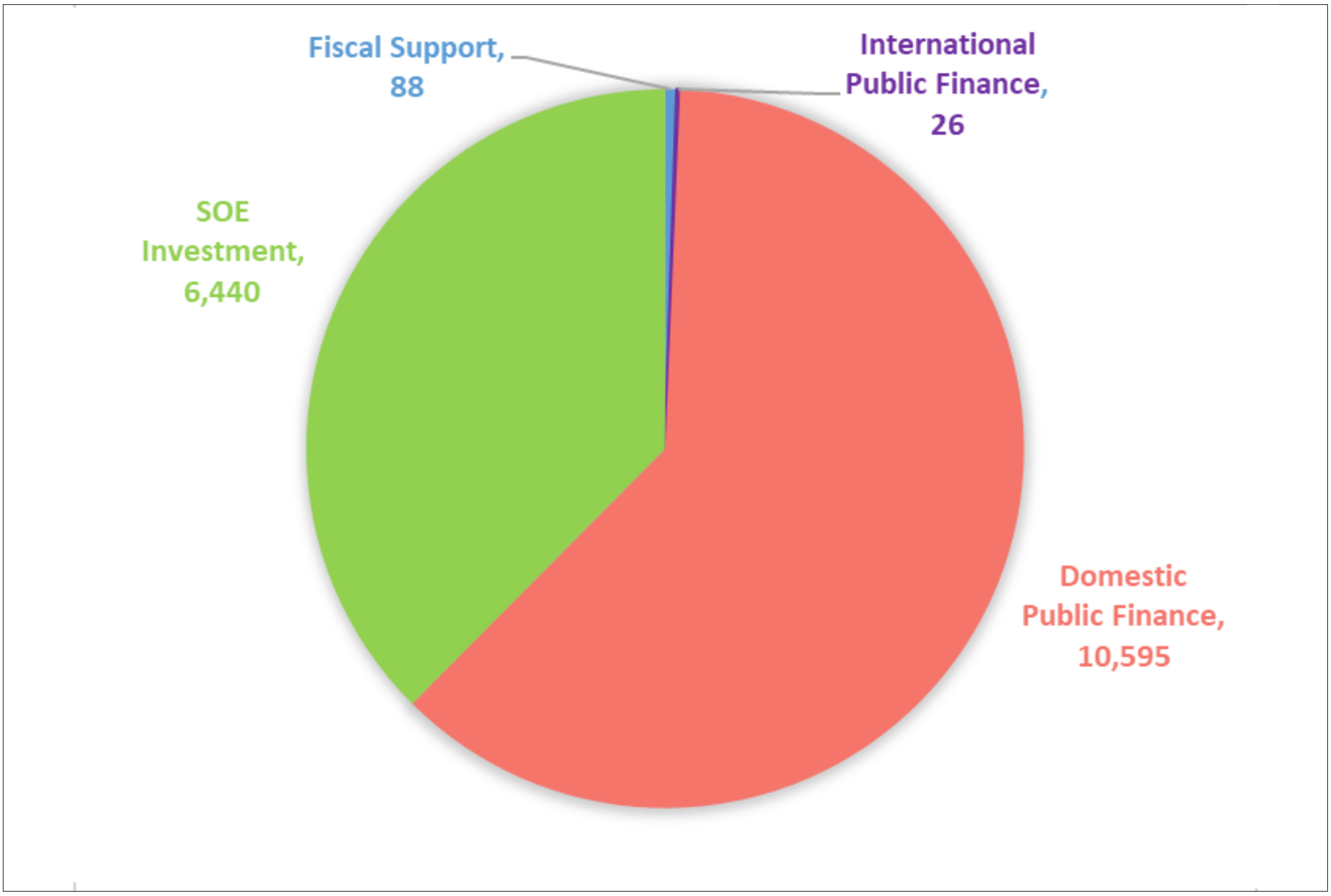
36 CO2 emissions for plants existing in 2013 are extrapolated until 2020 assuming the average plant load factor and specific energy consumption of the last 3 years for respective plants will continue until 2020. Only major sources like coal and lignite mines and oil wells are included.

7.3.2. Creation of potential stranded assets in India

Current global energy investment trends contradict the need to limit global warming to 1.5°C. Investments are still being made in fossil fuel mining and recovery, new fossil fuel electricity and heat generation capacity, long-term fossil fuel transformation infrastructure, and energy intensive end-use sectors, such as housing and transport.

In India coal power generation is still increasing (Malik et al., 2020), which means generation of more stranded assets in the near- or medium-term future, potentially jeopardising the country's financial system. India has 235 GW of power plants under construction, 15 per cent of world's share, and another 338 GW plants under various stages of planning, 17 per cent of world's share. In 2019, the country's banking system provided around USD 10.6 billion annually for domestic coal mining and coal-based power generation, primarily driven by domestic public institutions (ODI, 2019). Buckley (2020) found that more than half of the new capacity additions in 2019-2020 were from equity financed by the National Thermal Power Corporation (NTPC) and debt financing from the government-owned NBFC, Power Finance Corporation (PFC). Apart from NTPC and PFC, some state governments[37] also commissioned additional coal-based electricity generation. Despite the government's efforts to improve their viability, state owned DISCOMs are burdened with huge losses.

Figure 7.4 : Subsidies to coal, by sources in million USD (2016-17 average)



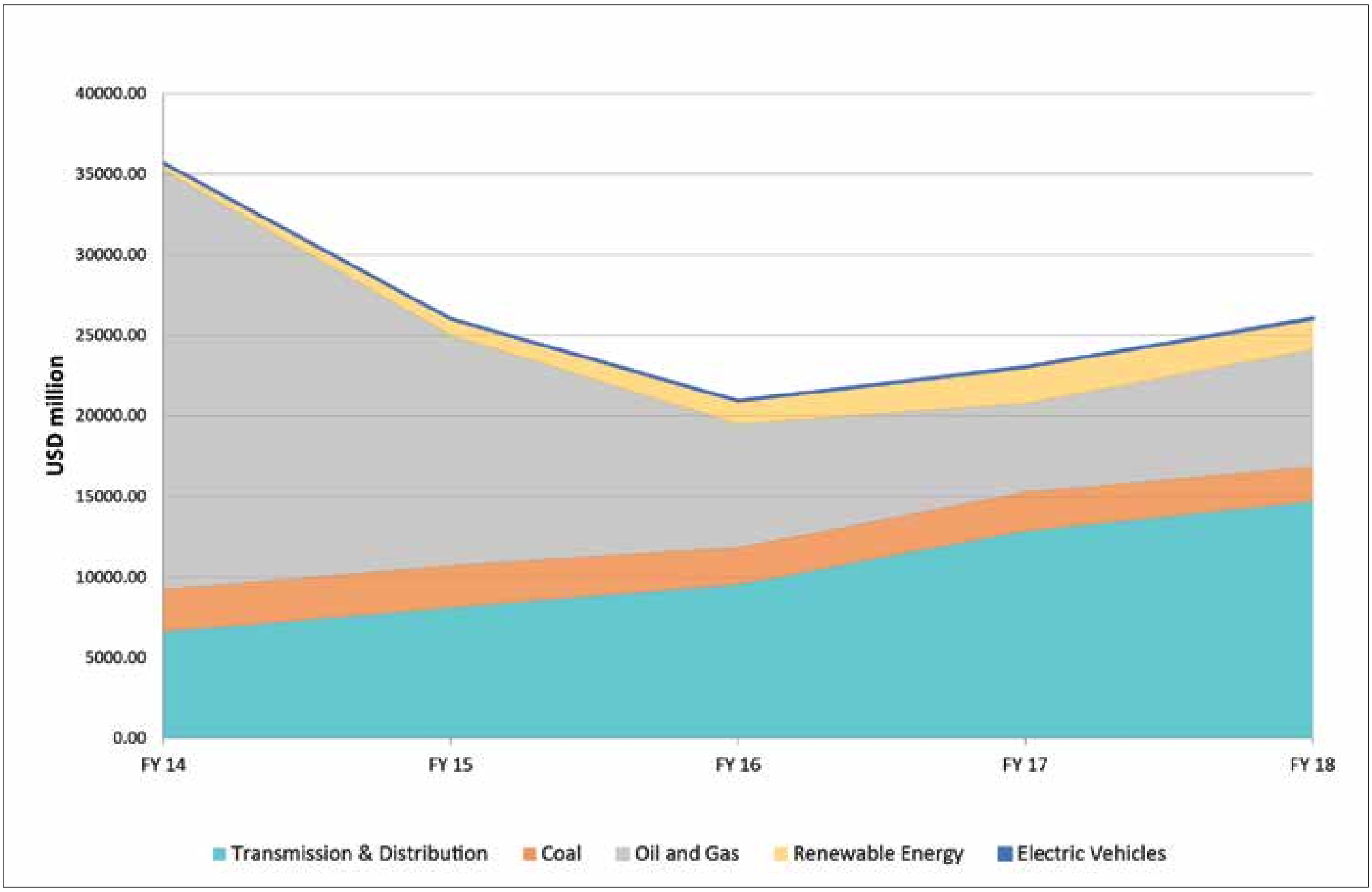
Source: ODI, 2019

37 State governments of Gujarat, Odisha, Rajasthan and Tamil Nadu. The states in total accounted for 20% of the additions to the coal power plant capacity.

Some of the government's interventions are also not in line with India's transition targets. Even though the cost of solar and wind has been reducing consistently (see section 5.5), government interventions continue to support coal. The government's support for coal, as evidenced by subsidies and investments (Table 7.2) hampers proliferation of appropriate market signals, delaying the transition. Current policy signals artificially dampen market signals by providing subsidies, loans at preferential rates and delaying enforcement of policies that would increase costs to producers (Worrall et al., 2019). Perverse fossil fuel subsidies also increase the dependency on imported fuel by creating carbon price distortion. Removal of fossil fuel subsidies could lower emissions by 16 per cent and increase GDP by almost 1 per cent (IMF, 2008).

The stressed and stranded assets pose a growing systemic financial risk for governments and financial institutions, particularly for the public sector that owns most of these assets (ODI, 2019). The government's share in USD 90 billion investments in coal-based power plants between 2006 and 2014 is over 50 per cent (Vishwanathan and Garg, 2020). In 2017, India's bailout for DISCOMs, Ujwal Discom Assurance Yojana (UDAY)[38], was equal to USD 11.8 billion (Soman et al., 2018). State-owned enterprises (SOE) remain active in coal mining and coal-fired power, contributing to over USD 6.4 billion investments annually (ODI, 2019). Many of these coal assets are at the risk of bankruptcy, further impairing the country's financial sector.

Figure 7.5 : Central government subsidies by energy type in USD millions (2014-18)



Source: Soman et al., 2018

38 The Union government launched UDAY in 2015 to turnaround the precarious financial condition of state power distribution companies that had accumulated losses and outstanding debt.

India has made some progress in renewables with increasing support from the government. Fiscal support to renewable energy increased by six times reaching USD 2.2 billion from 2014 to 2017 (Soman et al., 2018).

In 2019- 2020, 2.48 GW of thermal power plants were shut down, an unprecedented move in India (Buckley, 2020). The number of coal plant permits have also decreased with only 3 GW permitted in 2018 against 39 GW in 2010 (ODI, 2019), despite growing energy demand in the country. However, this trend may be due to periodical fluctuations in the capital investments at the sectoral level (ibid). Subsidies to electric vehicles are also growing, but remain relatively small, at USD 22.1 million in 2017 (Soman et al., 2018). The path dependence of the current investments in long-lasting carbon infrastructure limits future adaptability and constraints the transition.

7.3.3. Why is India still invested in coal?

Despite the clear consequences of continuing coal investments, governments have been slow to transition to low-carbon energy sources. The availability of competitive and faster (to install) renewable alternatives raises the question of why governments are still increasing the coal capacity. Renewable alternatives can be built at 30 per cent lower costs and in one-third the duration required to build coal-based power plants (Buckley et al., 2019, 2020).

The government's support for coal is influenced by the macroeconomic implications of this transition including impacts on the poor, jobs and revenue losses. Removing coal subsidies and introducing carbon taxes will increase fuel prices, impacting the poor most, in the absence of adequate safety nets. They (poor) may be forced to sell their assets and forego educational opportunities for children to salvage their livelihoods (Anbumozhi and Kawai, 2015). The low-carbon transition can increase socio-economic inequality in India, which is yet to resolve its poverty and inequality challenges.

Employment in the coal sector has been declining due to increasing labour productivity (CEEW, 2019), with 1,05,000 jobs lost between 2000 and 2015 due to mechanisation. Employment in the DISCOMs has also been decreasing because of privatisation. Decarbonisation in India is further expected to reduce coal-sector's employment by approximately 52 per cent between 2020 and 2050.

Although renewable energy has potential to create five times more jobs in 2050 than the coal-based sector employed in 2020 (CEEW, 2019), there are policy challenges in managing the transition and addressing 're-skilling' of the labour force. Issues like labour mobility, pension and support schemes for early retiring workers, and other logistical difficulties make the transition harder. India also faces the challenge of setting up an ecosystem for skilling and reskilling, and the nascent stage of technology for renewables makes industry specific learning difficult. The regional distribution of the new renewable opportunities also has social or political considerations.

Coal is a significant revenue source for Central and State governments (ODI, 2019). Coal India Limited (CIL)[39] contributed to INR 2.03 lakh crore to the Indian government between 2013 and 2019.

39 CIL, an Indian state-owned coal mining and refining corporation, is the largest coal-producing company in the world and the fifth largest employer in India. CIL ranks 8th among the top 20 firms responsible for a third of all global carbon emissions (Climate Accountability Institute, 2020).

The government also receives revenue from coal mines auctions, with INR 4,972 crore received from auction of 31 mines as of 2019. The energy sector PSUs, in mining and oil and gas exploration, are profitable (IEA, 2020) and rank among the top 10 profit making companies in India. In coal-intensive states like Odisha and Jharkhand, coal royalties make up more than half of total royalties of the states (Chakraborty et al., 2016). Coal plants termination will impact the revenue and development of these states. The transition also impacts coal-associated sectors like pensioners relying on support from coal-based companies (as explained in Box 7.1), and the Indian railway sector heavily dependent on coal transport for nearly 50 per cent of its total freight revenues (Pai and Zerriffi, 2021, Kamboj and Tongia, 2018).

To garner government support for climate aligned transitions, it is crucial to establish robust evidence of co- benefits that address developmental concerns. Vested interests in incumbent electric power systems, issues with DISCOMs, and land rights are also barriers to renewable energy transition. Further, coal continues to be the cheapest energy source in India. Pollution concerns by citizens or other climate change induced events are not yet a primary reason for the transition. Concerns about renewables deployment, increasing energy prices for end-users also deters the government from pacing up the transition. The result is that the government’s support for coal is not reducing as fast as it should.

Box 7.2: Impact of energy transitions on government revenues

Central and State governments rely heavily on the energy sector for their taxation revenues, with Centre's dependency nearly 25 per cent according to an analysis by energy group, Prayas (2021). The majority of this revenue comes from petroleum, natural gas and coal sectors, which contributed about INR 6 lakh crore of the total INR 6.5 lakh crore revenue generated by the energy sector in 2019-20. Prayas' study that analysed five states shows that the energy sector's contribution to the total tax revenues in the selected states varies from 10 per cent in Assam to about 17 per cent in Maharashtra (see Table below) highlighting states' reliance on the energy sector for revenues and variations across the states. Taxes and duties on electricity also contribute a significant portion of the total energy-sector tax revenue, ranging from about 3.2 per cent in Tamil Nadu to as high as 26 per cent in Maharashtra. The states cover a geographical mix of fossil fuel rich, renewable rich, relatively rich and poor states.

In some states like Chhattisgarh and Jharkhand, the non-tax revenues from the energy sector are also high due to royalties from coal. In Chhattisgarh, royalties amounted to about INR 3,450 crores in 2018-19 . In Jharkhand also royalties revenue and dividends exceeds the energy tax collection.

Table: Share of energy in the overall revenue of select states in 2018-19

Share of coal, petroleum, gas and electricity taxes in	All States and UTs	Assam	Chhattisgarh	Maharashtra	Rajasthan	Tamil Nadu
Tax revenue	13.2%	10.4%	13.7%	16.8%	14.5%	13.8%
Non-Tax revenue	4.7%	0.1%	12.5%	2.8%	0%	1%
Total revenue receipts	11%	5.1%	13.2%	14%	10.2%	11%

Source: Prayas (Energy Group), 2021

The electricity sector is likely to undergo a transformation faster than the other parts of the energy sector, implying a substantially reduced coal usage. This will impact the tax revenues of the Centre (about 4 per cent), and royalty earnings of coal-bearing states. In the transport sector, the big change would come from the gradually reduced use of petroleum products that contribute more than 80 per cent of the energy sector tax revenues to both the Centre and states. This will lead to a major shortfall in tax revenues. While publicly owned coal companies like CIL and NTPC have made explicit business diversification plans by pledging investments in renewable energy, solar wafer manufacturing and aluminium smelting (Pai and Zerriffi, 2021), it is unclear how the state governments are responding to this potential fiscal constraint.

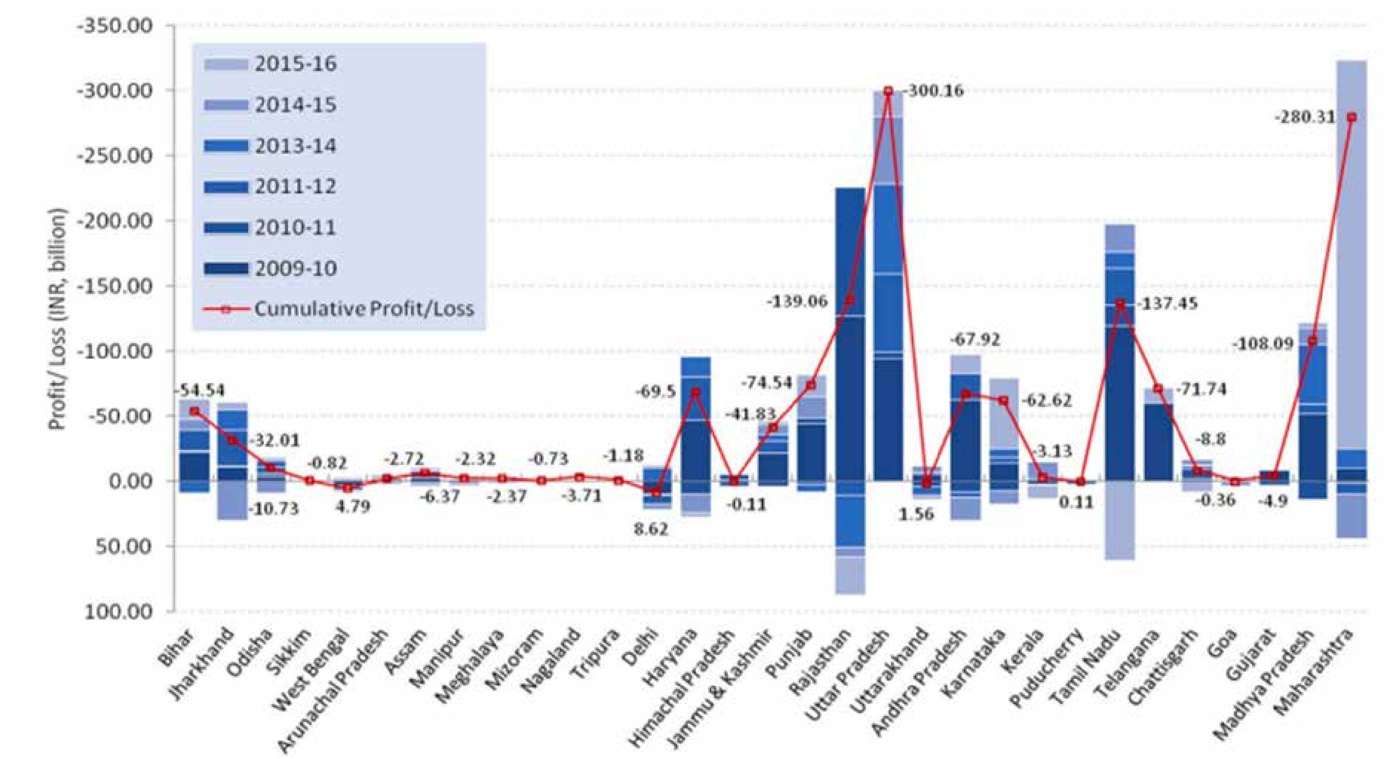
7.3.4. DISCOMs financial challenges and clean energy transition

India faces the complex task of decarbonising its energy sector while simultaneously grappling with the 20th century challenges of inefficient distribution systems. These inefficiencies revolve around access, affordability, and reliability that affect about 45 million Indian households[AR1] , which still receive less than 12 hours of electricity daily.

A significant hurdle in meeting energy demands is the precarious financial state of power distribution utilities (DISCOMs), leading to electricity supply inefficiencies. High aggregate technical and commercial (AT&C[AR2]) losses, attributed to obsolete infrastructure and pilferage, and the widening gap between revenues and supply, exacerbate the financial strain on DISCOMs (Verma et al., 2020). The long-term financial viability of DISCOMs poses serious challenges to India's low-carbon transition. Given their state of finances, DISCOMs remain underinvested in improving and upgrading power distribution and pose barriers to scaling of renewable energy infrastructure. This section summarises the financial challenges faced by DISCOMs, thereby limiting the scope of India's low-carbon transition.

While cutting down AT&C losses and resolving the debt burden of distribution companies has been an important element in India's electricity reform agenda, results so far have been unsatisfactory. An analysis of financial performance of state and UT Discoms from 2009-10 to 2015-16, shows that 27 out of 31 states and UTs were incurring high financial losses (see Figure 7.6).

Figure 7.6 : Year-wise cumulative profits/losses (without subsidies) of State DISCOMs

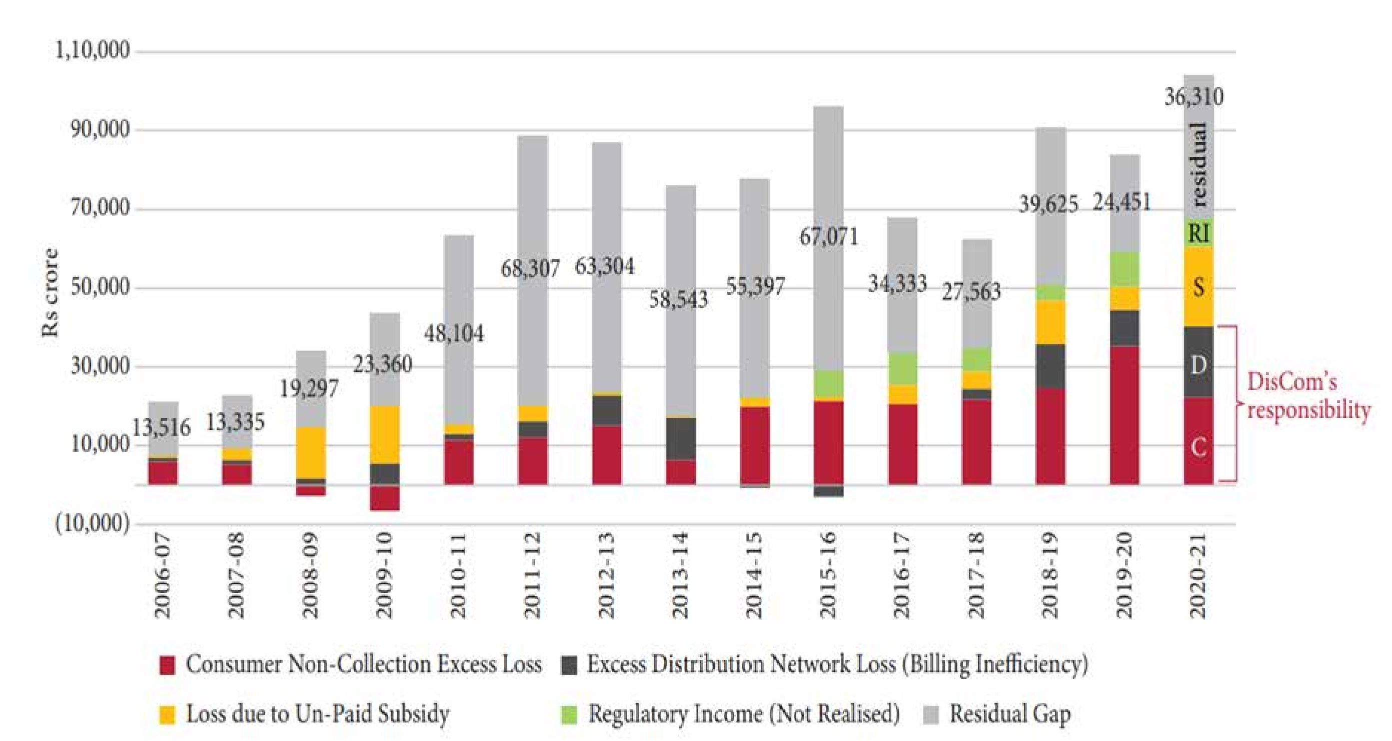


Source: PFC Report 2012,2014, 2016

Despite a long history of distribution sector reforms focussed on unbundling State Electricity Boards (SEBs) including corporatisation of distribution, transmission and generation, setting up of autonomous regulatory commissions, fostering competition, aligning costs with tariffs, the distribution sector remains the weakest link in India's power sector (Swain, 2016). The gap between average cost of power and average revenue realisation continues to widen every year, leading to accumulated debts and regulator assets of Discoms (ibid).

The Ministry of Power (MoP) has initiated several schemes, including UDAY in 2015, to enable financial turnaround and operational efficiency for DISCOMs. UDAY was specifically designed to reduce AT&C losses from 21 per cent in 2015 to 15 per cent in 2019. Despite its objectives, AT&C losses were reduced to only 18 per cent across 21 participating states. The Revamped Distribution Sector Scheme (RDSS), launched in 2021 with an outlay of INR 3.04 lakh crores over 5 years, targets a reduction in AT&C losses to 12-15 per cent and aims to eliminate the costs and revenue gap by FY 2024-25. While provisional figures for FY 2022-23 indicate a reduction to 15.4 per cent (PIB, 2023), the pan-India average remains 20.8 per cent (MoP, GoI, 2023). There continue to be serious concerns regarding long-term financial sustainability of the DISCOMs in the long run, despite such schemes (Patyal et al., 2023). Achieving long-term financial viability will require the DISCOMs to adopt effective commercial principles, especially at the operational level to run their businesses.

Figure 7.7 Annual operating gap (costs-revenues) of DISCOMs



Source: Devaguptapu & Tongia, 2023

Analysing DISCOMs cumulative losses from 2006 to 2021, Figure 7.7 (above) identifies four main components: unrealised regulatory income, loss due to billing inefficiencies, non-collection from consumers, and nonpayment of subsidies. Devaguptapu & Tongia (2023) note that non-performance of DISCOMs, in terms of billing and collection inefficiencies, account for only 30 per cent of the cumulative losses, while subsidy non-payment and regulatory asset creation contribute to 13 per cent of the losses. Yet, these components do not explain the 59 per cent residual gap in cumulative losses.

The residual gap points to an inadequacy in the current tariff structure, as it fails to cover costs sufficiently, even after considering various contributing factors. The reasons for this inadequacy remain inconclusive but factors like DISCOMs submitting insufficient tariff requests including during the true-up (reconciliation) process, facing regulatory denials, or encountering underlying procedural issues are important to consider. Additional factors, such as the two-year delay in true-up processes, contribute to a pipeline problem, leading to carrying costs for these companies. However, assigning primary responsibility for the residual gap solely to DISCOMs would be inaccurate (Devaguptapu & Tongia, 2023).

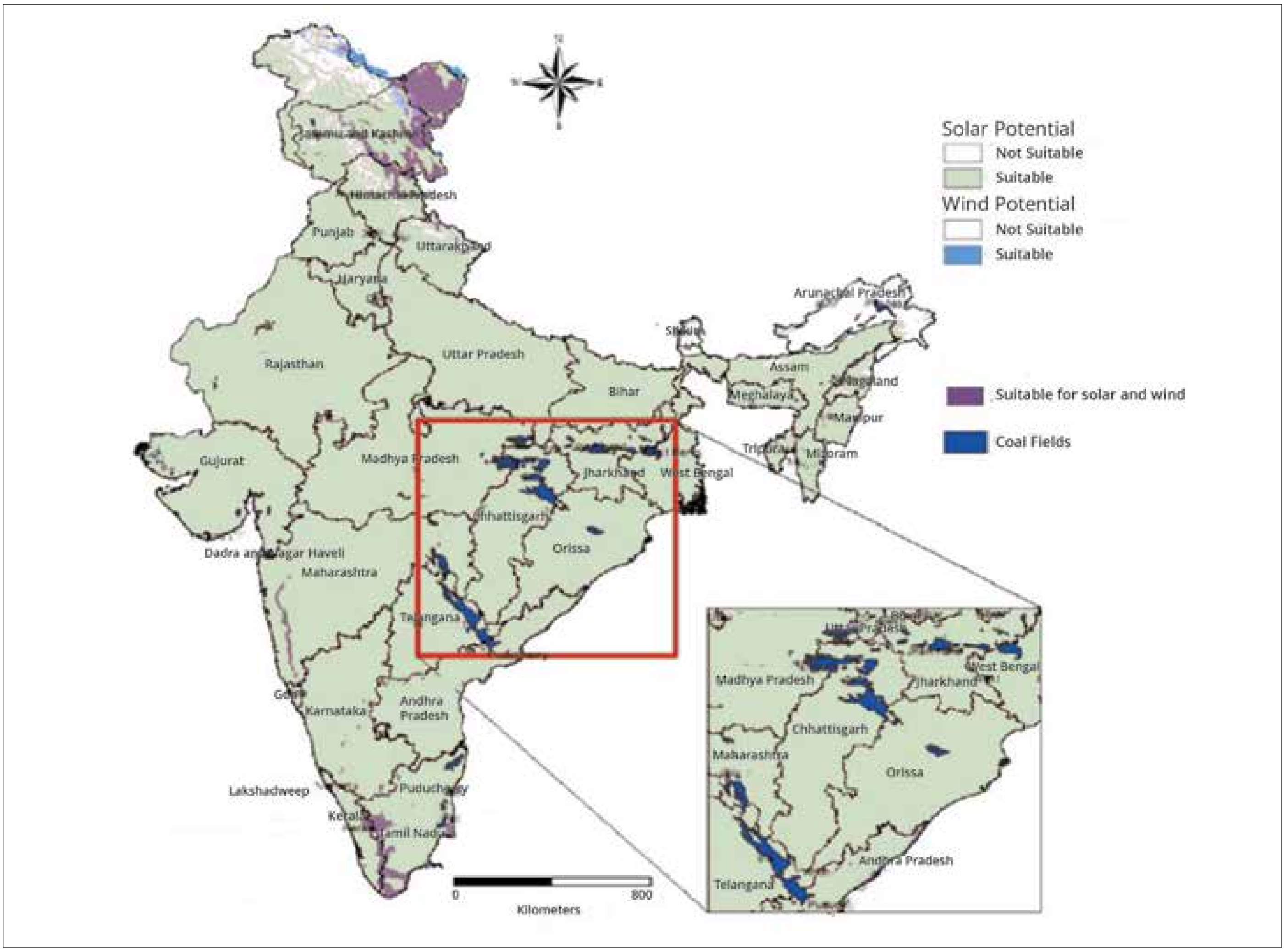
Examining the challenges in India's electricity distribution, especially for DISCOMs, reveals that financial revitalization alone isn't enough for sustained efficiency. Despite UDAY and RDSS efforts to curb AT&C losses and address the cost-revenue disparity, commercial principles pose a critical concern. The disconnect between input energy and revenue realisation at the field level underscores the need for enhancing commercial accountability. The current centralised approach to commercial accountability, primarily centered in corporate offices, leaves operational departments without a direct incentive structure for revenue generation. Achieving long-term financial viability demands a fundamental shift in DISCOM operations. Emphasising demand-side reforms can establish a balanced system, aligning between supply efficiency with consumer responsibility for sustainable electricity distribution in India.

7.4. Scope for a Just Transition in India

Estimating the impact of the transition on direct and induced unemployment is vital to framing policies to absorb the workers into other sectors. It is also important to estimate potential employment opportunities in different renewable alternatives, along with the regional distribution of these new jobs. Skilling and reskilling the new workforce is the most challenging aspect of the employment transition (CEEW, 2019). For instance, successful transition of coal miners to solar jobs is possible, if solar capacity in India increases by 37 times of its current capacity (Pai et al., 2020). Deploying resources and technology at this scale requires enormous support from governments and financial institutions.

Figure 7.8. shows the spatial distribution of the suitability of solar and wind energy, revealing that most coal fields have potential to get converted into solar power plants. Reskilling labour will also open up opportunities in other sectors. But, governments and stakeholders need to encourage human development in relevant fields. A study on solar jobs in India found that workers employed in the sector were contractual, and rarely provided with social security. New employment opportunities have to be long-term with real benefits to the workers (Jairaj et al., 2017). Comprehensive economic planning is essential to facilitate smooth transition and avoid economic upheavals in coal dependent regions or sectors.

Figure 7.8: Map of solar and wind potential, and coalfields in India



Source: Pai et al., 2020[40]

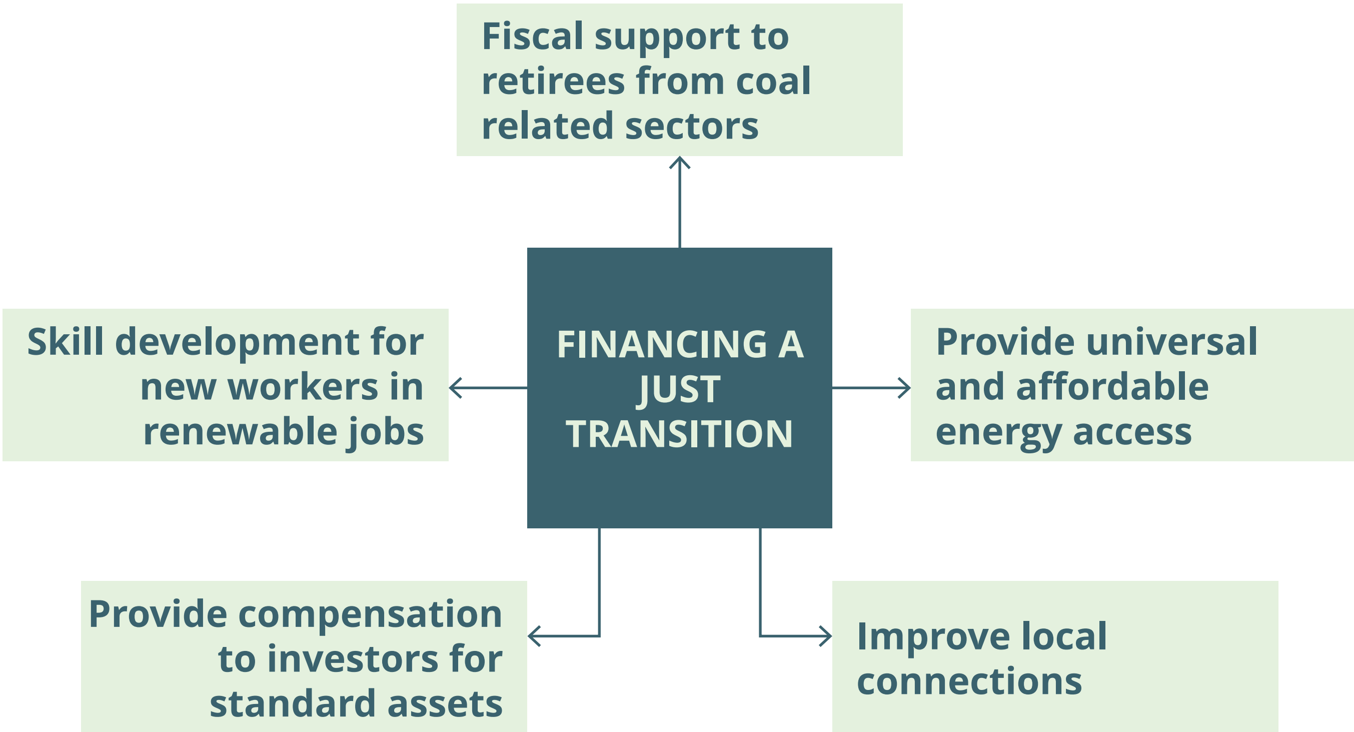
Around 120 districts, with about 25 per cent of the country's population, are heavily fossil fuel-dependent (Bhushan and Banerjee, 2021). Sixty of these 120 districts need to be zeroed in as they account for 95 per cent of coal and lignite production, 60 per cent of thermal power capacity and 90 per cent of automobile manufacturing. An employment transition is feasible as renewable energy offers more jobs than the coal sectors. In 2017, there was a 5.3 per cent increase in the number of jobs in the renewable energy sector worldwide, surpassing jobs in coal-intensive sectors, with 60 per cent of these jobs in Asia (IRENA, 2018).

This indicates great potential for India. Investments in sustainable transport systems are also essential to a just transition as re-employment may require different commuting patterns or migration for some. Figure 7.7 shows the various components to consider for financing a just transition in India.

Transition risks are expected to accumulate gradually till the mid-2020s, after which they will accelerate (Huxham et al., 2019). The government must allocate funds to compensate for stranded assets, proactively. Fossil fuel subsidy reform is vital even though it faces barriers like the subsidies that improve energy access for the poor. Direct cash or in-kind transfers can be targeted to help poor households instead of wholesale energy subsidies, which are relatively regressive (Bridle et al., 2019).

40 The blue points represent locations of coalfields in India. The map shows areas suitable for only solar power, only wind power, and both solar and wind power.

Figure 7.9: Components of financing a just transition



Source: Authors' compilation

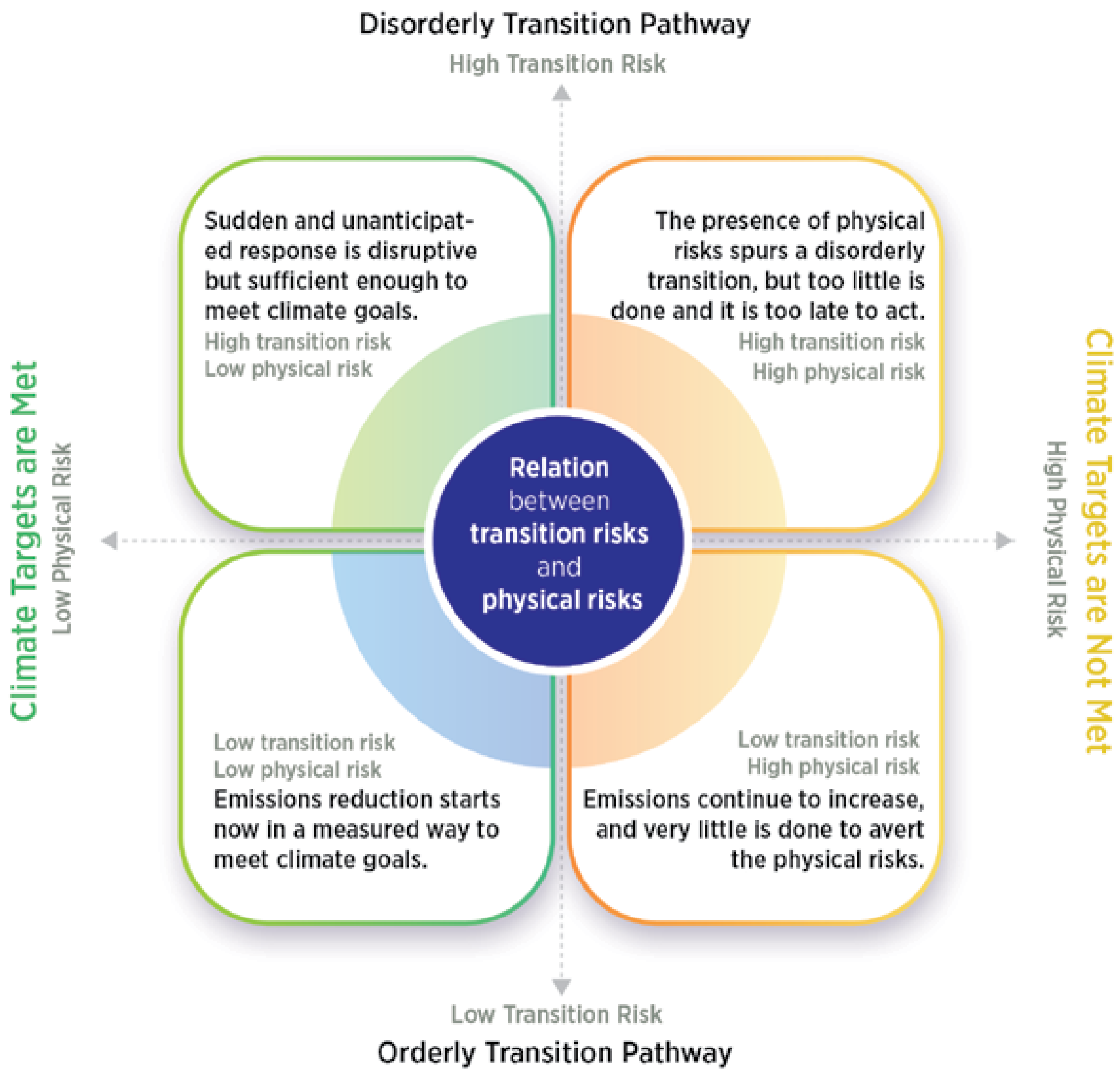
To increase finances for a just energy transition, the Central Bank and government policies need to attract private capital. Europe's InvestEU Programme is a good example of a financial vehicle that provides long-term funding to both public and private investors. At least 30 per cent of the InvestEU Programme is for financing investments that contribute to the EU's climate goals. And, 60 per cent of the investments under its 'Sustainable Infrastructure Window'[41] are supposed to contribute to the EU's climate and environmental objectives. By leveraging an EU budget guarantee that backs the investment of implementing partners like the European Investment Bank (EIB) Group, InvestEU improves its risk-bearing capacity. India needs similar dedicated funds to enable a smooth energy transition. Indicative blueprint or plans by the government of how socio-economic impact of the transition will be managed will help the private sector to firm up its investments. Budgetary allocations also need to be increased to (i) enable the energy transition and (ii) ensure that this transition is 'just'.

41 Sustainable Infrastructure window is one of the four policy windows across which the EU budget guarantee is distributed.

7.5. Issues to be Addressed

Even without explicit climate policies, the fossil fuels market may collapse, leading to stranded assets. To minimise the negative impacts, governments and Central Banks need to design timely policies (Battiston et al, 2017) as a delayed transition can lead to carbon lock-ins, and ecological, social, and long-term economic risks. Conversely, an abrupt transition can also lead to short-term economic, legal and political risks. A well-planned transition requires sufficient stakeholder engagement and agreement on implementation, potentially running over two decades. Rapidly closing power plants and fuel production assets without adequate replacement can limit the government's ability to spend on social programmes and have negative impacts on the workers and linked communities. Therefore, dialogue, coordination among governments, businesses, companies and labour unions is essential to arrive at consensus. While gradualism is suggested, it is important to note there is also a risk of being too late. Policy uncertainty around climate action weakens incentives for low-carbon technologies and leads to suboptimal choices (IEA, 2017). Climate policy uncertainty leads to a value of waiting, which could lead to a 5 to 10 per cent rise in electricity prices and a preference for investing in low capital-cost options.

Figure 7.10: Matrix of relation between transition risks and physical risks



Source: Climate-Related Market Risk Subcommittee, 2020

While considering transitional assistance policies, it is important to consider who gets the assistance and what kind of assistance should be given (Bos and Gupta, 2019). Governmental action for those left with stranded assets includes, full compensation, partial compensation (like grandfathering, phasing-out), or no relief for losses (for in- stance, focusing on phasing-in). Discussions with stakeholders are necessary to understand which compensation path is feasible for India as transition policies that are not inclusive can exacerbate developmental issues.

7.6. Conclusions

- India's energy transition is leading to the stranding of carbon-intensive assets, which can result in future revenue losses and depressed asset valuations.

- About USD 90 billion was invested in coal-based power plants over 2006-2014, with 50 per cent via public investment. Over 40 GW in 34 coal power plants that are concentrated in the public sector were classified as 'stressed' in 2018.

- The government's short-run support for coal is a barrier to, and will delay, the energy transition by dampening market signals on the cost-effectiveness of renewable energy.

- The precarious financial state of power distribution companies in India poses serious challenges to India's low-carbon transition. Financial revitalisation through schemes to cut AT&C losses and address cost-revenue disparity may not be enough unless commercial accountability issues get addressed.

- A just energy transition in India will have to address social risks of stranded jobs, its differential impact on communities, the cost of adaptation, building up resilience and making up for loss and damages. JTM in India needs to address various socio-economic challenges, including unemployment and energy poverty.

- India's energy transition risks could be hedged if both Central and State governments follow an orderly, coordinated set of policies with low uncertainty. Financial sector risks can be addressed if financial stakeholders internalise climate risks into their decision-making to limit further carbon lock-ins and stranded assets.

8.

ADAPTATION FINANCE

8. ADAPTATION FINANCE

Given India's high current vulnerability to extreme weather, adaptation is a top priority for the country (MoF, 2020). As climate change intensifies, India's adaptation costs will also increase. Department of Economic Affairs' (DEA) report (2020) has estimated India's cumulative climate adapting expenditure at INR 85.6 trillion, by 2030. Yet, while the commitment towards adaptation-related development spending has increased in domestic budgets, it is close to an order of magnitude less than what is needed. International finance flows to developing countries for adaptation are also limited, with the UNEP (2023) estimating flows to be ten to eighteen times less than required. On the whole, adaptation finance flows globally are also abysmally low, with adaptation finance only 7 per cent of the total climate finance in 2019-2020, (Buchner et.al, 2021) .

This is also because traditional financing for adaptation poses several challenges. Adaptation has primarily relied on public expenditure, as challenges of attribution and complex multidimensional risk profile, tends to crowd out private investment. The local and context-specific nature of adaptation clashes with limited local administrative and financial autonomy and the ability to deliver budgeted expenditure. Enabling low-cost finance for adaptation becomes difficult as financial resources are prioritised for mitigation. Further, conceptualising and tracking adaptation finance is more complicated than mitigation finance due to its close linkages with development.

Despite these challenges, India will have to significantly increase adaptation finance to reduce the climate vulnerability and exposure of its citizens. This will require and expansion of national and state budgets on climate adaptation and crowding in of private investment in resilience building and vulnerability reduction, where feasible and effective.

8.1. Issues in Financing Adaptation

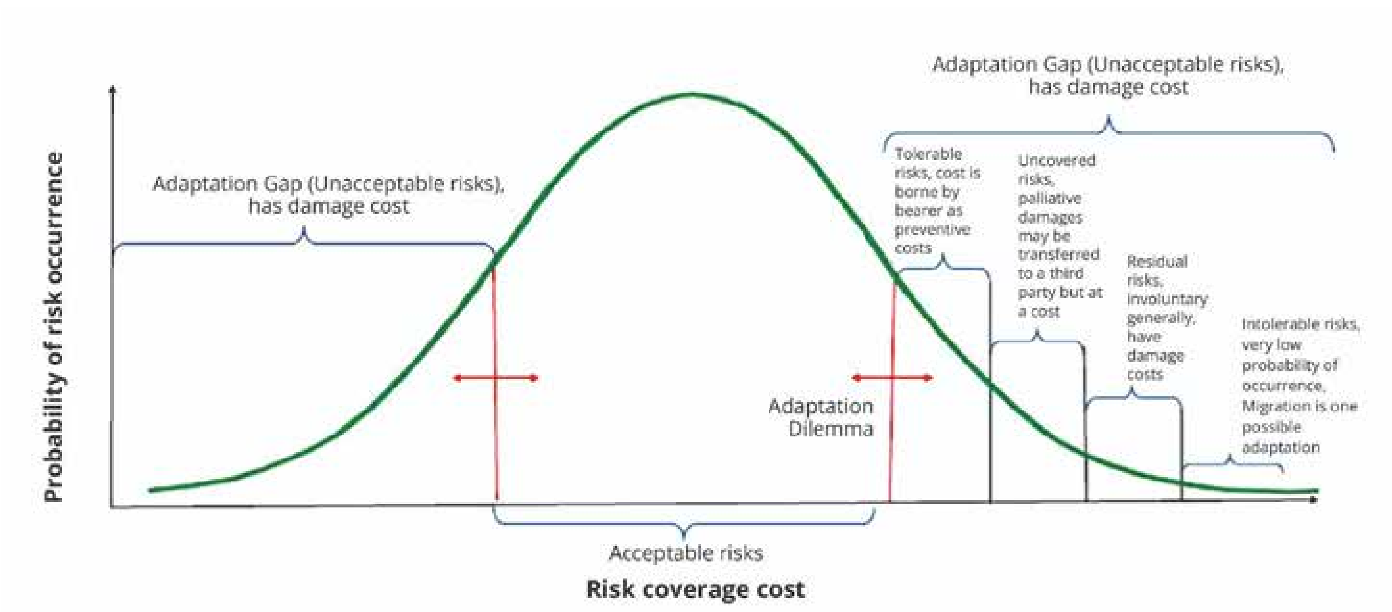
Adaptation finance is complex, involving multi-dimensional adaptive responses across system transitions (IPCC, 2022: IPCC, 2023) along with public infrastructure investment, technology development and human development (Chambwera et al., 2014). Changes in norms, regulations and individual behaviour are critical enabling conditions for adaptation.

Understanding the relation between adaptation and mitigation becomes important because their effective implementation requires coordinated funding. Adaptation needs are actions to avoid negative climate change impact and future risks (IPCC, 2014). Climate mitigation reduces adaptation needs, while delays in mitigation action increase unavoidable impacts (IPCC, 2014; Garg et al., 2015). The gap between adaptation needs and adaptation actions leads to 'unavoidable or residual impact', which could lead to losses and damages. Even with timely mitigation, adaptation actions are necessary due to the time lag between future emission reduction and current impacts (Garg et al., 2015). Hence, striking a dynamic balance between mitigation and adaptation is essential.

An adaptation gap represents the difference between implemented adaptation and societal goals, determined by competing priorities, resource limitations and tolerated impacts (UNEP, 2014). It gives rise to an 'adaptation dilemma' regarding acceptable risk levels and who bears the burden. The most vulnerable communities currently are exposed to climate impacts without choice (Garg et al., 2015). Figure 8.1 depicts this dilemma, through a risk lens. Excessive adaptation and over estimation of risks can lead to unnecessary investment and defensible expenditure. However, setting tolerable risk levels is challenging, and projected high levels of risk tolerance often result in under adaptation.

Systematic assessments for adaptation in India are limited, making it difficult to appraise investment needs, especially due to their close alignment with development. Standalone investments solely dedicated to adaptation are rare (Allan et al., 2019). This is because many sustainable developmental actions often act as adaptation actions by improving adaptive capacity and reducing vulnerability. The dynamic interaction between adaptation and development further adds to the complexity in assessments. Developing countries like India have to meet their national SDG targets by 2030, but resource limitations and competing priorities impose real constraints. The changing climate dynamically interacts with these goals, potentially impacting them positively and negatively.

Figure 8.1 : Risks and costs associated with adaptation gap



Source : Garg et al., 2015

Mission	Main Targets pertaining to adaptation
National Mission for Sustainable Agriculture (NMSA)	Enhances food security by making agriculture more productive, sustainable, remunerative and climate resilient
National Water Mission (NWM)	• Focuses on monitoring of groundwater, aquifer mapping, water quality monitoring and capacity building • Focuses attention on overexploited areas • Promotes basin-level integrated water resources management
National Mission on Sustainable Habitat (NMSH)	Develops sustainable habitat standards
National Mission on Strategic Knowledge for Climate Change (NMSKCC)	• Focuses on the Himalayan ecosystem and helps to formulate appropriate policies. • Sets up climate change centres in the existing institutions in Himalayan States

8.2. Adaptation Finance Flows

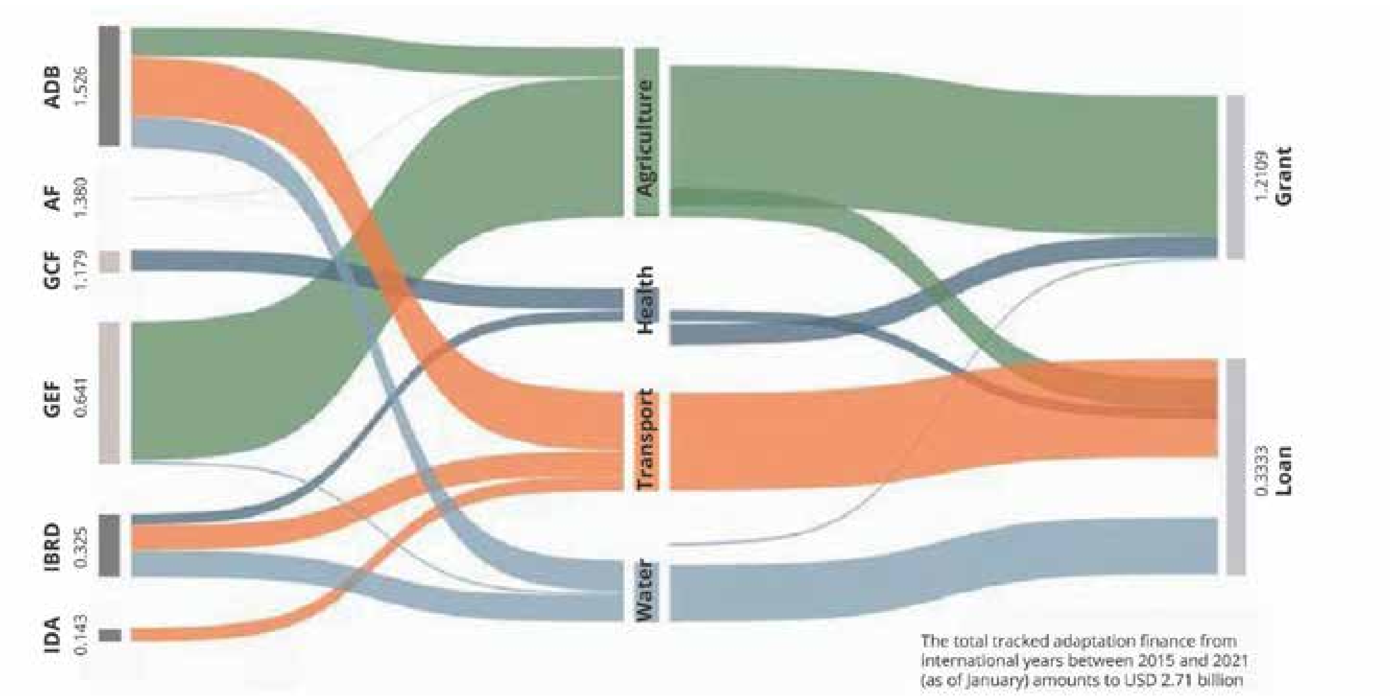
8.2.1. International finance flows

International climate finance available to India remains skewed towards mitigation rather than adaptation, with a prevalence of concessional loans over grants. Additionally, much of this finance needs backing by domestic public co-financing.

International climate adaptation finance to India, is completely overshadowed by the domestic mobilisation of adaptation finance (CPI, 2019; GCF, 2021). Typical financing pathways include multilateral development banks, bilateral and regional flows, and UNFCCC funds.

From 2015 to 2020, around 40 adaptation-focussed projects worth USD 2.7 billion were identified in India. Only a quarter of the projects were funded by UNFCCC, including GEF, GCF, and the Adaptation Fund. Multilateral agencies financed about 30 projects, with ADB being the most prominent. Many projects involved co-financing from the Government of India, state governments or other domestic sources (MoEFCC, 2021). The situation is similar for UNFCCC funded projects, with domestic mobilisation of USD 1.4 billion nearly 8.3 times higher than the grants provided by GEF and GCF.

Figure 8.2: Landscape of adaptation finance from international sources (2015–21)



Source: Based on data from MoEFCC, 2021

In terms of the funding structure, grants and loans are roughly equal, with a preference for loans. Agriculture, including natural resource management and rural development, received the highest share of climate adaptation funds, between 2015 and 2020, primarily through grants. Projects largely focussed on climate-smart actions, climate-proofing agriculture and livelihoods, and sustainable coastal protection. Transport, water management, and water-related infrastructure also received a large share of the investments, primarily as loans.

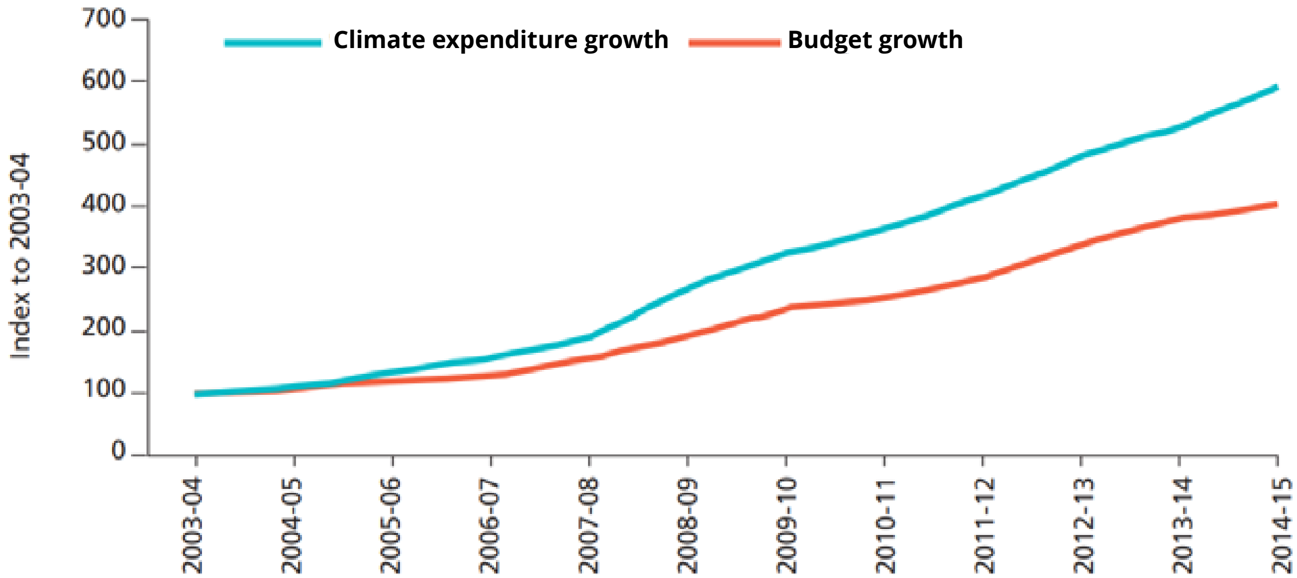
Compared to multilateral support, the increase in bilateral development finance was lower between 2013 and 2017 (UNEP, 2020). Bilateral development assistance is often influenced by donor's interests (Govindarajulu, 2015). In the Indian context, various bilateral agencies including GIZ, USAID, FCDO, International Fund for Agriculture Development (IFAD), Canada AID, SDC, and Japan Bank for International Cooperation (JBIC) have supported adaptation and environment management activities.

8.2.2. Domestic finance flows

Indian government budgets attempt to address development and adaptation in an integrated manner, instead of standalone adaptation investments (Allan et al., 2019). Domestic budgets are the primary source of funds for adaptation in India (Allan et al., 2019 ; MoF, 2020). The MoEFCC (2015) estimated adaptation spending at 1.45 per cent of GDP in 2000-01, while Ganguly and Panda (2009) estimated it at 1.7 per cent of GDP in 2006-07. Garg et al. (2015) analysed the annual budgets of thirty key governmental ministries and estimated spending on adaptation of INR 2,130 billion in 2014-15, which was 12 per cent of the annual budget and about 2 per cent of GDP

Development and adaptation-related outlays increased faster, by a factor of five, than overall annual budgetary outlays (Figure 8.3). Rural development, agriculture, consumer affairs and food and public distribution were key ministries contributing to joined-up development and adaptation expenditure.

Figure 8.3: Allocation to development activities that enhance adaptive capacity



Source: Kumar, 2018. Based on data from Garg et al., 2015

Yet, directed funding for adaptation outside development expenditure has declined in recent years. The NAFCC funds climate actions beyond development spending and had an allocation of INR 4,707 million till March 2020 (MoEFCC, 2021). Thirty projects worth INR 8,475 million have been approved and are being implemented in 26 states across key sectors. NAFCC that has played a critical role in funding for climate adaptation in India, received no budgetary allocation in 2023-24. As of 2013-14, international funding for adaptation in India was only about a third of the funds allocated under NAFCC (Garg et al., 2015).

The NAFCC provides Central grants to support state governments in implementing adaptation projects under the State Action Plans for Climate Change (SAPCC). These align with the NAPCC's agenda and address state-specific adaptation needs and priorities. Figure 8.4 shows that NAFCC funds have not grown significantly, with a decline post-2020-21.

In 2021-22, the actual spend on NAFCC was INR 590 million, which reduced to INR 340 million in the revised estimates of 2022- 23 and was nil in 2023-24 (MoEFCC, 2023). Besides NAFCC, SAPCCs and the National Mission on Himalayan Studies got no allocations in 2022-23.

The MoEFCC (the nodal ministry through which funds for adaptation are routed) received a total budgetary outlay of INR 30 billion (USD 360 million), a 24 per cent increase over the revised estimates of 2022-23 (PRS, 2023).

Other recent adaptation-linked schemes include the Mangrove Initiative for Shoreline Habitats and Tangible Incomes (MISTHI) aimed at safeguarding and rejuvenating mangrove habitats., which will be funded by pooling of funds from sources like MNREGA and CAMPA. The 18 per cent reduction in MNREGA, can be expected to have an impact on adaptation under drought proofing, water and conservation actions (Mookherjee, 2023). Government budgetary allocations for infrastructure and housing have increased through flagship Central Schemes like PMAY, AMRUT, SBM, and Smart Cities. These could help reduce vulnerability, if they were focussed on resilient buildings and infrastructure, which is still unclear. Technically, as discussed below, these schemes can be considered under the NMSH, which does not have independent funding.

Box 8.2: National Action Plan for Climate Change (NAPCC) Financing

The goals, allocation, and expenditures of some of the adaptation-oriented missions set up under the NAPCC.

Table: Expenditures under different adaptation-oriented missions (2011-17) in INR crore

Year	NWM		NMSA		NMSHE & NMSKCC	
	Budget estimate	Actual expenditure	Total allocation	Actual expenditure	Total allocation	Actual expenditure
2011-12	-	-	-	-	7.8	8
2012-13	0	0	-	-	19	19
2013-14	110	0.7	-	-	9	9
2014-15	40	1	1,343	1,355	24	24
2015-16	20	7	2,316	2,121	35	16
2016-17	25	5	3,158	2,604	55	44
2017 (till July)	15	-	-	-	51	17

Source: MoEFCC, 2018b

National Mission for Sustainable Agriculture (NMSA)

The NMSA was allocated INR 13,650 crore between 2012 and 2017 (CBGA, 2019) with a focus on agriculture research and crop improvement. Sub-missions under the NMSA address specific needs like Rainfed Area Development (RAD) and Agroforestry (SMAF). Between 2014 and 2017, targeted interventions like distribution of Soil Health Cards (SHCs) and Paramparagat Krishi Vikas Yojana (PKVY) were approved under the Soil Health Management (SHM) component of NMSA. The SHM allocation increased from INR 700 crore to INR 1,570 crore in 5 years.

National Mission on Sustainable Habitat (NMSH)

NMSH is implemented through the flagship programmes (Centrally-Sponsored Schemes) of MoHUA:

- Atal Mission on Rejuvenation and Urban Transformation (AMRUT) develops urban infrastructure including water supply, sewerage, sanitation, storm water drains, urban transport in 500 cities and towns. AMRUT Phase I (2015-20) had approved outlay of INR 77,640 crore (both Centre and state contribution). AMRUT Phase II (2021-25) has an outlay of INR 2.29 lakh crore and designed to provide universal water supply through functional taps in all 500 towns, besides improving water cycle management.

- Swachh Bharat Mission (SBM) seeks to make India open defecation free by building toilets, eradicating manual scavenging and achieving scientific management of municipal solid waste. SBM-U Phase I (2021- 25) had an allocation of INR 62,000 crores, which was increased to INR 1.41 lakh crore in Phase II.

- Smart Cities Mission (SCM) seeks to provide infrastructure, clean and sustainable environment through smart solutions in 100 cities. Various projects like flood mitigation, riverfront promenades, redesign of streets, smart grid and metering etc have been undertaken under SCM. About three-fourth of 7,800 SCM projects worth INR 1.8 lakh crores were completed by March 2023.

National Water Mission (NWM)

NWM has initiated action to prepare State Specific Action Plans (SSAP) for the water sector covering irrigation, agriculture, domestic water supply, industrial water supply and waste water utilisation for all states. NMSHE & NMSKCC Financing

The National Mission for Sustaining the Himalayan Eco-system (NMSHE) and National Mission on Strategic Knowledge for Climate Change (NMSKCC) are implemented by the Department of Science and Technology, (DST) as part of the Climate Change Programme (CCP). Between 2011 and 2014, 100 per cent of the funds allocated were utilised but the utilisation rate reduced to 45 per cent in 2015-16 and 79 per cent in 2016-17.

8.3. Assessing Adaptation Progress

Assessing the effectiveness of adaptation finance requires evaluating its outcomes. Yet, there is a dearth of universally agreed metrics for this (UNEP, 2020). However, the concept of 'Adaptation progress', can be examined in two ways. First, progress is measured against outputs of the adaptation process. Second, by evaluating adaptation impacts against reduced current and future climate risks. (UNEP, 2017).

Adaptation finance in India, is not formally tracked, making it difficult to assess adaptation output or impact. The following section tracks adaptation progress, via a 2018 Parliamentary Committee review on the progress of the NAPCC missions and an analysis of the outcomes of the World Bank funded 'Sustainable Livelihoods and Adaptation to Climate Change (SLACC)' project.

The Parliamentary Committee reviewed progress in enhancing the adaptive capacities of vulnerable sectors and populations through the NAPCC missions. The NAFCC allocated INR 118 crores for projects in 2015-16 and INR 94 crores in 2016-17, Out of the allocated INR 350 crores for NAFCC over 2015-17 only INR 212 crores (61 per cent) had been released. The Committee also recognised lack of seriousness in implementing some of these missions

NMSA made progress in increasing the resilience of agricultural systems to climate variability. This includes the National Innovations on Climate Resilient Agriculture (NICRA) and the crop insurance scheme called Pradhan Mantri Fasal Bima Yojana (PMFBY). NICRA was initiated by the Indian Council for Agricultural Research (ICAR) in 2011 to develop technological and other options to improve the resilience and adaptive capacity of farming and related sectors. NICRA partners with several agricultural research institutions, state agricultural universities, KVKs and NGOs and conducts technology demonstrations on flood/drought tolerant varieties of crops, and seed banks. The project has been implemented in 151 districts involving over one lakh farm families across the country. While NICRA has implemented pilots across the country, there is a need to scale it up to address the adaptation deficit caused by poverty and vulnerability.

The PMFBY, introduced in 2016, is an area-based insurance scheme that determines insurance payouts for yield lost due to natural calamities based on crop-cutting experiments. The PMFBY has improved on other schemes by removing premium caps and leveraging modern technology. However, the scheme has faced issues such as delay in crop-cutting , delayed or non-payment of insurance claims to farmers and lack of transparency, as noted by the Parliamentary Committee. Its big shortcoming is that it does not make farming more remunerative.

Box 8.3: Adaptation Progress

Despite action plans and some successful pilots, climate adaptation in critical climate hotspots in India like cities, drylands, and coastal areas is largely inadequate, as presented below

Cities

By 2031, around 600 million or 43 per cent of the country's population will live in urban areas (Revi et al., 2020). Urban areas in India face several challenges including inadequate access to affordable housing and green space, lower access to basic services, increasing per-user costs of public service, traffic congestion, air pollution. Increasing poverty and inequality, inadequate infrastructure and services, and population growth, contribute to increasing climate change vulnerability.

An evaluation of urban resilience in six cities of India (IIHS, 2018) shows most cities have prepared Disaster Management (DM) plans but city-level Hazard Risk Vulnerability Assessments (HRVAs) are available only for a few. There are also several gaps in emergency preparedness and institutional capacity. The cities were also found to focus largely on post-disaster relief and management rather than building resilience. The infrastructure expenditure of urban local bodies (ULBs) was not risk-targeted or focused on resilience building. An assessment of climate change adaptation action in 53 Indian cities also showed that urban adaptation is largely project-based and reactive, without incorporating long-term climate risks (Singh et al., 2021). The study found that only about half the cities reported adaptation actions with 67 per cent of these plans are in their implementation phase.

Coastal areas

Adaptation projects in coastal areas have aimed to provide climate resilient livelihoods like the NAFCC project in Kaipad and Pokkali coastal wetlands of Kerala, targeting about 250 coastal households. Project interventions include improving infrastructure to withstand the rise in sea level, tidal surges, and adapting agriculture to increasing salinity of the soil. Adaptive practices like planting tall varieties of salt-tolerant paddy and integrating fisheries with shrimp species are being introduced for sustainable aquaculture and enhancing overall productivity.

Another adaptation project in Gulf of Mannar in Tamil Nadu that faces extreme climate stress is focussed on restoration of seagrass and coral, artificial reef deployment and eco-development activities. After completion, the project is likely to provide 6,900 fishermen in 23 villages with climate resilient livelihoods and ecosystems. The Gujarat government has undertaken mangrove restoration along the coast of the Gulf of Kutch with similar efforts being made in the Sunderbans, in West Bengal to protect communities against storm surge and cyclones. These restoration projects have also been criticised for lack of suitability analysis, high incidence of mortality of saplings, poor site selection, and poor technical skills (Thivakaran, 2017).

Drylands

More than half of India's cultivated area is in drylands, contributing about 44 per cent of the total food production (Vijayan, 2016). The Central Research Institute for Dryland Agriculture (CRIDA) that works on agriculture in low rainfall regions has framed District Agriculture Contingency Plans (DACPs) for all districts to address major weather-extremes like drought, heat waves, cold waves, untimely rainfall, frost, hailstorms, pest and disease outbreaks.

So far, 614 district plans are completed out of 651 targeted rural districts. To ensure real-time use of these plans, interface meetings are organised with State government line departments before each cropping season. Noteworthy outcomes include increased food grain production in Madhya Pradesh despite deficit rainfall and yield loss prevention in Gujarat with only 80 per cent of usual rainfall (Srinivasrao, 2018). Maharashtra successfully implemented in-situ water conservation measures, micro irrigation technologies and high density planting of drought-resistant cotton (ibid).

The World Bank-funded 'Sustainable Livelihoods and Adaptation to Climate Change (SLACC)' aimed to enhance the adaptive capacity of rural poor engaged in farm-based livelihoods. Implemented by the Ministry of Rural Development from 2014 to 2019, it received USD 11 million from the World Bank. An extension to the NRLM, SLACC sought to bridge the gap in assessing climate change risks and build long-term resilience. It focussed on capacity building of community resource persons in climate adaptation and pilot-tested climate resilience to livelihood support activities of the NRLM in two well- performing states, Bihar and Madhya Pradesh. This was done by improving service provision, monitoring adaptation interventions, supporting community-based planning and technical support.

Independent evaluations found that SLACC improved the adaptive capacity of the rural poor engaged in farm livelihoods to cope with climate variability and change (World Bank, 2020). The program utilised digital applications to deliver periodic weather alerts and weather-adjusted farming practices, empowering women farmers and triggering behavioural changes to adopt climate resilient practices. However, sustaining these practices beyond the project duration proved to be challenging. The project also missed out non-farm livelihood adaptation measures, particularly for the many landless farmers. The success of the project relied on hiring educated and motivated professionals, as they could form relationships of trust with the farmers. While the evaluations noted significant achievements in meeting targets, it also pointed to the difficulty of defining and measuring farmers' climate resilience. Standardising and measuring resilience would enhance future project monitoring and evaluation.

Overall, improvements in adaptive capacity have been made, but progress has been slow, fragmented and difficult to assess. Small-scale effective projects are often not scaled up to maximise benefits, with preference for incremental activities over transformational ones (Prasad and Sud, 2018).

Box 8.4: Maladaptation

Maladaptation refers to adaptation interventions that inadvertently increase vulnerability to climate change and diminishes welfare (IPCC, 2014). Spatially and temporally, actions taken to reduce vulnerability in one system, sector or social group may increase vulnerability elsewhere (Barnett & O'Neill, 2013). Maladaptive responses can increase emissions, reduce incentives to adapt, create path dependencies, or improve adaptive capacity of one group at the expense of others. Actions are also considered maladaptive if their costs outweigh alternative options. Identifying maladaptation can be tricky, but certain strategies have been identified as risky in the literature. Urbanisation of flood-prone areas can increase vulnerability, while poor urban land-use planning can expose disadvantaged communities to environmental hazards. Maladaptation is often observed in agriculture and water sectors, such as over-abstraction of groundwater incentivised by subsidised electricity.

The case study of flood embankments in the Ghaghara river (Singh, 2020), tributary of the Ganges illustrates the consequences of maladaptation. The construction of embankments to regulate water flow and aid irrigation led to river course shifts and frequent floods in Uttar Pradesh, with floods displacing communities and forcing them to move inwards or migrate to cities. The National Disaster Management Authority of India notes that more than 7 million hectares are affected by floods annually in India. The annual flood damage between 1953 to 2018 was estimated at INR 5694 crores (NITI Aayog, 2021). The costs incurred in building embankments are compounded by flood damages and need for additional investments to avoid further damages.

It is crucial that governments recognise and avoid maladaptation but there is limited clarity and established metrics differentiating effective adaptation versus maladaptation. Some frameworks suggest actions aiming to increase adaptive capacity have the lowest risk, those reducing sensitivity carry a medium risk while actions aiming to reduce exposure carry the greatest risk to be maladaptive (Barnett and O'Neill, 2013).

8.4. India's Adaptation Finance Needs

India's NDCs have lower investment estimates for climate adaptation than mitigation. India's UNFCCC NDC submission (INDC, 2015) estimated an adaptation investment of USD 206 billion (at 2014-2015 prices) over 2015-30. This includes adaptation actions in key sectors like agriculture, forestry, infrastructure, water systems and ecosystems. This however, does not include funds for disaster management and resilience that may overlap with imputed Losses & Damage.The Asian Development Bank estimated an annual investment of 0.48 per cent of GDP to implement adaptation actions in India (ADB, 2014). Garg et al., (2015) estimated India's climate adaptation needs for over USD 1 trillion over 2015-30 for. The successful implementation of NAPCC, required USD 58 billion, over 2012-17, while SAPCC implementation across all Indian states required about USD 120 billion, over the same period. Table 8.1 shows SAPCC budgetary requirements compiled from a few states, with average annual expenditures requirements ranging from 0.013 per cent to 0.606 per cent of GSDP.

Table 8.1: Budget requirements of SAPCC from key states (2014-19)

State	Timelines mentioned in SAPCC	SAPCC Budget Requirement (INR crores)	Average Annual Expenditure (% of GSDP2015)
Gujarat	2014-19	24,775	0.5 %
Mizoram	2012-17	3,675	4.9 %
Odisha	2010-15	17,000	1 %
Punjab	2012-17	58,796	3 %
	2017-22	64,731	3.3 %
Tamil Nadu	2012-17	4,04,455	6.9 %
Uttar Pradesh	2014-18	46,946	1 %
Uttarakhand	2014-19	8,833	0.1 %

Source: Kumar, 2018

India's adaptation goal is closely linked to its development agenda. India's NDC aims to improve climate adaptation by investing in development sectors that are vulnerable to climate change and in alignment with SDGs on ending poverty, improving livelihoods, sustainable cities and universal access to basic services like water and sanitation and health.

The Department of Economic Affairs, GoI estimates cumulative costs of climate adaptation financing for the country to be INR 28.9 trillion (USD 349 billion) and INR 85.6 trillion (roughly USD 1 trillion) in 2020 and 2030 respectively (DEA,2020). The report pegs cumulative financing requirements for adaptation, forestry and energy to meet India's NDC goals to be about INR 119 trillion (roughly USD 1.3 trillion) in 2030. With cumulative finance availability of INR 29 trillion (USD 349 billion), the report states the financing gap for climate action for these sectors is INR 90 trillion (USD 1 trillion) in 2030.

The report highlights that India should prioritise adaptation with greater domestic investment than mitigation. In practice, this may be difficult to execute as there is limited State fiscal capacity to deliver on the SDGs. This implies that as a strategy of mainstreaming adaptation in State budgets, will be a serious challenge in fiscally strapped States. There is also an assumption that public expenditure would enable the leveraging of market and private financial resources for adaptation, which has structural constraints. There is currently limited use of debt as a financing instrument in India but its use is largely pegged to the ability of climate-resilient infrastructure to limit losses and contribute to economic growth.

Mainstreaming adaptation into development can reduce the fiscal burden on governments. Schmidt-Traub and Shah (2015) note that incremental investment for adaptation is sometimes expressed as percentage 'mark ups' of SDG investments. They proposed incremental investment of around 10 per cent of the total SDGs investments, roughly equal to USD2013128 to 133 billion for climate change adaptation and mitigation. In India, an estimated USD 9.4 to 9.8 billion is needed each year for SDGs and climate action, of which USD 1 billion is for synergistic activities addressing climate change (Schmidt-Traub and Shah, 2015)

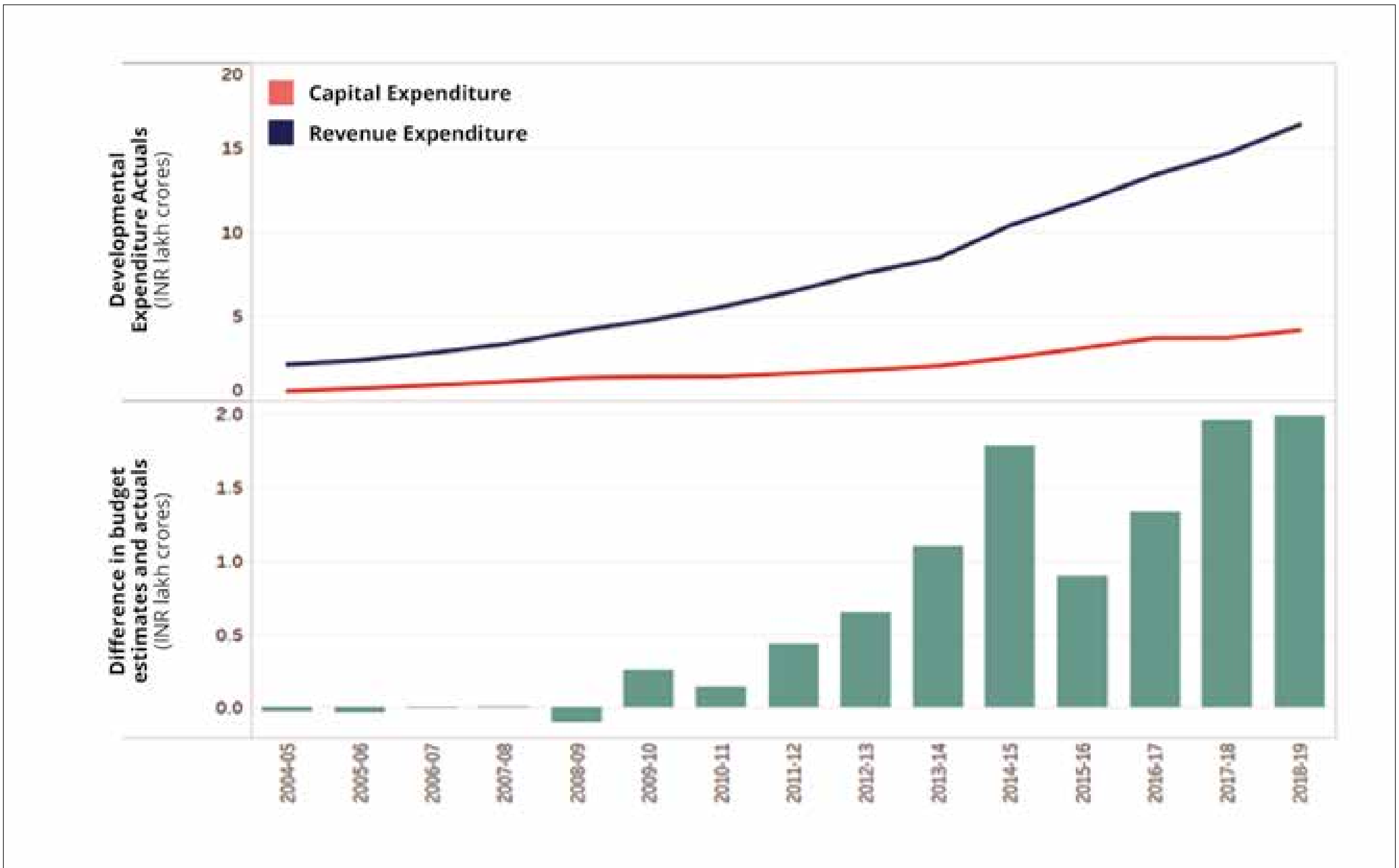
8.4.1. Adaptation finance gap

The Adaptation Finance Gap (AFG) is the difference between the amount of money needed for climate change adaptation and the actual or planned spending on adaptation (Resch et al., 2017). It can be expressed as a monetary value, or as a percentage of GDP. Estimating this gap is challenging due to the lack of robust estimates for projected climate impacts and the effectiveness of adaptation expenditure. Even though the adaptation gap is difficult to estimate, it is clear that current efforts are insufficient given the growing impact of climate change (UNEP, 2020). While international attention to adaptation financing is increasing, Indian public investment and private finance flows do not reflect these trends (UNEP, 2023).

A constraint to the reduction in the AFG for India is the current constrained fiscal position of State governments to undertake adaptation investments in addition to development and capital formation in resilient buildings and infrastructure and economic activity. An analysis of State budgets in 2020 showed that the fiscal deficit was high despite most of the budgets being presented before the onset of COVID-19 and there would be revisions to it considering the ramifications of the pandemic (RBI, 2020).

RBI analysis shows that post-pandemic State budgets, reported a mean fiscal deficit of 4.6 per cent of GSDP compared to 2.4 per cent before the pandemic. Many States are also increasing their borrowing as other sources of revenue are drying up. Capital spending by States has reduced from 2017 to 2020, affecting infrastructure development and service provisioning and increasing the vulnerability of the marginalised. In addition, actual expenditure is falling short of budgeted expenditure.

Figure 8.4: Trend in revenue and capital expenditure in India (2004–18 in INR lakh crores)



Source : RBI, 2020

8.4.2. Closing the global adaptation finance gap

The recent UNEP report (2023) estimates mean adaptation finance needs for all developing countries at USD 387 billion per year (range of USD 101- 975 billion) for 2021–30, based on data extrapolated from national NDCs, This works out to an estimated 1 per cent of these countries GDP (with a range of 0.25 to 2.50 per cent). The adaptation finance needs as an equivalent percentage to the GDP is the highest for South Asian and sub-Saharan African countries at an average of 2.4 per cent. The adaptation finance needs of developing countries is now estimated at 10-18 times the international public finance flows, over 50 per cent higher than the previous estimate of USD 79-612 billion (UNEP 2022, 2023).

The current global adaptation finance gap is estimated between USD 194 and USD 366 billion per year (UNEP, 2023). The report identifies seven ways to bridge the gap to reduce climate adaptation finance. This includes international adaptation finance, domestic spending and private sector finance as discussed elsewhere in this chapter. Beyond these dominant sources of adaptation finance, the report also recommends considering remittances (money sent by migrants to their families), increasing finance to small and medium enterprises (SMEs), reforming global finance infrastructure including IMF, World Bank, the World Trade Organisation to open up access to low income countries to faster credit, expanding of lending by MDBs by USD 1 trillion, and temporary suspension of debt. The report also calls for implementation of Article 2.1(c) of the Paris Agreement to make financial flows consistent with pathways to achieve low emissions and climate resilient development (UNEP, 2023).

Box 8.5 Climate investment in Tamil Nadu

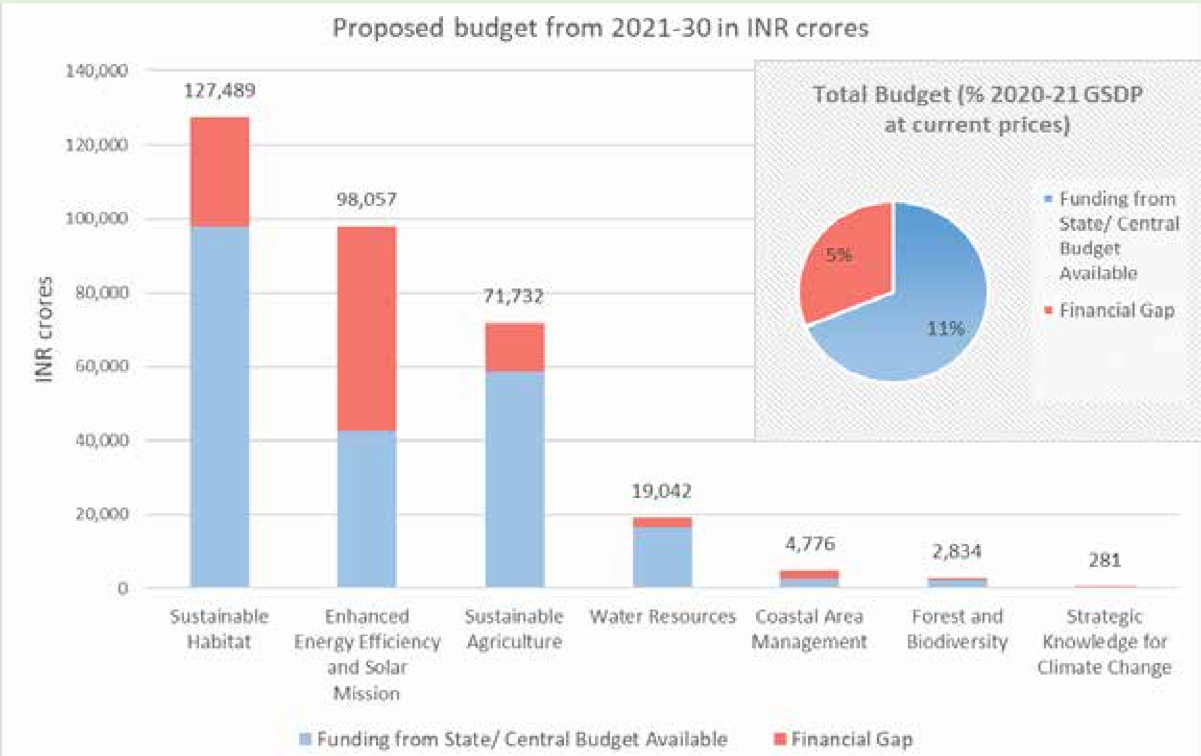
Domestic funding from the state budgets is the primary source of adaptation expenditure. Analysing trends and forecasts of adaptation expenditure from Tamil Nadu's SAPCC provides insights into the financial requirements for Indian states to fulfil their national plan commitments.

From 2012 and 2017, Tamil Nadu proposed 260 climate actions, with 59 per cent of these interventions focussed on adaptation and 5 per cent on both mitigation and adaptation. The estimated budget for implementing these actions over five years was INR 4 trillion, while only 26 per cent of the budget was allocated for adaptation, indicating the smaller size of adaptation projects compared to the mitigation ones. The SAPCC acknowledged difficulty in obtaining additional finance for adaptation, and identified high impact areas from ongoing sectoral activities for climate relevance (Mann, 2020).

More recently, Tamil Nadu has proposed 199 activities, with 56 per cent adaptation-based and 1 per cent cross-cutting for 2021-30,. The selection and prioritisation of these activities were based on their linkages with NDC targets and the SDGs. The nature of activities includes 64 per cent for investment, 18 per cent for capacity building, 11 per cent for research and assessment, 4 per cent pilot actions and 3 per cent for policy- related actions.

The total resource requirement is estimated at USD 46 billion, leaving a gap of USD 15 billion. In 2020-21, the state's fiscal deficit reached USD 8.5 billion, about 2.8 per cent of the GSDP, with outstanding liabilities projected to reach 22 per cent of the GSDP. Given these constraints, closing the adaptation finance gap becomes challenging, a common problem for most Indian State governments.

Figure : Proposed budget for Tamil Nadu's SAPCC (2021-30) in INR Crores



Source: Tamil Nadu SAPCC, 2019

8.5. Climate budgeting and mainstreaming climate adaptation investment

Limited access to incremental and ring-fenced financial resources can hinder effective mainstreaming of adaptation as development priorities overshadow climate action (Prasad and Sud, 2018; UNEP, 2020). To address this, climate budgeting that aligns State and Central budgets with adaptation needs and priorities for climate resilience are crucial.

Mainstreaming climate adaptation is a complex process, requiring integration of climate risks at every decision- making stage and building capacities at various levels, including policy, scientific and technical and at the grassroots implementation. However, many States have not incorporated adaptation into their budgetary and programmatic frameworks, with some failing to conduct detailed vulnerability assessments despite proposing them in their SAPCCs (Kumar, 2018).

States like Gujarat, Madhya Pradesh, Mizoram, Odisha and Tamil Nadu have identified sector-wise key priorities. Other states like Punjab mention broad activities in their SAPCCs, but they lack linkages with existing policies or proposed new policies. Tamil Nadu uses a multi-criteria approach to rank climate action activities based on their alignment with development. For instance, activities with higher synergies with development are ranked higher. Odisha has made progress in integrating climate action into its state budget (see Box 8.6).

Box 8.6: The need to mainstream climate change into subnational budgets

Projects under the SAPCCs rely heavily on State government budgets with limited funding from NAFCC and other international options. For instance, the allocated USD 50 million for 2015–17 can cover only one year of Kerala's planned activities, and even less for other states (Allen et al., 2016). While States can access some adaptation funds from MoEFCC, it is generally expected that they finance initiatives from existing budgets.

State governments spent USD 47.7 billion on adaptation in 2014-15, exceeding the central government's spending by USD 15 billion (Garg et al., 2015). Despite this, most SAPCCs face funding crunches due to the absence of specific budgetary allocations and ambiguity regarding funding sources (Allan et al., 2019; Jogesh and Dubash, 2015). Climate budgeting at the subnational level, using climate change impact appraisal methodologies to inform budgets, has been demonstrated by Odisha and Chattisgarh.

Odisha undertook a climate budgeting exercise across 11 departments, with technical support from the DFID-funded Climate Proofing Growth and Development (CPGD) programme. This led to identifying public investments vulnerable to climate change and opportunities for reconfiguring planned interventions to enhance resilience. Chattisgarh adopted a similar methodology, scoring and assessing programme benefits based on climate relevance and vulnerability, enabling the water resources department to request additional funding to build a climate resilience budget head.

However, many states do not follow climate budgeting techniques and struggle to link climate change to departmental activities. Weak leadership, inadequate awareness among the nodal departments, capacity gaps, inadequate staffing and restricted climate finance hinders effective implementation (Allan et al., 2019; Prasad and Sud, 2018). Identifying co-financing opportunities from on-going schemes allows for synergies and convergence possibilities. States like Andhra Pradesh, Assam, Gujarat, Himachal Pradesh, Karnataka and Maharashtra have identified co- financing opportunities from state resources besides the NAFCC funds.

8.5.1. Environmentally sound investment and green bonds

Sustainable finance involves integrating environmental, social and governance (ESG) criteria in financing and investment decisions. These may exist within business frameworks or can be operationalised via regulatory instruments, thus contributing to sustainable business and investment decisions, and economic development (Goel et al., 2022). Each ESG component has the potential to contribute to financial stability, primarily by fostering positive synergies through the production and consumption channels. Such instruments via careful design of projects have the potential of building localised adaptive capacities, climate resilient infrastructure and providing financing for mitigation technologies.

The past decade has witnessed a growing interest in ESG investing, expanding the scope of sustainable finance instruments to mobilise private sector investments for climate action. This has prompted the adoption of ESG regulations such as mandatory disclosures by companies and ratings, to promote sustainability in business practices at a wider scale in advanced economies. Dedicated ESG funds have emerged, creating a mechanism to support businesses to become climate friendly and also foster positive social and environmental value. Much work, however, needs to be done in this space to enable creation of a viable and sustained market that complements public action on climate change.

The Indian government has been putting in place a framework for sustainable finance to de-risk investments and win over the confidence of investors. This includes the issuance of sovereign green bond this year, the proceeds of which are intended to finance green projects that address mitigation or adaptation goals (DEA,2022). Projects that can receive funding include renewable energy, sustainable water and waste management, green buildings, climate change adaptation, biodiversity etc (ibid) . SEBI has also issued new sustainability reporting requirements under the Business Responsibility and Sustainability Report (BRSR) framework with more quantifiable metrics that will be made mandatory for top 1,000 listed firms to report ESG risks and associated financial implications (GOI, 2023a).

While green bonds are the most popular sustainable finance instrument in India, the majority of them have been for renewable energy projects. The country was the second-largest emerging green bond market after China, for the period 2012-2019. Notable contributors to the green bond issuance include the Indian Renewable Energy Development Agency (IREDA) and the Indian Railway Finance Corporation (IRFC). In 2018, the State Bank of India (SBI) entered the market with a USD 650 million Certified Climate Bond (Fatin, 2018). The country's green framework, though emerging, has broadened investment options in adaptation including for building climate resilient infrastructure projects, improving adaptive capacity of communities, and supporting biodiversity conservation initiatives.

8.6. Private Investment in Adaptation

Adaptation in India primarily relies on government expenditure and established financing instruments like bank loans, bonds, and private equity.

Private sector investment in adaptation in India is limited because of a primary focus on commercial gain tied to expectations of increased revenues, lower costs or lower risk and prevailing climate policies and institutional barriers. Key barriers to private investment in adaptation include:

- Financial barriers: like lack of long-term financing, lack of donor co-financing and limited credit facilitation.
- Institutional barriers: like lack of institutional capacity, path dependency in institutional arrangements, and lack of market access.
- Policy and regulatory barriers: including lack of policy initiatives and enforcement
- Informational barriers: like limited availability of climate data and information on climate risks, and asymmetric access to market information.

There are also significant gaps in estimating private involvement in Indian adaptation (Buchner et al., 2014). Despite these barriers, there is a growing interest in private sector engagement in adaptation due to emerging business opportunities (Adhikari and Safaee Chalkasra, 2023; Lofqvist et al., 2023; Lu, 2022). Publicly funded adaptation projects offer opportunities for collaboration with private actors, enlarging existing markets.

Public interventions by donors, development banks and developing country governments play a role in overcoming barriers and incentivising private finance of adaptation-related activities. These interventions can be financial or non-financial, including providing information on climate risks, enhancing awareness, ensuring coordination among public agencies, and incorporating climate change into policies and regulations like building codes, local zoning regulations.

Box 8.7: Private sector involvement in agri-advisory services

Availability of relevant and timely information on weather, diseases and disasters is essential for farmers to optimise their crop production. Therefore, the dissemination of agro-meteorological advisories to the farmers through different multi-channel systems like radio, television channels, newspapers, internet, SMS and IVR (Interactive Voice Response), is being carried out on a wide scale. There has been a proliferation of mobile phone-based applications and services in the agricultural sector in India that provide farmers with information on market prices, weather and agricultural techniques, through voice and SMS. Such mobile services have reached a large number of farmers in a short time, surpassing achievements of traditional extension approaches.

Private sector initiatives in mobile agri-advisory services in India

Agricultural initiative	Private sector involvement
Nokia Life Services	Developed by Nokia and bundled with Nokia mobile phones. Information on agriculture and allied sectors, weather and markets.
Behtar Jindagi	Developed by Idea Cellular. Advisories on agriculture and allied sectors, weather and markets.
Mkrishi	Developed by Tata Consultancy Services. Information on agriculture and allied sectors, weather and markets.
Avaaj Otalo	Developed by IBM India Research Laboratory and Development Support Centre an NGO in Gujarat. Advisories on agriculture and allied sectors, weather and markets.

Source: Kumar et al., 2014

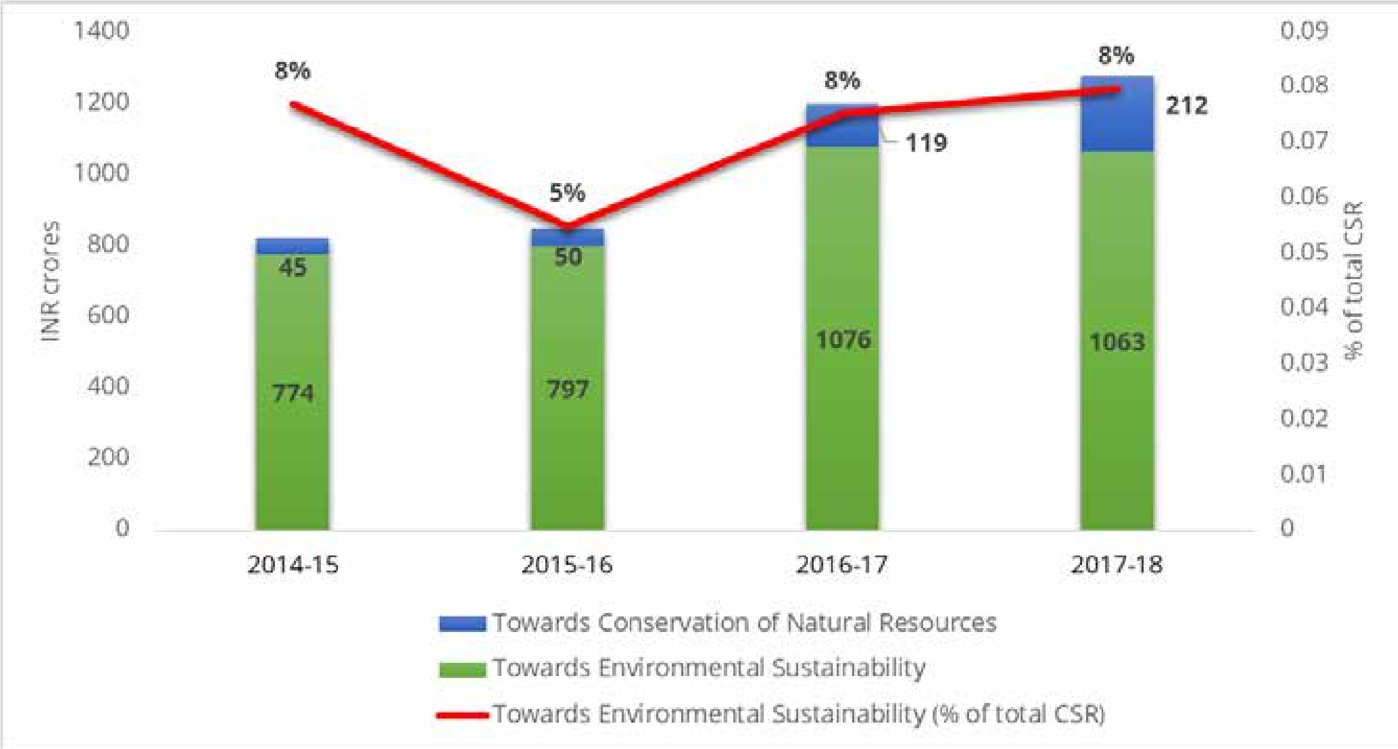
Public actors can mobilise private finance for adaptation investments by using blended finance to reduce capital costs, provide lines of credit to local finance institutions, and offer risk-sharing instruments like guarantees and political risk coverage. Financial interventions encompass public lending, risk guarantees, export credits and Public Private Partnerships (PPP). PPPs involve financial contributions from both public and private partners, with the public partner facilitating private engagement and sharing investment risks.

Private sector investments in adaptation often raise equity issues as they often target low-risk countries or regions, overlooking more vulnerable regions, if they have high risks. Developing countries' private finance portfolios tend to favour sectors like natural resource extraction over critical sectors such as health or education. Sectors like water and agriculture, crucial for livelihoods and adaptation attract less transnational private investment, or are focussed on large-scale export-oriented activities rather than in small-scale production that sustains local populations (Atteridge, 2011). Philanthropy, despite its limited financial resources, stands out as an exception, as its resources can be utilised more flexibly due to absence of expected returns.

8.6.1. Corporate social responsibility and climate adaptation

Currently, Corporate Social Responsibility (CSR) is the primary avenue of private sector contribution to climate action in India. CSR funds largely support education and health related projects with only 5 to 8 per cent dedicated to environmental sustainability (Figure 8.7). CSR is typically a suboptimal adaptation financing instrument as it lacks specific targeting to address climate risk or vulnerability.

Figure 8.5: CSR Expenditure in Environmental Sustainability (2014-18 in INR crores)



Source: Ministry of Corporate Affairs, 2019

8.7. Financing Loss and Damages

After decades of pressure from climate vulnerable developing countries and small islands, there was a hard-won consensus to set up a loss and damages (L&D) financing facility at COP 27 in Egypt in 2022. L&D was first proposed in the 1990s by a group of small island nations. It was formally recognized in 2013 through the Warsaw International Mechanism on Loss and Damage (WIM) and in 2015, Article 8 of the Paris Agreement provided a legal basis for WIM (IPCC, 2023). This is now an additional stream of climate finance, in addition to adaptation finance.

L&D is the outcome of residual risks due to adverse impacts of climate change that have not been addressed by adaptation and/or mitigation or where adaptation options don't exist because of lack of access and financial resources (IPCC, 2022; Singh et al., 2021). This also includes climate-related risks from extreme events like flooding, cyclones and slow-onset events like sea level rise and drought (Mechler and Deubelli, 2021). L&D is of two types, economic and uneconomic, and can be tangible, like loss of lives, infrastructure, property losses or intangible, like poor mental health and trauma, loss of cultural identity and displacement (Singh et al., 2021).

L&D affects people and regions unequally with people from developing countries, small islands, who have historically contributed the least to climate change, suffering the most. IPCC (2023) points out that nearly 3.6 billion people in Asia, Africa, Central and South America, and small islands are highly vulnerable to climate change and will face disproportionate climate risks and disasters. These nations often have the least financial and technical capacity to cover costs of climate-linked losses and damages (Aggarwal and Prasad, 2023) . For instance, floods in Pakistan in 2022 impacted the lives of 33 million people and led to damages worth 10 per cent of the country's GDP (ibid). The 2023 cloud bursts and floods in Himachal Pradesh have led to losses worth USD 0.48 billion (ibid).

A transitional committee of Global North and South members was with expanding and detailing the modalities of operationalizing the L&D fund at COP 28. Even though the L&D fund is agreed upon, there are several challenges to operationalise this facility. These include reluctance of developed countries to set up another fund, lack of an agreed L&D definition and activities, lack of agreement on recipients of the fund, the nature of funds, and funding arrangements, among others (Aggarwal and Prasad, 2023; Schultheiß et al., 2023). Several basic questions linked to the L&D fund still have to be negotiated from who pays, to whom, and how.

Aggarwal and Prasad (2023) recommend that L&D finance ought to be 'new, additional, predictable, adequate, fair, and debt-free'(p. 2). Their report calls for the setting up of the L&D fund as the third operating mechanism within UNFCC like GEF and GCF dedicated only for L&D, with developed nations being primary contributors towards it. Schultheiß et al., 2023 recommend grants-based finance and concessional loans for long term reconstruction, with small vulnerable countries and small islands being prioritised as beneficiaries and introducing caps or flexible ceilings per country. The operationalisation of the fund remains unsettled and will depend on negotiating capabilities and powers between the developed and the developing countries.

There is a close link between adaptation and L&D. Adaptation actions can reduce L&D, where they are feasible. L&D funding is also needed for disaster response, post-disaster resilience building, addressing impacts for slow- onset events that are beyond current adaptive capacities and noneconomic losses (Aggarwal and Prasad, 2023).

8.8. Conclusions

- The cumulative costs of climate adaptation financing for the country are estimated to be INR 28.9 trillion (USD 349 billion) and INR 85.6 trillion (roughly USD 1 trillion) in 2020 and 2030 respectively. Adaptation financing trends (USD 5 billion in 2020) indicate current finance is woefully inadequate to meet these costs.

- Despite the growing global attention towards adaptation, domestic budgetary support is the largest source of funds for adaptation in India. Some progress has been seen in building adaptive capacity in vulnerable sectors like agriculture, water resources, and urban areas, yet this is not commensurate with the needs.

- There are very few standalone investments wholly and specifically for adaptation. Most Indian adaptation investments are developmental expenditures with a small adaptation component.

- The COVID-19 pandemic exacerbated existing inequalities and development deficits, thereby increasing adaptation needs.

- Limited access to incremental and ring-fenced financial resources hinders effective mainstreaming of adaptation. States need to incorporate adaptation in their budgetary and programmatic frameworks, integrate climate risks in decision making processes, and build capacities across policy and sectors to mainstream adaptation.

- The private sector’s contribution towards adaptation in India is negligible due to many structural barriers. As new adaptation opportunities emerge, there is scope to expand this. Financial and policy interventions by governments, donors, development banks, and financial institutions are necessary to incentivise private adaptation finance.

CONCLUSION

CONCLUSION

Climate change will negatively affect India's economy leading to a projected annual Gross Domestic Product (GDP) loss of between 3 to 10 per cent by 2100 (Kompas et al., 2018; RBI, 2023). It is crucial to meet the 1.5°C target to prevent worsening and potentially irreversible impacts of climate change. Yet, meeting a global 1.5ºC target will require investments of 7 to 18 per cent of India's GDP2019 , with 8 per cent of India's GDP2015 required to achieve India's Nationally Determined Contribution (NDC) targets (MOEFCC, 2015; McCollum et al., 2018). India needs to redirect investment away from fossil fuel and carbon-intensive sectors into low-carbon and resilient development via coordinated climate adaptation and mitigation action. India's climate mitigation investments should focus on the energy transition and its climate adaptation investments should focus on filling the resilient infrastructure investment gap and securing productivity across agriculture, water and forestry sectors, to move towards a 1.5ºC goal.

India's energy transition is leading to the stranding of carbon-intensive assets and revenue losses. India's energy transition risks could be hedged if both the Central and State governments follow an orderly, coordinated set of policies with low uncertainty. The costs of decoupling India's economic growth from coal-based energy will have significant short-run macroeconomic impacts. These costs could be limited in the long run by appropriate policy choices, but deep distributional concerns will need to be addressed at scale. Over 7 million workers are employed in India's coal mines besides many more who work in related sectors, but remain largely unquantified. A 'just transition' will need to address the social risks of stranded jobs, its differential impacts on communities, the cost of adaptation and building resilience, and losses and damages.

India's cumulative adaptation costs were estimated at INR 29 trillion in 2020 and INR 86 trillion in 2030, calculated at 2012 constant prices (DEA, 2020). The total tracked green finance for adaptation in 2020 was INR 370 billion, falling woefully short of the required costs (CPI, 2022). Climate finance is also skewed in favour of mitigation, nearly 90 per cent compared to about 10 per cent for adaptation. Private sector investment in adaptation in India is also negligible due to many structural barriers.

Overall, tracked green finance in India was around USD 44 billion each year in 2019 and 2020 (CPI, 2022). This was a 150 per cent jump from 2017 and 2018 (ibid). While climate finance has made some progress in India over the past decade, there is an urgent need to scale up investments in climate action and a just climate transition to address the growing risks of climate change. Both physical and transition risks from climate change threaten the stability of India's financial system. It is imperative to reduce emissions and facilitate a smooth climate transition with minimal risks to the financial sector and all asset classes, and services that these investments create. This needs the recognition of climate change as a systemic risk, and integrating responses into the risk profiles of all financial actors and economic sub-sectors. The RBI, financial and sectoral regulators (especially in the energy sector) will need to expand their mandates and implement fiscal, monetary, and macro-prudential policies to address climate-induced systemic risks.

India's current climate finance investments are highly inadequate. They are primarily sourced from domestic public investment. There is a need to direct a larger proportion of private savings and investments towards a just energy transition, and resilient and sustainable low-carbon infrastructure, buildings, and services. While clear renewable energy policy signals have ensured enhanced private investment in the renewable energy sector, demand side (green buildings, energy efficiency) interventions are yet to gather momentum. Public co-investment through loan guarantees, concessional grants, deferred or income-contingent repayment, and political risk insurances, can help de-risk private investments in climate action (Hourcade et al., 2021). Public guarantees are an efficient de- risking mechanism as they help decrease policy uncertainty and lower the cost of capital for investments.

An effective and efficient energy transition requires climate-centric partnerships across India's financial system including the Central and State finance ministries, the RBI, infrastructure and agricultural financing institutions, commercial banks, institutional investors, asset owners, project developers, firms, and the insurance industry. Multilateral development banks, and special international climate finance institutions have a role to play in helping build robust systems, ratings and domestic institutional capacity to deliver a just energy transition and implement climate and disaster resilient infrastructure. Governments at all levels, can help reduce policy uncertainty and act in concert, and financial regulators can accelerate the incorporation of climate impacts and risks into financial decision-making.

Multilateral (MDBs) and Regional Development Banks (RDBs) can play a critical role in expanding financial commitments to climate finance, de-risking investments and building the confidence of private investors in India. This can be facilitated by the Central and State governments to leverage international climate finance based on domestic public investment. Institutional investors can facilitate investment in resilient low-carbon infrastructure, buildings and industry, from their long-term portfolios. Commercial banks can direct finance to resilient low-carbon investments; asset owners, project developers and firms will need to address physical risks from climate impact and transition risks from deep and rapid divestment. Setting up systems to track investments in mitigation and adaptation is crucial to ensure funds flow to those sectors and regions with high risk and high value for money.

At present, adaptation receives only a marginal portion of the climate finance flows with most of it mixed in with existing development investments. Adaptation investment, in the current form, is often misaligned with many of the SDGs but largely aligned with poverty reduction and meeting India's core development needs. Adaptation investment needs are expected to increase with increasing warming, and the exacerbation of existing vulnerabilities. With the COVID-19 pandemic reducing the adaptive capacity of many sections of the population, there is a need to focus on sustainable development interventions like universal basic services and health and education coverage.

Given current budgetary and resource constraints, Indian Central and State policymakers, regulators, and investors must consider synergies and trade-offs between sustainable development and climate adaptation and mitigation. Ignoring trade-offs can potentially block climate action, while ignoring synergies across targets can increase costs. It is important to internalise negative externalities, increase coordination across policies, and capitalise on synergies between climate mitigation, adaptation, and the SDGs.

India's energy sector decarbonisation is expected to lead to a decline in coal-sector employment by approximately 52 per cent between 2020 and 2050. Renewable jobs have the capacity to generate more employment, but expected employment losses and re-skilling investments need to be addressed through supportive policies.

India has taken steps to redirect finances towards climate action by reducing coal subsidies and introducing some green fiscal stimulus programs. Yet, significant additional finance is necessary to ensure a just transition. This requires a massive increase in resilient low-carbon investments, de-risking of the process of decarbonisation, and a systematic reduction in climate-related physical asset risks, while simultaneously ensuring adequate and inclusive socio-economic development.

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ABBREVIATIONS

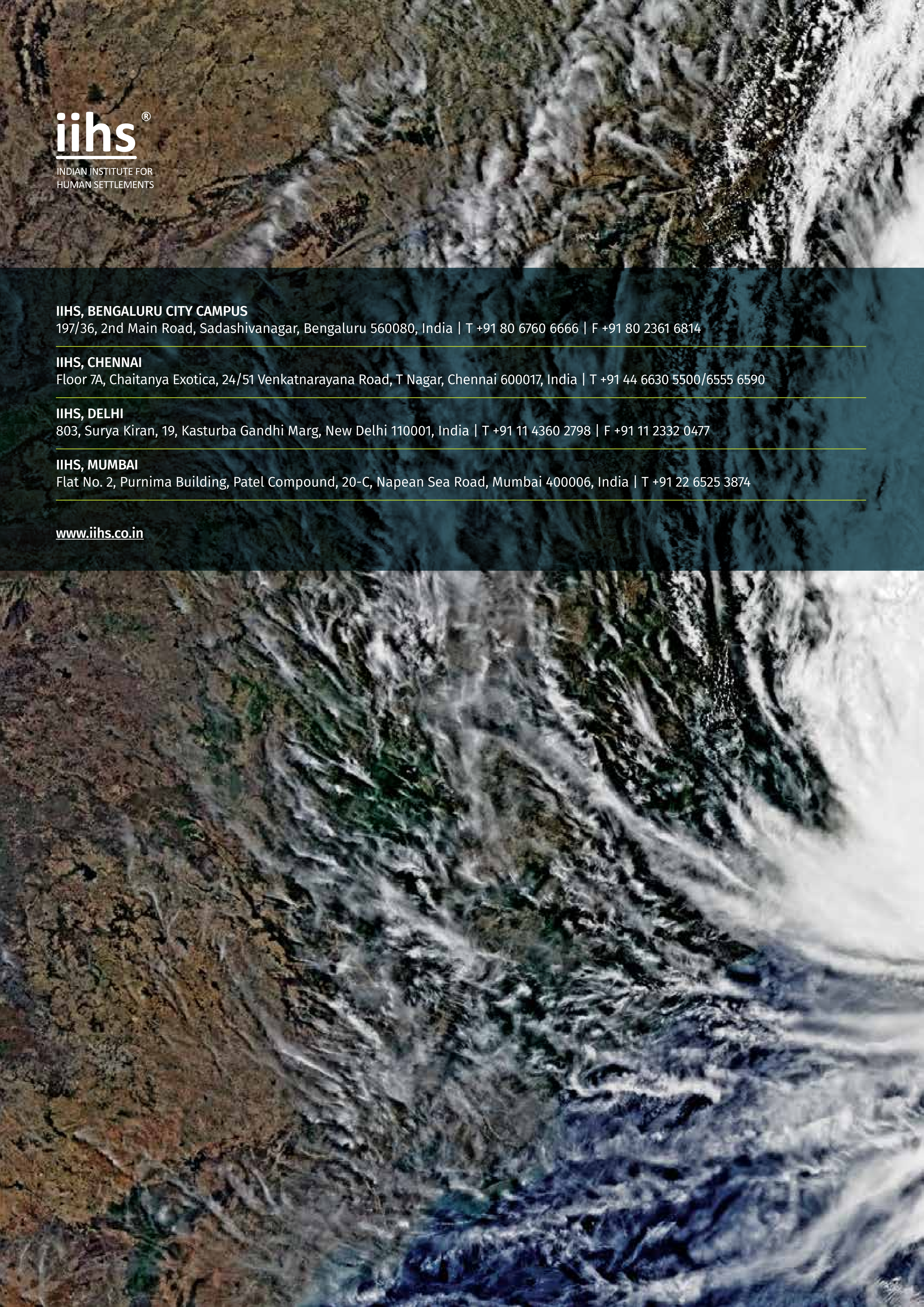
ADB	Asian Development Bank
AF	Adaptation Fund
AFB	Adaptation Fund Board
AIIB	Asian Infrastructure Investment Bank
AMRUT	Atal Mission on Rejuvenation and Urban Transformation
ANZ	The Australia and New Zealand Banking Group
AUM	Assets Under Management
BAU	Business as usual
BE	Budget Estimate
BFV	Blended Finance Vehicle
CAGR	Compound Annual Growth Rate
CAMPA	Compensatory Afforestation Fund Management and Planning Authority
CASA	Current and Savings Account
CCAP	Climate Change Action Programme
CCFU	Climate Change Finance Unit
CCP	Climate Change Programme
CCS	Carbon Capture and Storage
CDM	Clean Development Mechanism
CDR	Carbon Dioxide Removal
CER	Certified Emission Reduction
CFL	Compact Fluorescent Lamp
CIF	Climate Investment Fund
CIL	Coal India Limited
CMPFO	Coal Mines Provident Fund Organization
CPCB	Central Pollution Control Board
CPGD	Climate Proofing Growth and Development
CPol	Current Policies scenario
CRIDA	Central Research Institute for Dryland Agriculture
CSR	Corporate Social Responsibility
CTF	Clean Technology Fund
DAC	Development Assistance Committee
DACP	District Agriculture Contingency Plan
DAE	Direct Access Entity
DBS	Development Bank of Singapore
DEA	Department of Economic Affairs
DFI	Development Financial Institutions
DFID	Department for International Development
DISCOMs	Distribution Company
DM	Disaster Management

DST	Department of Science and Technology
EACC	Economics of Adaptation to Climate Change
ECBC	Energy Conservation Building Code
EDGIP	European Green Deal Investment Plan
EESL	Energy Efficiency Services Ltd.
EFC	Expenditure Finance Commission
EIB	European Investment Bank
EPFO	Employees Provident Fund Organisation
EV	Electric Vehicle
EWS	Early Warning Systems
FAO	Food and Agriculture Organization
FDI	Foreign Direct Investment
FIT	Feed-in Tariffs
FY	Financial Year
GCF	Green Climate Fund
GEF	Global Environment Facility
GFD	Gross Fiscal Deficit
GHG	Greenhouse Gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GMG	Gulf Merchant Group
GSDP	Gross State Domestic Product
GST	Goods and Services Tax
GVA	Gross Value Added
GW	Gigawatt
HRD	Human Resource Development
HRVA	Hazard Risk Vulnerability Assessment
HSBC	Hongkong and Shanghai Banking Corporation
IAM	Integrated Assessment Model
ICAR	Indian Council for Agricultural Research
ICF	International Climate Finance
IEA	International Energy Agency
IFAD	International Fund for Agriculture Development
IIP	Index of Industrial Production
ILO	International Labour Organization
IMF	International Monetary Fund
INDC	Intended Nationally Determined Contributions
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power Producers
IPSF	International Platform on Sustainable Finance

IRDAI	Insurance Regulatory and Development Authority of India
IREDA	Indian Renewable Energy Development Agency Limited
IRFC	Indian Railway Finance Corporation
IRP	Integrated Resource Plan
ISA	International Solar Alliance
IVR	Interactive Voice Response
JBIC	Japan Bank for International Cooperation
JICA	Japan International Cooperation Agency
JNNSM	Jawaharlal Nehru National Solar Mission
JTF	Just Transition Fund
JTM	Just Transition Mechanism
JTT	Just Transition Transaction
KREDL	Karnataka Renewable Energy Development Ltd
KSPDCL	Karnataka Solar Power Development Corporation Ltd
KVK	Krishi Vigyan Kendra
LAD	Local Area Development
LCOE	Levelized Cost of Electricity
LIC	Life Insurance Corporation of India
LNG	Liquefied Natural Gas
LPS	Large Point Sources
MDB	Multilateral Development Bank
MNRE	Ministry of New and Renewable Energy
MoEFCC	Ministry of Environment, Forest and Climate Change
MoF	Ministry of Finance
MoHUA	Ministry of Housing and Urban Affairs
MoRD	Ministry of Rural Development
MoUD	Ministry of Urban Development
MUFG	Mitsubishi UFJ Financial Group
NABARD	National Bank for Agriculture and Rural Development
NAFCC	National Adaptation Fund for Climate Change
NAPCC	National Action Plan for Climate Change
NBFC	Non-Banking Financial Company
NCDMA	National Clean Development Mechanism Authority
NCEEF	National Clean Energy and Environment Fund
NCEF	National Clean Energy Fund
NDB	New Development Bank
NDC	Nationally Determined Contribution
NDRF	National Disaster Response Fund
NEP	National Energy Policy
NGFS	Network for Greening the Financial System
NGO	Non-Governmental Organisations

NICRA	National Innovations on Climate Resilient Agriculture
NIDA	NABARD Infrastructure Development Assistance
NIE	National Implementing Entity
NLC	Neyveli Lignite Corporation
NMSA	National Mission for Sustainable Agriculture
NMSH	National Mission on Sustainable Habitat
NMSHE	National Mission for Sustaining the Himalayan Ecosystem
NMSKCC	National Mission on Strategic Knowledge for Climate Change
NPA	Non-Performing Asset
NRLM	National Rural Livelihoods Mission
NRLP	National Rural Livelihoods Project
NRM	Natural Resource Management
NTPC	National Thermal Power Corporation
NWM	National Water Mission
ODF	Open Defecation Free
ODI	Overseas Development Institute
OECD	Organisation for Economic Cooperation and Development
PAT	Perform Achieve and Trade
PFC	Power Finance Corporation
PFRDA	Pension Fund Regulatory and Development Authority
PKVY	Paramparagat Krishi Vikas Yojan
PMFBY	Pradhan Mantri Fasal Bima Yojana
PMI	Purchasing Managers Index
PM-KUSUM	Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan
PPP	Public Private Partnership
PSP	Pavagada Solar Park
PSU	Public Sector Undertaking
PTC	Power Trading Corporation
PV	Photovoltaics
R&D	Research and Development
RAD	Rainfed Area Development
RBI	Reserve Bank of India
RCP	Representative Concentration Pathway
RE	Renewable Energy
RE	Revised Estimates
REC	Renewable Energy Certificates
REC	Rural Electrification Corporation
RIDF	Rural Infrastructure Development Fund
RPF	Risk Factor Pathway
RPO	Renewable Purchase Obligations
SAAP	State Annual Action Plan

SAPCC	State Action Plan for Climate Change
SBI	State Bank of India
SBM	Swachh Bharat Mission
SCCC	Steering Committee on Climate Change
SCCF	Special Climate Change Fund
SCCL	Singareni Collieries Company Limited
SCM	Smart Cities Mission
SDC	Swiss Agency for Development and Cooperation
SDG	Sustainable Development Goal
SECI	Solar Energy Corporation of India
SERC	State Electricity Regulatory Commission
SFC	Standing Finance Committee
SHC	Soil Health Card
SHM	Soil Health Management
SIDBI	Small Industrial Development Bank of India
SJRP	Sector Jobs Resilience Plan
SLACC	Sustainable Livelihoods and Adaptation to Climate Change
SMAF	Sub-Mission on Agroforestry
SMS	Short Message Service
SOE	State Owned Enterprise
SSAP	State Specific Action Plans
SSP	Shared Socioeconomic Pathway
UDAY	Ujwal DISCOM Assurance Yojana
ULB	Urban Local Bodies
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNEP-FI	The United Nations Environment Programme Finance Initiative
UNFCCC	United Nations Framework Convention on Climate Change
UNISDR	United Nations Office for Disaster Risk Reduction
UPNRM	Umbrella Programme on Natural Resource Management
USAID	United States Agency for International Development
USD	United States Dollar
VGF	Viability Gap Funding



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