

Climate Finance and India's Transition towards a Low-Carbon Economy: Opportunities and Challenges

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Abstract

Climate finance has emerged as a critical instrument for accelerating India's transition towards a low-carbon and climate-resilient economy. As a developing economy with increasing energy demand, India faces the dual challenge of sustaining economic growth while reducing greenhouse gas emissions and strengthening resilience to climate change. This research article examines the role of climate finance in supporting renewable energy, energy efficiency, sustainable transportation, green hydrogen, industrial decarbonisation and climate adaptation. It uses a descriptive and analytical research design based on secondary data from the Government of India, NITI Aayog, the International Energy Agency (IEA), the Organisation for Economic Co-operation and Development (OECD), and the Climate Policy Initiative (CPI). NITI Aayog's 2025 report indicates that India's tracked green investment increased from approximately US\$17 billion in FY2016–17 to US\$57 billion in FY2021–22, while the IEA estimated clean-energy investment at US\$87 billion in 2024. Despite this progress, substantial additional investment is required to meet India's climate commitments and long-term net-zero objective for 2070. The article identifies high capital costs, limited access to affordable finance, technological risks, inadequate private-sector participation and insufficient funding for climate adaptation as major constraints. It argues that strengthening green bond markets, expanding blended finance, mobilising international concessional funding and improving climate-finance transparency can help address these challenges. The study concludes that climate finance must be integrated with India's broader development strategy to achieve an inclusive, economically viable and environmentally sustainable low-carbon transition.

Keywords: *Climate finance; green finance; low-carbon economy; renewable energy; green bonds; energy transition; sustainable development; India.*

1. Introduction

Climate change has become a major economic, environmental and developmental challenge. Rising temperatures, irregular rainfall, extreme weather events and increasing climate-related risks affect agricultural productivity, public health, infrastructure, water resources and livelihoods. These impacts create additional demands on public expenditure and threaten the sustainability of long-term economic growth. India's transition towards a low-carbon economy is particularly important because the country must expand energy access, create employment and improve living standards while progressively reducing the emissions intensity of its economy. This transition requires substantial investment in renewable energy, electricity transmission, battery storage, energy-efficient industries, electric mobility and climate-resilient infrastructure. Climate finance refers to financial resources used to support activities that reduce greenhouse gas emissions or help communities and economic systems adapt to climate change. These resources may

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originate from governments, commercial banks, development finance institutions, international climate funds, institutional investors and private enterprises. According to the OECD's Clean Energy Finance and Investment Roadmap of India, public finance and international development finance can help attract private capital by reducing investment barriers and improving the financial viability of clean-energy projects. India's policy framework includes its Nationally Determined Contributions (NDCs) under the Paris Agreement, the National Action Plan on Climate Change, renewable-energy programmes, sovereign green bonds and initiatives supporting green hydrogen and energy efficiency. These initiatives create opportunities for new investment, technological development and employment. However, the availability, affordability and distribution of climate finance remain important challenges. This article therefore examines the present climate-finance landscape in India, its role in the low-carbon transition, the opportunities it creates, and the policy measures needed to mobilise adequate and accessible financial resources.

Review of Literature

The Climate Policy Initiative's Landscape of Green Finance in India 2024 examines domestic and international public and private financial flows to clean energy, clean transportation, energy efficiency and selected adaptation sectors. The report provides a framework for understanding the sources, instruments and destinations of green finance in India.

The OECD's Clean Energy Finance and Investment Roadmap of India identifies barriers to investment in energy efficiency, offshore wind and green hydrogen. It emphasises the importance of policy certainty, targeted public funding, financial-market development and the mobilisation of private capital.

The IEA's World Energy Investment 2024 reports that India's clean-energy investment reached approximately US\$68 billion in 2023, substantially above the average for 2016–2020. It also highlights the importance of reducing financing risks to support further investment in clean energy.

The Economic Survey 2024–25 discusses climate adaptation expenditure and the importance of domestic resources in financing climate action. It also highlights the inadequacy of international climate-finance flows relative to the needs of developing countries.

Existing reports document the growth of green investment and the financing needs associated with India's energy transition. However, the relationship between financing instruments, the cost of capital, sectoral investment priorities and equitable access to adaptation finance requires continuing examination. This article brings these dimensions together in a descriptive policy analysis. It does not claim to establish a causal relationship between climate finance and emissions reductions because it does not estimate an econometric model or conduct project-level impact evaluation.

Objectives of the Study

The main objectives are:

1. To examine the concept and importance of climate finance in India's low-carbon transition.
2. To analyse trends in India's green and clean-energy investment.
3. To identify major sources and instruments of climate finance.
4. To examine investment opportunities in renewable energy, transportation, industry and climate adaptation.
5. To identify the financial, institutional and technological challenges affecting climate investment.
6. To suggest policy measures for mobilising climate finance and supporting inclusive, sustainable economic growth.

Research Methodology

The study adopts a descriptive and analytical research methodology based on secondary data.

- Data sources: NITI Aayog, Climate Policy Initiative, IEA, OECD, Government of India budget documents and official policy publications.
- Study period: Primarily FY2016–17 to 2024–25, depending on data availability.
- Methods: Trend analysis, comparison of published investment estimates, descriptive tables and conceptual diagrams.
- Scope: Climate finance for mitigation and adaptation, with particular attention to India's energy transition.
- Limitation: Published estimates use different definitions, coverage and reporting periods. They should not be treated as a single continuous statistical series without methodological adjustments.

Climate Finance and India's Low-Carbon Transition

Meaning and importance of climate finance

Climate finance includes domestic and international financial resources allocated to mitigation and adaptation activities.

Mitigation finance supports activities such as solar and wind power, electric vehicles, energy-efficient machinery and low-carbon industrial technologies. Adaptation finance supports measures such as climate-resilient agriculture, flood protection, drought management, water conservation and disaster-resilient infrastructure.

Climate finance is important for India for five major reasons:

- It helps mobilise investment for clean-energy infrastructure.
- It supports the adoption of low-carbon technologies.
- It can reduce the financial burden of climate-related disasters.
- It creates opportunities for green employment and technological innovation.
- It helps integrate environmental objectives with economic development.

Major sources of climate finance

Source	Financial instruments	Main applications
Central and state governments	Budget allocations, subsidies, public investment	Renewable energy, public transport, adaptation
Commercial banks	Project loans, working capital	Solar projects, energy efficiency
Development institutions	Long-term loans, concessional finance	Infrastructure and clean technology
Capital markets	Green bonds, sustainability-linked finance	Renewable energy, transport
International institutions	Grants, concessional loans, guarantees	Climate mitigation and adaptation
Private investors	Equity, venture capital, project finance	Green technology and clean energy
Carbon markets	Carbon-credit revenues	Eligible emissions-reduction projects

Public finance can fund public goods and help reduce project risks. Private finance can expand investment where projects generate sufficiently predictable returns. International concessional finance can be particularly important for projects that deliver significant climate benefits but face high costs or uncertain commercial returns.

Data Analysis: Climate Finance in India**Trends in green and clean-energy investment**

The following data illustrate the increase in India's green and clean-energy investment. The estimates are drawn from different reports and methodologies and should be interpreted separately.

Year or period	Investment estimate	Source
FY2016–17	US\$17 billion in tracked green investment	CPI, reported by NITI Aayog
FY2021–22	US\$57 billion in tracked green investment	CPI, reported by NITI Aayog
2023	US\$68 billion in clean-energy investment	IEA
2024	US\$87 billion in clean-energy investment	IEA estimate reported by NITI Aayog

Sources: NITI Aayog's Scenarios Towards Viksit Bharat and Net Zero: Financing Needs and IEA's World Energy Investment 2024.

The CPI-based figures refer to tracked green investment, while the IEA figures refer to clean-energy investment. Differences in sectoral coverage, definitions and estimation methods mean these values should not be combined into one uninterrupted growth series.

India's climate-finance requirements

India's long-term transition requires investment in power generation, electricity grids, storage, transport, industrial processes and other infrastructure.

NITI Aayog's 2025 report, Scenarios Towards Viksit Bharat and Net Zero: Financing Needs, estimates that for 2026–2050, the net-zero pathway requires approximately US\$8.1 trillion in investment, compared with US\$5.8 trillion under its Current Policy Scenario. The resulting incremental investment requirement is approximately US\$2.3 trillion over the period.

Table 2. Indicative investment requirements, 2026–2050

Investment scenario	Estimated investment
Current Policy Scenario	US\$5.8 trillion
Net-zero pathway	US\$8.1 trillion
Incremental investment requirement	US\$2.3 trillion

Source: NITI Aayog (2025). These are scenario-based cumulative investment estimates, not actual expenditure or a direct estimate of the entire climate-finance requirement.

The additional US\$2.3 trillion over 25 years is equivalent to an average of approximately US\$92 billion per year. This simple calculation illustrates the scale of additional investment implied by the two scenarios; actual annual requirements will vary over time.

The estimates underline why public budgets alone are unlikely to meet the full investment requirement. Domestic financial institutions, institutional investors, international development finance and private capital will all have roles to play.

Sectoral investment priorities

Renewable energy and electricity networks

Solar and wind projects require generation capacity, transmission lines, distribution-system upgrades and storage. Finance must support the entire electricity system rather than generation alone.



Sustainable transportation

Electric buses, charging infrastructure, railways and urban public transport can reduce dependence on fossil fuels when supported by suitable electricity and transport policies.



Industrial decarbonisation

Energy-efficient machinery, electrification, green hydrogen and low-carbon production processes can reduce industrial emissions. Financing is especially important for capital-intensive industrial upgrades.



Climate adaptation

Irrigation efficiency, drought-resistant agriculture, water conservation and resilient infrastructure protect livelihoods. These activities may not generate the direct cash flows required by conventional private lenders.

India's climate policy and financing framework

India's climate-finance framework combines domestic public spending, financial-market instruments, international cooperation and sector-specific programmes.

Important mechanisms include:

1. Nationally Determined Contributions: India's commitments under the Paris Agreement provide the policy context for emissions-intensity reductions and non-fossil electricity capacity.
2. Sovereign green bonds: These provide a mechanism for raising funds for eligible public expenditure with environmental benefits.
3. Renewable-energy programmes: Public policy and financial support help develop solar, wind and other non-fossil electricity capacity.
4. National Green Hydrogen Mission: Supports the development of green hydrogen production and related infrastructure.
5. Energy-efficiency programmes: Encourage reduced energy consumption in industry, buildings and other sectors.
6. International climate finance: Development institutions and climate funds can provide loans, grants, guarantees and technical assistance.

The IEA reported that India's first sovereign green bond issuance took place in January 2023, with two tranches totalling approximately US\$1 billion.

These instruments can support the transition, but their effectiveness depends on project selection, implementation capacity, transparent reporting and the additional investment they mobilise.

Diagram: How Climate Finance Supports a Low-Carbon Economy

Sources of Climate Finance

Government budgets · Banks · Green bonds · Private capital · International finance

Financial Mobilisation

Loans · Grants · Equity · Guarantees · Blended finance

Low-Carbon Investment

Renewable energy · Storage · Clean transport · Green industry · Adaptation

Expected Development Outcomes

Lower emissions · Greater resilience · Green employment · Sustainable growth

Conceptual framework developed for this article. Outcomes depend on project quality, implementation and monitoring; they are not automatic consequences of financing.

The framework illustrates how financial resources can be converted into productive low-carbon assets. Financial mobilisation is the intermediate step between sources of capital and actual climate outcomes. Effective institutions, appropriate project appraisal and transparent monitoring are required at each stage.

Opportunities for Climate Finance in India**Expansion of renewable energy**

India's renewable-energy sector offers opportunities for domestic and international investors. Solar and wind projects can attract private capital through long-term power-purchase agreements, project finance and green bonds. Investment in transmission and energy storage is also essential to integrate variable renewable electricity into the grid.

The Government of India's September 2026 announcement of a ₹1.86 trillion renewable-energy infrastructure programme, including support for transmission and battery storage, illustrates the continuing importance of infrastructure investment in the energy transition.

Development of green financial markets

Green bonds can connect investors seeking environmental investment opportunities with eligible climate-related projects. Other instruments, including sustainability-linked loans, transition finance and green infrastructure funds, can diversify the sources of finance.

A transparent framework for defining eligible projects and reporting the use of proceeds can help investors assess environmental benefits and financial risks.

Foreign investment and international cooperation

International development banks, climate funds and foreign institutional investors can provide capital, technology and technical expertise. Concessional loans, guarantees and grants can reduce the risks associated with projects that are essential for decarbonisation but not yet commercially competitive.

Employment and industrial development

Investment in renewable-energy equipment, battery manufacturing, electric mobility and energy-efficient construction can create employment opportunities and stimulate domestic manufacturing. Skill-development programmes are necessary to ensure that workers can participate in these emerging sectors.

Climate-resilient agriculture and rural development

Climate finance can support micro-irrigation, watershed development, water conservation, resilient agricultural practices and rural infrastructure. In states such as Telangana, these investments are relevant to agricultural productivity, groundwater management and rural livelihoods.

Challenges in Mobilising Climate Finance

- ❖ High cost of capital: High borrowing costs, perceived project risks and uncertainty over future revenues can make clean-energy investments expensive. Smaller developers may face greater difficulty obtaining affordable long-term finance.
- ❖ Limited availability of long-term finance: Many low-carbon infrastructure projects require substantial initial investment and take years to generate returns. Shorter-term lending and refinancing risks can constrain their development.
- ❖ Inadequate international climate finance: Developing countries require international support to meet climate objectives while financing other development priorities. The scale, accessibility and concessional terms of available funding remain important concerns.
- ❖ Unequal distribution between mitigation and adaptation: Renewable-energy projects can often generate identifiable revenue streams, whereas adaptation investments such as flood protection and drought resilience

frequently provide diffuse public benefits. Consequently, adaptation activities may struggle to attract private finance.

- ❖ Data and transparency constraints: Different institutions use different definitions, reporting periods and eligibility criteria for climate finance. Inconsistent reporting can make it difficult to identify actual financial flows, assess additional investment and measure results.
- ❖ Industrial transition and social adjustment: Emissions-intensive industries face technological, financing and employment challenges during decarbonisation. A just transition requires support for affected workers, communities and smaller enterprises.

NITI Aayog's assessment identifies the financing gap, the high cost of capital and the need to strengthen climate-finance institutions and reporting as important issues for India's net-zero transition.

Policy Suggestions

The following measures could help improve the availability, affordability and effectiveness of climate finance in India.

Policy measure	Proposed action	Expected contribution
Expand green bonds	Develop a predictable pipeline of eligible projects and transparent reporting	Diversify long-term funding
Promote blended finance	Combine public funds, concessional loans, guarantees and private investment	Reduce selected investment risks
Strengthen development finance	Expand suitable long-term lending for clean infrastructure	Address financing-duration mismatches
Improve adaptation finance	Increase support for agriculture, water, health and disaster resilience	Strengthen climate resilience
Mobilise international funds	Improve access to concessional finance and climate funds	Reduce financing costs for eligible projects
Develop climate-finance taxonomy	Establish clear definitions and eligibility criteria	Improve transparency and comparability
Support MSMEs	Provide energy audits, credit guarantees and affordable finance	Encourage industrial energy efficiency
Improve monitoring	Track allocations, disbursements, project outcomes and emissions reductions	Strengthen accountability
Promote a just transition	Support worker retraining and economic diversification in affected regions	Reduce adjustment costs

Strengthen public-private partnerships

Public institutions should focus on infrastructure, project preparation and risks that private investors cannot efficiently bear alone. Private capital can then finance commercially viable projects under transparent and predictable conditions.

Improve access to finance for adaptation

Dedicated funding windows are needed for projects that generate substantial social benefits without reliable commercial returns. Grants and concessional finance can be particularly useful for vulnerable communities and local governments.

Develop consistent climate-finance reporting

India would benefit from improved coordination among financial regulators, ministries, state governments and financial institutions. Reporting should distinguish between announced commitments, approved funding, actual disbursements and verified outcomes.

Integrate climate finance with state-level development

State governments can identify regional investment needs and prepare project pipelines aligned with local economic and environmental conditions. In Telangana, priorities could include solar energy, energy-efficient MSMEs, sustainable irrigation, groundwater conservation and climate-resilient agriculture.

Major Findings

The analysis produces the following findings:

1. Green investment has expanded. Published CPI and IEA estimates show increasing financial flows to green and clean-energy activities in India, although the estimates have different coverage and methodologies.
2. Future investment requirements remain substantial. NITI Aayog's net-zero scenario indicates an additional investment requirement of approximately US\$2.3 trillion for 2026–2050 compared with its Current Policy Scenario.
3. Public finance remains important. Government funding can support infrastructure and climate-related public goods, while also helping mobilise private investment.
4. The cost of capital matters. High financing costs and project risks can constrain the deployment of clean technologies.
5. Adaptation requires specific attention. Agriculture, water management and climate-resilient infrastructure may need grants, concessional finance and public expenditure.
6. Financial mobilisation must be accompanied by accountability. Transparent reporting and outcome measurement are essential to determine whether finance produces the intended climate benefits.

These are descriptive findings based on published reports. They should not be interpreted as causal estimates of the impact of climate finance on emissions, employment or GDP.

Conclusion

Climate finance is an essential component of India's transition towards a low-carbon and climate-resilient economy. The expansion of green investment demonstrates growing financial activity in renewable energy, clean transportation and other climate-related sectors. However, the investment requirements associated with India's long-term net-zero objective remain substantial.

The central challenge is not merely to increase the volume of finance but also to improve its affordability, accessibility, allocation and effectiveness. Public expenditure, commercial lending, green bonds, private equity and international climate finance need to complement one another. Public institutions can provide enabling infrastructure and support projects with significant social benefits, while private investors can contribute capital and innovation to commercially viable activities.

Particular attention should be given to electricity transmission and storage, industrial decarbonisation, energy efficiency, sustainable transport and climate adaptation. Financial support for adaptation is especially important because vulnerable households, farmers and local governments may lack the resources needed to respond to climate risks.

India can strengthen its climate-finance system by developing credible investment pipelines, reducing selected project risks, improving regulatory clarity, expanding concessional finance and adopting transparent monitoring frameworks.

State-level planning and support for MSMEs, workers and rural communities can help ensure that the transition is inclusive.

Ultimately, climate finance should be treated as a long-term development investment rather than only an environmental expenditure. Its contribution to sustainable economic growth will depend on effective institutions, sound project selection, technological progress and measurable environmental and social outcomes.

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