

INDIA ADAPTATION DOSSIER

2023-2024



Integrated Centre for Adaptation, Disaster Risk Resilience
and Sustainability (ICARS)

IIT Roorkee, Greater Noida Campus (NCR), India



INDIA ADAPTATION DOSSIER 2024

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Message

Climate change presents a formidable challenge to India's developmental aspirations, ecological sustainability, and human well-being. In response to this, the Government of India launched the National Action Plan on Climate Change (NAPCC), under which the Department of Science & Technology (DST) has been entrusted with the responsibility of implementing the National Mission on Strategic Knowledge for Climate Change (NMSKCC).

The NMSKCC represents a strategic pivot in India's climate response—placing science, data, and knowledge at the core of national resilience and adaptation planning. Under the NMSKCC a wide range of initiatives are being undertaken pan India including (i) carrying out various research programmes on human and institutional capacity building on climate change; (ii) establishing and strengthening multiple centre of excellences (CoEs); (iii) supporting major R&D programmes (MRDP) on climate change; (iv) developing knowledge network programmes on climate change developed; (v) establishing state climate change cells (NMSKCC-SCCC) etc. The Integrated Centre for Adaptation to Climate Change, Disaster Risk Resilience and Sustainability (ICARS) as a CoE at IIT Roorkee's Greater Noida Campus has been established under this mission. The centre aims to promote "Capacities and Public-Policy for Resilience and Sustainability (CAPP-RES) in Multi-hazard Environment" through an integrated and holistic coverage of DRR and Adaptation.

The National Adaptation Dossier is a comprehensive repository documenting India's evolving climate adaptation landscape on an annual basis. I complement the team at ICARS- IIT Roorkee, for working on this strategic endeavor and documenting the extensive work done in climate change adaptation within the country. I am sure of that it will be a use ref documents for all those strategic institutions and implementing agencies and other stakeholders in planning the implementations and monitoring activities.

Anita Gupta





Preface

Climate change presents one of the most critical challenges of our time, with its impacts reverberating across ecological, economic, and social systems. India is one of the worst climate effected countries in South Asia. The challenges seemingly differ both across regions and across all key sectors. Sectoral approaches is also linked with Disaster Risk Reduction. The point 1 of the Prime Minister’s 10 point Agenda on disaster risk reduction on “All development sectors must imbibe the principles of disaster risk management” supports the need to address the geographical and sectoral challenges of climate change and also highlights the need for adaptation, mitigation, and the developmental importance of integrating risk reduction into planning.

India has been a lead player in climate change disclosures and negotiations globally, and also in demonstrating its commitment internally. India’s NAPCC with its 8 missions has been an exemplary architecture for its adaptation commitments. The National Mission on Strategic Knowledge for Climate Change (NMSKCC) aims to build a strong knowledge and data base for climate science, impact assessment, and policy-making. It promotes research, climate modeling, capacity building, and international cooperation to support informed climate action in India. The Action Point 1 proceedings of the third National Platform for Disaster Risk Reduction (NPDRR) talks about the need to support research and review, addressing gaps and opportunities from emerging climatic, technological and developmental changes.

The India Adaptation Dossier is an attempt to systematically record India’s evolving landscape of climate adaptation strategies, programs, and policies. It serves as an extensive archive of policies, strategies, and initiatives implemented by key line Ministries, Government institutions as well as other stakeholders. This will serve as a national reference point for the policy makers, planners, researchers and for other stakeholders.

I am happy to present the first volume (year 2024-2025) which is an innovative and collaborative strategic outcome.

Prof. Anil K Gupta

Professor- WRDM & Principal Investigator,
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Acknowledgement

The National Adaptation Plan on Climate Change (NAPCC) being steered by the Ministry of Environment Forest and Climate Change (MoEFCC), aims to enable India to adapt to climate change and enhance the ecological sustainability of India's developmental path. NAPCC is being implemented through various nodal ministries for specific missions. The Department of Science and Technology (DST-Gol) is the nodal ministry for the National Mission on Strategic Knowledge for Climate Change (NMSKCC). The development of the India Adaptation Dossier on an annual basis is assigned to ICARS-IITR as a strategic mandate under this mission.

We acknowledge the significant guidance and support from MoEFCC especially Dr. Rajasree Ray (Economic Advisor), Dr. Ruchika Drall (Deputy Secretary), Ms. Sutanuka Sarkar (Deputy Director) and Ms. Swati Sharma (Consultant) for developing the India Adaptation Dossier for 2024. We are also thankful to Department of Science and Technology (DST-Gol), Prof. Abhay Karandikar (Secretary) and more particularly the CEST Division including Dr. Anita Gupta (Advisor & Head), Dr. Vandana Singh (Scientist-F) and Dr. Swati Jain (Scientist-D) for entrusting IIT Roorkee with the opportunity to undertake and work on the ICARS-CoE. A special note of thanks to Shri Amit Verma, NITI Aayog for the constant encouragement and support extended to ICARS.

The project team is thankful to Prof. K. K. Pant (Director, IIT Roorkee), Dr. Akhilesh Gupta (Distinguished Professor, CDMM, IIT Roorkee), and Dr. Thanga Raj Chelliah (HoD, WRD&M, IIT Roorkee) for their constant support and encouragement for undertaking the various strategic endeavours and ensuring the smooth functioning of ICARS. We also acknowledge the guidance and support of Padma Shri Prof. Anil Gupta (founder of Honey Bee Network and visiting professor at IIM Ahmedabad, Gujarat) on various endeavours of ICARS. From the ICARS team, a special thanks to the Co-PIs/ collaborators (Prof. Ashish Pandey, Prof. Manish Goyal (IIT Indore), Dr. Mohit Mohanty, Dr. Komal Tripathi, Dr. Rajarshi Dasgupta (IIT Delhi) and Prof. Akshay Dvivedi) for their collaborative efforts and valuable contributions to ICARS.

Special thanks to the collaborating team from Sphere India including Mr. Vikrant Mahajan (CEO, Sphere India), Ms. Nupur Tyagi (Programs Manager, Sphere India), Mr. Utkarsh Dwivedi (IAC Manager, Sphere India) and to Dr. Elia Jafar (Chief of Programmes, SaveLife Foundation), whose contributions were significant in drafting and finalizing this report. We also acknowledge the support extended by HCL Foundation in this process.

Further, I acknowledge Ms. Pritha Acharya (Project Scientist-II) for leading and coordinating the dossier. Thanks are also due to the team at ICARS including Ms. Richa Srivastava (Project Scientist-III), Dr. Ravi Katiyar (Project Scientist-II), Ms. Fatima Amin (Project Scientist-I), Dr. Jyoti Saini (Research Associate-AdaptDMIR), and Junior Research Fellows Mr. Deepak Pandey and Ms. Alpna for their contributions to the endeavours of the project.

Further we acknowledge the support of all the members from various key Ministries, organizations and other stakeholders who were involved and consulted during meetings for finalizing the India Adaptation Dossier.

We would like to extend our heartfelt appreciation to all the members who have participated in our working group meetings (annexure I) for their invaluable contributions, insightful review comments, and inputs, for our various strategic outcomes.

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Executive Summary

Purpose and Scope

The purpose of the Annual India Adaptation Dossier is to systematically document and evaluate India's efforts to adapt to climate change at all levels of governance. In order to address climate risks and improve resilience, it serves as an extensive archive of policies, strategies, and initiatives implemented by key line Ministries, Government institutions as well as other stakeholders. By synthesizing sectoral interventions and adaptation strategies, the dossier facilitates an evidence-based review of climate adaptation progress, informing decision-making, resource allocation, and policy recommendations.

Scope and Boundaries

The dossier primarily covers adaptation efforts implemented in 2023–2024 across key ministries, national agencies, and relevant stakeholders. It categorizes adaptation initiatives into sectoral and thematic areas, with a focus on identifying best practices, challenges, and gaps in climate resilience. The assessment also incorporates a set of adaptation indicators to evaluate the effectiveness of these initiatives in enhancing physical, economic, social, environmental, and systemic resilience.

Limitations

While the dossier strives to provide a comprehensive review, it is subject to data availability, methodological constraints in assessing adaptation outcomes, and variations in reporting standards across ministries and states. The scope of this dossier is broad, encompassing multiple sectors, ministries, and governance levels. However, it does not claim to be exhaustive, as adaptation is an evolving field with continuous advancements. The dossier highlights key initiatives; however, their effectiveness and impact require thorough evaluation through field assessments and stakeholder consultations. Additionally, the analysis does not encompass all adaptation initiatives at the sub-national or local levels due to the dynamic nature of climate adaptation planning and execution.

Analysis of Climate Adaptation Interventions

This edition evaluates adaptation efforts from 2023 to 2024, drawing insights from government orders, legal mandates, infrastructure investments, training programs, decision-support tools, and ecosystem restoration projects. It also assesses institutional mechanisms that promote adaptation planning and implementation at various levels. The dossier employs a set of adaptation indicators to assess the scope and effectiveness of these interventions. Physical indicators include climate-resilient infrastructure such as flood walls and coastal barriers. Economic indicators analyze resource allocation for adaptation projects and the cost-benefit aspects of adaptation investments. Social indicators examine the impact of adaptation measures on vulnerable populations, including women, children, and marginalized communities. Environmental indicators cover ecosystem restoration projects, such as mangrove restoration, and systems for accurate climate projections. Systemic indicators evaluate the integration of adaptation into policy frameworks, capacity-building initiatives, institutional arrangements, and the effectiveness of training programs in enhancing adaptive capacity.

By tracking these interventions, the dossier aims to provide a structured, data-driven assessment that informs future adaptation strategies, identifies gaps and needs, and supports climate resilience efforts across sectors.

Key Findings

In the recent years we have witnessed tremendous breakthroughs in India's climate adaption landscape, including improvements in institutional processes, policy frameworks, and cross-sectoral cooperation. An increasing focus on incorporating climate resilience into national and subnational development planning is observed through the analysis of adaptation initiatives by different Ministries between 2023 and 2024. Several states and stakeholders have pioneered innovative approaches, leveraging traditional knowledge and governance mechanisms to build resilience at various levels. However, challenges persist in scaling successful initiatives, ensuring sustained funding, and addressing vulnerabilities in marginalized and high-risk communities. Strengthening institutional mechanisms, fostering public-private partnerships, and enhancing knowledge-sharing mechanisms will be critical to bridging these gaps and advancing India's adaptation agenda.

Conclusion

India's climate adaptation efforts have made significant strides, with policies, funding mechanisms, and stakeholder engagement frameworks evolving to address growing climate risks. However, gaps in financing, policy coherence, and stakeholder integration persist, necessitating a more holistic and systemic approach to resilience-building. The integration of traditional knowledge with modern adaptation strategies, enhanced public-private partnerships, and community-led initiatives are essential to ensuring long-term sustainability. Strengthening multi-stakeholder coordination across governance levels will be critical in bridging these gaps and fostering inclusive, equitable, and climate-resilient development.

Additionally, while various adaptation initiatives have been implemented, the challenge remains in scaling up and replicating successful models across diverse geographies and socio-economic contexts. Ensuring the long-term viability of adaptation measures requires continuous monitoring, evaluation, and adaptation of policies based on emerging climate risks and scientific advancements. Strengthening institutional capacities, fostering regional and international collaborations, and promoting climate justice will be crucial in ensuring that adaptation efforts are not only effective but also equitable, benefiting the most vulnerable communities. A collective and sustained commitment from all stakeholders will be essential in steering India toward a resilient and adaptive future.

Way Forward

Moving forward, a multi-pronged approach is necessary to mainstream climate adaptation into national and subnational planning. This includes scaling up financial resources by leveraging private sector investments, climate insurance mechanisms, and blended finance models to close the adaptation funding gap. Strengthening policy frameworks, such as incorporating adaptation measures into State and District Disaster Management Plans, will ensure that resilience-building remains a core component of development planning. Additionally, enhancing climate literacy through targeted capacity-building programs for local communities, NGOs, and businesses will empower stakeholders to proactively manage climate risks.

Institutional mechanisms for stakeholder engagement must be further refined to ensure more structured and impactful collaboration. Establishing dedicated multi-stakeholder platforms that bring together government agencies, private sector actors, and civil society organizations will facilitate knowledge-sharing, resource mobilization, and innovation in adaptation strategies. Additionally, expanding the use of technology such as digital early warning systems, climate analytics, and predictive modeling can enhance preparedness and response capabilities. By adopting a forward-looking, inclusive, and well-resourced approach, India can strengthen its climate resilience and build adaptive capacities that protect vulnerable populations, ecosystems, and economic systems from future climate shock.

Glossary

a) Adaptation

The word ‘adaptation’ has been widely and variedly defined and used primarily in ecology, physiology/medical science and now a broader perspective in the sense of ‘adaptation to climate change’ as an explanation of ecological adaptation by humankind. Following are few definitions or concepts of adaptation:

Intergovernmental Panel on Climate Change: The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to the expected climate and its effects.ⁱ

UNFCCC: Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.

UNDP: Climate change adaptation refers to actions that help reduce vulnerability to the current or expected impacts of climate change like weather extremes and hazards, sea-level rise, biodiversity loss, or food and water insecurity.

UNEP: Adaptation to climate change refers to adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (Source: IPCC, 4th Assessment Report, WG II, Appendix 1, Glossary, 2007)ⁱⁱ

IDSRR: The adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. The broader concept of adaptation also applies to non-climatic factors such as soil erosion or surface subsidence.

EU Action, European Commission: Adaptation means anticipating the adverse effects of climate change and taking appropriate action to prevent or minimize the damage they can cause, or taking advantage of opportunities that may arise. It has been shown that well planned, early adaptation action saves money and lives later.ⁱⁱⁱ

Global Commission on Adaptation: In human systems, the process of adjustment to actual or expected climate and its effects in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate (UNEP, 2018).ⁱⁱⁱ

Green Climate Fund: Adapting to climate change is the process of adjusting and responding to actual or expected climate change and their effects.

With a few exceptions that are highly climate-specific, such as climate data collection and climate risk modeling, enabling communities to adapt means supporting development activities, but doing so in a way that is informed by an understanding of climate change, its effects, and how to cope with its likely consequences.

Multilateral Development Bank (AfDB, ADB, EBRD, EIB, IDBG, WBG): Climate adaptation is undertaken to lower the current and expected risks or vulnerabilities posed by climate change. For a project to be counted towards MDB adaptation finance, it must:

- Set out the climate vulnerability context for the project

- Make an explicit statement of intent to address climate vulnerability as part of the project
- Articulate a clear and direct link between the climate vulnerability context and the specific project activities

Convention on Biological Diversity: In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate (Intergovernmental Panel on Climate Change).^{iv}

b) Risk

The potential for adverse consequences for human or ecological systems, recognising the diversity of values and objectives associated with such systems. In the context of climate change, risks can arise from potential impacts of climate change as well as human responses to climate change. Relevant adverse consequences include those on lives, livelihoods, health and well-being, economic, social and cultural assets and investments, infrastructure, services (including ecosystem services), ecosystems and species.

In the context of climate change impacts, risks result from dynamic interactions between climate-related hazards with the exposure and vulnerability of the affected human or ecological system to the hazards. Hazards, exposure and vulnerability may each be subject to uncertainty in terms of magnitude and likelihood of occurrence, and each may change over time and space due to socio-economic changes and human decision-making.

In the context of climate change responses, risks result from the potential for such responses not achieving the intended objective(s), or from potential trade-offs with, or negative side-effects on, other societal objectives, such as the Sustainable Development Goals (SDGs). Risks can arise, for example from uncertainty in the implementation, effectiveness or outcomes of climate policy, climate-related investments, technology development or adoption, and system transitions.ⁱ

The potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. In the context of climate change impacts, risks result from dynamic interactions between climate-related hazards with the exposure and vulnerability of the affected human or ecological system to the hazards.^v

c) Resilience

The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner including through the preservation and restoration of its essential basic structures and functions through risk management.^{iv}

The capacity of interconnected social, economic and ecological systems to cope with a hazardous event, trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure. Resilience is a positive attribute when it maintains capacity for adaptation, learning and/or transformation.^v

d) Climate Change

A change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings such as modulations of the solar cycles, volcanic eruptions and persistent anthropogenic changes in the composition of the atmosphere or in land use.^v

e) **Disaster Risk Reduction**

DRR is aimed at preventing new and reducing existing disaster risk and managing residual risk, all of which contribute to strengthening resilience and therefore to the achievement of sustainable development (UNDRR, 2016).

f) **Early Warning Systems (EWS)**

The set of technical and institutional capacities to forecast, predict, and communicate timely and meaningful warning information to enable individuals, communities, managed ecosystems, and organisations threatened by a hazard to prepare to act promptly and appropriately to reduce the possibility of harm or loss. Depending upon context, EWS may draw upon scientific and/or Indigenous knowledge, and other knowledge types. EWS are also considered for ecological applications, e.g., conservation, where the organisation itself is not threatened by hazard but the ecosystem under conservation is (e.g., coral bleaching alerts), in agriculture (e.g., warnings of heavy rainfall, drought, ground frost, and hailstorms) and in fisheries (e.g., warnings of storm, storm surge, and tsunamis).^v

g) **Global Warming**

Global warming refers to the increase in global surface temperature relative to a baseline reference period, averaging over a period sufficient to remove interannual variations (e.g., 20 or 30 years). A common choice for the baseline is 1850–1900 (the earliest period of reliable observations with sufficient geographic coverage), with more modern baselines used depending upon the application.^v

h) **Mitigation (of Climate Change)**

Human intervention to reduce emissions or enhance the sinks of greenhouse gases

i) **Vulnerability**

The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and the lack of capacity to cope and adapt (IPCC 2022).



1. Introduction

This chapter explores the major disasters that impacted India in 2024, highlighting their scale, severity, and the challenges they posed to communities and response systems. It examines the widespread floods, cyclones, landslides, droughts, heatwaves, lightning strikes, and forest fires, emphasizing their increasing frequency and intensity. The chapter also delves into the broader implications of these disasters, including displacement, infrastructure damage, economic losses, and environmental degradation. By analyzing these events, this chapter aims to provide a comprehensive understanding of India's disaster landscape, emphasizing the urgent need for strengthened preparedness, resilience-building, and sustainable risk reduction measures.

1.1 About Integrated Centre for Adaptation to Climate Change, Disaster Risk Reduction and Sustainability (ICARS)

Disaster management has shifted from response and relief to a prevention-mitigation and preparedness approach, aligning with climate change adaptation, green-growth, and sustainability policies. India's diverse hazard and vulnerability settings necessitate the implementation of strategic endeavors using action research, policy research, case studies, and knowledge integration. A significant investment is needed in science-policy interface-based interventions to support capacity building and strategic actions at national and local levels. The Integrated Centre for Adaptation to Climate Change, Disaster Risk Reduction and Sustainability ICARS at IITR aims to promote capacities and public policy for resilience and sustainability in multi-hazard environments through policy research, action research, and knowledge integration interventions. The project includes four specialized units: policy planning tools, human capacity building research activities, research case studies, and knowledge integration. The aim is to support research, policy-planning, capacity building, international cooperation, governance, and localization, while engaging with collaborating institutes.

ICARS is a first and unique establishment of Govt. of India (a Joint Centre under DST) at IIT Roorkee's Gr. Noida Campus (NCR) - first ever institution on Adaptation to Climate change in India and this part of the world, and unique as it works on integration of

Adaptation with Disaster Resilience and Sustainability. ICARS's mandate is focused around policy linked research, action research, research to support capacity building, and research integration into policy and operational processes. As a first-of-its-kind joint government centre under DST, ICARS leads the effort to Integrate Policy-linked Research and Capacity Building.



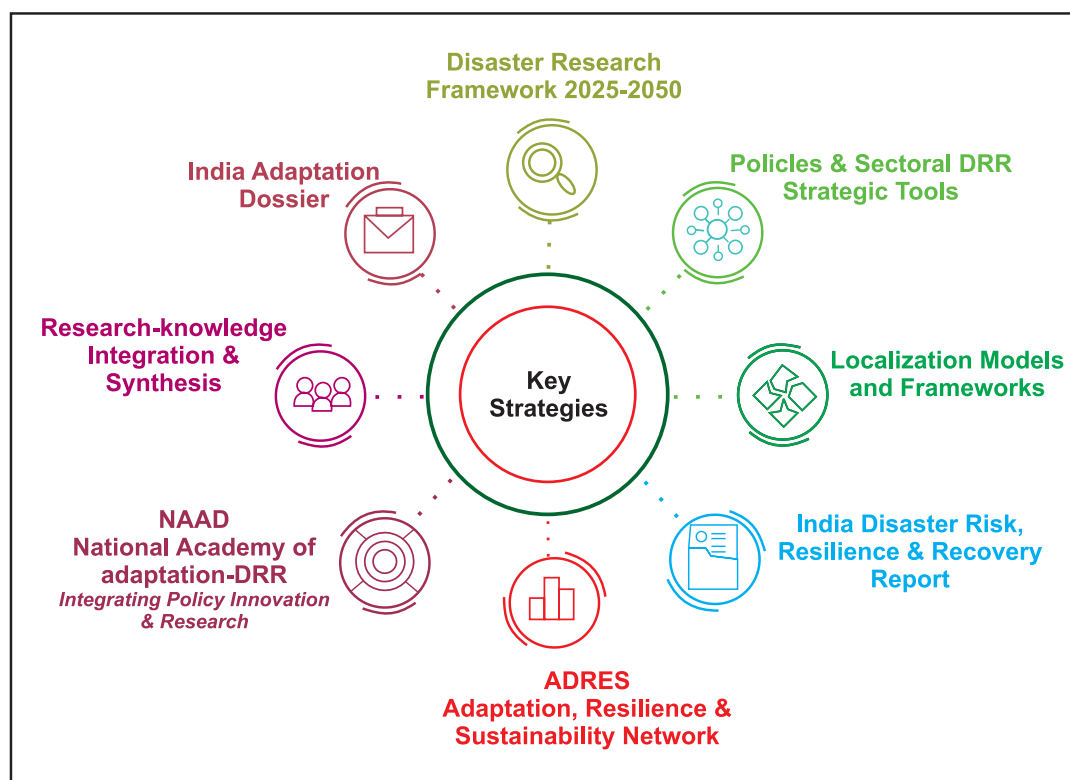


Figure 1: Key Strategies of ICARS, IIT-R

One of the Centre's key objectives is to undertake policy-oriented and action research to support policy formulation, improvement, and implementation across various levels and contexts in relevant areas. An example of such research is a national-level analysis of adaptation status, focusing on identifying needs, gaps, and strategies.

1.2 India Adaptation Dossier

In recent years, India's growing leadership in climate adaptation and disaster resilience has been reinforced through key national and international developments. The proceedings of the 2nd and 3rd National Platforms for Disaster Risk Reduction (NPDRR) underscored the urgent need for data-driven, risk-informed development and a unified climate-disaster database. In line with India's international commitments under the UNFCCC, the country has submitted its Third National Communication (TNC) and Initial Adaptation Communication (IAC), providing a comprehensive overview of national circumstances, sectoral vulnerabilities, and adaptation actions. ^{vii}

These submissions serve as a vital reference for the ongoing development of the National Adaptation Plan (NAP), highlighting the opportunity to align domestic adaptation efforts with global frameworks such as the Paris Agreement and the Sendai Framework.

The India Adaptation Dossier aims to compile adaptation strategies, assess sectoral vulnerabilities, and guide cross-sector coordination. It provides a knowledge base to support policy and planning, while also facilitating an annual stocktaking exercise of climate resilience actions." India Adaptation Dossier will include the followings:

- What: Strategies & Actions (Regional & Thematic)
 Who: Listing of Stakeholders, Institutional Mapping & Organizational Inventory
 Why/ Benefits:
- Addressing the Research Gaps
 - Reducing Duplicity
 - Help Scaling up & Replication of best practices

- Team Building & Consortiums
- Understanding Research Needs
- Understanding Policy Needs

By anchoring itself in the information from the TNC and IAC, the India Adaptation Dossier strengthens the foundation for India's future adaptation policies and supports a climate-resilient development paradigm.

1.3 Need for the Dossier

India's urgent need for robust climate adaptation planning is underscored by the growing evidence of loss and damage linked to climate change. A recent systematic review of 92 peer-reviewed studies reveals that India is already facing both economic and non-economic losses from climate-related events such as floods, droughts, cyclones, heatwaves, and sea-level rise. These losses include damage to infrastructure, agriculture, livelihoods, health, and even intangible assets like cultural heritage, mental well-being, and community cohesion.

Despite the growing burden, the absence of a standardized national database and consistent methodologies makes it difficult to quantify these losses and assess residual risks accurately. Most existing studies are retrospective, with limited insight into future loss and damage scenarios or slow-onset and non-economic losses.

The Third National Communication (TNC) and Initial Adaptation Communication (IAC) submitted to the UNFCCC recognize these challenges and call for enhanced coordination, data systems, and region-specific adaptation approaches. This fragmented yet growing body of evidence points to a clear and immediate need for coherent, data-driven, and regionally tailored adaptation strategies that are aligned with both national development priorities and global commitments under the Paris Agreement and the Sendai Framework.

This dossier responds to the urgent national need for a comprehensive, multisectoral, and regionally nuanced

understanding of climate change adaptation efforts across the country. The key needs this document addresses are:

- **Support for the upcoming National Adaptation Plan (NAP) of India:** India is currently in the process of preparing its first National Adaptation Plan. This dossier is intended to act as a foundational resource for the NAP by providing a structured repository of existing adaptation strategies, programmes, and policies across sectors and geographies. By compiling data and case studies from national, state, and local levels, it aims to strengthen policy alignment and help chart a coherent national strategy for building climate resilience.
- **Multisectoral and Regional Framing of Adaptation:** Adaptation challenges and strategies vary significantly across India's diverse ecological and socio-economic contexts, from glacial hazards in the Himalayas to cyclonic risks in coastal areas. This dossier adopts a regionalized approach, categorizing adaptation responses based on geography and sector, such as health, agriculture, infrastructure, water, and urban development, enabling a more targeted and effective planning framework for decision-makers.
- **Unified Repository of Adaptation Interventions:** A growing number of adaptation-related interventions are being undertaken by government departments, private sector entities, civil society, and academic institutions. However, these efforts are often fragmented and undocumented in a consolidated format. There is a critical need for a central document that collates, evaluates, and categorizes these efforts to identify gaps, avoid duplication, promote replication of good practices, and facilitate synergized action. This dossier serves as that much-needed centralized knowledge product.

By fulfilling these needs, the India Adaptation Dossier is envisioned not just as a record of ongoing work, but as a strategic tool for accelerating India's transition towards a climate-resilient development paradigm.

1.4 Objectives: Specifies the goals of the Dossier

The India Adaptation Dossier aims to comprehensively document the wide-ranging efforts undertaken by national and state governments, as well as non-state actors across India, in the realm of climate adaptation. This dossier serves as a key initiative within an ongoing annual exercise dedicated to analyzing and assessing adaptation strategies, policies, action plans, missions, tools, and case studies implemented at various governance levels.

By capturing and synthesizing these initiatives, the dossier will contribute to a structured and evidence-based annual stocktaking process on climate adaptation and resilience-building efforts. This assessment will provide valuable insights into the progress made across multiple sectors and thematic areas, fostering a holistic understanding of adaptation measures and their effectiveness in addressing climate vulnerabilities. Ultimately, the dossier aims to support informed decision-making, facilitate knowledge exchange, and strengthen collaborative efforts toward a climate-resilient future.

The objectives of the India Adaptation Dossier are to:

- **Document Adaptation Efforts:** Compile and analyze adaptation strategies, policies, and initiatives undertaken by national and state governments, as well as non-state actors.
- **Assess Gaps & Needs:** Identify sectoral and regional vulnerabilities, gaps in adaptation planning, and areas requiring policy or financial interventions.
- **Facilitate Stakeholder Coordination:** Strengthen collaboration among government agencies, institutions, and non-state actors to enhance the effectiveness of climate adaptation efforts.
- **Support Mainstreaming of Adaptation:** Provide insights and recommendations for integrating climate adaptation into sectoral policies, governance structures, and budgetary planning.

- **Enable Evidence-Based Decision-Making:** Offer a data-driven basis for annual stocktaking on climate adaptation progress, informing future policies and investment priorities.

1.5 Expected Benefits

The Adaptation Dossier will serve as a critical resource for multiple stakeholders. It will support the government in developing India's National Adaptation Plan under the NAPCC, and help policymakers identify gaps, set priorities, and align strategies across sectors. For researchers and academic institutions, it offers a valuable evidence base for analysis and innovation. The private sector and market players can use it to align investments with climate-resilient opportunities, while the public benefits through increased awareness and access to adaptation knowledge. Additionally, the dossier will strengthen coordination among ministries and stakeholders, enable tracking and evaluation of adaptation progress, support climate finance decisions, promote mainstreaming of adaptation into development planning, and contribute to long-term disaster risk reduction and resilience building across regions.



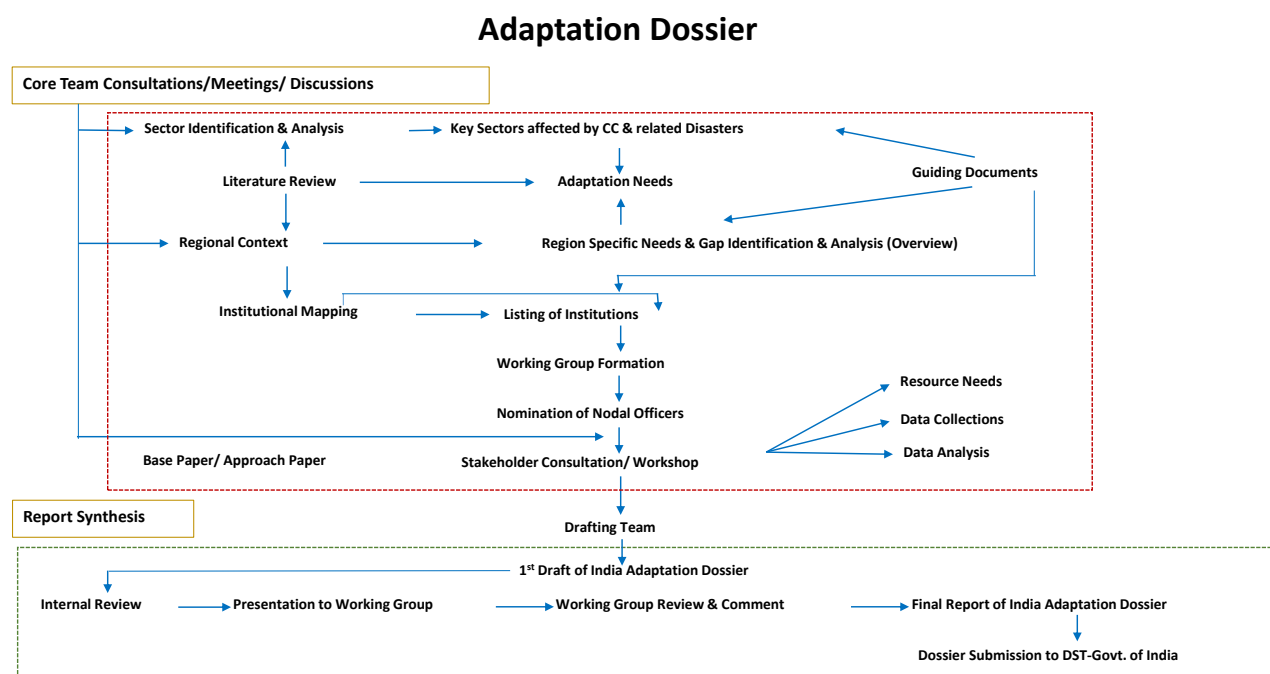


Figure 2: Methodology and process followed for the India Adaptation Dossier

1.6 Methodology

The methodology for the development of Dossier is described below:

- **Multi-Step, Participatory Process:** The methodology for developing the adaptation dossier begins with sector identification, literature review, and analysis of adaptation needs in climate-sensitive sectors.
- **Sector Identification:** Key climate-vulnerable sectors such as agriculture, water, health, ecosystems, infrastructure, and livelihoods were identified based on climate risk assessments, national priorities, and consultative processes.
- **Institutional Engagement & Data Collection:** Institutional mapping, listing of relevant ministries.
- **Drafting & Review Process:** A base/approach paper is developed, followed by the first version of the dossier.
- **High-Level Expert Consultations:** Two high-level consultations were held to present the progress and outcomes of the dossier. These engagements enabled key experts and stakeholders to provide feedback and validate the dossier's approach, findings, and policy relevance.
- **Submission of the final draft to DST:** The final version of the dossier, incorporating expert feedback and institutional inputs, was submitted to the Department of Science and Technology (DST) for consideration, dissemination, and further action.



Figure 3: RESSUMMIT 2025: National Consultation on Disaster Management & Infrastructure Resilience in Changing Climate & Environmental Risks on 10 February 2025 at ICARS, IIT Roorkee (GNEC) where Plenary Session on India Climate Change Adaptation Dossier & Disaster Research Agenda & Framework was organised (Left); National Consultation Meeting was organized on 7th May 2025 at Sanskriti Hall, First Floor, IIPA Campus, New Delhi to discuss the deliverables of the Integrated Centre for Adaptation, Disaster Risk Reduction and Sustainability (ICARS), IIT-Roorkee, Greater Noida Campus (DST Centre of Excellence), including Adaptation Dossier. The event witnessed active participation from dignitaries and experts representing key organizations, including DST, MoES, IMD, NIH, MoRTH, CSIR, IITR, NEERI, ICAR, FAO and many others. (Right)

1.7 Limitations

The key limitations in the current version of the India Adaptation Dossier are shared below:

- While the dossier strives to provide a comprehensive review, it is subject to data availability, methodological constraints in assessing adaptation outcomes, and variations in reporting standards across ministries and states.
- The scope of this dossier is broad, encompassing multiple sectors, ministries, and governance levels. However, it does not claim to be exhaustive, as adaptation is an evolving field with continuous advancements.
- The dossier highlights key initiatives; however, their effectiveness and impact require thorough evaluation through field assessments and stakeholder consultations.
- Data availability was limited to 2023–2024 annual reports from the Ministries.
- Direct consultations with ministries for data collection could not be conducted during this cycle.

- Site visits for ground-level validation were not possible.
- Additionally, the analysis does not encompass all adaptation initiatives at the sub-national or local levels due to the dynamic nature of climate adaptation planning and execution as this version focuses on sectoral analysis; geographic/regional aspects will be included in subsequent versions.

1.8 Context and Background

India is increasingly experiencing the impacts of climate change, from intensifying heatwaves and erratic monsoons to rising sea levels and glacial melt. These changes pose significant risks to lives, livelihoods, and ecosystems across diverse regions of the country. In this context, climate adaptation becomes an urgent necessity, not just an environmental response, but a developmental imperative.

The term “adaptation” describes the capacity of various species, each with unique genetic characteristics, to adjust to a range of conditions such as climate, food availability, habitat, protection, and movement. Climate adaptation specifically refers to the process by which individuals lessen the negative impacts of

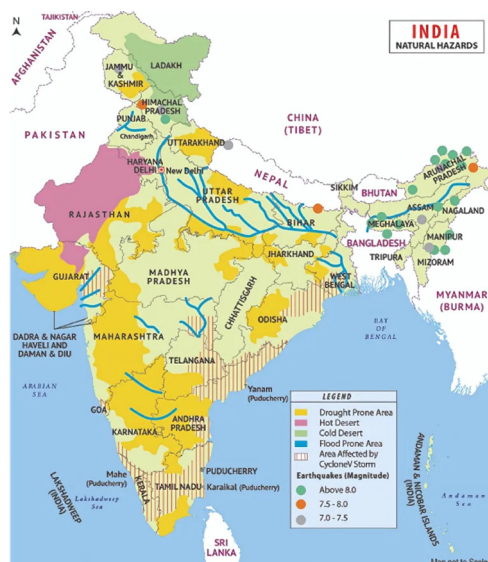


Figure 4: Vulnerability Profile of India (Source: www.mapsofindia.com)

climate on their health and well-being, while also making use of the opportunities presented by their climatic surroundings (Olmos, 2001). Adaptive capacity refers to the potential or ability of a system to respond to and accommodate climatic stimuli (i.e., to modify in order to better suit the conditions), while ‘adaptability’ is defined as the skill, competence, or capacity of a system to make similar adjustments.

Mitigation refers to human interventions aimed at reducing greenhouse gas sources or enhancing their sinks, while adaptation focuses on addressing the impacts of climate change. These two approaches are interdependent and should be addressed together through climate policies. Experts emphasize the need to support climate data with information on socio-economic and environmental resources. Adaptation also involves utilizing genetic diversity and ecosystem resilience, which require national programmes with adequate capacity and sustained support. Thus, Adaptation to climate change and its implications towards disaster management aims at developing a set of abilities to sustain in the given complex scenario of influences along human environment. ^{viii}

Adaptive Capacity is the ability of systems, institutions, humans and other organisms to adjust to potential

damage, to take advantage of opportunities or to respond to consequences. In the Indian context, this means strengthening infrastructure, promoting sustainable agriculture, protecting ecosystems, and supporting vulnerable communities through targeted policies and programs.

India is one of the most disaster-prone countries due to its vast size (3.287 million sq. km) and exposure to extreme climate events such as heatwaves, cyclones, droughts, and floods, worsened by global climate change. The landscape of India is prone to frequent extreme events with 65% being drought-prone, 12% flood prone and 8% prone to cyclones. ^{ix} Over 80% of India’s population reside in districts at risk of climate-change induced disasters. ^x The Indian annual mean surface air temperatures have risen by 0.6 °C century–1 between 1901 and 2018. ^{xi}

Each region of India faces unique climate hazards with the Himalayan Region prone to Avalanches, landslides, glacial lake outburst flood (GLOF) cloudbursts, and severe winter storms. The Western Region of India is prone to Heatwaves, droughts, lightning and the occasional cyclones. Similarly, Eastern and Central India are susceptible to Cyclones, floods, and heatwaves, lightning. The Southern Region of the

country experiences cyclones, floods, lightning and droughts. Coastal and Island Regions of India are also experiencing rising sea levels, storm surges, lightning, and coastal erosion.

India is ranked 127th out of 182 countries in the 2020 ND-GAIN Index, which calculates a country's vulnerability to climate change and other global challenges as well as their readiness to improve resilience. With frequent extreme events exacerbated by climate change every year and high social and economic costs, adaptation is a critical need for India. India is one of the most vulnerable countries to climate change, not only because of its physical exposure to climate-related disasters, but also due to the economic dependency of the majority of its population on climate-sensitive sectors, especially

agriculture and allied activities. The 2017-18 Economic Survey has recognized that farmers will lose between 18-25% of their incomes due to climate impacts, more in the unirrigated areas, which will comprise 40% of the net-sown area even if all irrigation potential is met.^{xiii}

As per the 2021 UNICEF report, India is ranked 26th among 163 countries indicating children in India as most 'at-risk' to the impacts of climate change, affecting their health, education, and protection.^{xiv} The highly vulnerable states in India with respect to current climate risk and the main drivers of vulnerability are Jharkhand, Mizoram, Orissa, Chhattisgarh, Assam, Bihar, Arunachal Pradesh, and West Bengal. Assam, Bihar, and Jharkhand have over 60% of districts in the category of highly vulnerable districts.^{xv}

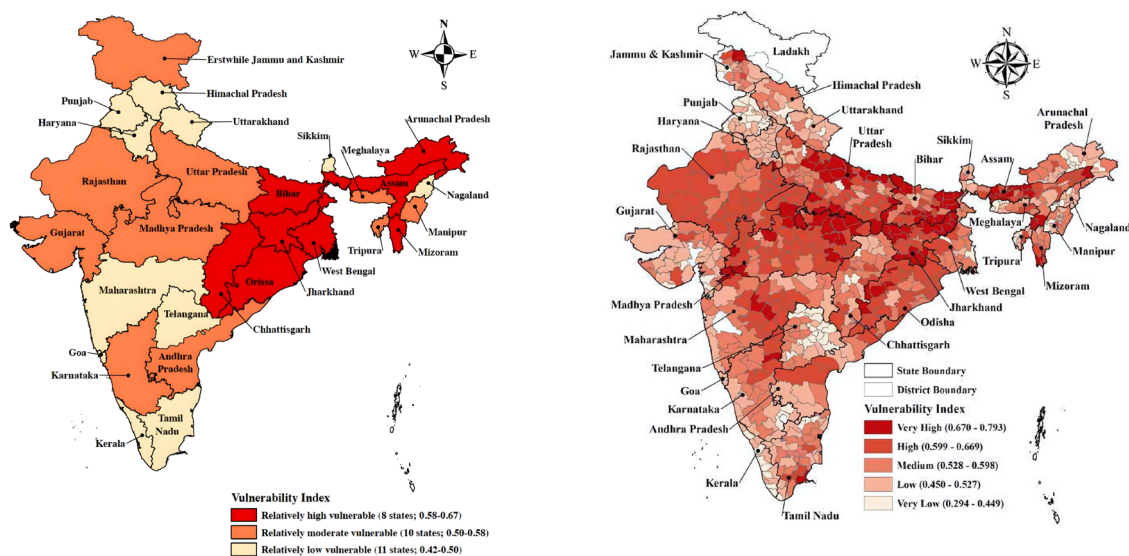


Figure 5 Vulnerability profile of Indian States and Districts (based on range of the vulnerability index).

(Source: Climate Vulnerability Assessment for Adaptation Planning in India using a common framework, 2019-20, DST)

The National Action Plan on Climate Change (NAPCC) charts India's development pathway aligned with addressing climate change effectively. Rising temperatures globally are expected to drive more intense and frequent climate extremes impacting everyday life of Indian citizens. Adaptation refers to the process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities (IPCC 2022).

Adapting to climate change is a necessity that India needs to undertake with intention and initiative. And this exercise needs to be integrated within sectoral and development policies across ministries at the national and state levels and implemented effectively by the states for the local contexts. India has been undertaking several resilience building initiatives in the sphere of disaster risk reduction and social protection over the past few decades. Understanding

and documenting these interlinkages in policies will enable different ministries to scale and report on potential adaptation initiatives. However, there is a lack of systematic methodology to evaluate the extent to which development programs address climate risk and vulnerability.^{xvi} Towards this, the dossier aims to outline indicators on what constitute adaptation activities and aims to classify the schemes under key nodal ministries under the PM's Conclave of Climate Change.

1.9 Recent Global Trends in Climate Change Adaptation Reporting

In recent years, climate change adaptation has gained considerable attention across global and regional platforms. A wave of influential reports and peer-reviewed studies released in 2023 and 2024 has underscored the growing urgency to enhance resilience against climate-induced disruptions. These publications have been pivotal in shaping discourse and action by offering comprehensive assessments of adaptation gaps, showcasing successful case studies, and recommending pathways to scale up implementation. One of the most influential contributions in this period was the IPCC's Sixth Assessment Synthesis Report (2023), consolidated evidence across working groups to highlight the growing but uneven landscape of global adaptation. It documented the scaling up of national adaptation planning in over 170 countries, while simultaneously noting the fragmented nature of implementation and the emergence of limits to adaptation, especially in high-risk regions like coastal zones and mountainous areas.

UNEP's Adaptation Gap Reports (2023 and 2024) further underscored the disconnect between adaptation needs and actual investments. The 2024 edition estimates that the annual adaptation finance gap for developing countries lies between USD 187–359 billion, with current international flows addressing only a fraction of the requirement. These reports strongly advocate for a shift toward anticipatory, strategic, and system-wide adaptation investments, while also calling for innovative financial instruments and greater integration of adaptation into national budgets and development planning.

Similarly, GCA's State and Trends in Adaptation Finance (2023) emphasized the chronic underfunding of adaptation relative to mitigation, with only 5–7% of total climate finance flows directed toward adaptation actions. It warned that adaptation finance must nearly quadruple to meet projected needs by 2030, particularly in vulnerable regions such as Africa and Asia-Pacific.

In the Asia-Pacific context, the Asian Development Bank's Asia-Pacific Climate Report 2024 and UNESCAP's 2024 Review of Climate Ambition both brought regional insights to the forefront. These reports stressed the importance of aligning National Adaptation Plans with development priorities, scaling up nature-based solutions, and building institutional capacity to deal with multi-hazard risks. The Asia-Pacific Disaster Report 2023 by UNESCAP also quantified adaptation investment needs and offered model-based insights into how countries can strengthen resilience through transformative disaster risk reduction.

Alongside these institutional reports, several systematic academic reviews have emerged. For instance, recent publications on India's adaptation responses highlight the predominance of agriculture-focused interventions, the underrepresentation of gender and mountain ecosystems in research, and the need for greater attention to soft adaptation measures like institutional capacity-building and policy reform.

1.9.1 Emerging Themes and Gaps across Global Adaptation Reports (2023–24)

Across these various sources, approximately 10 to 12 major global and regional adaptation reports and academic reviews were published in 2023–24 alone, indicating a sustained momentum in the adaptation discourse. Common themes emerging from these publications include:

- **Finance and Implementation Gap:** Almost all reports underscore a serious shortfall in adaptation finance relative to need. Most of the current financing is heavily mitigation-oriented, leaving adaptation initiatives struggling to mobilize sufficient resources.

- **Integration into Development Planning:** There is a strong emphasis on embedding adaptation into broader development processes particularly through national adaptation plans (NAPs), budgetary alignment, and integration into sectoral policies.
- **Focus on Vulnerable Populations and Systems:** Adaptation actions need to prioritize the most vulnerable, women, urban poor, indigenous populations, and climate-sensitive livelihoods across geographies. However, the research and reporting landscape still underrepresents many of these segments.
- **Nature-based and Systemic Solutions:** Many reports promote ecosystem-based adaptation (e.g., mangrove restoration, urban green infrastructure) and stress the need for systemic changes rather than isolated interventions.
- **Data, Capacity, and Governance:** A recurring recommendation is the strengthening of institutions, localized early warning systems, and risk-informed decision-making frameworks to enable more effective adaptation planning.

1.9.2 Positioning the India Adaptation Dossier: A Unique Two-Pronged Approach

While global and regional reports provide vital macro-level insights, the Adaptation Dossier distinguishes itself through its dual methodology, a combination of sectoral and regional analysis that captures the granular realities of climate adaptation in India.

Unlike many high-level reviews that present broad narratives, this dossier offers a detailed mapping of ministry-wise adaptation interventions across key sectors such as health, agriculture, energy, transport, and water. Simultaneously, it adopts a regional lens, acknowledging the diverse vulnerabilities and adaptive capacities across states and ecological zones. By categorizing interventions across five adaptation indicators: physical, economic, social, environmental, and systemic and four implementation types of policy, capacity-building, technology, and research, this document provides a robust framework for tracking progress and identifying gaps.

The Adaptation Dossier is designed as an annual publication, aiming to track the progress of climate change adaptation interventions year over year. For this inaugural 2023–24 edition, the focus remains solely on sectoral analysis, drawing on data and initiatives led by key Union ministries. Regional analysis will be introduced starting from the next edition, allowing for a more comprehensive understanding of adaptation at both functional and geographic levels.

Together, these approaches will enable a more granular, implementation-focused view of adaptation efforts, something that most global reports acknowledge as necessary but do not attempt at the country level. In doing so, this dossier not only aligns with global adaptation narratives but also advances them through context-sensitive, evidence-based documentation of India's evolving adaptation landscape.

1.10 Climate Change Adaptation Frameworks, Databases, and Research Needs

Over the past years, global scholarship and institutional assessments have collectively strengthened our understanding of climate change adaptation planning, its enabling conditions, and areas requiring urgent attention. The body of literature underscores a growing maturity in frameworks for adaptation assessment, the development of databases and decision-support systems, and the need for region- and sector-specific research to guide future strategies.

1.10.1 Adaptation Frameworks and Metrics

Recent international reports and research papers highlight a shift toward structured frameworks that enable systematic assessment and monitoring of adaptation efforts. The IPCC Sixth Assessment Synthesis Report (2023), for instance, offers a conceptual basis for understanding adaptation progress and constraints, including the typology of hard and soft adaptation limits and the need for integrated governance approaches (IPCC, 2023).

In a landmark paper, Magnan et al. (2023) applied structured expert judgment to evaluate the status of coastal adaptation globally. The study introduced a

quantifiable index of adaptation potential, revealing that current efforts in coastal cities have reached only ~50% of their full potential, with significant variation across high- and low-income countries. Similarly, Garschagen et al. (2024) used systematic scoring to evaluate adaptation in 199 coastal cities, concluding that most are still focused on incremental changes rather than systemic transformation.

These findings support the need for adaptation frameworks that are not only cross-sectoral and forward-looking, but also inclusive of social equity and ecological resilience.

1.10.2 Emerging Adaptation Databases and Decision Tools

Several recent efforts have focused on building adaptation-specific datasets and tracking mechanisms. For example, UNEP's Adaptation Gap Reports (2023, 2024) incorporate adaptation finance flows, national adaptation planning status, and investment estimates into a cohesive global dashboard. The reports stress the necessity for national-level adaptation tracking systems, tailored to sectoral priorities and local capacities (UNEP, 2023; 2024).

In academic literature, Ford et al. (2023) and Singh et al. (2022) have emphasized the co-production of knowledge and participatory data systems as crucial components for ensuring that adaptation data is accessible and actionable, especially for marginalized groups. Urban-focused studies by Garschagen et al. (2024) further argue for localized databases that can inform place-based urban resilience planning.

1.10.3 Identified Needs and Gaps in Adaptation Research

Despite increasing momentum, major research gaps remain in the adaptation field. A systematic review by Vij et al. (2025) finds that only 28% of published studies in India directly focus on adaptation, with most others offering general climate commentary or mitigation-centric insights. The review reveals skewed geographic coverage (with underrepresentation of Northeast India), limited attention to gender and urban

vulnerabilities, and a predominant focus on agriculture over sectors like health and infrastructure.

This imbalance echoes globally. Singh et al. (2022) point out that gender equality and social justice are often missing from adaptation programs, and that adaptation actions can inadvertently reinforce inequalities when poorly designed.

These insights collectively emphasize the need for:

- Greater focus on transformational adaptation
- Systematic impact assessments of adaptation measures
- Inclusion of social, gender, and equity indicators
- Expansion of regional and sectoral research, especially in vulnerable areas.

1.10.4 Framework Adopted for the India Adaptation Dossier

The growing ecosystem of adaptation frameworks, metrics, and databases provides a solid foundation for evidence-based climate action. However, as demonstrated by recent reviews and global assessments, substantial work remains to address data, knowledge, and inclusion gaps, particularly in countries like India where regional disparities and sector-specific vulnerabilities are pronounced.

The Adaptation Dossier aligns itself with this evolving discourse by adopting a unique sectoral and regional methodology, enabling the identification of ministry-led actions while capturing diverse regional risks and capacities. This structured approach ensures not only better tracking of interventions but also the mainstreaming of adaptation across development planning processes.

To do this effectively, the dossier is built around a dual-layered framework:

- Categories of Interventions that describe the type and nature of adaptation actions undertaken
- Adaptation Indicators that assess the impact domain of each intervention

1.10.4.1 Categories of Interventions

S.N.	Category of Interventions	Description
1	Policy and Regulatory Frameworks	This includes government orders, directives, policies, schemes, guidelines, and legal mandates
2	Capacity Building and Skill Development	Training programs, workshops, and initiatives aimed at enhancing institutional adaptive capacity.
3	Technological Innovations and Applied Solutions	Climate-resilient technologies, decision-support tools, and innovative adaptation practices.
4	Research, Data, and Knowledge Systems initiatives	Scientific studies, risk assessments, and knowledge-sharing

Table 1: Intervention Categories

1.10.4.2 Indicators of Interventions

S.N	Indicator	Description
1	Physical	Climate resilient infra e.g flood walls, coastal barriers
2	Economic	Resource allocation towards adaptation projects, cost benefit analysis of adaptation projects, economic benefits
3	Social	The impact of adaptation measures on vulnerable populations (e.g., women, children, marginalized communities,
4	Environmental	Ecosystem restoration projects that contribute to climate change resilience e.g restoration of mangroves, systems for accurate climate projections
5	Systemic	Policy level integration of adaptation into development planning, capacity building initiatives for adaptation planning and executing adaptation projects, institutional arrangements for adaptation planning and implementation. Training to enhance adaptive capacity, effectiveness of capacity building initiatives on enhancing adaptive capacity.

Table 2: Intervention Indicators

This matrixed framework allows the Adaptation Dossier to assess both the strategic intent and the on-ground effectiveness of adaptation initiatives. By applying this structured approach, it becomes possible to identify gaps, overlaps, and priority areas for scaling action in alignment with national climate objectives and local vulnerabilities.

1.11 Stakeholders Analysis: Key Ministries, Organizations, and Networks

The India Adaptation Dossier will be compiled following the following processes:

1. Stakeholder Mapping & Institutional Analysis:

Identify key institutions, government agencies, and non-state actors involved in climate adaptation. Following this, a mapping framework will be developed to categorize stakeholders based on their roles, expertise, and contributions. Nodal officers will be nominated by the relevant departments to form a working group for coordination.

2. Stakeholder Consultations & Regional Workshops: Consultations with policymakers, researchers, and practitioners to gather insights. Regional workshops will be organized to assess region-specific adaptation needs and gaps.

This stage will facilitate discussions on sectoral vulnerabilities, mainstreaming opportunities, and resource requirements.

3. **Approach Paper Development:** Develop a Base Paper/Approach Paper outlining key issues, adaptation strategies, and guiding frameworks. The approach paper will validate findings through stakeholder feedback and refine the analytical framework.
4. **Dossier Compilation & Review:** Following the above exercises to collect and analyze relevant data on adaptation efforts, policies, and case studies, a draft dossier summarizing sectoral analyses, institutional contributions, and policy

recommendations will be developed. The dossier will be shared for internal and working group reviews before finalizing the dossier for dissemination.

As per the framework of the National Platform for Disaster Risk Reduction (NPDRR), ministries and departments have been categorized into Group-A and Group-B to streamline coordination and accountability in climate adaptation and disaster risk reduction efforts. A similar categorization has been adopted for this adaptation dossier to systematically track and analyze sectoral interventions undertaken by various ministries.

Key Stakeholders: Disaster Management and Infrastructure Resilience Working Group	
1	National Disaster Management Authority (NDMA), New Delhi
2	Disaster Management Division, Ministry of Home Affairs (MHA)
3	Ministry of Earth Sciences (MoES)
4	Ministry of Health and Family Welfare (MoHFW)
5	State/UT Disaster Management Authority
6	Defence Geoinformatics Research Establishment (DGRE), DRDO Chandigarh
7	Central Water Commission, Ministry of Jal Shakti (MoJS), New Delhi
8	Central Research Institute for Dryland Agriculture (CRIDA)
9	Ministry of Ports, Shipping and Waterways (MoPS& W)
10	Ministry of Road Transport and Highways (MoRT&H)
11	Ministry of Power (MoP)
12	Ministry of Housing and Urban Affairs (MoHUA)
13	Indian Meteorological Department (IMD), Ministry of Earth Sciences (MoES)
14	Ministry of Railways (MoR)
15	Adaptation Cell, Ministry of Environment, Forest and Climate Change (MoEFCC)
16	Department of Science and Technology (DST)
17	Experts as special invitees as decided by the Chairperson

Table 3: Stakeholders Involved



2. National Adaptation Priorities, Strategies, Policies, Plans & Goals

This chapter outlines India's key national policies, strategies, and commitments related to climate change adaptation. It presents an organized list of plans, goals, and targets that guide the country's resilience-building efforts.

India's approach to climate change adaptation is shaped by a broad framework of policies, strategies, and institutional mechanisms designed to enhance resilience across diverse sectors and geographies. As a country with varied topography and high exposure to climate-related disasters, India requires a coordinated and inclusive adaptation strategy that not only strengthens systems but also addresses vulnerabilities at the grassroots level.

The 2nd session of the National Platform for Disaster Risk Reduction (NPDRR) highlighted key priorities that align closely with this approach. It recommended the promotion and integration of traditional disaster resilience and adaptation practices into mainstream policy and programs. It also emphasized the importance of embedding climate change adaptation and capacity-building measures across critical areas such as resilient infrastructure, public assembly buildings, ecosystems, agriculture-based livelihoods, and business establishments. Moreover, it identified lightning, heatwaves, and climate change adaptation as emerging and urgent issues that demand focused national attention. ^{xvii}

In this context, the current section presents an in-depth overview of India's national adaptation priorities, major sectoral programs, and policy instruments. It examines how these efforts align with international frameworks such as the Paris Agreement while addressing domestic imperatives.

By exploring adaptation initiatives across sectors like water resources, agriculture, infrastructure, and environmental conservation, this chapter aims to map India's evolving climate resilience strategy and offer insights for mainstreaming sustainability into national and regional development planning.

2.1 List of National Policies and Strategies

In order to address climate change adaptation, India has developed a comprehensive policy structure that involves resilience-building initiatives from a variety of industries. These programs seek to improve the nation's preparedness for climate-related disasters, protect vulnerable people, and preserve ecosystems. To guarantee that adaptation is included into development planning, the national and state governments of India have created sector-specific policies, funding mechanisms, and national missions in light of the country's varied geographic and climatic conditions.

2.1.1 National Action Plan on Climate Change

India's main framework for tackling climate change through adaptation and mitigation measures is the National Action Plan on Climate Change (NAPCC), which was introduced in 2008. Rising temperatures, unpredictable monsoons, droughts, cyclones, and sea level rise are just a few of the climate hazards that India, a fast-developing country with a broad range of ecosystems and socioeconomic backgrounds, faces. By incorporating adaptation strategies into

national policies, sectoral development plans, and governance frameworks, the NAPCC significantly contributes to the improvement of climate resilience. The eight national missions that make up the NAPCC's core are each designed to tackle distinct climate-related issues via sustainable resource management, policy interventions, and scientific research.

Thematic missions under the NAPCC:

1. National Solar Mission
2. National Mission for Enhanced Energy Efficiency
3. National Mission on Sustainable Habitat
4. National Water Mission
5. National Mission for Sustaining the Himalayan Ecosystem
6. National Mission for a Green India
7. National Mission for Sustainable Agriculture
8. National Mission on Strategic Knowledge for

Climate Change

The NAPCC's involvement in establishing climate governance at the federal, state, and local levels is among its most important adaptation contributions. The NAPCC promotes State Action Plans on Climate Change (SAPCCs), which enable individual governments to create regional adaptation plans suited to their particular vulnerabilities, in recognition of the fact that climate risks differ by region and industry. The mainstreaming of adaptation strategies into disaster risk reduction, forestry, agriculture, urban planning, and water resource management has been made possible in large part by these SAPCCs. The NAPCC facilitates a coordinated response to climate adaptation difficulties by encouraging cross-sectoral collaboration between ministries, research institutes, and civil society organizations.

Furthermore, the NAPCC has played a vital role in securing climate funds for adaptation. Funding channels like the National Adaptation Fund for Climate Change (NAFCC), which offers focused financial assistance for

climate resilience initiatives in areas that are at risk, have been made easier by it. Additionally, by linking India's adaptation efforts with international agreements like the Paris Agreement, the NAPCC makes it possible for the country to access global climate finance sources like the Global Environment Facility (GEF) and the Green Climate Fund (GCF). Projects associated with sustainable forestry, ecosystem-based adaptation strategies, and coastal preservation have been aided by these funding sources.

Despite its achievements, the NAPCC is still changing to meet new climate issues. To boost adaptation efforts, the government has prioritized climate-resilient infrastructure, nature-based solutions, and improved public-private collaborations in recent years. The NAPCC continues to be a dynamic and developing framework that guarantees adaptation is incorporated into all aspects of national development planning, safeguarding communities, ecosystems, and economic sectors from the effects of climate change as India faces growing climate hazards.

2.1.2 State Action Plan on Climate Change (SAPCC)

The Indian government directed all states and union territories to create their own State Action Plans on Climate Change (SAPCCs) in acknowledgment of the necessity of local and regional adaptation. Although they cater to state-specific vulnerabilities, socioeconomic circumstances, and environmental concerns, these plans are in line with the NAPCC framework. As of February 2023, thirty-four States/ Union Territories (UTs) have prepared their State Action Plan on Climate Change (SAPCC) in line with NAPCC taking into account the State-specific issues relating to climate change.

In order to ensure compliance with the general objectives of the NAPCC, each SAPCC has been tailored to reflect the distinct climatic difficulties and developmental priorities of the individual state. This cooperation makes it easier for the country to adopt a single approach for climate resilience. For example, the NAPCC's National Mission for Sustainable

Agriculture places a strong emphasis on promoting climate-resilient farming methods. In order to improve agricultural sustainability, states like Madhya Pradesh and Odisha have included this goal into their SAPCCs through the adoption of drought-resistant crop varieties and effective water management strategies.

Samples from various SAPCCs:

- **Odisha:** The state's SAPCC places a major focus on enhancing disaster management systems and encouraging sustainable coastal zone management because of its vulnerability to storms and coastal erosion. To protect coastal populations, the plan calls for actions including the restoration of mangroves and the creation of early warning systems.
- **Assam:** Assam's SAPCC concentrates on improving flood forecasting systems and encouraging community-based adaptation solutions because of the state's vulnerability to erosion and flooding. Embankment construction, wetland restoration, and strengthening the resilience of resource-dependent livelihoods are some of the actions taken.
- **Rajasthan:** The SAPCC in Rajasthan stresses rainwater collecting, afforestation, and the cultivation of drought-resistant crop types in response to the state's dry climate and water constraint. Initiatives to improve rural communities' ability to adapt through capacity-building programs are also included in the strategy.
- **Uttar Pradesh:** The SAPCC in Uttar Pradesh is focused on encouraging sustainable farming methods, increasing groundwater recharge, and boosting irrigation efficiency in order to address issues concerning agriculture and water resources. Enhancing institutional structures for efficient climate governance is another key component of the plan.
- **Maharashtra:** To address the state's increasing

water scarcity issues, Maharashtra's State Action Plan on Climate Change (SAPCC) places a strong emphasis on improving water usage efficiency, encouraging rainwater collection, and establishing wastewater recycling programs, especially in urban areas. To maximize water conservation and management, the plan lays out a number of tactics, such as eco-sanitation, enhanced stormwater drainage, and improved irrigation techniques.

- **Karnataka:** Karnataka's SAPCC combines measures for preserving the biodiversity of the Western Ghats while promoting organic farming methods in order to address issues related to agriculture and biodiversity loss. In order to assist farmers, the strategy also places a strong emphasis on advancing research on crop varieties that are climate adaptable.

2.1.3 National Adaptation Fund for Climate Change (NAFCC)

The Government of India created the National Adaptation Fund for Climate Change (NAFCC) in August 2015 to assist with adaptation efforts in states and Union Territories that are most vulnerable to the negative consequences of climate change. In keeping with the goals specified in the State Action Plans on Climate Change (SAPCCs), the fund uses a project-based approach. Among other areas, the NAFCC focuses on funding tangible adaptation projects in forestry, biodiversity, water resources, and agriculture. The goal of these initiatives is to make ecosystems and populations more resilient to climate change and variability.

As of February 2022, the NAFCC had approved 30 projects in 27 states and Union Territories in total (Ministry of Environment, Forest and Climate Change [MoEFCC], 2022). These initiatives are carried out in a way that supports sustainable development and are intended to address particular climate vulnerabilities. The National Bank for Agriculture and Rural Development (NABARD) serves as the National Implementing Institution in charge of project

facilitation and monitoring, while the Ministry of Environment, Forests, and Climate Change (MoEFCC) oversees the NAFCC's implementation.

The NAFCC is essential to strengthening India's resilience to climate change because it provides specific financial resources for climate adaptation, giving vulnerable areas the assistance they need to put successful adaptation plans into place.

2.1.4 Sectoral Policies supporting Climate Adaptation

India's climate adaptation efforts are integrated into various sectoral policies that address critical vulnerabilities in water management, agriculture, disaster risk reduction, and biodiversity conservation. By tackling sector-specific vulnerabilities and encouraging sustainable behaviors across multiple domains, these policies jointly strengthen India's resilience to climate change.

2.1.4.1 Water Management and Agriculture

- **National Water Policy (2012):** The Ministry of Water Resources developed the National Water Policy (2012), which promotes efficient water usage and sustainable irrigation methods while highlighting integrated water resource management. The necessity of conserving water and the advancement of water-saving technologies are also highlighted.
- **National Policy for Farmers (2007):** Smallholder farmers' climate adaptation and sustainable farming practices are the main topics of this policy. In order to improve farmers' lives, it promotes the use of crop types that are climate robust, better irrigation methods, and support networks.

2.1.4.2 Disaster Risk Reduction and Resilience

- **National Policy on Disaster Management, 2009:** A legal basis for risk mitigation, disaster preparedness, and post-disaster recovery is provided by this policy. It promotes community-based disaster preparedness, integrates risk reduction into development planning, and

highlights a comprehensive approach to disaster management.

2.1.4.3 Biodiversity and Ecosystem Conservation

- **National Biodiversity Action Plan (NBAP):** By encouraging conservation-based adaptation techniques, the NBAP makes sure ecosystems can withstand the effects of climate change. It describes steps to conserve biodiversity, use biological resources sustainably, and share the benefits of biological resources fairly.
- **National Plan for Conservation of Aquatic Ecosystems (NPCA), 2013:** National Wetland Conservation Programme (NWCP) was launched by MoEFCC in 1987 and was later merged with the National Lake Conservation Plan to form the National Plan for Conservation of Aquatic Ecosystems (NPCA) in 2013. The goal of the National Wetland Conservation Programme is to preserve wetland habitats, which are essential for controlling climatic variability. It focuses on managing and conserving wetlands to preserve their hydrological and ecological services.
- **National Agroforestry Policy (2014):** India was the first nation to implement a national agroforestry strategy in 2014, which aimed to integrate trees, crops, and cattle on the same piece of land. By encouraging tree-based farming systems, this strategy increases agricultural resilience, boosts production, and supports environmental sustainability. Other initiatives include Green India Mission, National Mission on Himalayan Studies, State Compensatory Afforestation Funds etc.

2.1.5 Climate Resilience and Adaptation Strategies

Programs for Climate-Resilient Agriculture: India has started initiatives to promote sustainable farming methods in recognition of the vital role that agriculture plays in society. The creation and dissemination of climate-resilient seed types, for example, aims to increase crop yields and resist

pests and illnesses. In the forthcoming crop season, Prime Minister Narendra Modi intends to plant at least 25% of paddy land with the 109 seed varieties he recently announced.

Engagement of the Private Sector: Through public-private partnerships, India promotes corporate investment in climate adaptation such as Pradhan Mantri Fasal Bima Yojna (PMFBY). To encourage renewable farming methods, businesses such as Varaha are working with smallholder farmers in Africa and South Asia. This program benefits the environment and the livelihoods of farmers by maintaining carbon in the soil and producing high-quality carbon credits.

Nature-based Solutions (NbS): The country is increasing its afforestation, wetland restoration, and mangrove conservation efforts. These natural remedies improve biodiversity, sustain livelihoods, and function as buffers against the effects of climate change.

Planning for Climate-Resilient Cities: The development of smart cities with heat-resistant infrastructure and effective water management systems is becoming a greater priority for urban regions. For instance, India plans to spend around \$300 million over two years to combat urban flooding and save water in Bengaluru, Chennai, Mumbai, and other large cities. To address frequent and severe flooding, this plan entails constructing new drainage systems and enlarging water bodies. Other initiatives include Smart Cities Mission, 2015, AMRU, 2015 etc.

2.2 “List of Plans, Goals and Commitments

In order to combat climate change and promote sustainable development, India has made important commitments and set significant goals. The nation has taken aggressive measures to meet its climate ambitions, with a focus on cutting emissions, increasing renewable energy, improving climate resilience, and encouraging sustainable lifestyles. India is striving for a more environmentally friendly future with projects like the LIFE movement, extensive afforestation projects, and developments in climate technology. Furthermore, the country

has exceeded important Nationally Determined Contribution (NDC) goals ahead of time and shown leadership in renewable energy, especially solar power. India’s major climate pledges, objectives, and accomplishments are listed in this section, along with the country’s progress.

2.2.1.1 Commitment and Goals

1. Promoting a Sustainable Lifestyle for Climate

Action: India has committed to advancing a sustainable way of living through the LIFE (Lifestyle for Environment) initiative, which encourages environmentally conscious behavioural changes among individuals and communities. This initiative aligns with India’s traditional conservation practices and aims to reduce carbon footprints at the grassroots level.

2. Reducing Emissions Intensity of GDP: India has pledged to reduce the emissions intensity of its GDP by 45% by 2030 compared to 2005 levels. By 2019, emissions intensity had already decreased by 33%, demonstrating strong progress toward this goal. According to India’s Third National Communication (TNC) to the UNFCCC, this reduction is primarily attributed to enhanced energy efficiency, industrial decarbonization, and policy-driven emissions control.

3. Expanding Renewable Energy Capacity: India has committed to ensuring that 50% of its total installed electric power capacity comes from non-fossil fuel sources by 2030. As of October 2023, India had achieved 43.81% of this target, with a total of 186.46 GW of installed non-fossil fuel capacity. India is also one of the world’s top five countries in installed solar power capacity, contributing to global renewable energy goals through the International Solar Alliance (ISA).

4. Creating an Additional Carbon Sink: India aims to create an additional carbon sink of 2.5 - 3 billion tonnes of CO₂ equivalent through afforestation and tree cover expansion by 2030. Between 2019 and 2021, India increased its forest and tree cover by 2,261 sq. km, contributing to this long-term target. Various

national afforestation programs, including the Green India Mission, have been instrumental in achieving this progress.

5. **Strengthening Climate Adaptation Investments:**

Recognizing the vulnerabilities posed by climate change, India is investing in agriculture, water resources, the Himalayan and coastal regions, health, and disaster management to enhance resilience. The National Adaptation Fund for Climate Change (NAFCC) supports these efforts, funding 30 adaptation projects across 27 states and Union Territories.

6. Mobilizing Climate Finance: To support its mitigation and adaptation initiatives, India is mobilizing domestic financial resources and securing international funding from sources such as the Green Climate Fund (GCF) and Global Environment Facility (GEF). India has also been advocating for climate justice by urging developed nations to fulfill their financial commitments under the UNFCCC's Loss and Damage Fund.

7. **Advancing Climate Technology and Research:**

India is focused on technological innovation and scientific research to accelerate climate action. Two key missions under the National Action Plan on Climate Change (NAPCC), the National Mission for Sustaining the Himalayan Ecosystem (NMSHE) and the National Mission on Strategic Knowledge for Climate Change (NMSKCC), are driving climate resilience research, glaciology studies, and extreme weather modelling.

8. India has shifted investments from hydropower to solar energy and other renewable sources, with solar receiving 35% of investments and wind energy 11%. A significant push towards energy efficiency is needed, with a global call for tripling investments in energy efficiency by 2030.

9. Introduction of ethanol blending (E20 fuel) in petrol to reduce reliance on fossil fuels. Expansion of metro rail networks and electric buses in major cities.

Additionally, India has established 11 State Climate Change Cells (SCCCs) across multiple states, launched a Centre of Excellence on Climate Change Research (DST-CoE-CCR) at the University of Allahabad, and is conducting climate risk research at IIT Gandhinagar.

2.2.1.2 Achievements

- India has already achieved two key NDC targets well ahead of 2030:
 - Reduced emissions intensity by 33% between 2005 and 2019 (on track to meet the 45% target).
 - Achieved 43.81% of its non-fossil fuel installed power capacity, surpassing the initial 40% target
- **Solar Energy Leadership:** India has become a global leader in solar power, with over 70 GW of installed solar capacity. The country's solar power generation has increased by 24 times in the last decade, reflecting its commitment to clean energy expansion.
- **Sustainable Cooling and Climate-Resilient Infrastructure:** At COP28, India showcased its progress in sustainable cooling technologies, resilient infrastructure, and climate-smart urban planning under the "One Sun, One World, One Grid" initiative.
- **Strengthening Climate Research and Policy Advocacy:** India has played an active role in global climate negotiations, particularly in advancing research on climate change vulnerability in the Himalayan region. At COP28, India hosted key discussions on green mountain communities and climate-resilient development strategies.

India's ambitious objectives, calculated actions, and noteworthy successes in carbon reduction, the growth of renewable energy, and climate adaptation demonstrate the country's dedication to climate action. The country has shown its commitment to a low-carbon future by surpassing important NDC

standards ahead of schedule and leading international efforts in sustainable energy. However, attaining long-term sustainability will require sustained investments in energy efficiency, afforestation, climate finance, and technological innovation. India continues to play a significant role in the global battle against climate change as it strengthens its climate policies and international partnerships, serving as a model for developing countries aiming for environmentally resilient and green growth.



3 Climate Adaptation Strategies

This chapter highlights various adaptation strategies- structural and non-structural, across various themes, with examples. The chapter further describes adaptation strategies and measures for different sectors and regions. It also describes the Eco-based adaptation strategies, Model laws and regulations related to adaptation, Stakeholder Engagement Strategies, along with International Engagements.

Climate change adaptation strategies are essential to reduce vulnerability and enhance the resilience of communities, ecosystems, and systems against the adverse impacts of climate change. In this dossier, a comprehensive set of adaptation strategies has been compiled and categorized to facilitate an integrated and actionable understanding. These strategies are broadly divided into structural and non-structural approaches. Structural strategies include physical, ecological, and technological interventions such as nature-based solutions, climate-resilient infrastructure, and ecosystem-based adaptation, aimed at directly mitigating the physical impacts of climate hazards. In contrast, non-structural strategies encompass policy reforms, capacity building, social inclusion, participatory governance, and data-driven planning, which support systemic resilience and enable communities to adapt through behavioral, institutional, and knowledge-based mechanisms. This classification helps identify opportunities for convergence and coordinated action across sectors and governance levels in order to build climate-adaptive systems at scale.

3.1 Adaptation Strategies

Strategies for adaptation involve essential actions designed to lessen the susceptibility of ecosystems, economies, and communities to the negative effects of climate change. By combining scientific advancements, traditional wisdom, and legislative initiatives, these tactics seek to increase resilience and reduce the hazards brought on by extreme weather, warming temperatures, and shifting precipitation patterns. Early warning systems, capacity building, and policy reforms are examples of non-structural adaptation strategies.

Structural adaptation strategies include flood barriers and climate-resilient infrastructure. In a rapidly changing climate, communities can reduce disruptions, protect livelihoods, and advance sustainable development by implementing proactive and region-specific adaptation methods.



Climate Change Adaptation Strategies		
Category	Theme	Example of Adaptation Strategies
Structural Adaptation Strategies	Grey Infrastructure	• Construction of climate -resilient embankments and levees
		• Elevated roads and flood -proof housing
		• Urban stormwater drainage systems
	Water Management Infrastructure	• Check dams, rainwater harvesting structures
		• Climate-resilient irrigation canals
		• Wetland restoration with bunding
	Ecosystem -based Adaptation	• Mangrove replantation with embankment support
		• Bio-shields (casuarina, bamboo) along coastlines and rivers
		• Green belts in urban areas
	Nature-based Solutions	• Permeable pavements and green roofs
		• Restoration of urban lakes with integrated blue -green infrastructure
	Health and Shelter	• Climate-resilient Primary Health Centres (PHCs)
		• Multi-hazard resilient shelters for floods, heatwaves, cyclones
	Agriculture	• Climate-resilient storage infrastructure (for grains, fodder)
		• Solar-powered cold chains and irrigation systems
		• Flood resilient farming techniques
Non-Structural Adaptation Strategies	Capacity Building	• Decentralized renewable energy infrastructure (e.g., microgrids in remote areas)
		• Elevated power distribution networks
		• Individual Capacity Building
	Governance	• Institutional Capacity Building
		• Community Capacity Building
	Policy and Planning	• Integrating climate risk into NDMPs/SDMPs/DDMPs /GPDPs
		• State Action Plans on Climate Change (SAPCCs)
		• Land use planning with climate lens
	Social Inclusion	• Climate budget tagging
		• Risk-informed urban planning regulations
	Education and Awareness	• GEDSI (Gender Equality, Disability, and Social Inclusion) adaptation planning
		• Inclusion of indigenous and disabled communities in adaptation design
	Financial Instruments	• Integration of climate literacy in school curricula
		• Mass campaigns on sustainable water and energy use
		• Climate risk insurance for farmers and MSMEs
		• Contingency funds for local adaptation

Climate Change Adaptation Strategies		
Category	Theme	Example of Adaptation Strategies
	Technology and Innovation	● Viability gap funding for NBS
		● Climate data platforms for real -time monitoring
		● Use of GIS for vulnerability mapping
		● Mobile apps for early warnings
	Inter-Agency Coordination	● Joint Early Warning and Disaster Preparedness Planning
		● Coordination among various departments and ministries

Table 4: Climate Change Adaptation Strategies

3.2 “Description of Adaptation Strategies and Measures for Different Sectors and Regions”

Numerous climatic hazards that different regions and economic sectors experience are being dealt with by India’s adaptation plans. Adaptation plans concentrate on region-specific vulnerabilities because of the nation’s vast and ecologically diverse geography, making sure that climate resilience gets built into governance frameworks, policy implementation, and community-led projects.

3.2.1 Coastal Regions: Strengthening Ecosystems and Infrastructure Resilience

The requirement to fight storm surges, saline water intrusion, and rising sea levels is what essentially induces adaptation in coastal areas. Protecting coastal populations requires the use of Ecosystem-based Adaptation (EbA) practices such as sand dune stabilization, wetland restoration, and mangrove conservation. These plans are being recognized by states like Tamil Nadu, West Bengal, and Odisha in along with engineered solutions like embankments and seawalls. In order to provide rapid evacuation and disaster preparedness, early warning systems (EWS) for cyclones, storm surges, and tidal flooding are being set up as part of coastal adaptation efforts. In order to reduce the dangers brought on by extreme weather events, coastal urban development also including climate-resilient infrastructure, such as elevated houses and improved drainage networks.

3.2.2 Agriculture-Dependent Regions: Promoting Climate-Smart Farming and Water Conservation

The objective of methods of adaptation in agriculture-dependent areas, which make up a significant portion of India’s rural economy, is to strengthen the availability of food and increase farming families’ quality of living. Agroforestry, micro-irrigation systems, and drought-resistant crop varieties are examples of climate-smart agriculture (CSA) practices that are being widely promoted. Initiatives such as the National Mission on Sustainable Agriculture (NMSA) encourage sustainable agriculture and the blending of traditional farming methods with modern technologies. Furthermore, governments like Rajasthan, Maharashtra, and Madhya Pradesh have placed a major focus on changing to climate-resilient cropping patterns, such as promoting millets and other resilient crops in semi-arid areas. Flood-resistant varieties of seeds and floating farming techniques are under consideration for maintaining productivity in flood-prone agricultural regions like Bihar and Assam. In order to reduce reliance on water and improve soil moisture retention, government programs are providing benefits for water-efficient irrigation methods including sprinkler and drip irrigation.

3.2.3 Urban Areas: Building Climate-Resilient Cities and Infrastructure

With respect to the unique climate problems that urban regions face, heat stress, water scarcity, and flooding, adaptation techniques that combine nature-

based solutions with climate-resilient infrastructure are needed. Permeable pavements, urban wetlands, vertical gardens, and green roofs are being used by cities to improve water absorption and control heat islands. Climate-responsive design is being promoted by smart city efforts, which make sure that new construction follows environmentally friendly and thermally adaptive plans. In addition, floodplain zoning, sustainable urban drainage systems, and enhanced waste management techniques are being developed to lessen urban flooding, especially in densely populated metropolitan areas like Delhi, Chennai, and Mumbai. In order to help reduce urban emissions while improving air quality, the National Mission on Sustainable Habitat also places a significant value on adaptive transportation options, such as expanded metro rail networks, pedestrian-friendly urban planning, and the use of electric vehicles.

3.2.4 Water-Stressed Regions: Ensuring Sustainable Water Management

The key objectives of adaptation strategies in regions with water shortages are to increase water availability, conserve it, and distribute it fairly. In states like Gujarat and Rajasthan, groundwater depletion is a serious issue that has led to the establishment of aquifer recharge, spring-shed management, and rainwater collecting methods. By supporting community-led groundwater management, the Atal Bhujal Yojana (ABHY) allows local government organizations to put climate-resilient water security plans into action. Furthermore, to improve water resource planning and predict future trends in water availability, technological advances like high-resolution climate scenario mapping are being used. Integrated river basin management strategies and embankment strengthening are being used in flood-prone riverine regions to increase resilience and prevent water-related disasters.

3.2.5 Mountainous and Himalayan States: Strengthening Disaster Preparedness and Ecosystem Restoration

The goal of climate adaptation in mountainous and Himalayan states is to reduce the dangers of landslides, extreme weather change, and glacial lake outburst floods

(GLOFs). In states like Uttarakhand, Himachal Pradesh, and Arunachal Pradesh, early warning systems and remote sensing technology are being used to monitor glacial melt and predict the possibility of disasters. In order to stop soil erosion and reduce the occurrence of landslides, afforestation and slope stabilization activities are also being carried out. Along with this, adaptation strategies such as spring rejuvenation and rainwater harvesting are also practiced in mountainous and hilly states under ecosystem restoration measures. In some areas, traditional architectural techniques, like building homes with wooden frameworks that can endure seismic shocks, are being revived to be included in climate-resilient building codes. Additionally, local farmers are adjusting to changing climate trends while maintaining soil fertility and retention of moisture because of community-driven projects promoting sustainable mountain agriculture, such as terrace farming and mixed cropping.

3.2.6 Cross-Sectoral Adaptation: Leveraging Technology and Stakeholder Collaboration

India's adaptation plans are gradually applying digital tools, climate information services, and capacity-building programs to improve resilience across all sectors. Disaster preparedness and long-term adaptation planning have been strengthened by the use of big data analytics, artificial intelligence (AI) for climate modelling, and satellite-based climate monitoring. To make sure that resilience-building is built into national development goals, ministries and local governments are including climate adaption measures into policy frameworks. To scale up successful measures and ensure that climate adaptation is inclusive and sustainable, multi-stakeholder collaborations, such as public-private partnerships and community-led adaptation programs, are essential. India is improving its capacity to address climate threats across its various regions and economic sectors by giving attention to a mix of ecosystem restoration, policy-driven adaptation, and advances in technology.

3.3 Locally Led Adaptation (LLA)

Local communities are often the most exposed to the impacts of climate change, yet they rarely have

a voice in the decisions that directly affect them. Locally Led Adaptation (LLA) promotes a shift in approach where local actors and communities are empowered to lead the planning and implementation of adaptation actions. It recognises the importance of local knowledge, priorities, and capacities in designing effective and sustainable responses to climate risks.

LLA supports the transfer of decision-making

authority and control over resources to local actors. At the same time, it focuses on strengthening the ability of local institutions to be inclusive, responsive, and flexible in dealing with uncertainties posed by climate change.

The goal is not only to localise control but also to enable local actors to drive climate action in a way that is socially just and rooted in the context of their needs and realities.

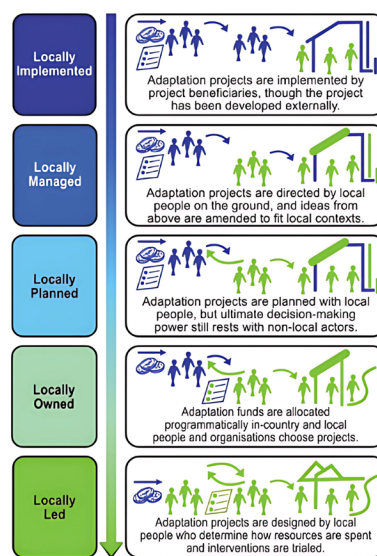


Figure 6 | Continuum of local contributions to adaptation programmes and projects.

(Source: Rahman, M.F., Falzon, D., Robinson, Sa. et al. Locally led adaptation: Promise, pitfalls, and possibilities. *Ambio* 52, 1543–1557 (2023). <https://doi.org/10.1007/s13280-023-01884-7> | <https://link.springer.com/article/10.1007/s13280-023-01884-7>)

3.3.1 Principles of Locally Led Adaptation

- Devolving decision-making to the lowest appropriate level to improve relevance and ownership
- Addressing structural inequalities experienced by women, youth, persons with disabilities, displaced people, Indigenous Peoples, and other marginalised groups
- Ensuring predictable and accessible funding that can support locally driven adaptation
- Investing in local capabilities to build long-term institutional strength
- Enhancing local understanding of climate risks and uncertainties through continuous learning
- Supporting flexible programming that allows adaptation to changing conditions
- Promoting transparency and accountability in local adaptation planning and financing
- Enabling collaboration among public institutions, private sector, civil society, and communities for effective joint action

However, some concerns remain. Local actors may prioritise immediate strategic needs, lack technical or

institutional capacity, or face challenges in managing adaptation funds. Local elites may dominate decision-making, and high transaction costs can discourage investment at the local level.

Despite these challenges, local actors including subnational governments, enterprises, community-based organisations, and households can be pivotal in implementing meaningful adaptation. With the right support, they can manage risks, resolve trade-offs, shift behaviours, and drive inclusive and scalable climate action.

3.4 Ecosystem-based Adaptation (EbA) Resilience

The strategy known as Ecosystem-Based Adaptation (EbA) uses ecosystem services and biodiversity to assist communities in adapting to the negative consequences of climate change. EbA lessens human populations' vulnerability to climate-related risks by preserving, repairing, and maintaining ecosystems such as forests, wetlands, and coastal regions, in a sustainable manner. For example, well-managed wetlands can absorb extra rainfall, reducing the risk of flooding, while healthy mangrove forests can act as natural barriers against storm surges. A key aspect of EbA is its emphasis on participatory, culturally appropriate, and gender-sensitive approaches, ensuring that adaptation strategies are inclusive and equitable. This involves integrating traditional knowledge with scientific research, fostering collaborative planning between local communities, scientists, and policymakers. Such collaboration ensures that adaptation measures are tailored to specific ecological and social contexts, enhancing their effectiveness and sustainability. EbA is a portion of the more general idea of nature-based solutions and has similarities with approaches such as climate-smart agriculture and ecosystem-based disaster risk reduction. Together, these strategies seek to strengthen social-ecological systems' resilience to the linked problems of biodiversity loss, climate change, and human well-being. The inclusion of EbA into international frameworks like the Paris Agreement and state policy highlights how well accepted

it is as a practical and affordable approach to climate adaptation. EbA provides an extensive route to sustainable development in the face of climate change by combining conservation and development objectives.

3.4.1 Information on EbA Strategies for Enhancing Resilience

By using natural ecosystems to reduce risks and increase adaptive capacities, ecosystem-based adaptation (EbA) methods are essential for increasing resilience to climate change. Through the preservation, restoration, and efficient management of ecosystems such as forests, wetlands, mangroves, grasslands, and agricultural landscapes, EbA provides sustainable solutions as climate change worsens extreme weather events, sea level rise, and ecosystem degradation. In addition to lowering vulnerabilities, these nature-based solutions give communities long-term socioeconomic and environmental advantages, maintaining their capacity to adapt to climate change.

Restoring mangroves in coastal areas is one of the best EbA tactics since they act as a natural barrier against tidal waves, storm surges, and coastal erosion. Mangrove conservation is essential because cyclones and rising sea levels are posing a growing threat to India's vast coastline. Mangrove ecosystems that have been restored, like those in the Sundarbans and Odisha, have shown promise in lessening the effects of cyclones while also sustaining local fisheries and rich biodiversity, both of which are essential for economic survival. By absorbing wave energy and preventing shorelines from eroding, coral reef restoration also offers crucial coastal protection. Afforestation programs like the Green India Mission help restore degraded lands, increase groundwater recharge, and stabilize riverbanks; wetlands like the East Kolkata Wetlands act as natural water purifiers, improving water quality while mitigating urban flooding; riparian buffer zones, established along rivers and lakes, help reduce soil erosion, control sediment flow, and maintain water quality, ensuring sustainable water availability for communities; and inland regions, watershed management through afforestation and soil

conservation plays a significant role in regulating water cycles, preventing flash floods, and reducing drought risks.

Another important area where EbA measures make a substantial contribution is agricultural resilience. Agroforestry, crop diversity, and sustainable irrigation are examples of climate-resilient farming techniques that increase output while lowering reliance on artificial fertilizers and pesticides. By adding trees to agricultural landscapes, for example, farms become more resilient to heat stress and protracted droughts because they give shade, increase soil fertility, and lower evapotranspiration. Rainwater harvesting and organic farming, which are extensively encouraged by programs like the Paramparagat Krishi Vikas Yojana (PKVY), improve soil moisture retention and groundwater recharge, increasing the climate resilience of agricultural systems. Urban forests, vertical gardens, green roofs, and permeable pavements are examples of green infrastructure solutions that help regulate temperature, enhance air quality, and manage stormwater in urban areas. These steps are being taken more frequently in Indian towns to lessen the risk of flooding and fight the urban heat island effect. For instance, Mumbai and Chennai have added rain gardens and bio-swales to improve flood resilience, while New Delhi has put in place a number of green corridors to reduce city temperatures. Urban planning that incorporates nature-based solutions can greatly lower the hazards to public health and infrastructure from flooding and excessive heat.

By involving local communities in conservation initiatives, EbA contributes significantly to social and economic resilience in addition to ecological and infrastructure resilience. The Zabo farming system in Nagaland and the community-led water conservation initiatives in Rajasthan are two examples of indigenous and traditional knowledge systems that show how successful nature-based strategies are at providing sustainable livelihoods. By giving people alternate means of income through ecotourism, sustainable fishing, and afforestation, participatory ecosystem restoration programs strengthen local communities.

The incorporation of EbA strategies within national climate adaptation plans, disaster risk reduction (DRR) plans, and policy frameworks is crucial to their effectiveness. Nature-based adaptation solutions are actively promoted across different ecological zones by government programs like the National Action Plan on Climate Change (NAPCC) and the National Adaptation Fund for Climate Change (NAFCC). To ensure context-specific resilience-building strategies, state governments have also incorporated EbA ideas into their localized climate action plans.

Cross-sectoral cooperation between governmental organizations, academic institutions, non-governmental organizations, and the commercial sector is essential to maximizing the potential of EbA. To scale up nature-based adaptation options in India, it is imperative to increase institutional capacities, provide sufficient finance for EbA initiatives, and raise community awareness. As the advantages of EbA are increasingly acknowledged, India is in a strong position to include ecosystem-based approaches into its long-term framework for climate resilience, guaranteeing a sustainable and adaptable future for communities that are at risk.

3.4.2 Guidance on Integrating EbA into Adaptation Plans

In order to improve resistance to climate change, Ecosystem-Based Adaptation (EbA) must be incorporated into climate adaptation strategies using a methodical methodology that harmonizes ecological, social, and economic objectives. Understanding how natural ecosystems may reduce climate risks and integrating nature-based solutions into national, state, and local adaptation plans are important first steps. In order to guarantee that ecosystem restoration and conservation become essential elements of resilience planning, governments should give EbA top priority in their National Adaptation Plans (NAPs), State Action Plans on Climate Change (SAPCCs), and Disaster Risk Reduction (DRR) strategies. For EbA integration to be successful, a science-based strategy is essential. In order to pinpoint regions where ecosystems offer crucial adaptation services like flood control, water

retention, and coastal protection, vulnerability assessments and ecosystem risk evaluations must be carried out. Policymakers can identify places that would most benefit from ecosystem restoration efforts, such as wetland conservation in flood-prone areas or mangrove reforestation in coastal areas that are prone to cyclones, by using Geographic Information System (GIS) mapping and climate modelling.

Community involvement should be combined with policy integration to make sure that adaption plans consider local requirements and traditional ecological knowledge. Involving farmers, fishermen, and indigenous populations in decision-making promotes sustainability and ownership of EbA projects. To scale up EbA activities, financing channels are essential. Under climate finance programs like the Green India Mission, the Compensatory Afforestation Fund Management and Planning Authority (CAMPA), and the NAFCC, governments should set aside specific money for nature-based adaptation. Financial support for EbA projects can also be improved by utilizing global financing sources like the Green Climate Fund and public-private partnerships.

To mainstream EbA across various governance levels, cross-sectoral cooperation is crucial. Integration of EbA into other policy areas can be enhanced by coordination between agricultural departments, urban planners, environmental ministries, and disaster management organizations. Programs that increase the capacity of practitioners, government representatives, and local stakeholders can also enhance the execution and oversight of EbA initiatives. Plans for adaptation should include EbA monitoring mechanisms with measurable indicators to assess ecological and socioeconomic gains to guarantee long-term effectiveness. Feedback systems, citizen science projects, and frequent effect evaluations can all aid in improving adaptive learning and strategy refinement. Through integrating EbA into national and subnational policies, enhancing institutional capabilities, and encouraging multi-stakeholder involvement, India may efficiently utilize ecosystem services to increase climate resilience and protect livelihoods.

Best Practice: Jal Utsav – Promoting Water Conservation:

The Gujarat government and the Dholakia Foundation cooperate to arrange the annual Jal Utsav celebration, which was introduced in November 2023. The event, which combines environmental awareness with cultural participation, is being held in Dudhala, Amreli district, with the goal of encouraging water conservation and sustainable practices. By creating more than 140 lakes throughout Gujarat, which together store more than 15 billion liters of water, Jal Utsav, known as India's first carbon-neutral festival has significantly improved water conservation. This large water restoration project has increased drought resistance, reduced water scarcity, and enhanced groundwater recharge. Jal Utsav ensures long-term sustainability by fostering a sense of environmental responsibility through the active participation of local people in conservation initiatives.

Lessons learned:

- In order to ensure long-term sustainability and impact, community engagement is key to the success of water conservation efforts.
- Projects to restore ecosystems can be more effective when traditional water management is combined with modern interventions.
- Large-scale environmental initiatives can incorporate carbon neutrality by using sustainable methods and strategic planning.

Best Practice: Green Credit Programme: Incentivizing Environmental Restoration:

The Green Credit Program was introduced by the Ministry of Environment, Forests, and Climate Change in October 2023 as part of the Lifestyle for Environment (LiFE) campaign. In order to improve ecosystem resilience, this market-based mechanism encourages voluntary environmental actions by people, communities, businesses, and the private sector. The program encourages the planting of trees, the conservation of water, sustainable agriculture, waste management, the reduction of air pollution, the preservation of mangroves, eco-labelling, and the

construction of sustainable infrastructure. The program promotes widespread involvement in ecosystem restoration by linking conservation initiatives with monetary rewards. By encouraging biodiversity conservation, improving carbon sequestration, and promoting nature-based solutions for climate adaptation, the Green Credit Programme is consistent with EbA principles. Its well-organized organization offers a template for combining financial rewards with ecological sustainability, showing how market-driven strategies can support conservation initiatives led by policy.

Lessons learned:

- Initiatives for climate adaptation and ecosystem restoration are widely supported by financial incentives.
- By encouraging nature-based solutions, market-based methods can effectively close the gap between economic development and environmental preservation.
- Collaboration across all sectors is essential to the successful execution and expansion of sustainability initiatives.

The Green Credit Program and Jal Utsav both highlight India's dedication to Ecosystem-based Adaptation (EbA) as an approach to lessen the effects of climate change. The Green Credit Program offers market-based incentives for environmental restoration, whereas Jal Utsav concentrates on water conservation through community involvement. These programs show how combining community-driven strategies, financial incentives, and cultural engagement may successfully improve ecosystem sustainability and climate resilience.

3.5 Model Laws and Regulations Related to Adaptation

In the case of *MK Ranjitsinh v. Union of India*, the Supreme Court of India delivered a historic ruling in March 2024 that specifically recognized climate rights under Indian law. By providing judicial recognition of the right to a clean, stable, and sustainable environment, this decision represents an important shift in India's

approach to climate regulation. The ruling promotes more accountability in environmental decision-making by strengthening the legal basis for efforts at climate adaptation and mitigation by introducing climate rights into the legal discourse. By integrating climate adaptation concerns into national and regional governance, this precedent-setting case opens the door for stricter implementation of climate laws. The Supreme Court's ruling reaffirms India's commitment to resilience-building and sustainable development by highlighting the judiciary's critical role in combating climate change.

3.6 Case Studies

Pre-Cyclone Exercise by IMD – Enhancing Preparedness and Early Warning Systems:

Tropical cyclones pose a serious threat to India, especially along its eastern and western coasts. In order to lessen the effects of these disasters, the Indian Meteorological Department (IMD) plays a vital role in forecasting and delivering early warnings. IMD assesses the ability to prepare of different stakeholders through yearly Pre-Cyclone and Post-Cyclone exercises in order to improve preparedness.

Best Practices and Implementation:

IMD, led by Director General Dr. Mrutyunjay Mohapatra, held a Pre-Cyclone Exercise for the April–June 2024 season. Key organizations like the Indian Armed Forces, the National Disaster Response Force (NDRF), the National Disaster Management Authority (NDMA), coastal state governments, and numerous ministries participated in the hybrid exercise, which took place at Mausam Bhavan in New Delhi.

In contrast to forecasts from the previous ten years, IMD's in-house "Decision Support System" has increased forecast accuracy by more than 50%. Additionally, the department uses a Multilingual Ensemble System to continuously monitor the weather and issue advisories based on specific locations. Furthermore, the public now has access to mobile applications and application programming interfaces which enable the real-time distribution of alerts. Through better forecasting and proactive disaster response, there were no reported

casualties during Cyclone Biparjoy, highlighting the effectiveness of these techniques. Another contribution from the National Cyclone Risk Mitigation Project (NCRMP), which is part of NDMA, is the creation of a Web-based Dynamic Composite Risk Atlas (Web-DCRA) for risk assessment and forecasting at the district level.

Lessons learned:

- Early warning systems that are continuously improved may significantly reduce the number of fatalities and financial losses.
- IMD, NDMA, NDRF, and other stakeholders working together improves preparedness and response to disasters.
- Utilizing modern technology, such as mobile applications and AI-driven forecasting methods, increases public access to critical meteorological data.
- Frequent exercises and drills guarantee preparedness and offer opportunities to improve standard operating procedures (SOPs).

Development of Flood and Drought-Tolerant Seeds – Enhancing Climate Resilience in Agriculture

India's agriculture is particularly vulnerable to climate change, as food security is put at risk by regular floods, droughts, and other extreme weather events. By conducting in-depth research and creating innovative seed types that are climate-resilient, the Indian Council of Agricultural Research (ICAR) has taken proactive steps to solve these issues.

Best Practices and Implementation:

More than 7,200 high-yielding crop varieties have been created by ICAR since 1969 through its network of 40 All India Coordinated Research Projects and 57 institutes. 2,681 stress-tolerant varieties were released between 2014 and 2023 with a focus on harsh climate conditions:

- Tolerance for floods and waterlogging: 73 types
- Tolerance for drought and moisture stress: 220 types
- 52 types that can withstand salinity and alkalinity

- Tolerance to heat stress: 49 types
- Thirteen types that are resistant to cold and frost

India's agricultural output has increased dramatically as a result of these developments, rising from 50.8 million tonnes in 1950–51 to 323.6 million tonnes by 2023. Breeding procedures have been improved for climate adaptation through the use of translational genomics and accuracy testing techniques.

Lessons learned:

- Climate resilience depends on funding agricultural innovation and research.
- Creating seed varieties that endure stress guarantees consistent food production even during severe weather conditions.
- Research and implementation are greatly accelerated by government sponsorship and policy-driven efforts.
- Increased productivity and food security are a result of better farming methods and higher seed replacement rates.

The significance of proactive disaster preparedness and climate adaptation in risk mitigation is highlighted in both case studies. The developments in climate-resilient agriculture and the effectiveness of India's early warning systems for managing cyclones are examples of best practices that other climate-vulnerable areas throughout the world might adopt. India has become more resilient to climate-related calamities thanks in large part to the integration of technology, research, and policy frameworks.

Box 1: Enhancing Climate Resilience of India's Coastal Communities

The Ministry of Environment, Forest and Climate Change, in partnership with UNDP, is implementing a six-year project (2019–2027) titled Enhancing Climate Resilience of India's Coastal Communities. Focused on Odisha, Andhra Pradesh, and Maharashtra, the project aims to improve climate resilience among vulnerable coastal populations, particularly women, by integrating ecosystem-based and community-led approaches into coastal planning and management.

The project invests in ecological infrastructure like mangroves and watershed restoration to buffer against storm surges and climate hazards, while promoting climate-resilient livelihoods such as SRI farming, crab fattening, and oyster cultivation. By 2023, nearly 98,000 rural beneficiaries had received training and technical support, with women accounting for about 40%.

More than 3,800 hectares of degraded coastal ecosystems have been restored, including nearly 3,000 hectares of mangroves. Community-led governance structures have been established to ensure local ownership and sustainable management. The initiative also fosters collaboration among 13 coastal states and union territories, government agencies, academic institutions, and civil society to strengthen coastal resilience and informed cross-sectoral planning.

This project supports national climate goals outlined in India's National Action Plan on Climate Change and the country's Nationally Determined Contribution.

3.7 Stakeholder Engagement Strategies

3.7.1 Frameworks for Engaging Local Communities, NGOs, and the Private Sector

3.7.1.1 Introduction

In the face of climate change and increasing disaster risks, effective adaptation strategies require a multi-stakeholder approach that includes local communities, non-governmental organizations (NGOs), and the private sector. Each stakeholder plays a crucial role in strengthening resilience by contributing knowledge, resources, and innovative solutions. An inclusive and participatory engagement framework is essential to ensure that adaptation efforts are both effective and sustainable. By integrating local wisdom with scientific approaches, promoting policy advocacy, and leveraging private-sector investments, a holistic strategy for resilience-building emerges.

The recommendations from the National Platform for Disaster Risk Reduction (NPDRR) highlight the

importance of locally led strategies for effective ecosystem-based approaches to disaster risk reduction (DRR) and climate adaptation. Conducting feasibility assessments using methods such as the Least Cost Method or cost-benefit analysis ensures that viable options are identified and implemented. Promoting systemic and strategic actions, including the integration of adaptation measures in State Action Plans on Climate Change (SAPCCs) and district-level Adaptation Action Plans, fosters long-term resilience. Involving local communities in these programs ensures ownership and enhances the creation of natural, social, and economic assets. Furthermore, developing a comprehensive framework to evaluate diverse approaches being implemented in India for DRR and climate adaptation strengthens policy coherence. Large-scale solutions must be implemented through systemic innovations by integrating effective approaches into State Disaster Management Plans (SDMPs), District Disaster Management Plans (DDMPs), and National and State Action Plans on Climate Change (NAPCCs/SAPCCs).

Additionally, structured coordination between government organizations (GOs) and NGOs plays a crucial role in enhancing efficiency, inclusivity, and sustainability in disaster management. The GO-NGO Coordination Guidelines emphasize the need for standardized protocols, transparent communication, and defined roles to prevent duplication of efforts and improve accountability. Strengthening public-private partnerships (PPPs) and leveraging Corporate Social Responsibility (CSR) investments are key strategies for improving disaster response mechanisms. The development of logistics hubs for pre-positioning essential supplies further enhances emergency preparedness, ensuring rapid and efficient relief distribution.

3.7.1.2 Engaging Local Communities

Local communities are the first responders to disasters and climate impacts, making their involvement indispensable in adaptation efforts. Community-Based Disaster Risk Reduction (CBDRR) provides a structured approach to empower communities in managing their risks. Participatory risk assessments enable communities to map hazards, vulnerabilities, and capacities, forming the foundation for localized disaster management plans. Establishing Village Disaster Management Committees (VDMCs) ensures that communities take an active role in preparedness, response, and recovery efforts.

A strong emphasis is placed on integrating traditional knowledge with modern risk reduction practices. Communities often possess valuable indigenous knowledge about coping mechanisms, which, when combined with scientific risk assessments, create a more robust adaptation strategy. Additionally, ecosystem-based adaptation strategies, such as afforestation and watershed management, enhance natural defenses against climate-induced disasters. Climate-resilient livelihoods, including diversified agriculture and micro-enterprise initiatives, further contribute to long-term resilience.

Public awareness campaigns play a significant role

in strengthening community engagement. Utilizing local media, folk art, and educational programs fosters climate literacy and encourages proactive risk reduction measures. The integration of digital tools, such as early warning systems, further enhances community preparedness.

3.7.1.3 Strengthening NGO Collaboration

Non-governmental organisations (NGOs) act as intermediaries between communities and government institutions, ensuring that adaptation efforts are inclusive and effectively implemented. Their role extends beyond emergency response to long-term capacity-building, advocacy, and policy development. Collaborative frameworks emphasize partnerships where NGOs contribute technical expertise, facilitate training programs, and mobilize resources to support community resilience initiatives.

One of the key aspects of NGO engagement is the coordination of efforts through structured platforms. Inter-Agency Groups (IAGs) provide a space for NGOs to align their strategies with government initiatives, ensuring a unified response to climate challenges. Policy advocacy is another crucial component, where NGOs engage with policymakers to integrate local voices into national adaptation frameworks. Capacity-building initiatives, including skill development workshops and disaster preparedness training, further empower communities to take ownership of resilience-building efforts.

NGOs also play a pivotal role in post-disaster recovery and rehabilitation. Their interventions in psychosocial support, livelihood restoration, and infrastructure rebuilding contribute to long-term sustainability. The emphasis on inclusive recovery ensures that marginalized and vulnerable groups receive targeted support, fostering social equity in adaptation planning.

3.7.1.4 Leveraging Private-Sector Engagement

The private sector is a key stakeholder in climate adaptation, offering financial resources, technological innovations, and sustainable business practices. Public-

Private Partnerships (PPPs) facilitate collaboration between businesses and government agencies to enhance infrastructure resilience and disaster preparedness. Corporate Social Responsibility (CSR) initiatives provide an avenue for private companies to invest in climate adaptation programs, such as the development of resilient housing, clean energy solutions, and microinsurance schemes for vulnerable populations.

The concept of humanitarian logistics hubs has emerged as a strategic approach to improving emergency response efficiency. These hubs integrate multimodal transportation, optimize warehousing networks, and enable smooth coordination between stakeholders. By leveraging real-time tracking systems and predictive analytics, logistics hubs ensure the pre-positioning and rapid deployment of essential supplies.

Risk transfer mechanisms, including climate insurance and parametric insurance models, offer financial protection against climate-induced economic shocks. Engaging microfinance institutions and cooperatives in resilience initiatives strengthens financial inclusion for vulnerable communities, enabling them to invest in adaptive strategies.

3.7.1.5 Institutional Support and Policy Integration

A comprehensive engagement framework requires institutional support and alignment with national and international policies. The Sendai Framework for Disaster Risk Reduction, the Paris Agreement, and the Sustainable Development Goals (SDGs) provide guiding principles for integrating stakeholder engagement into adaptation strategies. Decentralized governance structures, including district and local disaster management authorities, facilitate the effective implementation of community-led initiatives.

Formal multi-stakeholder coordination platforms ensure that government agencies, NGOs, and private-sector actors collaborate in a structured manner. The establishment of logistics hubs, capacity-building programs, and resource-sharing mechanisms further

strengthen institutional preparedness for climate adaptation and disaster resilience. Currently, there is limited to no engagement of key stakeholders including the private sector in mainstreaming disaster preparedness. Capacity building exercises must be undertaken on a widespread basis to ensure that private sector and other non-state actors are aware of climate change and assess the climate risk on their operations and value chains that impact critical services, people, communities, livelihoods and the wider economy.

3.8 International Cooperation

By making it easier to access financial resources, technological developments, and policy experience, international collaboration is essential to strengthening India's attempts to adapt to climate change. India actively engages in international agreements and activities to assist adaptation methods because of its vulnerability to the effects of climate change, including rising sea levels, extreme weather events, and water scarcity. The nation has been able to incorporate global best practices, obtain finance, and create climate-resilient policies that reflect its national interests thanks to these engagements.

3.8.1 Relevant International Agreements and Initiatives

India has ratified a number of international frameworks and agreements that influence its approaches to climate adaptation. The United Nations Framework Convention on Climate Change (UNFCCC) Paris Agreement (2015) is one of the most important, where India pledged to increase its capacity for adaptation through Nationally Determined Contributions (NDCs). The pact immediately promotes India's adaptation efforts by highlighting international cooperation in capacity building, technology transfer, and finance. The Sendai Framework for Disaster Risk Reduction (2015–2030) is another important framework that directs India's policies for resilience-building and disaster preparedness. By encouraging risk-informed infrastructure and climate-resilient agriculture, this framework has impacted India's State Action Plans on

Climate Change (SAPCCs) and the National Adaptation Fund for Climate Change (NAFCC). Furthermore, India actively participates in the Green Climate Fund (GCF) and the Global Environment Facility (GEF), which offer financial assistance for projects involving climate-resilient urban design, water management, and ecosystem-based adaptation. Large-scale projects like mangrove restoration in fragile coastal areas and climate-resilient agriculture in drought-prone areas are made possible by these initiatives in India. Additionally, India has participated in regional climate agreements that promote cross-border cooperation on catastrophe resilience, such as the disaster Management Framework of the South Asian Association for Regional Cooperation (SAARC). India's efforts to prepare for floods and cyclones have benefited from this initiative's enhancement of early warning systems and emergency response cooperation among South Asian countries.

Additionally, India has created international alliances such as the International Solar Alliance (ISA) to encourage the use of renewable energy, especially in developing countries that are vulnerable to climate change. The Coalition for Disaster robust Infrastructure (CDRI), which India started, is another significant project aimed at helping countries create climate-proof infrastructure, such as durable water management facilities, electricity systems, and transportation. In addition to supporting global resilience efforts, these accords and programs give India a strong basis for climate risk adaptation.

3.8.2 Opportunities for Collaboration and Knowledge Sharing

Through global cooperation and knowledge-sharing programs, India has a great chance to improve climate adaption. India can improve its ability to put creative, evidence-based adaptation plans into action by collaborating with international research institutes, multilateral organizations, and national governments.

Research collaboration and technological transfer

present a significant opportunity. India can gain access to advanced climate modelling tools, satellite-based monitoring systems, and resilient agricultural technology by utilizing collaborations with institutions such as the World Bank and the United Nations Environment Programme (UNEP). India may embrace climate-smart solutions for water conservation and infrastructure development by partnering with nations like the United Kingdom (via the Adaptation Research Alliance) and Germany (through the Indo-German Environment Programme). Climate financing is another important area where cooperation is needed. International financial organizations like the Asian Development Bank (ADB) and the Green Climate Fund (GCF) offer chances to expand climate-resilient projects, even though India has made progress in financing adaptation efforts through national programs like the National Adaptation Fund for Climate Change (NAFCC). These collaborations can aid in the growth of urban climate adaption initiatives, nature-based remedies like mangrove restoration, and early warning system extension.

Regional networks for exchanging knowledge can also be advantageous to India. India may share best practices with other nations dealing with comparable climate issues by interacting with organizations like the Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC) and the SAARC Climate Change Centre.

Additionally, by conveying its knowledge of disaster relief, ecosystem-based adaptation (EbA), and climate-resilient agriculture to poor countries in Africa and Southeast Asia, India may take the lead in South-South cooperation. India has a platform to help other vulnerable countries adopt sustainable climate adaption measures through initiatives like the India-UN Development Partnership Fund.

India can expand its knowledge base, draw in investment for climate adaptation, and create long-term resilience against the effects of climate change by continuing to participate in international networks.

India can guarantee a sustainable and adaptable future for its people and ecosystems by incorporating global knowledge into domestic policy and encouraging cross-sectoral cooperation.



4 Climate Adaptation Interventions by Key Ministries and Stakeholders

This chapter gives overview of the Adaptation Interventions from 2023-24 by different Ministries and Stakeholder are methodically documented into the following 5 key categories. To assess the scope and efficacy of these initiatives, this chapter utilizes a set of adaptation indicators, that describe the multifaceted nature of resilience-building.

In recognition of the sectoral nature of climate adaptation, this chapter documents interventions by various Union Ministries that play a pivotal role in strengthening India's resilience to climate change. The ministries covered here are selected based on their sectoral mandates and institutional responsibilities that directly or indirectly influence climate adaptation. An essential component of resilience-building initiatives is climate adaptation, which calls for coordinated interventions across several sectors and levels of governance. To address climate vulnerabilities, improve readiness, and mainstream resilience into development planning, Ministries and other important stakeholders are essential to the design and implementation of adaptation programs.

The 3rd session of the National Platform for Disaster Risk Reduction (NPDRR) reinforced this need for systemic and locally grounded action. It recommended promoting ecosystem-based and locally led approaches to climate adaptation and disaster risk reduction, supported by feasibility assessments such as cost-benefit and least-cost analysis. The session called for integrating adaptation measures into State and District Action Plans on Climate Change, while actively involving local communities to enhance ownership and strengthen social and natural assets. It further emphasized the

development of a comprehensive framework to evaluate and scale up adaptation solutions within SDMPs, DDMPs, and NAPCCs/SAPCCs. The importance of financial innovation was also highlighted, with a focus on improving risk assessment, reducing costs, and mobilizing private sector participation. Additionally, the session proposed a unified framework for evaluating and monitoring adaptation initiatives, supported by research institutions and scientific agencies including MoEF&CC, NDMA, NIDM, and DST. ^{xviii}

In this chapter, the adaptation efforts carried out by different ministries and stakeholders are methodically documented into the following broad categories:



S.No.	Category of Interventions	Description
1	Policy and Regulatory Frameworks	This includes government orders, directives, policies, schemes, guidelines, and legal mandates
2	Capacity Building and Skill Development	Training programs, workshops, and initiatives aimed at enhancing institutional adaptive capacity.
3	Technological Innovations and Applied Solutions	Climate-resilient technologies, decision-support tools, and innovative adaptation practices.
4	Research, Data, and Knowledge Systems	Scientific studies, risk assessments, and knowledge-sharing initiatives

Table 5: Categories of adaptation efforts by different ministries

This chapter evaluates adaptation efforts by documenting sectoral interventions carried out by different ministries for the years 2023–2024. To assess the scope and efficacy of these initiatives, this chapter utilizes a set of adaptation indicators, as shared below, that describe the multifaceted nature of resilience-building:

S.No.	Indicator	Description
1	Physical	Climate resilient infra e.g flood walls, coastal barriers
2	Economic	Resource allocation towards adaptation projects, cost benefit analysis of adaptation projects, economic benefits
3	Social	The impact of adaptation measures on vulnerable populations (e.g., women, children, marginalized communities,
4	Environmental	Ecosystem restoration projects that contribute to climate change resilience e.g restoration of mangroves, systems for accurate climate projections
5	Systemic	Policy level integration of adaptation into development planning, capacity building initiatives for adaptation planning and executing adaptation projects, institutional arrangements for adaptation planning and implementation. Training to enhance adaptive capacity, effectiveness of capacity building initiatives on enhancing adaptive capacity.

Table 6: List of Adaptation Indicators

As per the framework of the National Platform for Disaster Risk Reduction (NPDRR), ministries and departments have been categorized into Group-A and Group-B to streamline coordination and accountability in climate adaptation and disaster risk reduction efforts. A similar categorization has been adopted for this adaptation dossier to systematically track and analyze sectoral interventions undertaken by various ministries.

S.No.	Group-A
1	Ministry of Agriculture
2	Ministry of Home Affairs
3	Ministry of Earth Sciences
4	Ministry of Jal Shakti
5	Ministry of Science and Technology
6	Ministry of Panchayati Raj
7	Ministry of Rural Development

S.No.	Group-B
1	Ministry of Finance
2	Ministry of Health and Family Welfare
3	Ministry of Housing and Urban Affairs
4	Ministry of Environment & Climate Change
5	Ministry of Power
6	Ministry of Road Transport and Highways
7	Ministry of Ports, Shipping and Waterways

4.1 Group - A

4.1.1 Ministry of Agriculture and Farmers Welfare (MoA&FW)

In 2023–24, the Ministry of Agriculture advanced climate change adaptation through initiatives like the National Mission for Sustainable Agriculture (NMSA), NICRA, agroforestry, soil health management, and water-efficient practices. Institutional mechanisms such as the Climate Change Cell and Carbon Credit Cell, along with tools like GIS-based soil surveys and regenerative agriculture pilots, supported systemic

and field-level resilience. Farmer engagement was strengthened through capacity building, plantation drives, and global platforms like COP-28.

Suggestions: To build on this, the Ministry should enhance convergence with rural programs, localize climate-resilient practices, and operationalize carbon credit systems for smallholders. Retaining the thematic focus of NMSA within RKVY, scaling digital and agronomic advisory tools, and improving inclusion and ecological monitoring will further strengthen impact.

S.No.	Intervention	Indicator
	Sectoral Focus: Agriculture, Farmers' Welfare, Agroforestry	
1	Policy and Regulatory Frameworks	
1.1	National Mission for Sustainable Agriculture (NMSA): A flagship mission under NAPCC aiming to make agriculture climate resilient. Focus on Rainfed Area Development, On-Farm Water Management, and Soil Health Management	Systemic, Environmental, Economic
1.2	Subsuming of NMSA schemes under RKVY: Programs like PDMC, RAD, SHM, Agroforestry now operates under RKVY for better integration	Systemic
1.3	National Innovations on Climate Resilient Agriculture (NICRA): Flagship ICAR project to promote resilient agricultural practices. Lessons from NICRA are linked with RAD clusters for wider replication	Physical, Environmental
1.4	National Agroforestry Policy (SMAF): "Har Medh Par Ped" campaign encouraging tree-based farming; now continued under RKVY.	Economic, Environment
2	Capacity Building and Skill Development	
2.1	Mega Oil Palm Plantation Drive: Plantation drives across 11 states with over 5 lakh planting materials distributed. Included technical seminars for farmers	Social, Systemic, Environmental

2.2	Climate Change Cell (NRM Division): Coordinates inter-departmental actions on climate resilience in agriculture.	Economic, Systemic
2.3	RKVY-RAFTAAR Agri-Incubator and AMD Indo-German Project: Promotes innovation and entrepreneurship for sustainable agriculture	Environmental, Social
2.4	Workshops and Public Engagement: Explores linking carbon sequestration from agriculture with carbon markets to benefit smallholder farmers	Social, Systemic
3	Technological Innovations and Applied Solutions	
3.1	Natural Resource Management Trials (e.g., regenerative agri., digital agri.): Trials conducted with multiple partners on carbon sequestration, water management, and digital agri innovations	Environmental, Physical
3.2	Carbon Credit Cell (NRM Division): Explores linking carbon sequestration from agriculture with carbon markets to benefit smallholder farmers	Economic, Environmental
3.3	Soil and Land Use Survey of India (SLUSI): Generates scientific data for soil health, land use planning, watershed development etc.	Physical
4	Advocacy and International Collaboration	
4.1	Participation in COP-28 and Mission LiFE: Showcased India's initiatives on sustainable agriculture and soil health at global forums	Systemic, Environmental

Table 7: Interventions of MoA&FW

4.1.2 Ministry of Home Affairs (MHA)

The MHA demonstrates strong leadership in disaster risk governance and emergency preparedness. Key highlights include large-scale training under NCRMP and the recognition of the Coalition for Disaster Resilient Infrastructure (CDRI) as an international entity. Initiatives like the Global Infrastructure Risk Model (GIRI) and Dynamic Composite Risk Atlas reflect

technological innovation in risk assessment. Emphasis on ecosystem-based adaptation (e.g., mangrove restoration) and mental health integration into disaster plans reflects a multidimensional approach.

Suggestion: Future interventions could enhance anticipatory governance by integrating climate risk analytics into early-stage urban and rural planning frameworks.

S.No.	Intervention	Indicator
	Sectoral Focus: Risk Governance, Policy Implementation, Emergency Response and Crisis Management	
1	Policy and Regulatory Frameworks	
1.1	Recognition of CDRI as an International Organization: The Cabinet approved the recognition of the Coalition for Disaster Resilient Infrastructure (CDRI) as an international organization on 28.06.2023, granting necessary exemptions and privileges under the UN(P&I) Act, 1947.	Systemic, Economic
2	Capacity Building and Skill Development	
2.1	Capacity Building for Disaster Response: • 24,007 government officials trained through 925 capacity-building trainings. • 68,988 community representatives trained through 3,421 shelter-level trainings under NCRMP. (Page 195)	Systemic, Social

	• Training for IAS & Civil Services Officers on Disaster Management: Implemented at LBSNAA, Mussoorie, with an outlay of ₹3.75 Cr. for five years (2021-26). • Training for NDRF and Other Stakeholders: • NDRF trained 36,377 personnel, including SDRF, CAPF, and community representatives. • 4,345 community awareness programs benefiting over 1.1 million people.	
2.2	Landslide Risk Mitigation Scheme (LRMS): Implemented in Sikkim, Mizoram, Nagaland, and Uttarakhand. Includes landslide treatment, real-time monitoring, and training.	Physical, Environmental, Systemic
2.3	The National Workshop on Heat Wave 2024, organized by NDMA, focuses on advancing heat wave adaptation strategies as part of disaster risk reduction. It highlights the rising frequency and impact of heat waves in India, emphasizing Heat Action Plans (HAPs) for early warning, capacity-building, and mitigation. The workshop covers sector-specific strategies like cooling infrastructure, urban planning, and resilient agriculture while fostering multi-sectoral collaboration with IMD, MoES, and state governments. Discussions on Urban Heat Island effects, health data, and impact-based forecasting reinforce NDMA's commitment to science-driven, community-based resilience efforts.	Systemic, Social, Environmental, Physical
2.4	The Thematic Session on Climate Change Adaptation and Disaster Risk Reduction at the 3rd NPDRR (March 10-11, 2023) in New Delhi focused on integrating ecosystem-based adaptation (EBA) and nature-based solutions (NBS) for climate resilience. Discussions emphasized locally led strategies, indigenous knowledge, and policy integration into SDMPs and DDMPs. Key highlights included West Bengal's Mangrove Mission, wetland reclamation for flood mitigation, financing mechanisms for NBS, and private sector engagement. The session advocated for cost-effective risk reduction through the Least Cost Method (LCM) and systemic adaptation while stressing the need to mainstream climate adaptation into development policies with scientific and community-driven approaches.	Environmental, Social, Systemic
3	Technological Innovations and Applied Solutions	
3.1	Global Infrastructure Risk Model & Resilience Index (GRI): Launched by CDRI at COP28 in December 2023, it provides a probabilistic risk assessment for infrastructure sectors	Systemic, Economic, Physical
3.2	Web-based Dynamic Composite Risk Atlas (Web DCRA-DSS): A real-time impact forecast tool for cyclones, storm surges, and floods.	Systemic, Environmental, Physical
3.3	Pilot Project for Earthquake Resilience: Includes retrofitting lifeline buildings and training engineers in Tripura, Uttarakhand, and NDMC Delhi	Physical, Systemic
4	Research, Data, and Knowledge Systems	
4.1	Compendium of Traditional Earthquake Resilient Construction: Released in September 2023 to promote traditional, earthquake-resistant construction practices.	Systemic, Physical, Environmental

4.2	Biennial Report on Global Infrastructure Resilience led by CDRI: Launched in October 2023, compiling evidence for upscaling investment in infrastructure resilience	Economic, Systemic
4.3	The NDMA Guidelines on Mental Health and Psychosocial Support (MHPSS), released in September 2023, emphasize integrating mental health services into disaster adaptation to strengthen community resilience. They focus on preparedness, mitigation, and response planning within State and District Disaster Management Plans. Key aspects include capacity-building for first responders, community-based psychosocial support, telemedicine innovations, and policy integration to ensure structured mental health interventions in disaster-prone areas.	Social, Systemic
5	Others	
5.1	Sendai Framework Implementation Support: Financial aid for disaster professionals in hazard-prone districts.	Economic, Systemic

Table 8: Interventions of MHA

4.1.3 Ministry of Earth Sciences (MoES)

MoES has excelled in enabling climate-informed decision-making through innovations like impact-based forecasting, high-resolution air quality early warning systems, and the SAMUDRA marine advisory app. Their extensive training and awareness efforts also enhance societal preparedness.

Suggestion: There is scope to increase community-level engagement through localized climate information services in regional languages, especially for climate-sensitive sectors like agriculture and fisheries.

S.No.	Intervention	Indicator
	Sectoral Focus: Climate & Weather Services	
1	Policy and Regulatory Frameworks	
1.1	National Framework for Climate Services (NFCS): Initiated to provide sector-specific climate adaptation solutions, including early warning systems, disaster preparedness, and seasonal forecasting.	Systemic, Economic, Social
1.2	Impact Based Forecasting (IBF) is being issued for all severe weather events at district and city levels with inclusion of exposure and vulnerability parameters and suggested response actions.	Social, Environmental, Systemic
1.3	National Adaptation Plans for Climate-Sensitive Sectors: Guidelines developed to integrate climate adaptation strategies into coastal protection, water management, and extreme weather forecasting.	Systemic, Economic, Physical
2	Capacity Building and Skill Development	
2.1	Capacity Building in Weather Forecasting and Climate Adaptation: 200+ training programs conducted for state-level meteorological agencies and disaster response teams. Focus areas: Cyclone preparedness, monsoon variability, and extreme weather forecasting	Systemic, Social
2.2	Tsunami Mock Exercise was conducted in Andaman & Nicobar Islands in	Physical,

	coordination with NDMA and Andaman administration on 09 February 2023. IOCUNESCO conducted the Indian Ocean wide (IOWave23) Tsunami mock exercise during October 2023	Systemic
2.3	The Ministry organized specific activities with students and public participation as a part of Azadi Ka Amrit Mahotsav (AKAM). The total number of major awareness events conducted by MoES and its departments/institutes, as well as the number of places where these events were held, exceed 2575 which included 1137 Farmer Awareness Programs (FAPS,) fishermen awareness programs in 267 villages along the coast in collaboration with NGO partners, Yoga was performed by scientist teams from India and abroad at research stations including Bharati in Antarctica, Himadri in the Arctic, and Himansh, the high-altitude research station in the Himalayas, on International Yoga Day, 21 June 2023. More than 294958 participated in these events across the country from 15 August 2022 to 15 th August 2023.	Social, Economic, Environmental
3	Technological Innovations and Applied Solutions	
3.1	The NCMRWF Data Assimilation (DA) system makes continuous efforts to include new observations for improving its forecast quality. In this direction ATOVS satellite observations, Meteosat-10 Spinning Enhanced Visible and InfraRed Imager (SEVIRI) and Atmospheric Motion Vectors (AMV) observations, more Ground GPS observations, ISRO's Oceansat-3 and Microsat-2B observations and Reflectivity and radial velocity observations from more IMD Doppler Weather Radar observations have been used in assimilation from this year.	Environmental, Systemic
3.2	As part of seamless modeling activities, the National Center for Medium Range Weather Forecasting (NCMRWF), DM-Chem, a high resolution (330 m) city scale model for predicting fog in terms of visibility and PM 2.5 over Delhi & NCR region	Environmental, Systemic, Economic
3.3	A new website for disseminating information was released, including alerts for block-level weather forecast and advisories to benefit our agricultural community, including farmers, fisherfolk, and livestock rearers. The weather-related information shall be disseminated in English and Hindi and in regional languages in the future. The India Meteorological Department (IMD) will be collaborating with the Ministry of Panchayati Raj to share the real-time weather forecasts disseminated through this website with Heads and Members of the Gram Panchayats through SMS or WhatsApp.	Economic, Systemic, Social
3.4	A very high-resolution (400) Air Quality Early Warning System (AQEWS) integrated with A Decision Support System (DSS) for air quality has been developed, showing an accuracy of 88% for predicting extreme pollution events, which is much higher than the estimates available for a similar system across the globe. This early warning system provides: (1) near real-time observations of air quality and visibility over the Delhi region and details about natural aerosols like dust (from dust storms), fire information, and satellite AOD; (2) predictions of air pollutants based on the state-of-the-art atmospheric chemistry transport models; (3) warning messages, alerts, and bulletins; and (4) forecast of the contribution of non-local fire emissions to the air quality in Delhi. The statutory body, Commission for Air Quality Management (CAQM) in the National Capital Region and the Adjoining Regions, has used AQEWS and DSS extensively.	Environmental, Systemic, Economic

3.5	A new mobile application to provide comprehensive information on all ocean related services of the Indian National Centre for Ocean Information Services (INCOIS). The mobile app named SAMUDRA (Smart Access to Marine Users for Data Resources and ocean Advisories) provides information on ocean related services of INCOIS, including (but not limited to) potential fishing zone advisories, ocean state forecasts, and alerts on tsunamis, cyclones, storm surges, high waves, swell surges, etc. The app is designed using the latest technologies and will help disseminate information directly to users, especially coastal communities	Economic, Social, Systemic
3.6	A spar type 10m dia. fish cage culture system is fabricated and its functionality is demonstrated Off Ennore during August 2023. Development of the Deep Sea Autonomous Underwater Profiler (DAUP) operable up to 4000 m) is progressing with an indigenized 1000 cubic capacity variable buoyancy engine. Two units were produced in house and carried out performance tests in Bay of Bengal trials up to 500 m operations. Customized a small category heavy lift type Drone for marine applications (Fig. 3. 20 a) and was used for Ocean data collections at Pamanji Nellore and observation of Air Quality Index parameter up to 120 m vertical height near East Coast Road (ECR), Tamil Nadu coast-Mahabalipuram	Physical, Environmental, Economic
3.7	A new mobile application to provide comprehensive information on all ocean related services of the Indian National Centre for Ocean Information Services (INCOIS). The mobile app named SAMUDRA (Smart Access to Marine Users for Data Resources and ocean Advisories) provides information on ocean related services of INCOIS, including (but not limited to) potential fishing zone advisories, ocean state forecasts, and alerts on tsunamis, cyclones, storm surges, high waves, swell surges, etc. The app is designed using the latest technologies and will help disseminate information directly to users, especially coastal communities	Environmental, Systemic, Economic
3.8	A new web portal featuring the biodiversity of our Indian Ocean EEZ (Exclusive Economic Zone) was made open to the public. The web portal is called IndOBIS and can be assessed at https://indobis.in/ . The portal has been developed by the Centre for Marine Living Resources and Ecology (CMLRE), Kochi. IndOBIS provides information on marine species of the Indian Ocean, including their occurrence and scientific classification. It serves as one of the 30 regional nodes of the OBIS (Ocean Biodiversity Information System). OBIS is an international open-access web platform for data and information on biodiversity and biogeography of global marine life. OBIS is a project under the Intergovernmental Oceanographic Commission (IOC)-UNESCO International Oceanographic Data and Information programme	Environmental, Systemic, Economic
3.9	An advanced air quality early warning system (AQEWS) at a high resolution of 400 meters for the Delhi National Capital Region (NCR) was developed as part of the Smart Cities Mission (NP15) initiated by the Government of India. The forecasting system was strengthened by introducing a comprehensive multi-model ensemble for PM and PM forecasts specific to Delhi. This was a collaborative effort by integrating forecasts from various centers viz. ECMWF, NCAR, NASA, NOAA, NCMRWF, and IMD. A significant optimization milestone was achieved by fully automating the system which became operational in August 2023	Systemic, Economic, Environmental

Table 9: Interventions of MoES

4.1.4 Ministry of Jal Shakti (MoJS)

Significant contributions include the implementation of climate-resilient flood management systems, dam safety reforms, and aquifer mapping. Programs such as Atal Bhujal Yojana and Springshed Management show strong alignment with nature-based solutions.

Suggestion: Greater focus is needed on integrating climate risk considerations into all rural water supply schemes and mainstreaming these into State Water Action Plans.

S.No.	Intervention	Indicator
	Sectoral Focus: Water, Sanitation and Hygiene	
1	Policy and Regulatory Frameworks	
1.1	Dam Safety Regulations (2023-24): Implementation of legal provisions under the Dam Safety Act, 2021, focusing on risk mitigation for extreme climate events like Glacial Lake Outburst Floods (GLOFs). Risk assessments were carried out for 47 dams as part of climate adaptation strategies	Physical, Systemic, Environmental
	Flood Management and Border Areas Programme (FMBAP): The Union Cabinet approved ₹4,100 crore for 2021-26, focusing on climate-adaptive flood control, riverbank stabilization, and disaster resilience	Systemic, Social, Economic
2	Capacity Building and Skill Development	
2.1	Training on Climate Resilient Water Infrastructure: Conducted under the G20 framework, focusing on climate variability, water availability, and dam rehabilitation for resilience	Systemic, Economic, Social
2.2	Workshops on Groundwater Management for Climate Adaptation: Conducted under Atal Bhujal Yojana, training 39,000 Gram Panchayat officials to implement water security measures	Social, Systemic, Economic
2.3	The International Conference on Dam Safety 2023, organized by the Ministry of Jal Shakti, was held in Jaipur on September 14-15, 2023. Inaugurated by the Hon'ble Vice President of India, the event gathered global experts, researchers, and professionals to discuss dam safety. With around 800 delegates and 51 technical papers presented, the conference featured sessions on India's dam safety initiatives, Maharashtra's dam safety status, regulatory experiences from Australia, Indo-Danish and Indo-Australian water management collaborations, and World Bank initiatives on dam management.	Systemic, Social
2.4	NERIWALM Training on Traditional Water Management Practices: Focused on indigenous adaptation strategies like water conservation techniques used by Apatani, Chakhesang, and Bodo tribes in Northeast India	Social, Environmental
2.5	Springshed Management Training Programs: Implemented in Mizoram, Nagaland, and Arunachal Pradesh to mitigate climate change impacts on water availability	Environmental, Systemic
3	Technological Innovations and Applied Solutions	
3.1	High-Resolution Climate Scenario Mapping: Developed in collaboration with IIT Delhi, providing 10x10 km resolution climate projections for basin-scale water management	Systemic, Environmental, Economic

3.2	DHARMA (Dam Health and Rehabilitation Monitoring Application): Web-based application upgraded for climate risk assessment of dams	Systemic, Physical, Economic
4	Research, Data, and Knowledge Systems	
4.1	National Aquifer Mapping & Management (NAQUIM): A major groundwater conservation strategy, covering 25 lakh sq. km, supports climate-resilient water security planning	Environmental, Social, Economic
4.2	Flood Forecasting Model Development: Research conducted by IIT Delhi on high-resolution flood forecasting models to improve preparedness for extreme weather events	Systemic, Environmental, Economic
5	Others	
5.1	The National Water Mission (NWM), Ministry of Jal Shakti, launched the “Jal Shakti Abhiyan: Catch the Rain-2024” campaign on March 9, 2024, at NDMC Convention Centre, New Delhi, with the theme “Nari Shakti Se Jal Shakti.” The event, graced by the Hon’ble Minister of Jal Shakti, featured the virtual release of two books, screenings of short films, and a documentary on Ladakh. Women warriors, including Sarpanchs and VWSC members, shared their experiences, highlighting their vital role in water conservation and inspiring sustainable practices.	Social, Environmental, Systemic
5.2	Jal Shakti Abhiyan – Convergence with Rural Development Programs: Integration of MGNREGS, watershed management, and afforestation efforts to enhance climate resilience	Social, Economic, Environmental

Table 10: Interventions of MoJS

4.1.5 Ministry of Science and Technology (MST)

This ministry contributes significantly to scientific research and innovation through initiatives like climate change cells, glaciology training, and climate modeling centers. Their projects on hydro-climate extremes

and monsoon variability provide critical adaptation intelligence.

Suggestion: The Ministry could expand support to cross-disciplinary applied research focusing on socio-economic adaptation and technology uptake in vulnerable communities.

S.No.	Intervention	Indicator
	Sectoral Focus: Technology Development, Scientific Research & Innovation	
1	Policy and Regulatory Frameworks	
1.1	The Ministry established 11 State Climate Change Cells (SCCCs) – Phase II in Telangana, Tamil Nadu, Kerala, Puducherry, Karnataka, Chhattisgarh, West Bengal, Arunachal Pradesh, Nagaland, J&K, and Meghalaya. These cells focus on vulnerability assessment, capacity building, and aligning State Action Plans on Climate Change (SAPCC) with national missions.	Systemic, Economic
2	Capacity Building and Skill Development	

2.1	A Capacity Building Program in Glaciology was launched to train participants in glaciology, glacial hydrology, and climate change influences. It includes theoretical training, advanced research methodologies, and fieldwork.	Systemic, Social
2.2	The Human Capacity Building Programme at Indian Institute of Public Administration (IIPA), New Delhi, aims to strengthen stakeholders' ability to address climate change adaptation.	Systemic, Social
3	Technological Innovations and Applied Solutions	
3.1	A Centre of Excellence on Climate Change Research (DST-CoE-CCR) at the University of Allahabad was established to study Indian Summer Monsoon Rainfall (ISMR) variability under climate change. Focuses on climate modeling, downscaling, and evaluation.	Systematic
3.2	Project on Hydro-Climate Extremes (CE-HCE) at IIT Gandhinagar, studying extreme rainfall events, floods, droughts, heat waves, and compound extremes. Focuses on risk translation and resilience-building in water, agriculture, and infrastructure.	Systematic. Physical
4	Research, Data, and Knowledge Systems	
4.1	International Climate Research Conclave 2023 (ICRC-2023) co-organized at IIT Bombay. The report "India's Climate Research Agenda: 2030 and Beyond" was released, providing strategic direction for climate research.	Systemic, Economic
4.2	DST participation at COP-28, including a special side event on Climate Change Vulnerability in the Himalayan Region and Climate Resilient Development Strategy for the Indian Himalayan Region (IHR).	Systemic, Environmental

Table 11: Interventions of (MST)

4.1.6 Ministry of Panchayati Raj (MoPJ)

The Ministry of Panchayati Raj has demonstrated a strong systemic and governance-centric approach to climate adaptation. Through schemes like Revamped RGSA, Thematic GPDs, and LSDG Localization, Gram Panchayats are positioned as drivers of climate-resilient development. The integration of SDGs into grassroots planning, along with training via Mission Karmayogi and Digital Panchayat Learning Centers, ensures widespread

environmental awareness and technical capability at the local level. Technological models like Model GP Clusters and the Panchayat Development Index (PDI) add robustness to monitoring and knowledge-based decision-making.

Suggestions: MoPR can scale up digital climate vulnerability mapping for Panchayats and incentivize climate innovation champions at the village level to boost adaptation outcomes locally.

S.No.	Intervention	Indicator
	Sectoral Focus: Governance and Institutions	
1	Policy and Regulatory Frameworks	
1.1	Revamped Rashtriya Gram Swaraj Abhiyan (RGSA): Strengthening PRIs through training and capacity building with a focus on SDGs and Aspirational Districts. Includes thematic planning aligned with climate-sensitive goals.	Systemic, Social

1.2	Localization of Sustainable Development Goals (LSDGs): Adoption of 9 themes including Clean & Green Village, Water Sufficient Village, Self-Sufficient Infrastructure to localize climate-related SDGs through Gram Panchayats.	Environmental, Physical, Systemic
1.3	Thematic Gram Panchayat Development Plans (GPDPs): Integration of climate-related goals into GPDPs using 9 themes for convergence and effective local planning.	Systemic, Environmental
1.4	People's Plan Campaign (PPC) for 2024-25: Inclusive planning strategy to enable panchayats to adopt climate-adaptive plans aligned with LSDGs through community engagement.	Social, Systemic
2	Capacity Building and Skill Development	
2.1	Training & Capacity Building under Mission Karmayogi Bharat: Ministry-wide training programs including online iGOT modules and offline domain/functional training with 100% employee participation.	Systemic
2.2	Digital Panchayat Learning Centers (PLCs): Equipped with smart classrooms, internet kiosks, and digital libraries to enhance awareness and education, including environment and livelihood themes.	Economic, Social
2.3	Waste Management & Clean Environment Initiatives (e.g., Karji GP and PLCs): Community-led waste management, awareness campaigns, and training on environmental practices at grassroots level.	Environmental, Social
2.4	Capacity Building Unit & Annual Capacity Building Plan (ACBP): Structured approach to training MoPR officers and officials on governance, environment, and sustainability.	Systemic
3	Technological Innovations and Applied Solutions	
3.1	Model GP Clusters (e.g., Patajan GP, MP): Integrated, trained, and tech-enabled panchayats serving as examples for thematic and climate-resilient development planning.	Systematic, Physical
4	Research, Data, and Knowledge Systems	
4.1	Panchayat Development Index (PDI): Composite index based on 9 LSDG themes and 577 indicators to assess grassroots progress on sustainable and climate-resilient development.	Physical Systemic

Table 12: Interventions of MoPJ

4.1.7 Ministry of Rural Development (MoRD)

The Ministry of Rural Development has undertaken several impactful interventions targeting climate adaptation, especially in the domains of agriculture, livelihoods, and natural resource management. Flagship programs like the National Rural Livelihoods Mission (NRLM) and MKSP promote sustainable farming practices and organic agriculture, while schemes under MGNREGA and PMKSY enable climate-resilient infrastructure such as soil and water conservation structures and afforestation. Technological innovations

like GIS for watershed planning and climate-resilient housing (PAHAL) add long-term resilience value. Notably, the capacity-building initiatives have empowered over 1.5 lakh community-level resource persons and “Krishi Sakhis,” building localized expertise in adaptive farming.

Suggestions: MoRD can expand its adaptation portfolio by integrating climate-risk insurance for rural livelihoods and incentivizing regenerative agriculture and carbon farming models to strengthen resilience and ensure long-term sustainability.

S.No.	Intervention	Indicator
	Sectoral Focus: Livelihood and Agriculture, Natural Resource Management	
1	Policy and Regulatory Frameworks	
1.1	National Rural Livelihoods Mission (NRLM) – Mahila Kisan Sashaktikaran Pariyojana (MKSP): Focus on sustainable agriculture, agro-ecology, climate-resilient farming, biodiversity conservation, and reduction in GHG emissions	Environmental, Economic
1.2	Promotion of Integrated Farming Clusters: Supports each household with 3-4 livelihood improvements in climate-adapted clusters	Economic, Physical,
1.3	Sustainable Natural Resource Management – WDC-PMKSY: Soil & water conservation, diversified cropping, afforestation, protective irrigation	Physical, Environmental
1.4	Mission Water Conservation under MGNREGA: Focused on water-stressed blocks; 10.83 lakh NRM works completed in 2023–24	Physical, Environmental
1.5	NTFP Component under MKSP: Biodiversity-focused sustainable forest resource use and processing	Environmental, Economic
1.6	Organic Village Clusters (under DAY-NRLM): Promotion of organic farming & certification among SHG women; 3.16 lakh SHG women involved	Environmental, Economic
2	Capacity Building and Skill Development	
2.1	Training of Krishi Sakhis & Community Resource Persons: Over 9,967 Krishi Sakhis trained across 16 states; CRPs mobilized to spread sustainable agriculture knowledge	Social, Systemic
2.2	International Training on Green Economy and COP28 Participation: Global engagement on sustainability, climate resilience, green economy training	Systemic, Social
2.3	Capacity Building for Organic & Sustainable Agriculture: Creation of 1.56 lakh trained CRPs and promotion of local sustainable inputs	Environmental, Social
2.4	REWARD Programme (World Bank): Supports climate-resilient watershed development and science-based planning	Systemic, Environmental
3	Technological Innovations and Applied Solutions	
3.1	PAHAL Design – Climate Resilient Housing: Encourages construction of houses using climate-resilient technologies	Physical
3.2	Use of GIS & Remote Sensing in Watershed Planning: GIS-based scientific watershed planning across 2.64 lakh Gram Panchayats	Systemic

Table 13: Interventions of MoRD

4.2 Group - B

4.2.1 Ministry of Finance (MoF)

The Ministry has made commendable progress in establishing green finance mechanisms, such as Sovereign Green Bonds, the US-India Green Transition Fund, and Indo-German partnerships. The inclusion of climate-resilient infrastructure in national investment

pipelines and development of carbon credit trading mechanisms showcases systemic adaptation planning. Suggestion: The Ministry could institutionalize climate adaptation budgeting frameworks across all departments and states to better align development finance with long-term resilience goals.

S.No.	Intervention	Indicator
1	Financial Instruments & Funding Mechanisms	
1.1	Sovereign Green Bonds (SGrBs) – ₹16,000 Cr (2022-23) & ₹20,000 Cr (2023-24): Issued to mobilize resources for green infrastructure and reduce the carbon intensity of the economy.	Environmental, Economic
1.2	G20 Sustainable Finance Technical Assistance Action Plan (TAAP): Strengthens sustainable finance capacity-building for Emerging Markets & Developing Economies (EMDEs).	Economic, Systematic
1.3	US-India Green Transition Fund (USIGF) – \$2B Corpus: Structured as a credit fund to lower capital costs and attract private finance for renewable energy and green technologies to support large-scale green energy deployment.	Environmental, Economic
1.4	Indo-German Partnership for Green & Sustainable Development (€10B Commitment): Germany committed €2.118B till Nov 2023, including €1.54B in financing agreements under Indo-German Bilateral Development Cooperation to support green infrastructure and climate resilience.	Environmental, Economic
1.5	Energy Unit – ADB-GCF Green Finance Facility (GFF): Structured financing mechanism for renewable energy projects that enables access to large-scale competitive funding for green initiatives.	Economic, Systematic
2	International Collaborations & Global Coordination	
2.1	G20 Finance Track – Sustainable Finance & Climate Action: Led the global agenda on sustainable finance and multilateral climate investments.	Economic, Systematic
2.2	G20 Infrastructure Working Group – Key Deliverables on Sustainable Infrastructure: Strengthened multilateral development banks and promoted sustainable infrastructure financing.	Physical, Economic
2.3	Global Sovereign Debt Roundtable: Focused on debt restructuring and financial stability in vulnerable economies, including climate-vulnerable nations.	Economic, Systematic
2.4	12th India-EU Macroeconomic Dialogue (Feb 2024): Discussions on macroeconomy, climate change, green and digital transitions to strengthen India-EU cooperation in sustainability.	Systematic, Economic
2.5	US-India Green Transition Fund (USIGF): Collaboration between India and the US to finance green projects to encourage private investment in green energy.	Economic, Environmental
2.6	Indo-German Partnership for Green & Sustainable Development: Bilateral cooperation to fund sustainable development projects to strengthen international climate finance partnerships.	Economic, Environmental, Systematic
2.7	Sustainable Finance Working Group (SFWG) – G20 Initiative: Co-chaired by the US and China under G20 Italian Presidency to mobilize sustainable finance to supports global economic stability and green growth.	Systematic, Economic
3	Policies, Directives & Guidelines	
3.1	Harmonized Master List (HML) of Infrastructure Sub-sectors: Updated to include climate-resilient infrastructure categories.	Economic, Systematic

3.2	National Infrastructure Pipeline (NIP): Continued investments in sustainable infrastructure projects across multiple sectors.	Physical, Economic
3.3	Energy Unit – Carbon Credit Trading Scheme (CCTS) & Green Taxonomy: Developing regulatory mechanisms to facilitate carbon trading and access to green finance to encourage emission reduction and sustainable investments.	Systematic, Environmental
4	Economic Incentives & Green Mobility	
4.1	Public-Private Partnership (PPP) – Viability Gap Funding (VGF) Expansion: Revamped to support climate-resilient infrastructure and urban sustainability projects.	Systematic, Economic
4.2	Infrastructure Investment Project Development Fund (IIPDF) – Revamp: Enhanced to facilitate investments in sustainable public infrastructure projects.	
4.3	Customs Duty Exemption – Lithium-ion cell manufacturing for Evs: Exempted import duty on capital goods & machinery for EV battery production to boost domestic EV manufacturing, reduces dependence on imports.	Economic, Environmental

Table 14: Interventions of MoF

4.2.2 Ministry of Health and Family Welfare (MoHFW)

MoHFW has prioritized climate-resilient healthcare through the expansion of emergency life support systems and disaster health training programs. The Health Sector Disaster Preparedness and Response scheme is a vital step

toward resilient public health infrastructure.

Suggestion: Integration of climate change scenarios into national health planning (e.g., vector-borne disease modeling) can further strengthen public health resilience.

S.No.	Intervention	Indicator
	Sectoral Focus: Healthcare Infrastructure and Public Health	
1	Policy and Regulatory Frameworks	
1.1	Human Resource Development for Emergency Medical Services (HRDEMS): The scheme has provisions for setting up and equipping of National Emergency Life Support (NELS) Skill Centres at Government (Central/State) Medical Colleges across all States and UTs for imparting skill-based trainings to doctors, nurses and paramedics in emergency life support. As on 07th May 2024, 95 NELS Skill Centres are being set up at Government Medical Colleges across the country and Training of Trainers (ToTs) for doctors, nurses and paramedics in NELS course have been initiated at the established centres on a Pan-India basis.	Systemic, Social, Economic
1.2	Health Sector Disaster Preparedness and Response (HSDPR): The scheme aims to strengthen capacities of the health sector to prevent, mitigate and remain prepared to respond to the adverse outcome of disasters. This includes capacity building of specialized manpower in various facets of disaster management like public health preparedness for district level health officers, hospital preparedness for hospital managers, hospital safety for hospital administrators and hospital engineers, psychosocial care in disaster settings for psychiatrists, psychologists and social workers, training on medical management of radio-nuclear emergencies. Course curricula and training modules for these courses have been prepared and trainings have been initiated on a Pan-India level for said programmes	Systemic, Physical, Social
2	Capacity Building and Skill Development	
2.1	Training First Responders & Health Professionals by MoHFW: 124 training programs were conducted in 2023-24, training 27,428 professionals in emergency healthcare and disaster response	Systemic, Social, Physical

Table 15: Interventions of MoHFW

4.2.3 Ministry of Housing and Urban Affairs (MoHUA)

MoHUA integrates climate resilience across urban development schemes like Smart Cities, AMRUT, and PMAY. Noteworthy efforts include green roofs, early flood warning systems, and GIS-based planning. The CVI and e-governance tools also strengthen adaptive

governance.

Suggestion: The Ministry can further benefit from piloting heat-resilient urban design models in tier-2 cities and integrating blue-green infrastructure into town planning.

S.No.	Intervention	Indicator
	Sectoral Focus: Housing, Shelter, Urban Infrastructure & Services	
1	Policy and Regulatory Frameworks	
1.1	National Mission on Sustainable Habitat (NMSH) 2.0: Ministry of Housing and Urban Affairs (MoHUA) anchors this mission under the National Action Plan on Climate Change (NAPCC). The mission focuses on climate resilience, sustainable urban planning, and adaptation measures to mitigate climate change impacts. Smart Cities Mission & AMRUT: Urban development schemes that integrate climate adaptation by promoting green infrastructure, sustainable drainage systems, and flood management frameworks. Pradhan Mantri Awas Yojana (PMAY): Incorporation of climate-resilient building materials and energy-efficient designs in affordable housing initiatives.	Physical, Economic, Social
1.2	National Building Code: Updated to include climate-responsive building designs and disaster-resilient structures. National Urban Transport Policy (NUTP): Encourages low-carbon mobility solutions to mitigate urban climate risks. Swachh Bharat Mission 2.0: Focuses on waste-to-energy plants and landfill remediation, reducing urban environmental hazards.	Physical, Economic, Systemic
1.3	Barrier-Free Environment: Revised Harmonized Guidelines and Space Standards for Persons with Disabilities and Elderly Persons notified in October 2022. Building Regulations: Model Building Bye Laws (2016) and Unified Building Bye Laws for Delhi. Urban Planning & EV Infrastructure: Implementation of provisions in MBBL 2016 and URDPFI 2014 for Electric Vehicle Charging Infrastructure. AMRUT 2.0 Sub-Scheme: Focused on Drone Technology for urban development. Disaster Resilience in Urban Cities: Technical inputs for an ADB-assisted initiative.	Physical, Systemic
2	Capacity Building and Skill Development	
2.1	PIDPI Training: Capacity building for Public Interest Disclosure and Protection of Informers (PIDPI). BRIKS-MIS Workshops: State-level training on housing and urban development initiatives.	Systemic

	ITCN Program: Training under Infant, Toddler, and Caregiver-Friendly Neighbourhoods (ITCN).	
2.2	Capacity-building workshops on urban climate adaptation strategies, conducted under AMRUT and Smart Cities initiatives. Disaster-Resilient Infrastructure Training for urban planners and engineers to incorporate flood-resistant and heat-resilient designs.	Systemic, Social
2.3	MoHUA collaborates with NIUA (National Institute of Urban Affairs) to conduct training modules on climate resilience and disaster risk reduction for municipal authorities. Regional training hubs established under National Disaster Management Authority (NDMA) and MoHUA to facilitate cross-learning.	Systemic
3	Technological Innovations and Applied Solutions	
3.1	Urban Flood Early Warning System (UFEWS): Implemented in major cities for real-time flood forecasting and response planning. Climate Vulnerability Index (CVI): Developed for risk assessment in urban planning and infrastructure projects.	Physical, Economic
3.2	Geospatial Mapping for Urban Climate Risks: Used in Smart Cities for heat island mitigation and water resource management. Energy Efficiency Calculator: Integrated in housing projects under PMAY for climate-resilient design assessment.	Physical, Economic
3.3	GIS-Based Urban Planning: Implementation of GIS-based Master Plan Formulation under AMRUT. E-Governance Tools: Adoption of E-office, E-tendering, and ERP for transparency and efficiency.	Systemic, Economic
3.4	Waste Management Systems to optimize solid waste collection and recycling. Solar-Powered Street Lighting to promote energy-efficient urban infrastructure.	Environmental, Economic
4	Research, Data, and Knowledge Systems	
4.1	Green Roofs & Vertical Gardens in Delhi & Bangalore: Piloted under Smart Cities to reduce urban heat islands. Stormwater Management in Chennai: Development of permeable pavements and urban water storage systems.	Environmental, Physical
4.2	Housing Market Research: Analysis of market dynamics for housing policies. Urban Resilience Study: Research on disaster risk reduction in urban settings.	Systematic, Economic

Table 16: Interventions of MoHUA

4.2.4 Ministry of Environment, Forest and Climate Change (MoEFCC)

MoEFCC plays a central role in afforestation, biodiversity conservation, and coordination of the NAPCC and SAPCCs. Initiatives like CAMPA, NCAP, and the Green Credit Rules demonstrate comprehensive

environmental adaptation efforts.

Suggestion: There is an opportunity to strengthen state-level implementation by expanding technical and financial support mechanisms under NAFCC, especially for ecosystem-based adaptation.

S.No.	Intervention	Indicator
	Sectoral Focus: Environmental Conservation & Biodiversity	
1	Policy and Regulatory Frameworks	
1.1	Green Credit Rules notified under the Environment Protection Act, 1986. Draft Ecomark Certification Rules, 2023, published for public consultation. National Afforestation and Eco-Development Board (NAEB) initiatives, including Nagar Van Yojana and School Nursery Yojana. Compensatory Afforestation Fund Management and Planning Authority (CAMPA) schemes for forest conservation and afforestation. Guidelines under the National Clean Air Program (NCAP) for air quality management. Various schemes supported under the CAMPA Fund, including ecological sustainability projects.	Environmental, Economic
1.2	National Action Plan on Climate Change (NAPCC): Framework for India's long-term climate resilience strategy, India Cooling Action Plan (ICAP), National Clean Air Programme (NCAP): Reducing pollution and improving air quality in 131 cities.	Environmental, Systemic
1.3	COP-28 Engagement: India emphasized equitable climate action, accessible climate finance, and the operationalization of the Loss and Damage Fund. National Adaptation Fund for Climate Change (NAFCC): Funding for projects enhancing climate resilience.	Economic, Systemic
1.4	State Action Plans on Climate Change (SAPCCs): Support for states and UTs in addressing climate vulnerabilities and implementing regional strategies.	Systemic, Environmental
1.5	Urban Disaster Resilience: ADB-assisted project focused on enhancing urban resilience.	Physical, Economic, Systemic
2	Capacity Building and Skill Development	
2.1	Climate Resilience Workshops under Mission LiFE to promote environment-friendly lifestyle choices. Mass Awareness Programme to promote Mission LiFE, Training for forest officers on adaptive forest management through National Green India Mission. Technical training on geospatial mapping for climate adaptation in urban planning. Seminar on Livelihood Opportunities from Climate Resilient Solutions for a Carbon Neutral Ladakh.	Systemic, Social

2.2	Establishment of a National Knowledge Network (NKN) for air quality management and capacity building. Directorate of Forest Education conducting training for IFS officers, forest rangers, and front-line staff. Regional workshops and interaction meetings for air pollution control under NCAP. Training programs for RAC service technicians under the Montreal Protocol. Forest Research Institute (FRI) and Wildlife Institute of India (WII) conducting specialized training for conservation.	Systemic, Social
2.3	Forest Fire Prevention and Management Scheme: Provides financial aid for forest fire mitigation, involving National Disaster Response Force (NDRF) training.	Systemic, Physical
3	Technological Innovations and Applied Solutions	
3.1	Climate Vulnerability Index (CVI) for risk assessment and adaptation planning. Geospatial Mapping for Forest and Biodiversity Management to monitor climate-induced impacts PARIVESH 2.0: Digital platform for environmental clearance processes, ensuring climate risk assessments. Decision Support System (DSS) for Forest Management, integrating real-time climate data.	Environmental, Systemic, Economic
3.2	Deployment of Wildlife Information Management System (WMIS) and mobile app for monitoring wildlife. Implementation of drone pilot training for forest officials. E-Greenwatch system for monitoring CAMPA activities. Establishment of National Centre for Wildlife Forensics (NCWF).	Environmental, Physical
3.3	Disaster Management Cell: Established for monitoring forest fires and chemical accidents, with a 24-hour toll-free helpline.	Physical, Systemic
4	Research, Data, and Knowledge Systems	
4.1	Studies on economic losses due to forest fires in Uttarakhand and Madhya Pradesh. Research on conservation of endangered species such as the Gangetic River Dolphin, Great Indian Bustard, and Dugong. Development of public procurement policies for hiring trained RAC service technicians. Study on sustainable e-commerce cold chain infrastructure. Research initiatives under the SECURE Himalaya Project for ecosystem restoration.	Environmental, Economic
4.2	NIUA's Climate Resilient Cities Report: Highlights best practices in disaster mitigation and climate-responsive planning. MoHUA & IMD Collaborative Study: Research on impact of extreme weather events on urban infrastructure	Environmental, Systemic

Table 17: Interventions of MoEFCC

4.2.5 Ministry of Power (MoP)

The Ministry leads in emission reduction via schemes like PAT, UJALA, and floating solar power projects. Innovations in carbon credit trading and biomass co-firing, along with robust capacity building, demonstrate

alignment with climate mitigation and adaptation co-benefits.

Suggestion: Expanding the rural energy access agenda to include climate-resilient mini-grid systems would improve adaptation outcomes in underserved regions.

S.No.	Intervention	Indicator
	Sectoral Focus: Power Generation & Supply	
1	Policy and Regulatory Frameworks	
1.1	Launched in 2008, the National Action Plan on Climate Change (NAPCC) outlines India's strategy to tackle climate change through eight national missions. A pivotal component is the National Mission for Enhanced Energy Efficiency (NMEEE), which includes programs like the Perform, Achieve & Trade (PAT) scheme. This scheme has successfully averted approximately 30 million tonnes of CO ₂ emissions, with projections to prevent an additional 30 million tonnes by 2020. India's commitment to reducing its emissions intensity by 33 to 35 percent by 2030 from 2005 levels is a testament to its dedication to sustainable development.	Economic, Social, Environmental, Systemic
1.2	The Carbon Credit Trading Scheme (28th June 2023, amended on 19th December 2023) established the Indian Carbon Market (ICM) to facilitate the trading of carbon credit certificates. The scheme aims to decarbonize the Indian economy by pricing greenhouse gas emissions and enabling the exchange of carbon credits. It consists of two mechanisms: the compliance mechanism and the offset mechanism. Under the compliance mechanism, obligated entities must meet prescribed greenhouse gas emission reduction targets. If they reduce emissions below the target, they receive carbon credit certificates, which can be traded. The offset mechanism allows non-obligated entities to register projects that reduce, remove, or avoid emissions, making them eligible for carbon credit certificates. The scheme is expected to play a significant role in India's climate action by providing financial incentives for emission reduction.	Economic, Environmental, Systemic
1.3	The Central Electricity Regulatory Commission (CERC) plays a critical role in regulating the generation, transmission, and distribution of electricity across India. During the period from April 2023 to March 2024, CERC issued several tariff regulations, including measures for promoting renewable energy integration and enhancing grid stability. The commission also issued guidelines on open access charges and grid connectivity standards to support the transition towards clean energy.	Economic, Systemic, Environmental
1.4	The Joint Electricity Regulatory Commission (JERC) regulates electricity distribution and retail supply in Union Territories and certain states. In 2023-24, JERC introduced tariff orders promoting renewable energy procurement and enhancing consumer grievance redressal mechanisms.	Economic, Social, Systemic
1.5	The Bureau of Energy Efficiency (BEE) carries out several regulatory functions under the Energy Conservation Act, 2001. The EC Act provides a legal framework	Economic, Systemic

	for energy efficiency initiatives in the country. During 2023-24, BEE continued to enforce energy efficiency norms for designated consumers across sectors like power, transport, and buildings. BEE is also responsible for setting energy performance standards under the Standards and Labelling Programme, supporting the implementation of the PAT Scheme, and regulating carbon credit trading under the Carbon Credit Trading Scheme.	
1.6	The Perform, Achieve and Trade (PAT) Scheme is a flagship policy that aims to improve energy efficiency in energy-intensive industries by setting specific energy consumption reduction targets. It involves assessing the baseline energy consumption of designated consumers and setting targets to reduce energy usage over a defined period. Successful entities receive Energy Saving Certificates, which can be traded with other entities.	Economic, Systemic, Environmental
1.7	The Petroleum and Natural Gas Regulatory Board Act (PNGRB Act) also plays a role in regulating the distribution of natural gas, which is considered a transitional fuel in India's energy mix. The act promotes the development of city gas distribution networks and encourages the use of cleaner fuels as part of the country's energy transition efforts.	Economic, Systemic, Environmental
1.8	The Biomass Utilization for Power Generation through Co-firing in Coal-based Power Plants (October 2021) mandates thermal power plants to co-fire 5-10% biomass pellets along with coal, aimed at reducing carbon emissions and promoting sustainable waste management. This policy was further expanded through a Policy Addendum (3rd May 2023), which included various types of agro-residues such as paddy straw, mustard stalk, and other biomass materials for pellet production. The ministry revised the biomass policy on 16th June 2023, making it mandatory for thermal power plants to co-fire 5% biomass from FY 2024-25, with the requirement increasing to 7% from FY 2025-26.	Environmental, Economic, Systemic
1.9	The Standards and Labelling (S&L) Programme provides energy efficiency ratings for 38 appliances, helping consumers make informed choices about energy-efficient products. The Go Electric Campaign, launched in 2021, creates public awareness about the benefits of electric vehicles and electric cooking. The EV Yatra Portal and Mobile App, launched in December 2022, acts as a national database for public EV charging stations, offering real-time information to EV users.	Economic, Social, Environmental
1.10	The UJALA Programme distributes affordable LED bulbs, tube lights, and energy-efficient fans, significantly reducing energy consumption. The Street Lighting National Programme (SLNP) replaces conventional streetlights with LED lights across India, contributing to energy conservation and emission reduction.	Economic, Social, Environmental
1.11	The Revised Guidelines and Standards for Charging Infrastructure for Electric Vehicles (27th April 2023) set comprehensive directions for the development of EV charging networks. The guidelines cover provisions for land availability from public and private entities, single-part electricity tariffs for charging stations, revenue-sharing models, and service fees based on solar and non-solar hours. They also mandate a 20% discount in electricity supply rates during solar hours to	Economic, Systemic, Environmental

	encourage daytime charging. The guidelines aim to ensure uniformity, promote the installation of public charging stations, and facilitate open access to electricity supply for charging operators.	
1.12	The Corporate Social Responsibility (CSR) Policy has been adopted by several public sector undertakings under the Ministry of Power. It emphasizes environmental sustainability, including projects on afforestation, biodiversity conservation, and renewable energy adoption. These CSR activities contribute to climate adaptation and mitigation efforts.	Economic, Social, Environmental
1.13	The National Electricity Policy and National Electricity Plan guide the overall development of the power sector, with provisions for increasing renewable energy capacity and enhancing grid resilience. The Tariff Policy supports the integration of renewable energy by setting guidelines for power procurement and promoting cost-effective clean energy generation.	Economic, Systemic, Environmental
1.14	SJVN, a public sector undertaking under the Ministry of Power, is primarily engaged in hydroelectric power generation. The SJVN Environment Policy reaffirms the company's commitment to sustainable power generation and transmission while minimizing environmental impacts. The policy outlines various measures for pollution control, biodiversity conservation, and the adoption of green technologies. The company has taken initiatives to implement renewable energy projects, including solar and wind power, and promote energy-efficient practices to align with India's climate action goals	Economic, Environmental, Systemic
1.15	Policy measures to promote the Hydropower sector have been implemented to encourage renewable energy generation. The government has taken steps to streamline project approvals, provide financial assistance, and promote pumped storage hydropower projects to ensure grid stability and sustainable energy supply.	Economic, Systemic, Environmental, Physical
2	Capacity Building and Skill Development	
2.1	The National Power Training Institute (NPTI) plays a key role in providing capacity -building programs on power sector reforms, energy conservation, and the adoption of clean energy technologies. The institute conducts customized training programs on various aspects of power generation, transmission, distribution, and regulatory frameworks. The training modules cover areas such as renewable energy integration, grid stability, and energy efficiency practices, catering to professionals across the power sector.	Economic, Social, Systemic
2.2	The National Smart Grid Mission (NSGM) focuses on capacity-building activities to strengthen India's smart grid infrastructure. NSGM facilitates training programs, workshops, and knowledge-sharing platforms to enhance the technical skills of power sector professionals.	Economic, Social, Systemic
2.3	A Memorandum of Understanding (MoU) was signed among the National Skill Development Corporation (NSDC), National Skill Development Fund (NSDF), Power Sector Skill Council (PSSC), and POWERGRID for skill development training of 6000	Economic, Social

	unemployed youth in the power sector. As of March 2024, over 5400 trainees have completed their training across 25 locations in India.	
2.4	An MoU with the Power Sector Skill Council (PSSC) was signed to provide skill development training to 6000 candidates for the implementation of smart metering under the Revamped Distribution Sector Scheme (RDSS) of the Government of India across the country.	Economic, Social
2.5	The Central Power Research Institute (CPRI) also contributes to capacity building by offering customized training programs on power system testing, research methodologies, and advanced energy technologies. The institute regularly conducts training sessions and workshops for stakeholders across the power sector.	Economic, Systemic
2.6	The Bureau of Energy Efficiency (BEE), under the Go Electric Campaign, supports the establishment of EV Accelerator Cells in seven states, including Maharashtra, Delhi, Tamil Nadu, and Karnataka. These cells play a key role in capacity building by acting as institutional mechanisms that promote the development of EV charging infrastructure. They coordinate between various stakeholders such as state governments, private sector players, and utilities to create an enabling environment for electric mobility. The EV Accelerator Cells facilitate technical assistance, knowledge-sharing, and infrastructure development essential for the widespread adoption of electric vehicles. These cells coordinate the development of EV charging infrastructure and promote electric mobility.	Economic, Social, Environmental
3	Technological Innovations and Applied Solutions	
3.1	The Ministry of Power leverages digital platforms like the e-NAM Portal for trading agro-residue commodities and the SAMARTH Website for managing the biomass pellet supply chain. These platforms facilitate the procurement of biomass for co-firing in thermal power plants.	Economic, Systemic, Environmental
3.2	NTPC has implemented an elaborate Enterprise Risk Management Framework to address emerging business risks, including regulatory compliance, cyber security threats, and operational challenges. The framework aligns with the globally recognized ISO 31000 (Risk Management Guidelines) and ensures that risk assessments are regularly conducted.	Systemic, Economic
3.3	The Risk Management Committee (RMC), consisting of Functional Directors and Independent Directors, reviews risks, formulates mitigation strategies, and reports key risks to the Board on a quarterly basis. The system monitors risks through Key Risk Indicators (KRIs) and has received a Letter of Conformity validating its compliance.	Systemic, Economic
3.4	PFC has an integrated Risk Management Framework that identifies and mitigates risks impacting its business operations. The framework includes an Asset Liability Management Committee (ALCO), which monitors liquidity and interest rate risks. The Board Level Risk Management Committee (BLRMC), comprising Board members, is responsible for evaluating key risks and suggesting mitigation measures.	Systemic, Economic

3.5	PFC has appointed a Chief Risk Officer (CRO) to oversee the implementation of risk management strategies in line with regulatory guidelines from the Reserve Bank of India. The Ministry of Power leverages digital platforms like the e-NAM Portal for trading agro-residue commodities and the SAMARTH Website for managing the biomass pellet supply chain. These platforms facilitate the procurement of biomass for co-firing in thermal power plants.	Systemic, Economic
3.6	The EV Yatra Portal serves as an online platform providing information on the availability of EV charging stations, supporting the transition to electric mobility.	Social, Systemic, Environmental
3.7	The SAMARTH Mission demonstrates the use of biomass pellets in thermal power plants, contributing to emission reduction and sustainable energy practices. The mission plays a critical role in utilizing agricultural residue to produce biomass pellets, which are co-fired along with coal in thermal power plants, promoting circular economy principles and reducing air pollution from stubble burning.	Environmental, Economic
3.8	NTPC Floating Solar Power Projects at Ramagundam and Kayamkulam represent innovative adaptation initiatives that harness water bodies to generate clean energy. These projects minimize land use while enhancing renewable energy generation capacity.	Environmental, Economic, Systemic
3.9	Jawaharlal Nehru National Solar Mission (JNNSM): Launched in January 2010, the Jawaharlal Nehru National Solar Mission (JNNSM) is a significant initiative by the Government of India to promote solar energy. Initially, the mission set a target of achieving 20 GW of solar power by 2022, which was later revised to 100 GW in 2015. The mission continues to drive India's renewable energy agenda, with ongoing efforts to achieve and potentially exceed the 100 GW target in the coming years.	Environmental, Economic
3.10	NTPC's Carbon Capture Utilization and Storage (CCUS) project explores technologies for capturing CO ₂ emissions from thermal power plants and reusing them for industrial applications or storing them underground. This approach supports decarbonization efforts and aligns with India's climate action targets.	Environmental, Economic, Systemic
4	Research, Data, and Knowledge Systems	
4.1	The EV Digest (2024) is an annual publication that provides comprehensive information on the current status of India's e-mobility ecosystem. The publication offers insights into policy implementation, market trends, and technological advancements in electric mobility.	Social, Systemic
4.2	NETRA's Green Hydrogen Projects focus on renewable hydrogen generation and microgrid systems, including: - 1 TPD Green Hydrogen Generation from Sea Water at NTPC Simhadri: This project focuses on producing green hydrogen through the electrolysis of seawater using renewable energy - Green Hydrogen Grid Design & Development at NETRA premises: The project aims to design and develop a green hydrogen-based microgrid system to support	Environmental, Economic, Systemic

	clean energy applications. - Hydrogen Generation through High-Temperature Steam Electrolyzer at NETRA premises: This project explores the use of high-temperature steam electrolyzers for efficient hydrogen production.	
4.3	The Central Power Research Institute (CPRI) conducts research on emerging power sector technologies, including renewable energy integration and grid stability. CPRI provides research-based solutions and testing facilities to promote the adoption of sustainable energy technologies.	Systemic, Environmental
5	Others	
5.1	The Ministry of Power provides funding assistance for various renewable energy and energy efficiency projects through schemes such as the Revamped Distribution Sector Scheme (RDSS) and SAMARTH Mission. Financial assistance is also available under the MNRE and CPCB Financial Assistance Schemes for the establishment of biomass pellet manufacturing units. The Reserve Bank of India has categorized biomass pellet manufacturing under Priority Sector Lending (PSL) to facilitate access to credit.	Economic, Systemic, Environmental
5.2	The Ministry allocates resources through the UJALA Programme and Street Lighting National Programme (SLNP) for promoting energy efficiency and renewable energy adoption. Revenue-sharing models and subsidies are implemented to support the development of EV charging infrastructure.	Economic, Social, Environmental
5.3	The PAT Scheme has resulted in annual energy savings of Rs. 55,000 crore and reduced CO2 emissions by approximately 110 million tonnes. The UJALA Programme has achieved energy savings of 176.2 billion kWh per year, with an estimated monetary saving of Rs. 70,477 crore.	Economic, Environmental
5.4	The Ministry facilitates biomass pellet procurement through the GeM Portal and provides financial assistance under the SAMARTH Mission to promote biomass utilization in thermal power plants.	Economic, Systemic, Environmental
5.5	The Carbon Credit Trading Scheme serves as a key strategy for integrating climate risks into national budgeting, enabling the trading of carbon credits to incentivize emission reductions. The inclusion of EV infrastructure and biomass programs in national policies aligns with India's decarbonization goals.	Economic, Systemic, Environmental

Table 18: Interventions of MoP

4.2.6 Ministry of Road Transport and Highways (MoRTH)

MoRTH has taken major strides in integrating climate adaptation into infrastructure planning. The HighCAP policy, green highways mission, and use of recycled

materials in road construction show a clear move toward climate-resilient transport systems.

Suggestion: Future policies can incorporate vulnerability mapping into all new road planning and develop sector-specific adaptation plans for high-altitude and coastal highways.

S.No.	Intervention	Indicator
	Sectoral Focus: Road Infrastructure Development and Transport & Mobility	
1	Policy and Regulatory Frameworks	
1.1	The Ministry of Road Transport and Highways (MoRTH) has introduced several legal and regulatory measures to improve sustainability, road safety, and environmental management. Key legal frameworks include the Motor Vehicles Act, 1988, and the Central Motor Vehicles Rules, 1989, which set out vehicle emission standards and safety norms.	Systematic, Physical
1.2	The Bharatmala Pariyojana, launched as an umbrella program, aims to improve logistics efficiency and connect remote regions with better road infrastructure. This program contributes to reducing the carbon footprint by enhancing the efficiency of freight movement and reducing fuel consumption.	Systematic, Physical, Environmental
1.3	The Vehicle Scrapping Policy, introduced in 2021 and operationalized during 2023-24, is a critical step towards phasing out old and unfit vehicles to curb pollution and promote sustainable practices. In September 2024, MoRTH urged automobile manufacturers to establish vehicle scrapping centers, which is expected to boost new vehicle sales by 18-20%, significantly reducing vehicular emissions.	Systematic, Physical, Environmental
1.4	The PM Electric Drive Revolution in Innovative Vehicle Enhancement (PM E-DRIVE) Scheme, approved in 2024, aims to promote electric vehicle adoption with a budget allocation of \$1.3 billion. The scheme provides subsidies for two-wheelers, three-wheelers, ambulances, and trucks. It is expected to accelerate the transition towards electric mobility and increase EV sales to 30% by 2030, contributing to India's climate mitigation goals.	Physical, Economic, Environmental, Systemic
1.5	MoRTH has also notified Emission Standards for Construction Equipment Vehicles and Tractors to ensure environmentally friendly construction activities. These standards have been implemented from 1st October 2020 (Trem IV) and from 1st April 2024 under Bharat Stage (CEV/Trem)-V norms.	Physical, Environmental, Systemic
1.6	The Ministry promotes the use of recycled materials in road construction, including urban solid waste and inert materials, under specific policy guidelines. Municipal Corporations are responsible for material management, while NHAI ensures compliance with environmental norms.	Physical, Economic, Environmental
1.7	The National Green Highways Mission (NGHM), launched as part of the Green Highways Policy (2015), aims to mitigate the adverse impacts of vehicular pollution and deforestation. It promotes tree plantations along national highways to improve environmental sustainability and offset emissions from road transport.	Physical, Environmental, Systemic
1.8	The Ministry issued a notification regarding the Methanol Blending of gasoline to reduce vehicle exhaust emissions and lower dependency on crude petroleum imports.	Physical, Economic, Environmental
1.9	The Green Highways (Plantation, Transplantation, Beautification & Maintenance)	Physical,

	Policy 2015 is a landmark policy aimed at enhancing environmental sustainability along national highways. Under this policy, tree plantations are carried out along highways to improve aesthetics, mitigate air pollution, and strengthen roadside ecosystems.	Environmental, Systemic
1.10	The Ministry collaborated with the Japan International Cooperation Agency (JICA) in July 2023 to issue guidelines for developing highways in mountainous regions. These guidelines provide comprehensive measures for slope protection, tunnel construction, and climate-resilient infrastructure development, addressing the vulnerability of hilly areas to natural disasters.	Physical, Environmental, Systemic
1.11	The National Highway Climate Adaptation Policy and Guidelines (HighCAP) is a project that aims to integrate Disaster Risk Reduction (DRR) and climate adaptation into the highway sector. This policy focuses on infrastructure elements such as pavements, protection structures, bridges, drainage systems, hill-slopes, dump sites, and embankments, promoting the adoption of nature-based solutions.	Physical, Environmental, Systemic
1.12	The Swachhatta Pakhwara Campaign, organized between 15th-30th September 2023, promoted cleanliness and the use of recycled materials in highway construction, reinforcing the Ministry's commitment to sustainability.	Physical, Social, Environmental
2	Capacity Building and Skill Development	
2.1	The Indian Academy of Highway Engineers (IAHE), the apex training institute under MoRTH, conducts capacity-building programs for engineers and stakeholders. The training modules cover topics such as road safety, sustainable road construction practices, disaster resilience, and advanced construction technologies. IAHE collaborates with international institutions to integrate global best practices in highway infrastructure development.	Social, Systemic
2.2	The Parvatmala Pariyojna is a flagship scheme aimed at developing ropeway infrastructure in hilly areas. As part of the project, the Ministry organizes skill development programs for local communities to build capacities in ropeway operation and maintenance, thereby creating employment opportunities and promoting sustainable transport systems.	Social, Economic, Systemic
2.3	The Ministry also supports capacity-building initiatives through the National Highways Excellence Awards, which recognize exemplary practices in road safety, sustainable infrastructure, and technological innovations.	Social, Systemic
2.4	The Ministry collaborates with The Energy and Resources Institute (TERI) to conduct studies and develop strategies for climate adaptation and mitigation in the highway sector, enhancing institutional capacity in addressing climate risks.	Environmental, Systemic
3	Technological Innovations and Applied Solutions	
3.1	The Integrated Road Accident Database (iRAD) is a digital platform developed by MoRTH in collaboration with IIT Madras. The system collects, stores, and analyzes accident data to identify high-risk locations and formulate targeted interventions. The platform enhances road safety by enabling evidence-based decision-making and planning.	Physical, Systemic

3.2	MoRTH has commissioned Climate Risk and Adaptation Assessments to evaluate the vulnerability of national highways to climate change-induced extreme weather events. These studies recommend mitigation strategies and climate-resilient infrastructure designs to minimize risks.	Environmental, Systemic
3.3	The Ministry is also working on developing Climate and Disaster Resilient Infrastructure to enhance the resilience of highways against climate change impacts like sea-level rise, extreme precipitation, and rising temperatures.	Physical, Environmental, Systemic
3.4	The BhoomiRashi Portal streamlines the land acquisition process by digitizing documentation and providing transparency in transactions. The portal reduces project delays, indirectly contributing to reduced greenhouse gas emissions by accelerating infrastructure development.	Economic, Systemic
3.5	The RajmargYatra and NHA One mobile applications facilitate public access to information on road conditions, toll payments, and emergency services, contributing to more efficient and eco-friendly transport operations. These citizen-centric applications enhance commuting experiences and reduce emissions through better route planning.	Physical, Economic, Systemic
3.6	The Parvatmala Pariyojna ropeway projects are a prime example of sustainable transport systems in hilly regions. These projects reduce vehicular emissions, provide eco-friendly alternatives to road transport, and improve connectivity in difficult terrains.	Physical, Environmental, Economic
3.7	The NHA Sustainability Report highlights several key environmental sustainability initiatives, including a reduction of 18.44% in direct emissions from FY 2019-20 to 2021-22. The report also documents the plantation of approximately 2.74 crore saplings along highways to offset vehicular emissions.	Environmental, Systemic
3.8	NHA has implemented over 100 Wildlife Crossings across 20 states to reduce man-animal conflict and promote biodiversity conservation.	Physical, Environmental
3.9	NHA has partnered with various stakeholders such as State Rural Livelihood Missions (SRLM), Self Help Groups, CSR partners, and NGOs to organize collaborative plantation drives. Notably, a nationwide plantation drive in July 2022 resulted in the planting of around 1.1 lakh plants in a single day across 114 locations.	Environmental, Social, Systemic
3.10	The Parvatmala Pariyojna ropeway projects are a prime example of sustainable transport systems in hilly regions. These projects reduce vehicular emissions, provide eco-friendly alternatives to road transport, and improve connectivity in difficult terrains.	Physical, Environmental, Economic
3.11	The Ministry has adopted Optical Fibre Cable (OFC) infrastructure along highways to enhance digital connectivity and promote smart transportation. Additionally, the use of plastic waste in road construction is encouraged under various projects to promote sustainable infrastructure practices.	Physical, Environmental, Systemic
3.12	The FASTag system, an Electronic Toll Collection (ETC) initiative, significantly reduces vehicle idling time at toll plazas, leading to lower emissions and fuel	Economic, Environmental,

	consumption. This initiative plays a crucial role in reducing the carbon footprint of highway operations.	Systemic
3.13	The Ministry encourages the use of sustainable construction practices by promoting the use of recycled materials such as urban solid waste and inert materials. Policy guidelines have been issued to support the integration of such materials in highway construction, with Municipal Corporations responsible for material management and NHAI ensuring adherence to environmental regulations.	Physical, Environmental, Systemic
3.14	The PM E-DRIVE Scheme encourages the shift to electric vehicles, with provisions for subsidizing electric buses and other public transport vehicles. This initiative supports low-carbon transport systems and contributes to national climate action goals.	Physical, Economic, Environmental
4	Research, Data, and Knowledge Systems	
4.1	MoRTH collaborates with research institutions like IIT Madras and the Central Road Research Institute (CRRI) to develop innovative solutions in road safety and sustainable infrastructure. Research areas include the use of recycled materials in road construction, slope stabilization techniques, and disaster-resilient infrastructure designs.	Physical, Environmental, Systemic
4.2	The Indian Academy of Highway Engineers (IAHE) and CRRI play a vital role in driving research and knowledge dissemination in sustainable road infrastructure. These institutions provide comprehensive databases and technical expertise to support ongoing and future projects.	Systemic, Social

Table 19: Interventions of MoRTH

4.2.7 Ministry of Ports, Shipping and Waterways (MoPSW)

Notable for introducing the 'Harit Sagar' guidelines, the Ministry promotes low-emission fuels and green ship incentives. The deployment of hybrid vessels and zero-emission container ships signals early leadership

in maritime adaptation.

Suggestion: Additional focus could be placed on climate-proofing coastal port infrastructure and supporting small-scale fisher livelihoods through adaptive port planning.

S.No.	Intervention	Indicator
	Sectoral Focus: Ports	
1	Policy and Regulatory Frameworks	
1.1	Zero Carbon Emission Goal, 'Harit Sagar' the Green Port Guidelines were launched on 10 May 2023.	Environmental, Systematic
1.2	Harit Nauka Guidelines, launched at the 1st IWDC meeting on 8th January 2024, puts forth a strong commitment towards furthering passenger transport through waterways in an environmentally friendly and sustainable manner by promoting the adoption of low-emission fuel (CNG/LNG/electric/ hydrogen/ methanol) for inland vessel operations (Green Vessels).	

1.3	Green Ship Incentive 'Harit Shrey' Scheme – Mormugao Port (Ports)	Environmental, Economic, Systematic
2	Infrastructure and Technological Adoption	
2.1	Four major ports, Deendayal Port, Visakhapatnam Port, New Mangalore Port and VOC Port, generating more renewable energy than their demand.	Environmental, Physical
2.2	Cochin Shipyard Limited delivered 5 Electric Hybrid 100 Pax Water Metro boats for Kochi Water Metro Project. Kochi Water Metro plan to scale upto 78 vessels, whiis the world's single largest fleet of electric ferries.	Environmental, Physical, Economic
2.3	Steel cutting of Zero Emission Feeder Container vessel being built for Samskip Group, Norway.	Environmental, Systematic
3	Research, Innovation and Capacity Building	
3.1	India's First Indigenously Built Hydrogen Fuel Cell Ferry (under National Green Hydrogen Mission) (Ship Building)	Innovation, Research
3.2	CSL upgraded to "GreenCo Gold" from "GreenCo Silver" by CII (Ship Building)	Systematic
3.3	International Conference on Green Ship Recycling and Scrapping Policy (Gandhinagar, Gujarat, 12th Sept 2022)	Environmental, Systematic, Economic
4	Green Shipping & Logistics	
4.1	LNGC Aseem's 500th successful LNG transport voyage (Shipping)	Environmental, Economic

Table 20: Interventions of MoPSW

4.3 Funding and Resources

4.3.1 Climate Adaptation Finance

India requires significant investments in climate adaptation efforts to ensure sustained development progress in face of exacerbating climate impacts. While the government of India has made significant inroads for addressing the critical adaptation needs of the country, the adaptation needs are huge and increasing over time. Given that the states are responsible for implementing contextual adaptation-related interventions, the collective annual investment needs of six states alone amounts to INR 444.7 billion from 2021 to 2030.^{xix} Given the magnitude of finance required and the significant funding gaps, new and innovative models of financing adaptation by engaging public and private finance.

4.3.2 Adaptation funding mechanisms and grants

Under the 2023-24 Budget^{xx}, the Ministry of Environment, Forest and Climate Change (MoEFCC) received an allocation from a revised estimate of Rs

2,478 crore in the last budget to Rs 3,079.4 crore. A separate budget has been allocated for the National Mission on Natural Farming, at Rs 459 crore. The finance minister announced a new project, 'Mangrove Initiative for Shoreline Habitats & Tangible Incomes' or MISHTI, through convergence between MGNREGA, CAMPA Fund and other sources. 'Amrit Dharohar', another new scheme, will be implemented over the next three years to "encourage optimal use of wetlands, and enhance biodiversity, carbon stock, eco-tourism opportunities and income generation for local communities. Three centres of excellence for Artificial Intelligence will be set up in top educational institutions and leading industry players will "partner in conducting interdisciplinary research, develop cutting-edge applications and scalable problem solutions in the areas of agriculture, health, and sustainable cities. Central assistance of Rs 5,300 crore will be given to the Upper Bhadra Project in the drought-prone central region of Karnataka.

4.3.2.1 National Adaptation Fund for Climate Change (NAFCC)

The National Adaptation Fund for Climate Change (NAFCC) was established in August, 2015 to meet the cost of adaptation to climate change for the State and Union Territories of India, particularly vulnerable to the adverse effects of climate change. NABARD has been designated as National Implementing Entity (NIE) for

implementation of adaptation projects under NAFCC by Govt. of India. The government has set up a budget provision of Rs.350 crores for the year 2015-16 and 2016-17.^{xxi} This scheme has continued beyond the 12th Five Year Plan till 31st March 2020 with a financial implication of Rs. 364 crores. From 2015-19, 30 Projects are Sanctioned worth Rs. 847.48 cr. covering 26 States and 2 UTs with 19 lakh project beneficiaries.^{xxii}

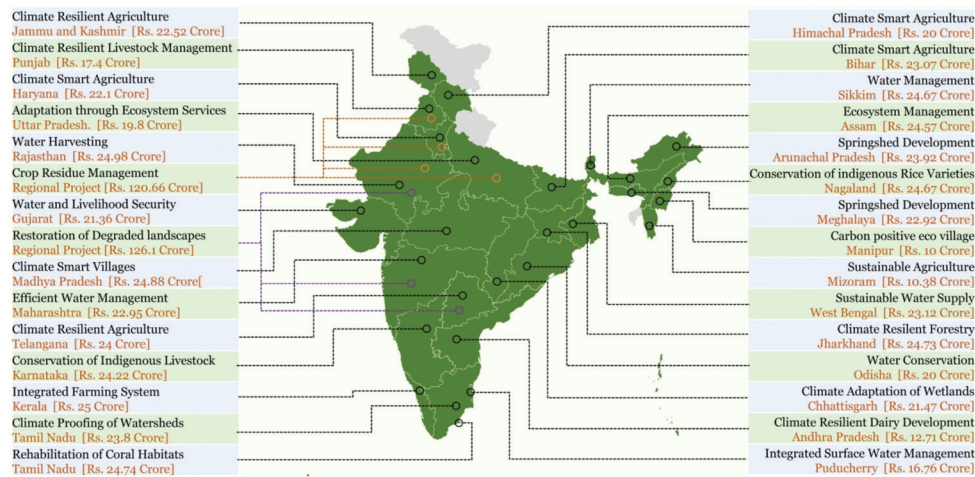


Figure 7 | Map showing projects under NAFCC in the country^{7,8}
(Source:: NAFCC Portfolio highlights in India)

4.3.2.2 Climate Change Action program (CCAP)

Climate Change Action program (CCAP)^{xxiii} is a central sector scheme, initially launched in 2014, with a total outlay of Rs. 290 crores for a duration of five years. The scheme has now been extended up to 2025-26 and consists of eight broad sub-components including the National Action Plan on Climate Change (NAPCC) coordination, State Action Plan on Climate Change (SAPCC), National Institute on Climate Change Studies & Actions, National Carbonaceous Aerosols Programme (NCAP), Long Term Ecological Observations (LTEO), International negotiations and capacity building.

4.3.2.3 Allocations by the Finance Commission

Through the Finance Commission, the Indian government provides states with funding to carry out climate adaptation strategies as part of the State Action Plans on Climate Change (SAPCCs). These grants encourage localized resilience solutions by enabling states to address climate vulnerabilities unique to a given region.

4.3.3 Strategies for integrating climate risks into national budgeting.

State Action Plans on Climate Change (SAPCCs) need to be funded and strengthened to mainstream disaster preparedness and climate change adaptation across their activities. Given that SAPCC is a critical component to address climate change as per India's NDC, there has been limited progress in aligning the SAPCCs with NAPCC to evaluate national efforts. The exercise and onus to align SAPCCs with NAPCC have been assigned to the respective states. However, this exercise currently does not have a common framework or structure for reporting making it difficult to aggregate the sub-national activities at the national level.

In the updated NDC presented by India in 2022 under the Paris Agreement, enhanced investments are earmarked for development programs in vulnerable sectors for adaptation. Under the 2018 guidelines provided by the central government to update SAPCCs, states are required to align their plans with NDC giving equal prioritisation to mitigation and adaptation and provision for financing SAPCCs through state budgets.¹³



5 Cross Cutting Themes

This chapter highlights the interconnected systems—such as water, health, agriculture, energy, ecosystems, and urban infrastructure—that are particularly vulnerable to climate change and influence resilience across sectors. It underscores the importance of integrating these cross-cutting themes into climate adaptation planning to avoid maladaptation and maximize co-benefits.

5.1 Introduction

Cross-cutting themes are those issues and systems that intersect with multiple sectors and influence the overall resilience of communities and ecosystems. These themes such as water, health, agriculture, energy, forests, coastal systems, and urban environments often experience cascading impacts from climate change. Their trans-sectoral nature makes them essential to consider alongside sector-specific interventions for effective climate change adaptation.

Addressing these themes is not just a supplementary exercise but a central requirement for climate-resilient development. The Intergovernmental Panel on Climate Change (IPCC) notes that adaptation options such as climate services, early warning systems, and risk management practices ‘have broad applicability across sectors’ and offer multiple co-benefits when deployed inclusively (IPCC, 2022). Similarly, the UNEP Adaptation Gap Report 2023 highlights that successful national adaptation plans increasingly target agriculture, water, ecosystems, and key cross-cutting systems such as health, urban infrastructure, and social protection (UNEP, 2023).

This dossier includes cross-cutting themes to provide a more integrated understanding of how climate risks manifest across systems, and how they may be addressed through synergistic interventions. The IPCC (2022) emphasizes that interventions focused solely on sectoral silos may lead to maladaptation or missed opportunities for collaboration. Therefore, cross-cutting themes have been included in this adaptation dossier to enable a systems-based analysis that can

inform national and sub-national planning.

5.2 Future Predictions on Cross Cutting themes

Future climate projections indicate significant and multifaceted risks for India, with especially pronounced impacts across sectors such as agriculture, water resources, health, and infrastructure. Rising temperatures, altered precipitation patterns, and an increase in the frequency and intensity of extreme weather events are expected to exacerbate existing vulnerabilities, particularly in climate-sensitive regions like coastal areas, arid zones, and mountainous terrains. These projections underscore the urgent need for comprehensive and forward-looking adaptation strategies. The future predictions considered in this dossier are based on data and analysis from the G20 Climate Risk Atlas (<https://www.g20climaterisks.org/india/>), which provides region-specific insights into climate risks and highlights the potential socioeconomic impacts of inaction.



5.2.1 Temperature Projections

Under a low emissions scenario projected temperature variations will remain contained under +1.5°C, both by 2050 and 2100. Under a high emissions scenario,

with no reduction in GHG emissions, much greater temperature anomalies are expected by both 2050 and 2100.

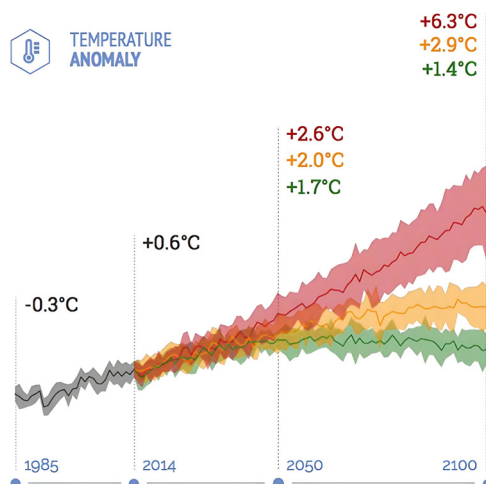


Figure 8 | Projected temperature scenario.

(Source: Climate Risk Atlas Impacts, Policy, Economics, India)

5.2.2 Precipitation

The precipitation regime in India is very complex and is mainly governed by monsoon winds from the southwest. The rainy season is between June and September, during which almost 75% of annual precipitation occurs.

Average precipitation in India is around 1,250 millimetres per year, although a huge spatial variation can be detected. The west coast and north-east India receive more than 4,000 millimetres of precipitation per year. On the other hand, areas such as western Rajasthan and adjacent parts of Gujarat, Haryana, and Punjab see less than 600 millimetres per year. The rest of the country receives moderate precipitation. Due to the nature of monsoons, annual precipitation is highly variable.

Precipitation trends show a very complex signal, under all emissions scenarios, with a very large variability among climate models. This can be explained considering the complexity of the precipitation regime and dynamics requiring more detailed spatial and temporal analysis.

5.2.3 Ocean Warming

India's marine exclusive economic zone (EEZ) has mostly warm coastal waters, which are characterized by a mosaic of ecosystems such as coral reefs, backwaters, mangroves, and seagrasses meadows. Indian coastal systems can be divided in two main areas: the Bay of Bengal and the Laccadives region on the western side. Projected annual changes within the marine EEZ for the two most significant marine indicators of climate change: sea surface water temperatures and pH. Seawater temperature changes are in line with the definitions of each scenario, with maximum values in 2100 close to +4°C under a high emissions scenario. Seawater surface pH becomes more acidic in all scenarios, closely reflecting rising atmospheric CO₂ concentrations, and only a low emissions scenario leads to a stable condition by 2100.

5.2.4 Indian Coastal Regions

5.2.4.1 Sea Level Rise

Relative sea level rise has been observed over the past century around the coast of India, with a yearly average increase of approximately 1.56 millimetres per year since the 1990s. The latest IPCC projections

indicate that, by 2050, global sea levels may rise between 0.18 metres, under a low emissions scenario, and 0.23 metres, under a high emissions scenario.

Extreme Sea Level: On average, one in 100 extreme sea level events are expected to rise from 2.05 metres at present day to 2.23 metres by 2050 under a medium emissions scenario.

Future Storms: The wave climate influencing the Indian coast is very dynamic and driven by seasonally reversing monsoon winds. Annual average significant wave height ranges from 1.5 to 2.5 metres, with the highest waves reaching more than 3 metres.

Recent projections show an increase in wave heights and periods along much of the Indian coast, with maximum wave heights increasing by more than 30% in some locations. At most locations along the east coast, wave periods are expected to increase by almost 20%, whereas along the west coast an increase of around 10% is expected. Similarly, water elevation due to cyclone activity is expected to increase.

Soil Erosion and Coastal Floods: Under a medium emissions scenario, the population exposed to the annual coastal flood level is expected to increase from 17 million to 21 million by 2050.

Future sea level rise is a projection based on different global warming scenarios, at approximately 100 centimetres by the end of 2100, with consequent inundation during extreme sea level events.

5.2.5 Water

5.2.5.1 Water Runoff

If temperatures rise by 1.5°C, 2°C or 4°C, 17%, 33.4% or 43% of the country will likely experience an increase in runoff, while 3%, 6.4% or 17% of the surface of the country will likely experience a decrease in runoff, respectively.

5.2.5.2 Droughts

Droughts pose enormous challenges for drinking and irrigation water supply and also affect the economy of

India, where more than 68% of people are dependent upon agriculture. Moreover, about 18% of India's total area is drought-prone, and about 50 million people are annually affected by drought. India faces droughts due to poor summer monsoons caused by natural climate variability or climate change.

In the Deccan Plateau region of India significant drought conditions occur once in 3 years. The Deccan region sees the highest frequency of severe droughts in all of India.

5.2.5.3 Groundwater

Rapid groundwater depletion remains one of India's most profound sustainability challenges. Extraction of non-renewable groundwater for irrigation in India was used on about 68 cubic kilometres of land per year for the year 2000, which is the highest in the world.

Sustaining groundwater is essential for meeting the needs of food and water in the current and projected future climate, and these necessities appear even more urgent in the northwest regions such as Punjab. There are uncertainties associated with groundwater recharge under climate change, which are linked to precipitation projections under the future climate. Groundwater storage is projected to increase in some Indian areas under the future climate in the absence of groundwater extraction for irrigation primarily due to projected increase in precipitation. Nevertheless, longer droughts and projected increase in irrigation water demands can pose further challenges to already depleted groundwater resources in India.

5.2.5.4 Floods

The increased risk of flash floods as a result of changing rainfall patterns over India has been reported in several recent studies. Extreme precipitation events in India in the past caused flooding, affected the economy, and resulted in the loss of lives. For instance, an extreme precipitation (940 millimetres in 18 hours) event in Mumbai (July 2005) was a disaster that led to flooding that affected 20 million people and caused around 1,200 deaths. Similarly, Mumbai experienced flooding in September 2017 due to extreme precipitation (330

millimetres in 24 hours), which largely affected road transportation. Furthermore, Chennai received 483 millimetres of precipitation in 48 hours in November 2015, which had a devastating impact causing widespread damage.

By 2050 slight changes in the number of days with intense precipitation (more than 50 millimetres of rain) is expected, with a small increase of 0.20 days under a

low emissions scenario and 0.32 days under a medium emissions scenario.

5.2.5.5 Water Stress

India’s water stress level is considered high for the recent past (1960-2014 average), and it is expected to remain that way in the near future (2030-2050) based on climate change projections.

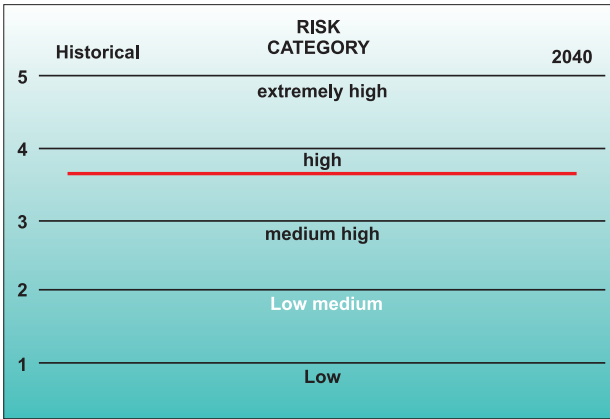


Figure 9 | Water Stress Scenarios.
(Source: G20 Climate Risk Atlas Impacts, Policy, Economics, India)

5.2.6 Agriculture

5.2.6.1 Crop Productivity

Crop productivity refers to the harvested yield of a crop per unit of land area. It is strongly influenced by climate and other environmental and management factors. Increasing temperatures will have a strong negative effect on rice yield, especially in the northern and central areas where 15% to 40% of current rainfed rice locations may be at risk. Positive effects on rice yield can be expected in the southern, and to a certain extent eastern, regions. Productivity of wheat is projected to decrease by upto 20% in some areas. The strongest decline is expected over central and south-central areas, whereas an increase is foreseen for cooler environments. Sugarcane is a climate sensitive crop and will show a marked decline in crop yields due to higher temperatures overcoming optimum level for photosynthesis. Mango production may be harmed in tropical regions with already prevailing high temperatures. On the other hand, rising minimum temperatures are extending farming into new areas which were previously too cold for mango production.

To meet agricultural demand for a growing population and cope with climate risks, it will be essential to further promote usage of wastewater and sustainable agriculture through water-efficient adaptation practices.

5.2.7 Forests

Forests cover 25% of India with a steady increase in recent decades. According to recent calculations by the Ministry of Environment Forest and Climate Change, the total carbon stock of Indian forests is over 7 gigatonnes of carbon (of which over 20% in Himalayan forests). Indian forests are a crucial carbon sink.

In southern areas, a slight increase in forest productivity is expected due to the fertilizing effect of rising CO₂ and temperatures. Conversely, some sub-Himalayan areas may see a decline due to increased drought stress caused by water regime modifications.

5.2.7.1 Forest Fires

By 2050, under both low and medium emission

scenarios, a decrease in burned area is expected in tropical and subtropical broadleaf forests over central India. However, a slight increase in burned area is expected over north and north-western areas dominated by xeric shrublands, deciduous forests and alpine steppes.

5.2.8 Urban India

India's urbanization rate is expected to grow from 35% in 2020 to more than 50% in 2050. Migration from rural areas due to climate impacts is expected to contribute substantially to this increase in urban population.

5.2.8.1 Heatwaves and Heat Stress

Between 1965 and 2010, heat waves increased by an average of 0.23 cases per decade and their duration extended by 0.71 days per decade. Regular heatwave events occur almost every year over most of the

country, in particular in the northwest and the south-eastern parts. Average duration of heatwaves over northwest India is between 5 to 7 days per season.

Between 1960 and 2009, mean temperatures in India increased by 0.5°C and heat related mortality also rose. In 2010, more than 1,300 people died in the city of Ahmedabad due to heatwaves, with subsequent heatwaves in 2013 and 2015 killing more than 1,500 and 2,500 people across the country. During the intense heatwave of 2016, temperatures reached 52.4°C in the city of Jaisalmer. Heatwaves will become more frequent and prolonged, extending the periods of overheating in urban areas.

The report projects an increase in the frequency of heat waves by mid-century by a factor of 2.5 compared to the recent past (1976–2005 average).

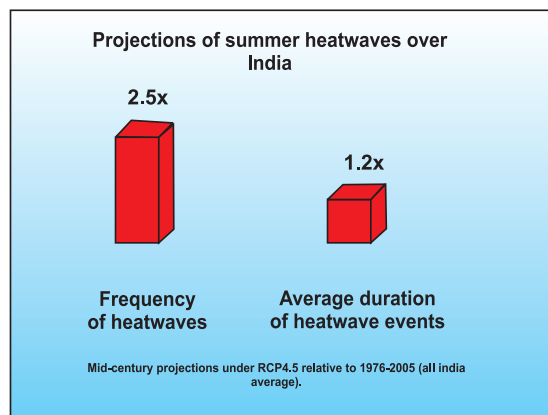


Figure 10 | Projected scenario of heatwaves.

(Source: NDMA and IITM Pune https://ndma.gov.in/sites/default/files/PDF/Heatwave-workshop/13012024/session1/IITM_Pune.pdf)

5.2.8.2 Construction

The construction sector in India plays a pivotal role in economic growth, contributing nearly 9% to the national GDP and employing over 51 million people. However, it is also a significant contributor to climate change due to high energy use, extensive resource extraction, and greenhouse gas (GHG) emissions. Globally, buildings and construction account for nearly 37% of energy and process-related CO₂ emissions, with India being a fast-growing emitter due to rapid urbanization and infrastructure expansion (GlobalABC, 2022).^{xxv} Key environmental concerns include embodied carbon from cement and steel production, construction and

demolition (C&D) waste, and heat island effects from poorly planned urban growth.

To adapt the sector for a climate-resilient future, India must integrate low-carbon construction practices, enhance material efficiency, and promote the use of sustainable building materials such as fly ash bricks, bamboo, and recycled aggregates. Policy frameworks like the Eco-Niwas Samhita, Energy Conservation Building Code (ECBC), and C&D Waste Management Rules (2016) provide initial regulatory direction, but their implementation remains uneven. Transitioning towards net-zero buildings, scaling up green certifications (e.g., GRIHA, IGBC), and mandating

climate-risk assessments for large infrastructure projects are essential steps forward. Further, interlinking construction practices with ecosystem-based adaptations such as green roofs, permeable pavements, and bio-climatic design—can help mitigate emissions while increasing resilience to climate extremes.

5.2.9 Health

With a population of 1.4 billion and increased climate change risks due to coastal and inland river flooding, increased heat stress, water and food insecurity, and changes in the occurrence of climate-sensitive diseases, India's decades of advancement in health and social development may be threatened. Extremely hot days (temperatures higher than 35°C) are expected to increase from approximately five per year in 2010, to around 42 per year in 2100. As a result, the death rate due to climate change is projected to increase by 10% equivalent to 60 deaths per 100,000 people by the end of the century. By 2100, around 1.5 million additional deaths due to climate change are expected in India.

5.2.9.1 Heat related mortality

Between 1960 and 2009, an increase of 0.5°C in summer mean temperatures increased the probability of mass heat-related mortality by 146%. Under a high emissions scenario, excess mortality will increase by 10% by 2100. This is equivalent to 1.54 million excess deaths per year due to climate change by 2100 under a high emissions scenario. However, under a medium emissions scenario, this number is projected to decline by 80%. In 2018, there was an 84% increase in heat-related deaths in India compared to the 2000 to 2004 baseline.

5.2.9.2 Impact on Labour

Future climate change will reduce global total labour in the low-exposure sectors by 18 percentage points and by 24.8 percentage points in the high-exposure sectors under a 3.0°C warming scenario. The effects of climate change on the livelihoods of vulnerable workers engaged in subsistence farming, the informal economy, and the tourism sector has been increasing. 1°C increase in annual temperatures leads to a 2% decline in industrial productivity in India. Total labour is expected to decline by 13.4% under a low emissions scenario, and by 24% under a medium emissions scenario.

5.2.9.3 Climate Change and Dengue & Zika

Climate change is likely to expand the geographical distribution and suitability of several vector-borne human infectious diseases including dengue. The risk of dengue transmission is increased by warming climates, as the growth and development of mosquitoes are significantly influenced by temperature, precipitation, and humidity.

Zika virus has spread to at least 49 countries and territories since 2013. Climate change impacts on transmission suitability risk have increased over the years and future warming over 1.3 billion additional people could face suitable transmission temperatures for Zika by 2050.

Under a medium emissions scenario, 98.1% of the population will be at risk of transmission-suitable mean temperatures for dengue by 2050, whereas 97% will be at risk under a high emissions scenario. In the case of Zika, 97.2% of the population will be at risk by 2050 under medium emissions.

5.2.9.4 Climate Change and Malaria

Malaria presents a significant public health challenge in India, with more than one million reported annual cases. 76.7% of the Indian population will be at risk of malaria under a low emissions scenario in 2050, whereas 73.7% will be at risk under a high emissions scenario.

5.2.9.5 Pollution and Premature Mortality

1.67 million deaths were attributable to air pollution in 2019, accounting for 17.8% of total deaths in the country. By 2060, 2,039 deaths will be caused by outdoor air pollution per year per million people, compared to 508 in 2010.

5.2.10 Energy

India's energy demand has grown fast, tripling over the last 30 years, and increasing by 60% in per capita terms. Energy consumption is the world's third highest (908 million tonnes of oil equivalent). India claims over 10% of the global increase in energy demand since 2000. Per capita energy use and emissions are still less than half the global average.

5.2.10.1 Future Energy Demand

In India, higher cooling needs are projected to require additional installed power generation capacities of 36 gigawatts by mid-century and 136 gigawatts by the end of the century under a high emissions scenario. Energy demand is predicted to increase, as the small drop in heating demand is going to be more than compensated by the vast increase in cooling needs, resulting in a net increase of energy demand of about 1,714 PJ (475 billion Kwh) by 2050 under a medium emissions scenario.

5.2.10.2 Cooling Needs

It is expected that India will face an increasing number of extreme heat spells. Very strong increase in cooling needs is expected all over the country, particularly in the southern and in the central states, where the capital New Delhi and the largest cities are located. Moderate increases are expected only near the northern border. This may result in increasing pressure on already constrained energy infrastructure assets.^{xxvi}

5.3 Vulnerability Assessments

5.3.1 Climate Vulnerability Assessment for Adaptation Planning in India using a common Framework, 2019-20^{xxvii}

This report presents an all-India assessment to identify the most vulnerable states and districts in terms of current climate risk and the key factors driving their vulnerability. The analysis follows a standardized set of indicators and a common methodology, while individual states have also

conducted district-level vulnerability assessments.

The state-level vulnerability indices in this report range from 0.42 to 0.67, indicating that all states face concerns related to vulnerability.

States with relatively higher vulnerability: Jharkhand, Mizoram, Odisha, Chhattisgarh, Assam, Bihar, Arunachal Pradesh, and West Bengal are primarily concentrated in the eastern region, highlighting the need for prioritizing adaptation measures.

District-level vulnerability indices range from 0.34 to 0.75, with Assam, Bihar, and Jharkhand having more than 60% of their districts classified as highly vulnerable. Since vulnerability indices are relative measures, all states and districts experience some degree of vulnerability, but certain regions require more urgent and targeted adaptation interventions.

5.3.2 Mapping India's Climate Vulnerability, CEEW, 2021^{xxviii}

Twenty-seven out of thirty-five states and Union Territories in India are highly vulnerable to extreme hydro-meteorological disasters and their compounded impacts. The western and central zones face greater susceptibility to drought-like conditions and their cascading effects. The northern and north-eastern zones are more prone to extreme flood events and their associated impacts.

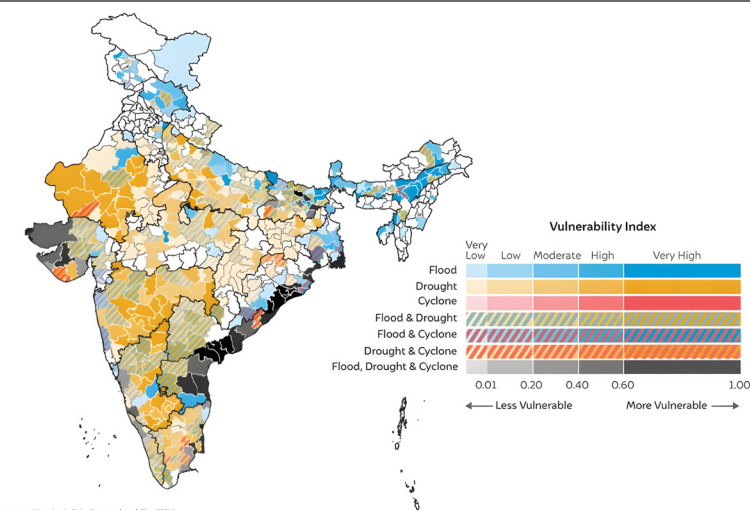


Figure 11 | Vulnerability Index of India.

(Source: Mohanty, Abinash, and Shreya Wadhawan. 2021. Mapping India's Climate Vulnerability – A District Level Assessment. New Delhi: Council on Energy, Environment and Water. <https://www.ceew.in/sites/default/files/ceew-study-on-climate-change-vulnerability-index-and-district-level-risk-assessment.pdf>)

Meanwhile, the eastern and southern zones are highly vulnerable to extreme cyclonic events, with an increasing frequency of cyclones, floods, and droughts occurring simultaneously.

The southern and western regions experience the highest vulnerability to extreme droughts, with recurring impacts each year, predominantly in the form of agricultural droughts. Since the 2000s, the northern, eastern, and central zones have exhibited moderate vulnerability, largely affected by meteorological and agricultural droughts. The north-eastern region remains the least vulnerable to extreme drought events.

More than 59 percent of districts in the eastern zone face high vulnerability to extreme cyclones, while over 41 percent of districts in the western zone are identified as cyclone hotspots. The western coast has witnessed increasing cyclone vulnerability over the past decade (2010–2019). The northern and north-eastern zones experience fewer extreme cyclone events, making them relatively less vulnerable, while the central zone has no identified hotspots for cyclones.

The intensification of drought-like conditions across India contributes to the cyclogenesis process, where depressions transform into deep depressions and subsequently into cyclonic storms over the rapidly warming Indian Ocean. Since these cyclones often bring floods, several districts along the eastern and western coasts are exposed to all three extreme events. This complex interplay of hazards presents significant challenges for mitigation and adaptation efforts.

A surge in extreme events has been observed across India since 2005, primarily driven by landscape disruptions. Various studies, including UNEP (2009), have confirmed the impact of landscape changes on the frequency and intensity of extreme events. Additional factors such as the urban heat island effect, land subsidence, and microclimate changes are also contributing to the intensification of these events.

5.3.3 Building India's Climate Resilience

With less than a decade to accelerate climate action, policies must adopt a razor-sharp focus on mitigating the compounded impacts of climate extremes. Risk

assessment principles should be central to India's climate risk mitigation strategy. Identifying risks is the first step toward building climate-resilient economies and societies.

Key recommendations include:

- Develop a high-resolution Climate Risk Atlas (CRA) to map critical vulnerabilities at the district level and improve the identification, assessment, and projection of chronic and acute risks such as extreme climate events, heat and water stress, crop loss, vector-borne diseases, and biodiversity collapse. The CRA can also enhance coastal monitoring and forecasting, which are essential given the rapid intensification of cyclones and other extreme events.
- Establish a centralised climate-risk commission to coordinate the environmental de-risking mission (Ghosh 2021).
- Implement climate-sensitivity-led landscape restoration, focusing on rehabilitating, restoring, and reintegrating natural ecosystems as part of the developmental process.
- Integrate climate risk profiling with infrastructure planning to enhance adaptive capacity.
- Enable climate risk-linked adaptation financing by creating innovative Climate Vulnerability Index (CVI)-based financing instruments that incorporate climate risks for effective risk transfer mechanisms.

India urgently requires national and sub-national strategies to safeguard its population and economic growth from climate risks. With a 1.5°C warmer future becoming increasingly inevitable, proactive measures must be in place to withstand its impacts and ensure a faster, more resilient recovery when disasters occur. Failing to act now could set back the country's development trajectory by decades.

5.3.4 Climate Vulnerability Assessment for the Indian Himalayan Region using a Common Framework, 2018-19 ^{xxix}

There are four broad categories of indicators used in

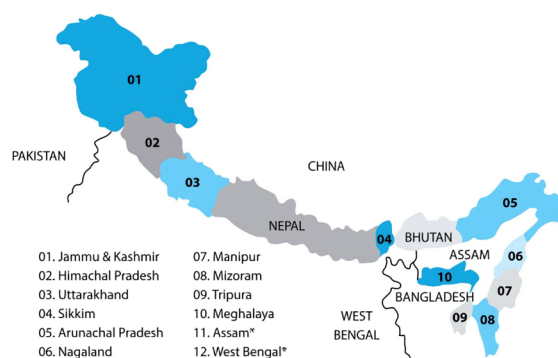


Figure 12 | Climate Vulnerability Index of Indian Himalayan States.

(Source: | Climate Vulnerability Assessment for the Indian Himalayan Region using a Common Framework 2018-19, https://dste.tripura.gov.in/sites/default/files/2024-07/District_Climate%20VA_2018_19.pdf)

the assessment based on those discussions: 1) socio-economic, demographic status and health; 2) sensitivity of agricultural production; 3) forest dependent livelihoods; and 4) access to information, services and infrastructure. Each of these broad indicators has two to six sub-indicators for the state level analysis. The weights to be assigned to each indicator were first discussed during the Methodology Workshop and were finally communicated by the states after they went back and had discussions with the relevant departments. The project team used the average of the weights communicated by the states for each indicator to carry out the state-level vulnerability assessment. The weighted average of normalised values of the indicators were used to derive a composite vulnerability index for each and a vulnerability ranking was developed based on that. Based on similar indicators district level vulnerability assessments were carried out by each of the states.

Based on the composite vulnerability index values, the states have been ranked from highest vulnerability to lowest vulnerability. The vulnerability index is highest for Assam (0.72) and Mizoram (0.71), followed by Jammu & Kashmir (0.62), Manipur (0.59), Meghalaya and West Bengal (both 0.58), Nagaland (0.57), Himachal Pradesh and Tripura (0.51 both), Arunachal Pradesh (0.47) and Uttarakhand (0.45). Sikkim is the least vulnerable state with the index being 0.42. It is important to note that vulnerability is a relative measure, which means that this assessment does not portray Sikkim, Uttarakhand or Arunachal Pradesh as having low vulnerability in an absolute sense. It also

does not imply that the mentioned drivers are the only drivers of vulnerability of the mentioned states. These states are least vulnerable relative to the other IHR states and also have several inherent drivers of vulnerability that need to be addressed. District-level vulnerability profiles developed by each of the states help in identifying most vulnerable districts in the state and their respective drivers. State and district-level vulnerability maps are also created for all 12 states.

5.3.5 Climate Resilient Cities, Assessing differential vulnerability to climate hazards in urban India, 2024^{xxx}

The report highlights the increasing impact of climate change on Indian cities, emphasizing the necessity of assessing vulnerability to design effective resilience and adaptation strategies. It introduces the Climate Hazard and Vulnerability Assessment (CHVA) as a comprehensive tool to analyze climate risks and their social implications.

Key Findings

- Understanding Differential Vulnerability:** Traditional vulnerability assessments often focus on climatic hazards but overlook the socio-economic and political factors that shape how communities experience these risks. The CHVA integrates these dimensions to offer a holistic understanding of urban vulnerability.
- Spatial and Social Inequalities:** The CHVA applies a spatial approach to assess climate risks, ensuring that urban marginalized communities, who often reside in the most hazard-prone areas, are

prioritized in resilience planning. The assessment includes indicators such as literacy, access to services, housing conditions, and employment vulnerabilities.

- **Climate Risks in Indian Cities:** The report details key climate threats faced by urban populations, including rising temperatures, urban heat islands, increased frequency of floods, landslides, and air pollution. For example, in Mumbai, over 200 landslide-prone locations overlap with informal settlements, highlighting the compounded risks faced by vulnerable communities.
- **Case Studies from Indian Cities:** The CHVA was piloted in Mumbai, Bengaluru, and Kochi, demonstrating how cities can use disaggregated data to prioritize climate action. In Bengaluru, more than 50 indicators were analyzed to assess risk levels at the ward level, while in Mumbai, localized consultations informed adaptation strategies.
- **Role of Stakeholder Engagement:** The report emphasizes the importance of multi-stakeholder collaboration, involving municipal agencies, community organizations, and citizens in climate resilience planning. Public consultations, sectoral meetings, and participatory mapping have been instrumental in developing city-specific climate action plans.

Key Recommendations

- **Strengthening Data Infrastructure:** Cities should improve the availability and accessibility of climate data by maintaining open-source repositories and collaborating with national and state GIS agencies.
- **Institutionalizing Climate Risk Assessments:** CHVA should be integrated into governance mechanisms to ensure periodic climate vulnerability assessments and adaptation planning.
- **Prioritizing High-Risk Communities:** Local governments should focus adaptation efforts on the most vulnerable populations, ensuring that resilience measures address socio-economic disparities.

- **Promoting Participatory Approaches:** Cities should engage marginalized communities in climate action planning, using inclusive methods such as community-driven data collection and ground-truthing assessments.
- **Scaling Climate Action Beyond Urban Cores:** As urban expansion continues, the CHVA should be applied to peri-urban areas to address emerging climate risks beyond city centers.

The report ultimately calls for a transformative approach to urban resilience, moving beyond incremental adaptations to more systemic interventions that address climate justice, urban inequality, and long-term sustainability.

5.3.6 A district level Assessment of vulnerability of Indian agriculture to climate change ^{xxxi}

This paper assesses the vulnerability of Indian agriculture to climate change at the district level, providing insights into the regions' most at risk and requiring targeted adaptation strategies. The study applies the Intergovernmental Panel on Climate Change (IPCC) framework to measure vulnerability using three components: exposure, sensitivity, and adaptive capacity. A total of 572 rural districts were analyzed using 38 indicators, and projections for the period 2021–2050 were derived from the PRECIS climate model under the A1B scenario.

5.3.6.1 Key Findings

- **Regional Variations in Agricultural Vulnerability:**
 - o The most vulnerable districts are concentrated in Rajasthan, Gujarat, Madhya Pradesh, Karnataka, Maharashtra, Uttar Pradesh, and Bihar.
 - o Northwestern India, Indo-Gangetic Plains, and semi-arid regions of Peninsular India exhibit high sensitivity due to land degradation, over-reliance on agriculture, and limited irrigation facilities.
 - o Districts along the West Coast, northeastern states, and parts of Andhra Pradesh and Odisha are comparatively less vulnerable due to better adaptive capacity.

- **Factors Driving Agricultural Vulnerability:**
 - o Exposure to Climate Change: Changes in temperature (1–4°C rise) and rainfall (9–16% increase) will lead to more frequent droughts, floods, and heatwaves.
 - o **Sensitivity Factors:** Large net sown area, high rural population density, and low soil water-holding capacity make many districts particularly sensitive to climatic variations.
 - o **Adaptive Capacity Constraints:** Low literacy rates, high poverty, weak market linkages, and limited irrigation infrastructure restrict the ability of farmers to cope with climate change.
- **Projected Climate Hazards:**
 - o Increased drought incidence in central and western India.
 - o Erratic rainfall patterns with a decline in pre-monsoon and early monsoon rains affecting cropping cycles.
 - o Rise in heatwaves and extreme weather events affecting crop yields, livestock, and rural livelihoods.

5.3.6.2 Key Recommendations

- **Enhancing Climate Resilience:**
 - o Expand irrigation networks and promote water-efficient agriculture to mitigate the impact of erratic rainfall.
 - o Develop drought-resistant crop varieties and climate-smart farming practices tailored to vulnerable regions.
- **Strengthening Adaptive Capacity:**
 - o Increase investment in rural education, market infrastructure, and financial inclusion for small and marginal farmers.
 - o Encourage crop diversification and sustainable soil management to reduce sensitivity to climate risks.
- **Improving Climate Data and Early Warning Systems:**
 - o Strengthen district-level climate monitoring

and promote community-based disaster preparedness.

- o Integrate climate risk assessments into agricultural planning to ensure region-specific adaptation strategies.
- **Policy and Institutional Interventions:**
 - o Focus on integrated watershed management to enhance groundwater recharge and soil conservation.
 - o Implement targeted climate adaptation policies for high-risk districts, including financial support for climate-resilient practices.

The study underscores the urgent need for proactive adaptation measures in Indian agriculture, emphasizing a multi-pronged approach involving technological, institutional, and policy-driven solutions. The findings provide critical insights for policymakers to design targeted interventions that reduce agricultural vulnerability and enhance resilience to climate change.

5.4 Climate Information and Services

Climate services are the provision and use of climate data, information and knowledge to assist decision-making. Climate services require appropriate engagement between the recipient of the service and its provider, along with an effective access mechanism to enable timely action.^{xxxii} Climate Information and Services play a crucial role in understanding, predicting, and responding to climate-related challenges. These services rely on climate data portals, databases, and modelling tools to provide accurate and up-to-date information on temperature trends, precipitation patterns, extreme weather events, and future climate scenarios. Resources like IPCC climate models and scenario planning frameworks, ranging from high-emission to low-emission trajectories, help researchers, policymakers, and disaster risk managers assess potential climate impacts and formulate adaptive strategies. Beyond research, these tools support policy development, infrastructure planning, risk assessment, and sustainable resource management, making them essential for informed decision-making in climate resilience and mitigation efforts.

5.4.1 Climate Data Portals and Databases

S.No.	Climate Data Portal / Database	Agency
1	Climate Finance Data Portal	UNFCCC
2	Climate Change Knowledge Portal (CCKP)	World Bank
3	UNSDG Data Portal	UNSDG
4	National Data and Analytics Platform (NDAP)	NITI Aayog
5	Climate Services Information System (CSIS)	WMO
6	Earth Observation System Data and Information System	NASA
7	IPCC Data Distribution Centre (DDC)	IPCC
8	Global Carbon Atlas	Global Carbon Project
9	Climate Change Knowledge Hub (CCK-Hub)	FAO
10	Global Framework for Climate Services (GFCS)	GFCS
11	IMD Climate Data Portal	IMD
12	Environmental Information Centre (ENVIS)	MoEFCC
13	India Climate & Energy Dashboard	NITI Aayog
14	Open Government Data (OGD) Platform India	GoI
15	National Information System for Climate and Env. Studies	NRSC

Table 21: Climate Data Portals and Databases

5.4.2 Climate Modelling and Scenario Planning

Climate models are based on well-established physical principles and have been demonstrated to reproduce observed features of the recent climate and past climate changes. ^{xxxiii} Future greenhouse gas (GHG) emissions are the product of very complex dynamic systems, determined by driving forces such as demographic development, socio-economic development, and technological change. Their future evolution is highly uncertain. Scenarios are alternative images of how the future might unfold and are an appropriate tool with which to analyse how driving forces may influence future emission outcomes and to assess the associated uncertainties. They assist in climate change analysis, including climate modeling and the assessment of impacts, adaptation, and mitigation. The possibility that any single emissions path will occur as described in scenarios is highly uncertain. ^{xxxiv}

Climate models can be tested through forecasts based on initial conditions. Climate models are closely related

to the models that are used routinely for numerical weather prediction, and increasingly for extended range forecasting on seasonal to interannual time scales. ^{xxxv}

5.4.3 Tools for relaying climate information to the local level in India

In India, various tools are used to relay climate information to the local level, ensuring timely and effective communication for climate adaptation and disaster preparedness. The India Meteorological Department (IMD) provides real-time weather forecasts, early warning alerts, and seasonal climate outlooks through mobile apps like Mausam, Meghdoot, and Damini, which cater to farmers, disaster management authorities, and the general public. The Common Alerting Protocol (CAP) integrates multi-hazard early warning systems, disseminating alerts via SMS, television, radio, and social media. Additionally, Krishi Vigyan Kendras (KVKs) and Farmer Producer Organizations (FPOs) play a key role in translating

complex climate data into actionable advisories for farmers. Geographic Information Systems (GIS) and remote sensing technologies further enhance climate risk mapping and localized planning. Civil society organizations also contribute by using participatory tools such as community radios, village-level information boards, and training workshops, ensuring that even the most vulnerable populations receive and understand crucial climate-related information.

5.5 Early Warning Systems (EWS)

According to United Nations, Early Warning System is, 'an adaptive measure for Climate Change, using integrated communication systems to help communities prepare for hazardous climate-related events.' EWS uses a variety of tools and methods, such as sensors, data analysis, and communication channels, to gather information to detect potential threats or hazards and provide advance information or warning to individuals or organisations that may be affected.

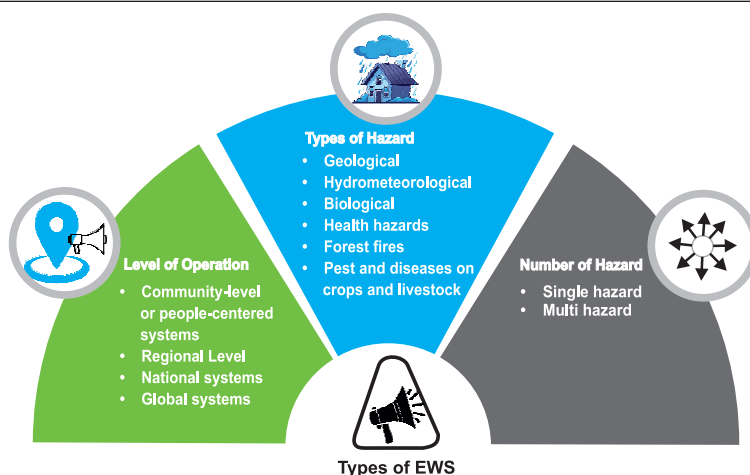


Figure 13 | Types of EWS.

(Source: Wadhawan, Shreya. 2023. *Strengthening India's Disaster Preparedness with Technology: A Case for Effective Early Warning Systems*. New Delhi: Council on Energy, Environment and Water <https://www.ceew.in/sites/default/files/how-can-india-strengthen-climate-disaster-preparedness-with-effective-multi-hazard-early-warning-systems.pdf>)



Figure 14 | Overview of the evolution of EWS globally.

(Source: Wadhawan, Shreya. 2023. *Strengthening India's Disaster Preparedness with Technology: A Case for Effective Early Warning Systems*. New Delhi: Council on Energy, Environment and Water <https://www.ceew.in/sites/default/files/how-can-india-strengthen-climate-disaster-preparedness-with-effective-multi-hazard-early-warning-systems.pdf>)

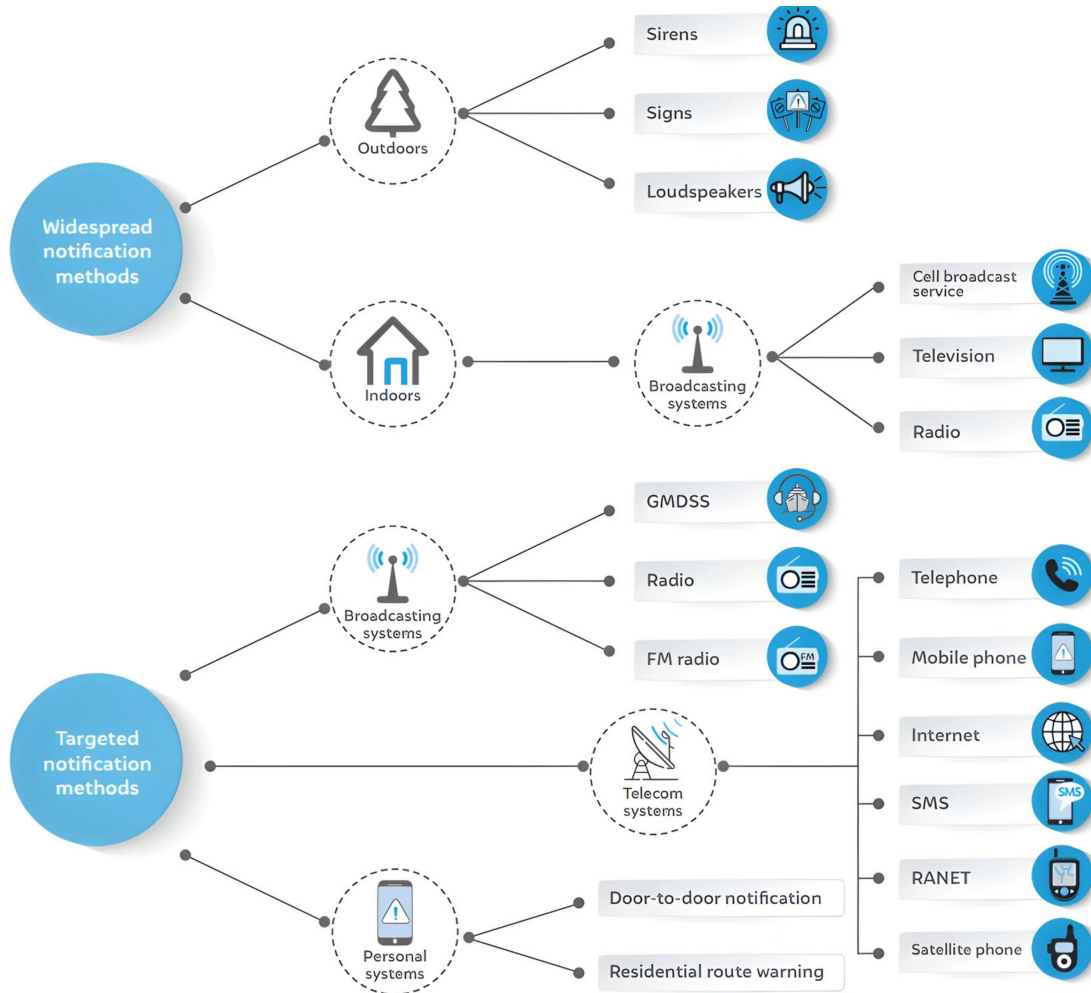


Figure 15 | Available methods for information dissemination.
(Source: Wadhawan, Shreya. 2023. Strengthening India's Disaster Preparedness with Technology: A Case for Effective Early Warning Systems. New Delhi: Council on Energy, Environment and Water <https://www.ceew.in/sites/default/files/how-can-india-strengthen-climate-disaster-preparedness-with-effective-multi-hazard-early-warning-systems.pdf>)

5.5.1 Information on existing EWS for climate hazards

India has a wide variety of EWS and MHEWS for different hazards. The Indian Tsunami Early Warning System was inaugurated on 15 October 2007 by the Ministry of Earth Sciences, Government of India, to provide early warnings of earthquakes and tsunamis in the Indian region. The Indian National Centre for Ocean Information Services (INCOIS), Hyderabad, and the National Centre for Seismology (NCS) are the nodal agencies for coordinating and operationalising the National Tsunami Early Warning Centre and receive support from the India Meteorological Department (IMD).

The Central Water Commission (CWC) is the nodal

flood forecasting authority in India, which has installed 331 flood forecasting stations in the country until December 2021 (Ministry of Jal Shakti 2021). The IMD supports the flood warning services of the CWC by providing observed and forecasted rainfall data, which helps in making accurate and timely flood forecasts. Several states in India have also partnered with private companies to install flood EWS, specifically to disseminate early warning information at the regional level, for example, FLEWS in Assam, iFLOWS Mumbai in Maharashtra, and Flood Management Information System (FMIS) in Bihar. As a novel initiative, the Ministry of Earth Sciences and the Tamil Nadu state government have developed CFLOWS-Chennai, a web

GIS-based decision-making support system, integrating data and outputs derived from weather forecast models and hydrologic, hydraulic, and hydrodynamic models. It is India's first integrated coastal flood warning system.

Further, cyclone EWS in India function as multi-hazard EWS, providing critical information on cyclones and their intensity, likely point and time of landfall, associated heavy rainfall, strong winds and storm surges, along with their impact, and advice to the general public, media, fisherfolk, and disaster managers (IMD 2022). Currently, seven cyclone warning centres have been established by the IMD, which has developed state-of-the-art tools for cyclone warning services (Ministry of Earth Sciences 2021). Under the National Cyclone Risk Mitigation Project (NCRMP) Phase I and II, suitable structural and non-structural measures to mitigate the effects of cyclones in the coastal states and UTs of India are currently underway in collaboration with the NDMA (PIB 2021). The centre and several state governments have also developed several application programming interfaces (APIs), apps, and dashboards such as SATARK and TNSMART to transfer information to communities. Different central authorities in India are responsible for disseminating early warnings regarding specific hazards such as the Ministry of Agriculture and Farmers Welfare (MoAFW) for droughts, the Ministry of Health and Family Welfare (MoHFW) for epidemics, and the Geological Survey of India for landslides. Given India's heterogeneous climate and the dynamism shown in heat extremes, the IMD also set up a forecast system under the National Monsoon Mission to issue early warnings and alerts for heat and cold waves. ^{xxxvi}

5.5.2 Guidance on developing and improving EWS

- **(MHEWS) Mainstreaming Inclusive and Community-Led Multi-Hazard Early Warning Systems**
 - o EWS should integrate closely with communities to ensure inclusivity and trust.
 - o Regular and inclusive engagement, considering diverse groups (gender, age, disabilities, literacy levels, etc.), enhances sustainability.
 - o Best practices can be learned from Bangladesh's Community-Based Early
- Warning System (CEBWS).
 - o Use simple and innovative communication methods like local languages, pictorial messages, mobile alerts, and social media.
- **Leveraging New-Age Technologies:**
 - o Strengthen communication channels between state and district emergency centers to ensure timely warnings.
 - o Adopt smart technologies like IoT, AI, and data analytics to enhance forecasting and disaster preparedness.
 - o Improve mobile-based alert systems, real-time sensor networks, and predictive modeling for early detection.
- **Investing in Regional Real-Time Flood Monitoring Sensors:**
 - o Address gaps in India's flood monitoring system by deploying low-cost flood sensors at regional levels.
 - o Establish data-sharing mechanisms with national agencies like CWC to enable targeted warnings.
 - o Standardize protocols for real-time data collection and dissemination for efficiency.
- **Enhancing Public-Private Partnerships:**
 - o Collaborate with private players to improve EWS financing, innovation, and transparency.
 - o Engage tech companies to develop cost-effective and advanced monitoring solutions.
 - o Promote corporate social responsibility (CSR) contributions towards disaster resilience efforts.
- **Leveraging International Knowledge Exchange:**
 - o Participate in global collaborations (e.g., COP, G20) to learn best practices in disaster resilience.
 - o Adopt international advancements in data collection, risk assessment, and information dissemination.
 - o Strengthen training programs and capacity-building efforts through global partnerships.



6 Monitoring and Evaluation

Effective climate adaptation requires not only the implementation of strategies but also robust systems to monitor, evaluate, and refine those efforts. Recognizing this, Chapter 7 has been included in the India Adaptation Dossier to emphasize the critical role of Monitoring and Evaluation (M&E) in ensuring accountability, learning, and continual improvement of adaptation interventions. While India has made notable progress in climate adaptation planning across sectors, significant gaps remain in systematically tracking progress, measuring outcomes, and linking results to climate resilience indicators. Currently, monitoring is often fragmented, output-focused, and lacks standardized metrics to evaluate the effectiveness, efficiency, and equity of adaptation actions across regions and sectors.

To address these challenges, this chapter highlights the need for a harmonized national adaptation M&E framework that is indicator-based, inclusive of vulnerable groups, and aligned with both national goals and international reporting obligations such as those under the Paris Agreement. Recommendations include developing a centralized adaptation tracking system, promoting regular outcome-level evaluations, integrating M&E into national and state-level budgeting and planning cycles, and building institutional capacities for adaptive learning. The chapter aims to set the foundation for a more accountable and evidence-based adaptation ecosystem in India.

6.1 M&E Framework for Adaptation:

To strengthen climate adaptation in line with mitigation efforts, under the Paris Agreement, Parties are expected to submit and periodically update adaptation communication within their communication to the UNFCCC. Under this framework, Parties should outline their adaptation priorities, implementation and support needs, plans and actions. These provisions are to ensure that adaptation action is highlighted, understood and implementation of the same is enhanced globally.

The guiding principles under the Paris Agreement for adaptation communication outline that it must be country-driven and flexible in the mode of reporting without burdening developing country Parties. This communication should be submitted and updated periodically as a component of or in conjunction with other communications or documents, including a NAP, an NDC and/or an NC. ^{xxxvii}

National adaptation communication is expected to include information on the climate vulnerabilities,

institutional frameworks, national adaptation priorities, progress on adaptation strategies and goals, best practices, and highlight gaps in implementation. These are to be outlined under the suggested indicators highlighted in the table below:



Content of National Adaptation Communication to the UNFCCC	
(a)	National circumstances, institutional arrangements and legal frameworks;
(b)	Impacts, risks and vulnerabilities, as appropriate;
(c)	National adaptation priorities, strategies, policies, plans, goals and actions;
(d)	Implementation and support needs of, and provision of support to, developing country Parties
(e)	Implementation of adaptation actions and plans, including:
(i)	Progress and results achieved
(ii)	Adaptation efforts of developing countries for recognition;
(iii)	Cooperation on enhancing adaptation at the national, regional and international level, as appropriate;
(iv)	barriers, challenges and gaps related to the implementation of adaptation;
(v)	good practices, lessons learned and information-sharing;
(vi)	monitoring and evaluation;
(f)	adaptation actions and/or economic diversification plans, including those that result in mitigation co-benefits;
(g)	how adaptation actions contribute to other international frameworks and/or conventions;
(h)	gender-responsive adaptation action and traditional knowledge, knowledge of indigenous peoples and local knowledge systems related to adaptation, where appropriate; and
(i)	any other information related to adaptation.

Table 22: Content of National Adaptation Communication to the UNFCCC

Key aspects of adaptation communications	
Aspect	Provision
Purpose	To increase visibility and profile of adaptation, its balance with mitigation, and to enhance action, support, learning and understanding
Role in the global stocktake	- Provide information on state of adaptation, experience, priorities - Contribute to review of progress and enhanced implementation
Guiding principles	- Country-driven, flexible, voluntary - No additional burden or basis for comparison or review
Considerations related to submission	- With vehicle document (e.g. NAP, NDC, NC, BTR) or independently - Vehicle document should be clearly identified - Submitted in time to inform each global stocktake
Content	- Information on circumstances, institutions, vulnerabilities, priorities, plans, needs, progress, co-benefits, other frameworks, gender, indigenous knowledge - Parties are invited to include ex ante information; provide information on elements (a-d) in the annex to decision 9/CMA.1, and additional information on elements (e-i) - Parties may tailor the information depending on the vehicle document
Recording in a public registry	Recorded in a public registry maintained by the secretariat
Support	- GEF: invited to support adcom preparation under existing mandates - Other institutions: support adaptation in accordance with adcom priorities

Figure 16 | Vulnerability Index of India .

(Source: Report of the Adaptation Committee. Addendum. Draft supplementary guidance for voluntary use by Parties in communicating information in accordance with the possible elements of an adaptation communication. https://unfccc.int/sites/default/files/resource/sb2022_05a01.pdf)

6.1.1 Global Stocktake

The National Adaptation Communications (ADCOMs) are also expected to provide inputs to the global stocktake that assesses progress towards Paris Agreement goals. Through biennial synthesis reports adaptation efforts by developing countries are recognized and highlighted through inter alia ADCOMs.

As per the Global Stocktake Synthesis Report, while there has been considerable progress in addressing adaptation needs, there remains a significant gap in the scale of resources required for adaptation. As per OECD, 80% of adaptation efforts are incremental, highlighting

the lack of transformative approaches required to mitigate the scale of climate impacts anticipated. ^{xxxviii} As per the United Nations Adaptation Gap Report 2023, global adaptation efforts require humongous financial resources with the estimated adaptation finance gap estimated between US\$187-359 billion per year. ^{xxxix} The scale of collateral requires innovative approaches to mobilise additional financial resources. Given the limited support, it becomes essential to align national strategies and development pathways for climate adaptation through the judicious use of national resources.



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MINISTRY OF
SCIENCE AND
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09:00 to 05:30 pm



07.05.2025

National Consultation Meeting

पर

Deliverables of

**Integrated Centre for Adaptation to Climate Change,
Disaster Risk Reduction and Sustainability (ICARS)
IIT Roorkee Gr. Noida Campus, (DST CoE)**



7 Way Forward

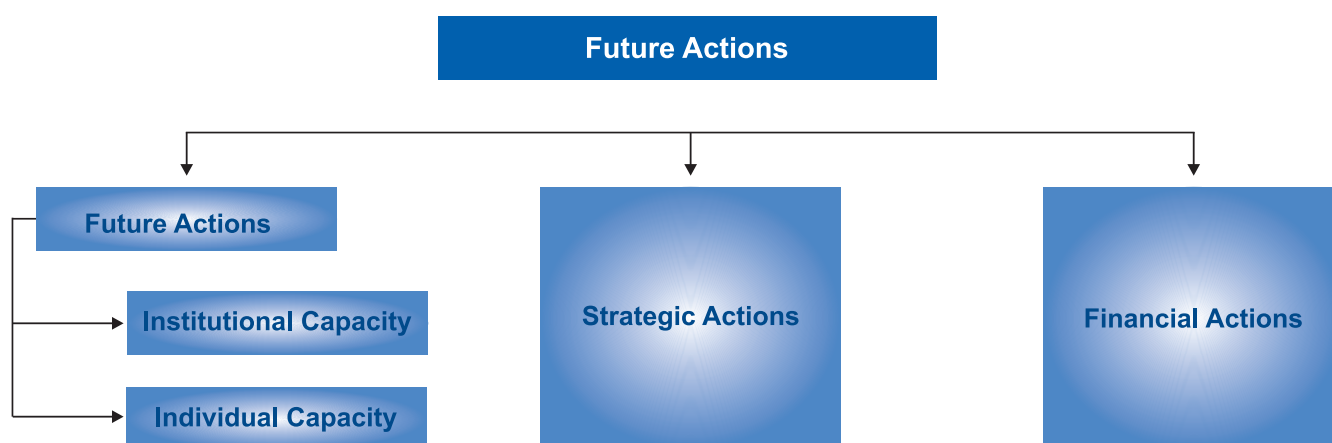
7.1 Summary of Key Findings

There is a lack of coordination between climate planning authorities and sectoral implementing agencies, leading to fragmented efforts. Many officials face challenges in interpreting technical climate assessments and integrating them into project design and budget planning. Additionally, limited capacity to secure external funding and a lack of broader institutional ownership beyond the commitment of a few motivated individuals hinders progress. Without dedicated planning frameworks and budgetary allocations, climate change remains a peripheral concern within state economic and development planning.

Despite frequent extreme events, for instance, flooding in numerous states, they are inadequately addressed through the perspective of climate change. While many policies, schemes and other regulatory instruments have been identified under nodal ministries contributing to adaptation efforts, regularly monitoring and evaluating the impacts

and outcomes are essential to maximise synergies. Beyond declaration of policies and schemes, effective on-ground implementation should be evaluated for alignment with climate goals of India. An equal emphasis on adaptation along with mitigation initiatives are essential for building climate resilience in the country. These priorities therefore need to be reflected in policy implementation across ministries, sectors, and bureaucratic levels to translate into effective climate adaptation. Various strategies for integrating climate adaptation in planning and implementation have been outlined through this adaptation dossier. The synergies in various existing policies need to be identified, aligned and enhanced for resilience building. Similarly, current gaps in planning and execution of climate adaptation aligned practices must also be addressed and alleviated to achieve our climate goals as well as climate resilient development.

7.2 Future Actions



7.2.1 Strategic Actions

- Develop region-specific adaptation strategies based on localized climate risks and vulnerabilities.
- Prioritize adaptation actions for key sectors such as agriculture, water resources, urban planning, and public health.
- Foster collaboration with local governments, civil society, academia, and private sector stakeholders.
- Organize multi-stakeholder consultations and knowledge-sharing platforms to gather diverse perspectives.
- Conduct annual stocktaking exercises to assess adaptation progress and challenges.
- Regularly update the dossier with emerging best practices, lessons learned, and new adaptation initiatives.

7.2.2 Financial Actions

- Strengthen mechanisms for mobilizing domestic and international climate finance for adaptation projects.
- Build technical capacity for preparing bankable adaptation proposals to access funds from global climate finance mechanisms.
- Ensure adaptation considerations are integrated into budgeting and project planning processes.

7.2.3 Capacity Building

7.2.3.1 Institutional Capacity Building

- Strengthen alignment between climate adaptation policies and sectoral development plans at national and state levels.
- Encourage inter-ministerial coordination to integrate adaptation across multiple sectors.
- Establish dedicated adaptation planning cells within key ministries and state governments.
- Develop measurable indicators to assess the effectiveness of adaptation interventions.
- Ensure adaptation considerations are integrated into budgeting and project planning processes.
- Promote climate-resilient infrastructure and nature-based solutions in development projects.
- Create a centralized database for tracking adaptation initiatives, progress, and best practices.

7.2.3.2 Individual Capacity Building

- Develop targeted capacity-building programs for government officials and practitioners on adaptation planning and implementation.
- Build technical capacity for preparing bankable adaptation proposals to access funds from global climate finance mechanisms.

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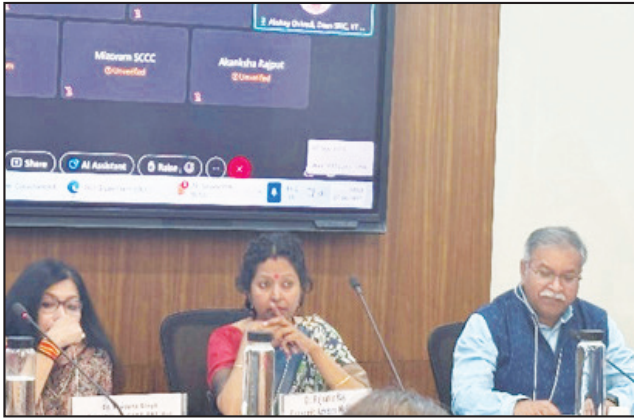
Annexure I

Name and Organization of the Working Group Members

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Photo Gallery





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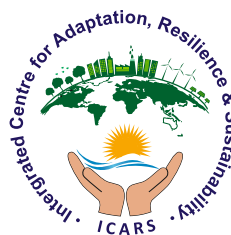
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Indian Institute of Technology Roorkee,
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The Integrated Centre for Adaptation, Disaster Risk Resilience and Sustainability (ICARS) is a joint centre of Excellence established by the Department of Science and Technology (DST), Govt. of India at the Greater Noida Campus of Indian Institute of Technology, Roorkee. The centre aims to promote "Capacities and Public Policy for Resilience and Sustainability (CAPP-RES)" through policy-linked research, action research, research to support capacity building and knowledge integration under the broad mandates of the National Mission on Strategic Knowledge for Climate Change (NMSKCC). This is a unique facility established on integrated and holistic coverage of DRR and Adaptation. ICARS promotes professional advances, leadership, and supports policy-planning, capacity building and localization of resilience agenda.



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