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INDIA FIRST BIENNIAL TRANSPARENCY REPORT

TO THE

UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

LiFE Lifestyle for Environment

प्रकृतिः रक्षति रक्षिता
Nature Protects if She is Protected

Ministry of Environment, Forest and Climate Change
Government of India

INDIA
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INDIA

FIRST BIENNIAL TRANSPARENCY REPORT (BTR)

TO THE

UNITED NATIONS FRAMEWORK
CONVENTION ON CLIMATE CHANGE (UNFCCC)

LiFE
Lifestyle for Environment

NATCOM Cell, Climate Change Division
Ministry of Environment, Forest and Climate Change
Government of India

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BHUPENDER YADAV

LiFE
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MINISTER
ENVIRONMENT, FOREST AND CLIMATE CHANGE
GOVERNMENT OF INDIA

FOREWORD

With a profound sense of responsibility and pride, we present India's First Biennial Transparency Report (BTR) to the UNFCCC. As a country vulnerable to climate change impacts yet committed to equity and climate justice, India reaffirms its strong dedication to the global climate effort.

India recognizes that addressing the climate crisis requires a transparent, inclusive, and collective approach. We continue to build on the foundation laid by the Paris Agreement, focusing on ambitious mitigation, adaptation, and resilience strategies while also honouring our responsibility to ensure sustainable development for all. This Biennial Transparency Report outlines progress toward fulfilling our Nationally Determined Contributions (NDCs) and provides an overview of our greenhouse gas (GHG) inventory, actions taken, and climate finance efforts over the reporting period.

India has made significant strides in reducing emissions intensity, expanding renewable energy capacity, improving energy efficiency, and enhancing the carbon sinks of our forests. As part of our commitment to transparency, we are presenting this report in accordance with the Enhanced Transparency Framework (ETF) under the Paris Agreement. We believe that transparency is not only vital for tracking progress but also for building trust among nations, encouraging mutual learning, and facilitating the exchange of best practices.

This report also highlights the challenges faced by developing countries like India in implementing climate actions in a context of limited financial resources, technology gaps, and capacity constraints. It underscores the importance of the principle of "common but differentiated responsibilities and respective capabilities" (CBDR-RC), which calls for differentiated support from developed countries to help developing nations meet their climate goals.

India's efforts to combat climate change are deeply intertwined with our goals of poverty reduction, sustainable livelihoods, and social equity. We are committed to promoting an inclusive and just transition to a low-carbon, climate-resilient economy, ensuring that no one is left behind in this journey.

The Biennial Transparency Report highlights India's ongoing efforts not only to fulfill its climate commitments but also to surpass them, taking bold actions for the welfare of our people and the environment. We remain strongly dedicated to collaborating with the international community to achieve global climate goals and help build a sustainable future for everyone.

This report is a testament to India's unwavering commitment to the global climate agenda, as we continue to forge ahead with determination, collaboration, and a shared sense of purpose.

(Bhupender Yadav)

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कीर्तवर्धन सिंह
KIRTI VARDHAN SINGH

एक कदम स्वच्छता की ओर

सत्यमेव जयते

राज्य मंत्री
पर्यावरण, वन एवं जलवायु परिवर्तन
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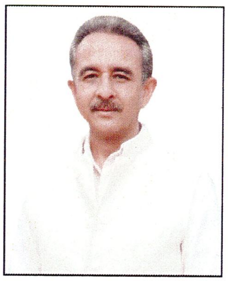

PREFACE

India's First Biennial Transparency Report represents an important milestone in our national and global efforts to combat climate change. It reflects our enduring commitment to transparency, accountability, and responsible climate action, and demonstrates our resolve to contribute meaningfully to the global response under the UNFCCC and its Paris Agreement.

As a developing country with a large and diverse population, India faces unique challenge of balancing developmental priorities with climate imperatives. Nevertheless, guided by the principles of equity and common but differentiated responsibilities, India has consistently demonstrated leadership through a development pathway that is inclusive, sustainable, and climate-resilient.

India is firmly on course to achieve its 2030 Nationally Determined Contributions (NDCs). Our rapidly expanding renewable energy sector, now exceeding 265 GW, positions India as a global frontrunner in clean energy. Today, non-fossil fuel sources contribute more than 50% of the country's installed electric power capacity, underscoring our decisive shift toward low-carbon energy systems.

Complementing these achievements is the national initiative, Mission LiFE (Lifestyle for the Environment), which promotes mindful consumption and sustainable living across communities, businesses, and households. By encouraging environmentally responsible choices, Mission LiFE strengthens India's climate efforts and supports our long-term vision of sustainable development.

Despite our progress, India continues to face challenges such as limited access to financial resources, technology gaps, and the ongoing need for capacity-building. These realities highlight the importance of enhanced international support, particularly from developed countries, to ensure that developing nations can implement climate action without compromising on developmental aspirations.

As we present this Biennial Transparency Report, India reaffirms its determination to pursue its climate goals with integrity and ambition, while safeguarding the well-being of present and future generations. We look forward to strengthened global cooperation and shared action in building a greener, more resilient world.

(Kirti Vardhan Singh)

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सत्यमेव जयते

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SECRETARY
GOVERNMENT OF INDIA
MINISTRY OF ENVIRONMENT, FOREST AND CLIMATE CHANGE

MESSAGE

Climate change is a collective challenge, and equitable solutions are essential for ensuring a resilient and sustainable future. India, as a Party to the Paris Agreement and a responsible member of the global community, recognizes the central importance of transparency in strengthening global climate action. In this spirit, India is proud to submit its First Biennial Transparency Report (BTR) to the United Nations Framework Convention on Climate Change (UNFCCC), reaffirming the commitment to limiting global temperature rise to the goals of the Paris Agreement.

India's climate strategy is anchored in domestic priorities such as poverty alleviation, energy access, economic growth, and ecosystem conservation. The Ministry of Environment, Forest and Climate Change (MoEFCC) plays a pivotal role in integrating climate considerations into national policies, ensuring that climate action contributes to sustainable development and enhance national resilience.

The scale and urgency of the climate challenge is undeniable. Yet, India remains confident that through sustained domestic efforts and enhanced international collaboration, we can achieve our climate objectives. We emphasize the crucial importance of global cooperation, especially through adequate finance, technology transfer, and capacity-building support to developing nations.

The BTR provides a comprehensive account of India's climate actions across key areas, GHG emissions, progress toward Nationally Determined Contributions (NDCs), mitigation and adaptation measures, and climate finance. Tracking progress against our NDCs enables us to evaluate the effectiveness of our policies and actions to combat climate change, identify areas requiring additional focus, and take corrective action where necessary. The MoEFCC, together with relevant ministries and agencies, continues to strengthen monitoring and reporting systems to ensure accurate assessment of national climate actions.

I extend my appreciation to all individuals and institutions involved in the preparation of this report. Their dedication has been instrumental in presenting a robust, transparent, and comprehensive BTR for India.

(Tanmay Kumar)

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भारत सरकार
पर्यावरण, वन और जलवायु परिवर्तन मंत्रालय
ADDITIONAL SECRETARY
GOVERNMENT OF INDIA
MINISTRY OF ENVIRONMENT, FOREST & CLIMATE CHANGE

Message

India's First Biennial Transparency Report (BTR) reaffirms our strong and enduring commitment to climate action under the United Nations Framework Convention on Climate Change (UNFCCC). This report offers a transparent and detailed overview of India's climate policies, actions, and progress, underscoring our resolve to strengthen climate resilience and contribute meaningfully to global climate goals.

Although India accounts for only a small share of historical Global Greenhouse Gas (GHG) emissions, we have consistently demonstrated leadership in climate governance. Our efforts remain focused on strengthening our actions to implement the Nationally Determined Contributions (NDCs) and adopting pathways that decouple economic growth from emissions.

The BTR highlights significant actions across mitigation and adaptation. Between 2005 and 2022, India reduced the emission intensity of its GDP by 37.38%, reflecting major gains in energy efficiency, renewable energy expansion, and low-carbon development. This progress places India firmly on track to achieve a 45% reduction in emission intensity by 2030.

India's transition to clean energy continues to accelerate, with non-fossil fuel sources now accounting for more than 52% of cumulative electric power installed capacity, surpassing our 2030 target well ahead of time. Our forests and tree cover sequestered 2.44 billion tonnes of CO_2 between 2005 and 2022, advancing toward our NDC goal of creating 2.5 to 3 billion tonnes of additional carbon sinks by 2030.

This report not only documents our progress but also reflects India's proactive approach to transparency and continual improvement of national climate reporting system. It also underscores the need for stronger international support, particularly in finance, technology transfer, and capacity-building, to help developing nations enhance climate resilience.

I extend my sincere appreciation to the NATCOM team and to all officials, scientists, institutions, and ministries whose collective expertise and commitment have made this BTR possible. I am confident that this report will serve as an important resource for understanding India's GHG inventory, climate actions, and policy framework.

Agarg

(Amandeep Garg)

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ABBREVIATIONS

4E	End to End Energy Efficiency
AB	Aerial Bunched
AD	Activity Data
AGB	Above Ground Biomass
AgDSM	Agriculture Demand Side Management
AHP	Analytical Hierarchy Process
AIGMF	All India Glass Manufacturers' Federation
AIPA	Apex Committee for Implementation of Paris Agreement
AITDC	Advanced Industrial Technology Demonstration Centre
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
APU	Auxiliary Power Units
AR	Assessment Report
AR5	Fifth Assessment Report
ATF	Aviation Turbine Fuel
ATAL JAL	Atal Bhujal Yojana
AT&C	Aggregate Technical & Commercial losses
ATMA	Agriculture Technology Management Agency
BAU	Business As Usual
BCM	Billion Cubic Metres
BEAMS	Beach Environment and Aesthetics Management System
BEE	Bureau of Energy Efficiency
BEEP	Building Energy Efficiency Programme
BERPD	Bureau of Economic Research and Policy Development
BGB	Below Ground Biomass
BGREI	Bringing Green Revolution to Eastern India
BHS	Biodiversity Heritage Sites
BITS	Birla Institute of Technology and Science
BPL	Below Poverty Line
BPO	Business Process Outsourcing
BRSR	Business Responsibility and Sustainability Reporting
BTR-1	First Biennial Transparency Report
BUR	Biennial Update Reports
BUR-4	Fourth Biennial Update Report
BWUE	Bureau of Water Use Efficiency
C	Confidential
CAAP	City Clean Air Action Plan
CAP	City Climate Action Plans
CAPF	Central Armed Police Forces
CaCO3	Calcium Carbonate
CAMPA	Compensatory Afforestation Fund Management and Planning Authority
CAFÉ	Corporate Average Fuel Economy
CAGR	Compound Annual Growth Rate
CBDR-RC	Common but Differentiated Responsibilities and Respective Capabilities
CBFS	Carbon Content of Feed Stock
CBG	Compressed Bio-Gas
CBIT	Capacity-building for establishing an integrated and Enhanced transparency framework for climate actions and support measures
CCA	Community Conserved Areas
CCVA	Climate Change Vulnerability Assessment
CCF	Carbon Content Factors
CCI	Cement Corporation of India Limited
CCO	Coal Controller Organisation

ABBREVIATIONS

CCTS	Carbon Credit Trading Scheme
CCUS	Carbon Capture, Utilization, and Storage
CDB	Coconut Development Board
CDM	Clean Development Mechanism
C-DOT	Centre of Development of Telematics
CDP	Crop Diversification Programme
CDRI	Coalition for Disaster Resilient Infrastructure
CEA	Central Electricity Authority
CEIIC	Clean Energy International Incubation Centre
CEF	Carbon Emission Factors
CH_4	Methane
CIH	Central Institute of Horticulture
CII	Confederation of Indian Industry
CGWB	Central Groundwater Board
CMA	Cement Manufacturers Association
CMA	Conference of the Parties serving as the meeting of the Parties to the Paris Agreement
CNG	Compressed Natural Gas
CO_2	Carbon Dioxide
COP	Conference of the Parties
CPCB	Central Pollution Control Board
CPHEEO	Central Public Health and Environmental Engineering Organisation
CRCAP	City Resilience Climate Action Plan
CRISIL	Credit Rating Information Services of India Limited
CRMI	Cyclone Risk Mitigation Infrastructure
CRIDA	Central Research Institute for Dryland Agriculture
CRM	Crop Residue Management
CRRI	Central Road Research Institute
CRTs	Common Reporting Tables
CS	Country-Specific
CSCAF	Climate Smart Cities Assessment Framework
CSD	Climate Sensitive Diseases
CSIR	Council of Scientific and Industrial Research
CSMRS	Central Soil and Materials Research Station
CRV	Climate Resilient Villages
CSIR-CIMFR	Council of Scientific & Industrial Research - Central Institute of Mining and Fuel Research
CSTEP	Center for Study of Science, Technology and Policy
CTFs	Common Tabular Formats
CVI	Coastal Vulnerability Index
CWC	Central Water Commission
CWPRS	Central Water and Power Research Station
D	Default
DACP	District Agriculture Contingency Plans
DAHD	Department of Animal Husbandry and Dairying
DGMS	Directorate General of Mines Safety
DARE	Department of Agricultural Research and Education
DACFW	Department of Agriculture Co-operation and Farmers Welfare
DC	Designated Consumers
DDUGJY	Deen Dayal Upadhyaya Gram Jyoti Yojana
DEA	Department of Economic Affairs
DEMU	Diesel Electric Multiple Unit
DIC	Dissolved Inorganic Carbon
DIPP	Department of Industrial Policy & Promotion

ABBREVIATIONS

DISCOMS	Distribution Companies
DoHI	Department of Heavy Industry
DoRD	Department of Rural Development
DoS	Department of Space
DoWR, RD & GR	Department of Water Resources, River Development and Ganga Rejuvenation
DPIIT	Department for Promotion of Industry and Internal Trade
DRIP	Dam Rehabilitation and Improvement Project
DRI	Disaster Resilient Infrastructure
DRR	Disaster Risk Reduction
DSR	Direct Seeded Rice
DSS	Decision Support System
DST	Department of Science and Technology
DW&S	Department of Drinking Water and Sanitation
DW	Deep Water
EC Act	Energy Conservation Act
EbA	Ecosystem-Based Adaptation
ECBC	Energy Conservation Building Code
EERR	Emergency Essential Resource Reserve
EESL	Energy Efficiency Services Limited
EHC	Environmental Health Cell
ENS	Eco Niwas Samhita
ENSO	El Niño Southern Oscillation
EPI	Energy Performance Index
EPR	Extended Producer Responsibility
ERK	Emergency Responder Kits
ERP	Enterprise Resource Planning
ERSS	Emergency Response Support System
ESCerts	Energy Savings Certificates
ESG	Environmental, Social, and Governance
ETF	Enhanced Transparency Framework
FAI	Fertilizer Association of India
EWDS	Early Warning Dissemination Systems
FAME	Faster Adoption and Manufacturing of Hybrid and Electric Vehicles
FCM	Forest Cover Mapping
FDI	Foreign Direct Investment
FHTC	Functional Household Tap Connections
FL	Forestland
FLCTD	Facility for Low Carbon Technology Deployment
FSI	Forest Survey of India
FMAP	Financing Mitigation and Adaptation Projects
FP	Flood-Prone
FRIP	Finance for Resilient Infrastructure Programme
FSG	Food Security Groups
FSI	Forest Survey of India
FTGRAS	Forest Tree Genetic Risk Assessment System
FX	Flexibility
FY	Financial Year
GBA	Global Biofuels Alliance
GCF	Green Climate Fund
GCP	Green Credit Program
GCRI	Gender-based Climate Risk Index
GDP	Gross domestic Product

ABBREVIATIONS

GEF	Global Environment Facility
Gg	Gigagram
GGC	Green Guarantee Company
GGEF	Green Growth Equity Fund
GHG	Green House Gas
GIM	Green India Mission
GIS	Gas Insulated Substations
GIS	Geographic Information Systems
GJ	Giga Joule
GL	Grassland
GNARE	General Network Access Regulations with special provisions for RE
GNHCP	Green National Highways Corridor Project
GoI	Government of India
GP	Gram Panchayats
GRB	Gender-Responsive Budgeting
GRIHA	Green Rating for Integrated Habitat Assessment
GS	Gold Standard Registry
GSDP	Green Skill Development Programme
GW	Gigawatt
GWMR	Ground Water Management & Regulation
GVA	Gross Value Added
GWPs	Global Warming Potentials
HI	Heat Index
HFC	Hydrofluorocarbons
HMNEH	Horticulture Mission for North East and Himalayan States
HOG	Head-on Generation
HPO	Hydro Purchase Obligations
HWF	Heat Wave Frequency
IARI	Indian Agricultural Research Institute
IBM	Indian Bureau of Mines
ICAR	Indian Council of Agricultural Research
ICAR- NICRA	Indian Council of Agriculture Research - National Innovations for Climate Resilient Agriculture
ICFRE	Indian Council of Forestry Research and Education
ICZMP	Integrated Coastal Zone Management Project
IDRN	India Disaster Response Network
IE	Included Elsewhere
IEA	International Energy Agency
IFAD	International Fund for Agricultural Development
IFFCO	Indian Farmers Fertilizer Cooperative Limited
IFMS	Intensification of Forest Management Scheme
IGBC	India Green Building Council
IHR	Indian Himalayan region
IIP	Indian Institute of Petroleum
IISc	Indian Institute of Science
IIMA	Indian Institute of Management Ahmedabad
IIT	Indian Institute of Technology
IMCT	Inter-Ministerial Central Teams
IMD	India Meteorological Department
IM-PDS	Integrated Management of Public Distribution System
INCOIS	Indian National Centre for Ocean Information System
INM	Integrated Nutrient Management
IOCL	Indian Oil Corporation Limited

ABBREVIATIONS

IPCC	Intergovernmental Panel on Climate Change
IPCC GL	IPCC Guidelines
IPDS	Integrated Power Development Scheme
IPMU	Integrated Project Management Unit
IPPU	Industrial Processes and Product Use
IPR	Intellectual Property Rights
IRAF	Infrastructure Resilience Accelerator Fund
IRIS	Infrastructure for Resilient Island States
ISA	International Solar Alliance
ISFR	Indian State of Forest Report
ISSB	International Sustainability Standards Board
ISRO	Indian Space Research Organisation
ISTS	Inter-State Transmission System
IUINDRR	Indian Universities and Institutions Network for Disaster Risk Reduction
IVA	Integrated Vulnerability Assessment
India-WRIS	India Water Resources Information System
IWP	Indian Wetland Province
IWRM	Integrated Water Resource Management
JFM	Joint Forest Management
JFMC	Joint Forest Management Committee
JJM	Jal Jeevan Mission
kWh	Kilowatt-hour
KCA	Key Category Analysis
LeadIT 2.0	Leadership Group for Industry
LiFE	Lifestyle for Environment
LHZ	Landslide Hazard Zonation
LNG	Liquefied Natural Gas
LPA	Long Period Average
LPG	Liquid Petroleum Gas
LRMS	Landslide Risk Mitigation Scheme
LTEO	Long Term Ecological Observatories
LT-LEDS	Long-Term Low Carbon/Emissions Development Strategy
LULUCF	Land Use, Land-Use Change and Forestry
MDFs	Moderately Dense Forests
MgCO3	Magnesium carbonate
MAP	Management Action Plan
MDF	Moderately Dense Forest
MGNREGA	Mahatma Gandhi National Employment Guarantee Act
M&E	Monitoring and Evaluation
MFRA	Marine Fisheries Regulation Act
MHA	Ministry of Home Affairs
MIDH	Mission for Integrated Development of Horticulture
MISHTI	Mangrove Initiative for Shoreline Habitats & Tangible Incomes
MNCFC	Mahalanobis National Crop Forecast Centre
MNRE	Ministry of New and Renewable Energy
MoAFW	Ministry of Agriculture and Farmers Welfare
MoC	Ministry of Coal
MoCA	Ministry of Civil Aviation
MoCI	Ministry of Commerce and Industry
MoCF	Ministry of Chemicals and Fertilizers
MoEFCC	Ministry of Environment, Forest and Climate Change
MoES	Ministry of Earth Sciences

ABBREVIATIONS

MoF	Ministry of Finance
MoHFW	Ministry of Health & Family Welfare
MoHUA	Ministry of Housing and Urban Affairs
MoFAHD	Ministry of Fisheries, Animal Husbandry and Dairying
MoJS	Ministry of Jal Shakti
MOVCDNER	Mission Organic Value Chain Development in North Eastern Region
MoM	Ministry of Mines
MoP	Ministry of Power
MoPNG	Ministry of Petroleum and Natural Gas
MoPSW	Ministry of Ports, Shipping and Waterways
MoR	Ministry of Railways
MoRTH	Ministry of Road Transport and Highways
MoS	Ministry of Steel
MoSPI	Ministry of Statistics and Programme Implementation
MoWR	Ministry of Water Resources
MPA	Marine Protected Areas
MPGs	Modalities Procedures and Guidelines
MSW	Municipal Solid Waste
MRV	Monitoring, Reporting, and Verification
MSE	Madras School of Economics
MSME	Micro, Small and Medium Enterprises
MSSRF	M.S. Swaminathan Research Foundation
MRV	Monitoring, Reporting, and Verification
MT	Million tonne
$MtCO_2e$	Million tonnes of Carbon dioxide equivalent
MTOE	Million Tonnes of Oil Equivalent
MW	Megawatt
NA	Not Available / Not Applicable
NABARD	National Bank for Agriculture and Rural Development
NAQUIM	National Aquifer Mapping & Management
NAFCC	National Adaptation Fund on Climate Change
NAfP	National Afforestation Program
NATCOM	National Communications
NAP	National Adaptation Plan
NAPCC	National Action Plan on Climate Change
NBSS&LUP	National Bureau of Soil Survey and Land Use Planning
NBM	National Bamboo Mission
NCs	National Communications
NCAP	National Clean Air Programme
NCCR	National Centre for Coastal Research
NCDC	National Centre for Disease Control
NCERT	National Council for Research and Training
NCM	National Coastal Mission
NCRMP	National Cyclone Risk Mitigation Project
NCU	Neem Coated Urea
NDAIAPA	National Designated Authority for the Implementation of Article 6 of the Paris Agreement
NDC	Nationally Determined Contribution
NDEM	National Database for Emergency Management
NDMA	National Disaster Management Authority
NDMF	National Disaster Mitigation Fund
NDMIS	National Disaster Management Information System
NDMP	National Disaster Management Plan

ABBREVIATIONS

NDRF	National Disaster Response Force
NDRMF	National Disaster Risk Management Fund
NDRI	National Dairy Research Institute
NDVI	Normalized Difference Vegetation Index
NDRR	National Disaster Response Reserve
NDZ	No Development Zones
NE	Not Estimated
NEGCCH	National Expert Group on Climate Change & Health
NCV	Net Calorific Values
NEERI	National Environmental Engineering Research Institute
NEP	National Education Policy
NEMMP	National Electric Mobility Mission Plan
NF_3	Nitrogen trifluoride
NFSM	National Food Security Mission
NHAI	National Highways Authority of India
NHB	National Horticulture Board
NHM	National Horticulture Mission
NIAS	National Institute of Advanced Studies
NICRA	National Innovations on Climate Resilient Agriculture
NID	National Inventory Document
NIDM	National Institute of Disaster Management
NISE	National Institute of Solar Energy
NITI Aayog	National Institution for Transforming India Aayog
NIUA	National Institute of Urban Affairs
NLRMP	National Landslide Risk Mitigation Programme
NMFP	National Marine Fisheries Policy
NMHS	National Mission on Himalayan Studies
NMSA	National Mission for Sustainable Agriculture
NMSH	National Mission on Sustainable Habitat
NMSHE	National Mission for Sustaining the Himalayan Ecosystem
NPCCHH	National Programme on Climate Change and Human Health
NPDM	National Policy on Disaster Management
NPDRR	National Platform for Disaster Risk Reduction
NRLM	National Rural Livelihood Mission
NRSC	National Remote Sensing Centre
NSAS	National Shoreline Atlas System
NSC	National Steering Committee
NTFP	Non-Timber Forest Products
N_2O	Nitrous Oxide
NO	Not Occurring
NWM	National Water Mission
ODF	Open Defecation Free
OF	Open Forests
OFWM	On-Farm Water Management
OL	Other Land
OTH	Other
PAT	Perform, Achieve and Trade
PDMC	Per Drop More Crop
PIB	Press Information Bureau
PF	Protected Forests
PFC	Perfluorocarbons
PHL	Post Harvest Loss

ABBREVIATIONS

PKVY	Paramparagat Krishi Vikas Yojana
PLI	Production Linked Incentive
PMAY-G	Pradhan Mantri Awas Yojana – Grameen
PMAY-U	Pradhan Mantri Awas Yojana – Urban
PMCCC	Prime Minister's Council on Climate Change
PMFBY	Pradhan Mantri Fasal Bima Yojana
PM-KISAN	Pradhan Mantri Kisan Samman Nidhi
PM-KUSUM	Pradhan Mantri Kisan Urja Suraksha Evam Utthan Mahabhiyan
PMKSY	Pradhan Mantri Krishi Sinchayi Yojana
PMUY	Pradhan Mantri Ujjwala Yojana
PMMSY	Pradhan Mantri Matsya Sampada Yojana
PPAC	Petroleum Planning and Analysis Cell
PPP	Purchasing Power Parity
PRI	Panchayati Raj Institutions
PSP	Pumped Storage Project
PTR	Puddled Transplanted Rice
PV	Photovoltaic
QA/QC	Quality Assurance and Quality Control
RAD	Rainfed Area Development
RAFTAAR	Remunerative Approaches for Agriculture and Allied sector Rejuvenation
RAMA	Refrigeration and Air Conditioning Manufacturers Association
R&D	Research and Development
RBP	Ration Balancing Programme
RCO	Renewable Consumption Obligations
RCP	Representative Concentration Pathway
RE	Renewable Energy
REC	Renewable Energy Certificate
REMCs	Renewable Energy Management Centres
RES	Renewable Energy Sources
RPO	Renewable Purchase Obligations
RF	Reserved Forests
RKVY	Rashtriya Krishi Vikas Yojana
RH	Relative Humidity
SAAP	State Annual Action Plans
SACHET	Common Alerting Protocol-based Integrated Alert System
SAPCC	State Action Plan on Climate Change
SAPCCHH	State Action Plan for Climate Change and Human Health
SATAT	Sustainable Alternative Towards Affordable Transportation
SBM	Swachh Bharat Mission
SDG	Sustainable Development Goals
SDM	Species Distribution Modelling
SDMF	State Disaster Mitigation Fund
SDRF	State Disaster Response Fund
SDRMF	State Disaster Risk Management Fund
SEBI	Securities and Exchange Board of India
SEC	State Executive Committee
SF_6	Sulphur Hexafluoride
SFM	Sendai Framework Monitor
SHC	Soil Health Card
SHE RISES	Responsive, Inclusive, Safe & Equitable Spaces Framework
SIDS	Small Island Developing States
SIAM	Society of Indian Automobile Manufacturers

ABBREVIATIONS

SIDBI	Small Industries Development Bank of India
S&L	Standard and Labelling
SL	Settlements
SLNP	Street Lighting National Programme
SLR	Sea Level Rise
SMAM	Sub-Mission on Agricultural Mechanization
SST	Sea Surface Temperature
SMAF	Sub-Mission on Agro-forestry
SOC	Soil Organic Carbon
SRI	System of Rice Intensification
SWM	Solid Waste Management
T1	Tier 1
T2	Tier 2
T3	Tier 3
TAC	Technical Advisory Committee
TACCC	Transparency, Accuracy, Completeness, Consistency, and Comparability
TCFD	Task Force on Climate-related Financial Disclosures
TERI	The Energy and Resources Institute
TIO	Tropical Indian Ocean
TNC	Third National Communication
TOF	Trees Outside Forest
TWh	Terawatt-hour
UDMA	Urban Disaster Management Authority
UJALA	Unnat Jyoti by Affordable LEDs for All
ULBs	Urban Local Bodies
UNFCCC	United Nations Framework Convention on Climate Change
UNDP	United Nations Development Program
UNDRR	United Nations Office for Disaster Risk Reduction
UNEA	United Nations Environment Assembly
UNGA	United Nations General Assembly
UNIDO	United Nations Industrial Development Organization
URET	Uniform Renewable Energy Tariff
USDA	Unites States Department of Agriculture
UT	Union Territories
VCM	Vinyl Chloride Monomer
VDF	Very Dense Forests
VL	Visceral Leishmaniasis
VRE	Variable Renewable Energy
WCS	Water Conservation Structures
Web-DCRA	Web-based Dynamic Composite Risk Atlas
WEM	With Existing Measures
WIMS	Water Information Management System
WMO	World Meteorological Organization
WRI	World Resources Institute

KEY HIGHLIGHTS

India, as a Party to both the United Nations Framework Convention on Climate Change (UNFCCC) and its Paris Agreement, has furnished three National Communications (NCs) and four Biennial Update Reports (BURs) to the UNFCCC, so far. India's Third National Communication (TNC), containing the national GHG inventory for the year 2019, was submitted in December 2023 and its Fourth Biennial Update Report (BUR-4) containing the national GHG inventory for the year 2020 was submitted in December 2024.

Under Article 13 of the Paris Agreement, from 2024 onwards, all Parties must submit Biennial Transparency Reports (BTRs), which replace the earlier Biennial Report (BR) and BUR requirements. India's first Biennial Transparency Report (BTR-1) presents updated information according to Decision 18/CMA.1, i.e., Modalities Procedures and Guidelines (MPGs) and 5/CMA.3, for the transparency framework for action and support referred to in Article 13 of the Paris Agreement.

India's submission of its first BTR-1 reflects not only its steadfast commitment to the UNFCCC and the Paris Agreement, but also its determination to advance climate action in accordance with its national circumstances, capacities, and developmental priorities. India's BTR-1 includes information on the national greenhouse gas (GHG) inventory for 2005, 2020, 2021, and 2022, as well as tracking progress in implementing and achieving its NDCs.

In 2022, India's total GHG emissions, excluding Land Use Land-Use Change and Forestry (LULUCF) were 3,396 million tonnes of CO_2eq and 2,824 million tonnes of CO_2eq with the inclusion of LULUCF. Between 2005 and 2022, India's GHG emissions, excluding the LULUCF sector, increased by approximately 69.71%, rising from 2,001 million tonnes CO_2eq to 3,396 million tonnes CO_2eq. This growth was primarily driven by the energy sector, which has been central to the country's industrialization and modernization. Over the same period, India achieved significant progress in strengthening its carbon sinks, with net removals from the LULUCF sector increasing from –206 million tonnes CO_2eq in 2005 to –572 million tonnes CO_2eq in 2022, reflecting an enhancement of about 177.56%. As a result, India's net national emissions (including LULUCF) registered an overall increase of 57.33% between 2005 and 2022.

These trends need to be interpreted in the context of India's national circumstances. While absolute emissions have increased, the emissions intensity of GDP has consistently declined, reflecting a progressive decoupling of economic growth from GHG emissions. India's per capita GHG emissions continue to remain well below the global average.

India's achievements in respect of the NDC targets:

- India has progressively continued decoupling economic growth from GHG emissions, which can be attributed to policies promoting renewable energy deployment and policies aimed at improving the energy efficiency across the economy. As a result of these combined efforts, the emissions intensity of GDP reduced by 37.38% by 2022 compared to the base year of 2005.
- There has been a significant increase in non-fossil fuel-based sources in India, largely driven by a rapid increase in the installed capacity of solar photovoltaic (PV) based power supply and wind energy, alongside a steady rise in hydro and nuclear power capacity. As a proportion of total installed capacity in India, non-fossil fuel-based installed power capacity was 38.3% in 2020, 40.2% in 2021, and 42.5% in 2022. against the NDC pledge of achieving 50% by 2030.
- Recently, in June 2025, the target of enhancing the share of non-fossil fuel energy resources in total electric power installed capacity has been achieved five years ahead of the committed timeline of 2030.
- India's forest and tree cover has consistently increased, creating an additional carbon sink of 2.44 billion tonnes of CO_2 equivalent from 2005 to 2022.

KEY HIGHLIGHTS

India is increasingly vulnerable to the impacts of climate change, including from extreme weather events, changing rainfall patterns, and rising sea levels. These risks are further intensified by financial, institutional, and technological constraints, making urgent and effective climate adaptation a national imperative. Limited international adaptation finance and the escalating costs of Loss and Damage highlight the urgent need for enhanced global support for stronger resilience measures.

Achieving India's climate goals necessitates substantial financial, technological, and capacity-building support, underscoring the critical role of international assistance. While India has made significant progress in domestic policy and action, challenges persist in accessing adequate external resources. So far, India has largely met its requirements through domestic resources, with minimal support from international climate finance. There is limited availability of concessional finance, advanced technologies, and tailored capacity-building programs.

India advocates for scaling up new and additional grant-based highly concessional finance and non-debt financial instruments. India strongly advocates financial support for climate action that is affordable, predictable, accessible, and commensurate with the articulated needs and development aspirations of developing nations.

CHAPTER-1

NATIONAL INVENTORY REPORT OF ANTHROPOGENIC EMISSIONS BY SOURCES AND REMOVALS BY SINKS OF GREENHOUSE GASES

NATIONAL INVENTORY REPORT OF ANTHROPOGENIC EMISSIONS BY SOURCES AND REMOVALS BY SINKS OF GREENHOUSE GASES

1.1 Overview

India, as a Party to both the United Nations Framework Convention on Climate Change (UNFCCC) and its Paris Agreement, has furnished three National Communications (NCs) and four Biennial Update Reports (BURs) to the UNFCCC, so far. Under Article 13 of the Paris Agreement, from 2024 onwards, all Parties must submit Biennial Transparency Reports (BTRs), which replace the earlier BR and BUR requirements. India's first Biennial Transparency Report (BTR-1) presents updated information according to Decision 18/CMA.1, i.e., Modalities Procedures and Guidelines (MPGs) and 5/CMA.3, for the transparency framework for action and support referred to in Article 13 of the Paris Agreement.

India's submission of its first Biennial Transparency Report (BTR) as a party to the Paris Agreement aligns with its perspective on the importance of the multilateral process under the UNFCCC in addressing the challenge of climate change. India is currently one of the fastest-growing economies in the world, home to almost one-sixth of humanity. Its growth momentum is integral to global development and essential to meeting sustainable development goals. Several challenges confront India's development agenda, including climate change. India's contribution to global warming is minimal. Nevertheless, India is committed to combating climate change by making development choices that ensure the growth and development of the economy along low-carbon pathways toward net zero by 2070.

For a developing country of India's size, scale, and socio-economic diversity, preparing a comprehensive and accurate national greenhouse gas (GHG) inventory posed considerable challenges, further intensified by the additional data and reporting obligations introduced under the Enhanced Transparency Framework (ETF) of the Paris Agreement. To meet these enhanced requirements, India has strengthened institutional arrangements, improved sectoral engagement, and mobilized specialized technical expertise across diverse domains. This effort has required significant financial and human resources to ensure methodological consistency, accuracy, and transparency. The submission of India's first BTR thus reflects not only its steadfast commitment to the UNFCCC and the Paris Agreement, but also its determination to advance climate action in accordance with its national circumstances, capacities, and developmental priorities.

This chapter presents a summary of India's GHG inventory. The detailed inventory is available in the standalone National Inventory Document (NID) and Common Reporting Tables (CRTs).

In BTR-1, India has provided its national greenhouse gas (GHG) inventory for the years 2005, 2020, 2021, and 2022. In 2022, India's total GHG emissions, excluding Land Use Land-Use Change and Forestry (LULUCF), were 3,396,372 Gg of CO_2eq and 2,824,549 Gg of CO_2eq with the inclusion of LULUCF. Between 2005 and 2022, India's GHG emissions, excluding the LULUCF sector, increased by approximately 69.71%, rising from 2,001,288 Gg CO_2eq to 3,396,372 Gg CO_2eq. This growth was primarily driven by the energy sector, which has been a central component of the country's industrialization and modernization. Over the same period, India achieved significant progress in strengthening its carbon sinks, with net removals from the LULUCF sector increasing from −206,020 Gg CO_2eq in 2005 to −571,823 Gg CO_2eq in 2022, reflecting an enhancement of about 177.56%. As a result, India's net national emissions (including LULUCF) registered an overall increase of 57.33% between 2005 and 2022.

These trends need to be interpreted in the context of India's national circumstances. While absolute emissions have increased, India's per capita GHG emissions continue to remain well below the global average. At the same time, the emissions intensity of GDP has consistently declined, reflecting a progressive decoupling of economic growth from GHG emissions. This demonstrates the effectiveness of policies and measures that promote energy efficiency and the expansion of renewable energy.

1.2 Institutional Arrangements for GHG Inventory

Scientific and research institutions from across India, in collaboration with various government agencies, contributed to the development of the national inventory for BTR-1. The inventory preparation is managed by the Ministry of Environment, Forest, and Climate Change of India (MoEFCC), which involves collaborating with various expert institutions to compile sector-specific data and conduct research for the development of country-specific emission factors. In their respective fields of sectoral expertise, fifteen Indian institutions completed the inventory preparation exercise. The activity data required for preparing the inventory were provided by various ministries, government departments, and institutions (Figure 1.1 and Table 1.1). The institutions involved in creating inventories across various industries are listed in Figure 1.2. A detailed institutional arrangement is provided in Chapter 7.

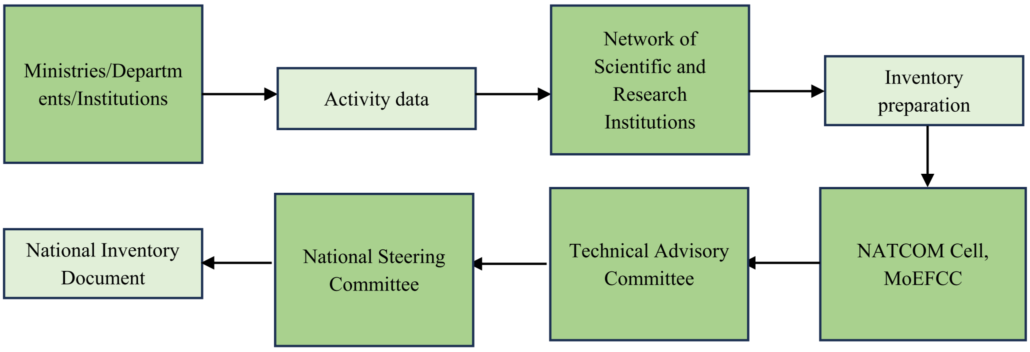

Figure 1.1: Institutional Arrangement for the preparation of the National GHG inventory

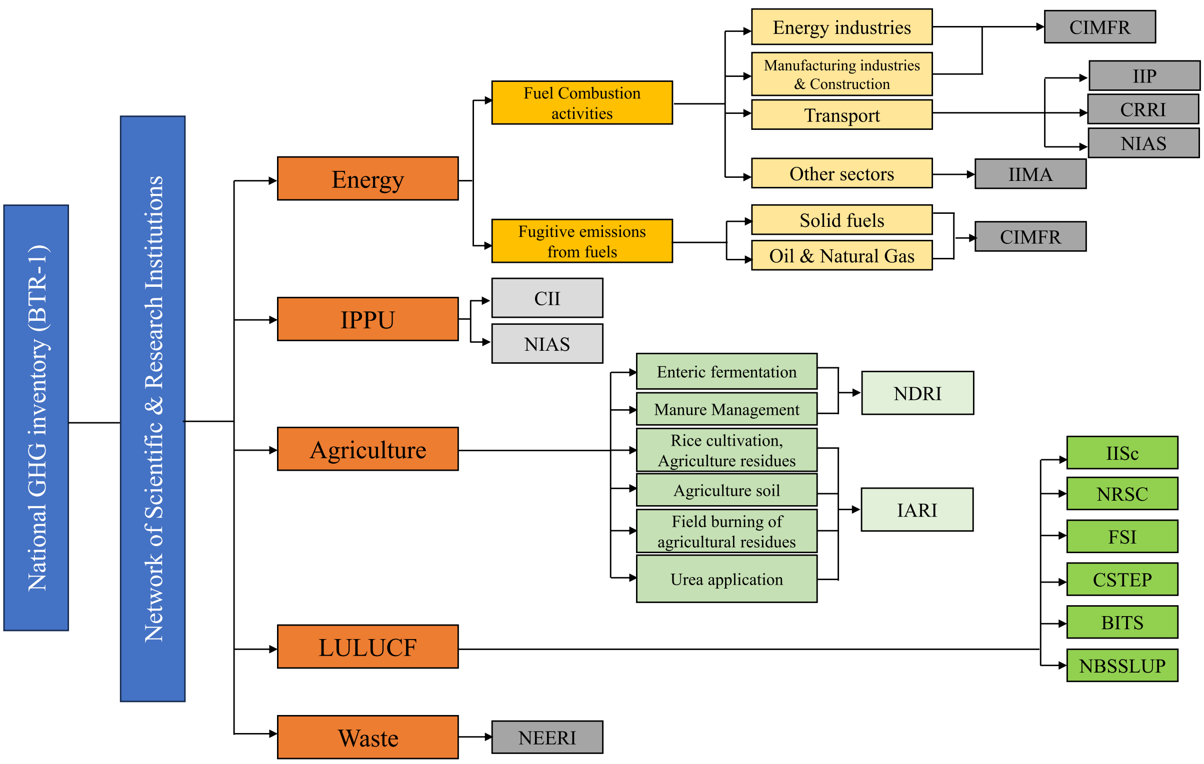

Figure 1.2: Institutions involved in BTR-1 GHG inventory preparation

BITS	:	Birla Institute of Technology and Science, Pilani, K K Birla Goa Campus
CII	:	Confederation of Indian Industry, New Delhi
CIMFR	:	Central Institute of Mining and Fuel Research, Dhanbad
CRRI	:	Central Road Research Institute, New Delhi
CSTEP	:	Centre for Study of Science, Technology and Policy, Bengaluru
FSI	:	Forest Survey of India, Dehradun
IARI	:	Indian Agricultural Research Institute, New Delhi
IIMA	:	Indian Institute of Management, Ahmedabad
IIP	:	Indian Institute of Petroleum, Dehradun
IISc	:	Indian Institute of Science, Bengaluru
NBSSLUP	:	National Bureau of Soil Survey & Land Use Planning, Nagpur
NDRI	:	National Dairy Research Institute, Karnal
NEERI	:	National Environmental Engineering Research Institute, Nagpur
NIAS	:	National Institute of Advanced Studies, Bengaluru
NRSC	:	National Remote Sensing Centre, Hyderabad

Table 1.1: Data providers (ministries/departments/institutions/organisations) for the preparation of National GHG Inventory

Ministries/Departments of Government of India	Institutions/Organisations
Department of Health and Family Welfare (DoHFW)	All India Glass Manufacturers' Federation (AIGMF)
Department for Promotion of Industry and Internal Trade (DPIIT)	Bureau of Energy Efficiency (BEE)
Department of Agricultural Research and Education (DARE)	Cement Corporation of India (CCI) Limited
Department of Agriculture and Farmers Welfare (MoAFW)	Cement Manufacturers Association (CMA)
Department of Animal Husbandry and Dairying (DAHD)	Central Electricity Authority (CEA)
Department of Chemicals and Petrochemicals (DCPC)	Central Pollution Control Board (CPCB)
Department of Economic Affairs (DEA)	Credit Rating Information Services of India Limited (CRISIL)
Department of Fertilizers (DoF)	Directorate General of Mines Safety (DGMS)
Department of Fisheries (DoF)	Fertiliser Association of India (FAI)
Department of Space (DoS)	Forest Survey of India (FSI)
Department of Water Resources, River and Ganga Rejuvenation (DoWR, RD & GR)	Indian Bureau of Mines (IBM)
Ministry of Civil Aviation (MoCA)	Indian Council of Forestry Research and Education (ICFRE)
Ministry of Coal (MoC)	Indian Farmers Fertilizer Cooperative Limited (IFFCO)
Ministry of Earth Sciences (MoES)	Indian Space Research Organization (ISRO)
Ministry of Heavy Industry (MHI)	Mahalanobis National Crop Forecast Centre (MNCFC)
Ministry of Housing and Urban Affairs (MoHUA)	National Institute of Solar Energy (NISE)
Ministry of Micro, Small & Medium Enterprises (MSME)	National Institution for Transforming India Aayog (NITI-Aayog)
Ministry of Mines (MoM)	Ozone Cell, Ministry of Environment, Forest and Climate Change
Ministry of New and Renewable Energy (MNRE)	Petroleum Planning and Analysis Cell (PPAC)
Ministry of Petroleum and Natural Gas (MoP&NG)	Refrigeration and Air Conditioning Manufacturers Association (RAMA)
Ministry of Power (MoP)	Society of Indian Automobile Manufacturers (SIAM)
Ministry of Railways (MoR)	
Ministry of Road Transport and Highways (MoRTH)	

Ministries/Departments of Government of India	Institutions/Organisations
Ministry of Statistics and Programme Implementation (MoSPI)	
Ministry of Steel (MoS)	

1.3 Methodology for preparation of GHG inventory

The preparation of India's GHG inventory for its first BTR is guided by the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. India remains committed to the principles of transparency, accuracy, completeness, consistency, and comparability (TACCC), which serve as the foundation of the reporting process under ETF. A central element of this commitment is the progressive enhancement of the inventory through the integration of higher-tier methodologies and the development of country-specific emission factors and parameters that better capture India's national circumstances, thus minimizing its uncertainties and strengthening the overall quality and reliability of the emission estimates.

The estimation of GHG emissions and removals in BTR-1 employs a combination of methodological tiers and data sources, selected based on the significance of each source/sink category, the availability and quality of data, and the national capacity to apply advanced approaches. The methodological tiers, as defined by the IPCC, are applied as follows:

- **Tier 1 (T1):** Basic methods using default emission factors provided in the IPCC Guidelines.
- **Tier 2 (T2):** Intermediate methods employing country-specific emission factors or parameters for key activity data.
- **Tier 3 (T3):** Advanced methods involving detailed modeling, facility-level data, or comprehensive inventory systems.

Emission factors are categorized as:

- **Default (D):** Default values provided in the IPCC Guidelines.
- **Country-Specific (CS):** Data developed to reflect India's unique geographical, climatic, and economic conditions.
- **Sector-Specific (SS):** Information sourced directly from industries or specific economic sectors.
- **Other (OTH):** Values taken from sources other than the default ones provided in the IPCC Guidelines

Notation keys used are as follows:

- **Not Occurring (NO):** Categories or processes, including recovery, that do not occur within a Party
- **Not estimated (NE):** Activity data and/or emissions by sources and removals by sinks of GHGs that have not been estimated but for which a corresponding activity may occur within a Party
- **Not applicable (NA):** Activities under a given category that do occur within the Party but do not result in emissions or removals of a specific gas
- **Confidential (C):** Emissions by sources and removals by sinks of GHGs where the reporting would involve the disclosure of confidential information.

The application of these methodological choices across all sectors is summarized in Table 1.2.

Table 1.2:Summary report for methods applied to India's GHG inventory for the first BTR

Code	GHG source and sink categories	CO_2		CH_4		N_2O		HFC		PFC		SF_6		NF_3	
		Method	EF	Method	EF	Method	EF	Method	EF	Method	EF	Method	EF	Method	EF
1.	Energy														
1A.	Fuel combustion														
1A1.	Energy industries	T1, T2, T3	D, CS, SS	T1, T2	D	T1, T2	D								
1A2.	Manufacturing industries and construction	T1, T2, T3	D, CS, SS	T1, T2	D	T1, T2	D								
1A3	Transport	T1	D, CS	T1	D	T1	D								
1A4	Other sectors	T1	D	T1	D	T1	D								
1A5	Other (please specify)	T1	D,CS	T1	D,CS	T1	D,CS								
1B.	Fugitive emissions from fuels														
1B1.	Solid fuels	NA	NA	T2	CS	NA	NA								
1B2.	Oil and natural gas and other emissions from energy production	T1	D	T1	D	T1	D								
1C	CO_2 transport and storage	NO	NO												
2	Industrial processes and product use														
2A	Mineral industry	T1, T2	D, CS												
2B	Chemical industry	T1, T2	D, CS	T1	D	T1, T2	D	T1	D, CS	NA	NA	NA	NA	NA	NA
2C	Metal industry	T1	D	T1	D	NA	NA	NA	NA	T1	D, OTH	T1	D	NA	NA
2D	Non-energy products from fuels and solvent use	T1	D	NA	NA	NA	NA								
2E	Electronic industry					NA	NA	NA	NA	T1	D	NE	NE	NE	NE
2F	Product uses as substitutes for ODS							T1	D, CS	NO	NO	NO	NO	NO	NO
2G.	Other product manufacture and use					NE	NE			NE	NE	T1	D	NO	NO

Code	GHG source and sink categories	CO_2		CH_4		N_2O		HFC		PFC		SF_6		NF_3	
		Method	EF	Method	EF	Method	EF	Method	EF	Method	EF	Method	EF	Method	EF
2H.	Other (please specify)	IE	IE	IE	IE	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
3	Agriculture														
3A.	Enteric fermentation			T1, T2	D, CS										
3B.	Manure management			T1, T2	D, CS	T1, T2	D, CS								
3C	Rice cultivation			T2	CS										
3D	Agricultural soils			NA	NA	T2	CS								
3E	Prescribed burning of savannahs			NO	NO	NO	NO								
3F	Field burning of agricultural residues			T1,T2	D	T1,T2	D								
3G	Liming	NE	NE												
3H	Urea application	T2	D												
3I	Other carbon-containing fertilizers	NO	NO												
3J	Other (please specify)	NA	NA	NA	NA	NA	NA								
4.	Land use, land-use change, and forestry														
4A	Forest land	T2	CS	T2	D, CS	T2	D, CS								
4B	Cropland	T2	CS	NA	NA	NO	NA								
4C	Grassland	T2	CS	NO	NA	T2	D, CS								
4D	Wetlands	NE	NE	NE	NE	NE	NE								
4E.	Settlements	T2	CS	NO	NA	NO	NA								
4F	Other land	NA	NA	NA	NA	NA	NA								
4G.	Harvested wood products	T2	D												
4H.	Other (please specify)	NA	NA	NA	NA	NA	NA								

Code	GHG source and sink categories	CO_2		CH_4		N_2O		HFC		PFC		SF_6		NF_3	
		Method	EF	Method	EF	Method	EF	Method	EF	Method	EF	Method	EF	Method	EF
5	Waste														
5A	Solid waste disposal			T1, T2	D										
5B	Biological treatment of solid waste			T1, T2	D	NE	NE								
5C	Incineration and open burning of waste	T2	D	T1, T2	D	NE	NE								
5D	Wastewater treatment and discharge			T1, T2	D, CS	T1	D, CS								
5E	Other (please specify)	NE	NE	NE	NE	NE	NE								
6.	Other (please specify)														
	Memo items														
1D1	International bunkers														
1D1a	Aviation	T1	D	T1	D	T1	D								
1D1b.	Navigation	T1	D	T1	D	T1	D								
1D2	Multilateral operations	C	C	C	C	C	C								
1D3	CO_2 emissions from biomass	NA	NA												
1D4	CO_2 captured	NO	NO												
5F1	Long-term storage of C in waste disposal sites	T1	D												
	Indirect N_2O					NA	NA								
	Indirect CO_2	T1	D												

T1- Tier 1; T2- Tier 2; T3- Tier 3; EF: Emission Factor; SS- Sector Specific; CS- Country Specific; D- IPCC Default, OTH: Other; NO-Not Occurring, NA-Not Applicable, NE-Not Estimated; C-Confidential

For preparing the GHG inventory, India has used the 100-year time-horizon Global Warming Potential (GWP) values from the IPCC Fifth Assessment Report (AR5), as mandated by the UNFCCC for the Biennial Transparency Reports. Table 1.3 presents the 100-year GWP values from the IPCC AR5 that have been applied in this inventory. The selection of these values ensures consistency, transparency, and comparability with the inventories of other nations.

Table 1.3: GWPs used in National Inventory preparation

Name of Gases	Chemical formula	Global warming potential (GWP)
Carbon dioxide	CO_2	1
Methane	CH_4	28
Nitrous oxide	N_2O	265
HFC-23	CHF_3	12400
HFC-32	CH_2F_2	677
HFC-125	CHF_2CF_3	3170
HFC-134a	CH_2FCF_3	1300
HFC-143a	CH_3CF_3	4800
HFC-152a	CH_3CHF_2	138
HFC-227ea	CF_3CHFCF_3	3350
HFC-236fa	$CF_3CH_2CF_3$	8060
HFC-245fa	$CH_2FCF_2CHF_2$	858
HFC-365mfc	$CH_3CF_2CH_2CF_3$	804
HFC-43-10mee	$CF_3CHFCHFCF_2CF_3$	1650
Sulphur hexafluoride	SF_6	23500
PFC-14	CF_4	6630
PFC-116	C_2F_6	11100

Source: IPCC, 2013: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

1.4 Quality Assurance (QA), Quality Control (QC)

India's QA/QC system for the preparation of its GHG Inventory under the BTR-1 was designed in accordance with the 2006 IPCC Guidelines (Volume 1, Chapter 6) and the 2019 Refinement. The system ensures transparency, accuracy, consistency, comparability, and completeness (TACCC) of the inventory and builds upon the institutional framework established during the BUR. The MoEFCC and other government agencies involved in the reporting on climate change must ensure that the methodologies used in the reporting and inventories of emissions and removals meet the standards necessary to uphold the highest level of accuracy. Government agencies have to follow internal routines to plan, prepare, check and act/follow up on quality assurance and control work and consult one another with the aim of developing and maintaining a coordinated quality system. The IPCC Good Practice Guidelines section's list of Tier 1 and Tier 2 inventory level QA and QC procedures is used.

Quality Control

Quality control is the check that is made during the inventory preparation on different types of data, emission factors, and calculations. The quality control takes place according to general requirements (Tier 1) and Source Category-specific (Tier 2) QC procedures, which apply to all types of data used as support material for the reporting, and the specific requirements for quality control (Tier 2), which are applied to certain types of data and/or emission. In this inventory preparation exercise, both general Tier 1 and source specific Tier 2 QC measures, according to the 2006 IPCC Guidelines, have been carried out as follows:

i. Checked whether assumptions and criteria for the selection of activity data, emission factors, and other estimation parameters were documented and compared with international agency estimates.

ii. Checked for transcription errors in data input and references.

iii. Checked that emissions and removals were calculated correctly.

iv. Checked that parameters and units were correctly recorded and that appropriate conversion factors were used.

v. Checked the integrity of database files.

vi. Checked for consistency in data between source categories.

vii. Checked that the movement of inventory data among processing steps is correct.

viii. Checked that uncertainties in emissions and removals are estimated and calculated correctly.

ix. Checked time series consistency.

x. Checked completeness.

xi. Compared the reference and sectoral approach.

xii. Conducted trend checks.

xiii. Review of internal documentation and archiving.

In addition to the above general QC measures, for BTR-1, Tier 2 quality control is applied to key categories identified through Key Category Analysis (KCA), based on their cumulative emissions contributions and emission trends which includes:

i. Expert review of country-specific emission factors for sectors such as coal combustion and fugitive emissions from energy sector; enteric fermentation, rice cultivation and manure management from agriculture sector etc.

ii. Inter-annual trend analysis to identify unexpected spikes or drops in emissions.

iii. Internal consistency checks within sub-categories and the application of IPCC-recommended uncertainty ranges.

Quality Assurance

According to IPCC Good Practice Guidance, good QA procedures require an objective review to assess the quality of the inventory and identify areas for improvement. Furthermore, it is a good practice to use QA reviewers who have not been involved in preparing the inventory. In India, the MoEFCC examines the inventory to determine its quality and potential for improvement. To prepare the national GHG inventory, the following duties and tasks must be completed.

i. Information needs were complied with the methodological requirements stipulated by the 2006 IPCC Guidelines.

ii. Prepared and sent information queries to select data sources using official correspondence, telephone, and e-mail.

iii. Identified potential data sources, including organizations and independent experts.

iv. Collected data (activity data and emission factors) for all source/sink categories for Energy, IPPU, Agriculture, Waste, and LULUCF Sectors.

v. Analyzed information to use for the calculation of emissions and reductions.

vi. Checked the reliability of input data through comparison of the same or similar data from alternative data sources and time-series assessment to identify changes that cannot be explained.

vii. Processed and archived data.

viii. Assessed consistency of the methodologies applied and recalculated for inventory improvement.

ix. Checked reliability of results and elimination of errors.

x. Developed and implemented QC procedures.

xi. Implemented Quality assurance conducted by MoEFCC and relevant experts.

xii. Key category analysis was done.

xiii. Uncertainty assessment analysis was done.

xiv. Final validation by the Technical Advisory Committee and the National Steering Committee through MoEFCC.

xv. Prepared the final version of the inventory report.

1.5 Summary of National GHG Inventory

India initiated its greenhouse gas (GHG) inventory estimations in 1994 with the submission of its Initial National Communication to the UNFCCC. Since then, the country has consistently updated its national inventories, with the most recent estimates provided in the Third National Communication and the Fourth Biennial Update Report (BUR-4), submitted in 2024. BUR-4 included GHG emissions and removals for the inventory year 2020.

Now, as part of its enhanced transparency obligations under the Paris Agreement, India has prepared its First Biennial Transparency Report (BTR-1). This report includes GHG inventory data for four key years: 2005, 2020, 2021, and 2022.

India's GHG emissions trajectory from 2005 to 2022 excluding Land Use, Land-Use Change and Forestry (LULUCF) sector, increased by approximately 69.71% rising from 2,001,288 Gg CO_2eq to 3,396,372 Gg CO_2eq. This trend is primarily driven by the energy sector, which has fueled the nation's industrialization and modernization. Simultaneously, India has demonstrated remarkable success in enhancing its carbon sinks in the LULUCF sector increased by approximately 177.56% over the same period, from -206,020 Gg CO_2eq in 2005 to -571,823 Gg CO_2eq in 2022,. Consequently, India's net national emissions (including LULUCF) grew by 57.33% between 2005 and 2022.

These trends must be viewed within India's national context. Despite the absolute increase, India's per capita GHG emissions remain significantly below the global average. Furthermore, the emissions intensity of India's GDP has shown a consistent and substantial decline, indicating a progressive decoupling of economic growth from GHG emissions. This achievement highlights the success of policies focused on energy efficiency, renewable energy deployment, and low-carbon technologies.

A sector-wise assessment of India's greenhouse gas (GHG) emissions for the years 2005, 2020, 2021, and 2022 highlights the varying contributions of different economic activities to the national emissions profile (Table 1.4 and Figure 1.3). Detailed GHG emissions for the year 2022 are given in Appendix I.

Table 1.4: Sector-wise National GHG emission in $MtCO_2e$ for 2005, 2020, 2021 and 2022

Sectors	Total Million tonnes (Mt) CO_2 Equivalent				% Change (2005-2022)
	2005	2020	2021	2022	
Net Emission	1795.27	2411.85	2598.90	2824.55	57.33
Total Emission	2001.29	2974.09	3162.47	3396.37	69.71
1. Energy	1248.69	2128.20	2290.17	2492.07	98.40
2. IPPU	247.09	255.51	279.87	301.02	21.83
3. Agriculture	443.44	498.26	502.58	509.44	14.88
4. LULUCF	-206.02	-562.24	-563.57	-571.82	177.56
5. Waste	62.06	92.12	89.85	93.84	51.21

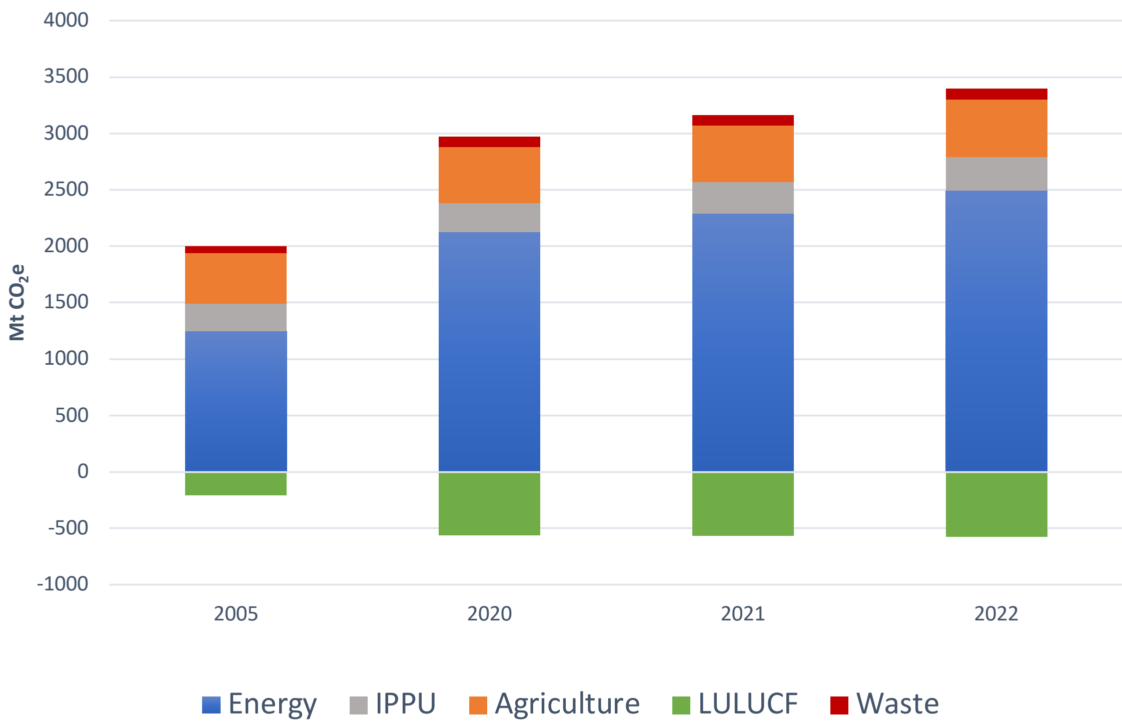

Figure 1.3: Sector-wise National GHG emission in Mt CO_2e for 2005, 2020, 2021 and 2022

1.5.1 Energy sector

The energy sector is the most critical contributor to India's national greenhouse gas (GHG) emissions. It continues to be the largest and fastest-growing source, responsible for about 73% of total emissions (excluding LULUCF) in 2022. Emissions from this sector nearly doubled, rising by about 99.6% from 1,248,692 GgCO_2eq to 2,492,069 GgCO_2eq, from 2005 to 2022. This sharp increase is mainly attributed to fuel combustion for electricity generation and industrial use.

The sector includes emissions from two major activities:

- Fuel Combustion: The dominant source, covering emissions from the burning of fossil fuels for electricity and heat generation, industrial manufacturing, transportation (road, rail, aviation, etc.), and energy use in households and commercial spaces.

- Fugitive Emissions: Release of gases during the extraction, processing, storage, and transportation of fossil fuels such as methane from coal mining and natural gas operations.

Emissions from the energy sector have been estimated for carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) and are reported in India's national greenhouse gas (GHG) inventory.

CO_2 emissions from Electricity and Heat Production is identified as a key category from this sector in 2022, which is also the largest single source in India's national inventory. Other key categories within this sector include CO_2 emissions from non-specified industries, Iron and Steel production, Road Transportation, Residential use, and non-metallic mineral industries. Figure 1.4 provides an overview of distribution of the GHG emissions within the energy sector for 2022.

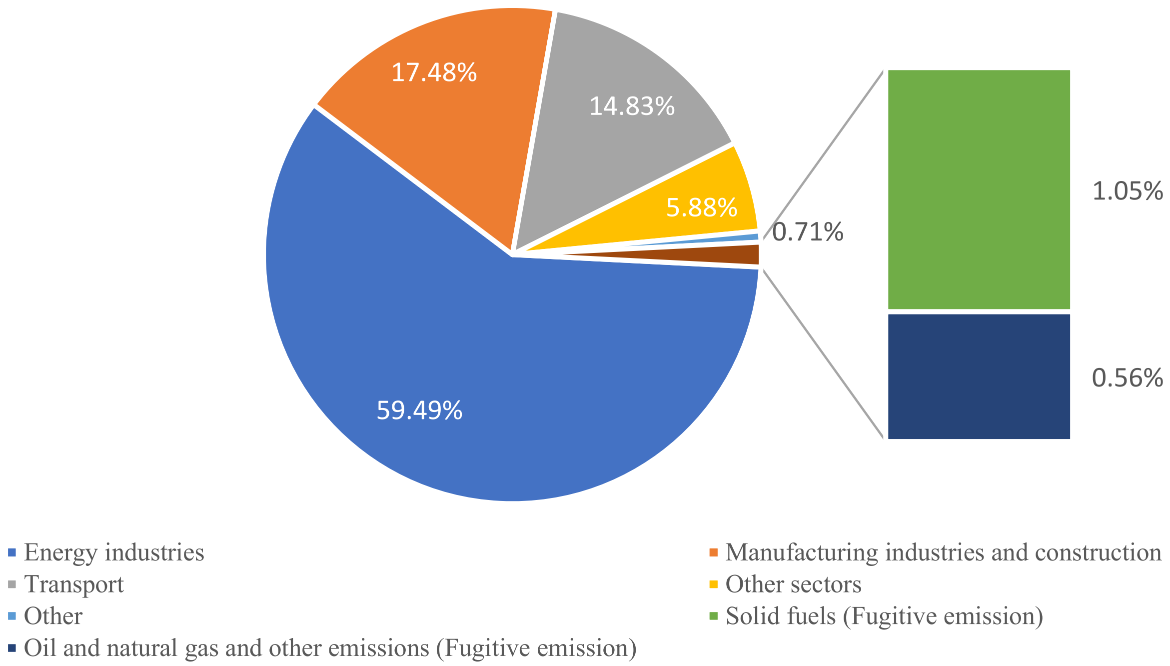

Figure 1.4: Share of total direct GHG emissions by source category from energy sector for 2022

1.5.2 Industrial Processes and Product Use (IPPU)

The IPPU (Industrial Processes and Product Use) sector is a major contributor of national greenhouse gas emissions, showing a 21.83% rise from 247,092 Gg CO_2eq in 2005 to 301,023 Gg CO_2eq in 2022. This increase is largely driven by rapid growth in manufacturing and infrastructure, especially in the cement and metal industries. In 2022, the sector accounted for around 9% of total emissions, excluding LULUCF. Greenhouse gas emissions from industrial processes occur in two main ways:

- As byproducts of non-energy-related industrial activities.
- From the use of specific substances within manufacturing processes.

Sources within this sector include non-energy emissions from mineral industry, chemical industry, metal production, non-energy products derived from fuels and solvent use, electronics manufacturing, product uses as substitutes for ozone-depleting substances (ODS), other product manufacturing and uses, and miscellaneous categories.

The gases covered in this sector include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6). CO_2 emissions from cement production is identified as a key category from this sector in 2022. Figure 1.5 provides an overview of distribution of the emissions within the IPPU sector for 2022.

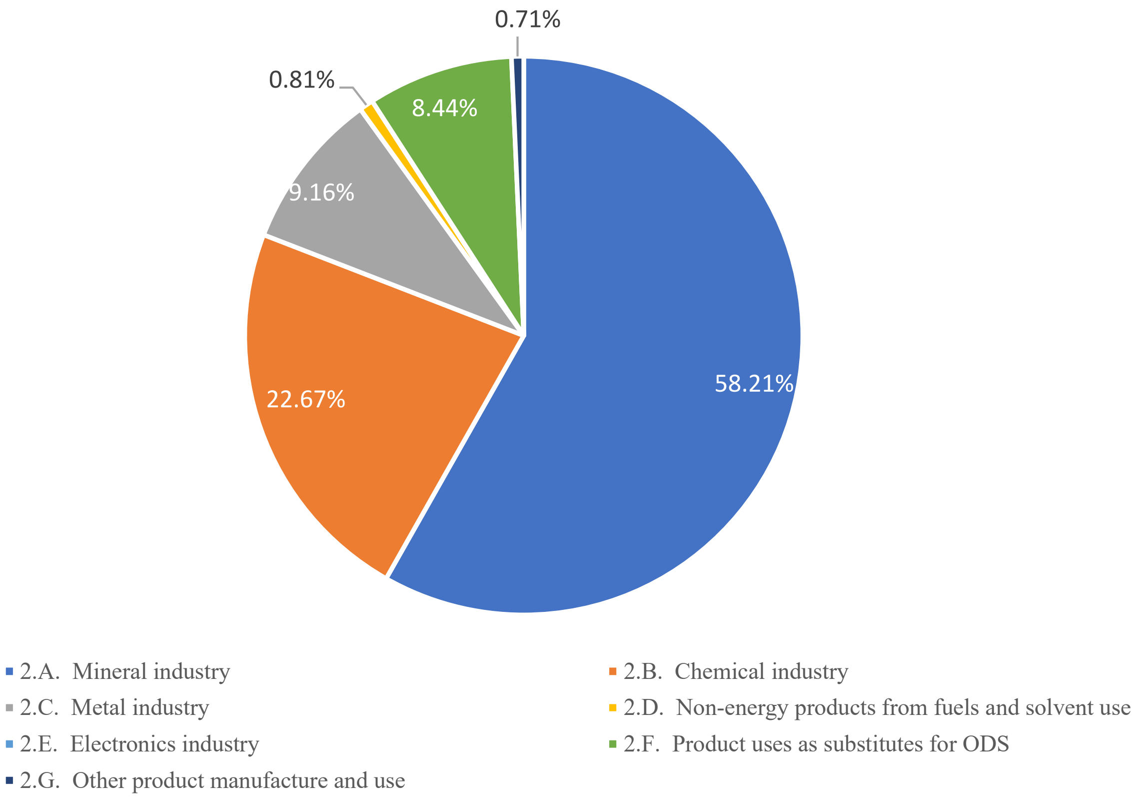

Figure 1.5: Share of total direct GHG emissions by source category from IPPU sector for 2022

1.5.3 Agriculture sector

India's agriculture sector showed the slowest growth in emissions, increasing by 15% from 443,443 Gg CO_2eq in 2005 to 509,439 Gg CO_2eq in 2022. In 2022, this sector was responsible for about 15% of the country's total greenhouse gas emissions, excluding LULUCF. Figure 1.6 provides an overview of emission distribution within the agriculture sector for 2022.

The agriculture sector emits three main greenhouse gases: carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). CH_4 from enteric fermentation are accounted for various livestock including cattle, buffalo, sheep, goats, horses, mules, asses, mithun, yak, and swine. Both CH_4 and N_2O emissions from manure management are reported for these livestock groups as well as poultry (hens, ducks, broilers). CH_4 emissions from rice cultivation are also included. The agricultural soils category encompasses both direct and indirect N_2O emissions from soils. Prescribed burning of savannahs is reported as "Not Occurring" in India. CH_4 and N_2O emissions from field burning of crop residues are included. CO_2 emissions from limestone application to soils are "Not Estimated" due to lack of detailed data, while CO_2 emissions from urea application are reported separately under Urea application.

The 2022 key category analysis underscores the sector's primary sources of emissions, identifying three key categories from this sector: CH_4 emissions from enteric fermentation and rice cultivation, as well as N_2O emissions from managed soils.

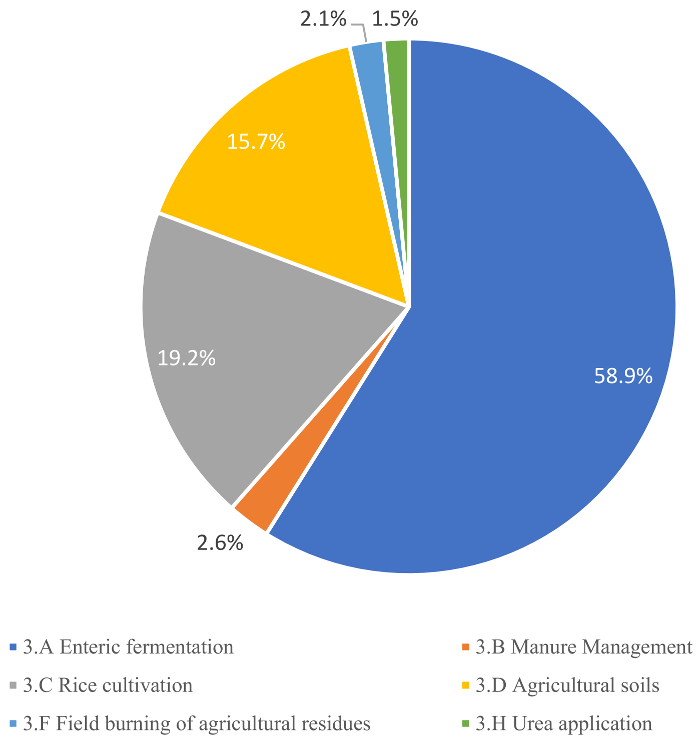

Figure 1.6: Share of total direct GHG emissions by source category from agriculture sector for 2022

1.5.4 Land Use, Land-Use Change and Forestry (LULUCF) sector

The LULUCF sector stands out as a significant and growing net sink. CO_2 removals from this sector increased by approximately 177.56% from 2005 (-)206,020 $GgCO_2eq$ to 2022 (-)571,823 $GgCO_2eq$, underscoring the effectiveness of India's large-scale afforestation and conservation programs.

The GHGs estimated for the Forestland includes CO_2, CH_4 and N_2O, Grassland includes CO_2 and N_2O, for Croplands, and Settlements only CO_2 is estimated. The list of IPCC emissions / removals categories considered, GHGs estimated for its BTR-1 reporting are provided in Table 1.5.

Table 1.5: IPCC emissions / removals categories considered and GHGs estimated

IPCC Reporting Categories	GHGs estimated
Forestland (FL)	CO_2, CH_4, N_2O
Cropland (CL)	CO_2
Grassland (GL)	CO_2, N_2O
Settlements (SL)	CO_2
Other Land (OL)	NA (Not Available)
Harvested Wood Products (HWP)	CO_2

The share of GHG emissions within the LULUCF sector for the 2022 is presented in Figure 1.7 below:

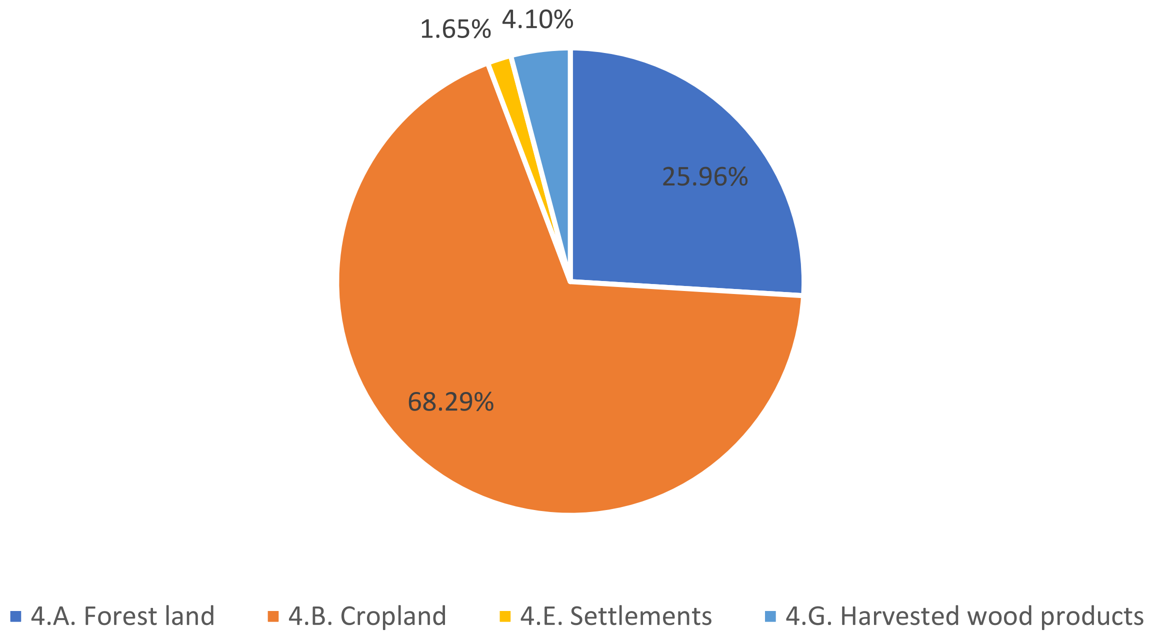

Figure 1.7: Share of total GHG sink by source category from LULUCF sector in 2022

1.5.5 Waste sector

Emissions from the waste sector increased by 51% between 2005 (62,061 Gg CO_2eq) and 2022 (93,842 Gg CO_2eq), driven largely by rising population, urbanization, and associated waste generation. In 2022, India's waste sector contributed 2.76% to the country's net greenhouse gas (GHG) emissions, excluding emissions from LULUCF. Figure 1.8 provides an overview of emission distribution within the waste sector for 2022.

India's waste sector accounts for emissions of three greenhouse gases: carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Emission sources within this sector includes CH_4 emissions from solid waste disposal, biological treatment of solid waste, wastewater treatment and discharge, CO_2 emission from incineration and open burning of waste, N_2O emissions from wastewater treatment and discharge.

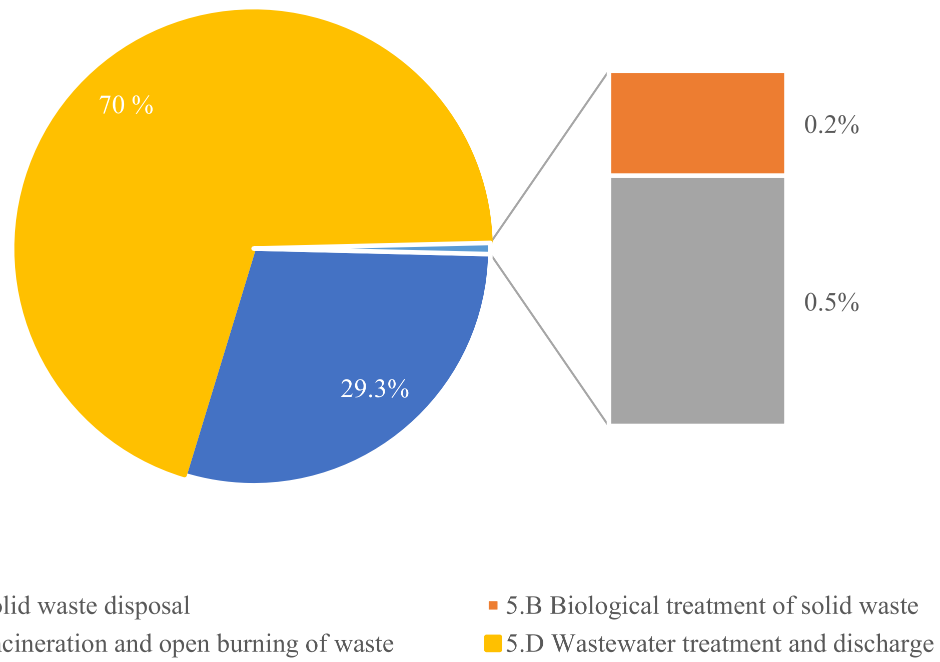

Figure 1.8: Share of total direct GHG emissions by source category from waste sector for 2022

1.6 Emission trends

The sectoral distribution of India's greenhouse gas (GHG) emissions reveals a shifting pattern from 2005 to 2022 (Figure 1.9). In 2005, the energy sector accounted for 62.4% of total emissions, followed by agriculture at 22.15%, IPPU at 12.4%, and waste at 3.1%. In 2022, the energy sector reached 73.4% of total emissions. Meanwhile, agriculture's share declined further to 15.0%, while IPPU decreased modestly to 8.9% and the waste sector remained stable at 2.8%.

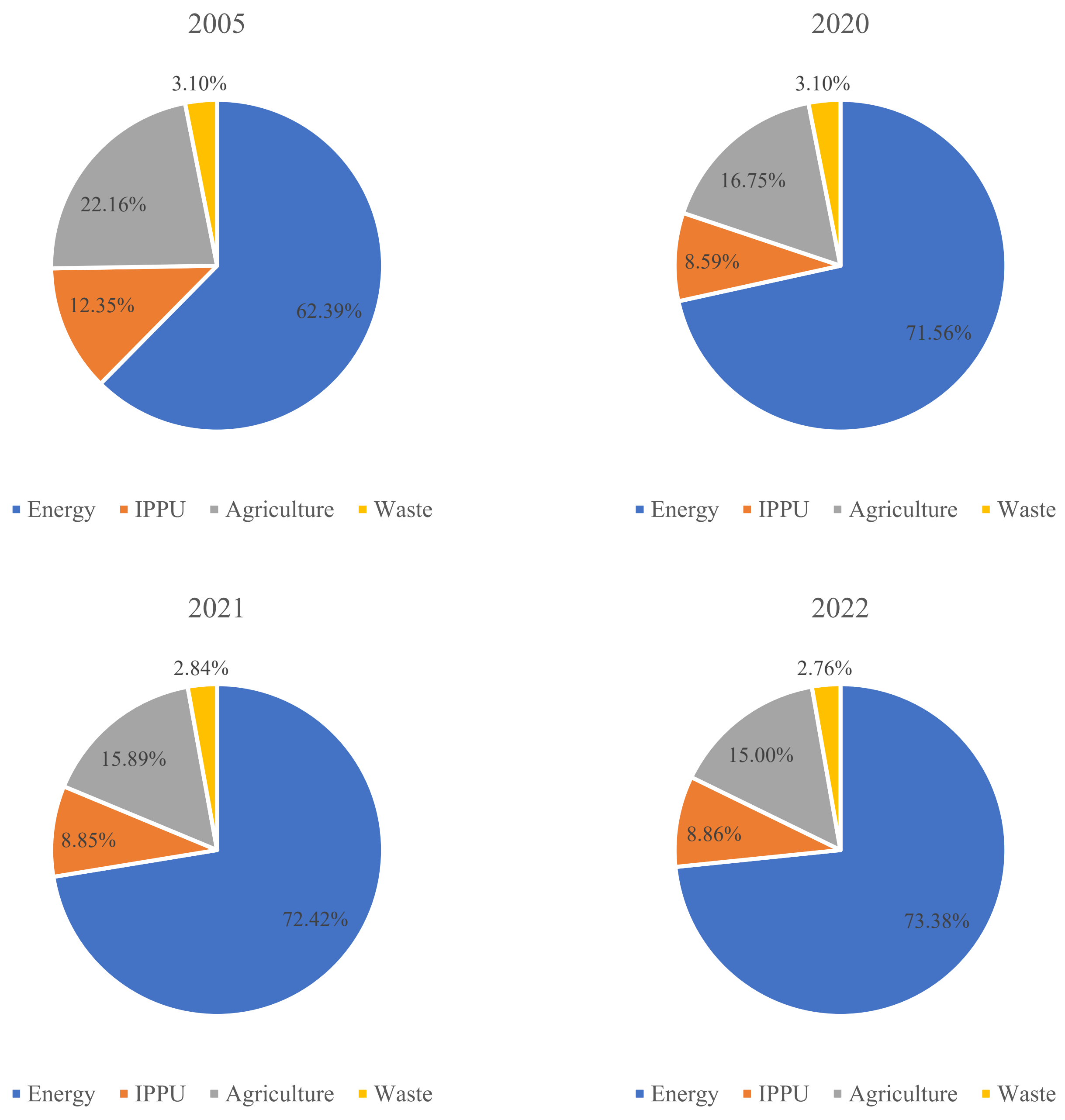

Figure 1.9 Share of GHG emissions (GgCO₂e) by sector, 2005, 2020, 2021, and 2022

The composition of India's GHG emissions profile has also evolved between 2005 and 2022 (Figure 1.10). In 2005, carbon dioxide (CO_2) accounted for 69.1% of total emissions, followed by methane (CH_4) at 22.9%, nitrous oxide (N_2O) at 4.1%, and other gases contributing 3.9%. The trend of rising CO_2 share continued in subsequent years, reaching 78.9% in 2022. In parallel, the relative contribution of CH_4 decreased to 14.8% in 2022. The share of N_2O exhibited a gradual decline from 4.1% in 2005 to 3.7% in 2022, while the shares of other gases remained relatively small but increased slightly, reaching 1.8% in 2022.

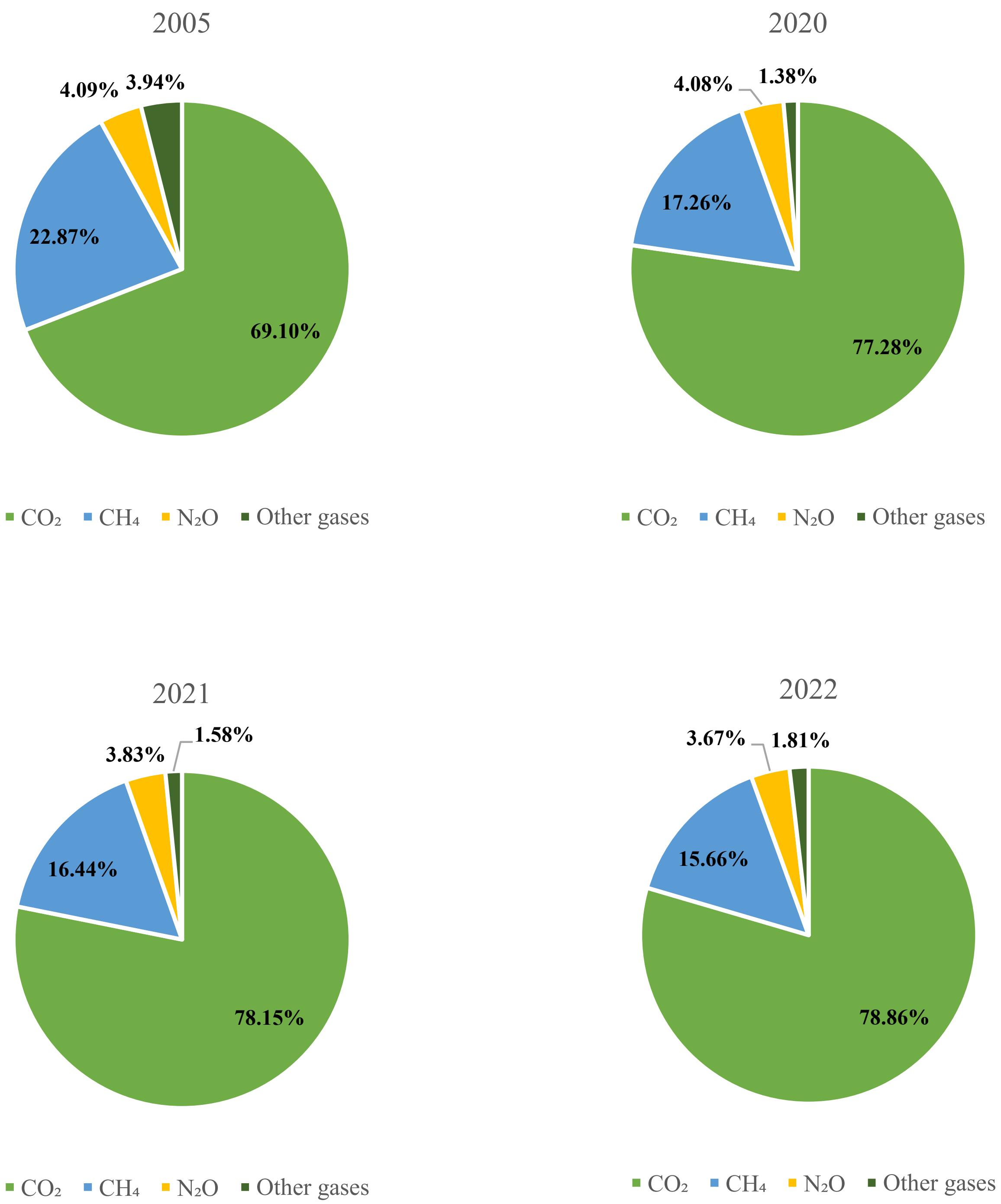

Figure 1.10: Share of gas-wise emissions for 2005, 2020, 2021 and 2022

1.7 Key categories in 2022 inventory

Key category analysis is an essential element of a national GHG inventory, providing a systematic means to identify the emission sources and sinks that exert the greatest influence on a country's total GHG emissions and removals. In line with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories and the Modalities, Procedures, and Guidelines (MPGs), India has undertaken a key category analysis for the inventory year 2022.

As per the flexibility provisions extended to developing country Parties under paragraph 25 of the MPGs, India applied IPCC Approach 1 (Level Assessment) for this exercise. A threshold of 85 percent was adopted, wherein all categories that cumulatively account for 85 percent of the national total emissions or removals are identified as "key categories."

1.7.1 Key Categories without LULUCF

Without the LULUCF sector, a total of 11 key categories were identified for 2022. The results highlight the energy sector as the predominant contributor to India's GHG emissions. Within this sector, CO_2 emissions from electricity generation emerged as the single most significant key category. The second-largest contributor is CO_2 emissions from road transportation in the energy sector. Whereas CH_4 emissions from the enteric fermentation of the agriculture sector are identified as the third largest key category. A summary of all key categories is provided in Table 1.5.

Table 1.6: Summary of level assessment without LULUCF for 2022 with approach 1

S. No.	Categories	Gas	CO_2eq (Gg)	%	Cumulative %
1	1.A.1.a.i. Electricity generation	CO_2	1383394	40.73%	40.73%
2	1.A.3.b. Road transportation	CO_2	325039	9.57%	50.30%
3	3. A. Enteric fermentation	CH_4	300170	8.84%	59.14%
4	1.A.2.g.viii. Other (non-specified industry)	CO_2	181728	5.35%	64.49%
5	1.A.2.a. Iron and steel	CO_2	159898	4.71%	69.20%
6	2.A.1. Cement production	CO_2	152265	4.48%	73.68%
7	1.A.4.b. Residential	CO_2	98165	2.89%	76.57%
8	3.C. Rice cultivation	CH_4	97920	2.88%	79.45%
9	1.A.1.b. Petroleum refining	CO_2	82740	2.44%	81.89%
10	3.D.1. Direct N_2O emissions from managed soils	N_2O	64617	1.90%	83.79%
11	1.A.2.f. Non-metallic minerals	CO_2	51898	1.53%	85.32%
Total			3396372		

1.7.2 Key Categories with LULUCF

When the LULUCF sector is included, the analysis identified 12 key categories for 2022. The dominant emission sources remain consistent with the non-LULUCF assessment. However, two new categories are introduced: CO_2 removals from cropland remaining cropland category and forestland remaining forestland are identified as key categories, while the non-metallic minerals category is excluded as it doesn't fall within the cumulative 85% of the national total emissions/removals.

Table 1.7: Summary of level assessment with LULUCF for 2022 with approach 1

S. No.	Categories	Gas	CO_2eq (Gg)	%	Cumulative %
1	1.A.1.a.i. Electricity generation	CO_2	1383394	34.74%	34.74%
2	4.B.1. Cropland remaining cropland	CO_2 Removal	394333	9.90%	44.64%
3	1.A.3.b. Road transportation	CO_2	325039	8.16%	52.80%
4	3. A. Enteric fermentation	CH_4	300170	7.54%	60.34%
5	1.A.2.g.viii. Other (non-specified industry)	CO_2	181728	4.56%	64.90%
6	1.A.2.a. Iron and steel	CO_2	159898	4.02%	68.92%
7	2.A.1. Cement production	CO_2	152265	3.82%	72.74%
8	4.A.1. Forest land remaining forest land	CO_2 Removal	151342	3.80%	76.54%

S. No.	Categories	Gas	CO_2eq (Gg)	%	Cumulative %
9	1.A.4.b.i. Stationary combustion	CO_2	98165	2.47%	79.01%
10	3.C. Rice cultivation	CH_4	97920	2.46%	81.47%
11	1.A.1.b. Petroleum refining	CO_2	82740	2.08%	83.54%
12	3.D.1. Direct N_2O emissions from managed soils	N_2O	64617	1.62%	85.17%
Total			3982330		

The key category analysis clearly indicates that India's emissions are primarily driven by CO_2 from energy and industrial activities, and CH_4 and N_2O from agriculture. It also powerfully affirms the critical importance of preserving and enhancing India's forest cover as a natural carbon sink. The findings from this analysis will guide the National Inventory Improvement Plan, ensuring that efforts are focused on the most significant categories to enhance the transparency, accuracy, completeness, consistency, and comparability of future inventories.

Note: This chapter summarizes the National Inventory Document (NID). Further details and references are available in the standalone NID.

Appendix I: Detailed GHG emissions from India in 2022 (Gg)

Source/Sink Categories	CO_2	CO_2 Removal	CH_4	N_2O	HFC	PFC	SF_6	Total CO_2 Equivalent
Net Emission	**2682727**	**578891**	**19037**	**476**	**20.3**	**1.32**	**0.09**	**2824549**
Total Emission	**2678327**		**18992**	**470**	**20.3**	**1.32**	**0.09**	**3396372**
1. Energy	2434229		1476	62.28				2492069
1.A. Fuel combustion activities (sectoral approach)	2431992		131	62.26				2452172
1.A.1. Energy industries	1475934		17.09	23				1482506
1.A.2. Manufacturing industries and construction	432947		39.86	6.07				435670
1.A.3. Transport	359044		70.53	32.12				369532
1.A.4. Other sectors	146297		3.24	0.93				146635
1.A.5. Other	17771		0.72	0.14				17829
1.B. Fugitive emissions from fuels	2237		1345	0.02				39897
1.B.1. Solid fuels			931					26065
1.B.2. Oil and natural gas and other emissions from energy production	2237		414	0.02				13832
1.C. CO_2 Transport and storage	NO		NO	NO				NO
1.C.1. Transport of CO_2	NO		NO	NO				NO
1.C.2. Injection and storage	NO		NO	NO				NO
1.C.3. Other	NO		NO	NO				NO
1.D. Memo items								
1.D.1. International bunkers	7716		0.29	0.21				7780
1.D.2. Multilateral operations								NO
1.D.3. CO_2 emissions from biomass	805332							805332
1.D.4. CO_2 captured	NO		NO	NO				NO
2. Industrial Processes and Product Use (IPPU)	235854		36.89	9.51	20.3	1.32	0.09	301023
2.A. Mineral industry	175231							175231
2.A.1. Cement production	152265							152265
2.A.2. Lime production	22609							22609
2.A.3. Glass production	331							331
2.A.4. Other process uses of carbonates	27							27
2.B. Chemical industry	40797		36.79	9.51	3.08			68235
2.B.1. Ammonia production	12428	NA	NA					12428
2.B.2. Nitric acid production				8.39				2224
2.B.3. Adipic acid production	NE							NE
2.B.4. Caprolactam, glyoxal and glyoxylic acid production	NO			1.12				296
2.B.5. Carbide production	96		NO					96
2.B.6. Titanium dioxide production	66							66
2.B.7. Soda ash production	1029							1029
2.B.8. Petrochemical and carbon black production	27178		36.79					28208
2.B.9. Fluorochemical production					3.08	NO	NO	23888

Source/Sink Categories	CO_2	CO_2 Removal	CH_4	N_2O	HFC	PFC	SF_6	Total CO_2 Equivalent
2.B.10. Other	NE		NE	NO	NO	NO	NO	NE,NO
2.C. Metal industry	17370		0.1	NO	NO	1.32	0.004	27580
2.C.1. Iron and steel production	IE		IE					IE
2.C.2. Ferroalloys production	10013		0.1					10016
2.C.3. Aluminium production	6908					1.32		17017
2.C.4. Magnesium production	309				NO	NO	0.004	407
2.C.5. Lead production	102							102
2.C.6. Zinc production	38							38
2.C.7. Other	NO		NO	NO	NO	NO	NO	NO
2.D. Non-energy products from fuels and solvent use	2456		NA	NA				2456
2.D.1. Lubricant use	2323		NA	NA				2323
2.D.2. Paraffin wax use	133		NA	NA				133
2.D.3. Other	NE		NE	NE				NE, NO
2.E. Electronics industry				NO	NO, NE	NE	NE	NE, NO
2.E.1. Integrated circuit or semiconductor				NO	NO	NO	NO	NO
2.E.2. TFT flat panel display				NO	NO	NO	NO	NO
2.E.3. Photovoltaics					NO	NO	NO	NO
2.E.4. Heat transfer fluid					NO	NE	NO	NO,NE
2.E.5. Other				NO	NE	NO	NO	NO, NE
2.F. Product uses as substitutes for ODS					17.22	NO	NO	25397
2.F.1. Refrigeration and air conditioning					8.07	NO	NO	15172
2.F.2. Foam blowing agents					2.15	NO	NO	1076
2.F.3. Fire protection					0.47	NO	NO	1634
2.F.4. Aerosols					3.93	NO	NO	4131
2.F.5. Solvents					0.001	NO	NO	2.06
2.F.6. Other applications					2.6	NO	NO	3382
2.G. Other product manufacture and use	NA		NA	NA, NE	NO	NO	0.09	2124
2.G.1. Electrical equipment					NO	NO	0.09	2124
2.G.2. SF6 and PFCs from other product use						NE	NE	NE
2.G.3. N_2O from product uses				NE				NE
2.G.4. Other	NA		NA	NA	NO	NE	NE	NA,NE,NO
2.H. Other	IE, NE, NA		NA, IE	NA, NE	NO	NO	NO	IE, NE, NA, NO
2.H.1. Pulp and paper	IE		IE	NE	NO	NO	NO	IE, NE, NO
2.H.2. Food and beverages industry	NE		IE	NE				NE, IE
2.H.3. Other *(please specify)*	NA		NA	NA	NO	NO	NO	NA, NO
3. Agriculture	7746		14703	339.68				509439
3.A. Enteric fermentation			10720					300170
3.A.1. Cattle			6025					168696

Source/Sink Categories	CO_2	CO_2 Removal	CH_4	N_2O	HFC	PFC	SF_6	Total CO_2 Equivalent
3.A.2. Sheep			321					8982
3.A.3. Swine			8.44					236
3.A.4. Other livestock			4366					122256
3.B. Manure management			186	29.82				13099
3.B.1. Cattle			102	18.5				7763
3.B.2. Sheep			2.74	0.13				112
3.B.3. Swine			3.19	2.22				677
3.B.4. Other livestock			77.44	8.98				4547
3.B.5. Indirect N_2O emissions				NA				NA
3.C. Rice cultivation			3497					97920
3.C.1. Irrigated			2552					71448
3.C.2. Rain-fed			770					21573
3.C.3. Deep water			175					4899
3.C.4. Other *(please specify)*			NO					NO
3.D. Agricultural soils			NA	302.08				80052
3.D.1. Direct N_2O emissions from managed soils				243.84				64617
3.D.2. Indirect N_2O Emissions from managed soils				58.25				15436
3.E. Prescribed burning of savannahs			NO	NO				NO
3.E.1. Forest land *(specify ecological zone)*			NO	NO				NO
3.E.2. Grassland *(specify ecological zone)*			NO	NO				NO
3.F. Field burning of agricultural residues			300	7.77				10451
3.F.1. Cereals			217	5.62				7564
3.F.2. Pulses			NO	NO				NO
3.F.3. Tubers and roots			NO	NO				NO
3.F.4. Sugar cane			47	1.23				1648
3.F.5. Other			36	0.92				1239
3.G. Liming	NE							NE
3.G.1. Limestone $CaCO_3$	NE							NE
3.G.2. Dolomite $CaMg(CO_3)_2$	NE							NE
3.H. Urea application	7746							7746
3.I. Other carbon-containing fertilizers	NA							NA
3.J. Other *(please specify)*	NA		NA	NA				NA
4. Land Use, Land-Use Change and Forestry (LULUCF)	4400	578891	45	5.34				-571823
4.A. Forest land		151342	45	0.72				-149896
4.A.1. Forest land remaining forest land		151342	45	0.72				-149896
4.A.2. Land converted to forest land	NE	NE	NE	NE				NE
4.B. Cropland		394333	IE,NA	IE,NA				-394333
4.B.1. Cropland remaining cropland		394333	IE	IE				-394333
4.B.2. Land converted to cropland	NE	NE	NA	NA				NE,NA

Source/Sink Categories	CO_2	CO_2 Removal	CH_4	N_2O	HFC	PFC	SF_6	Total CO_2 Equivalent
4.C. Grassland	4400		NE	4.61				5622
4.C.1. Grassland remaining grassland	4400		NE	4.61				5622
4.C.2. Land converted to grassland	NE		NE	NE				NE
4.D. Wetlands		NE	NE	NE				NE
4.D.1. Wetlands remaining wetlands		NE	NO	NE				NE,NO
4.D.2. Land converted to wetlands		NE	NA	NE				NE,NA
4.E. Settlements		9507	NE	NE				-9507
4.E.1. Settlements remaining settlements		9507	NO	NE				-9507
4.E.2. Land converted to settlements		NE	NA	NE				NE,NA
4.F. Other land		NE	NE	NE				NE
4.F.1. Other land remaining other land								
4.F.2. Land converted to other land		NE	NA,NE	NE				NE, NA
4.G. Harvested wood products (Approach A/B/C)		23709						-23709
4.G.1. Solid wood		22851						-22851
4.G.2. Paper and paperboard		858						-858
4.G.3. Other *(please specify)*		NE						NE
4.H. Other *(please specify)*								
5. Waste	498.33		2776	58.93				93842
5.A. Solid waste disposal			983					27523
5.A.1. Managed waste disposal sites			135					3767
5.A.2. Unmanaged waste disposal sites			681					19062
5.A.3. Uncategorized waste disposal sites			168					4694
5.B. Biological treatment of solid waste			7.46	NE, NO				209
5.B.1. Composting			7.46	NE, NO				209
5.B.2. Anaerobic digestion at biogas facilities			0.00	NE, NO				NO
5.C. Incineration and open burning of waste	498		NE, NO, IE	NE, NO, IE				498
5.C.1. Waste incineration	179		NE, NO, IE	NE, NO, IE				179
5.C.2. Open burning of waste	319		NE, NO	NE, NO				319
5.D. Wastewater treatment and discharge			1785	58.93				65611
5.D.1. Domestic wastewater			781	58.93				37474
5.D.2. Industrial wastewater			1005	NE				28137
5.D.3. Other			NA	NO				NO
5.E. Other *(please specify)*	NE	NE	NE	NE				NE

CHAPTER-2

INFORMATION NECESSARY TO TRACK PROGRESS MADE IN IMPLEMENTING AND ACHIEVING NATIONALLY DETERMINED CONTRIBUTIONS UNDER ARTICLE 4 OF THE PARIS AGREEMENT

INFORMATION NECESSARY TO TRACK PROGRESS MADE IN IMPLEMENTING AND ACHIEVING NATIONALLY DETERMINED CONTRIBUTIONS UNDER ARTICLE 4 OF THE PARIS AGREEMENT

2.1 Background Information

Tracking progress toward Nationally Determined Contributions (NDCs) is a mandatory requirement under the Paris Agreement's Enhanced Transparency Framework (ETF). UNFCCC decisions, particularly Decisions 18/CMA.1 and 5/CMA.3, outline the modalities, procedures, and guidelines for how Parties should regularly monitor, report their mitigation actions and achievement of NDC targets. These decisions establish common reporting tables, structured summaries, and methodological guidance to ensure consistency, comparability, and clarity in communicating progress. This chapter has been prepared in alignment with the requirements of the ETF.

2.2 National Circumstances and Institutional Arrangements

2.2.1 Government Structure and Institutional Arrangements

The National Communications (NATCOM) Integrated Project Management Unit (IPMU), headed by the National Project Director, under the GEF-UNDP-GoI Project, has been established in the Ministry of Environment, Forest and Climate Change (MoEFCC) of the Government of India (GoI), for the preparation of National Communications, including BURs and BTRs. The IPMU coordinates with the line Ministries, Organizations, and Departments of the GoI, the Network of Scientific and Research Organisations, and other institutions that provide relevant information and data. The activities are supervised by the National Steering Committee (NSC), comprising representatives from various line Ministries and Departments, under the technical guidance of the Technical Advisory Committee (TAC), which comprises representatives from various scientific and research organizations in the country. Detailed information regarding the NSC and TAC is provided in Chapter 7 on Additional Information.

Following is the list of the Network of Scientific and Research Organisations for the preparation of the NDC tracking chapter of BTR-1:

i. Indian Institute of Management (IIMA), Ahmedabad
ii. National Institute of Advanced Studies (NIAS), Bangalore
iii. The Energy and Resources Institute (TERI), New Delhi
iv. Central Research Institute for Dryland Agriculture (CRIDA) of Indian Council of Agricultural Research, Hyderabad
v. Forest Survey of India (FSI), Ministry of Environment, Forest and Climate Change, Dehradun

Various line Ministries and Government Departments that are concerned with providing different types of information and data required for the compilation of NDC tracking have been listed in Table 2.1.

Table 2.1: Key Ministries and Departments providing data for tracking NDC progress

Departments and Ministries, Government of India	Sector	Data/Information Provided	Monitoring and Reporting Instrument
Central Electricity Authority, Ministry of Power	Energy	State/UT generation of renewable energy and electricity generation from fuel sources.	Data repository (monthly, quarterly, and annually); CO_2 baseline study.
Central Electricity Regulatory Commission, Ministry of Power	Energy	Efficiency of power plants.	Adheres to the Indian Electricity Grid Code for monitoring and reporting.
Bureau of Energy Efficiency, Ministry of Power	Energy	Energy efficiency measures across the country, such as PAT, S&L Programme, and ECBC.	Inbuilt monitoring, reporting, and verification mechanisms of initiatives and schemes.
Ministry of Statistics and Programme Implementation	Energy	Installed capacity, production, consumption, import, export, and energy indicators.	Database for energy sources (annually).
Energy Efficiency Services Limited, Ministry of Power	Energy	Energy Efficiency of LED Streetlights in the Country.	Remotely monitoring through a central control system (annually).
National Sample Survey Office, Ministry of Statistics and Programme Implementation	Industry	Data on industrial energy use form an important baseline for estimating industrial emissions.	Findings reported in the Annual Survey of Industries.
Green Highways Division, Ministry of Road Transport and Highways	Transport	Survival and growth of plants along highways in the country.	Monitoring and reporting via geo-tagging.
Forest Survey of India, MoEFCC	Forestry	Forest, Trees Outside of Forest (TOF), carbon stock, and forest cover in the country.	Field data inventory; satellite mapping findings reported in India State of Forest Report (biennially).
Ministry of Statistics and Programme Implementation	Forestry	Afforestation schemes across the country.	Performance reports (quarterly).
Indian Council of Forestry Research and Education, MoEFCC	Forestry and various other sectors	Green credits from afforestation and other activities under the Green Credit Program.	Auditors/verifiers (periodically).
Indian Space Research Organisation -National Remote Sensing Centre, Department of Space	Climate resilience	Extreme weather events via spatial flood early warning models using very high-resolution technology.	Real-time reporting (daily); annually. Relevant for the adaptation component of NDC
India Meteorological Department, Ministry of Earth Sciences	Climate resilience	Operates weather and climate monitoring, detection and warning services for various sectors of the economy.	Real-time reporting (daily); annually. Relevant for the adaptation component of NDC
National Disaster Management Authority, Ministry of Home Affairs	Climate resilience	Preparedness for extreme weather events and early warning systems in the country.	Reports data hourly, daily, weekly, and monthly. Relevant for the adaptation component of NDC

Following Ministries, Departments, and their relevant organizations ensure the domestic implementation of various policies and measures relevant to India's NDCs:

- Ministry of Heavy Industry
- Ministry of Coal
- Ministry of Commerce and Industries
- Ministry of Environment, Forest and Climate Change
- Department of Economic Affairs
- Ministry of Micro, Small and Medium Enterprises
- Ministry of New and Renewable Energy
- Ministry of Petroleum and Natural Gas
- Ministry of Power
- Ministry of Railways
- Ministry of Road Transport and Highways
- Ministry of Steel

2.2.2 India's National Circumstances

India has a negligible contribution to the historical cumulative emissions, consuming far less than its fair share of the global carbon budget. India's per capita energy consumption and consequently its per capita GHG emissions also remain extremely modest even in the year 2022. To bridge its developmental gaps, meet its aspirations, and ensure the well-being of all of its people, India needs to considerably enhance its energy supply. With the increasing impacts of climate change, urgent attention to social and economic growth and development is also critical for building climate resilience, reducing vulnerability, and adapting to changing climatic conditions. India's Long-Term Low Carbon Development Strategy (LT-LEDS) submitted to the UNFCCC in year 2022 states that *"mindful of the need to combat climate change and the potential for continued technological and competitive opportunities from a low-carbon development pathway, India will pursue low-carbon development strategies within its fair share of the global carbon budget, aimed at meeting India's 2070 Net Zero pledge, on the basis of equity and in accordance with the principle of Common but Differentiated Responsibilities and Respective Capabilities and national assessments of its development futures"*. The four key elements of India's Long-Term Low Carbon Development Strategy are given here:

i. India's low historical contribution to cumulative global emissions (4% of global emissions between 1850 and 2019), and its right to a fair share of the carbon space for present and future developmental needs

ii. The importance of addressing the concerns of millions of people living in energy poverty and improving India's overall energy security (India represents ~18% of the global population, and yet its annual primary energy consumption per capita was 27.3 gigajoules in 2023, far lower than many developed and developing countries)

iii. India's commitment to shift to low-carbon development pathways and address issues of household energy, energy security, and energy for the development of all sectors of the economy.

iv. Building adaptation capacities to mitigate potential climate impacts and to sustain India's growth and development, including the general improvement of the human development index of its entire population.

India's commitment to sustainable development, contributing equitably to global efforts to mitigate climate change, and achieving climate-resilience requires a growth trajectory that is equitable, inclusive, and sustainable. India's current national circumstances, as well as its developmental challenges, dictate that adaptation to climate change is an overriding priority, and therefore the focus of India's climate policy. Weather variability and extreme events have an impact on all sectors of the Indian economy and their related supply chains. This is in addition to the direct physical and economic impacts on people. Few countries in the world are as vulnerable to the effects of climate change as India is, with a significant section of its population still dependent on primary sectors such as agriculture, its vulnerable coastal areas and islands, the Himalayan region with its diverse sub-systems including glaciers, desert regions in the western part of the country, and its diverse forest ecosystems spread across the country. It is important to emphasize that these ecosystems are not only a collection of flora and fauna, but also home to and support a large number of communities and their livelihoods. Ensuring the continued and enhanced well-being of all its people and ecosystems, protecting them from the impacts of climate change, and ensuring growth and development to build resilience and long-term sustainability while being a responsible actor in the global climate regime is therefore the cornerstone of India's climate policy.

2.2.3 Geographical and Climate Profile

The mainland of India extends between 66°E to 98°E and 8°N to 36°N. With a total land area of over 3.28 million square kilometers. India is the seventh-largest country in terms of land area (it has approximately 2.4% of the world's land area) and is home to over 18% of the global population. India has a diverse geography, with its landscape varying from snow-capped mountain ranges to deserts, plains, hills, plateaus, coastal regions, and islands. It also has climatic conditions ranging from continental to coastal, from cold to hot extremes, from extreme aridity and negligible rainfall to excessive humidity and torrential rainfall. The oceans, Himalayas, and the Thar Desert strongly influence India's climate. The Arabian Sea, the Indian Ocean, and the Bay of Bengal surround the southern or peninsular part of India. The Himalayan and adjoining mountain ranges extend from Kashmir in the Northwest to Arunachal Pradesh in the Northeast. These mountain ranges protect India from the extremely cold and dry winds of Central Asia during winter. Furthermore, they act as an effective physical barrier for the rain-bearing southwest monsoon winds to cross the northern frontiers of India. Land areas in the country's north have a continental climate, characterized by severe summer heat that alternates with extremely cold winters. Coastal climatic conditions are found in the Southeast and western regions.

The months of June, July, August, and September constitute the core of the southwest monsoon season in most parts of the country; however, the actual monsoon period in different regions of the country depends on the onset and withdrawal dates. The southwest monsoon season is the principal provider of precipitation, with the country receiving 74% of its annual rainfall during this season. Although there is interannual variability, the total precipitation during the Indian summer monsoon has remained largely stable from 1901 to 2024 and has shown a weak decreasing trend over the last few decades. The retreat phase of the southwest monsoon is followed by the northeast monsoon, which starts in October and continues till December. The northeast monsoon is a transition season associated with establishing the north-easterly wind regime over the Indian peninsular region. The meteorological subdivisions of the southern peninsula, namely coastal Andhra Pradesh, Rayalaseema, Tamil Nadu, Kerala and south interior Karnataka, receive a good amount of rainfall during this season.

Surface air temperature shows wide spatial and seasonal variation over India. During the coldest months of December and January, the mean maximum temperature varies from 33°C in some parts of the country to about 12°C in the plains of the north, while the mean minimum temperature varies from about 25°C in the extreme south to about 3°C in the plains of the north. The five warmest years on record in descending order are 2024 (+0.65°C), 2016 (+0.54°C), 2009(+0.40°C), 2010 (+0.39°C), and 2017 (+0.38°C). Furthermore, 10 out of the 15 warmest years have been observed in the recent 15 years (2010-2024). The past decade (2015-2024) was also the warmest decade on record, with a decadal-averaged annual mean temperature anomaly (Actual-LPA) of 0.31°C. Between 1901 and 2023, India's annual mean temperature showed a significant rising trend of 0.68°C per 100 years. This includes a notable increase in maximum temperatures at a rate of 0.89°C per 100 years and a relatively slower rise in minimum temperatures at 0.46°C per 100 years. Although this warming trend is significant, it is slower than the global average - an observation that is only partially attributed to the generally lower rates of warming expected in lower latitudes.

More detailed information on India's geographic and climatic profile is provided in Chapter 3, which focuses on the impacts of climate change and adaptation.

2.2.4 Socio-economic and Demographic Profile

According to the last Census of India in 2011, the country had a total population of 1210.9 million (623.2 million males and 587.6 million females), out of which about 377.1 million (about 1/3rd of the total population) lived in urban areas. The 2011 census showed an increasing trend in literacy in the country . The literacy rate in the country was 74.04 per cent, 82.14 per cent for men, and 65.46 per cent for women. According to projections by the Technical Group on Population Projections, India's population in 2024 is estimated to be 1,400.7 million (or 1.4 billion) people (MoHFW, 2020).

India is the most populous country in the world, and according to the United Nations-Habitat's World Cities Report (2022), its urban population is projected to grow to 675 million by 2035 (2/5th of its population). This figure is projected to increase to over 2/3rd of the Indian population by 2050. The report also projects that by 2030, more megacities will be added to the existing six in India (cities with a population of more than 10 million people with a population density of more than 2000 persons per square kilometer).

India's economy is vibrant, on a consistent growth path, with continuing efforts at reform and considerable innovations in policy and governance across various sectors that have sustained this growth. As a consequence, it also attracts considerable foreign direct investment. Eradication of poverty and continuous improvement in the well-being of its people are priorities for India. According to the World Bank, India has halved the share of its population living in extreme poverty (below $2.15 per person per day; 2017 PPP) between 2011 and 2019 (World Bank Poverty and Inequality Portal and Macro Poverty Outlook, 2023). Rural India plays a significant role in the Indian economy. Forty-five percent of India's workforce (of 565 million people) depends on agriculture and allied activities. Table 2.2 provides a snapshot of the Indian economy.

Table 2.2: Snapshot of the Indian economy

Indicator	Value in INR (FY 2024-25)
Nominal GDP	330.68 lakh crore
Nominal GDP Growth Rate (year on year)	98%
GVA - Agriculture, forestry & fishing, mining and quarrying (nominal)	59,26,078 crore
GVA – Manufacturing, construction, electricity, gas and water supply (nominal)	76,03,402 crore
GVA - Trade, hotels, transport & communication (nominal)	52,57,396 crore
GVA- Financial, real estate & professional services (nominal)	68,81,866 crore
GVA - Public administration, defence & other services	43,53,290 crore
Forex Reserves (2024-25)*	57,12,141 crore
Export of Major Commodities (2024-25)*	37,01,070 crore
Cumulative Gross FDI Equity Inflow (2003-04 to 2024-25)**	69,70,923 crore

NOTES

- Nominal GDP, GDP growth rate, and GVA are taken from the Ministry of Statistics and Programme Implementation's Press note on Provisional Estimates of Annual Gross Domestic Product (GDP) for 2024-25. (https://mospi.gov.in/sites/default/files/press_release/NAD_PR_30may2025.pdf) and Economic Survey 2025-26 Statistical Appendix. (https://www.indiabudget.gov.in/economicsurvey/doc/Statistical-Appendix-in-English.pdf)
- GVA values are at Basic Prices by Economic Activity (at Current Prices)

** Forex reserves, exports of major commodities, and FDI inflow data are taken from the Reserve Bank of India's Handbook of Statistics on Indian Economy 2024-25.*

*** Cumulative FDI inflow is calculated using Table 146 on Foreign Investment Inflows from the Handbook of Statistics on Indian Economy 2024-25.*

2.2.5 Sectoral Overview

India's historical contribution to global GHG emissions is relatively small - approximately 4%, despite having around 18% of the world's population (Climate Equity Monitor, n.d.), reflecting its modest share in the historical accumulation of greenhouse gases in the atmosphere. As a developing country with low per capita primary energy consumption - 27.3 gigajoules (GJ) in 2023 (IEA, n.d.) - India's energy demand will grow substantially to support its development needs. India's current energy consumption is 1/3rd of the global average (78 GJ per person) and may be contrasted also with the high-income countries average of 119 GJ/person and the United States consumption, among the highest in the world, at 277 GJ/person.

Although India's emissions are likely to rise with increasing energy demand, it is committed to pursuing a low-carbon development strategy. This approach aligns with India's fair share of the global carbon budget and its pledge to achieve net-zero emissions by 2070, respecting principles of equity, Common but Differentiated Responsibilities and Respective Capabilities (CBDR-RC), and its national development priorities. India's growth is also crucial for building resilience and reducing its vulnerability to climate impacts that are expected to intensify with continued global warming.

Power

India's per capita electricity consumption remains significantly lower than the world average, at 1,331 kWh per person in 2022-23. India's total electricity consumption reached 1,440.31 TWh in 2022-23 (provisional), an increase of about 9.4 % from 2021-22 (CEA, 2023).

While coal remains the predominant source of electricity generation in India, Renewable Energy Sources (RES) have grown in generation capacity and installed capacity over the years. In its updated NDC, India has stated that it aims to have 50 per cent of its cumulative installed electric power capacity from non-fossil fuel sources by 2030, supported by technology transfer and affordable international financing, including from the Green Climate Fund (GCF).

Given India's growing economy and electricity needs, the challenge of low-carbon development in the power sector is significant. Despite the multiple challenges of ensuring energy access, affordability, reliability, and energy security, India's efforts for low-carbon development in the power sector have steadily contributed to the global effort for climate change mitigation.

Additionally, the Government has taken several initiatives to incentivize the higher penetration of non-fossil fuel sources in India's total electricity mix. Listed below in table 2.3 are a few of these initiatives.

Table 2.3: Regulations to incentivize higher penetration of non-fossil fuel sources

i	Electricity Act, 2003	Lays the foundation for the development of renewable energy in India.
ii	National Electricity Policy, 2005	Emphasizes the urgent need to promote the generation of electricity from renewable sources.
iii	Tariff Policy, 2006	Detailed provisions for renewable energy in tariff regulation and other relevant matters
iv	National Action Plan on Climate Change, 2008	Range of policy initiatives to address climate change including the target of installing 100 GW of solar power
v	Tariff Policy, 2016	Promotes the Renewable Energy Certificate (REC) mechanism for compliance with Renewable Purchase Obligations (RPO).
vi	Incentives extended to VRE sources in the operational phase	Renewable energy sources, along with nuclear power plants, are accorded 'must run' status
vii	Waiver of Inter-State Transmission Charges for Solar and Wind Energy	No inter-state transmission charges and losses may be levied on solar and wind energy projects
viii	Deviation Charges Relaxation	Deviation charges relaxed for wind or solar, or hybrid wind-solar-based stations
ix	Green Term Ahead Market	Facilitates additional avenues to RE generators for the sale of renewable energy. It also enables entities to procure renewable power at competitive prices to meet their RPOs and provides a platform to consumers and utilities to buy green power.
x	Green Day Ahead Market	Marketplace for trading of RE Power on a day-ahead basis
xi	Renewable Energy Management Center	The Government of India has set up the Renewable Energy Management Centres (REMCs) at the National, State, and Regional levels for real-time monitoring of RE generation.

xii	Green Hydrogen technology	The Ministry of New and Renewable Energy will establish a single portal for all statutory clearances and permissions required for the manufacture, transportation, storage, and distribution of Green Hydrogen and Green Ammonia.
xiii	Green Energy Open Access	Green Open Access is allowed to any consumer, and the limit of Open Access Transaction has been reduced from 1 MW to 100 kW for green energy, to enable small consumers also to purchase renewable power through open access.
xiv	General Network Access Regulations with special provisions for RE (GNARE),	CERC has issued a single regulation for the Connectivity and General Network Access to the inter-State Transmission System on 7th June 2022, repealing separate regulations for connectivity and network access that existed earlier. This new regulation has a distinct provision for connectivity to RE consumers. It also enables a single application for the grant of connectivity and access to the ISTS network. The regulation is under further amendment as of now.
xv	Uniform Renewable Energy Tariff (URET)	Ministry of Power (MoP) introduced "Uniform Renewable Energy Tariff (URET)" by incorporating the same in the Electricity (Amendment) Rules 2022 (29th December 2022). The prices discovered in different bids for a specific kind of RE (called a central pool consisting of bids across three years) shall be aggregated so that the consumers will pay a uniform price irrespective of the prices of the individual RE Generators. MoP vide order dated 17th March 2023 notified Grid-India as the Implementing Agency for the implementation of "Uniform Renewable Energy Tariff for Central Pool". MoP vide OM dated 14th Feb 2024, notified two Pools viz "Solar Power Central Pool" and "Solar-Wind Hybrid Central Pool for implementation under URET starting from 15th February 2024.
xvi	Renewable Purchase Obligations (RPO) & Renewable Consumption Obligations (RCO)	The Government of India has amended the Energy Conservation Act, 2001 (EC Act) wherein as per Section 14 (x), the Central Government has powers to specify the minimum share of consumption of non-fossil resources (renewable energy sources) by designated consumers as energy or feed stock and specify different shares of consumption for different types of non-fossil resources for different designated consumers.

Industry

The industrial sector is a cornerstone of the Indian economy, contributing significantly to the country's gross value added. It represents 31% of India's GDP and employs over 121 million people. In the year 2022-23, the industrial sector experienced a growth of 6.7%, with manufacturing emerging as a key driver of economic expansion. Key sectors, including automotive, engineering, cement, textiles, steel, chemicals, pharmaceuticals, and consumer durables, are pivotal to this growth trajectory (BEE, 2023b).

The industrial sector can be broadly classified into energy-intensive industries and light industries. Energy-intensive industries, including iron and steel, chemicals, petroleum refining, cement, aluminum, and pulp and paper, account for a significant portion of energy consumption within the sector. Light industries encompass activities such as food processing, textiles, wood products, printing and publishing, and metal processing. The manufacturing sector plays an important role in the economy, contributing over a quarter of the GDP while consuming approximately half of the available commercial energy resources. In FY 2022-23, the total final energy consumption by the industrial sector in India was 270,000 ktoe (P), making it the largest consumer of energy in the country, accounting for 48.95% of the total final energy consumption. The most energy-intensive sub-sector within the industrial sector was the Iron and Steel sector, accounting for 15.15% of industrial energy use, followed by chemicals and petrochemicals at 4.56%, and construction at 1.80% (MoSPI, 2024b).

In recent years, there has been a notable increase in the emphasis on energy efficiency within the industrial sector through initiatives like the Perform, Achieve and Trade (PAT) scheme. PAT serves as a regulatory tool aimed at reducing Specific Energy Consumption in energy-intensive industries, employing a market-based approach to enhance cost-effectiveness through the certification and trading of excess energy savings certificates (ESCerts). Designated Consumers (DCs) in key sectors are identified and notified under the scheme, mandated to appoint energy managers, submit annual energy consumption reports, and conduct regular energy audits. The scheme has evolved through seven cycles, currently encompassing 13 sectors comprising of 1196 DCs. In PAT-VII, 707 DCs from various sectors including Aluminium, Cement, Chlor-Alkali, Iron and Steel, Pulp and Paper, Textile, Thermal, Commercial buildings (hotels), Petroleum Refinery, Railways and DISCOMS have been notified with an overall energy saving target of 8.485 MTOE.

Transport

India is one of the world's most rapidly expanding economies, with an average economic growth rate of 7 percent over the last two decades (Chakraborty 2021), which in turn has significantly increased the need for efficient transportation of goods and people. In this context, the transportation sector becomes a fundamental element of India's economic growth, contributing to its socio-economic development and addressing the increased mobility needs stemming from rapid urbanization.

The transport sector, as detailed by the Bureau of Economic Research and Policy Development (BERPD, 2018), includes roadways, railways, waterways, and airways, listed in order of their contribution to the Gross Domestic Product (GDP). From 2017-18 to 2021-22, the sector's contribution to the Gross Value Added (GVA) averaged at 4.4% at current prices and 4.5% at constant prices (MoSPI, 2024a). The electricity consumption in railways increased from 19.02 TWh in FY 2017-2018 to 31.81 TWh in FY 2023-24 (MoR, 2024). Likewise, there was an increase in the consumption of natural gas (40.1%), motor spirit (33.6%), and furnace oil (159.8%). In contrast, the consumption of high-speed diesel declined (-56.5%) during this period.

However, there is an increasing recognition of the importance of managing demand alongside the adoption of innovative technologies. Modifications in urban structures, behavioural initiatives, circular and shared economies, as well as digitalization, are facilitating systemic shifts that decrease the demand for transport services or promote the usage of more efficient modes of transportation. Innovation in technologies includes the surge in electro mobility for terrestrial transportation, along with the development of advanced biofuels and hydrogen-based fuels for maritime and aerial transport. Low carbon development of land-based, long-haul, heavy-duty vehicles through battery-electric vehicles (including Electric Road Systems) and, in certain scenarios, is complemented by hydrogen and biofuel-based solutions (with medium confidence) is being explored and can become viable in the future.

Waste

The Waste sector is the largest contributor to urban emissions after the energy sector in India. Waste management is mainly controlled by municipal authorities and is a key focus for city-level efforts to reduce emissions. In 2020, the waste sector contributed 2.56 per cent to total greenhouse gas emissions, with 73.89 per cent coming from wastewater treatment and discharge, and 25.31 per cent from solid waste disposal. The waste sector contributed 75,641 Gg of CO_2, equivalent to total GHG emissions in 2019 (MoEFCC, 2024).

To ensure effective waste management, specialized legislation has been enacted and periodically revised to adapt to evolving environmental conditions. Further, the Government of India has taken various initiatives to promote the Circular Economy in various sectors. The metal industry is a highly energy-intensive industry and has a large production of waste, e.g., from the iron and steel industry. Technologies for the utilization of such waste to develop state-of-the-art steel slag roads have been developed in the country, which could be effectively front-ended for wider use.

Forestry

The National Forest Policy of India aims to achieve 33% forest and tree cover across the country's geographical area. From 2009 to 2021, India's forest cover increased from 6,92,027 sq.km to 7,15,342.61 sq.km, while the total tree cover increased from 95,027 sq.km to 1,12,014.34 sq.km. This growth has resulted in a combined expansion of tree and forest cover from 23.81% to 25.17% of the nation's geographic area during the same period (FSI, 2024).

Forests are crucial for mitigating and adapting to climate change. They provide important ecosystem services and act as significant carbon sinks. In its NDC, India has pledged to create an additional carbon sink of 2.5 to 3.0 billion tonnes of CO_2eq through additional forest and tree cover by 2030. The total carbon stock in the country's forest is estimated to be 7,285.5 million tonnes in 2021, indicating an increase of 81.5 million tonnes compared to the last assessment. The annual increase of carbon stock is estimated at 40.75 million tonnes (149.42 million tonnes of CO_2 equivalent). Soil organic carbon constitutes the largest portion of forest carbon, comprising 55.06%, followed by Above Ground Biomass (AGB) at 32.69%, Below Ground Biomass (BGB) at 10.09%, Litter at 1.48%, and dead wood at 0.78%. (FSI, 2024).

India ranks third globally with respect to the net gain in average annual forest area between 2010 and 2020. This gain is mainly attributed to the robust framework and policies of the National and State Governments that have promoted and safeguarded forests. Schemes such as the Green India Mission (GIM), Compensatory Afforestation Fund Management and Planning Authority (CAMPA), National Afforestation Program (NAfP), Green Highway Policy - 2015, Policy for enhancement of Urban Greens, National Agro-forestry Policy, and Sub-Mission on Agro-forestry (SMAF), etc. are a few of the important policy interventions of the Government of India.

Agriculture

The agriculture sector in India plays a crucial role in ensuring food and nutritional security and provides livelihood support to about 42.3 per cent of the population (PIB, 2024). The threat of climate change poses a challenge for sustainable agricultural growth and hence this sector must become resilient to increasing climatic variability and change. GoI has formulated several schemes/plans with an aim to evolve and implement strategies for making Indian agriculture more resilient to the changing climate. The share of agriculture and allied sectors, including livestock, fishery, and forestry, in the total economy contributes to 18.2 per cent of the country's GVA at current prices during 2022-23 (MoSPI, 2024a).

India's voluntary declaration excludes mitigation in the agricultural sector. Agriculture in India, as in many developing countries, is characterised by smallholder farming. The adaptation burden in this sector is currently, and also expected to be, very high, and smallholder farmers have not contributed to greenhouse gas emissions responsible for warming so far. The Indian government has therefore focused on and implemented numerous measures to enhance the sector's resilience to climate change and improve its capacity to adapt to climatic variability. Nevertheless, given the scale of agricultural activities in the country, the Government of India has also adopted several initiatives to reduce the carbon intensity of agricultural production while sustaining its economic contribution through sustainable practices and increased productivity.

2.2.6 Legal, institutional, administrative, and procedural arrangements

The Government of India has taken several regulatory measures (acts and policies) to ensure environmental protection, climate change mitigation, and a higher penetration of non-fossil fuel-based electricity supply sources. Some of these are listed here.

i. **Air (Prevention and Control of Pollution) Act, 1981:** It provides for the prevention, control, and abatement of air pollution in India. It was last amended in 1987.

ii. **Environment (Protection) Act, 1986:** It was enacted with the objective of providing for the protection and improvement of the environment. It empowers the Central Government to establish authorities charged with the mandate of preventing environmental pollution in all its forms and to tackle specific environmental problems that are peculiar to different parts of the country. It was last amended in 1991.

iii. **Energy Conservation Act, 2001:** Efficient use of energy and its conservation

iv. **Electricity Act 2003:** Lays the foundation for the development of renewable energy in India

v. **National Electricity Policy 2005:** Emphasizes the urgent need to promote the generation of electricity from renewable sources.

vi. **Tariff Policy 2006:** Detailed provisions for renewable energy in tariff regulation and other relevant matters

vii. **National Action Plan on Climate Change 2008:** Range of policy initiatives to address climate change, including the target of installing 100 GW of solar power.

viii. **National Green Tribunal Act, 2010:** It was enacted to provide for the establishment of a National Green Tribunal for the effective and expeditious disposal of cases relating to environmental protection and conservation of forests and other natural resources including enforcement of any legal right relating to environment and giving relief and compensation for damages to persons and property and for matters connected therewith or incidental thereto.

ix. **Tariff Policy 2016:** Promotes the Renewable Energy Certificate (REC) mechanism for compliance with Renewable Purchase Obligations.

x. **Energy Conservation (Amendment) Act, 2022:** It includes provisions for putting in place a domestic carbon market.

xi. **Incentives extended to VRE sources in the operational phase:** RE sources along with nuclear power plants are accorded 'must run' status

xii. **Waiver of Inter-State Transmission Charges for Solar and Wind Energy:** No inter-state transmission charges and losses may be levied on solar and wind energy projects

xiii. **Renewable Purchase Obligations & Renewable Consumption Obligations:** The Government of India has amended the Energy Conservation Act, 2001 wherein as per Section 14 (x), the Central Government has powers to specify minimum share of consumption of non-fossil/RE resource by designated consumers as energy or feed stock and specify different shares of consumption for different types of non-fossil resources for different designated consumers.

The following is a list of relevant regulations that were enacted over the years to help conserve India's forests (MoEFCC, 2025).

i. **Indian Forest Act, 1927:** Consolidates the law relating to forests, the transit of forest produce, and the duty leviable on timber and other forest produce.

ii. **Forest Conservation Act, 1980:** Restricts and regulates the de-reservation of forests or use of forest land for non-forest purposes without the prior approval of the Central Government and lays down the prerequisites for the diversion of forest land for non-forest purposes.

iii. **The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006:** Recognizes the rights of forest-dwelling Scheduled Tribes and other traditional forest dwellers over the forest areas inhabited by them and provides a framework.

To ensure effective waste management, some of the relevant laws, rules, and regulations are listed below:

i. Manufacture, Storage, and Import of Hazardous Chemicals Rules (1989)

ii. Construction and Demolition Waste Management Rules (2016)

iii. Hazardous and other Wastes (Management and Transboundary Movement) Rules (2016) and as amended (2016, 2017, 2018, 2019, 2020, 2021, 2022, and 2023)

iv. Plastic Waste Management Rules (2016) and as amended (2018, 2021, 2022)

v. Solid Waste Management Rules (2016) and as amended (2019 and 2020)

vi. Bio-medical Waste Management Rules (2016) and as amended (2018 and 2019)

vii. Ash Utilization Notification (2021) and as amended (2022 and 2024)

viii. Battery Waste Management Rules (2022) and as amended (2023 and 2024)

ix. E-Waste (Management) Rules (2022) and as amended (2023)

x. Green Credit Rules (2023) and Methodology for calculating green credit (2024)

National Action Plan on Climate Change (NAPCC)

The Ministry of Environment, Forest and Climate Change of the Government of India set up the Expert Committee on Impact of Climate Change in 2007 to assess the impact of climate change on water resources, agriculture, natural ecosystems, health, and coastal zones. The committee was also tasked to assess and enhance climate modelling capabilities. The National Action Plan on Climate Change (NAPCC) was released by the Prime Minister in June 2008 to enable the country to adapt to climate change and enhance the ecological sustainability of India's development. It stresses that maintaining a high growth rate is essential for increasing the living standards of the vast majority of people in India and reducing their vulnerability to the impacts of climate change (PIB, 2021). There are currently nine national missions under the NAPCC which focus on promoting understanding of climate change, adaptation and mitigation, energy efficiency and natural resource conservation. These are listed below.

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 Eco-system
6. National Mission for a Green India
7. National Mission for Sustainable Agriculture
8. National Mission on Strategic Knowledge for Climate Change
9. National Mission on Climate Change and Human Health

Apex Committee for Implementation of Paris Agreement

The Apex Committee for Implementation of the Paris Agreement (AIPA), is an inter-ministerial committee set up in November 2020. It works on, inter alia, coordination, communication, and reporting of India's Nationally Determined Contribution to the UNFCCC; monitoring and review of climate goals to fulfil the requirements under the Paris Agreement; and providing guidance for Action Plans under different climate-related missions. AIPA reflections on the carbon trading scheme for the energy sector and enhancing the scope of the existing energy savings trading mechanism in March 2021 led to the Energy Conservation (Amendment) Act, 2022, in December 2022. It includes provisions for putting in place a domestic carbon market (PIB, 2023)

National Designated Authority for the Implementation of the Paris Agreement

The Government of India has also notified the National Designated Authority for the Implementation of Article 6 of the Paris Agreement (NDAIAPA) in May 2022 to develop processes and frameworks for international carbon trading. The NDAIAPA has identified activities that will be eligible for trading of carbon credits under Article 6.4 and Article 6.2 of the Paris Agreement involving bilateral and cooperative approaches (PIB, 2023). These activities are classified into three categories: i) GHG mitigation, ii) Alternate materials, and iii) Removal activities. They are listed below:

GHG mitigation:

i. Renewable energy with storage (only stored component)
ii. Solar thermal power plant
iii. Off-shore wind
iv. Green Hydrogen
v. Compressed bio-gas
vi. Emerging mobility solutions like fuel cells
vii. High-end technology for energy efficiency
viii. Sustainable Aviation Fuel
ix. Best available technologies for process improvement in hard-to-abate sectors
x. Tidal energy, Ocean Thermal Energy, Ocean Salt Gradient Energy, Ocean Wave Energy, and Ocean Current Energy
xi. High Voltage Direct Current Transmission in conjunction with renewable energy projects

Alternate materials:

xii. Green ammonia

Removal activities:

xiii. Carbon Capture Utilization and Storage (CCUS)

2.3 Description of a Party's NDC under Article 4 of the Paris Agreement, including updates

Nationally Determined Contributions are central to the Paris Agreement, representing each country's pledge to contribute to the global effort to mitigate climate change, adapt to its impacts, and cope with loss and damage. India has set ambitious targets for itself and is on track to meet them.

In its updated NDCs (submitted in 2022), India has declared eight goals, which are listed below.

1. To put forward and further propagate a healthy and sustainable way of living based on traditions and values of conservation and moderation, including through a mass movement for 'LIFE'– 'Lifestyle for Environment' as a key to combating climate change.

2. To adopt a climate friendly and a cleaner path than the one followed hitherto by others at corresponding level of economic development.

3. To reduce Emissions Intensity of its GDP by 45 percent by 2030, from 2005 level.

4. To achieve about 50 percent cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030, with the help of transfer of technology and low-cost international finance including from Green Climate Fund (GCF)

5. To create an additional carbon sink of 2.5 to 3 billion tonnes of CO_2 equivalent through additional forest and tree cover by 2030.

6. To better adapt to climate change by enhancing investments in development programmes in sectors vulnerable to climate change, particularly agriculture, water resources, the Himalayan region, coastal regions, health, and disaster management.

7. To mobilize domestic and new & additional funds from developed countries to implement the above mitigation and adaptation actions in view of the resource required and the resource gap

8. To build capacities, create domestic framework and international architecture for quick diffusion of cutting-edge climate technology in India and for joint collaborative R&D for such future technologies

2.4 Information necessary to track progress

India's Nationally Determined Contribution (NDC) comprises eight goals, three of which (Goals 3, 4, and 5) are quantitative, while the remaining five are non-quantifiable (Goals 1, 2, 6, 7, and 8). The quantitative goals are summarized in Appendix II as follows: Table A1.1 (Goal 3), Table A1.2 (Goal 4), and Table A1.3 (Goal 5). These three quantitative goals have been selected for tracking progress under Article 4 of the Paris Agreement as they include measurable targets. The following indicators were used for the three quantitative NDC goals to support tracking of progress made in implementing and achieving them under Article 4 of the Paris Agreement in India.

1. **Indicator for NDC goal 3:** Emissions Intensity of GDP (%)

2. **Indicator for NDC goal 4:** Cumulative (2005-2022) and year-wise (2021 and 2022) electric power installed capacities from non-fossil fuel-based energy sources

3. **Indicator for NDC goal 5:** Estimate of additional carbon sink through forest and tree cover – cumulative (2005-2022) and year-wise (2021 and 2022)

While the non-quantifiable goals are not tracked in the same manner, this chapter outlines the strategic approach to implementing them, highlighting ongoing efforts and initiatives aligned with those objectives.

The sections below provide detailed information relevant to tracking progress in the implementation and achievement of India's NDC.

Goal 1: To put forward and further propagate a healthy and sustainable way of living based on traditions and values of conservation and moderation, including through a mass movement for 'LIFE'– 'Lifestyle for Environment' as a key to combating climate change

Goal Description

The ultimate objective of this goal is to create enabling conditions and preferences that lead to higher resource efficiency through responsible consumption and production choices. The instruments of achieving this goal include a combination of regulation, information sharing, and awareness creation to create markets for resource-efficient products and services. While it is difficult to assess the progress under this goal through a single measure, the most significant policy aligned with the overall direction of India's climate policy is the promotion of energy-efficient appliances.

Information necessary to track progress made in achieving Goal 1

The scope for this goal is quite broad and is made further difficult to measure as India is a growing economy and both consumption and production are bound to increase. While the progress on specific initiatives aligned with this goal may be quantified, overall progress is to be measured in terms of the types of initiatives that have been implemented by the Government of India, strengthening the policy direction towards promoting responsible consumption, production, and behavioural change.

Progress made in achieving Goal 1

India is advancing NDC Goal 1 through Mission LiFE (Lifestyle for Environment). Announced by the Prime Minister of India at COP26 and formally launched by the Government in 2022, it is a global movement to promote sustainable lifestyles through mindful consumption and behavioural change. It aims to mobilize 1 billion people by 2028 to adopt eco-friendly habits across seven key themes, including saving water, energy, and reducing waste. Over 3.93 crore people have participated in 19.45 lakh events, and over 1 billion trees have been planted under the "Ek Ped Maa Ke Naam" campaign. Internationally recognized by UNEA and referenced in several global forums, Mission LiFE positions India as a leader in driving sustainable consumption and climate action.

Under its "Save Energy" theme, India has implemented impactful demand and supply-side measures to promote energy efficiency. Programs such as the Unnat Jyoti by Affordable LEDs for All (UJALA), Standards & Labelling, Building Energy Efficiency Programme and Municipal Demand Side Management among others have undertaken the retrofitting of public infrastructure and improved municipal energy use. On the supply side, the Perform Achieve Trade (PAT) scheme has driven major energy savings and emissions reductions across high-impact industries, viz., aluminium, steel, cement, and chemicals, demonstrating India's strong progress in climate action through energy efficiency.

Goal 2: To adopt a climate-friendly and cleaner path than the one followed hitherto by others at the corresponding level of economic development.

Goal Description

The objective of this goal is to establish a strong framework that integrates climate-friendly and cleaner development into all levels of policymaking and planning, as per local circumstances and development priorities. India's climate friendly development policy framework is designed to enhance living standards, stimulate economic growth, contribute to climate mitigation efforts, and enhance climate resilience of communities. Compared to many developed countries, India adopted such policy framework early in its development process. As a result, despite the growth in India's energy generation and consumption, India's per capita emissions have never surpassed the global average.

Information necessary to track progress made in achieving Goal 2

India is embedding climate-friendly and cleaner development pathways into national and sub-national planning through the implementation of the National Action Plan on Climate Change (NAPCC) and State Action Plans on Climate Change (SAPCCs). Nine national missions under NAPCC address specific areas of solar energy, enhanced energy efficiency, sustainable habitat, water, sustaining Himalayan ecosystems, greening India, sustainable agriculture, human health, and strategic knowledge for climate change. All 34 States and Union Territories of India have formulated SAPCCs aligned with India's NDCs and are revising them to reflect updated climate goals, local priorities, and meeting the Sustainable Development Goals (SDGs). These frameworks mainstream climate action into development policies, focusing on adaptation, mitigation, and resilience building.

Progress made in achieving Goal 2

Per capita emissions are a critical metric for assessing a country's environmental impact relative to its population size. India's per capita emissions are significantly lower than those of many countries with similar levels of per capita GDP. The annual per capita GHG emissions from India were 1.8 tCO_2e in 2019, which is approximately one quarter of the global average of 6.8 tCO_2e (see Figure 2.1). India's per-capita GHG emissions are not going to exceed those of developed countries even while pursuing policies of development and economic growth. This highlights India's lower carbon footprint and underscores the country's efforts to maintain a sustainable development trajectory.

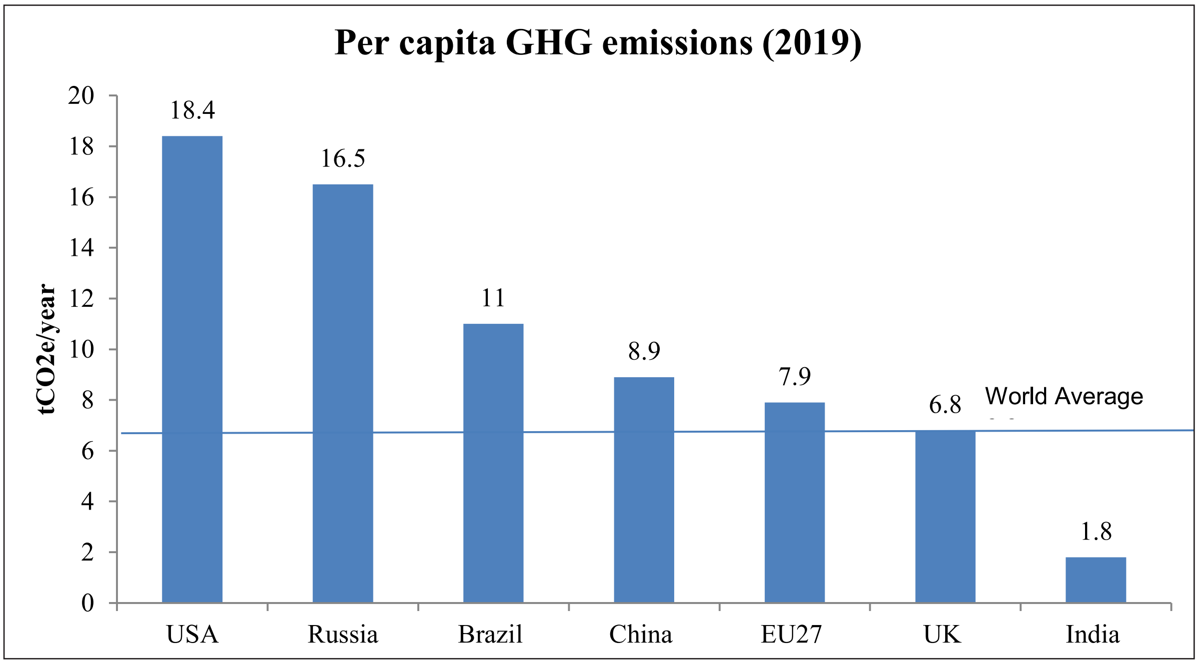

Figure 2.1: Per Capita GHG Emissions (2019) of select countries

Source: Emissions data from Third National Communication (for India) and Our World in Data (https://ourworldindata.org/grapher/per-capita-ghg emissions?tab=table&time=earliest..2019 - for other countries); population data from World Bank projections

Goal 3: Reduce Emissions Intensity of GDP by 45 per cent by 2030, from 2005 level.

Goal Description

The primary objective under this goal is to achieve a 45% reduction in the emissions intensity of GDP by 2030, relative to 2005 levels. Emissions intensity of GDP refers to the ratio of greenhouse gas (GHG) emissions to GDP, serving as a measure of how much emissions are produced per unit of economic output. This goal measures the balance between sustainable economic growth and achieving this growth through low-carbon development.

The agriculture sector in India is dominated by smallholder farmers and is extremely vulnerable to the impacts of climate change. India considers adaptation to climate change as the major priority for the agricultural sector. Therefore, India's pledge does not include emissions from the agriculture sector, even though India does implement several mitigation actions in the agriculture sector.

Information necessary to track progress made in achieving Goal 3

As the emissions intensity of GDP is itself an indicator, policies undertaken for efficiency improvement and low-carbon development can be mapped directly to this goal. Table 2.4 shows the indicator used and its value for estimating the progress of NDC Goal 3.

Table 2.4: Indicator used and its value for estimating the progress of NDC Goal 3

NDC goal 3	Mathematical formulation	Emissions intensity of GDP in Base Year 2005 (tCO_2e/INR Million)	Emissions intensity of GDP in 2021 (tCO_2e/INR Million)	Emissions intensity of GDP in 2022 (tCO_2e/INR Million)	Reduction in emissions intensity of GDP during 2005-2021	Reduction in emissions intensity of GDP during 2005-2022	Reduction in emissions intensity of GDP goal for 2030 from 2005 level
Emissions Intensity of GDP	Emissions intensity of GDP = (GHG emissions/ GDP)	23.283	14.270	14.580	-38.71%	-37.38%	- 45%

Source: GDP (at 2011-12 constant prices) data taken from Economic Survey 2024-2025, Ministry of Finance (MoF, 2025) and Emission values were taken from India's updated GHG inventory for 2021 & 2022

Progress made in achieving Goal 3

India's economy is growing at a fast pace, with its GDP (at current prices) and GDP (at constant prices) showing a growth rate of 9.8% and 6.5%, respectively, in FY 2024-25 (Provisional estimates from the Ministry of Statistics and Programme Implementation for FY 2024-25). However, India's GHG emissions intensity of GDP is witnessing a decoupling due to the implementation of effective climate policies. The decoupling of economic growth and GDP can be attributed to policies promoting renewable energy deployment and policies aimed at improving the energy efficiency of all economic activity. As a result of these combined efforts in energy efficiency and expansion of renewable energy, the emissions intensity of GDP reduced by 37.10% by 2022 compared to the base year of 2005. Some of the policies being implemented in the energy (power & transport) and industrial sectors at national as well as state level include: the Perform Achieve and Trade (PAT) scheme, the Standards and Labelling programme, the Street Light National Programme, policies aimed at reducing transmission and distribution losses, adopting super critical or ultra-super critical technologies in thermal power plants, incentivizing the addition of new power generation capacity from renewable energy sources (solar, wind, biomass, bagasse co-generation, small hydro, etc.) through policies for non-curtailment for renewable energy and the provision of capital subsidies etc. The mitigation policies and measures that have been implemented to achieve this NDC goal are listed in Section 2.5 and CTF 5 of Appendix II.

Goal 4: To achieve about 50 percent cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030, with the help of transfer of technology and low-cost international finance, including from the Green Climate Fund (GCF)

Goal Description

This goal specifies that India will aim to achieve about 50% of its cumulative electric power installed capacity from non-fossil fuel sources by 2030. This target is conditional on the transfer of technology and availability and access to low-cost international financing.

Information necessary to track progress made in achieving Goal 4

The indicator used for assessing this target is installed capacity from non-fossil fuel sources (solar, wind, biomass/cogeneration, waste to energy, small and large hydro power and nuclear power) as a proportion of total power installed capacity (See Equation 1)

$$\text{\% of Non-Fossil Fuel Installed Power Capacity} = \frac{\text{Non-Fossil Fuel Installed Capacity (GW)}}{\text{Total Installed Capacity (GW)}} \tag{1}$$

Progress made in achieving Goal 4

There has been a significant increase in non-fossil fuel-based sources in India, largely driven by a rapid increase in the installed capacity of solar photovoltaic (PV) based power supply and wind energy, alongside a steady rise in hydro and nuclear power capacity. As a proportion of total installed capacity in India, non-fossil fuel-based installed power capacity was 38.3% in 2020, 40.2% in 2021, and 42.5% in 2022. against the NDC pledge of achieving 50% by 2030. Figure 2.2 shows the share of fossil fuel-based and non-fossil fuel-based installed power capacity in India between 2005 to 2022.

This achievement has been made possible by a range of policies that incentivize renewable energy generation and its integration into the national electricity grid. It must be emphasized, however, that while the implementation of these policies has enhanced non-fossil fuel-based power generation capacity, significant costs accompany this achievement. The energy transition requires substantial capital investment in generation capacity, grid transmission, and distribution infrastructure, accompanied by high upfront costs. So far, India has largely met these requirements through domestic resources, with minimal support from international climate finance.

Despite housing 18% of the global population, India's historical contribution to cumulative CO_2 emissions between 1850 and 2019 stands at less than 4%. As India continues its clean energy transition, achieving the NDC goal will critically depend on accelerated technology transfer and access to affordable low-cost international climate finance, particularly from mechanisms such as the Green Climate Fund (GCF).

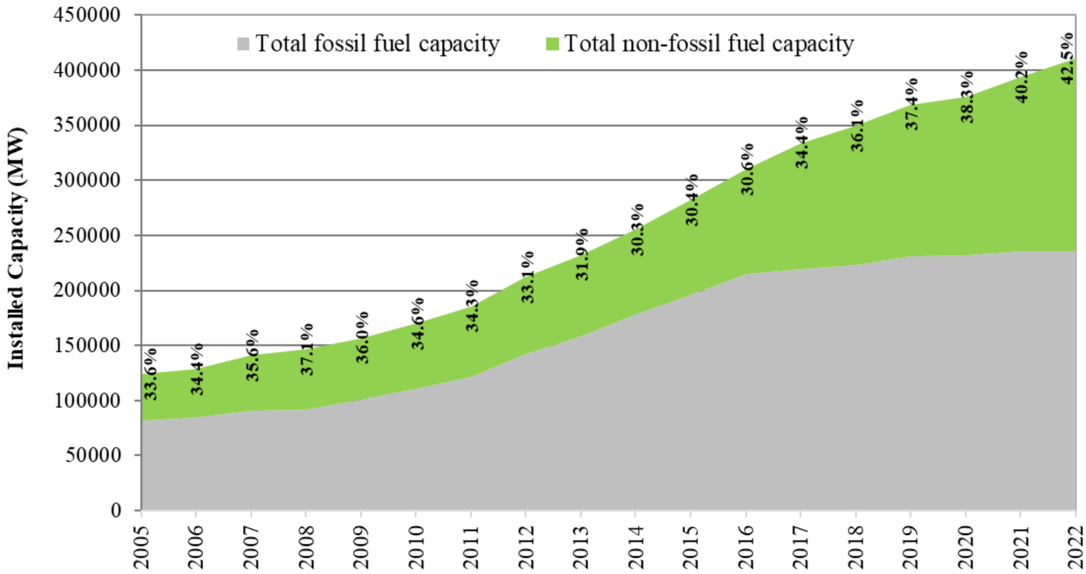

Figure 2.2: Installed capacity showing the share of fossil and non-fossil fuel sources from 2005 to 2022

Source: Monthly and Annual reports published by Central Electrical Authority, Ministry of Power, Government of India.

Goal 5: To create an additional carbon sink of 2.5 to 3 billion tonnes of CO_2 equivalent through additional forest and tree cover by 2030

Goal Description

The NDC goal focuses on creating additional carbon sink of 2.5 billion to 3.0 billion tonnes through forest and tree cover by 2030. India is making concerted efforts to meet the NDC goal and is on the way to achieve the target well before 2030. This could be possible because of high priority accorded to conservation and restoration by the National and State governments in India which is reflected in a strong framework of Policies, Acts & Rules and programmes like Indian Forest Act, 1927, Wildlife protection Act, 1972, National Forest Policy, 1988, Forest Conservation Act, 1980, Central and State sponsored Schemes like, Green India Mission (GIM), CAMPA, MGNREGA, National Afforestation Programme (NAP), Green Highway Policy, 2015, Policy for enhancement of Urban Greens, National Agro-forestry Policy and Sub-Mission on Agro-forestry (SMAF) etc. such as to ensure conservation of forests and biodiversity, enhance green cover and participation of people in the conservation activities while protecting rights of forest dependent communities.

Information necessary to track progress made in achieving Goal 5

The Forest Survey of India (FSI), a subordinate office of the MoEFCC and mandated with periodic assessment of the forest resources of the country, assesses the carbon stock in India's forests through its biennial publication "The India State of Forest Reports" (ISFR). The carbon stock estimates published in ISFR, are used for reporting greenhouse gas (GHG) inventories under the Land Use, Land-Use Change and Forestry (LULUCF) sector, as required by the UNFCCC. For this purpose, the definition of forest used in India's National Communication includes "All lands that are equal or more than one hectare in area, with a minimum tree canopy cover of 10%, regardless of ownership or legal status". This definition also includes orchards, bamboo, and palm areas. However, there are many small patches of trees which are less than 1 ha in extent, in village woodlots, homesteads and trees along linear features such as roads, canals, bunds, trees in urban areas and also scattered trees etc. which do not get included in the forest cover due to technological limitations of satellite data used for the forest cover mapping. The extent of such small patches of the trees outside the RFA is estimated as tree cover using a methodology based on stratified random sampling, and estimated partly by using high-resolution data and partly from field inventory data. Since all such trees also store carbon and are part of India's Nationally Determined Contribution (NDC) commitments, their carbon stock is estimated separately. Therefore, to effectively track progress toward NDC goals, carbon stock estimates from both forest cover and tree cover are considered. Table 2.5 gives derived estimates for carbon stock in 'forest and tree cover' of India in different years.

Table 2.5: Estimates for carbon stock in 'forest & tree cover' of India

Year	Forest Carbon from Forest & Tree Cover CO_2eq (billion tonnes)	Report
2005	28.14	ISFR 2007
2011	28.97	ISFR 2013
2013	29.40	ISFR 2015
2015	29.59	ISFR 2017
2017	29.79	ISFR 2019
2019	30.11	ISFR 2021
2021	30.43	ISFR 2023

Progress made in achieving Goal 5

Forest and tree cover in India has shown a gradual and steady increasing trend in the last decades. India is among the few countries in the world to achieve an increasing trend in forest cover. This is even more creditable as there is a large dependence of tribal communities and other villagers living in the fringe areas of most forests for their daily needs of fuel wood, fodder, small timber, and non-timber forest produce (NTFPs). As per the GHG inventory for the year 2022, reported in this BTR, the forest net sink and carbon sequestration is 0.149 billion tonnes of CO_2 equivalent. Thus, India has achieved 2.44 billion tonnes of additional carbon sink from forest and tree cover by 2022, against its target of sequestering 2.5-3 billion tonnes of CO_2 equivalent through increased forest and tree cover by 2030.

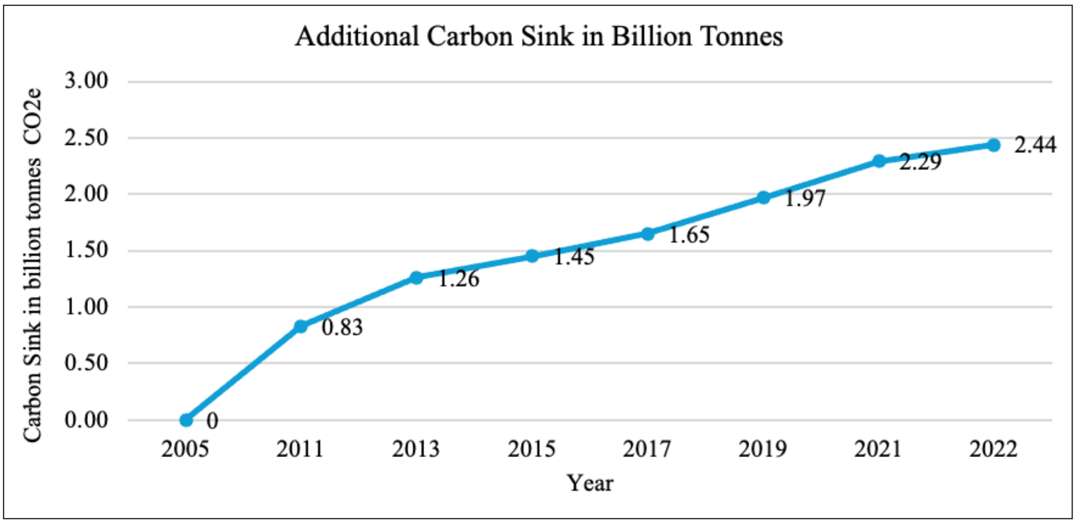

Figure 2.3: Progress over the years of NDC Goal 5: Creation of an additional carbon sink of 2.5 to 3 billion tonnes of CO_2 equivalent through additional forest and tree cover by 2030

The brief description and information necessary to track progress made in each three quantitative NDC goals, i.e., NDC goals 3, 4 & 5, in common tabular formats, i.e., CTF 1, 2, 3, and 4, are given in Appendix II.

Goal 6: To Better Adapt to Climate Change by Enhancing Investments in Development Programmes in Sectors Vulnerable to Climate Change, particularly Agriculture, Water Resources, the Himalayan Region, Coastal Regions, Health, and Disaster Management

Goal Description

The objective of this goal is to mainstream climate change adaptation in sectoral development strategies, particularly in those sectors and regions that are vulnerable to climate change, viz., agriculture, water resources, the Himalayan region, coastal regions, health, and disaster management. The relevant policies are those that simultaneously address the imperative of climate change adaptation, i.e., reducing vulnerability, enhancing adaptive capacities and resilience, along with delivering developmental objectives, i.e., increased productivity, enhanced and equitable access to resources, economic development, and so on.

Information necessary to track progress made in achieving Goal 6

India's National Action Plan on Climate Change (NAPCC) outlines a strategic approach to strengthen climate adaptation and ecological sustainability. Five of its nine missions focus on key sectors where adaptation is an over-riding priority, i.e., water, agriculture, habitat, Himalayan ecosystems, and health. Additionally, the Green India and Strategic Knowledge missions contribute significantly to adaptation. At the state level, State Action Plans on Climate Change (SAPCCs) serve as vital tools to integrate adaptation into local development tailored to regional vulnerabilities, especially in sectors such as agriculture, water, health, forests, and disaster management. Besides adaptation-centric and sector-specific national missions under the NAPCC, a number of sectoral policies and programmes have been implemented, which provide a channel for budgetary allocation for sector-specific adaptation.

Progress made in achieving Goal 6

India has long strived for the inclusion of climate action within its budgetary processes, to couple the pursuit of its development goals with ecological sustainability. Adaptation criteria are explicitly considered in the devolution of public funds from the Central to the State Governments, with climate adaptation components being a substantial part of the budgetary frameworks of several Ministries and Departments at the federal level. Local-level action towards climate change adaptation and resilience building among communities is actively promoted in India. In 2021-22, India's total expenditure on adaptation-related activities amounted to INR 13.35 trillion, amounting to 5.6% of the total GDP. For comparison, this was significantly higher than the expenditure in the FY 2015-16, when 3.7% of the GDP of that year was spent on adaptation-related activities, amounting to a sum of INR 5.06 trillion (MoEFCC, 2023). India has been amplifying its efforts towards building climate resilience and improving adaptive capacities, despite the pressurizing competitive demand for financial and natural resources within its fast-growing economy.

Goal 7: To Mobilize Domestic, and New & Additional Funds from Developed Countries to Implement the Mitigation and Adaptation Actions in view of the Resource Required and the Resource Gap

Goal description

This goal includes domestic policies and institutional measures for reforming the finance sector and encouraging financial flows. Mobilizing international climate finance through measures such as engaging in carbon markets, bilateral and multilateral partnerships, etc., is also part of efforts taken under this goal.

India's NDCs seek to address climate change in a balanced way, acknowledging the country's vulnerability to climate change as well as its developmental needs. They take into account India's ambitious perspective towards climate action, while foregrounding the requirements of its people in terms of healthcare, education, food security, energy demand, water supply, sustainable habitats, and equitable opportunities. Consequently, the NDC also stresses upon the need to mobilize new and additional funds domestically, and from developed countries to support India's nationally determined low-carbon development strategies and the implementation of various envisioned mitigation and adaptation plans.

Information necessary to track progress made in achieving Goal 7

Finance is key to the effective implementation of the NDCs. Through integrating climate change mitigation and adaptation imperatives into development planning, domestic finance can be mobilized. However, this alone is not sufficient to meet the NDC goals. Access to new and additional funds from developed countries and international financial markets is necessary to bridge the gap. For example, it is estimated that investments of around US$ 4.5 trillion are required by India till 2040 to develop infrastructure to improve economic growth and community wellbeing (Department of Economic Affairs, 2020). Article 4.4 of the UNFCCC also mandates that developed country Parties and other developed Parties included in Annex II shall assist developing country Parties in meeting costs of adaptation to the adverse effects of climate change.

Progress made in achieving Goal 7

India has mobilized substantial domestic resources to implement its climate mitigation and adaptation goals through a robust policy framework, targeted national missions, and regulatory reforms. Key initiatives, such as the National Solar Mission, Green Hydrogen Mission, and Energy Efficiency programs, drive clean energy investments. Meanwhile, adaptation efforts are supported through missions focused on agriculture, water, forestry, and urban resilience. Financial tools such as sovereign green bonds, Production Linked Incentive (PLI) schemes, and the revamped Carbon Credit Trading Scheme further attract private investment. Regulatory support from RBI and SEBI has strengthened green finance and ESG integration. Despite this progress, enhanced international finance remains critical to scale up efforts.

India views current international climate finance as insufficient in scale, speed, and quality, with most flows dominated by non-concessional loans. Limited support has been available from sources such as the Green Climate Fund, Global Environment Facility, and Climate Investment Funds. On the other hand, India has contributed significantly through co-financing some of its key initiatives. India emphasizes the need for more grants and concessional finance from international public sources to effectively support its climate goals.

Goal 8: To build capacities, create a domestic framework and an international architecture for the quick diffusion of cutting-edge climate technology in India and for joint collaborative R&D for such future technologies

Goal description

This goal emphasizes the importance of building capacities and creating both a domestic framework and an international architecture to facilitate the rapid diffusion of cutting-edge climate technology within the country. It includes policy measures and initiatives undertaken to build capacities, encourage innovation and research and development (R&D), and encourage the accelerated adoption of climate technologies.

Information necessary to track progress made in achieving Goal 8

This goal highlights India's commitment to fostering innovation and collaboration in the field of climate technology, aiming to integrate advanced solutions that address climate change effectively. By promoting joint collaborative research and development for future technologies, India seeks to accelerate the deployment of sustainable and efficient climate technologies, ensuring that the nation is well-equipped to meet its environmental goals and contribute meaningfully to global climate efforts.

Progress made in achieving Goal 8

India has made notable strides in strengthening its domestic framework and global engagement to accelerate the development, diffusion, and adoption of cutting-edge climate technologies. The Government's R&D budget has increased significantly, supporting a robust innovation ecosystem that includes startups focused on clean tech and climate action.

India’s commitment to innovation is reflected in its improving performance in the Global Innovation Index 2024, where it now ranks 39th among the 133 innovation-driven economies. Through Mission Innovation, India co-leads key global R&D challenges and has launched the Clean Energy International Incubation Centre (CEIIC) to support breakthrough technologies. The National Green Hydrogen Mission, National Bioenergy Program, and other sectoral initiatives further demonstrate India's focus on technology-led transitions.

Capacity-building efforts such as Skill India, the Green Skill Development Programme (GSDP), and international fellowships in bioenergy and clean technologies are preparing a skilled workforce for a low-carbon economy. At the international level, India’s leadership in the International Solar Alliance (ISA) and the launch of the Green Hydrogen Innovation Centre underline its pivotal role in shaping the global climate technology architecture. These combined efforts are positioning India as a hub for collaborative R&D, innovation diffusion, and technology-driven climate action.

2.5 Mitigation Policies, Actions, and Plans

CTF 5 in Appendix II presents key mitigation policies and measures, actions and plans, including those with mitigation co-benefits resulting from adaptation actions and economic diversification plans, related to implementing and achieving the NDC under Article 4 of the Paris Agreement. This table lists 9 major key policies being implemented at the national level in GHG inventory sectors such as energy (including power, transport, etc.) and industry.

GHG mitigation from four key policies, namely, the Standards & Labelling (S&L) programme, solar power policy, wind power policy, and Perform Achieve Trade (PAT) scheme, was estimated for the years 2021 and 2022. Brief methodology and assumptions used for estimating avoided GHG emissions for these 4 key policies are described in Appendix III. GHG emissions avoided from another 5 key policy initiatives namely, the promotion of other renewable energy technologies, the Street Light National Program, policies aimed at the adoption of supercritical/ultra-super critical technology for coal-based power generation, reduction in transmission and distribution losses, ethanol-blended petrol programme, listed in CTF 5 in Appendix II, were not estimated either due to the difficulty in acquiring data/information specific to these policies as per the CTF requirement and preliminary stage of methodology development for the same.

In addition to the above-mentioned policies and measures, a range of other important initiatives for climate change mitigation across major sectors are also being implemented which are listed and discussed below.

2.5.1 Policies and Measures in the Power Sector

Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY)

The DDUGJY, launched in December 2014 by the Ministry of Power, Government of India, aims to strengthen the electricity distribution system. Activities include establishing new substations, upgrading old ones, and expanding power lines. Electrification efforts covered villages nationwide, with off-grid solutions where grid connectivity was impractical or expensive.

Integrated Power Development Scheme (IPDS)

The Integrated Power Development Scheme (IPDS), launched in December 2014 by the Ministry of Power, Government of India, focuses on enhancing distribution infrastructure projects. This includes strengthening sub-transmission and distribution networks in urban areas, implementing metering for transformers/feeders/consumers in urban areas, enabling IT infrastructure such as Enterprise Resource Planning (ERP) and smart metering, and deploying technologies such as Gas Insulated Substations (GIS) and Real-Time Data Acquisition Systems (RT-DAS). These are aimed at reducing Aggregate Technical & Commercial (AT&C) losses, with additional funding for underground (UG) cabling, Aerial Bunched (AB) cables, and metering. All distribution utilities are eligible for financial assistance under this scheme, with funding allocated based on achievement of milestones.

Smart Meter National Program

Energy Efficiency Services Limited (EESL), Ministry of Power, through its JV IntelliSmart, is implementing a Smart Metering Program to enhance efficiencies for distribution utilities. Smart meters are pivotal for smart grid initiatives, crucial to meet challenges of the newly evolving energy mix for achieving uninterrupted 24x7 power supply. Connected via a web-based monitoring system, smart meters reduce commercial losses, boost revenues, and aid power sector reforms.

Street Lighting National Programme (SLNP)

On January 5, 2015, the Prime Minister of India initiated the Street Lighting National Programme (SLNP) for a nationwide shift from conventional streetlights to smart, energy-efficient LEDs. It is being implemented by the Energy Efficiency Services Limited (EESL), Ministry of Power.

Unnat Jyoti by Affordable LEDs for ALL (UJALA)

On January 5th, 2015, the Prime Minister of India launched the UJALA program, under which LED bulbs, LED Tube lights and Energy efficient fans are being sold to domestic consumers for replacement of conventional and inefficient variants.

Thermal Power

The Ministry of Power implemented the Perform, Achieve and Trade (PAT) scheme, targeting energy efficiency in large industries, including Thermal Power Stations consuming over 30,000 toe annually. Covering 239 Thermal Power Stations with a capacity of around 197 GW, this scheme mandates reducing Net Heat Rate over three-year cycles, leading to decreased coal consumption and CO_2 emissions. Many Thermal Power Plants have been upgraded to more efficient technologies, transitioning from subcritical to supercritical and ultra-supercritical technology, resulting in improved efficiency and reduced coal consumption and emissions.

Hydropower

The Government of India has notified the Hydro Purchase Obligations (HPO), waiver of Inter State Transmission System (ISTS) charges for Hydro Power Projects and Pumped Storage projects (PSPs) and tariff rationalization to lower tariffs from hydro power projects in initial years post commissioning to incentivize hydro power.

Renewable Energy Sources

The Indian government has established minimum share of consumption of non-fossil sources (renewable energy) by designated consumers as energy or feedstock and different share of consumption for different types of non-fossil sources for different designated consumers in respect of electricity distribution licensee and other designated consumers, to be in effect till March 2030 under the Energy Conservation Act, 2001. Along with this, the Government of India is implementing the Production Linked Incentive (PLI) Scheme across the nation, with an allocation of ₹24,000 crores for High Efficiency Solar PV Modules.

Under the National Bioenergy Programme, following bioenergy schemes are currently being implemented - Programme on Energy from Urban, Industrial and Agricultural Wastes/ Residues (Waste to Energy Programme); Scheme to Support Promotion of Manufacturing of Briquettes and Pellets and Biomass (Non-Bagasse) Based generation in Industries in the Country; Biogas Programme for installing small (1-25 cubic meters) and medium size biogas plants (above 25 m3 – 2500 m3) for clean cooking purposes and decentralized power generation (off-grid) and thermal application.

Government of India notified the Offshore Wind Energy Policy in October 2015. For the initial phase of developments, the Ministry of New and Renewable Energy has identified zones each off the coast of Gujarat and Tamil Nadu. The Offshore Wind Energy Lease Rules, 2023 were notified on 19th December 2023, under The Territorial Waters, Continental Shelf, Exclusive Economic Zones and Other Maritime Zones Act, 1976 (80 of 1976), to regulate the grant of lease of offshore areas for development of offshore wind energy projects.

National Green Hydrogen Mission (NGHM)

The Ministry of New and Renewable Energy is executing the National Green Hydrogen Mission, endorsed by the Union Cabinet on January 4, 2023, with a budget of ₹19,744 crore. The main objective is to establish India as the global hub for production, usage and export of Green Hydrogen and its derivatives.

To complement this, Council for Scientific and Industrial Research (CSIR) has launched Hydrogen Mission for technology innovation and development. The mission program envisages development of indigenized technologies at system level, enable capacity building, pursue path-breaking ideas to upgrade technologies and participate in techno-economics/ road mapping/ testing activities to support National Green Hydrogen Mission of India.

2.5.2 Policies and Measures in the Industry Sector

Perform, Achieve and Trade (PAT) Scheme

The Perform, Achieve and Trade (PAT) scheme, launched in 2012, is a regulatory instrument designed to reduce specific energy consumption in energy-intensive industries. It features a market-based mechanism that enhances cost-effectiveness by certifying excess energy savings, which can be traded. It is being implemented by the Bureau of Energy Efficiency, Ministry of Power.

PAT is a mechanism for improving the energy efficiency of energy-intensive industries. Specific high-energy-intensive industries are identified as Designated Consumers (DCs) within certain key sectors, who are required to appoint an energy manager, file annual energy consumption returns, and conduct regular mandatory energy audits. The key tasks in the PAT mechanism are to set the methodology for deciding the Specific Energy Consumption (SEC) norms for each designated consumer in the baseline year and in the target years, devise a verification process for SEC, finding ways of issuing the Energy Savings Certificates, operationalization of the trading process for ESCerts in addition to the compliance and reconciliation process for ESCerts.

PAT has evolved through 7 cycles of 3 years each. PAT cycle –VII was notified for the period of FY 2022-23 to 2024-25, wherein 707 DCs have been notified with an overall energy saving target of 8.485 MTOE in the following 9 Energy Intensive Sectors, i.e., Aluminium, Cement, Chlor-Alkali, Iron and Steel, Pulp and Paper, Textiles, Thermal Power Plant, Railways, and DISCOM. During the 2022-23 fiscal year, the above units under PAT saved 25.77 Million Tons of Oil Equivalent (MTOE), which is approximately 8% of their total annual energy consumption.

For PAT cycle VIII, 1333 Designated Consumers across thirteen sectors (Aluminium, Cement, Chlor-Alkali, Fertilizer, Iron and Steel, Pulp and Paper, Textiles, Thermal Power Plant, Refinery, Railways, DISCOM, Petrochemicals, and Buildings) have been given energy conservation targets under the scheme. These targets are set for a three-year period.

Currently, designated consumers under 13 energy-intensive sectors, including thermal power plants, refineries, iron and steel, and textile industries, are covered under the Perform-Achieve-Trade (PAT) scheme. With the introduction of the Carbon Credit Trading Scheme (CCTS) in June 2023, nine sectors, which are greenhouse gas emission-intensive, including refineries, iron and steel plants, and textile industries, will gradually transition to the CCTS by the financial year 2026-27. The remaining four energy-intensive sectors, including thermal power plants, will continue to be covered under the PAT scheme. The addition of new energy-intensive industries through energy audits is a continuous process under the PAT scheme.

BEE-GEF-UNIDO Project 'Promoting Energy Efficiency and Renewable Energy in selected Micro, Small and Medium Enterprises (MSME) clusters of India'

The United Nations Industrial Development Organization (UNIDO), in collaboration with the Bureau of Energy Efficiency, and in partnership with the Global Environment Facility (GEF), the Ministry of MSME, and the Ministry of New and Renewable Energy (MNRE), is executing this project. The project has an objective to develop and promote a market environment for introducing energy-efficient technologies and enhancing the use of renewable energy technologies in process applications. BEE-UNIDO program is operational in 23 MSME clusters, including Hand tools, Ceramics, Dairy, Foundry, Brass. 599 small-scale energy-efficient projects implemented in the clusters as of 2023.

Facility for Low Carbon Technology Deployment (FLCTD)

Commencing in 2016, the Facility for Low Carbon Technology Deployment (FLCTD) project seeks to foster innovation in low carbon technology solutions, addressing prevalent technology gaps within Indian industrial and commercial sectors. It is being executed in collaboration with the Bureau of Energy Efficiency (BEE) and funded by the Global Environment Facility (GEF), this project is overseen by the United Nations Industrial Development Organization (UNIDO). The project aims to facilitate the validation of innovative low-carbon technology, thereby assisting in the deployment and scaling up of low-carbon technologies in India, promoting innovation of low-carbon technology solutions that address the existing technology gaps in the Indian industrial and commercial sectors. The project has two components: Component 1 – Development of an awards methodology to identify and select competitive technology for project support and Component 2 – Technical assistance for the Technology Transfer Support Facility.

SIDBI "4E Scheme-End to End Energy Efficiency" Scheme

SIDBI 4e scheme was launched to provide financial support to MSMEs. It helps MSMEs implement new technology and other energy efficiency measures. It mainly focuses on implementing those technologies in which machinery consumes less energy and provides a big output. The MSME receives financial assistance ranging from ten lakhs to 1.5 Crores under this sustainable finance scheme. All the important faculties like verification support, implementation Support, and monitoring support will be provided to the qualified MSME at a very low cost.

2.5.3 Policies and Measures in the Transport Sector

Emission Standards and Auto Fuel Policy of 2003

The Auto Fuel Policy of 2003 aimed to curtail vehicular emissions through stringent fuel quality standards and efficient fuel supply measures. Significant amendments were made to The Central Motor Vehicles Rules, 1989, by 2018, requiring vehicles manufactured before April 1, 2020, to meet BS-IV standards, notable for reducing Sulphur emissions by 80%. This scheme is being implemented by Ministry of Petroleum & Natural Gas, Ministry of Urban Development, Ministry of Road Transport and Highways.

Corporate Average Fuel Economy (CAFE)

Ministry of Power introduced the CAFE norms in FY 2017-18 and the second phase started in FY 2022-23. CAFE Norms for passenger vehicles aim to reduce overall fuel consumption. These norms, coupled with standards for heavy-duty and light commercial vehicles introduced in 2017 and 2019, respectively, have led to significant avoidance of emissions.

Green National Highways Corridor Project (GNHCP)

This project targets economic policy, human development, urban and rural development, and environmental management. The project's success indicators include enhancing natural resource efficiency, reducing construction emissions, and implementing green technologies over 2,500 kilometres of highways. The Project is being implemented by the National Highways Authority of India (NHAI), Ministry of Road Transport and Highways, Government of India.

National Electric Mobility Mission Plan (NEMMP)

Launched in 2013 by the Ministry of Heavy Industries, the National Electric Mobility Mission Plan (NEMMP) 2020 aims to achieve national fuel security by promoting hybrid and electric vehicles in the country. The government aims to provide fiscal and monetary incentives to kick-start this nascent technology.

Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME)

FAME India Scheme incentivizes the adoption of electric vehicles across various segments. Phase II of FAME, launched in April 2019 with a budget of INR 10,000 Crores, supports the electrification of public and shared transport, including subsidizing e-buses, e-three-wheelers, e-passenger cars, and e-two-wheelers, alongside developing charging infrastructure to alleviate range anxiety among electric vehicle users. FAME-I encouraged electric and hybrid vehicle purchase by providing financial support. FAME-II focused on the electrification of public transport infrastructure and charging. This scheme is being implemented by the Ministry of Heavy Industries

Expansion of Metro Networks

Metro Rail development continues to expand, with 700 kilometres of operational track in 18 cities and 900 kilometres under construction across 27 cities. Innovations such as 'Metrolite' and 'Metro Neo' cater to varying city transit needs, serving as standalone systems and feeders to high-capacity metro networks. Several metro projects have registered/applied for Green House Gas (GHG) emission under two platforms viz. Clean Development Mechanism (CDM) under UNFCCC and the Gold Standard Registry (GS) to demonstrate emission reduction. The Committee have been apprised that Delhi metro has earned 4.4 million carbon credits from CDM and GS projects. Bhopal and Indore metros are being planned/designed according to the India Green Building council (IGBC) Platinum Rating leading to Carbon Credits in due course.

Ethanol Blended Petrol Programme

The Ethanol Blended Petrol program being implemented by the Ministry of Petroleum and Natural Gas aims to boost biofuel usage in India by blending different types of biofuels with petrol. The "National Policy on Biofuels" of 2018 and 2022 amendments set targets to achieve 20% ethanol blending in petrol and 5% biodiesel blending in diesel by 2030. Efforts have intensified, and it's projected that 20% ethanol blending in petrol will be reached by 2025-26.

Initiatives in the Indian Railways

Indian Railways has undertaken several initiatives aimed at mitigating climate change by enhancing energy efficiency and promoting sustainable practices. The adoption of advanced three-phase locomotive technology, along with systems like Auxiliary Power Units (APUs), Computerized Fuel Management Systems, and the head-on Generation (HOG) system, has significantly reduced diesel consumption and energy wastage. Notably, regenerative braking in locomotives allows energy generated during braking to be fed back into the grid, contributing to overall energy conservation. A major step toward energy efficiency has been the implementation of 100% LED lighting across all railway stations and within coaches, reducing the carbon footprint of railway operations. The development of Dedicated Freight Corridors along the Eastern and Western routes is not only enhancing freight capacity but also shifting cargo from road to rail, which is a more energy-efficient mode of transport. In addition, Indian Railways is promoting the use of alternative fuels through biodiesel blending programs and the deployment of CNG/LNG-based dual-fuel engines in DEMU trains. Solar energy is also being harnessed through the installation of solar panels on select trains.

2.5.4 Policies and Measures in the Waste Sector

Atal Mission for Rejuvenation and Urban Transformation (AMRUT)

AMRUT, being implemented by the Ministry of Housing & Urban Affairs, aims to enhance the quality of life, particularly for the poor and disadvantaged, by providing essential civic amenities such as water supply, sewerage, urban transport, and parks. Launched in June 2015 as the first national urban water-focused mission, AMRUT focuses on infrastructure development to improve citizen services. AMRUT 2.0, introduced on October 1, 2021, aims to make cities 'Aatma Nirbhar' (self-reliant) and 'water secure'. by extending universal water supply coverage and achieving 100% sewerage and septage management in 500 AMRUT cities.

Swachh Bharat Mission (SBM) – Rural

Launched in 2014 by the Ministry of Jal Shakti, Government of India, SBM is the world's largest sanitation initiative aimed at achieving an Open Defecation Free India. The programme led to the construction of over 10 crore individual household toilets, taking sanitation coverage from 39% in 2014 to 100% in 2019, when around 6 lakh villages declared themselves Open Defecation Free (ODF). As a significant milestone, 75% of villages are now ODF Plus under Swachh Bharat Mission - Rural.

Swachh Bharat Mission (SBM) – Urban

The SBM (Urban) aims to achieve three main objectives: (a) Attaining 100% Open Defecation Free (ODF) status, (b) Ensuring 100% scientific Solid Waste Management (SWM), and (c) Behaviour change through 'Jan Andolan' in all statutory towns. It is being implemented by the Ministry of Housing & Urban Affairs.

Programme on Energy from Urban, Industrial and Agricultural Wastes/Residues

The National Bioenergy Programme, launched in 2022 by the Ministry of New and Renewable Energy, includes three sub-themes: (i) Waste to Energy Programme (Programme on Energy from Urban, Industrial, and Agricultural Wastes/ Residues); (ii) Biomass Programme (Scheme to support Manufacturing of Briquettes & Pellets and Promotion of Biomass (non-bagasse) based cogeneration in Industries; and (iii) Biogas Programme: for promotion of family type Biogas plants. This program aligns with other government initiatives such as the Galvanizing Organic Bio-Agro Resources Dhan scheme of Department of Drinking Water and Sanitation, and the Sustainable Alternative Towards Affordable Transportation (SATAT) of Ministry of Petroleum and Natural Gas (MoPNG). It's goal is to enhance the production and availability of Compressed Bio-gas (CBG) as an alternative clean fuel for cooking and transportation.

2.5.5 Policies and Measures in the Buildings Sector

National Mission for Sustainable Habitat (NMSH)

Executed by the Ministry of Housing and Urban Affairs, the objective of NMSH is to mitigate and adapt to climate change within the built environment, encompassing sectors such as buildings, waste management, and transportation. One of its pivotal goals is to enhance energy efficiency in buildings by expanding the reach of the Energy Conservation Building Code (ECBC), which focuses on optimizing energy demand in new and large commercial buildings. NMSH operates through four flagship missions, namely the Atal Mission on Rejuvenation and Urban Transformation (AMRUT), Swachh Bharat Mission, Smart Cities Mission, and Urban Transport Programme.

Energy Conservation Building Code (ECBC)

The ECBC serves as a regulatory instrument aimed at monitoring the energy footprint within commercial buildings in India. Initiated by the Bureau of Energy Efficiency (BEE) in 2007, it sets minimum energy performance standards. In June 2017, the ECBC 2017 was introduced, encompassing both existing and forward-looking advancements in building technology and aiming to reduce energy consumption while promoting low-carbon growth going beyond the provisions outlined in ECBC 2007. An ECBC compliant building is one with minimum level of energy efficiency of 20% compared to a standard baseline. Buildings achieving energy efficiency levels of 30-35% are designated as ECBC Plus, while those achieving 40-45% are labelled Super ECBC Buildings.

Building Energy Efficiency Programme (BEEP)

Launched in 2017 by the Energy Efficiency Services Limited (EESL), Ministry of Power, BEEP aims to retrofit existing public, institutional, and industrial buildings with energy-efficient appliances and systems. Focused interventions primarily centers on lighting and air-conditioning systems, with initiatives including the retrofitting of energy-efficient ceiling fans, air conditioners, and LED lights.

Star Rating System for Commercial Buildings

Initiated by the Bureau of Energy Efficiency (BEE), the Star Rating Scheme for commercial buildings in India aims to promote energy efficiency measures. It categorizes buildings into four types: office buildings, business process outsourcing (BPO) centers, shopping malls, and hospitals, rating them based on their Energy Performance Index (EPI).

Eco Niwas Samhita (ENS) for Residential Buildings

The ENS, an ECBC tailored for residential buildings, was launched in 2018 by the Ministry of Power. It aims to enhance the energy efficiency of residential building design and construction, leading to reduced electricity consumption over their lifecycle. The code applies to all residential structures, including those within mixed-use developments, built on plots exceeding 500sqm. However, in 2024 BEE has published Energy Conservation and Sustainable Building Code (ECSBC), replacing ECBC.

Residential labeling programme

The Residential Labeling Program addresses the rising energy consumption in India's residential sector by promoting the construction of energy-efficient homes. Launched by the Ministry of Power on December 14, 2018, through EcoNiwas Samhita (ENS) 2018, the program sets minimum energy performance standards and encourages energy-efficient building designs.

Pradhan Mantri Awas Yojana – Urban (PMAY-U) and Pradhan Mantri Awas Yojana – Grameen (PMAY-G)

PMAY-U is a central government initiative launched in 2015 to address urban housing shortages. PMAY-G targeting rural housing promotes locally appropriate technologies and designs for rural housing construction. It is being implemented by the Ministry of Housing & Urban Affairs and the Ministry of Rural Development.

Standards and Labeling Programme (S&L)

Initiated in 2006, the Standards and Labelling (S&L) Programme is a key focus area for Bureau for Energy Efficiency. It sets energy performance standards for appliances and rates their efficiency on a scale of 1 to 5 stars.

Pradhan Mantri Ujjwala Yojana

Launched in May 2016 by the Ministry of Petroleum and Natural Gas, the scheme aims to provide LPG—a clean and sustainable cooking fuel — to rural and economically disadvantaged households that traditionally rely on fuels like firewood, coal, and cow dung cakes, which are harmful to health and the environment. The scheme initially targeted releasing eight crore LPG connections by March 2020. Ujjwala 2.0 introduced an additional 1.6 crore LPG connections, particularly benefiting migrant households. The Government of India has further approved the release of 75 lakh more connections, raising the overall target to 10.35 crore connections, which are currently being distributed.

Indian Green Building Council (IGBC)

The Indian Green Building Council (IGBC), part of the Confederation of Indian Industry (CII), offers diverse services, including developing new green building rating programs, certification services, and training programs. Various stakeholders participate in IGBC activities, fostering a sustainable built environment locally through policy advocacy, capacity building, networking, and awareness programs. The IGBC's green building rating programs have resulted in significant benefits, including 30-40% energy cost savings and 20-30% water consumption savings per million square feet per year of built space.

Green Rating for Integrated Habitat Assessment (GRIHA)

GRIHA is a green building rating system developed independently in India by The Energy and Resources Institute, in collaboration with the Ministry for New and Renewable Energy, Government of India. Adopted as the national rating system for Green Buildings in India in 2007, GRIHA rates buildings based on their Energy Performance Index using 31 criteria.

2.5.6 Policies and Measures in the Forestry Sector

National Forest Policy and the Forest (Conservation) Act, 1980, Forest (Conservation) Amendment Act, 2023

The Forest (Conservation) Act, 1980, reflects the nation's commitment to preserving its forest and wildlife resources. Since its enactment, the annual rate of forest land diversion for non-forest purposes has decreased significantly. Mitigative measures such as compensatory afforestation, Net Present Value realization, and wildlife conservation plans have been implemented for the 1.2 million hectares of forest land diverted post-enactment. The Forest (Conservation) Amendment Act, 2023, aims to clarify the application of the Act across different land types, promote plantation on non-forest land, and enhance forest productivity to fulfil national and international commitments regarding NDCs and carbon neutrality.

Compensatory Afforestation Fund and Compensatory Afforestation Management and Planning Authority (CAMPA)

The Compensatory Afforestation Fund Management and Planning Authority (CAMPA) is meant to promote afforestation and regeneration activities as a way of compensating for forest land diverted to non-forest uses. Under CAMPA, significant plantation efforts have been conducted across both non-forest and degraded forest lands.

National Mission for Green India

The National Mission for Green India (GIM) is one of the eight Missions outlined under the National Action Plan on Climate Change (NAPCC). It aims at protecting; restoring and enhancing India's diminishing forest cover and responding to climate change by a combination of adaptation and mitigation measures. The goals of this Mission are: To increase forest/tree cover to the extent of 5 million hectares (mha) and improve quality of forest/tree cover on another 5 mha of forest/non-forest lands; To improve/enhance eco-system services like carbon sequestration and storage (in forests and other ecosystems), hydrological services and biodiversity; along with provisioning services like fuel, fodder, and timber and non-timber forest produces (NTFPs); To increase forest based livelihood income of about 3 million households.

National Afforestation Program

The objective of the National Afforestation Programme (NAfP) scheme is ecological restoration of degraded forests and to develop the forest resources with people's participation, with a focus on improvement in the livelihoods of the forest-fringe communities, especially the poor. The plantation species under the schemes is selected by the implementing agencies/the members of Joint Forest Management Committees (JFMC) on the basis of their needs, ecological conditions and other local factors in consultation with the Forest Department. The native forest species are encouraged for plantation in the forest areas giving importance to trees with multiple uses. NAfP is a centrally sponsored scheme which is implemented with the fund sharing pattern of 60: 40 percent between Centre and States wherein the sharing pattern for Northeastern and hilly States is 90:10. The latest India State of Forest Report (ISFR 2023) revealed that the total forest and tree cover of the country is 8,27,356.95

square kilometres (which is 25.17 percent of the geographical area of the country) compared to 7,94,245 sq km (24.16 percent) in ISFR 2015. This is an increase of 33,111.95 sq km of forest and tree cover of the country.

Nagar Van Yojana

Nagar Van Udyan was a pilot scheme that ran from 2015 to 2018, where 46 urban forests were created across 16 states on over 3,663 Ha of land with an expenditure of over INR 50 Crores. On World Environment Day in 2020, the scheme was restructured as Nagar Van Yojana, with an aim of creating 200 Urban forests over the next five years till 2024-2025. These forests will range in area from a minimum 10 Ha up to 50 Ha. Preference will be given to proposals that entail rejuvenation of degraded forest lands within city limits or on their fringes. Every year, 40 such urban forests are envisaged to be developed.

Mangrove Initiative for Shoreline Habitats and Tangible Income (MISHTI)

MISHTI was announced in the Union Budget 2023-24 to promote and conserve mangroves. Mangroves are unique, natural eco-system having very high biological productivity and carbon sequestration potential, besides working as a bio-shield. The Programme will cover approximately 540 sq. km area across nine coastal States and four UTs in five years (2023-2028).

2.5.7 Policies and Measures in the Agriculture Sector

System of Rice Intensification (SRI)

The SRI is included in the National Food Security Mission (NFSM) and Bringing Green Revolution to Eastern India (BGREI) programs. SRI is a promising and resource-saving method of rice cultivation. It is being implemented by the Ministry of Agriculture & Farmers Welfare.

Direct Seeded Rice (DSR)

Direct-seeded rice is one of the most efficient, sustainable, and economically viable rice production systems when compared to the conventional puddled transplanted rice (PTR) method that encourages quicker planting and maturing, conserves scarce resources like water and labor, reduces greenhouse gas emissions that contribute to climate change, and is more conducive to mechanization. The quantum of water application gets reduced significantly and increases savings on irrigation water by 12-35 per cent under efficient water management practices and energy due to reduced quantum of water application. DSR significantly reduces methane emissions, and develop strategies to mitigate increased N_2O emissions under aerobic conditions, ensuring a safer environment. It is being implemented by the Ministry of Agriculture & Farmers Welfare.

Crop Diversification Programme (CDP)

The goal of this programme is to divert the cultivation area from water-intensive paddy to alternative crops such as pulses, oilseeds, coarse/nutri cereals, cotton, and agroforestry, with the objective of addressing the issues of declining soil fertility and depleting water table in these states. Under CDP, for replacing paddy crop, assistance is provided for four major interventions viz., alternate crop demonstrations, farm mechanization and value addition, site-specific activities and contingency for awareness, training, monitoring, etc. This enables the reduction of CH_4 emissions associated with paddy production.

Avoiding crop residue burning- Sub-Mission on Agriculture Mechanization (SMAM)

To support the efforts of the Governments of Punjab, Haryana, Uttar Pradesh, and NCT of Delhi in addressing the air pollution caused by stubble burning and to subsidize machinery required for in-situ management of crop residue, a Central Sector Scheme on Crop Residue Management (CRM) was implemented from 2018-19. The scheme promotes the usage of machines such as super straw management systems, happy seeder, super seeder, smart seeder, zero till seed cum fertilizer drill, mulcher, paddy straw chopper, hydraulically reversible mould board plough, crop reapers and reaper binders for in-situ management of crop residue and balers & rakes which are used for straw collection in the form of bales for other ex-situ uses of straw.

Mission for Integrated Development of Horticulture (MIDH)

MIDH is a Centrally Sponsored Scheme that has been implemented since 2014-15 to promote the holistic growth of the horticulture sector covering fruits, vegetables, root & tuber crops, mushrooms, spices, flowers, aromatic plants, coconut, cashew and cocoa. MIDH consists of 5 schemes in horticulture viz. (i) National Horticulture Mission (NHM), (ii) Horticulture Mission for North East and Himalayan States (HMNEH), (iii) National Horticulture Board (NHB), (iv) Coconut Development Board (CDB), (v) Central Institute of Horticulture (CIH), Nagaland. The main objectives of this mission are to encourage the comprehensive development of the horticulture sector, including coconut, through regionally differentiated strategies based on the comparative advantage of each state/region and its diverse agro-climatic features.

Sub-Mission on Agroforestry (SMAF)

This scheme also known as "Har Medh Par Ped" promotes the simultaneous cultivation of trees and crops. The objective of National Agroforestry Policy aims to encourage and expand tree plantation in association with crops and livestock to improve productivity, employment, income and livelihoods of rural households, especially the small and marginal farmers; to ensure availability of quality planting material like seeds, seedlings, clones, hybrids, improved varieties, etc.; to popularize various agroforestry practices/models suitable to different agro-ecological regions and land use conditions; to create database, information and knowledge support in the area of agroforestry; and to provide extension and capacity building support to agroforestry sector. The scheme facilitates planting of selected tree species in States that have relaxed transit regulations for such trees. The major objective is to create an additional source of income for farmers and contribute to carbon sequestration.

National Bamboo Mission (NBM)

The restructured NBM was launched in 2018-19 with an aim to develop the complete value chain of the bamboo sector to link growers with consumers starting from planting material, plantation, creation of facilities for collection, aggregation, processing, marketing, micro, small and medium enterprises, skill development and brand building initiative in a cluster approach mode. The objectives of the NBM include increasing the area under bamboo plantation in non-forest Government and private lands, supplement farm income, meet the raw material requirement of industries, increase the green cover and enhance the carbon sequestration potential.

Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) – Per Drop More Crop (PMKSY-PDMC)

PMKSY aims to improve on-farm water use efficiency, enhance the adoption of precision irrigation and other water saving technologies (more crop per drop) and enhance the recharge of aquifers. PMKSY- PDMC mainly focuses on enhancing water use efficiency at farm level through precision/micro-irrigation (drip and sprinkler irrigation) systems. Micro-irrigation helps in water saving as well as reduced fertilizer usage through fertigation, labour expenses, other input costs and overall income enhancement of farmers. The PDMC also promotes activities such as micro level water harvesting/ storage viz., farm pond, secondary storage structure, construction of tube wells / bore wells (shallow / medium), restoration / renovation of small tank, recharge of defunct bore well etc. These activities are to be mandatorily linked with micro-irrigation to make potential use of the available water for higher water use efficiency.

Solarization of Agriculture - Pradhan Mantri Kisan Urja Suraksha Evam Utthan Mahabhiyan (PM-KUSUM)

PM-KUSUM scheme aims for de-dieselization of the farm sector, providing water and energy security to farmers, increasing the income of farmers, and curbing environmental pollution. The scheme has three components targeted to achieve solar power capacity addition of 34.8 GW by 31.3.2026 with total central financial support of Rs. 34,422 Cr. Component A involves setting up 10,000 MW of decentralized ground/stilt-mounted solar power plants on barren/fallow/pasture/marshy/cultivable land of farmers. Installation of 14 lakh stand-alone solar pumps in off-grid areas through component B and solarization of 35 lakh grid-connected agriculture pumps through individual pump solarization and feeder-level solarization through component C. The scheme involves the replacement of diesel pumps with solar pumps and panels that would result in daytime reliable power for irrigation, enhancing farmers' income by selling surplus solar power at pre-determined rates to DISCOMS and reducing the electricity subsidy burden of the state/DISCOMs.

Neem Coated Urea

The Government of India, since 2016, has made it mandatory to manufacture 100% neem coated urea as it has higher nitrogen use efficiency and lower loss of nitrogen due to inhibition of nitrification process in soil compared to prilled urea.

Agriculture Demand Side Management (AgDSM)

The AgDSM initiative encompasses strategies and policies designed to alter power consumption behaviors among consumers, particularly farmers. All AgDSM projects in India prioritize the substitution of inefficient agricultural pump sets with BEE star-rated energy-efficient models, while also promoting awareness about the benefits of using energy efficient pumps. In addition to increased energy usage, the current pump sets indirectly contribute to groundwater wastage, as farmers presently lack incentives to monitor or adjust the pump operation based on the actual water demand for irrigating crops, wherein AgDSM emerges as an appealing choice to curb both water and energy wastage in the agricultural sector. This program ensures energy efficiency in agricultural demand management by reducing overall power consumption, enhancing groundwater extraction efficiency, alleviating subsidy burdens on state utilities, and steering clear of additional investments in power plants. Energy Efficiency Services Limited (EESL) under the aegis AgDSM, is implementing the Energy Efficient Pump Program to distribute BEE 5-star energy efficient agricultural pumps and ensures a minimum of 30% reduction in energy consumption with smart control panels which can be remotely operated to enhance the ease of operation of pumps by the farmers.

Balanced Ration for Livestock

Implemented by the Ministry of Fisheries, Animal Husbandry and Dairying, the main objective of the Ration Balancing Programme (RBP) is to produce an optimum quantity of milk at the least cost from milch animals by readjusting, wherever required, the proportion of locally available dietary feed ingredients, so as to provide them adequate amounts of proteins, minerals, vitamins as well as energy. The benefits of RBP include an increase in milk production with more fat and solids-not-fat, net daily income, reproduction efficiency, growth rate in calves leading to early maturity, general health of animals, and reduced inter-calving period, thereby increasing the productive life of animals. Various agencies such as dairy cooperatives, service-providing organizations, and NGOs can implement this programme.

Feeding bypass proteins

Bypass protein is a protein that is not degraded by rumen microbes. By bypassing the rumen, more metabolizable protein is made available to help the milch animals meet their amino acid requirements for milk production. By feeding high-quality bypass protein, dairy producers can increase their metabolizable protein yield and reduce the amount of crude protein in the diet, thus reducing ammonia volatilization and nitrogen excretion. It also helps to control salmonella and reduce the mold growth when used with cattle feed. In India, crop residues that form the bulk of feed resources are of inferior quality with more degradable protein which results in lower production and higher GHG emissions. Commercial bypass protein supplements are available with different seed meals and these bypass proteins reduce the degradability in the rumen. The main purpose of establishment of bypass protein units is to improve the availability of the protein and essential amino acids from feed to cattle. This scheme is implemented by the Ministry of Fisheries, Animal Husbandry and Dairying.

2.5.8 Policies and Measures in the Water Sector

Jal Jeevan Mission (JJM)

The Ministry of Jal Shakti, Government of India, in collaboration with the states, is executing the Jal Jeevan Mission (JJM) with the aim of ensuring tap water access to every rural household in the country by 2024. The Jal Jeevan Mission will be based on a community approach to water and will include extensive Information, Education and communication as a key component of the mission. JJM seeks to foster a grassroots movement for water, making it a universal priority. The components supported under JJM include developing in-village piped water supply infrastructure to connect every rural household, establishing reliable drinking water sources or enhancing existing ones for long-term sustainability, implementing bulk water transfer, treatment plants, and distribution networks to cater to every rural household, introducing technological solutions to address water quality issues, and retrofitting completed and ongoing projects to provide Functional Household Tap Connections (FHTCs) at a minimum service level of 55 lpcd, along with managing greywater.

There are various other schemes that support the water sector; however, many of these are cross-cutting in nature and have already been discussed in earlier sections. Examples include initiatives such as "Per Drop More Crop," which focus on efficient water use in agriculture and other related areas.

2.6 Summary of GHG Emissions and Removals

According to the MPGs, each Party that submits a stand-alone national inventory report shall provide a summary of its GHG emissions and removals in a tabular format. According to decision 5/CMA.3, the CTF table 6 should be in accordance with the common reporting table 10. The summary of GHG Emissions and Removals is provided in CTF 6 of the Appendix II. For more details on the trends in greenhouse gas emissions and removals, please refer to Chapter 2 of NID of BTR-1.

2.7 Projections of GHG Emissions and Removals

Since India's NDC goals are not linked to any Business-as-Usual (BAU) projections, reporting projections of GHG emissions and removals is not mandatory. India has an economy-wide NDC goal to reduce the GHG emissions intensity of GDP by 45% by 2030, compared to 2005 levels. Projections for this goal are provided in this section. All other NDC goals are either sectoral or qualitative. Therefore, projections for other NDC goals have not been provided, as trends for indicators used to measure these goals are subject to impact due to overall macro-economic trends as well as global developments, which introduces a significant amount of uncertainty in projections. As these uncertainties may also impact projections for indicators used to measure the emissions intensity goal, we only provide projections for the 'With Existing Measures' (WEM) scenario.

Due to capacity constraints, India has availed the "Flexibility (FX)" provision for providing the projections of GHG emissions and removals until 2030 (end year of India's updated NDC) under "With Measures" scenario in CTF-7 of BTR-1.

Methodology used for projections of GHG emissions and removals

Projection of GHG emissions and removals for the WEM scenario has been estimated using estimates of GDP at constant prices for the base year 2011-12, sourced from the Economic Survey 2024-2025, Ministry of Finance (MoF, 2025). GDP growth rates for future years, i.e., from 2022 to 2030, for the baseline scenario were provided by the Department of Economic Affairs, Ministry of Finance. The growth rates for GHG emissions (both with and without GHG removals from LULUCF) were estimated by taking the annual average growth rate from 2005 to 2022.

The reduction in GHG emissions intensity of GDP by 2030 relative to the 2005 level was projected for the WEM scenario (baseline GDP growth rate), as shown in Table 2.6 and Figure 2.4.

Table 2.6:WEM scenario and description for projections of GHG emission and GDP by 2030 from 2005 base year

Scenario	Scenario description and rationale	GDP growth rate	Scenario Description	Annual average growth in GDP	Annual average growth in total GHG emissions from 2005 - 2022
WEM	This scenario assumes that current levels of GDP and GHG emissions decoupling will hold and continue in the future based on policies and measures which are already being implemented and will continue till 2030.	Baseline	GDP growth rates for the future projection were provided by DEA, Ministry of Finance for baseline growth rate. The growth rate for each GHG inventory sector was either based on past trends (CAGR) or assumed as per expert judgement.	7%	3.39% (with LULUCF) & 3.80% (without LULUCF)

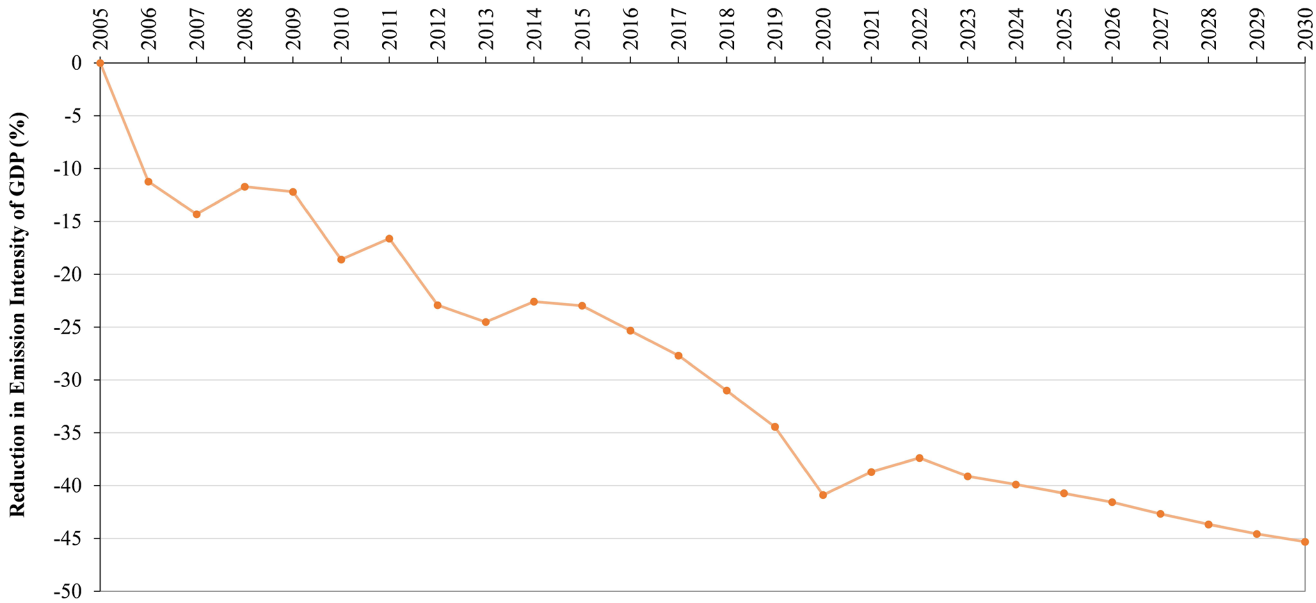

Figure 2.4: Projection of reduction in GHG Emissions Intensity of GDP by 2030 from 2005 level for WEM scenario

The analysis from WEM scenario presented in Table 2.6 and Figure 2.4 shows that India's emissions intensity of GDP is projected to reduce significantly by 2030 from 2005 levels due to the implementation of current policies and measures. India is therefore well on track to achieve its NDC goal 3 of reducing its emissions intensity of GDP by 2030 (refer to Table 2.7).

Table 2.7: Emissions Intensity of GDP (tCO_2e/INR Million) for 2005, 2021, 2022 and 2030

Emissions Intensity of GDP (tCO_2e/INR Million at 2011-12 constant price) & its reduction (%) relative to the base year 2005				
Scenario	**2005**	**2021**	**2022**	**2030**
WEM	23.283	14.270	14.580	12.732
Reduction target	-	-38.71%	-37.38%	-45.32%

India's GHG emissions have increased at an average growth rate of about 3.80% (without emission sink/removal from LULUCF) and 3.39% (with emission sink/removal from LULUCF) between 2005 and 2022. GHG emission projections were estimated for each of the GHG inventory sectors i.e. Energy, IPPU, Agriculture, LULUCF and Waste through past growth trends and using expert opinion. For the WEM scenario (excluding emissions from agriculture sector), GHG emissions in 2030 is projected to be 4.21 $GtCO_2e$ (without emission removal from LULUCF) and 3.60 $GtCO_2e$ (with emission removal from LULUCF). Figure 2.5 shows India's GHG emissions from 2005-2022 and its projection from 2023-2030 for WEM scenario (excluding agriculture emissions) both with and without LULUCF sector emissions.

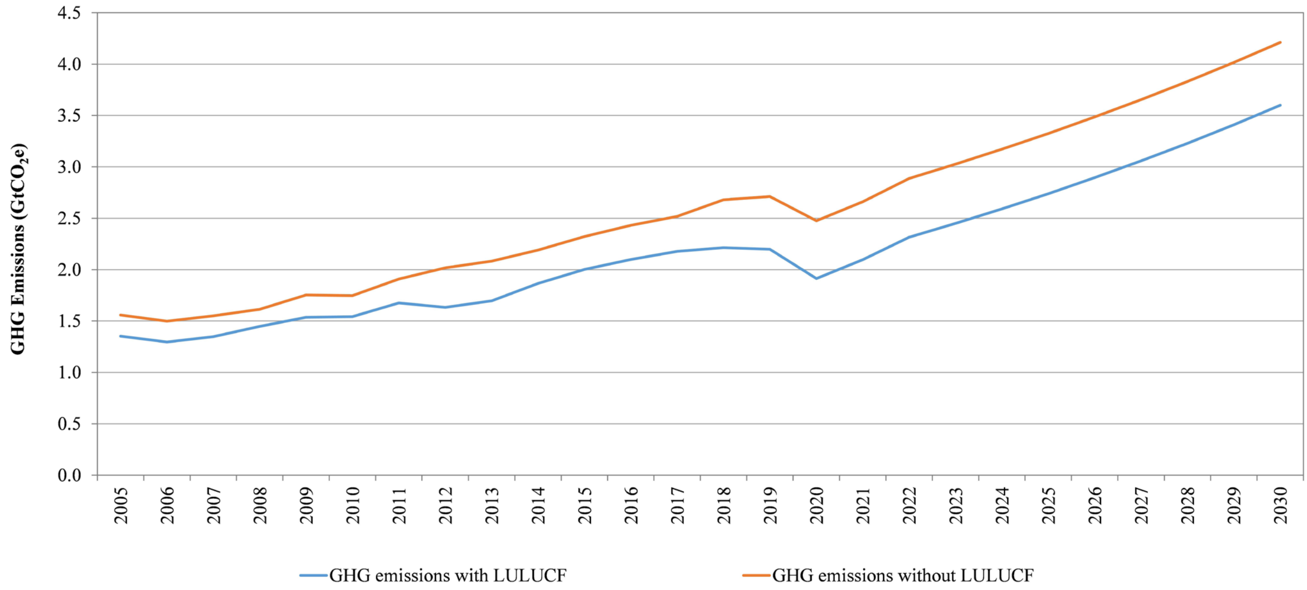

Figure 2.5: India's GHG emissions (2005-2022) and its projection (2023-2030) for the WEM scenario, excluding agriculture emissions and with/without LULUCF emissions.

Appendix II: Common Tabular Formats (CTFs)

Table A1.1: Description of NDC Goal 3

1	Targets description	45% reduction of emissions intensity of GDP by 2030 from 2005 levels; This is the ratio of India's GHG emissions to GDP in any given year.
2	Target years or periods	The goal year is 2030. This is a single year goal.
3	Reference points/Base Year	The base year is 2005.
4	Time frames	1 January 2005 to 31 December 2030
5	Scope and coverage	The total greenhouse gas emissions for India (covering all gases) excluding emissions from the agriculture sector, for a given year.
6	ITMOs to be used or not	No
7	Updates/clarifications	NA

Table A1.2: Description of NDC Goal 4

1	Targets description	Approximately 50% of installed power capacity from non-fossil fuel sources by 2030
2	Target years or periods	The goal year is 2030. This is a single year goal.
3	Reference points/Base Year	While this target measures achievement against a future state (2030 total capacity), progress tracking uses annual installed capacity data from non-fossil sources as a proportion of total installed capacity. The indicator allows transparent assessment of implementation without requiring a historical baseline, consistent with the nature of capacity expansion targets in the power sector.
4	Time frames	Target date is 31 December 2030
5	Scope and coverage	The goal is specific to the power sector. Non-fossil fuel sources of power generation include power generation from solar, wind, biomass, hydro power, nuclear and other renewable energy sources such as geothermal, ocean, tidal etc. but exclude coal, lignite, gas, and diesel-based power generation.
6	ITMOs to be used or not	No
7	Updates/clarifications	Achievement of this goal is conditional upon adequate provision of technology transfer and access to low-cost international finance, including from the Green Climate Fund, consistent with Article 4, paragraph 5 of the Paris Agreement, which recognizes that peaking of emissions will take longer for developing country parties. This conditionality reflects the principle that developing countries require enhanced support to pursue ambitious climate action while addressing developmental priorities and achieving fair and equitable contribution to global climate goals.

Table A1.3: Description of NDC Goal 5

1	Targets description	To create an additional carbon sink of 2.5 to 3 billion tonnes of CO_2 equivalent through additional forest and tree cover by 2030.
2	Target years or periods	The target year is 2030.
3	Reference points/Base Year	The reference point is the carbon sink level in 2005. The target measures the additional carbon sink created over and above this starting point
4	Time frames	Target date is 31 December 2030

5	Scope and coverage	The goal is specific to the forestry sector. An additional carbon sink could be created through additional forest and tree cover in the country
6	ITMOs to be used or not	No
7	Updates/clarifications	NA

CTF 1: Structured summary: Description of selected indicators

Indicator(s) selected to track progress[a]	Description
{Indicator}	
Emissions Intensity of GDP (GHG/GDP)	This is the ratio of emissions to GDP. It is calculated as the mathematical product of (Energy Intensity of GDP) and (Emissions Intensity of Energy). i.e. Emissions/GDP = (Energy/GDP) * (Emissions/Energy)
Information for the reference point(s), level(s), baseline(s), base year(s) or starting point(s), as appropriate[b]	2005
Updates in accordance with any recalculation of the GHG inventory, as appropriate[b]	NA
Relation to NDC[c]	NDC Goal 3: Reduce Emissions Intensity of its GDP by 45 percent by 2030, from 2005 level
Cumulative electric power installed capacity from non-fossil fuel-based energy resources	The indicator used for assessing this target is installed capacity from non-fossil fuel sources (solar, wind, biomass/ cogeneration, waste to energy, small and large hydro power and nuclear power) as a proportion of total power installed capacity.
Information for the reference point(s), level(s), baseline(s), base year(s) or starting point(s), as appropriate[b]	NA
Updates in accordance with any recalculation of the GHG inventory, as appropriate	NA
Relation to NDC[c]	NDC Goal 4: To achieve about 50 percent cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030, with the help of transfer of technology and low-cost international finance including from Green Climate Fund (GCF).
Additional carbon sink	It includes contributions from forest cover and trees outside forests, with carbon sequestration measured cumulatively from 2005 up to the target year, 2030.
Information for the reference point(s), level(s), baseline(s), base year(s) or starting point(s), as appropriate[b]	2005
Updates in accordance with any recalculation of the GHG inventory, as appropriate[b]	NA
Relation to NDC[c]	NDC Goal 5: To create an additional carbon sink of 2.5 to 3 billion tonnes of CO_2 equivalent through additional forest and tree cover by 2030.

Notes:

(1) Pursuant to para. 79 of the MPGs, each Party shall report the information referred to in paras. 65–78 of the MPGs in a narrative and common tabular format, as applicable.

(2) A Party may amend the reporting format (e.g. Excel file) to remove specific rows in this table if the information to be provided in those rows is not applicable to the Party's NDC under Article 4 of the Paris Agreement, in accordance with the MPGs. (3) The Party could add rows for each additional selected indicator and related information.

a. Each Party shall identify the indicator(s) that it has selected to track progress of its NDC (para. 65 of the MPGs).

b. Each Party shall provide the information for each selected indicator for the reference point(s), level(s), baseline(s), base year(s) or starting point(s), and shall update the information in accordance with any recalculation of the GHG inventory, as appropriate (para. 67 of the MPG

c. Each Party shall describe for each indicator identified how it is related to its NDC (para. 76(a) of the MPGs).

CTF 2: Structured summary: Definitions needed to understand NDC

	Definitions[a]
Definition needed to understand each indicator:	
{Indicator}	
Emissions Intensity of GDP (GHG/GDP)	It is the ratio of GHG emissions to GDP is calculated as the mathematical product of (Energy Intensity of GDP) and (Emissions Intensity of Energy). i.e. Emissions/GDP = (Energy/GDP) * (Emissions/Energy)
Any sector or category defined differently than in the national inventory report:	
{Sector}	NA
{Category}	NA
Definition needed to understand mitigation cobenefits of adaptation actions and/or economic diversification plans:	
{Mitigation co-benefit(s)}	NA
Any other relevant definitions:	NA
Cumulative electric power installed capacity from non-fossil fuel-based energy resources	It is the ratio (%) of cumulative installed capacity of electric power from non-fossil fuel-based energy resources which includes total installed capacity of renewable energy sources (solar, wind, Biomass, small hydro) including large hydro power and nuclear power to total installed capacity of electric power from all energy resources (both fossil and non-fossil fuel energy sources)
Any sector or category defined differently than in the national inventory report:	
{Sector}	NA
{Category}	NA
Definition needed to understand mitigation cobenefits of adaptation actions and/or economic diversification plans:	
{Mitigation co-benefit(s)}	NA
Any other relevant definitions:	NA
{Indicator}	
Additional carbon sink of 2.5 to 3 billion tonnes of CO_2e	This indicator includes contributions from forest cover and trees outside forests, with carbon sequestration measured cumulatively from 2005 up to the target year, 2030.
Any sector or category defined differently than in the national inventory report:	
{Sector}	NA
{Category}	NA
Definition needed to understand mitigation cobenefits of adaptation actions and/or economic diversification plans:	
{Mitigation co-benefit(s)}	NA
Any other relevant definitions:	NA

Notes:

(1) Pursuant to para. 79 of the MPGs, each Party shall report the information referred to in paras. 65–78 of the MPGs in a narrative and common tabular format, as applicable.

(2) A Party may amend the reporting format (e.g. Excel file) to remove specific rows in this table if the information to be provided in those rows is not applicable to the Party's NDC under Article 4 of the Paris Agreement, in accordance with the MPGs.

(3) The Party could add rows for each additional sector, category, mitigation co-benefits of adaptation actions and/or economic diversification plans, indicator and any other relevant definitions.

a. Each Party shall provide any definitions needed to understand its NDC under Article 4, including those related to each indicator identified in para. 65 of the MPGs, those related to any sectors or categories defined differently than in the national inventory report, or the mitigation co-benefits of adaptation actions and/or economic diversification plans (para. 73 of the MPGs).

CTF 3: Structured summary: Methodologies and accounting approaches – consistency with Article 4, paragraphs 13 and 14, of the Paris Agreement and with decision 4/CMA.1

Reporting requirement	Description or reference to the relevant section of the BTR
For the First NDC under Article 4:[a]	
Accounting approach, including how it is consistent with Article 4, paragraphs 13–14, of the Paris Agreement (para. 71 of the MPGs)	India's first NDC accounting approach ensures environmental integrity through the use of IPCC-assessed methodologies, maintains transparency through comprehensive reporting of all relevant emissions data, ensures completeness by covering all anthropogenic emissions within the NDC scope, and avoids double counting by using consistent national inventory data. This approach is consistent with Article 4, paragraphs 13-14 of the Paris Agreement.
For the second and subsequent NDC under Article 4, and optionally for the first NDC under Article 4:[b]	
Information on the accounting approach used is consistent with paragraphs 13–17 and annex II of decision 4/CMA.1 (para. 72 of the MPGs)	GHG emissions data used to account for the NDC are sourced from the National Inventory Report (NIR), which is prepared following the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. This ensures consistency with the guidance outlined in decision 4/CMA.1.
Explain how the accounting for anthropogenic emissions and removals is in accordance with methodologies and common metrics assessed by the IPCC and in accordance with decision 18/CMA.1 (para. 1(a) of annex II to decision 4/CMA.1)	The preparation of India's GHG inventory, which forms the basis for NDC accounting, is guided by the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Emissions are aggregated using 100-year Global Warming Potential (GWP-100) values from the IPCC's Fifth Assessment Report (AR5), in line with decision 18/CMA.1.
Explain how consistency has been maintained between any GHG data and estimation methodologies used for accounting and the Party's GHG inventory, pursuant to Article 13, paragraph 7(a), of the Paris Agreement, if applicable (para. 2(b) of annex II to decision 4/CMA.1)	GHG emissions data used for NDC accounting are the same values reported in the National Inventory Report. Uniform methodologies, consistent with IPCC guidelines, are applied for both the national GHG inventory and the tracking of NDC targets to ensure there are no inconsistencies.
Explain how overestimation or underestimation has been avoided for any projected emissions and removals used for accounting (para. 2(c) of annex II to decision 4/CMA.1)	Methods used to estimate emissions for projections are identical to the methods used in the GHG inventory and projected forward based on current policy assumptions. Details of projections can be found in section F. Projections of GHG Emissions and Removals of NDC tracking chapter of BTR-1 as applicable. Potential double-counts, zero-counts, and sources of potential over- or underestimations have been identified in the relevant sections in the NIR and the methods used to avoid them are detailed there.
For each NDC under Article 4:[b]	
Accounting for anthropogenic emissions and removals in accordance with methodologies and common metrics assessed by the IPCC and adopted by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement:	
Each methodology and/or accounting approach used to assess the implementation and achievement of the target(s), as applicable (para. 74(a) of the MPGs)	The methodologies for tracking India's three NDC goals are as follows: • Goal 3 (Emissions Intensity): Progress is tracked by calculating the ratio of total GHG emissions (excluding agriculture) from the national inventory to the national Gross Domestic Product (GDP) for a given year. • Goal 4 (Non-Fossil Fuel Capacity): Progress is measured as the percentage of cumulative installed electric power capacity from non-fossil fuel sources relative to the total cumulative installed capacity in a given year. • Goal 5 (Carbon Sink): Progress is assessed by estimating the cumulative additional carbon sink created through forest and tree

Reporting requirement	Description or reference to the relevant section of the BTR
	cover since 2005, using data and methodologies from the forestry sector.
Each methodology and/or accounting approach used for the construction of any baseline, to the extent possible (para. 74(b) of the MPGs)	The baselines for the NDC goals are constructed as follows: • Goal 3: The baseline is the emissions intensity of GDP recorded for the base year 2005, calculated using the national GHG inventory and GDP data for that year. • Goal 4: A baseline year is not applicable for this goal, as the target is a proportion of the total installed capacity in the target year 2030. • Goal 5: The reference point is the carbon sink level in 2005. The target measures the additional carbon sink created over and above this starting point
If the methodology or accounting approach used for the indicator(s) in table 1 differ from those used to assess the implementation and achievement the target, describe each methodology or accounting approach used to generate the information generated for each indicator in table 4 (para. 74(c) of the MPGs)	The methodology and accounting approach used for the indicator in table 1 and table 4 are consistent.
Any conditions and assumptions relevant to the achievement of the NDC under Article 4, as applicable and available (para. 75(i) of the MPGs)	The achievement of NDC Goal 4 is conditional on the transfer of technology and the availability of and access to low-cost international financing. This support is crucial for developing countries to pursue ambitious climate action, consistent with the principles of equity and common but differentiated responsibilities and respective capabilities (CBDR-RC).
Key parameters, assumptions, definitions, data sources and models used, as applicable and available (para. 75(a) of the MPGs)	Data sources for tracking NDC progress include official government statistics and National GHG inventory compilation processes following QA/QC procedures outlined in the National Inventory Report. Activity data quality ranges from Tier 2-3 depending on sector availability, with continuous efforts to enhance data collection systems.
IPCC Guidelines used, as applicable and available (para. 75(b) of the MPGs)	The 2006 IPCC Guidelines for National Greenhouse Gas Inventories were used.
Report the metrics used, as applicable and available (para. 75(c) of the MPGs)	100-year GWPs listed in table 8.A.1 of the IPCC Fifth Assessment Report (AR5) were used for the GHG emission related target.
For Parties whose NDC cannot be accounted for using methodologies covered by IPCC guidelines, provide information on their own methodology used, including for NDCs, pursuant to Article 4, paragraph 6, of the Paris Agreement, if applicable (para. 1(b) of annex II to decision 4/CMA.1)	NA
Provide information on methodologies used to track progress arising from the implementation of policies and measures, as appropriate (para. 1(d) of annex II to decision 4/CMA.1)	Information used to track progress arising from the implementation of policies and measures in the relevant sectors can be found in the NDC tracking chapter.
Where applicable to its NDC, any sector-, category or activity-specific assumptions, methodologies and approaches consistent with IPCC guidance, taking into account any relevant decision under the Convention, as applicable (para. 75(d) of the MPGs)	For the emission related NDC target, emissions of the gases covered have been calculated based on the 2006 IPCC Guidelines. Detailed sectoral methodologies are provided in the National Inventory Report, Chapter 3 (Energy Sector), Chapter 4 (IPPU), Chapter 5 (Agriculture), Chapter 6 (LULUCF), Chapter 7 (Waste), with tier-level specifications documented in it.

Reporting requirement	Description or reference to the relevant section of the BTR
For Parties that address emissions and subsequent removals from natural disturbances on managed lands, provide detailed information on the approach used and how it is consistent with relevant IPCC guidance, as appropriate, or indicate the relevant section of the national GHG inventory report containing that information (para. 1(e) of annex II to decision 4/CMA.1, para. 75(d)(i) of the MPGs)	NA
For Parties that account for emissions and removals from harvested wood products, provide detailed information on which IPCC approach has been used to estimate emissions and removals (para. 1(f) of annex II to decision 4/CMA.1, para. 75(d)(ii) of the MPGs)	The Production Approach, as prescribed by IPCC guidelines, is used for estimating emissions and removals from harvested wood products. Under this approach, emissions from wood products are accounted for in the year of harvest based on production data, ensuring consistency with international reporting standards while reflecting India's forestry management practices.
For Parties that address the effects of age-class structure in forests, provide detailed information on the approach used and how this is consistent with relevant IPCC guidance, as appropriate (para. 1(g) of annex II to decision 4/CMA.1, para. 75(d)(iii) of the MPGs)	NA
How the Party has drawn on existing methods and guidance established under the Convention and its related legal instruments, as appropriate, if applicable (para. 1(c) of annex II to decision 4/CMA.1)	The emissions of the gases covered have been calculated based on the 2006 IPCC Guidelines. The methodological level ("Tier") used depends on the availability of data in the various sectors. The emissions of the gases covered has been aggregated in terms of global warming potential over a 100-year time horizon (GWP 100), based on the values stipulated in the IPCC's Fifth Assessment Report (AR5).
Any methodologies used to account for mitigation cobenefits of adaptation actions and/or economic diversification plans (para. 75(e) of the MPGs)	NA
Describe how double counting of net GHG emission reductions has been avoided, including in accordance with guidance developed related to Article 6 if relevant (para. 76(d) of the MPGs)	India does not currently plan to use Internationally Transferred Mitigation Outcomes (ITMOs) towards achieving its NDC. Internally, double counting is avoided through a centralized national GHG inventory system that ensures emissions and removals are tracked uniquely across all sectors.
Any other methodologies related to the NDC under Article 4 (para. 75(h) of the MPGs)	NA
Ensuring methodological consistency, including on baselines, between the communication and implementation of NDCs (para. 12(b) of the decision 4/CMA.1):	
Explain how consistency has been maintained in scope and coverage, definitions, data sources, metrics, assumptions and methodological approaches including on baselines, between the communication and implementation of NDCs (para. 2(a) of annex II to decision 4/CMA.1)	The scope and coverage, definitions, data sources, metrics, methodological approaches, and accounting approach reported in this BTR and used to track progress towards implementing and achieving the NDC are the same for each reporting year.
Explain how consistency has been maintained between any GHG data and estimation methodologies used for accounting and the Party's GHG inventory, pursuant to Article 13, paragraph 7(a), of the Paris Agreement, if applicable (para. 2(b) of annex II to decision 4/CMA.1) and explain	GHG emissions used to account for NDC are the values reported in the National Inventory Report. The scope and coverage, definitions, data sources, metrics, methodological approaches, and accounting approach reported in this BTR and used to track progress towards implementing and achieving the NDC are the same for each reporting year.

Reporting requirement	Description or reference to the relevant section of the BTR
methodological inconsistencies with the Party's most recent national inventory report, if applicable (para. 76(c) of the MPGs)	
For Parties that apply technical changes to update reference points, reference levels or projections, the changes should reflect either of the following (para.2(d) of annex II to decision 4/CMA.1):	
Technical changes related to technical corrections to the Party's inventory (para. 2(d)(i) of annex II to decision 4/CMA.1)	No technical changes or methodological updates have been applied during this reporting period. Should technical corrections or accuracy improvements become necessary in future reporting cycles, these will be transparently documented in accordance with paragraph 2(d) and 2(e) of Annex II to Decision 4/CMA.1, ensuring methodological consistency is maintained.
Technical changes related to improvements in accuracy that maintain methodological consistency (para. 2(d)(ii) of annex II to decision 4/CMA.1)	No technical changes or methodological updates have been applied during this reporting period. Should technical corrections or accuracy improvements become necessary in future reporting cycles, these will be transparently documented in accordance with paragraph 2(d) and 2(e) of Annex II to Decision 4/CMA.1, ensuring methodological consistency is maintained.
Explain how any methodological changes and technical updates made during the implementation of their NDC were transparently reported (para. 2(e) of annex II to decision 4/CMA.1)	No technical changes or methodological updates have been applied during this reporting period. Should technical corrections or accuracy improvements become necessary in future reporting cycles, these will be transparently documented in accordance with paragraph 2(d) and 2(e) of Annex II to Decision 4/CMA.1, ensuring methodological consistency is maintained.
Striving to include all categories of anthropogenic emissions or removals in the NDC and, once a source, sink or activity is included, continuing to include it (para. 3 of annex II to decision 4/CMA.1):	
Explain how all categories of anthropogenic emissions and removals corresponding to their NDC were accounted for (para. 3(a) of annex II to decision 4/CMA.1)	NA
Explain how Party is striving to include all categories of anthropogenic emissions and removals in its NDC, and, once a source, sink or activity is included, continue to include it (para. 3(b) of annex II to decision 4/CMA.1)	NA
Provide an explanation of why any categories of anthropogenic emissions or removals are excluded (para. 4 of annex II to decision 4/CMA.1)	NA
Each Party that participates in cooperative approaches that involve the use of ITMOs towards an NDC under Article 4, or authorizes the use of mitigation outcomes for international mitigation purposes other than achievement of its NDC	
Provide information on any methodologies associated with any cooperative approaches that involve the use of ITMOs towards an NDC under Article 4 (para. 75(f) of the MPGs)	NA

Reporting requirement	Description or reference to the relevant section of the BTR
Provide information on how each cooperative approach promotes sustainable development, consistent with decisions adopted by the CMA on Article 6 (para. 77(d)(iv) of the MPGs)	NA
Provide information on how each cooperative approach ensures environmental integrity consistent with decisions adopted by the CMA on Article 6 (para. 77(d)(iv) of the MPGs)	NA
Provide information on how each cooperative approach ensures transparency, including in governance, consistent with decisions adopted by the CMA on Article 6 (para. 77(d)(iv) of the MPGs)	NA
Provide information on how each cooperative approach applies robust accounting to ensure, inter alia, the avoidance of double counting, consistent with decisions adopted by the CMA on Article 6 (para. 77(d)(iv) of the MPGs)	NA
Any other information consistent with decisions adopted by the CMA on reporting under Article 6 (para. 77(d)(iii) of the MPGs)	NA

Notes:

(1) Pursuant to para. 79 of the MPGs, each Party shall report the information referred to in paras. 65–78 of the MPGs in a narrative and common tabular format, as applicable.

(2) A Party may amend the reporting format (e.g. Excel file) to remove specific rows in this table if the information to be provided in those rows is not applicable to the Party's NDC under Article 4 of the Paris Agreement, in accordance with the MPGs.

a. For the first NDC under Article 4, each Party shall clearly indicate and report its accounting approach, including how it is consistent with Article 4, paras. 13–14, of the Paris Agreement (para. 71 of the MPGs)

b. For the second and subsequent NDC under Article 4, each Party shall provide information referred to in chapter III.B and C of the MPGs consistent with decision 4/CMA.1. Each Party shall clearly indicate how its reporting is consistent with decision 4/CMA.1(para. 72 of the MPGs). Each Party may choose to provide information on accounting of its first NDC consistent with decision 4/CMA.1 (para. 71 of the MPGs).

CTF 4: Structured summary: Tracking progress made in implementing and achieving the NDC under Article 4 of the Paris Agreement [a]

	Unit, as applicable	Reference point(s), level(s), baseline(s), base year(s) or starting point(s), as appropriate (paras. 67 and 77(a)(i) of the MPGs)	Implementation period of the NDC covering information for previous reporting years, as applicable, and the most recent year, including the end year or end of period (paras. 68 and 77(a)(ii–iii) of the MPGs)		Goal level[b]	Goal year or period	Progress made towards the NDC, as determined by comparing the most recent information for each selected indicator, including for the end year or end of period, with the reference point(s), level(s), baseline(s), base year(s) or starting point(s) (paras. 69 -70 of the MPGs)
		2005	**2021**	**2022**			
Indicator(s) selected to track progress of the NDC or portion of NDC under Article 4 of the Paris Agreement (paras. 65 and 77(a) of the MPGs):							
Emissions Intensity of GDP (GHG/GDP) Reduction	%	0	- 38.71	- 37.38	- 45.00	2030	India has demonstrated substantial progress in implementing its NDC goal, achieving a -37.38 % reduction in GHG emissions intensity of GDP by 2022 compared to the 2005 baseline. This represents strong pathway toward the 45% reduction target by 2030, indicating strong implementation momentum and effective policy measures.
Increase in cumulative electric power installed capacity from non-fossil fuel-based energy resources	%	33.6%	40.2%	42.5%	50%	2030	India is progressing in implementation of its NDC goal of cumulative electric power installed capacity from non-fossil fuel-based energy resources. In 2022, its cumulative installed capacity of non-fossil electric power was 42.5%.
Additional carbon sink	$BtCO_2e$	0	2.29	2.44	2.5-3.0	2030	India is progressing in implementation of its NDC goal of creating additional carbon sink during the period of 2021-22 since the indicator selected is above its base year 2005. In 2022, its additional carbon sink was 2.44 $BtCO_2e$ above the reference year (2005).
Where applicable, total GHG emissions and removals consistent with the coverage of the NDC (para. 77(b) of the MPGs)	NA	NA	NA	NA	NA	NA	NA

	Unit, as applicable	Reference point(s), level(s), baseline(s), base year(s) or starting point(s), as appropriate (paras. 67 and 77(a)(i) of the MPGs)	Implementation period of the NDC covering information for previous reporting years, as applicable, and the most recent year, including the end year or end of period (paras. 68 and 77(a)(ii–iii) of the MPGs)		Goal level[b]	Goal year or period	Progress made towards the NDC, as determined by comparing the most recent information for each selected indicator, including for the end year or end of period, with the reference point(s), level(s), baseline(s), base year(s) or starting point(s) (paras. 69 -70 of the MPGs)
Contribution from the LULUCF sector for each year of the goal period or target year, if not included in the inventory time series of total net GHG emissions and removals, as applicable (para. 77(c) of the MPGs)	NA	NA	NA	NA	NA	NA	NA
Each Party that participates in cooperative approaches that involve the use of ITMOs towards an NDC under Article 4 of the Paris Agreement, or authorizes the use of mitigation outcomes for international mitigation purposes other than achievement of the NDC, shall provide (para. 77(d) of the MPGs):	NA	NA	NA	NA	NA	NA	NA

Notes:

(1) Pursuant to para. 79 of the MPGs, each Party shall report the information referred to in paras. 65–78 of the MPGs in a narrative and common tabular format, as applicable.

(2) A Party may amend the reporting format (e.g. Excel file) to remove specific rows in this table if the information to be provided in those rows is not applicable to the Party's NDC under Article 4 of the Paris Agreement, in accordance with the MPGs. (3) The Party could add rows for each additional selected indicator.

a. *This table could be used for each NDC target in case Party's NDC has multiple targets.*

b. *Parties may provide information on conditional targets in a documentation box with references to the relevant page in their biennial transparency report.*

CTF 5: Key mitigation policies and measures, actions and plans, including those with mitigation co-benefits resulting from adaptation actions and economic diversification plans, related to implementing and achieving a nationally determined contribution under Article 4 of the Paris Agreement

Sr. No.	Name	Description	Objectives	Type of instrument	Status	Sector(s) affected	Gases affected	Start year of implementation	Implementing entity or entities	Estimates of GHG emission avoided (Mt-CO_2e)		
										Achieved (2021)	Achieved (2022)	Expected (2030)
1	Standards & Labelling (S&L) programme	To help consumers make an informed choice about various energy consuming appliances, in terms of energy savings, that would result based on each appliance's energy efficiency performance.	To reduce the end-use energy consumption of appliances without diminishing the service levels; to create awareness amongst the consumers, to make an informed decision considering the cost-effectiveness & energy performance while purchasing appliances; to monitor and verify energy savings, etc.	Regulatory & Economic	Implemented	Energy	CO_2	2006	Bureau of Energy Efficiency, Ministry of Power, Government of India	55.4	57.9	FX
2	Solar power policy	It emphasizes on reducing the cost of solar generation by extensive R&D, scaling up the project development and enabling policy environment	To create an enabling policy framework to make India a global leader in solar energy and to achieve cumulative 50% of non-fossil power capacity by 2030.	Economic	Implemented	Energy, Power	CO_2	2010	Ministry of New and Renewable Energy, Government of India	55.5	76.9	FX

Sr. No.	Name	Description	Objectives	Type of instrument	Status	Sector(s) affected	Gases affected	Start year of implementation	Implementing entity or entities	Estimates of GHG emission avoided (Mt-CO_2e)		
										Achieved (2021)	Achieved (2022)	Expected (2030)
3	Wind power policy	To promote wind power projects in entire country through private sector investment by providing various fiscal and financial incentives	To catalyse commercialization of grid interactive wind power and to achieve cumulative 50% of non-fossil power capacity by 2030.	Economic	Implemented	Energy, Power	CO_2	2010	Ministry of New and Renewable Energy, Government of India	52.5	57.5	FX
4	Perform Achieve Trade (PAT) scheme	It is a regulatory instrument to reduce Specific Energy Consumption in energy intensive industries, with an associated market-based mechanism to enhance the cost effectiveness through certification of excess energy saving which can be traded.	It is a mechanism for improvements in energy efficiency of energy intensive industries.	Regulatory & Economic	Implemented	Energy, Industry	CO_2	2012	Bureau of Energy Efficiency, Ministry of Power, Government of India	36.9	36.9	FX
5	Other renewables (biomass, bagasse co-generation, small hydro and other)	To promote small hydro, biomass power and bagasse cogeneration in the country.	To provide social and environmental benefits by mitigating air, water, and land pollution apart from providing clean fuels. It will enable to achieve cumulative 50% of non-fossil power capacity by 2030.	Economic	Implemented	Energy, Power	CO_2	2010	Ministry of New and Renewable Energy, Government of India	NE	NE	FX

Sr. No.	Name	Description	Objectives	Type of instrument	Status	Sector(s) affected	Gases affected	Start year of implementation	Implementing entity or entities	Estimates of GHG emission avoided (Mt-CO_2e)		
										Achieved (2021)	Achieved (2022)	Expected (2030)
6	Street Light National Program (SLNP)	Energy Efficiency Services Limited (EESL) replaces the conventional street lights with LEDs at its own costs and the consequent reduction in energy and maintenance cost of the municipality is used to repay EESL over a period of time.	To replace conventional street lights with smart and energy efficient LED street lights across India.	Economic	Implemented	Energy	CO_2	2015	EESL, Ministry of Power, Government of India	NE	NE	FX
7	Adopting supercritical/ ultra-super critical technology for coal-based generation	Enhancing energy efficiency by adopting super critical/ultra super critical technology. Only 1 per cent rise in efficiency reduces CO_2 emission by 2-3 per cent.	To reduce the emission for each kWh of electricity generated	Economic	Implemented	Energy, Power	CO_2	2011	Central Electricity Authority, Ministry of Power, Government of India	NE	NE	FX
8	Reduction in Transmission and Distribution (T & D) losses	By the end of 2013, each of the country's five regional grids was interconnected to operate at a synchronous frequency in an effort to transfer power from generation sources to load centres more efficiently.	To improve the quality, reliability and affordability of power supply to consumers through a financially sustainable and operationally efficient distribution sector by reducing AT & C losses to reach 12–15%.	Economic	Implemented	Energy, Power	CO_2	2008	Central Electricity Authority, Ministry of Power, Government of India	NE	NE	FX

Sr. No.	Name	Description	Objectives	Type of instrument	Status	Sector(s) affected	Gases affected	Start year of implementation	Implementing entity or entities	Estimates of GHG emission avoided (Mt-CO_2e)		
										Achieved (2021)	Achieved (2022)	Expected (2030)
9	Ethanol Blended Petrol (EBP) programme	To increase indigenous production of ethanol through Government's multiple interventions such as: Re-introduction of administered price mechanism; Opening of alternate route for ethanol production; Amendment to Industries Act, 1951; Reduction in GST on ethanol meant for EBP programme from 18% to 5%, etc.	To achieve 10% ethanol blending in petrol by 2021-22 and 20% by 2030. Efforts have intensified, and it's projected that 20% ethanol blending in petrol will be reached by 2025-26.	Regulatory & Economic	Implemented	Energy, Transport	CO_2	2003	Ministry of Petroleum and Natural Gas, Government of India	NE	NE	FX

Notes:

a. *Each Party shall provide information on actions, policies and measures that support the implementation and achievement of its NDC under Article 4 of the Paris Agreement, focusing on those that have the most significant impact on GHG emissions or removals and those impacting key categories in the national GHG inventory. This information shall be presented in narrative and tabular format (para. 80 of the MPGs).*

b. *For each Party with an NDC under Article 4 of the Paris Agreement that consists of mitigation co-benefits resulting from Parties' adaptation actions and/or economic diversification plans consistent with Article 4, para. 7, information to be reported under paras. 80, 82 and 83 of the MPGs includes relevant information on policies and measures contributing to mitigation cobenefits resulting from adaptation actions or economic diversification plans (para. 84 of the MPGs).*

c. *Parties may indicate whether a measure is included in the 'with measures' projections.*

d. *Additional information may also be provided on the cost of the mitigation actions, non-GHG mitigation benefits, and how the mitigation action interacts with other mitigation actions, as appropriate (para. 83(a–c) of the MPGs).*

e. *Parties should identify actions, policies and measures that influence GHG emissions from international transport (para. 88 of the MPGs).*

f. *Parties should, to the extent possible, provide information about how actions, policies and measures are modifying longer-term trends in GHG emissions and removals (para. 89 of the MPGs).*
g Parties shall, to the extent possible, provide information on the types of instrument: regulatory, economic instrument or other (para. 82(d) of the MPGs).

h. *Parties shall, to the extent possible, use the following descriptive terms to report on status of implementation: planned, adopted or implemented (para. 82(e) of the MPGs).*

i. *Parties shall, to the extent possible, provide information on sector(s) affected: energy, transport, industrial processes and product use, agriculture, LULUCF, waste management or other (paras. 81 and 82(f) of the MPGs).*

j. *Each Party shall provide, to the extent possible, estimates of expected and achieved GHG emission reductions for its actions, policies and measures in the tabular format; those developing country Parties that need flexibility in the light of their capacities with respect to this provision are instead encouraged to report this information (para. 85 of the MPGs).*

k. *To the extent available, each Party shall describe the methodologies and assumptions used to estimate the GHG emission reductions or removals due to each action, policy and measure. This information may be presented in an annex to the biennial transparency report (para. 86 of the MPGs).*

CTF 6: Summary of greenhouse gas emissions and removals in accordance with the common reporting table 10 emission trends – summary

GREENHOUSE GAS EMISSIONS AND REMOVALS	Reference year/period for NDC	Base year	2005	2020	2021	2022	Change from reference year to latest reported year
	CO_2 equivalents (kt)						(%)
CO_2 emissions without net CO_2 from LULUCF	2005	2005	1382873.49	2298059.5	2471411.64	2678327.08	93.68
CO_2 emissions with net CO_2 from LULUCF	2005	2005	1174534.13	1732998.74	1904964.83	2103836.1	79.12
CH_4 emissions without CH_4 from LULUCF	2005	2005	457729.19	513416.69	519844.3	531772.86	16.18
CH_4 emissions with CH_4 from LULUCF	2005	2005	458543.93	514551.7	521119.6	533026.52	16.24
N_2O emissions without N_2O from LULUCF	2005	2005	81870.35	121461.31	120994.67	124655.71	52.26
N_2O emissions with N_2O from LULUCF	2005	2005	83374.61	123143.59	122595.67	126069.76	51.21
HFCs	2005	2005	47713.56	30063.48	38524.43	49284.47	3.29
PFCs	2005	2005	30254	9027.85	9760.6	10109.14	-66.59
Unspecified mix of HFCs and PFCs	2005	2005	NO	NO	NO,NE	NO	NO
SF_6	2005	2005	847.61	2063.94	1937.35	2222.68	162.23
NF_3	2005	2005	NO	NO	NO,NE	NE, NA	NE, NA, NO
Total (without LULUCF)	**2005**	**2005**	**2001288.21**	**2974092.78**	**3162472.98**	**3396371.95**	**69.71**
Total (with LULUCF)	**2005**	**2005**	**1795267.85**	**2411849.31**	**2598902.47**	**2824548.67**	**57.33**
Total (without LULUCF, with indirect)	**2005**	**2005**	**NA**	**NA**	**NA**	**NA**	**NA**
Total (with LULUCF, with indirect)	**2005**	**2005**	**NA**	**NA**	**NA**	**NA**	**NA**

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Reference year/period for NDC	Base year	2005	2020	2021	2022	Change from reference year to latest reported year
	CO_2 equivalents (kt) (3)						(%)
1. Energy	2005	2005	1248691.98	2128201.78	2290174.02	2492068.63	99.57
2. Industrial processes and product use	2005	2005	247092.43	255511.63	279869.36	301022.82	21.83
3. Agriculture	2005	2005	443443.16	498255.75	502578.62	509438.75	14.88
4. Land use, land-use change and forestry	2005	2005	-206020.35	-562243.47	-563570.5	-571823.28	177.56
5. Waste	2005	2005	62060.64	92123.63	89850.98	93841.75	51.21
6. Other	2005	2005	NO	NO	NO	NO	NO
Total (with LULUCF)	**2005**	**2005**	**1795267.85**	**2411849.31**	**2598902.47**	**2824548.67**	**57.33**

Notes:

According to paragraph 91 of the MPGs, each Party that submits a stand-alone national inventory report shall provide a summary of its GHG emissions and removals. This information shall be provided for those reporting years corresponding to the Party's most recent national inventory report, in a tabular format.

CTF 7: Information on projections of greenhouse gas emissions and removals under a 'with measures' scenario [a,b]

	Most recent year in the Party's national inventory report (Mt CO_2 eq)[c]	Projections of GHG emissions and removals (Mt CO_2 eq)[c]			
	2022	2025	2030	2035	2040
Sector[d]					
Energy	2492.07	2873.36	3642.83	FX	FX
Transport	Included in Energy Sector	Included in Energy Sector	Included in Energy Sector	FX	FX
Industrial processes and product use	301.02	354.92	467.04	FX	FX
Agriculture	509.44	522.48	544.96	FX	FX
LULUCF	-571.82	-586.01	-610.43	FX	FX
Waste	93.84	96.26	100.42	FX	FX
Other (specify)					
Gas					
CO_2 emissions including net CO_2 from LULUCF	FX	FX	FX	FX	FX
CO_2 emissions excluding net CO_2 from LULUCF	FX	FX	FX	FX	FX
CH_4 emissions including CH_4 from LULUCF	FX	FX	FX	FX	FX
CH_4 emissions excluding CH_4 from LULUCF	FX	FX	FX	FX	FX
N_2O emissions including N_2O from LULUCF	FX	FX	FX	FX	FX
N_2O emissions excluding N_2O from LULUCF	FX	FX	FX	FX	FX
HFCs	FX	FX	FX	FX	FX
PFCs	FX	FX	FX	FX	FX
SF_6	FX	FX	FX	FX	FX
NF_3	FX	FX	FX	FX	FX
Other (specify)	FX	FX	FX	FX	FX
Total with LULUCF	2824.55	3261.01	4144.81	FX	FX
Total without LULUCF	3396.37	3847.01	4755.24	FX	FX

Notes:

a. *Each Party shall report projections pursuant to paras. 93–101 of the MPGs; those developing country Parties that need flexibility in the light of their capacities are instead encouraged to report such projections (para. 92 of the MPGs).*

b. *Those developing country Parties that need flexibility in the light of their capacities with respect paras. 93–101 of the MPGs can instead report using a less detailed methodology or coverage (para. 102 of the MPGs).*

c. *Projections shall begin from the most recent year in the Party's national report and extend at least 15 years beyond the next year ending in zero or five; those developing country Parties that need flexibility in the light of their capacities with respect to this provision have the flexibility to instead extend their projections at least to the end point of their NDC under Article 4 of the Paris Agreement (para. 95 of the MPGs).*

d. *In accordance with para. 82(f) of the MPGs.*

CTF 8: Information on projections of greenhouse gas emissions and removals under a 'with additional measures' scenario [a,b]

	Most recent year in the Party's national inventory report (kt CO_2 eq)[c]	Projections of GHG emissions and removals (kt CO_2 eq)[c]			
	2022	2025	2030	2035	2040
Sector[d]	NE	NE	NE	NE	NE
Energy	NE	NE	NE	NE	NE
Transport	NE	NE	NE	NE	NE
Industrial processes and product use	NE	NE	NE	NE	NE
Agriculture	NE	NE	NE	NE	NE
LULUCF	NE	NE	NE	NE	NE
Waste	NE	NE	NE	NE	NE
Other (specify)	NE	NE	NE	NE	NE
Gas					
CO_2 emissions including net CO_2 from LULUCF	NE	NE	NE	NE	NE
CO_2 emissions excluding net CO_2 from LULUCF	NE	NE	NE	NE	NE
CH_4 emissions including CH_4 from LULUCF	NE	NE	NE	NE	NE
CH_4 emissions excluding CH_4 from LULUCF	NE	NE	NE	NE	NE
N_2O emissions including N_2O from LULUCF	NE	NE	NE	NE	NE
N_2O emissions excluding N_2O from LULUCF	NE	NE	NE	NE	NE
HFCs	NE	NE	NE	NE	NE
PFCs	NE	NE	NE	NE	NE
SF_6	NE	NE	NE	NE	NE
NF_3	NE	NE	NE	NE	NE
Other (specify)	NE	NE	NE	NE	NE
Total with LULUCF	NE	NE	NE	NE	NE
Total without LULUCF	NE	NE	NE	NE	NE

Notes:

a. *Each Party shall report projections pursuant to paras. 93–101 of the MPGs; those developing country Parties that need flexibility in the light of their capacities are instead encouraged to report such projections (para. 92 of the MPGs).*

b. *Those developing country Parties that need flexibility in the light of their capacities with respect paras. 93–101 of the MPGs can instead report using a less detailed methodology or coverage (para. 102 of the MPGs).*

c. *Projections shall begin from the most recent year in the Party's national report and extend at least 15 years beyond the next year ending in zero or five; those developing country Parties that need flexibility in the light of their capacities with respect to this provision have the flexibility to instead extend their projections at least to the end point of their NDC under Article 4 of the Paris Agreement (para. 95 of the MPGs).*

d. *In accordance with para. 82(f) of the MPGs.*

CTF 9: Information on projections of greenhouse gas emissions and removals under a 'without measures' scenario [a,b]

	Most recent year in the Party's national inventory report (kt CO_2 eq)[c]	Projections of GHG emissions and removals (kt CO_2 eq)[c]			
	2022	2025	2030	2035	2040
Sector[d]	NE	NE	NE	NE	NE
Energy	NE	NE	NE	NE	NE
Transport	NE	NE	NE	NE	NE
Industrial processes and product use	NE	NE	NE	NE	NE
Agriculture	NE	NE	NE	NE	NE
LULUCF	NE	NE	NE	NE	NE
Waste	NE	NE	NE	NE	NE
Other (specify)	NE	NE	NE	NE	NE
Gas					
CO_2 emissions including net CO_2 from LULUCF	NE	NE	NE	NE	NE
CO_2 emissions excluding net CO_2 from LULUCF	NE	NE	NE	NE	NE
CH_4 emissions including CH_4 from LULUCF	NE	NE	NE	NE	NE
CH_4 emissions excluding CH_4 from LULUCF	NE	NE	NE	NE	NE
N_2O emissions including N_2O from LULUCF	NE	NE	NE	NE	NE
N_2O emissions excluding N_2O from LULUCF	NE	NE	NE	NE	NE
HFCs	NE	NE	NE	NE	NE
PFCs	NE	NE	NE	NE	NE
SF_6	NE	NE	NE	NE	NE
NF_3	NE	NE	NE	NE	NE
Other (specify)	NE	NE	NE	NE	NE
Total with LULUCF	NE	NE	NE	NE	NE
Total without LULUCF	NE	NE	NE	NE	NE

Notes:

a. *Each Party shall report projections pursuant to paras. 93–101 of the MPGs; those developing country Parties that need flexibility in the light of their capacities are instead encouraged to report such projections (para. 92 of the MPGs).*

b. *Those developing country Parties that need flexibility in the light of their capacities with respect paras. 93–101 of the MPGs can instead report using a less detailed methodology or coverage (para. 102 of the MPGs).*

c. *Projections shall begin from the most recent year in the Party's national report and extend at least 15 years beyond the next year ending in zero or five; those developing country Parties that need flexibility in the light of their capacities with respect to this provision have the flexibility to instead extend their projections at least to the end point of their NDC under Article 4 of the Paris Agreement (para. 95 of the MPGs).*

d. *In accordance with para. 82(f) of the MPGs.*

CTF 10: Projections of key indicators [a,b]

	Unit, as applicable	Most recent year in the Party's national inventory report, or the most recent year for which data are available	Projections of key indicators[d]			
		2022	2025	2030	2035	2040
Key indicator(s)[c]						
Emissions Intensity of GDP (GHG/GDP)	%	- 37.38	NE	NE	NE	NE
Cumulative electric power installed capacity from non-fossil fuel-based energy resources	%	42.5	NE	NE	NE	NE
Additional carbon sink	$BtCO_2e$	2.44	NE	NE	NE	NE

Notes:

The Party could add rows for each additional key indicator.

a. *Each Party shall report projections pursuant to paras. 93–101 of the MPGs; those developing country Parties that need flexibility in the light of their capacities are instead encouraged to report such projections (para. 92 of the MPGs).*

b. *Those developing country Parties that need flexibility in the light of their capacities with respect paras. 93–101 of the MPGs can instead report using a less detailed methodology or coverage (para. 102 of the MPGs).*

c. *Each Party shall also provide projections of key indicators to determine progress towards its NDC under Article 4 of the Paris Agreement (para. 97 of the MPGs).*

d. *Future years extended to at least 15 years beyond the next year ending in zero or five; those developing country Parties that need flexibility in the light of their capacities with respect to this provision have the flexibility to instead extend their projections at least to the end point of their NDC under Article 4 of the Paris Agreement (para. 95 of the MPGs).*

CTF 11: Key underlying assumptions and parameters used for projections [a,b]

Key underlying assumptions and parameters[c]	Unit, as applicable	Most recent year in the Party's national inventory report, or the most recent year for which data are available	Projections of key indicators[d]			
		2022	2025	2030	2035	2040
{Key underlying assumption/parameter}	NE	NE	NE	NE	NE	NE

Notes:

The Party could add rows for each additional key underlying assumptions and parameters.

a. *Each Party shall report projections pursuant to paras. 93–101 of the MPGs; those developing country Parties that need flexibility in the light of their capacities are instead encouraged to report such projections (para. 92 of the MPGs).*

b. *Those developing country Parties that need flexibility in the light of their capacities with respect paras. 93–101 of the MPGs can instead report using a less detailed methodology or coverage (para. 102 of the MPGs).*

c. *Each Party shall also provide projections of key indicators to determine progress towards its NDC under Article 4 of the Paris Agreement (para. 97 of the MPGs).*

d. *Future years extended to at least 15 years beyond the next year ending in zero or five; those developing country Parties that need flexibility in the light of their capacities with respect to this provision have the flexibility to instead extend their projections at least to the end point of their NDC under Article 4 of the Paris Agreement (para. 95 of the MPGs).*

CTF 12: Information necessary to track progress on the implementation and achievement of the domestic policies and measures implemented to address the social and economic consequences of response measures[a]

Sectors and activities associated with the response measures[b]	Social and economic consequences of the response measures[c]	Challenges in and barriers to addressing the consequences[d]	Actions to address the consequences[e]
NA	NA	NA	NA

Notes:

a. *Each Party with an NDC under Article 4 that consists of adaptation actions and/or economic diversification plans resulting in mitigation co-benefits consistent with Article 4, para. 7, of the Paris Agreement shall provide the information necessary to track progress on the implementation and achievement of the domestic policies and measures implemented to address the social and economic consequences of response measures (para. 78 of the MPGs).*

b. *In accordance with para. 78(a) of the MPGs.*

c. *In accordance with para. 78(b) of the MPGs.*

d. *In accordance with para. 78(c) of the MPGs.*

e. *In accordance with para. 78(d) of the MPGs.*

Appendix III: Methodologies and assumptions used to estimate the GHG emissions reductions or removals by policies and measures listed in Section D (CTF5)

The methodologies and assumptions used for estimating GHG emission mitigations (avoidance) for policies and measures listed in Section D (CTF5) are briefly discussed below.

Standards & Labelling (S&L) Program

S & L program has included energy efficiency labelling i.e. star-rated labelling (1 star to 5 star) to total 38 appliances, of which 16 appliances are under mandatory labeling and 22 appliances are under voluntary labeling as of October 2024. GHG emissions avoided from sales of star-labeled appliances were sourced from "Impact of Energy Efficiency Measures" reports published every year by Bureau of Energy Efficiency (BEE) for FY 2020-21, 2021-22 and 2022-23.

Avoided CO_2 emissions due to the S & L program were about 55.4 $MtCO_2$ in 2021 and 58.2 $MtCO_2$ in 2022.

Solar power policy & Wind power policy

Policies for various renewable energy (RE) sources contribute to the avoidance of GHG emissions. The assumption is that since RE generation capacity was built, these sources have replaced grid-based fossil fuels. The 75% operating margin and 25% build margin of the national power grid were assumed to represent the GHG emissions avoided by RE, as per the approved methodology by the Central Electricity Authority (CEA) of GoI. The annual electricity data for both generation capacity and actual generation for solar, wind, and other renewables are compiled for 2020, 2021, and 2022 from monthly renewable energy generation reports and other relevant reports published by CEA. Annual GHG emissions avoided because of Solar or wind power generation can be estimated using the following equation A1.

Total GHG emissions CO_2 saved for year-i = Electricity generation from Solar/Wind power for year-i baseline CO_2 emission factor for year-i* (A1)

Avoided CO_2 emission ($MtCO_2e$) due to solar power policy was 55.5 in 2021 and 76.9 in 2022. While avoided GHG emissions ($MtCO_2e$) due to various wind power policy was 52.5 in 2021 and 57.5 in 2022.

Perform Achieve and Trade (PAT) scheme

PAT scheme aims to enhance EE in energy-intensive industries. The total number of designated consumers (DCs) for PAT cycle-I (2012–2015) was 478, covering eight sectors, namely aluminum, cement, chlor-alkali, fertilizer, iron and steel, pulp and paper, textile, and thermal power plants. Three more sectors, namely petroleum refinery, railways, and electricity distribution companies, were added in PAT cycle-II (2016-2018) with 621 DCs. While PAT cycle -III (2018-2020) was notified to 116 DCs from six sectors, viz. Thermal Power Plant, Cement, Aluminum, Pulp & Paper, Iron & Steel, and Textile. PAT cycle IV (2019-2021) was notified to 109 DCs with a total energy savings target of 0.6998 Mtoe from 8 sectors consisting of 6 existing sectors of PAT cycle I and two new sectors, i.e., Petrochemicals & Buildings. PAT cycle–V (2020-2022) was notified to 110 DCs from existing sectors of Aluminum, Cement, Chlor-Alkali, Commercial Buildings (Hotels), Iron & Steel, Pulp & Paper, Textile, and Thermal Power Plant were notified with a total energy savings target of 0.5130 Mtoe.

Total CO_2 emissions avoided due to PAT cycles (I to V) were about 31 $MtCO_2$ (cycle I), 68.43 $MtCO_2$ (cycle II), 5.60 $MtCO_2$ (cycle III), 2.96 $MtCO_2$ (cycle IV), and 2.68 $MtCO_2$ (cycle V).

Avoided CO_2 emissions due to PAT scheme (cycle I-V) for the years 2021 and 2022 were the same, i.e., 36.9 $MtCO_2$.

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CHAPTER-3

INFORMATION RELATED TO CLIMATE CHANGE IMPACTS AND ADAPTATION UNDER ARTICLE 7 OF THE PARIS AGREEMENT

INFORMATION RELATED TO CLIMATE CHANGE IMPACTS AND ADAPTATION UNDER ARTICLE 7 OF THE PARIS AGREEMENT

3.1 National Circumstances, Institutional Arrangements, and Legal Frameworks

Introduction

Like most developing countries, India's adaptation challenge is one that arises out of a climate challenge in whose making it has had little or even negligible contribution. As the Summary for Policymakers of the Working Group III contribution to the Sixth Assessment Report of the IPCC has noted, South Asia has contributed only about 4 percent of global CO_2 emissions, and India's share will be less than this. The global surface temperature has already increased by more than 1.1 °C above pre-industrial levels, which is more than 2/3rd of the way to the 1.5-degree goal.

Net CO_2 emissions of countries included in the Annex-1 to the UNFCCC, in 2020 were 12.56 $GtCO_2$ (UNFCCC, 2024). Even according to their own projected long-term emission reduction targets and net zero target years, they will emit (assuming a linear reduction between 2020 and 2050), more than 188 $GtCO_2$, that is well over a third of the remaining carbon budget available for 1.5°C warming (with 50% probability) in 2023, though their global population share is no more than approximately 17 percent. Without the developed countries taking the lead and their inadequate performance in providing the means of implementation, combined with the lack of compensation for their historical overconsumption of the carbon budget through negative emissions, the difficulty in adhering to a 1.5°C temperature goal is evident.

Hence, national and global adaptation goals need to be cognizant of the full temperature goal of the Paris Agreement (as stated in Art. 2.1(a): "Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels").

India's experience clearly shows the fundamental prerequisite of development to adaptation, especially in reducing vulnerability and exposure. It is essential to note that reducing vulnerability and exposure is a challenge across the entire economy and society of all developing countries and cannot be restricted to only particular categories of vulnerable nations or particularly marginalized communities. India's experience, as well as the scientific literature, shows clearly the fundamental role of basic social and economic development in managing vulnerability and promoting adaptation.

In this connection, it is relevant to recall that the Summary for Policymakers of the IPCC Working Group II contribution to AR6 notes in B.1.6: "Regions and people with considerable development constraints have high vulnerability to climatic hazards (high confidence)." Further in B.3.2, it is noted: "In the near term, climate-associated risks to natural and human systems depend more strongly on changes in their vulnerability and exposure than on differences in climate hazards between emissions scenarios (high confidence)."

Furthermore, it is essential to note that adaptation is an unwelcome additionality to development, increasing the cost of development. It would be unscientific to consider development as a co-benefit to adaptation or vice-versa without any reference to costs. References to the terminology of "climate resilient development" cannot obscure two fundamental points. First, adaptation cannot be conflated with mitigation through the use of the term resilience. Second, it is especially important to recognize where and how adaptation and mitigation take place and the variation in the relative burden of both these aspects within and between countries. Between and within countries, it is also important to recognize the economic, political and social inter-dependence of different regions and hence a simplistic view of adaptation and mitigation having equal priority at all spatial scales or equal priority at all scales of governance and the scale of jurisdiction of all institutions, would be incorrect.

As the IPCC noted in SPM of Working Group II, AR6: "Climate resilient development pathways are progressively constrained by every increment of warming, in particular beyond 1.5°C, social and economic inequalities, the balance between adaptation and mitigation varying by national, regional and local circumstances and geographies, according to capabilities including resources, vulnerability, culture and values, past development choices leading to past emissions and future warming scenarios, bounding the climate resilient development pathways remaining, and the ways in which development trajectories are shaped by equity, and social and climate justice." And again: "Opportunities for climate resilient development are not equitably distributed around the world. Climate impacts and risks exacerbate vulnerability and social and economic inequities and consequently increase persistent and acute development challenges, especially in developing regions and sub-regions."

These findings further indicate that one of the major constraints on adaptation is the scarcity of the remaining carbon budget, with the Annex-I countries having consumed a disproportionate share of the global carbon budget (IPCC, 2022a) and that this is not to be considered a purely mitigation question. The need for equitable access to the global carbon budget for adaptation clearly follows from the IPCC's finding, cited above, that "past development choices leading to past emissions and future warming scenarios, bounding the climate resilient development pathways remaining, and the ways in which development trajectories are shaped by equity, and social and climate justice."

Another reason to emphasize the global aspect of the adaptation challenge is the question of the provision of the means of implementation. While adaptation action is undoubtedly local, it is universally recognized that communities and regions require assistance, support, knowledge, and means of implementation from outside, from beyond the region, and from beyond national borders. Developing countries require finance, technology transfer, and capacity building support for adaptation.

The most damaging consequence of the failure of the provision of these means of implementation for climate action has been on adaptation. While climate finance has fallen far short of the promised USD 100 billion for several years now, the proportion of available climate finance provided to adaptation has been a minor fraction. Once again, as in mitigation, means of implementation is also a cross-cutting issue and forms a fundamental element for every thematic issue on which further considerations need to be built upon. Globally, the share of climate finance going to adaptation has been minuscule, especially compared to the needs of developing countries. Appropriate consideration of adaptation finance as part of the overall issue of climate finance can be found in later chapters of this BTR.

The residual due to climate change and climate extremes after adaptation is taken into account is what must be referred to as loss and damage. Loss and damage arise if adaptation is inadequate or the nature of the hazard is such as to overwhelm the adaptation currently undertaken. Dealing with loss and damage is a necessity as is adaptation to current climate variability, which is an essential pre-requisite to learning for the future. India has invested in both these aspects of climate action, predominantly through domestic resources and investment.

The following sections illustrate the challenges of adaptation in key sectors for India, focusing on the impacts and some of the key adaptation initiatives in each of these sectors. The structure of the chapter follows the format provided in Section IV of the Annex in 18/CMA.1 as provided in the document FCCC/PA/CMA/2018/3/Add.2. It is also noted that in submitting BTRs, the provision of information on impacts and adaptation is non-mandatory and hence voluntary.

The information in this chapter covers some of the key sectors relevant to India for adaptation. They are i) agriculture, ii) forests, iii) biodiversity and wildlife, iv) water, v) the Himalayan ecosystem, vi) coastal ecosystems, and vii) cities. Gender is addressed in a separate section, as it constitutes a cross-cutting theme. Another section at the end provides a short summary of the adaptation component of the SAPCC, which are the State-level counterparts of the NAPCC.

3.1.1 Overview: Geographic and Climatic Parameters

The mainland of India extends from 66°E to 98°E and 8°N to 36°N, with a total land area of over 3.28 million square kilometers. The country also borders Pakistan, Bhutan, Bangladesh, and Myanmar. India is the seventh largest country in the world (approximately 2.4% of the world's land area). India has a diverse geography, encompassing everything from snow-capped mountain ranges and arid western deserts to fertile plains, rolling hills, expansive plateaus, lush coastal areas, and remote islands. Its climate is equally varied, ranging from continental to coastal conditions, with extremes of heat and cold, intense aridity with minimal rainfall, and regions that experience high humidity and heavy rainfall during the monsoon.

Precipitation

Nearly three-fourths of India's annual rainfall occurs during the southwest monsoon season, though its distribution varies greatly across regions. The Indian monsoon, a key component of the global monsoon system, shifts in wind direction seasonally—blowing from the northeast during the cooler months and reversing to the southwest during the warmer months. This seasonal reversal brings heavy rainfall to much of the country between June and September, marking the primary rainy season. However, the onset and withdrawal of the monsoon show significant year-to-year variation across different regions. The timing, intensity, and distribution of rainfall have a profound influence on agriculture, water resources, and various ecosystems across the country.

The all-India average annual rainfall normal based on data obtained between 1971-2020 is 1160.1 mm. The rainfall amount exceeds 1000 mm annually in areas to the East of India and extends to over 2500 mm along almost the entire West Coast and northeast India. In contrast, areas west of a line connecting Porbandar, Delhi, and Ferozepur in Punjab experience a sharp decline in rainfall, dropping from around 500 mm to less than 150 mm in the far western regions.

On average, about 868.6 mm of rainfall is received over the country between June and September during the monsoon season. The southwest monsoon season rainfall accounts for 74.0% of the annual rainfall.

Although there is inter-annual variability, the total precipitation during the Indian summer monsoon has remained largely stable over the period 1901-2024 and has shown a weak decreasing trend during the recent few decades (Figure 3.1).

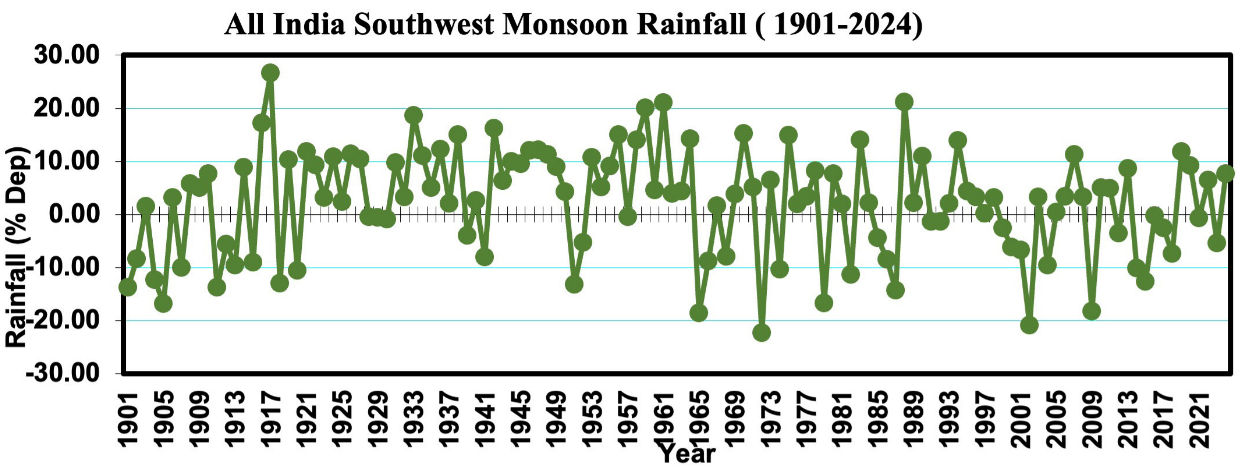

Figure 3.1: Percentage departure of area-weighted monsoon season rainfall over India as a whole (1901-2024). Source: IMD

However, state-wise reports from the India Meteorological Department (IMD) on observed rainfall trends and variability based on the recent 30 years of data (1989-2018) (Guhathakurta et al., 2020), reveal significant declining trends in southwest monsoon rainfall over Uttar Pradesh, Bihar, West Bengal, Meghalaya, and Nagaland. In contrast, most other states do not exhibit any significant changes in monsoon rainfall during this period. Additionally, these five states, along with Arunachal Pradesh and Himachal Pradesh, have shown notable decreases in annual rainfall. At the district level, rainfall trends for both the southwest monsoon and annual totals display even greater variability over the extended period from 1901 to 2022 (Figure 3.2).

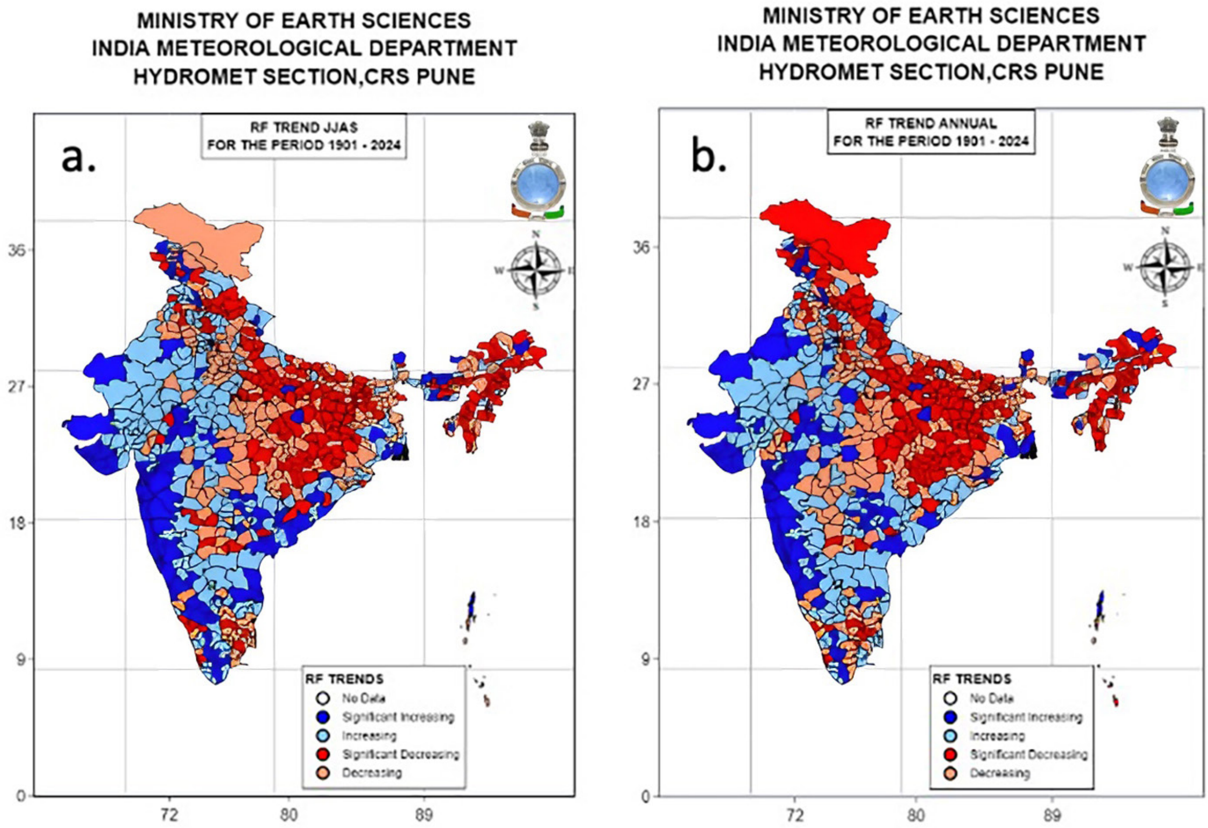

Figure 3.2: Trend in district rainfall during (a) monsoon season (JJAS) and (b) annual for the period 1901-2024. Source: IMD

Temperature variation in India

The surface air temperatures across India exhibit significant spatial and seasonal variations. In the coldest months of December and January, the mean maximum temperature varies from 33°C in certain regions of the country to about 12°C in the northern plains. During the same period, the mean minimum temperature varies from about 25°C in the far south to nearly 3°C in the northern plains.

The five warmest years on record in descending order are 2024 (+0.65°C), 2016 (+0.54°C), 2009(+0.40°C), 2010 (+0.39°C) and 2017 (+0.38°C). Furthermore, 10 out of the 15 warmest years have been observed in the recent 15 years (2010-2024). The past decade (2015-2024) was also the warmest decade on record. The past decade (2015-2024) was also the warmest decade on record, with a decadal-averaged annual mean temperature anomaly (Actual-LPA) of 0.31°C. Between 1901 and 2023, India's annual mean temperature exhibited a significant rising trend of 0.68°C per 100 years (Figure 3.3). This trend included a notable increase in maximum temperatures at a rate of 0.89°C per 100 years and a relatively slower rise in minimum temperatures at 0.46°C per 100 years. Although this warming trend is significant, it is slower than the global average—an observation only partially attributed to the generally lower rates of warming expected in lower latitudes.

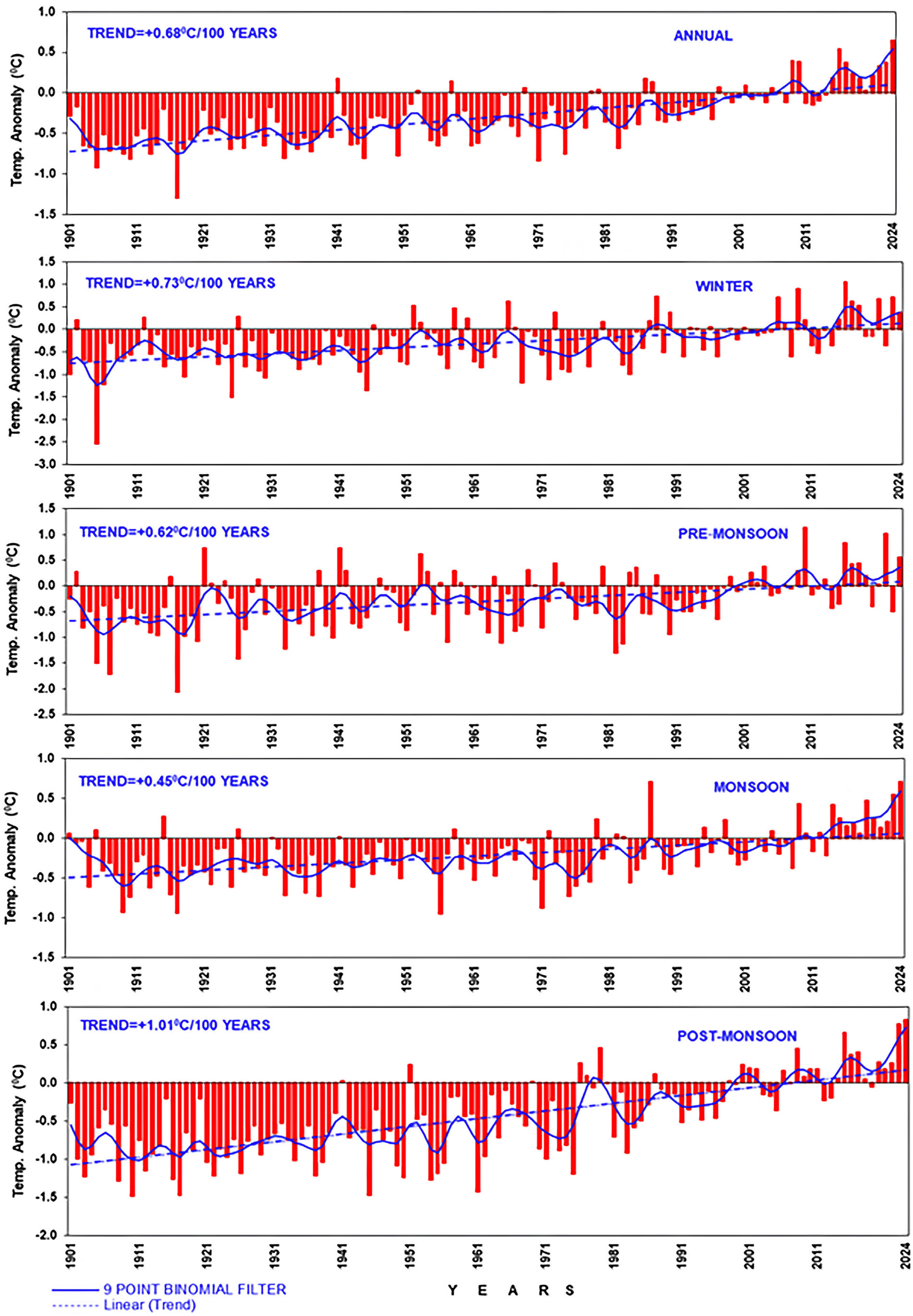

Figure 3.3: All India mean temperature anomalies: (A) Annual (B) Winter (C) Pre-monsoon (D) Monsoon and (E) Post-monsoon for the period 1901-2024. Source: IMD

Note: Mean temperature anomalies are shown as vertical bars, and the solid blue curve has sub-decadal time scale variations smoothed with a binomial filter. (Departures from 1991-2020 average).

Spatial analysis of warming trends based on mean annual temperature anomalies from 1901 to 2024 (Figure 3.4) reveals a significant increasing trend across most of India. However, certain regions, including parts of Ladakh, Uttar Pradesh, Odisha, Jharkhand, eastern Madhya Pradesh, Vidarbha, and Gujarat, show a significant decreasing trend.

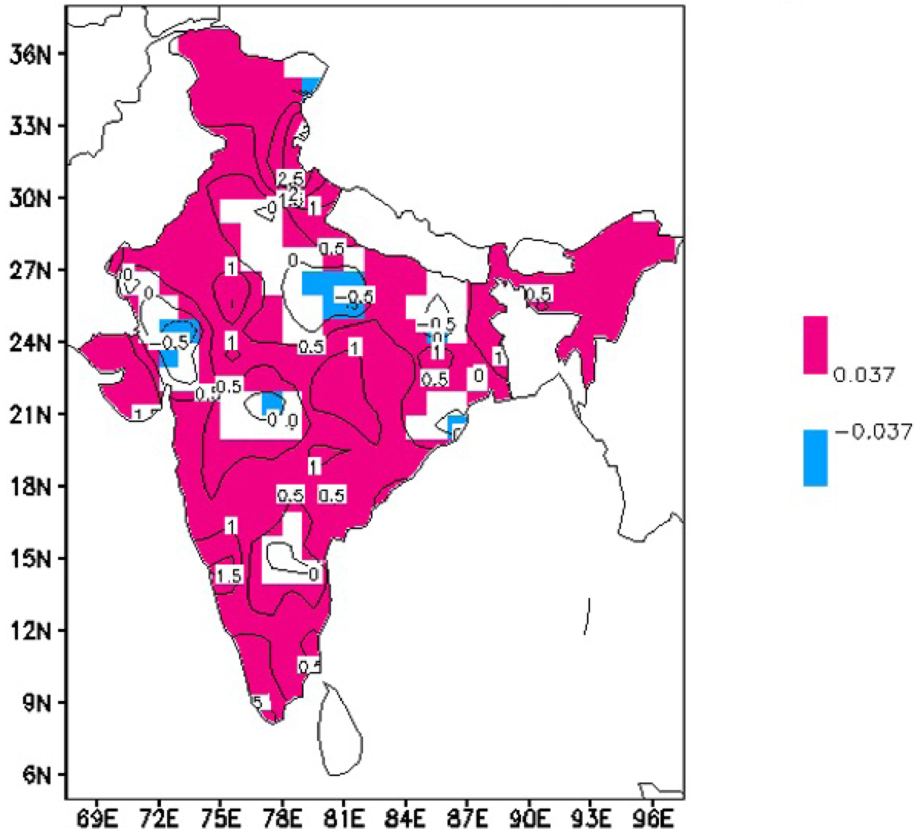

Figure 3.4: Annual mean temperature anomaly trends (°C/100 years) 1901– 2024. (Departure from 1991-2020 average). Source: IMD

Note: Anomaly trends are shown as contour lines. The trends significant at the 95% level are shaded. Positive trends are shown in red, while the negative trends are shown in blue.

Extreme weather events

The main extreme weather events affecting different regions of India are variations in rainfall, cyclones, heatwaves, and cold waves.

Analysis of the one-day extreme rainfall series has shown that the intensity of extreme rainfall has increased over coastal Andhra Pradesh and adjoining areas, Saurashtra and Kutch, Odisha, West Bengal, parts of northeastern India, and eastern Rajasthan. Though the flood risk has increased significantly over India (Guhathakurta et al, 2011), there has been a significant decrease both in intensity and frequency of extreme rainfall over Chhattisgarh, Jharkhand and some parts of northern India. Pai et al. (2014), using 0.25 ° × 0.25 ° gridded data, found that during recent decades, there has been a significant decrease in moderate rainfall events, while heavy and very heavy rainfall events have increased in frequency.

The state-wise reports from IMD on observed rainfall trends and variability based on recent 30 years data (1989-2018) (Guhathakurta et al., 2020) indicate that there is a significant increasing trend in the number of dry days during the monsoon season over the south coastal regions of Andhra Pradesh, Bihar, northern parts of Chhattisgarh, Jharkhand, Madhya Pradesh, Odisha, Tamil Nadu, Uttar Pradesh and West Bengal. Annually, all these states along with Telangana also show significant increasing trends on dry days, whereas Gujarat, Karnataka, Maharashtra, Rajasthan, and Punjab states show significant decreasing trends during dry days.

A significant increasing trend in the frequency of heavy rainfall events is observed over Saurashtra and Kutch, Southeastern parts of Rajasthan, Northern parts of Tamil Nadu, Northern parts of Andhra Pradesh, and adjoining areas of Southwest Odisha, many parts of Chhattisgarh, Southwest Madhya Pradesh, West Bengal, Manipur and Mizoram, Konkan and Goa, and Uttarakhand. The trend analysis of the frequency of light to moderate rainfall (2.5 mm < rainfall< 64.5 mm) indicates significant increasing trends over Rajasthan, Gujarat, Maharashtra, Andhra Pradesh, northern parts of Madhya Pradesh and parts of Odisha and Chhattisgarh, whereas significant decreasing trends are seen over Uttar Pradesh, Bihar, Jharkhand, Punjab and northeastern parts of the country during the southwest monsoon season.

Figure 3.5 illustrates the decadal variability of annual frequencies of rainfall events of different intensities. The decades 1981-90, 1991-2000 and 2001-2010 had the highest percentage frequency of extremely heavy and very heavy rainfall categories among all the 20 decades. The percentage of dry days has increased in the recent few decades whereas the percentage of very light and light to moderate rainfall which is crucial for agriculture and other applications has decreased in the recent few decades.

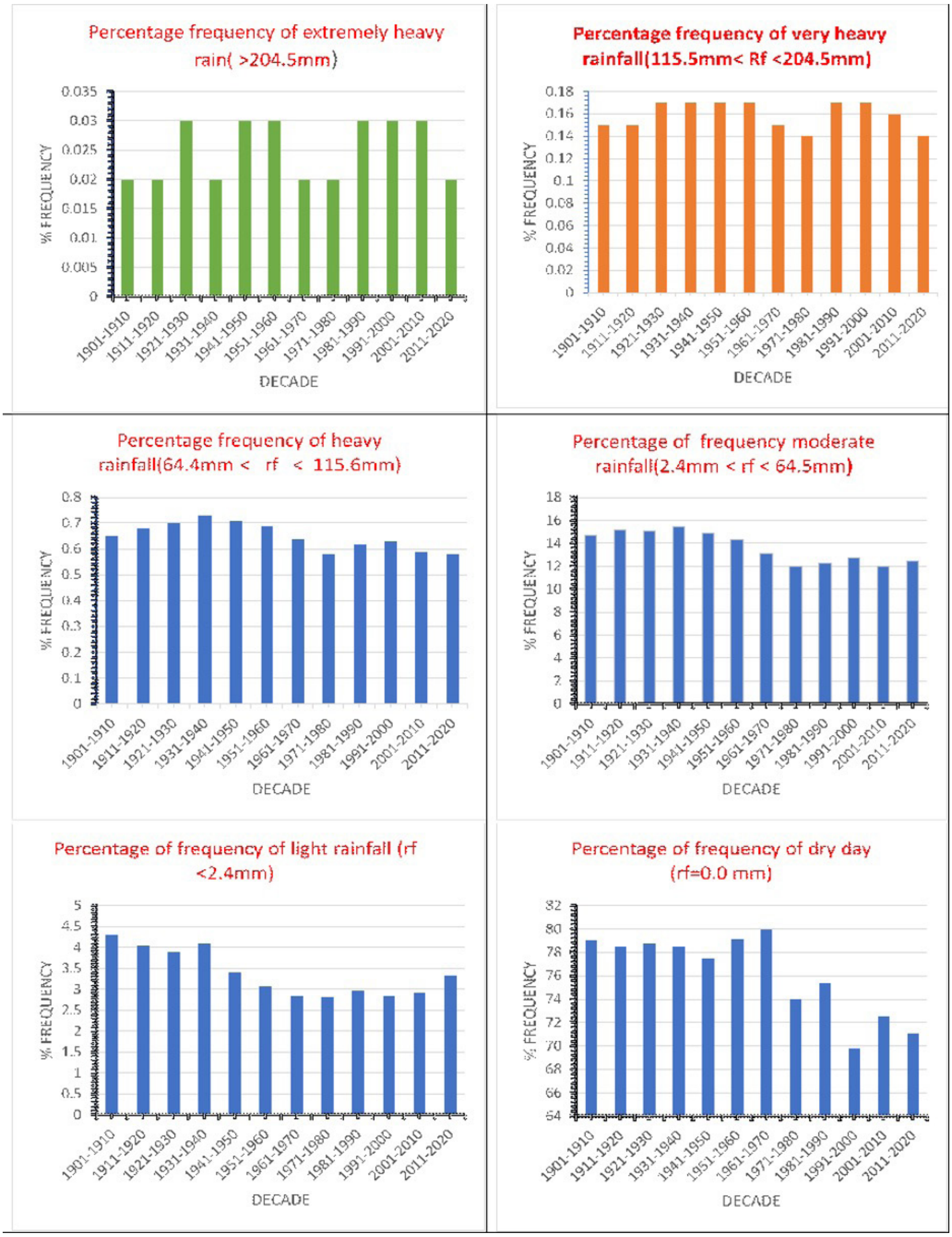

Figure 3.5: Decadal variability of annual frequencies of different rainfall events over India. Source: IMD

As illustrated in Figure 3.6 (a), the frequency of cyclonic disturbances over the Indian region during the monsoon season has shown a significant decreasing trend over the past 74 years (1951–2024), with a 99% confidence level. Tropical cyclones are more frequent during the post-monsoon season (October to December). However, as shown in Figure 3.6(b), the frequency of cyclonic storms over the North Indian Ocean during this period has also exhibited a statistically significant decreasing trend, with a 95% confidence level. Based on data from 1891 to 2024, an average of five cyclones form annually over the North Indian Ocean (comprising the Bay of Bengal and the Arabian Sea), with approximately four developing over the Bay of Bengal and one over the Arabian Sea. However, a declining trend in the total number of Cyclonic Disturbances (CDs, including both cyclonic storms and depressions) has been observed during the period 1951 to 2024, as illustrated in Figure 3.6.

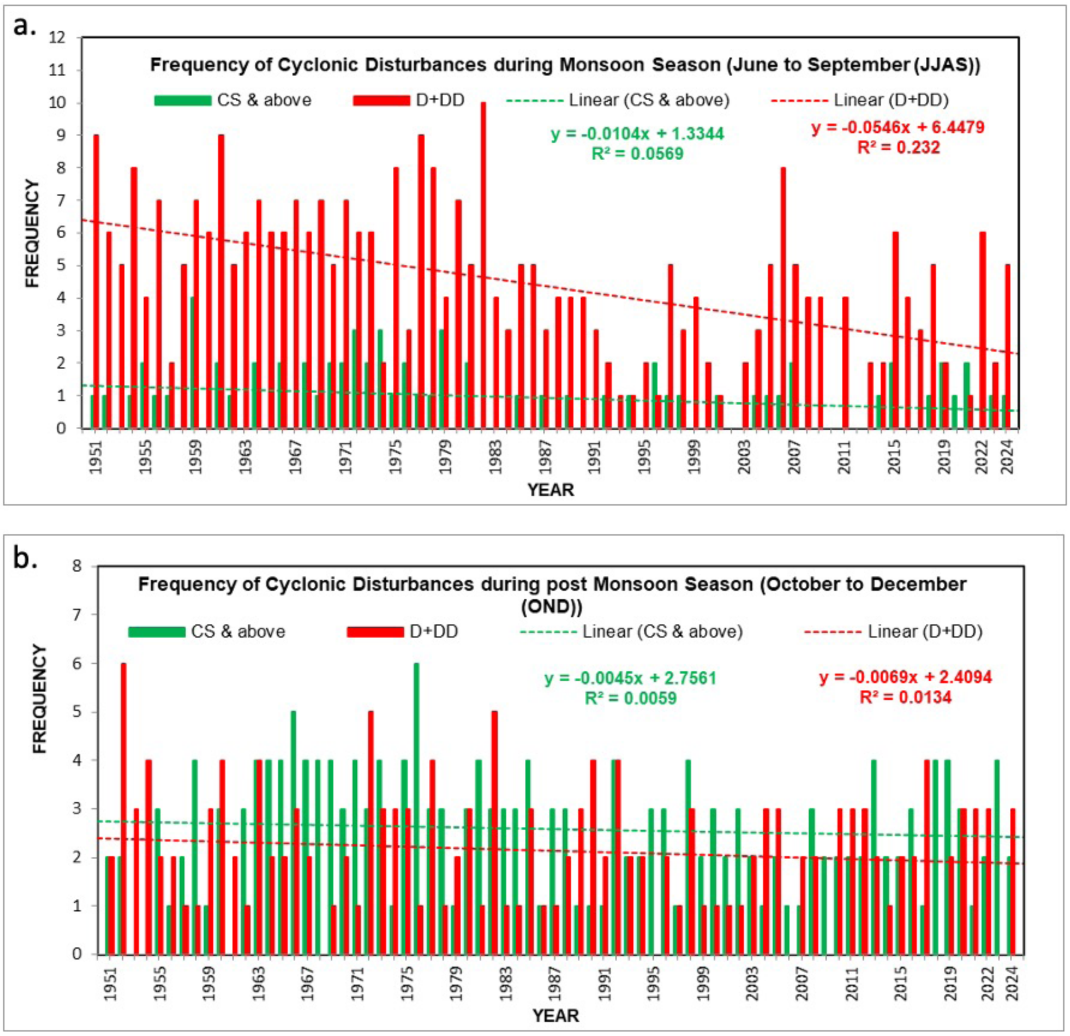

Figure 3.6: Frequency of depressions and cyclonic storms formed over the northern Indian Ocean and land during (a) monsoon season and (b) post-monsoon season (1951-2024). Source: IMD (2024b)

This is consistent with the significant decreasing trend in the CDs for the Monsoon and post-monsoon seasons, as well as in the annual frequency found by Mohapatra et al (2017).

Thirteen coastal states and Union Territories (UTs) in the country, encompassing 96 districts, including 72 coastal and 24 non-coastal ones, are affected by tropical cyclones. The performance of cyclone landfall, track and intensity forecast has shown significant improvement during the recent decade (IMD, 2024) and accurate prediction of cyclones has resulted in a reduction in death toll due to any very severe cyclonic storm to less than hundred.

Heatwaves and cold waves

In India, heatwaves generally occur between March and June, occasionally extending into July. They are most frequent over the Indo-Gangetic plains, with the northern regions of the country typically experiencing 5–6 heatwave events annually. Temperatures exceeding 46°C have been recorded in several areas, particularly in north and central India. The IMD criteria for declaring heatwave and cold wave are described in IMD Forecasting Circular No. 5/2015 (3.7), (IMD, 2015).

Between 1961 and 2024, most stations across India recorded increasing trends in heatwave occurrences, except for a few locations in the plains along the Himalayan foothills, southern central India, and eastern India, which exhibited decreasing trends (Figure 3.7a). In contrast, cold wave days showed a decreasing trend at the majority of stations across the country (Figure 3.7(b)).

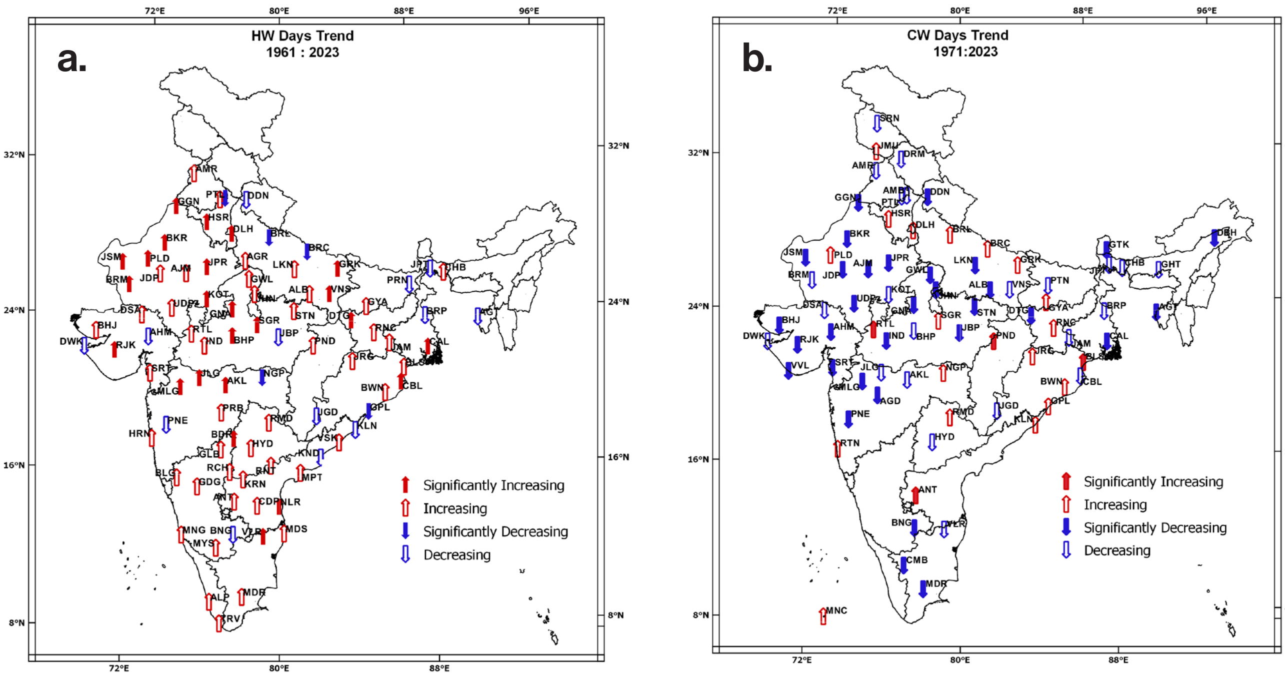

Figure 3.7: (a) Trends in the Heat Wave (HW) days in April, May and June for the period 1961–2024.
(b) Trends in the Cold Wave (CW) days during December, January and February for the period 1961–2024. Source: IMD (2023)

Note: Figures show heat wave days measured across 103 stations and cold wave days measured across 86 stations. Red rising (blue falling) arrows represent the increasing (decreasing) trends. Filled arrows represent trends that are significant at the 5% level, based on the nonparametric Mann–Kendall test.

At the national level, the NDMA is leading efforts by supporting State-level heat action plans and facilitating coordination at the national level through updated National Guidelines for Preparation of Action Plan – Prevention and Management of Heat Wave. State governments currently dealing with the Heat Wave crisis have prepared Heat Action Plans and Do's and Dont's to alleviate the impact of heat waves. Heat Wave Guidelines aim to facilitate the stakeholders in preparing a Heat Wave Action Plan by providing insights into heat-related illness and the necessary mitigative and response actions to be undertaken.

Rohini et al. (2022) examined the seasonal-scale predictability of heatwave characteristics—such as frequency and duration—using percentile-based criteria within climate models. Earlier, Rohini et al. (2016) demonstrated the effectiveness of these percentile-based criteria in identifying observed heatwaves from gridded datasets (Figure 3.8) and in generating monthly and seasonal heatwave outlooks for India. Since 2023, the IMD has been issuing monthly and seasonal heatwave outlooks for the Indian region using a Multi-Model Ensemble (MME) approach.

The IMD continues to provide the vital seasonal outlook for the hot weather season, and daily temperature forecasts for over 447 cities. The IMD forecasts are a critical trigger for prompting early warnings of extreme heat by city officials. Sustained efforts - timely release, updating, and effective implementation of the National Guidelines on Heat Wave, preparation of Heat Action Plans by vulnerable States and cities, regular follow-up and monitoring by National Disaster Management Authority (NDMA), extensive awareness generation campaigns, and preparedness workshops have significantly brought down the number of heat-related deaths and illnesses in the past few years.

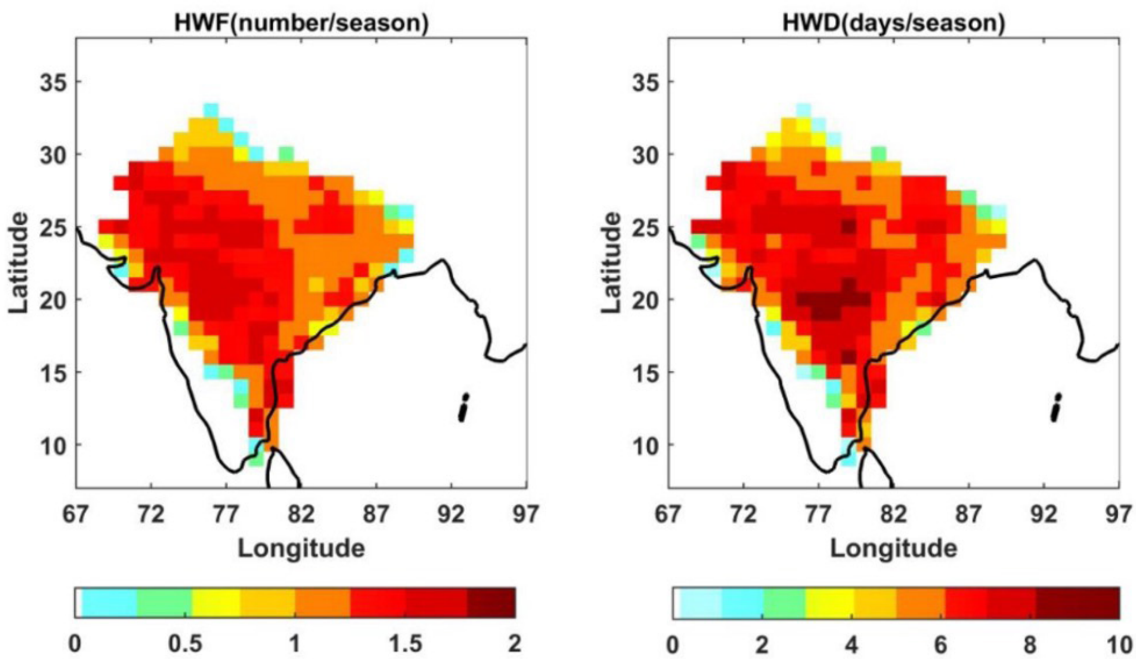

Figure 3.8: Spatial distribution of a) heat wave frequency, b) heat wave days and during MAMJ. Period 1961-2021 using IMD 1x1 gridded data sets. Source: IMD (2023)

Heatwave-related mortality has reduced from 2040 deaths in 2015 to 1111 deaths in 2016, and further reduced to 384 deaths in 2017 and 25 deaths in 2018. From 2019 to 2021, no loss of life was reported due to heatwaves, mainly due to the continuous occurrence of La Niña events. However, the heatwave-related mortality reported for the years 2023 and 2024 is 181 and 180, respectively.

Table 3.1: Weather extremes in India in the recent years (2022-2024)

Year	Month	Event	States Affected
2022	Jan. and Mar.-Dec.	Heavy rainfall resulting in floods, Landslide	Madhya Pradesh, Himachal Pradesh, Sikkim, Maharashtra.
	Jan. - Dec.	Lightning and Thunderstorm	Bihar, Madhya Pradesh, Maharashtra, Jharkhand, Uttar Pradesh, Rajasthan, Chhattisgarh
	May	Severe Cyclonic Storm ASANI over the Bay of Bengal	Andhra Pradesh.
	Oct.	Cyclonic Storm SITRANG over the west-central and adjoining east-central Bay of Bengal	Assam and Mizoram.
2023	May	Extremely Severe Cyclonic Storm MOCHA over the northeast Bay of Bengal	Mizoram.
	Jun.	Extremely Severe Cyclonic Storm BIPARJOY over Northeast Arabian Sea.	Rajasthan, Gujarat
	Oct.	Extremely Severe Cyclonic Storm TEJ over the Arabian Sea.	No adverse weather over the west coast of India was reported due to this system.
		Very Severe Cyclonic Storm HAMOON over the Bay of Bengal	No adverse weather conditions were reported over the coast of India due to this system.
	Nov.	Cyclonic Storm MIDHILI over the northwest Bay of Bengal.	Tripura and Mizoram.

Year	Month	Event	States Affected
	Dec.	Severe Cyclonic Storm MICHAUNG over the southwest Bay of Bengal	Tamil Nadu, Andhra Pradesh, and Telangana.
2024	Jan - Oct	Lightning & Thunderstorm	Bihar, Madhya Pradesh, Uttar Pradesh, Odisha, Telangana, Jharkhand, Maharashtra, West Bengal, Rajasthan, Andhra Pradesh, Chhattisgarh
	Jan-Dec	Floods and Heavy Rains	Kerala, Madhya Pradesh, Assam, Karnataka, Rajasthan, Andhra Pradesh, Maharashtra, Telangana, Bihar
	Mar- Jun	Heat Wave	Uttar Pradesh, Bihar, Telangana, Jharkhand, Maharashtra, Odisha, Rajasthan
	May	Severe Cyclonic Storm REMAL	Mizoram, West Bengal, Meghalaya, Nagaland, Manipur, Assam
	Oct	Cyclonic Storm FENGAL	Tamil Nadu, Puducherry
	Nov-Dec	Severe Cyclonic Storm DANA	West Bengal

Source: IMD

3.1.2 Water

Climate change impacts have direct consequences for water security. The GoI recognises that climate change manifests itself in important ways through significant changes in the water cycle. The initiatives taken in the water sector in the last decade reflect the importance of water management in reducing vulnerability and building climate resilience. Consequently, the focus of various government initiatives has been on issues such as river rejuvenation, holistic river basin management, increasing storage capacity, enhancing the efficiency of existing dams, water conservation and recharge, and ensuring the security of water supply. In tandem with this, the hydrological monitoring network has been significantly expanded to mitigate the impacts of floods and droughts.

India has approximately 4% of the world's freshwater resources, despite comprising around 18% of the world's population (Gulati et al., 2019).

Table 3.2: State of water resources in India

Parameters	Measures
Geographical Area	328.74 Mha
Annual Rainfall (2020)	1289.6 mm
Major River Basins (as per Reassessment of Water Availability in India using Space Inputs, June 2019)	20 Nos.
Catchment Area of Major River Basins (as on June 2019)	32,71,953 Km^2

Source: Central water Commission, Annual Report 2023 (CWC, 2023)

The contribution of groundwater is nearly 62% in irrigation, 85% in rural water supply, and 50% in urban water supply. According to the Central Water Commission, the annual average per capita water availability in India in 2031 is assessed to decline from 1,486 cubic meters in 2021 to 1,367 cubic meters per person. Annual per-capita water availability of less than 1,700 cubic meters is considered a water-stressed condition, whereas annual per-capita water availability below 1,000 cubic meters is considered water scarcity. These figures, therefore, underline the importance of water in India's climate policies and actions.

Table 3.3: Ground water Resources assessment 2020 to 2023

S. No.	Ground Water Resources Assessment	2020	2022	2023
1	Annual Ground Water Recharge (BCM)	436	438	449
2	Annual Extractable Ground Water Resource (BCM)	398	398	407

S. No.	Ground Water Resources Assessment	2020	2022	2023
3	Annual Ground Water Extraction for Irrigation, Domestic & Industrial uses (BCM)	245	239	241
4	Stage of Ground Water Extraction (%)	62%	60%	59%

Source: Central Water Commission (CWC), Annual Report 2023 (CWC, 2023).

Note: Due to the COVID-19 pandemic, monitoring data in 2021 was insufficient.

The total annual groundwater recharge in the country has been assessed as 449.08 BCM (assessment in 2023) and the amount of groundwater that can be safely extracted each year is 407.21 BCM.

The dynamic groundwater resources of the country are being periodically assessed jointly by the Central Groundwater Board (CGWB) and state governments. As per the 2023 assessment of CGWB, out of the total 6,553 assessment units (Block/ Taluks/ Mandals/ watersheds/ Firkas) in the country, 736 units in various States/ UTs (11.23 per cent) have been categorized as 'Over-exploited', where the annual groundwater extraction is more than the annual extractable groundwater resource. There are 199 units categorized as 'Critical', while 698 units are categorized as 'Semi-critical'. The aforementioned assessment also reports 4,793 units as 'Safe' and 127 units as 'Saline' (CWC, 2023).

According to the National Register of Large (Specified) Dams, September 2023 (NRLD 2023), India has a total of 6138 completed large dams in operation, with an additional 143 dams under construction. These had a combined storage of 343.605 BCM (of which 18.763 BCM was under construction), and a live storage of 253.508 BCM. There are also several thousand smaller dams. These dams are vital for ensuring the water security of the country.

The Dam Rehabilitation and Improvement Project (DRIP) is an externally aided project with financial assistance from the World Bank, that targets rehabilitation and improvement in the performance of selected dams in the country.

Institutional Arrangements and Governance:

The jurisdiction of water resources in India with respect to their planning, development and management is with the States as per the 7th Schedule. According to the 74th Constitutional Amendment, as outlined in the 12th Schedule, Urban Local Bodies (ULBs) are responsible for providing water supply to citizens within their jurisdiction. Legal provisions related to water are available in the constitution, court decisions, central and state laws, and various irrigation acts. In recent times, numerous efforts are being undertaken to enable better management of water resources, especially groundwater (NIUA, 2024).

The GoI approved and set up the National Water Mission (NWM) as per the NAPCC in June 2008. The main objective of NWM is "conservation of water, minimizing wastage and ensuring its more equitable distribution both across and within States through integrated water resources development and management. NWM goal No. 4 is "to increase water use efficiency by 20%". "Sahi-Fasal" is a campaign launched by NWM to nudge Indian agriculture to promote crops that use less water but more efficiently, have high nutritional quality, and are economically remunerative to farmers. Efforts are made to wean farmers away from water-intensive crops, to less water-intensive crops. It also aims to achieve effective pricing of inputs (water and electricity), protect the environment, and assist policymakers in improving procurement policies, as well as create appropriate storage facilities and markets.

Ministry of Jal Shakti (MoJS), GoI

To deal with water issues in an integrated manner under a single umbrella, MoJS has been created by the central government in May 2019. The Ministry includes two Departments namely, the Department of Water Resources, River Development & Ganga Rejuvenation (DoWR, RD & GR) and the Department of Drinking Water and Sanitation (DW&S). The mandate of DoWR, RD & GR includes development, conservation and management of water as a national resource; overall national perspective of water planning and coordination in relation to diverse uses of water and interlinking of rivers; formulation of general policy, guidelines and programmes for development and regulation of the country's water resources; conservation, development, management and pollution abatement of rivers; regulation and development of inter-state rivers and river valleys; water laws and legislations; assessment of water quality; and matters relating to rivers common to India and neighbouring countries. To complement these efforts and ensure comprehensive management of water resources, the MoJS was established, consolidating various water-related initiatives and responsibilities under a unified framework.

Legal and Policy Framework:

The national legislation applicable to water includes the Water Prevention and Control of Pollution Act 1974, the Air Prevention and Control of Pollution Act 1977, the Environment Protection Act 1986, the Forest Conservation Act 1980 (amended in 1988), the Public Liability Insurance Act 1991, and the Environment Assessment Development of Projects Act 1994. (NIUA, 2024).

The National Water Policy, crafted by India's Ministry of Water Resources, directs the planning and development of water resources. It addresses the scarcity of water by promoting sustainable usage and management. Key aspects include integrating water planning into overall development strategies, ensuring fair distribution, promoting efficient water utilization, and advocating for conservation and groundwater management. The policy also emphasizes community involvement and prioritizes essentials such as drinking water, agriculture, and environmental protection. To combat river water pollution, it employs rigorous monitoring, regulatory actions, and public education. Originally enacted in 1987 and subsequently amended in 2002 and 2012, this policy underscores India's commitment to sustainable development and management of its water resources.

Various irrigation and river water rejuvenation schemes in India have multiple objectives like expanding the cultivable area under assured irrigation, improving water use efficiency, groundwater recharge, improvement and restoration of water bodies, thereby increasing the tank storage capacity and revival of lost irrigation potential, increased availability of drinking water, improvement of the catchment of tank commands etc. The positive impact of irrigation/multipurpose projects on climate change is in flood control, generation of hydropower and groundwater recharge, and providing security of livelihoods through assured irrigation.

The Pradhan Mantri Krishi Sinchayi Yojana, approved in July 2015, combines the twin objectives of optimizing investments in storage projects by prioritizing the completion of long-pending major and medium irrigation projects and improving water use efficiency in agriculture through a variety of measures.

Diverse interventions were devised under the Namami Gange Programme to enhance the health and ecosystem of the Ganga River. Namami Gange was approved as a flagship programme in June 2014. The Ganga River Basin Management Plan recommends eight important areas where restorative actions must be carried out in a mission mode. The approach followed in the case of Ganga has Been expanded to 13 more rivers by the MoEFCC.

The Jal Shakti Abhiyan was launched in 2019. It is a time-bound, mission-mode water conservation campaign launched in July 2019 in 1,592 blocks out of 2,836 blocks of 256 water-stressed districts of the country.

Atal Bhujal Yojana (ATAL JAL) is a World Bank-aided Central Sector Scheme of the GoI with an outlay of INR 60 billion, focusing on community participation and demand-side interventions for sustainable groundwater management in identified water-stressed areas.

Several important institutions, regulatory bodies, and ongoing research and development efforts aim to regulate water resources, provide real-time information, and facilitate the more efficient utilization of these resources. Some of these are mentioned below:

- CWC has been a premier technical organization in the field of water resources in the country since 1945. The Commission is entrusted with the general responsibility of initiating, coordinating, and furthering, in consultation with the State governments concerned, schemes for control, conservation, and utilization of water resources throughout the country for irrigation, flood control, drinking water supply, and hydropower development. The CWC also provides a flood forecasting service that covers 20 major river systems in the country across 25 States and UTs. This includes the presence of 333 stations, of which 199 are level forecasting stations on major rivers and 134 are inflow forecasting stations on major dams/ barrages.
- The Central Water and Power Research Station (CWPRS) located in Pune, is an apex research and development institution in the field of hydraulics and allied research in the water and power sector. It works towards creating safe and economic planning and design of water resource structures, river engineering, hydropower generation, and ports and waterways projects.
- The Central Soil and Materials Research Station (CSMRS) is an organization that conducts field and laboratory investigations and promotes research on issues pertaining to geotechnical engineering, concrete technology, construction materials, and associated environmental issues. These subjects have a direct bearing on the development of irrigation and power in the country and function as an adviser and consultants in the above fields to various projects and organizations in India and abroad. The Research

Station is involved in the safety evaluation of existing hydraulic structures and quality control and quality assurance of construction for various river valley projects.

- Water Information Management System (WIMS) is a centralised data aggregating platform for the collection of regular time-series data for groundwater and surface water resources through telemetry sensors and through web-based input facilities from different data points spread across the country. Different central and State agencies are sharing their time series data on rainfall, river levels, discharge, reservoir levels, groundwater levels, surface and groundwater quality, etc., on the platform.
- The India Water Resources Information System (India-WRIS) is a GIS-enabled public platform for the display and dissemination of water resources information. The time series data received through WIMS, along with data on other hydrometeorological parameters and allied themes, is displayed through maps and dashboards on a GIS framework over the portal for ease of understanding of users.

Floods and droughts

India faces escalating risks of floods and droughts, influenced by both human activities, including regional aerosol emissions, and global warming that alter hydrological patterns (Chakraborty et al., 2020). These extreme events impact water availability and outcomes that depend on water such as agricultural production and agricultural productivity. Monsoon rainfall, a critical component of India's agricultural economy, is becoming increasingly variable with more frequent dry spells and intense wet spells (Figure 3.9). This unpredictability has resulted in increasing frequency of riverine and pluvial floods due to extreme rainfall events, particularly in urban and mountainous regions that are susceptible to flash floods (Sharma et al., 2018; Jain & Singh, 2022). Conversely, droughts are exacerbated by prolonged precipitation deficits and rising temperatures, leading to soil moisture depletion, water scarcity, and significant agricultural stress (Mishra et al., 2024; Aadhar & Mishra, 2020).

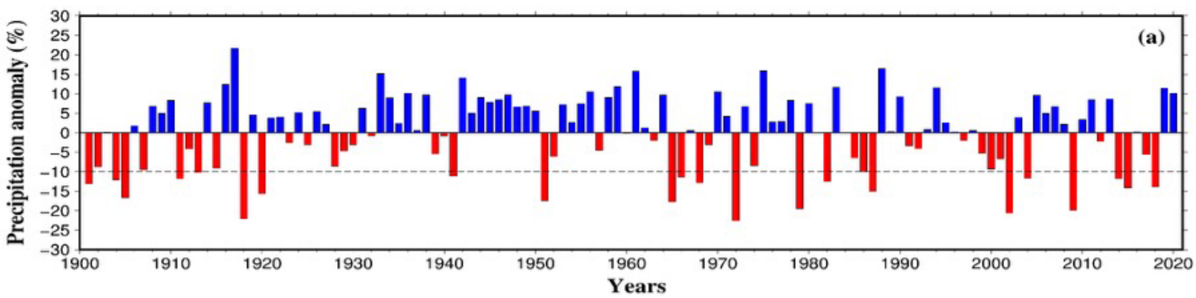

Figure 3.9: India-averaged annual precipitation anomaly from 1901-2020. Source: Based on 1901-2020 IMD dataset

Floods and drought events have had profound impacts across India, causing extensive damage, displacement, and loss of life. Major flooding events, such as those in Mumbai (2005), Bihar (2007-2008), Uttarakhand (2013), and Kerala (2018), led to severe consequences for local populations (Mohanty et al, 2020). Such hydrological extremes present significant socioeconomic challenges. For example, the 2023 floods in Himachal Pradesh and Uttarakhand alone caused estimated economic losses of INR 100 to INR 150 billion, in addition to the loss of lives and damage to infrastructure (Kushwaha et al, 2024). The frequency and spatial extent of droughts over the country have increased significantly, along with an increase in intensity, mainly confining to the central parts, including the Indo-Gangetic plains of India, over the period 1951-2016. (Krishnan et al , 2020a). The extreme drought of 2002 affected over 300 million people in India (Bhat, 2006), and the severe droughts in the Gangetic region and Maharashtra in 2014 and 2015 were classified as 500-year return period events, resulting in acute water scarcity and impacting millions (Mishra et al, 2016). In recent decades, droughts have become frequent, occurring approximately once every three years (Aadhar and Mishra, 2017; Mishra et al, 2016; Shah and Mishra, 2015). Furthermore, whiplash events—sudden transitions between floods and droughts or vice versa—are becoming increasingly common and severe due to shifting climate patterns and monsoon active and break spells. India's monsoon-dominated climate makes the region particularly vulnerable to these extremes. This dual threat of floods and droughts highlights the urgent need for robust adaptation measures to enhance resilience against climate-induced challenges. Effective strategies must address the complex interactions between climate dynamics, land use changes, and water resource management to safeguard food security (Ali et al, 2019; Allan et al, 2020).

3.1.3 Agriculture

Indian agriculture, with more than 86% of all operational holdings being small and marginal, is particularly vulnerable to climatic hazards. Its robust performance is essential to meet the food requirements of the population of 1.4 billion (MoA&FW, 2022). At present, India produces about 328.85 Million Tonnes (MT) of total food grains, 39.6 MT of oil seeds, 442.52MT of sugarcane and an estimated 355.25 MT of horticultural produce (MoA&FW, 2024). During 2022-23, total milk production in the country was 230.58 MT, total egg production was 138.38 billion numbers, total meat production was 9.77 MT with poultry meat contributing about 51.14% and total fish production was 17.55 Mt (MoFAH&D, 2023 &2024).

Despite this, India still imports substantial quantities of edible oil and pulses. In addition, the per capita availability of several commodities is less than global levels. For example, per capita edible oil consumption is 19.7 kg/year, egg availability is 101 eggs per annum, and that of milk is 459 grams per day. With a projected increase in population to ~1.6bn, estimated demand by 2047 for many commodities is projected to increase by anywhere between 2-3 times current production levels. Added to these, there exists a significant yield gap for many crops and commodities.

For instance, wheat yield in India is about 3.54 Mg/ha as compared to the world's best national average of 9.39 Mg/ha. Thus, the yield gap is almost 60% as compared to that of best average yielding nation (Naresh Kumar, 2023).

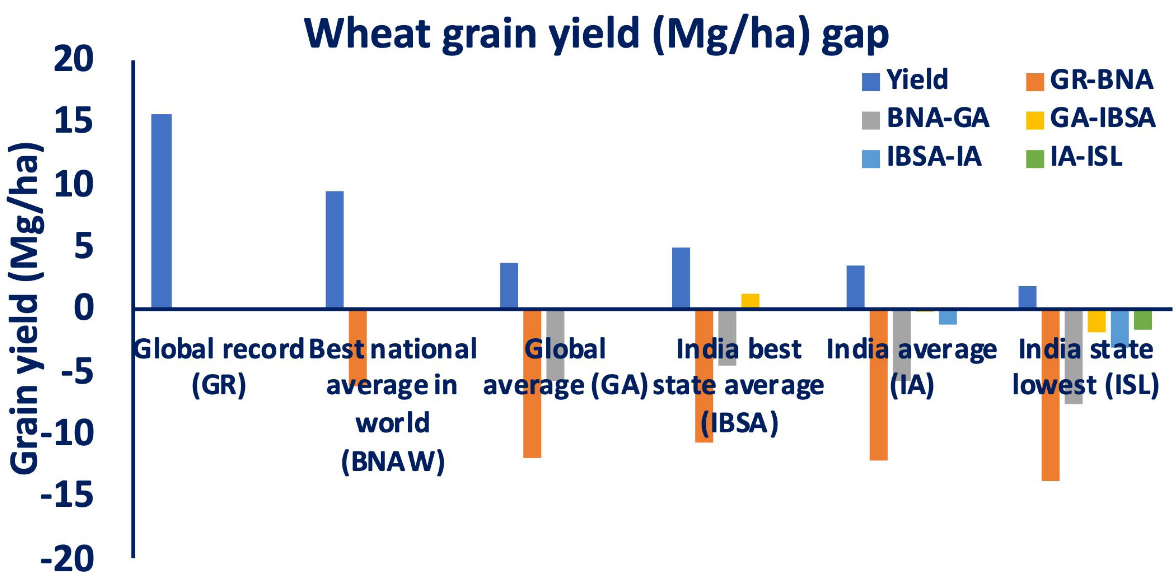

Figure 3.10: Yield gap in wheat from the global levels and within India. Source: Naresh Kumar (2023)

Similarly, the average milk yield per animal per day for exotic/crossbred animals is 8.55 kg/day/animal, and for indigenous/non-descript animals is 3.44 kg/day/animal (MoAHF&D, 2023). Domestic production of edible oil is able to meet just about 40-45% of its edible oil requirements (NITI Ayog, 2024), mainly due to significant yield gaps ranging from 0.8 to 2.4 times of the global best-performing nations for respective edible oil crops.

In addition to these significant yield gaps, Indian agriculture is facing substantial losses due to climatic stresses, posing significant challenges to crop production and the livelihood security of farmers. Wheat crop in 2021-22 and 2022-23 has witnessed climatic hazards viz., heat wave in March-April 2022 and extreme rainfall events in March-April 2023 coinciding the grain filling period resulting in production loss to the tune of 4.5 MT in 2021-22 and 1.5 MT in 2022-23. In the case of soybean, production of 118.6 MT in 2013-14 could not be achieved in subsequent years due to extreme rainfall events coinciding with the pod maturation stage resulting in a 9.5 to 30.75% production loss (MoA&FW data). There have been several such incidences of climate hazard-driven production losses in tomato, onion, fruit crops, vegetables etc. resulting in significant impacts on producers and consumers alike due to production loss and increase in market prices.

Agriculture and allied activities (horticultural crops, livestock, fishing, forestry, and logging) are the largest sector in terms of livelihood and employment and contribute significantly to the Indian economy

Agriculture retained 46.1 percent of the total workforce in 2023-2024 (Economic Survey, 2025). The share of agricultural and allied sector activities in the economy's total Gross Value Added (GVA) stands at 16.6 percent in 2023-24 (Economic Survey, 2025) MoSPI, 2023). The agricultural sector is most vulnerable to climate change and, conversely, the most important sector for adaptation in India. Millions of people depend on it for their livelihood, particularly small and marginal farmers whose growth is essential to escape poverty and achieve a minimal standard of living. Indian farmers, especially the marginal, small, and medium farmers, have traditionally grappled with the effects of climate variability.

The development of agricultural production and productivity is key to rural development in India and is also crucial to addressing poverty reduction concerns. In this context, it is important to note three broad observations in the case of agriculture and climate change in India. First, climate variability and long-term climate change affect not just production and productivity in Indian agriculture but also the incomes and livelihoods of small and marginal farmers in India, as well as agricultural workers. The second is the predominance of small and marginal farmers and the absence of large-scale or "industrial agriculture" in India. These small and marginal farmers engaged within it are particularly vulnerable to climate variability, extreme events, and long-term climate change. Thirdly, the risks faced by the agricultural sector (and allied activities) include risks from extreme events, climate variability, low levels of productivity, as well as general conditions of socioeconomic well-being in rural regions of India.

Indian agriculture continues to be vulnerable to weather vagaries despite self-sufficiency in food grain production, and uncertainty in the prediction of those events further adds to the challenges to farmers, causing widespread losses of agricultural output. Heatwaves, droughts, and floods have caused significant damage to crop production and harvesting activities in India.

India's Third National Communication has noted that the low water holding capacity of soils and low groundwater availability have contributed to high risk in 56 and 13 districts respectively. Degraded lands are the major cause of vulnerability in 13 districts. High frequency of droughts in 156 districts, cyclones in 93 districts and floods in 61 districts have been major factors contributing to risk.

Slow-onset events are equally pertinent for agriculture sector in India. This may include land degradation, groundwater depletion, and the reduction in water absorption capacity. These factors have a direct impact on agricultural productivity and livelihoods, particularly in India's rainfed and arid regions. Addressing these challenges is crucial for enhancing climate resilience and promoting sustainable agricultural practices. Adaptive strategies such as water-efficient irrigation, agroforestry, soil restoration, and climate-smart farming should be emphasized to ensure long-term sustainability and food security in the face of climate change.

Institutional arrangements and Governance:

The adaptation to climate change impacts on agriculture is multi-dimensional. Efforts to make Indian agriculture climate resilient, include technological innovations by the research Institutions, policy backstopping by the National and state Governments and developmental initiatives by several stakeholders. Given the magnitude and diversity of agricultural systems in India, the governance of impacts has been in focus under the NAPCC, National Adaptation Plans (NAP). Under NAPCC, the agricultural sustainability is being addressed under National Mission for Sustainable Agriculture (NMSA) well supported by several other relevant missions and ministries. The Food Security act covers right to food for every citizen. Under this the Government has been providing assured food grains to >80 million population.

Legal and Policy Framework

Despite the above factors, there has been a consistent increase in the production of both food grains and horticultural crops in India. This indicates the importance of the development of climate-resilient crop varieties, appropriate farming systems, social security and welfare measures, and other interventions, as part of development and ongoing climate adaptation. Some of the policy measures undertaken to address the risks of climate variability and climate change include, inter alia:

- Important schemes and long-term adaptation strategies: Several current strategies and policies are also important in addressing the climate and socio-economic risks faced by the agriculture and allied activities sector. These include- the National Plan for Dairy Development, National Live Stock Management Programme, National Food Security Mission, NMSA, National Mission on Agricultural Extension and Technology, Prime Minister Fasal Bima Yojana, National Horticulture Mission, PMKSY, Integrated

Management of Public Distribution System(IM-PDS), Pradhan Mantri Awas Yojana (Grameen), Rural Infrastructure Development Fund (NABARD), Mahatma Gandhi National Employment Guarantee Act, National Rural Livelihood Mission (NRLM), Pradhan Mantri Kisan Samman Nidhi (PM-KISAN), Pradhan Mantri Matsya Sampada Yojana (PMMSY).

- To improve organic farming systems and to enhance the farmer's incomes specific schemes are being implemented including- Paramparagat Krishi Vikas Yojana (PKVY), Rashtriya Krishi Vikas Yojana (RKVY) - Remunerative Approaches for Agriculture and Allied sector Rejuvenation (RAFTAAR). To improve soil health and reduce environmental pollution 5.91 million ha area has been brought under organic farming by 2021-22.
- Rainfed Area Development Scheme: The Rainfed Area Development (RAD) scheme focuses on the integration of farming systems with activities such as agroforestry, horticulture, livestock, fishery, and apiculture, which will enhance productivity, increase income opportunities for farmers, and minimize risks associated with climatic variability, such as droughts, floods, and extreme weather events.
- National Innovations on Climate Resilient Agriculture (NICRA): This is a network project of the Indian Council of Agricultural Research (ICAR) launched in February 2011, which aims to enhance the resilience of Indian Agriculture to climate change and climate vulnerability through strategic research and technology demonstration. Under the NICRA project, seed varieties/hybrids of rice, mung bean, maize, and lentils resistant to diseases and extreme weather conditions were developed and released.
- Monitoring pest attacks and plague: Aiming at real-time reporting of desert locust infestation, the Android mobile application "eLocust3m" was implemented in 2020, which resulted in effective desert locust control. Towards strengthening the ground control fleet for locust control new vehicle-operated ULV sprayers with advanced features have been procured during 2020.
- Insurance and Risk support: The Pradhan Mantri Fasal Bima Yojna is the largest crop insurance scheme in the world in terms of farmer enrolments that is implemented by the -GoI. This scheme provides insurance coverage and financial support to the farmers in the event of failure of any of the notified crops because of natural calamities, pests and diseases. Over the past 6 years, the total premium paid by farmers towards this scheme amounted to INR 251.86 billion and the money received as claims amounted to INR1.2 trillion.

3.1.4 Forests

India is one of the few countries where forest and tree cover has increased in recent years, transforming the country's forests into a net sink owing to national policies aimed at the conservation and sustainable management of forests. It is important to note that this increase, notwithstanding the fact that in India, forests are also heavily populated, apart from being an important source of raw materials, income, and employment for millions. The vulnerability of forests, the need for their conservation, and addressing the development concerns of populations within forest areas are three broad concerns that guide India's policy in this sector.

As per the latest assessment, forests and tree cover has increased from 23.4% in 2005 to 25.2% of the geographical area of India in 2023, covering 8,27,356.95 sq. km., with an increase of 1445.81 sq.km. over the last assessment in 2023. Globally, India ranks third in terms of the average annual net gain in the forest area. This increase in total forest cover is mainly attributed to an increase in very dense forest (all lands with tree canopy density of 70 percent and above), which rose by 19.54 percent between 2011 and 2021. Open forest (all lands with tree canopy density between 10-40 percent) also improved by 6.71 percent, while moderately dense forest (all lands with tree canopy density between 40-70 percent) declined by 4.32 percent between 2011 and 2021. The forest sector employs around 6.23 million people and is a source of livelihood for several communities, especially tribal communities. In terms of absolute, per capita, and annual rates, India has among the lowest rates of gross deforestation in the world. The carbon stock in forests is estimated to be 7,204 million tonnes.

According to the India State of Forest Report (2023), forest cover refers to all tree patches of one or more hectares in size, with a canopy density of more than 10%. Forest area refers to those areas recorded as forests in government records including Reserved Forests (RF), Protected Forests (PF) and Unclassed Forests as specified by the Indian Forest Act (1927) or other State Forest Acts. It can include natural forests and tree growth as well as human-made forest cover including tree-crops and plantations. Forest cover in India is classified in terms of canopy density into three types- Very Dense Forest (VDF), Moderately Dense Forest (MDF), and Open Forest (OF). Table 3.4 below describes the forest cover area in terms of the broad classification types.

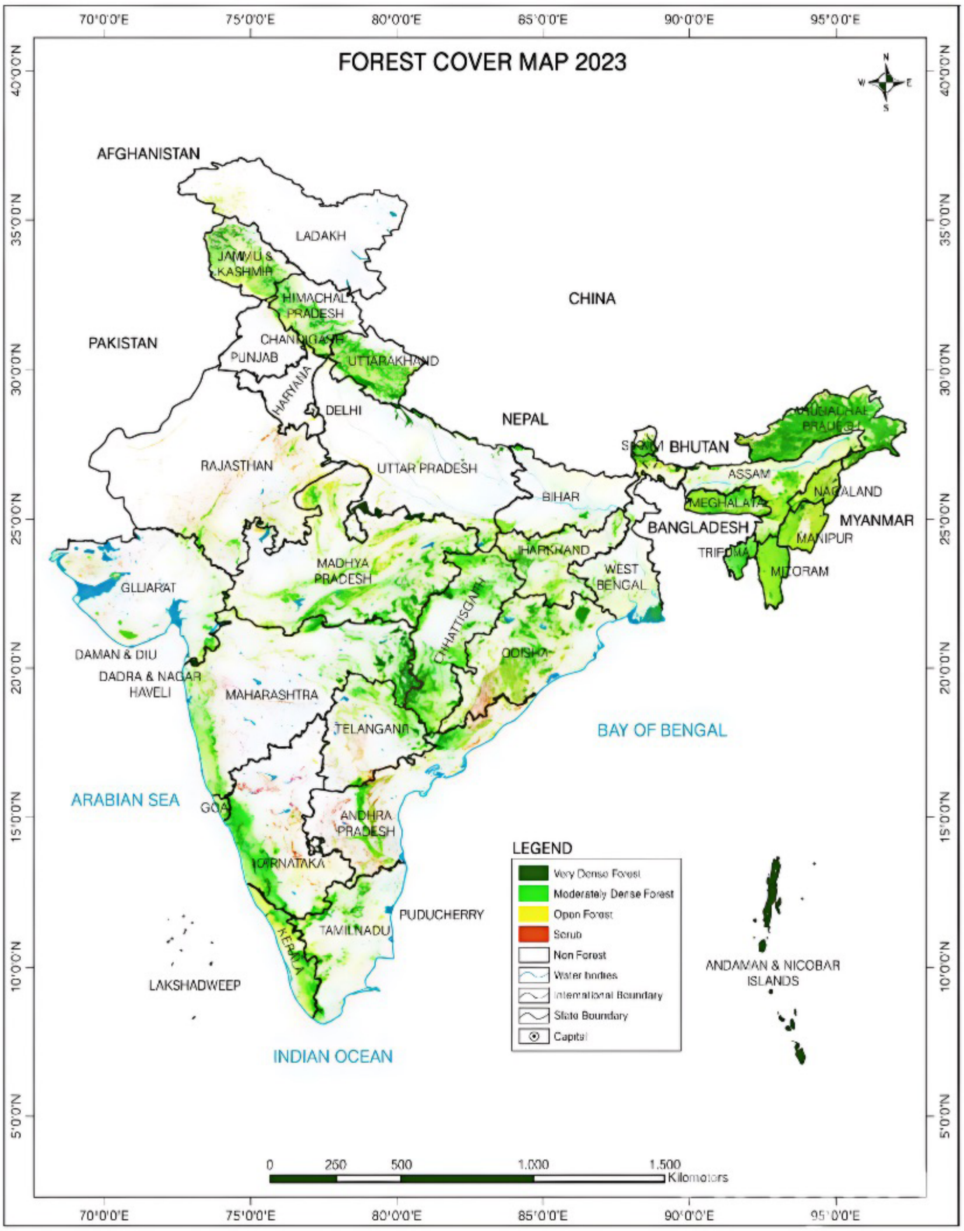

Figure 3.11: Forest Cover Map of India 2023 Source: India State of Forest Report 2023

Table 3.4: Forest Cover of India

Forest cover classification	Area (sq km)	Percentage of total geographic area
Very Dense Forest	102502.2	3.12
Moderately Dense Forest	307673.28	9.36
Open Forest	305167.13	9.28
Total Forest Cover	715342.61	21.76
Scrub	43622.64	1.33
Non- Forest Area	2528503.63	76.91

Source: India State of Forest Report 2023

For definitions of forest cover classification, see India State of Forest Report, 2023. The distribution of total forest cover across the country is described in Figure 3.11. The protected areas network of the country consists of 106 National Parks, 573 Wildlife Sanctuaries, 123 Conservation Reserves and 220 Community Reserves (Table 3.5).

Table 3.5: Number and area under protected areas network

Protected Area	Nos.	Total Area (mha)	% of the Country Geographical Area
National Park	106	4.44	1.35
Wildlife Sanctuary	573	12.72	3.87
Community Reserve	220	0.15	0.04
Conservation Reserves	123	0.56	0.17
Total	**1022**	**17.86**	**5.43**

Source: Protected Areas of India ENVIS-WII (2024).

Institutional arrangements and governance

The forest resources in India are administered by the MoEFCC at the national level and by the State Forest Departments at the State level. The MoEFCC is responsible for planning, promoting, coordinating, and overseeing the implementation of various environment, forest, and climate change-related policies and programmes with the objectives of conservation of forests and biological diversity, prevention and control of pollution, afforestation and restoration of degraded forest areas, and protection of the environment. The State Forest Departments are responsible for planning, implementing, and monitoring of programmes in the forestry sector at the State level.

Forest Departments of respective States/Union territories are responsible for the protection, conservation, administration and development of forests. Forest Range is the smallest functional unit of forestry administration for the execution of works in the field. Functional Divisions include Working Plan, Silviculture, Wildlife, Research, Social Forestry, Watershed Management etc. which carry out specific functions related to forest management.

Joint Forest Management is an approach and program initiated in the context of the National Forest Policy, 1988 (Government of India, MoEFCC, 1988), wherein State Forest Departments support local forest-dwelling and forest fringe communities to regenerate, protect, and manage identified degraded forests, India recognizes the share of the protecting communities over forest produce. The local communities and the State Forest Department jointly plan and implement forest regeneration and development programmes, and the communities are rewarded with a substantial share of the forest produce in return for their efforts in the protection and management of forests. About 1,18,213 Joint Forest Management Committees in the States and Union Territory of Andaman & Nicobar Islands are managing about 22.94 mha of forests in the country (ICFRE, 2011).

Legal and policy frameworks and regulations

Various policies, acts and legislations in India are a strong testimony of the country's commitment to the philosophy of conservation, protection and sustainable management of forests. Some of the key policies, laws and regulations governing the conservation, protection and sustainable management of forests are the following:

- Indian Forest Act, 1927 (amended in 2017)
- Wildlife (Protection) Act, 1972 (amended in 1993)
- Forest (Conservation) Act, 1980 (amended in 1988)
- Environment (Protection) Act, 1986
- National Forest Policy, 1988
- Panchayat (Extension to Scheduled Areas) Act, 1996
- Biological Diversity Act, 2002
- National Environment Policy, 2006
- The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006
- National Green Tribunal Act, 2010
- National Water Policy, 2012
- National Agroforestry Policy, 2014
- Green Highways (Plantation, Transplantation, Beautification and Maintenance) Policy, 2015
- Compensatory Afforestation Fund Act, 2016
- Draft National Forest Policy, 2018

- National Action Plan on Forest Fires 2018
- National Working Plan Code – 2023
- Forest (Conservation) Amendment Act, 2023
- Biological Diversity (Amendment) Act, 2023
- National Afforestation Programme
- Nagar Van Yojana
- National Rural Livelihoods Mission

3.1.5 Himalayan Ecosystem

The Himalayas are the world's youngest and largest mountain range, encompassing four biogeographic regions that contribute to its rich biodiversity and endemism (Myers et al., 2000; Sharma, 2017; Payne et al., 2020). Despite being one of the global biodiversity hotspots and covering 18% of the global mountain area, the Himalayas are also one of the least explored mountain systems in the world. The Himalayan glacier systems are an important ecosystem within the Indian sub-continent. The Himalayan Mountain range supplies water to major Indian rivers, including the Ganga and the Brahmaputra. Water supply from snow and glacier melt affects the livelihood of large Himalayan Mountain communities. The fragile landscapes of the Himalayan region are highly susceptible to a changing climate, and there is a growing concern about its effect on the communities depending on locally available resources (Hughes et al., 2021; Qian et al, 2019; Wester et al., 2019; Chakraborty et al., 2018; Wester et al., 2020; Yadav et al., 2021; Wani et al., 2022). Climate change concerns in the Himalayas are multifaceted, encompassing floods, droughts, landslides, human health, biodiversity, endangered species, agriculture, livelihood, and food security (Kuniyal et al., 2021).

With geographical coverage of over 5.3 lakh km^2, the Indian Himalayan region (IHR) holds the northern boundary of India and stretches over Jammu and Kashmir in the west to Arunachal Pradesh in the east, encompassing eleven mountainous states (fully/partially) and two Union territories (Bhatt et al., 2021). While the region represents nearly 4% of the total human population of the country, it exhibits a diversity of ethnic groups (30%; 171 out of a total of 573 reported scheduled tribes in India). The great wealth of biological diversity in the region is attributed to the wide variety of bio-physical conditions across the IHR (Rawal et al., 2021).

Richness and representativeness of biodiversity elements

Status of Plant Biodiversity: According to the latest scientific studies, the Indian Himalayan region is a harbour of 11,743 native plant species belonging to 2,320 genera in 244 families (Wani et al., 2024). The synthesis of plant diversity database (324 floristic studies published between 1872 and 2022), the angiosperms are represented by 11,695 (99.6%) species belonging to 2303 genera in 236 families; however, gymnosperms are represented by 48 (0.4%) species belonging to 17 genera in 8 families. Furthermore, a total of 771 alien plant species (cultivated 375; naturalized 396) belonging to 459 genera in 112 families were recorded from IHR, based on a review of 141 studies published during the years 1934 to 2022 (Wani et al., 2022). The representation of plant biodiversity from the IHR is shown in below Table 3.6.

Table 3.6: Plant biodiversity in the Indian Himalayas

Plant Species	Number	References
Angiosperms	8700	(Singh & Pusalkar, 2020)
Gymnosperms	51	
Pteridophytes	766	
Bryophytes	1955	
Specific groups		
Trees	2199	(Wani et al., 2023)
Endemic species	1076	(Tiwari et al., 2024)
Wild edible	675	(Samant and Dhar, 1997)
Medicinal plants	1748	(Samant et al., 1998; Mehta et al., 2023)

Plant Species	Number	References
Threatened plants	456	(Mehta et al., 2020; Mehta et al., 2023)
Alien plants	771	(Wani et al., 2023)

Endemic Plant Species in IHR: A total of 1076 endemic plant taxa, including 1061 angiosperms, 3 gymnosperms, and 12 pteridophytes belonging to 432 genera and 100 families, were recorded from the Indian Himalayan Region (IHR) (Tiwari et al., 2024). The richness of endemic plants was found to be maximum in Arunachal Pradesh (294), followed by Meghalaya (213) and Sikkim (212). The maximum number of endemic taxa was found in the family Orchidaceae (115), followed by Asteraceae (79) and Poaceae (63).

Threatened plant species in IHR: A total of 456 threatened taxa belonging to 233 genera and 87 families were reported from IHR, from which 85 taxa were included in higher extinction risk categories (18 CR, 34 EN, 31 VU, 02 EW) including 41 trees, 34 herbs, 3 shrubs, 3 mosses, 2 vines, and 2 bryophytes belonging to 56 genera under 41 families (Mehta et al., 2020; Mehta et al., 2023). Of the 456 taxa, 112 species are medicinal, and 19 are included in higher threat categories (e.g., CR-7, EN-7, Vu-5). Among the Himalayan states, Arunachal Pradesh harbours the maximum number of threatened taxa with 34 species, followed by Meghalaya (33) and Assam (28 species).

Institutional Arrangements and Governance

There is no separate institutional arrangement for the Himalayan ecosystem as it is covered by several State jurisdictions and also by the jurisdiction of national institutions as relevant to various aspects of the ecosystem.

Legal and Policy Framework

The National Mission for Sustaining the Himalayan Ecosystem (NMSHE), one of the 9 missions under NAPCC has recognized the Himalayan ecosystem as vital for preserving the country's ecological security. It also underlines the intense vulnerability of this ecosystem to both anthropogenic and climatic perturbations. However, several aspects of the magnitude and consequences of the impacts of climate change and loss of plant biodiversity are in need of further study. The future of plant biodiversity in the region is an important aspect of the future of local communities and downstream-dependent people. Understanding climate change impact, vulnerability, and adaptation in Himalayan plant biodiversity is urgently required to develop sound strategies for its conservation and sustainable utilization.

3.1.6 Coastal Regions, Marine Ecosystems, and Wetlands

India’s coastline spreads over nine states and five union territories and is recorded to be about 11,099 km (Survey of India, 2023). It includes 1,298 offshore island territories. Furthermore, it is important to note that 26% of the Indian population lives within 100km of the shoreline, with most coastal areas being low-lying and vulnerable to disasters such as Tsunamis, Storm Surges, and Sea level rise. The figure below shows the population density across the Indian shoreline and the presence of the population in the low-elevated costal zones of India.

Coastal regions are unique because of their position at the interface of the atmosphere, lithosphere, and hydrosphere. Across its coast, India's important marine ecosystems include wetlands, mangroves, tidal mudflats, lagoons, beaches, marshes, and coral reefs. More specifically, within the peninsular region of India, there are 25 Marine Protected Areas (MPAs), 97 significant estuaries, 34 major lagoons, 5,790 sq. km of coral reefs, and mangroves spread over 4975 sq. km (MoEFCC, 2019d; FSI, 2019). The impacts of climate variability and extreme events on these systems affect India's coastal community and strategically important infrastructures.

Densely populated coastal zones of India are affected by various short- and long-term events including continuous coastal processes, rising sea levels, and human interventions. Mohanty et al (2017) examined at coastal vulnerability mapping index of the Indian coastline and estimated that the highest percentage of coastal erosion has taken place along the West Bengal coast at 70% followed by Kerala (65%), Gujarat (60%), and Odisha (50%). The coastlines of the remaining states recorded less than 50% of coasts under erosion (Mohanty, et al 2017).

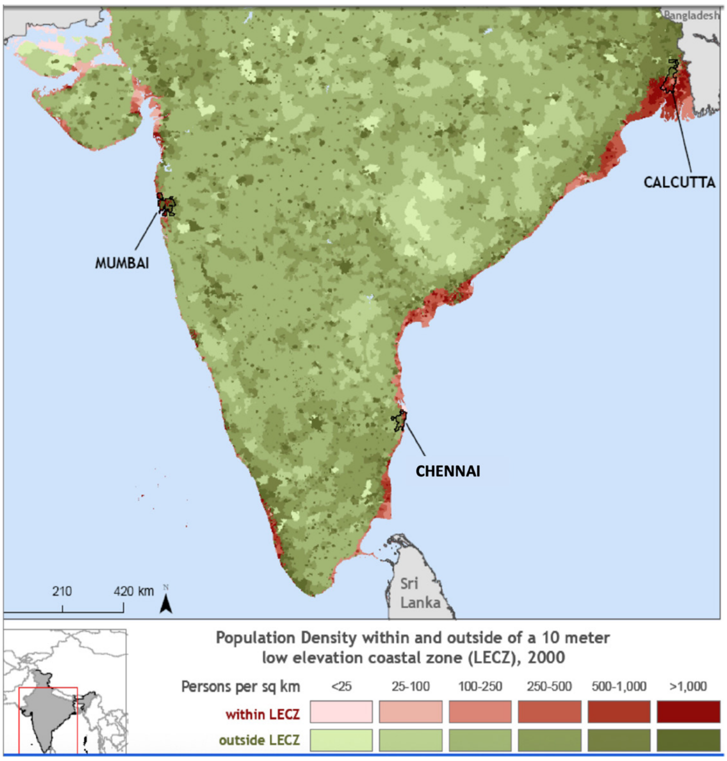

Figure 3.12: Population density within and outside 10 m low elevation coastal zone (2000). (Source: INCOIS (2012)

Further, the Coastal Vulnerability Map Index prepared by the INCOIS has analysed 6907.18 km of the Indian coastline (1990 to 2018) and observed that 33.6% of the coastline has been under varying degrees of erosion for the past 28 years. The latest atlas of the Coastal Vulnerability Index mapping is slated to be released soon, but the figure below provides the existing vulnerability index map of India's coastline from 2012.

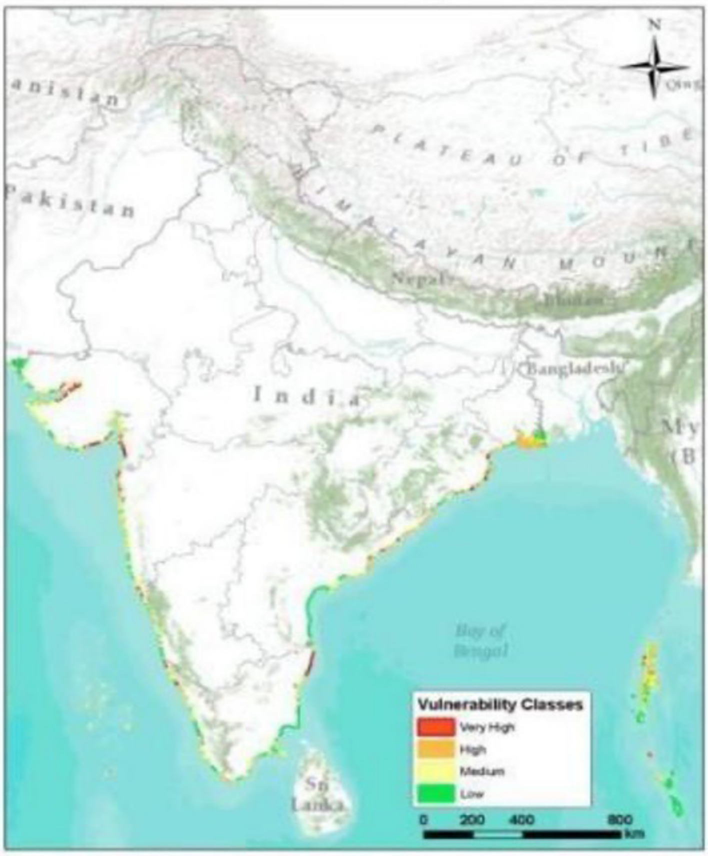

Figure 3.13: Coastal Vulnerability Index Atlas of India (2012). Source: INCOIS (2012)

An additional threat that must be monitored in this regard is climate change-induced sea level rise. Sea level rise in the near and long-term future will affect populations, including fisherfolk, salt pan workers, farmers in coastal agriculture, the urban population and urban settlements. The coastal vulnerability of populations in India from climate change is a significant threat. A study conducted by INCOIS indicates that the current sea level rise along the Indian coast is about 1.7 mm/year (Nidheesh et al 2020).

The Ministry of Earth Sciences (MoES) estimates, based on observations, that the sea level in the Indian Ocean is rising at an average rate of about 1.7 mm/year, with 3.3 mm/year in the recent decades (1993-2015). However, this rate of sea level rise includes both the thermal expansion of ocean water and the subsidence or uplift of land at various locations along the Indian coast. The latter data on land subsidence is not available over a long period of time. Under the aegis of the MoES, The National Centre for Coastal Research (NCCR), has developed a digital Atlas called National Shoreline Atlas System (NSAS). This atlas provides periodical information to state authorities in terms of monitoring shoreline changes, erosion, and accretion hotspots. The NCCR and coastal state administrative institutions work together on designing suitable coastal protection structures to mitigate the effects of changing climate.

Wetlands play an important role as an ecosystem as well as play a role in carbon sequestration. The National Wetland Inventory project has been carried out to update the wetland inventory and perform decadal change analysis (2017-18 vs 2006-07) using Indian Remote Sensing satellite data. At the country scale, 2,31,195 wetlands (> 2.25 ha) were mapped in 2017-18, covering an area of 15.98 million ha. A decadal wetland change analysis for the earlier inventory of the 2006- 07 timeframe revealed an increase of 0.64 Mha (4.18%) compared to the earlier inventory.

Institutional Arrangements and Governance:

MoEFCC, GoI, has notified the Coastal Regulation Zone Notification, 2019, to conserve and protect coastal stretches and marine areas and ensure livelihood security for fishermen and other local communities. The coastal regulations, however, permit the setting up of erosion control measures on the coast. The notification also provides for No Development Zones (NDZ) along various categories of coastal areas to protect India's coastline from encroachment and erosion.

The Government has also implemented the Integrated Coastal Zone Management Project (ICZMP), a World Bank-assisted project, in identified stretches of Gujarat, Odisha, and West Bengal from 2010 to 2020 to protect and conserve the coastal and marine environment of the country. This includes the development of an integrated coastal zone management plan, the prevention of soil erosion, the establishment of shelterbelt and mangrove plantations, the strengthening of requirements for ecosystem monitoring, biodiversity conservation, and the sustainable livelihoods of coastal communities.

The Ministry of Environment, Forest and Climate Change launched the 'Mangrove Initiative for Shoreline Habitats & Tangible Incomes (MISHTI)' in 2023 to promote and conserve mangroves as a unique natural ecosystem with very high biological productivity and carbon sequestration potential, besides working as a bio-shield. MISHTI envisages the restoration and reforestation of mangroves, covering approximately 540 km^2, spreading across nine states and three Union Territories for five years, commencing in 2023–24 onwards. The States have also been encouraged to take part in activities under MISHTI through convergence with the existing schemes/ programs. Overall, the mangrove cover of the country witnessed an increase of 252 km2 between 2015 and 2021.

Legal and Policy frameworks

Legal and Regulatory Framework, such as the Maritime Zones of India (Regulation of Fishing by Foreign Vessels) Act, The Coastal Aquaculture Authority Act, The Environment (Protection) Act, The Wildlife (Protection) Act, etc., are some of the key steps undertaken for the management of the fisheries sectors by the GoI. To conserve marine species, the GoI has notified 130 Marine Protected Areas across the Coastal States and Islands; in addition, 106 coastal and marine sites have been identified and prioritized as Important Coastal and Marine Biodiversity Areas (ICMBAs) to take care of marine species conservation. Fishing zones are demarcated to separate traditional, small-scale fishers from industrial trawlers to reduce conflicts and overfishing, whereas fishing licenses are issued to regulate the number of fishing vessels and ensure adherence to sustainable practices. Each coastal state in India has its own Marine Fisheries Regulation Act (MFRA) to regulate fishing activities within territorial waters (up to 12 nautical miles). The National Marine Fisheries Policy (NMFP) provides guidelines for the sustainable development of marine fisheries, ensuring ecological and economic balance.

3.1.7 Biodiversity

India harbours major parts of four global biodiversity hotspots that provide habitats for high concentrations of endemic taxa (Myers, 2003) and provide habitats to some of the largest wild populations of large, wide-ranging mammals (Sukumar, 1989; Ranganathan et al. 2008). However, with these ecosystems, plants and animals facing the threat of climate change, management actions aimed at ensuring their adaptation to a changing climate are of increasing importance (Bhatt et al., 2018). India has four biodiversity hotspots in its national territory including the Himalayas, the Indo-Burma region, the Western Ghats and Sundaland.

Institutional arrangements for governance for impacts and all sectors relevant to adaptation

Large areas rich in biodiversity are often Protected Areas (PAs) in India, whose governance and management are by state Forest Departments, and overall, under the supervision of MoEFCC. Further, the National Biodiversity Authority, State Biodiversity Boards, and the Union Territory Biodiversity Councils are statutory bodies under the MoEFCC that oversee issues related to the conservation and sustainable use of biological resources, and the fair and equitable sharing of benefits arising from their use. Biodiversity governance is implemented at the smallest scale of governance through Biodiversity Management Committees that are constituted at the Panchayat level (the unit of village administration).

The National Mission for a Green India, under the National Action Plan on Climate Change, aims to help vulnerable species/ecosystems adapt to a changing climate. It aims at "greening" activities that enhance ecosystem services (e.g., carbon sequestration, hydrological services), biodiversity, and other provisioning services like the production of NTFPs.

While these specialised institutions and plans exist with respect to aiding the adaptation of species and ecosystems to climate change, substantial biodiversity and wildlife in India continue to exist outside PAs, in areas which also have large human populations. There are several other Ministries and Departments (e.g., Ministry of Rural Development, Dept of Land Resources, Ministry of Jal Shakti, Ministry of Panchayati Raj), whose work includes important elements of facilitating the adaptation of ecosystems and species to climate change (Ganguly & Panda 2010).

Legal and policy frameworks and regulations

Legislation such as the Indian Forest Act, 1927 (aimed at preserving and protecting forests), the Wild Life (Protection) Act, 1972 (aimed at the conservation, protection and management of wildlife), the Forest (Conservation) Act, 1980 (aimed at mitigation forest conversion and deforestation), the Environment (Protection) Act, 1986 (aimed at protection and improvement of the environment) and the Biological Diversity Act, 2002 (amended 2023) (aimed to conserve biological diversity, promote sustainable use of its components, and ensure fair and equitable sharing of benefits arising from the use of biological resources and associated traditional knowledge) have played a key role in protecting forests, wetlands, grasslands, and other ecosystems, and the biodiversity in these ecosystems in India. Hence, these legislations have an important role to play in overseeing the management of the adaptation of ecosystems, biodiversity, and wildlife to climate change. Policies such as the National Forest Policy, 1988 (which envisages that 33% of India's area should be under forest/tree cover) and the National Wildlife Action Plan 2017-2031 (which adopts a landscape approach to wildlife conservation) are also important tools towards these aims.

Further, the Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006 (aimed at recognizing the rights of forest dwellers to use and occupy forest land), provides the local Gram Sabha (village assembly) a central role in the implementation of the Act. A similar role is played by the Joint Forest Management Committees, which encourage the joint management of forests by Forest Departments in collaboration with local people.

Finally, developmental policies can also play an important role in facilitating ecosystem adaptation to climate change. For example, the MGNREGA, 2005, aims to enhance livelihood security in rural areas by providing 100 days of wage employment every year. This employment occurs in rural development programs, including activities that have implications for the adaptation of ecosystems to climate change, such as watershed development and afforestation (Chaturvedi et al. 2014).

3.1.8 Cities

A settlement is defined as urban in India in the population census as one with (i) a minimum population of 5,000; (ii) at least 75% of the male main working population is engaged in non-agricultural pursuits, and (iii) a density of population of at least 400 persons per sq km. At the time of the 2011 population census, there were 7,935 towns in the country, an increase of 2,776 since the previous census (Table 3.7). Table 3.7 also shows that there are two categories of urban settlements (referred to as towns generically), namely, statutory towns and Census towns. The statutory towns are those administrative units identified/ declared as such by the state governments. Of the 7,935 urban settlements (towns) identified in the 2011 population census, 3,894 (49%) did not have urban administrative arrangements (municipal corporation/ municipality/ nagar palika) and are referred to as census towns. Census towns are the ones identified by the population census of India as urban but do not have urban administration. In fact, there is a significant increase in the number of census towns from 2001 to 2011 (an increase of 172% over the decade). This trend is expected to continue going forward as more and more village panchayat areas have urban characteristics but have not been declared as urban administration by their respective state governments. Table 3.7 below presents the trend of urban transition in India from 1981-2011.

Table 3.7: India's Urban Transition, 1981–2011

Year	Number of Towns/ Urban Areas			Total Urban Population (in millions)	Urbanisation Level (Urban population to total population)	Annual Exponential Growth of Urban Population
	Total	Statutory	Census			
1981	3,891	2,620	1,271	159.5	23.34	3.87
1991	4,615	2,922	1,693	217.6	25.71	3.15
2001	5,161	3,734	1,427	286.1	27.81	2.77
2011	7,935	4,041	3,894	377.1	31.16	2.80

Source: compilation from Census of India

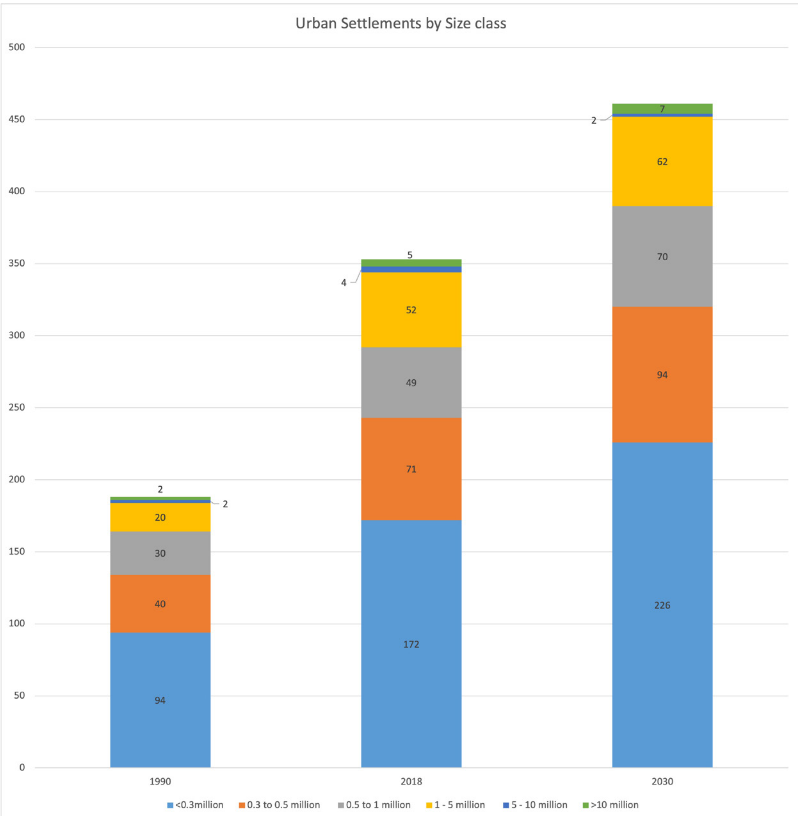

Figure 3.14: Urban Settlement by Size Class. Source: Compilation from Census of India

Urbanisation levels are uneven across India, with states in western and southern India, and states around Delhi having a high level of urbanisation. Large states with low urbanisation levels, Uttar Pradesh, Madhya Pradesh, and West Bengal, also have large urban populations and large cities. There are total of 298 Urban Agglomerations in India, of which 39 are in Uttar Pradesh, 25 in West Bengal, 23 in Gujarat, 36 in Andhra Pradesh, 25 in Tamil Nadu, 18 in Kerala. (Ministry of Urban Development, 2013)

The urban population is distributed across different sizes of settlements (Figure 3.14). The urban structure of India is well balanced, with small cities (< 300,000 population) are in the highest number whereas the cities with 10 million plus population are the least. The number of cities/towns in a size class category decline with the increase in the size of the population (Figure 3.14). The only exception is size class 0.5 to 1.0 million class, which has fewer cities.

The report of the Word Urbanization Prospects states: "India will contribute most to the urban increment with the addition of 416 million urban dwellers, nearly doubling the size of its urban population between 2018 and 2050 (United Nations, Department of Economic and Social Affairs, Population Division, 2019). The total urban population is projected to be 870 millions by 2050 (Mathur et al, 2021) or 52.8% of the total population of India (Mathur et al, 2021)

Institutional Arrangements and Governance:

The Ministry of Housing and Urban Affairs (MoHUA) of the GoI was established in the mid-1980s. MoHUA oversees urban development and housing in India and is the lead ministry for the NMSH. Initially launched in 2010 and revised in 2021 as NMSH 2.0, the mission's core purpose is to promote and facilitate climate action strategies across different sectors (NIUA, 2024).

The 74th Constitutional Amendment, which recognizes Urban Local Bodies, was enacted in 1992. More recently, a series of programs such as JNNURM, SCM, AMRUT, JJM and SBA were implemented to address the challenges of inadequate infrastructure and institutional capacity.

NITI Aayog is the key agency for coordinating and monitoring the SDGs in India, having developed the SDG India Index and dashboard to track progress at both national and sub-national levels, including an SDG Urban India Index.

In addition to organizations such as MoHUA and MoEFCC, another key national body for addressing urban climate change is the NDMA, the apex body for disaster management, led by the Prime Minister. Coordinated by the Home Ministry, NDMA is responsible for preparing policies, plans, and guidelines, while the National Institute of Disaster Management (NIDM) handles capacity-building efforts. Together, NDMA and NIDM provide essential guidelines and training for urban areas to address hazards such as floods, heatwaves, and earthquakes. A significant development is the proposed Disaster Management (Amendment) Bill, 2024, which aims to create an Urban Disaster Management Authority (UDMA) to manage disasters in state capitals and other major cities. This bill, by also strengthening existing disaster management authorities, marks a critical step towards integrating urban climate change and disaster management at the local level. (NIUA 2024)

Legal and Policy frameworks:

National Urban Policy Framework

The National Urban Policy Framework encourages states to develop their respective state urban policies and implementation plans. It supports the formulation of State Urban Policies, shifting from a top-down approach to a more decentralized and context-based one. It offers an integrated and coherent approach to urban planning, emphasizing the importance of understanding cities as human capital clusters and promoting a sense of place within urban environments. It advocates for dynamic urban planning that moves away from static Master Plans towards evolving ecosystems, highlighting the need to build for density and create public spaces that encourage social interactions. Environmental sustainability is a core pillar of the NUPF, emphasizing the importance of environmentally friendly urban practices and infrastructure development to ensure sustainable growth and development in urban areas. It emphasizes the importance of cities becoming financially self-sufficient, which is essential for their long-term sustainability and growth (NIUA, 2018).

As cities are the source of 44% of current emissions, local-level climate action is progressively integrating into urban policy. Several government initiatives such as the Smart Cities Mission, Swachh Bharat Mission-Urban, and AMRUT, contribute significantly to adaptation and mitigation efforts as co-benefits to their original mandate. These programs contribute to promoting low-carbon urban growth, reduce GHG emissions intensity, and enhance the resilience of Indian cities to climate change impacts details of which are mentioned in the table below (NIUA 2024a).

Table 3.8: List of Missions / Programmes GoI

Mission/ Programme	Period	Plan	Contents	Components to deal with climate change adaptation
Smart City Mission	2015 to ongoing	Smart City Proposals	Area-based and Pan-city project proposals in urban mobility, affordable housing, water and waste-water management, sanitation, safety and security, health and education, and energy security	Provides opportunity to prepare resilience plans at local level Water supply essential for adaptation to heat Water supply system to be protected against floods Housing codes to include heat-proofing; codes also required for informal housing Roofing of housing to be storm-proof Residential neighbourhoods to have adequate green cover for reducing surface temperatures and water percolation for ground water recharge to address drought conditions Devices for data collection on temperature, relative humidity, and pollution
AMRUT	2015 to ongoing	State Annual Action Plans (SAAP) prepared in three phases*	Water Supply system, Sewerage, Septage, Storm Water Drainage, Urban Transport (motorized and non-motorized transport, public transport, parking), Green Space and Parks; Statutory Master Plans	All components as above Development of green and blue infrastructure is essential in climate change adaptation to heat, storms, floods, and drought
Pradhan Mantri Awas Yojana (PMAY) – Urban	2015 to ongoing	Either using the existing SPCPoA or HFAPoA	Housing and real estate development	Housing codes to include heat-proofing; codes also required for informal housing Roofing of housing to be storm-proof Residential neighbourhoods to have adequate green cover for reducing surface temperatures and water percolation for ground water recharge to address drought conditions
National Sustainable Habitat Mission	2021-2030	None	Largely focuses on mitigation efforts; has components of urban planning, green cover, biodiversity, air quality, water management and urban governance.	- One of its's objective is building resilience of cities to climate change impacts and strengthening their capacities to 'bounce back better' from climate related extreme events and disaster risks.

Mission/ Programme	Period	Plan	Contents	Components to deal with climate change adaptation
State-level town planning and urban development acts	-	Regional, City, Sub-city, and Local Area Plans	Comprehensive plans for various horizon periods; these are statutory plans and hence have to be implemented; deal with land requirements	These plans deal with land, building regulations (that can include green building codes, standards for open and green spaces at various levels in the city IPCC's Working Groups II and III highlight importance of spatial plans for adaptation and mitigation purposes Master Plans at the city level are spatial plans, that has potential to integrate all the climate change adaptation measures requiring land Master Plans also has potential to integrate sectoral plans such as those related to transport, water and sanitation, green cover, etc.

Source: NIUA (2024a)

3.1.9 Health

Acting on increasing climate change impacts on health, India broadened its commitment through the launch of the 'Mission on Health' in 2015. To fulfil the objectives of this national mission, an expert committee (the National Expert Group on Climate Change & Health, NEGCCH) was commissioned. The NEGCCH, supported by the National Centre for Disease Control (NCDC), drafted the Action Plan in 2018. To further strengthen India's health infrastructure, MoHFW launched the National Programme on Climate Change and Human Health (NPCCHH) under the umbrella of the ongoing National Health Mission (NHM) in 2019.

Institutional Arrangements and Governance

The Ministry of Health & Family Welfare (MoHFW) under the GoI) is the main coordinating agency for Indian action against climatic impacts on human health. MoHFW, through the National Centre for Disease Control (NCDC) located in New Delhi (the nodal technical agency), has developed a multi-pronged collaborative framework for the achievement of the five specific objectives of NPCCHH. Leveraging the hidden strength of India's Health and Family Welfare System implicit in its multi-layered infrastructure involving the GoI and the state governments, multi-lateral institutes, and non-governmental organizations (NGOs), for each of the 5 objectives of NPCCHH, the functional arrangement has been planned to revolve around the nodal agency and identified supportive Department/Ministry.

Building on this institutional foundation, significant progress has been made in establishing dedicated structures and mechanisms for coordinated programme delivery. At the national level, the NPCCHH has institutionalized a robust governance framework to coordinate and implement climate–health actions across the country. A dedicated Climate Change and Human Health (CC&HH) Division has been established under the National Centre for Disease Control (NCDC), to oversee programme planning, coordination, and monitoring. In addition, technical expert groups and Centres of Excellence (CoEs) have been identified to provide subject-specific guidance on climate-sensitive health concerns. The programme also benefits from strategic partnerships with other government and non-government organizations, to institutionalize joint action, technical collaboration, and capacity building.

The State Nodal Officers and District Nodal Officers for climate change and human health have been identified in every state and district. Each state and UT in the country has developed its State Action Plan for Climate Change and Human Health (SAPCCHH) that will provide specific directives for the State -level implementation of key actions proposed for each of the five core objectives of NPCCHH and routine monitoring/evaluation of the achievement of their relevant indicators. Various premiere organizations in the country have been designated as Centre of Excellences (CoE) to support the state governments in achieving these goals within the proposed short-term (first two years), medium-term (up to five years), and long-term (up to fifteen years) timelines.

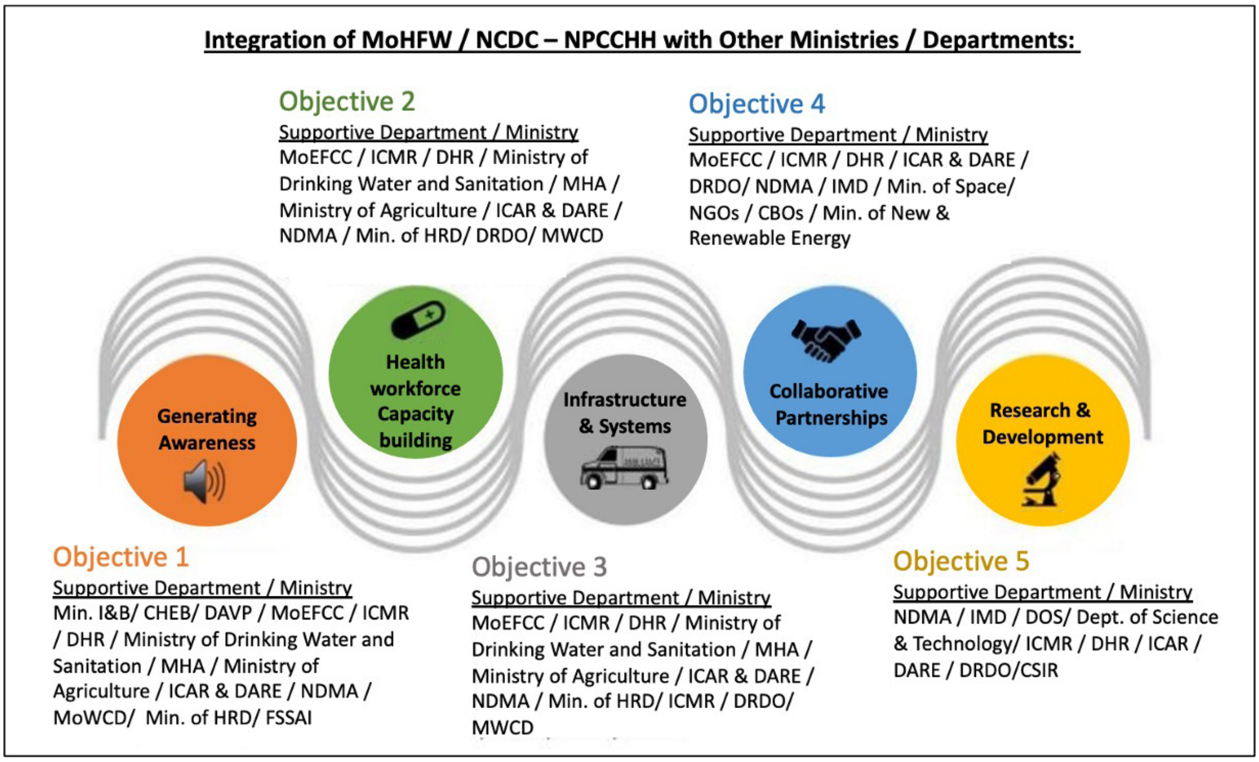

Figure 3.15: Integration of MoHFW/NCDC-NPCCHH with other Ministries. Source: Compilation for this report and NAPCCHH

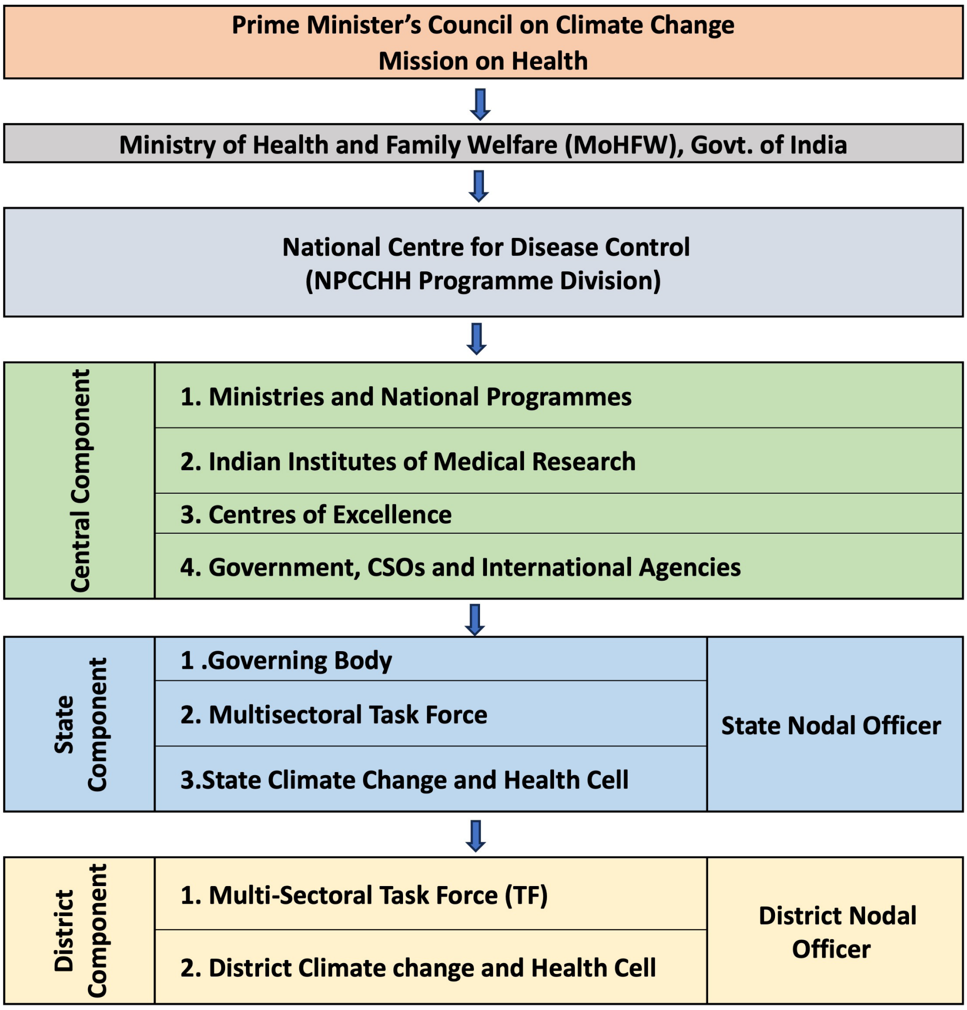

Figure 3.16: Organizational framework of the National Programme on Climate Change and Human Health (NPCCHH). Source: NCDC

To ensure decentralized implementation, the NPCCHH has established State and District-level institutional mechanisms to serve as dedicated coordination units facilitating inter-departmental convergence and supporting integrated planning and implementation. Climate Change and Human Health Cells (CCHH Cells) at different levels act as platforms for joint action among health, Climate Change, disaster management, water and sanitation, energy and other relevant departments, ensuring that adaptation strategies are context-specific and responsive to regional vulnerabilities and local health needs.

Furthermore, these institutional mechanisms enable the mainstreaming of climate considerations into health planning, promote evidence-based decision-making, and strengthen policy coherence between health, climate and other sectors. Regular review meetings, technical consultations, and knowledge-sharing workshops have been institutionalized to enhance coordination, ensure accountability, and sustain progress toward achieving the national adaptation goals under the NPCCHH framework.

3.1.10 Gender

Gender equality and empowerment are important determinants of development and important to achieving national as well as global Sustainable Development Goals. India has more than 700 million women and girls of whom a large percentage reside in rural or marginal urban environments. They are constrained by a number of socio-cultural and economic factors due to strict gendered codes of behaviour, gender-based intra-household distribution of work and patriarchal systems.

A recent national study has shown that 92 percent of women aged 15-59 years are involved in domestic work, child and elderly care and spend almost 299 minutes per day on the task as compared to only 97 minutes by men (MOSPI, 2020). Rural women are also extensively involved in agriculture and livestock keeping, which are often seen as an extension of household activities, thus adding to their workload. However, it is concerning to note that women's labour force participation rate has been declining over time, significantly due to the burden of domestic work as seen by analysis of NSSO and PLFS data (Ghosh et al., 2018). Only 21% of women are engaged in paid work as compared to 69% of men (IWWAGE, 2021), causing a huge imbalance in ownership, access to and control over resources leading to significant gaps in human as well as gender-based development. South Asia has the widest gender gap of 16.3% in human development.

A significant contributing factor to India's climate risk at the present time arises from the economic and social vulnerability of women. Gender-transformative measures, policies and action that lower such vulnerability is key to reducing India's overall climate risk.

Climatic changes and extremes can make the situation worse for rural and peri-urban women as extreme events impact the lives and livelihoods of families, increase the collection time of fuelwood, fodder, and freshwater leading to reduced time for education, skill development, and income generation, exacerbating the existing gender-based inequalities. Spending such large amounts of time fulfilling their practical gender needs, encompassing the procurement of resources to run the household, leads to time poverty for women in participating in the workforce and the market economy, and consequently, a gross neglect of their strategic gender needs. An analysis of data from 114 countries has shown that high human development alone is not sufficient for achieving gender parity; instead, there must be an emphasis on gender-sensitive and gender-transformative policies and programs (UN Women and UNDP, 2023). To build the adaptive capacity of women to climate change and enable them to lead climate-resilient lives, there have been frequent calls for taking gender transformative measures including advocating for gender-positive policies and proactive action.

Institutional arrangements and governance

India's parliamentary system and Constitution have guaranteed the equality of women in the political processes and governance structure, including the right to vote, since Independence. To further promote the full participation of women in governance and politics, recent legislation prescribes that women will also have a 33 percent reservation in elected legislative assemblies of States and the national parliament once a new census is carried out and fresh delimitation of constituencies undertaken (GOI, 2023). At the level of local governance, covering Panchayats in rural areas and urban local bodies in urban areas, a 33 percent reservation for women in elected seats has been mandatory since a Constitutional amendment in 1992. Several States have exceeded this mandatory limit with 21 States and 2 Union Territories having provided 50 percent reservation in village panchayats and 17 States and 1 Union Territory having provided 50 per cent reservation in urban local bodies. Mandatory inclusion of women or mandatory opening up of opportunities of women have ensured increasing opportunities for women in the social, economic and political life of the country (Rajya Sabha, 2023).

Legal and Policy Frameworks:

The GoI has adopted a comprehensive, lifecycle-based policy framework to empower women across social, economic, political, and legal domains. From constitutional safeguards and landmark laws against violence and discrimination, to transformative schemes like Beti Bachao Beti Padhao, Mission Shakti, and movements like the historic Nari Shakti Vandan Adhiniyam, the focus has shifted from women's development to women-led development. Women's participation has surged in education—especially in STEM—skilling, entrepreneurship through Self-Help Groups, and public service. Legal reforms and labour codes promote safe and inclusive workspaces, while schemes like PM Awas Yojana, DAY-NRLM, and agricultural support initiatives have empowered women financially and socially. From grassroots governance to defence forces and aviation, women are now leading across sectors, driving inclusive and sustainable national growth (PIB, 2025).

In the context of energy access and climate policy, the Pradhan Mantri Ujjwala Yojana (PMUY), launched in May 2016, is a noteworthy case study, with the dual objectives of empowering women and enabling social change. PMUY provides LPG (Liquefied Petroleum Gas) connections to women from Below Poverty Line (BPL) households, thereby reducing exposure to serious health hazards associated with cooking based on fossil fuels. As many as 103.3 million households across India had PMUY connections till 01.03.2025. This shift has led to a revolution in clean fuel cooking in the country, as burning residential solid fuels accounts for 58% of black carbon emissions and is a significant contributor to household air pollution. Research studies conducted across different states in India on outcomes of PMUY on women and children have shown reduced drudgery of women in fuel collection, better eye and respiratory health, increased participation in income generating entrepreneurial activities leading to enhanced financial security of women as well as better educational outcomes for children. Schemes such as PMUY are gender-transformative in nature and help achieve SDG 5, 7, and 13, which pertain to gender equality, affordable and clean energy, and climate action.

SHE RISES Framework: Developed by the MoHUA and GoI, the SHE Rises Framework developed a comprehensive approach for the gender-based transformation of Indian cities. Recognising that women primarily have to bear the burden of caregiving to the children, elderly, and the sick due to the patriarchal systems, the SHE RISES framework calls for due recognition of the care economy for the progress of family, community, as well as the state. It calls for making cities responsive to the needs of women who live in underserved communities with inadequate access to housing and related services. To reduce their vulnerability and risk to climatic and or stresses, it calls for making cities inclusive, safe, and equitable. It recognises the importance of addressing gender concerns in the four domains of public spaces and infrastructure, provision of services and amenities, women-friendly mobility and transport, as well as addressing gender-based violence. The framework has been pilot tested in six Indian cities including the city of Kakinada in Andhra Pradesh where progress in gender responsiveness was observed. The components of the framework are strongly aligned with several SDGs such as SDG 5 pertaining to gender equity and equality, SDG 11 dealing with sustainable cities and communities as well as SDG 13 relating to climate action.

3.2 Impacts, Risks and Vulnerabilities

In the following sector-wise discussion, the impact, risks and vulnerabilities associated with each sector will be based on a sector-specific account highlighting particular aspects of the risks and vulnerabilities of the sector, as well as the outcome of an indicator-based sector-wise vulnerability assessment at the district scale (and/or agro-climatic zone) for the key sectors.

Some sector specific and several administrative jurisdiction-based vulnerability and risk assessments for India have been conducted over the years and reported in the scientific literature. A few notably have been reported by government departments. Among these may be noted the "Climate Vulnerability Assessment for Adaptation Planning in India Using a Common Framework" (Dasgupta et al, 2020), under the aegis of the Department of Science and Technology, Govt of India (DST) and the "District-Level Climate Risk Assessment for India: Mapping Flood and Drought Risks Using IPCC Framework", again prepared under the aegis of the DST (Dasgupta et al 2024). Another important contribution has been the ICAR-CRIDA study under the National Innovation on Climate-Resilient Agriculture programme, titled, "Risk and Vulnerability Assessment of Indian Agriculture to Climate Change," (Rama Rao et al, 2019).

The impact of human-induced global climate change on the regional climate and monsoons of the Indian subcontinent, adjoining Indian Ocean, and the Himalayas is comprehensively discussed in Krishnan et al (2020a). It documents the regional climate change projections based on the climate models used in the IPCC

Fifth Assessment Report (AR5) and climate change modeling studies using the IITM Earth System Model (ESM) and CORDEX South Asia datasets. The effects of climate change over the Indian subcontinent involve complex physical processes on different space and time scales, especially given that the mean climate of this region is generally shaped by the Indian monsoon and the unique high-elevation geographical features such as the Himalayas, the Western Ghats, the Tibetan Plateau, and the adjoining Indian Ocean, Arabian Sea, and Bay of Bengal. It also presents policy-relevant information based on robust scientific analysis and assessments of the observed and projected future climate change over the Indian region.

However, in the following, the indicator-based vulnerability and risk assessment, both current and for the future, prepared for the NAP, is used, which provides sector-wise and spatially disaggregated assessments. This provides a uniform methodology for the relevant sectors that can be elaborated and improved as necessary in successive BTRs.

The assessment was conducted for the core sectors (Agriculture and Allied Sectors, Water, Health, Forests, Ecosystem, and Biodiversity) to construct a district-level, sector-wise understanding of climate risks. This helped in developing evidence-based adaptation actions for each sector.

The assessment, along with its associated indicators, encompassed the key components of climate risk, including historical and future hazards, exposure, and vulnerabilities in core sectors. In addition, specific exposure and vulnerability indicators relevant to cross-cutting sectors (Poverty Alleviation and Livelihood, Traditional Knowledge and Heritage, and Disaster Management and Infrastructure) were identified and incorporated into the risk assessment of core sectors.

A district-level climate risk score was generated for each core sector. The assessment covered all 787 districts of India, spread across 15 agroclimatic zones.

The risk projections were carried out using data from the ensemble CORDEX regional downscaled climate models and data from government sources. The assessment incorporated all the potential rapid onset (acute) and slow onset (chronic) climate hazards relevant for various agroclimatic regions and sectors. These were flood, cyclone, heat waves, drought, sea-level rise, rainfall-induced landslides, glacial lake outburst floods, forest fires and cold waves. Only the core sectors exposed to each hazard were considered in the assessment.

The assessment was carried out by considering the baseline period 1986–2005 and the future period 2026–2045. Future climate risks were projected considering RCP2.6 and RCP4.5 scenarios and compared with the baseline to identify agroclimatic regions facing the highest risks for each of the core sectors. A total of 43 hazard indicators, 34 exposure indicators, and 95 vulnerability indicators were considered overall for the assessment. The study provides insights through the identification of multi-hazard (aggregated hazards) risks, along with a detailed understanding of risks disaggregated by individual hazards. This comparison helped in identifying suitable adaptation strategies for each sector.

The full study covers the hazard-wise climate risk index for each sector and a combined climate risk index for each sector. Of course, only the relevant hazards for every sector were used in the determination of the combined risk indices. In the following, only the combined climate risk index is reported for a compact presentation of the key findings.

3.2.1 Water

Vulnerability assessment of water resources

The average annual water resources of Indian River basins for the 30-year study period (1985–2015) have been assessed at 1999.20 billion cubic metres (BCM). During the same period, the mean annual rainfall was estimated at 3,880 BCM, as reported by the CWC in its Water Resources Assessment Report published in 2019. Despite the availability of substantial surface water resources, India remains heavily dependent on groundwater for water needs. According to the NITI Aayog Report (2023–24), the annual water utilization stands at 690 BCM from surface water sources and 447 BCM from groundwater sources. This dependency on groundwater is primarily attributed to the temporal and spatial variability in surface water availability across seasons and regions.

The assessment of water availability is critical for ensuring the sustainable management of water resources, particularly in the face of emerging challenges such as urbanisation, industrialisation, and climate change. According to the Ministry of Jal Shakti, the average annual per capita water availability in 2021 was estimated at 1486 cubic meters, based on the annual water availability figure of 1999.2 BCM assessed in the CWC's 2019 study. As per internationally accepted norms, a country is considered to be under "water stress" when the per capita water availability falls below 1700 cubic meters. In India, this metric has been steadily declining due to the continuous increase in population. According to a press release by the Ministry of Jal Shakti, the average annual per capita water availability was 1816 cubic meters in 2001, which reduced to 1545 cubic meters in 2011, 1486 cubic meters in 2021, and is further projected to decline to 1367 cubic meters by 2031.

According to the National Water Policy (2012), water demand across various sectors, including agriculture, domestic use, hydropower, recreation, navigation, and industry, is increasing significantly, driven by population growth, warming climate, and the rapid expansion of economic activities. As per the Ministry of Water Resources (MoWR) assessment, based on the CWC XI Plan Report and the Standing Committee's estimates, the sector-wise water demand projections for India are as follows:

Table 3.9: Sector-wise projected water demand (in BCM) for India

Sector	2010 (in BCM)	2025 (in BCM)	2050 (in BCM)
Irrigation	688	910	1072
Domestic Use	56	73	102
Industrial Use	12	23	63
Energy Generation	5	15	130
Other Use	52	72	180
Total	**813**	**1093**	**1447**

Source: Derived from Table 6.1.1 of MOSPI (2014)

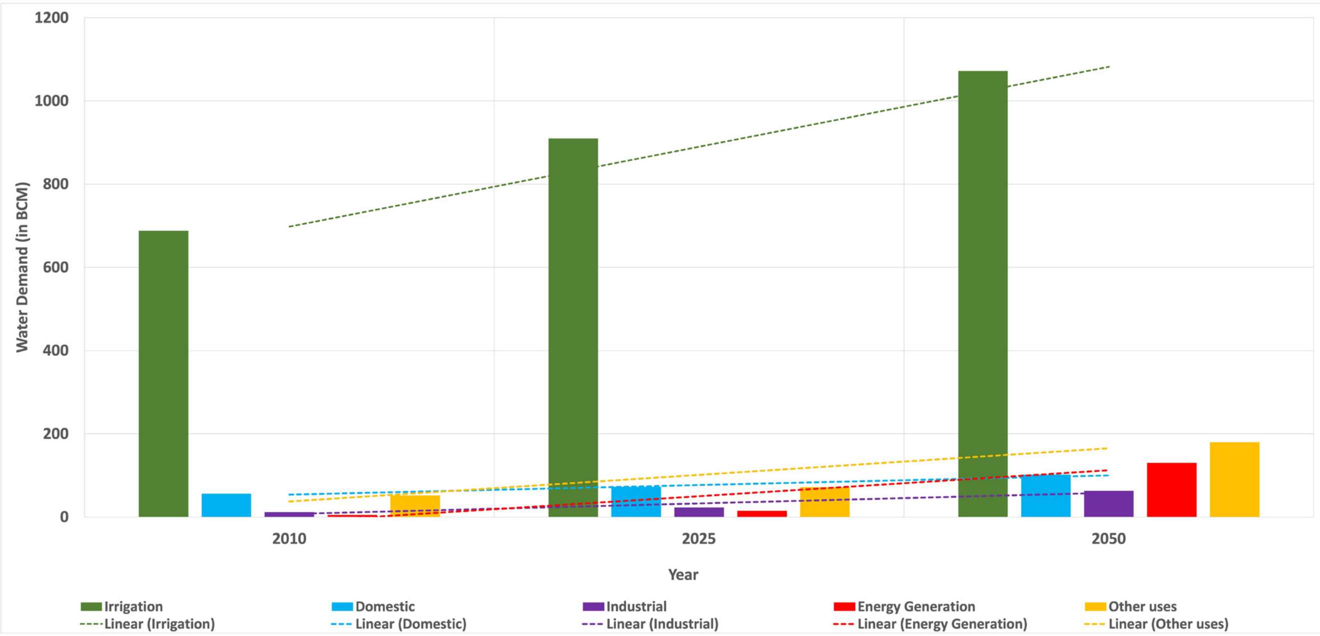

Figure 3.17: Projected Water Demand (in BCM) for Various Sectors. Source: Derived from Table 6.1.1 of MOSPI (2014)

The data indicates a sharp increase in total water demand, which is projected to rise from 813 BCM in 2010 to 1093 BCM in 2025, and further to 1447 BCM by 2050. The most significant growth is anticipated in the irrigation and energy sectors, reflecting the dual pressure of ensuring food security and power generation for a growing economy. These projections underscore the need for integrated water resource management, prioritization of efficient water use, and the development of sustainable water infrastructure to meet future demands.

According to the Groundwater Resource Assessments conducted in recent years, the groundwater extraction for irrigation was, 221.46 BCM in 2017, 217.61 BCM in 2020 and 208.49 BCM in 2022. This declining trend in groundwater extraction for irrigation may reflect increased efficiency in water use or the effects of regulatory interventions. As per the Dynamic Ground Water Resources Assessment–2022, detailed state-wise data highlights the proportion of irrigation demand being met through groundwater across different regions. The average annual utilizable surface water resources of Indian River basins are estimated at 690 BCM, which also contributes significantly to meeting the irrigation requirements alongside groundwater sources. These figures underscore the critical role of both surface and groundwater in sustaining the agricultural sector and highlight the need for balanced and sustainable resource management, especially in the face of increasing demand and climatic uncertainties.

The year 2024 has witnessed significant improvements in groundwater resource management in India. Key findings from the latest assessment, as compared to the 2017 baseline, indicates that the total annual groundwater recharge has increased by 15 BCM, indicating enhanced replenishment efforts and improved hydrological conditions. Groundwater extraction has declined by 3 BCM, reflecting more efficient utilization and the impact of conservation policies. Recharge from tanks, ponds, and Water Conservation Structures (WCS) has shown a consistent upward trend over the past five assessment cycles. In 2024, recharge from these sources increased by 0.39 BCM compared to 2023. Compared to 2017, recharge from these traditional structures increased from 13.98 BCM to 25.34 BCM, marking a net rise of 11.36 BCM. Furthermore, the proportion of over-exploited assessment units has declined significantly, from 17.24% in 2017 to 11.13% in 2024, indicating positive outcomes from groundwater regulation and sustainable management interventions. These advancements reflect the effectiveness of ongoing efforts in groundwater conservation, artificial recharge, and community-based water resource management initiatives across the country.

With India's population projected to exceed 1.7 billion by 2050, the demand for water resources is expected to rise significantly. In addition to the growing need for food security, rapid urbanization and industrialization will further intensify the pressure on existing water resources. As per government estimates, India's water demand is expected to increase by over 70% by 2025, creating a substantial demand–supply gap in the years ahead. Currently, nearly 75% of India's districts, encompassing approximately 640 million people, are identified as hotspots for water-related disasters.

Climate projections indicate a likely increase in both temperature and precipitation across major Indian River basins under warming climate scenarios. However, for the anticipated rise in precipitation to meaningfully contribute to available water resources, it must be effectively captured and stored, either as groundwater recharge or surface water storage. Therefore, enhancing water storage capacity, both through natural and artificial means, will be essential to adapt to future climatic uncertainties and ensure water security in a changing environment.

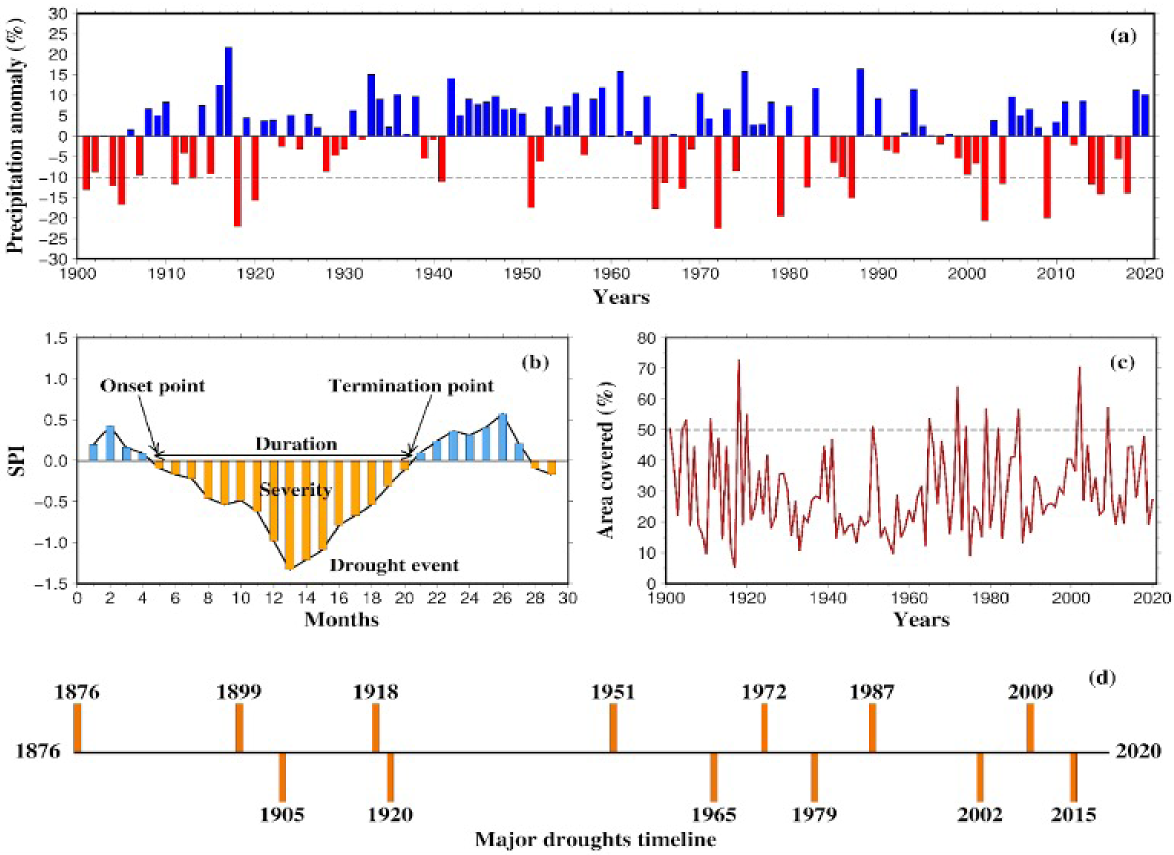

Figure 3.18: India-averaged annual precipitation anomaly from 1901-2020 and Major drought timelines (Source: Mishra et al 2024)

India faces escalating risks of floods and droughts, largely influenced by climate change and human activities that alter hydrological patterns (Mishra et al., 2024). These extreme events impact water availability, agricultural productivity, and socioeconomic stability across the country. Climate variability, coupled with anthropogenic factors, is projected to intensify extreme hydrological events, with changing precipitation patterns leading to more frequent dry and wet spells that dictate the severity of both floods and droughts. Monsoon rainfall, a critical component of India's agricultural economy, is becoming increasingly unpredictable with high interannual variability (Figure 3.18).

This unpredictability has resulted in frequent riverine and pluvial floods due to extreme rainfall events, particularly in urban and mountainous regions that are susceptible to flash floods (Sharma et al., 2018; Jain & Singh, 2022). Conversely, droughts are exacerbated by prolonged precipitation deficits and rising temperatures, leading to soil moisture depletion, water scarcity, and significant agricultural stress (Mishra et al., 2024; Aadhar & Mishra, 2020; Williams et al., 2012; Pendergrass et al., 2020).

Floods and drought events have had profound impacts across India, causing extensive damage, displacement, and loss of life. Major flooding events, such as those in Mumbai (2005), Bihar (2007-2008), Uttarakhand (2013), and Kerala (2018), resulted from extreme rainfall combined with saturated soil, leading to severe consequences for local populations (Mohanty et al., 2020). Recently, the frequency and intensity of such hydrological extremes have increased, presenting significant socioeconomic challenges. For example, recent floods in Himachal Pradesh and Uttarakhand alone caused estimated economic losses of INR 10,000 to INR 150 billion, in addition to the loss of lives and damage to infrastructure (Kushwaha et al., 2024). Meanwhile, droughts have also intensified; since 1997, drought-prone areas in India have expanded by 57% (World Bank, 2023). The extreme drought of 2002 affected over 300 million people in India (Bhat, 2006), and the severe droughts in the Gangetic region and Maharashtra in 2014 and 2015 were classified as 500-year return period events, resulting in acute water scarcity and impacting millions (Mishra et al., 2016). In recent decades, droughts have become frequent, occurring approximately once every three years (Aadhar and Mishra, 2017; Mishra et al., 2016; Shah and Mishra, 2015).

Climate Change impact projection on water resources

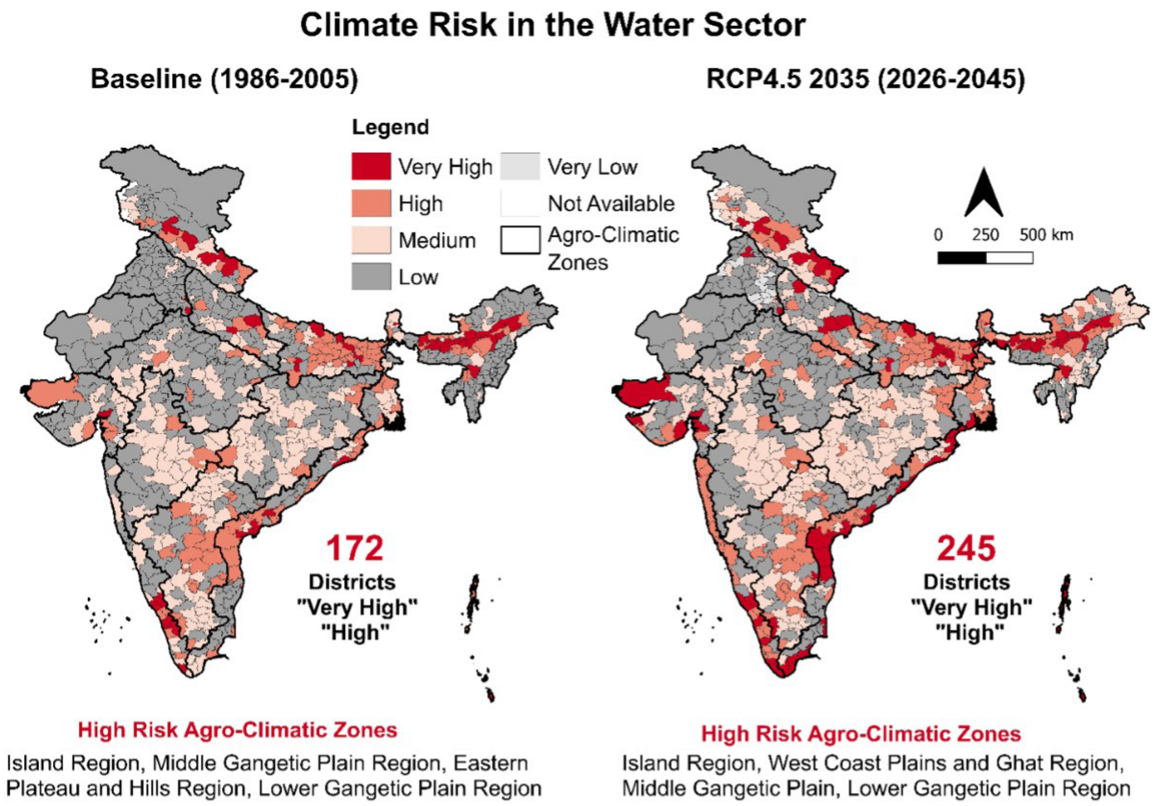

Figure 3.19: Climate risk in water sector. Source: National Adaptation Plan

Following the impact and vulnerability assessment conducted as part of the preparation of the NAP, the map shown in figure 3.19 shows the climate risk assessment for the water sector.

Observed Climate Risk due to Floods and Droughts

A separate study on current drought and flood risk at the district level has also been carried out under the aegis of the Department of Science and Technology, GoI (Dasgupta et al., 2024). The flood and drought risk indices were developed based on the current probability of flood/drought hazards for 1970–2019, exposure to the hazard, and system vulnerability. Based on the relative values of the flood and drought risk indices, the districts have been categorised as 'very high', 'high', 'medium', 'low', and 'very low' risk-prone. The report aims to compare 698 districts in India in general (Part IIA) and districts within a particular state/UT (Part IIB).

The key findings of the report are as follows:

Flood Risk Assessment

- The flood risk arises at the intersection of flood hazard, exposure, and vulnerability.
- The district-level flood risk indices range from 0.015 to 0.688 across India, indicating that flood risks vary significantly across districts.
- 51 districts fall in the 'Very High' flood risk category (0.440–0.688) and 118 districts fall in the 'High' flood risk category (0.284–0.439).
- About 85% of the districts in the 'Very High' or 'High' flood risk category are in Assam, Bihar, Uttar Pradesh, West Bengal, Gujarat, Odisha, and Jammu and Kashmir.

Drought Risk Assessment

- The drought risk arises at the intersection of drought hazard, exposure, and vulnerability.
- The district-level drought risk indices range from 0.042 to 0.644, indicating the wide variation in drought risk across districts.
- 91 districts fall in the 'Very High' drought risk category (0.510–0.644) and 188 in the 'High' drought risk category (0.450–0.509).
- More than 85% of the districts in the 'Very High' or 'High' drought risk category are located in Bihar, Assam, Jharkhand, Odisha, Uttar Pradesh, Maharashtra, West Bengal, Karnataka, Tamil Nadu, Chhattisgarh, Kerala, Uttarakhand, and Haryana.

Dual Risk of Flood and Drought

- Of the top 50 districts with the highest flood risk and the top 50 with the highest drought risk, 11 districts are at a 'Very High' risk of flood and drought. Districts facing this dual risk include Patna in Bihar; Alappuzha in Kerala; Charaideo, Dibrugarh, Sibsagar, South Salmara-Mankachar, and Golaghat in Assam; Kendrapara in Odisha; and Murshidabad, Nadia, and Uttar Dinajpur in West Bengal.

Observed and Projected Changes in Floods in India

India has witnessed a significant increase in flood frequency and intensity over recent decades, largely driven by intensified rainfall patterns and changes in land use that exacerbate flood risk. The duration of extreme rainfall and antecedent soil moisture conditions are critical factors influencing flood events. Notably, multi-day precipitation has emerged as a prominent driver of high flow events in Indian river basins, with more than 70% of instances where extreme precipitation (EP) precedes high flow occurring under wet antecedent conditions (Nanditha & Mishra, 2022). Analysis of historical data reveals that extreme monsoon precipitation events have become increasingly frequent, with both the frequency and volume of heavy rainfall episodes on the rise (Figure 3.20). The northern and northeastern regions of India have experienced a decline in annual maximum rainfall and three-day accumulated rainfall, but the occurrence of floods indicates the role of other potential factors in flooding.

Future projections indicate an elevated risk of both riverine and pluvial floods as climate change intensifies precipitation patterns, making them more erratic and severe (Nanditha & Mishra, 2022). Pluvial floods, which are directly caused by intense rainfall, are projected to increase in frequency, particularly during multi-day precipitation events under both low warming (SSP1-2.6) and higher levels of warming.

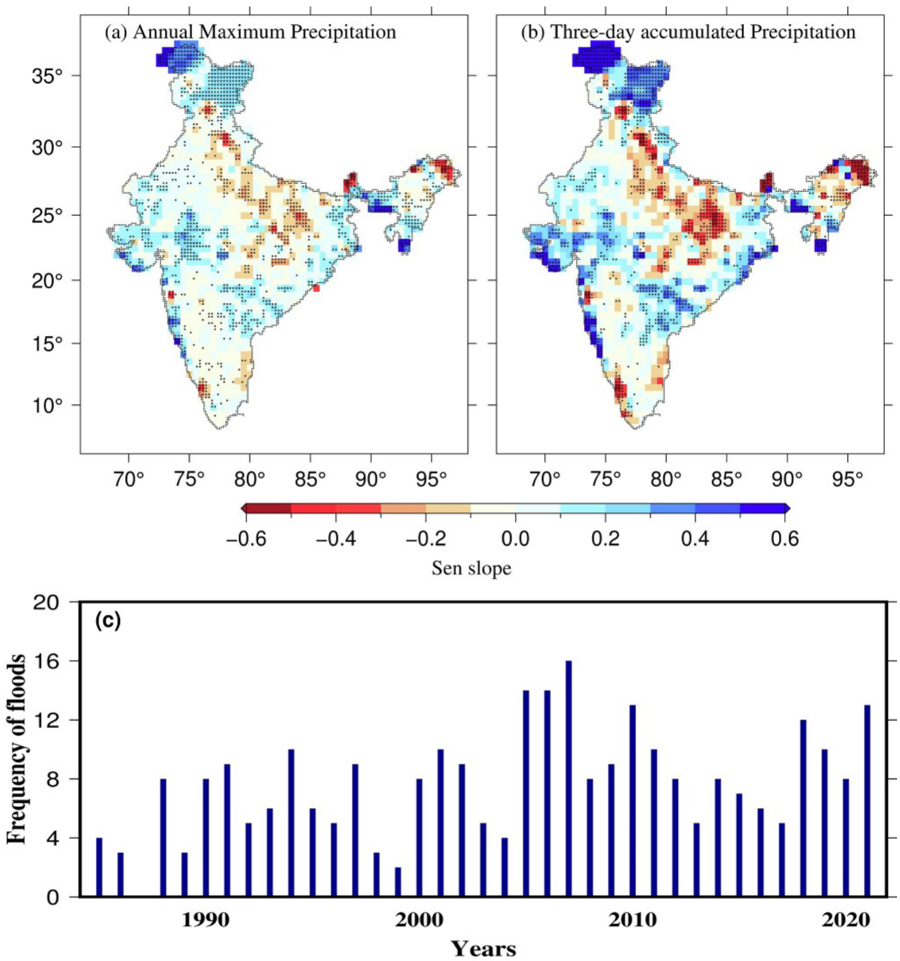

Figure 3.20: The trend (mm/year) in (a) annual maximum precipitation and (b) 3-day accumulated precipitation from 1901-2018 based on India Meteorological Department (IMD) data. (c) Frequency of severe flood events over India (Dartmouth), during the 1985-2021 period. Source: Nanditha & Mishra, 2022.

Model simulations suggest that future multi-day rainfall and flooding episodes will become more common and severe, with the likelihood of extreme floods rising significantly by mid-century (Ali & Mishra, 2018; Nanditha & Mishra, 2022). However, the complex interplay between precipitation extremes, catchment characteristics, and land use changes creates varying responses across different river basins, which require further study.

Observed and Projected Changes in Droughts in India

Droughts in India are closely linked to the variability of the summer monsoon, with drought events commonly triggered when monsoon precipitation falls below 90% of the long-term average (Mishra et al., 2020). The Gangetic plains, a critical agricultural region, have experienced notable increases in aridity, which amplifies the impacts of drought on crop yields and water availability (Aadhar & Mishra, 2019). Severe drought years, such as 2002, 2009, and 2014-2015, have resulted in widespread agricultural losses and water shortages (Mishra et al., 2019). Hydrological droughts, which impact water resources, have become more frequent, especially in southern India where northeast monsoon deficits exacerbate water scarcity (Mishra et al., 2021). Across India, the severity and spatial coverage of droughts have increased significantly since the 1970s (Figure 3.21), with central and northern agrarian regions being frequently impacted (Ganguli & Reddy, 2014; Mallya et al., 2016). States such as Haryana, Punjab, Rajasthan, and parts of Maharashtra experience regular severe droughts, affecting major staples like wheat and rice (IMD Pune, 2013; World Bank Group, 2013). Analysis of historical data indicates that the most severe meteorological droughts occurred in 1923, 2002, 1937, and 1907 for June through September, with the most extreme summer monsoon drought in 1918 (Mishra, 2020). These events, along with notable droughts in 1899, 1876, 1965, and 2000, underscore the significant impacts of droughts on agricultural productivity and water resources. Additionally, unsustainable groundwater extraction is compounding drought impacts, leaving many regions vulnerable to prolonged dry periods as groundwater levels continue to deplete (Mishra et al., 2024b; Dangar et al., 2021).

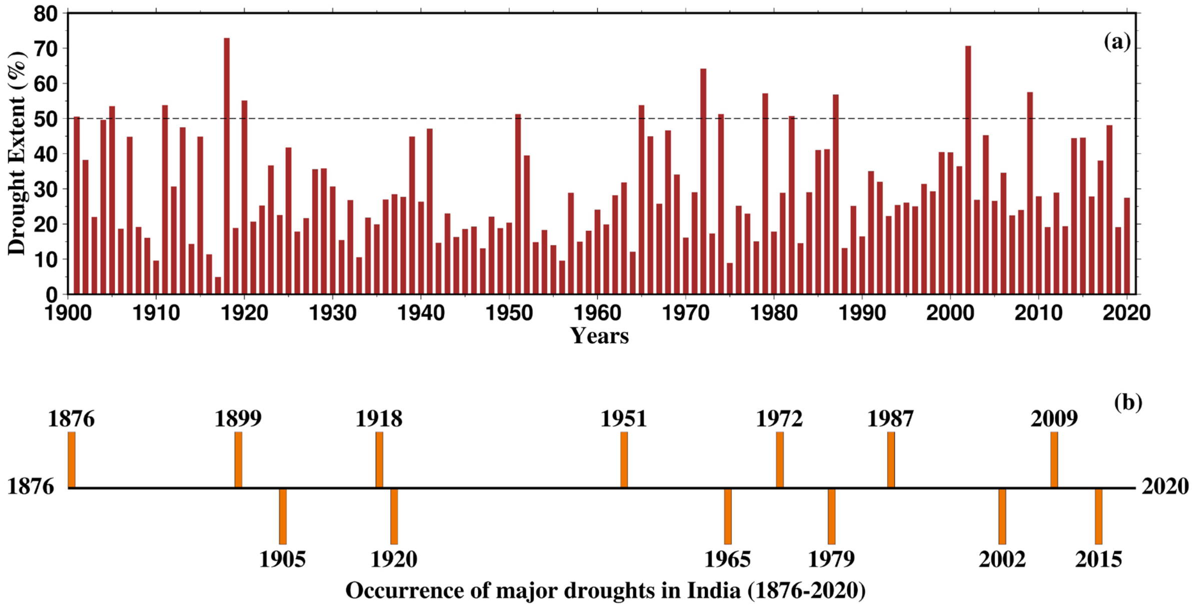

Figure 3.21: Percentage of area under drought during monsoon season in India based on standardised precipitation index (SPI). (Source: Mishra, 2020)

Note: Drought area estimation considers grids with 4-month SPI values below -0.5 for September. (b) Bar plot of timeline of major droughts occurred in India between 1876-2020.

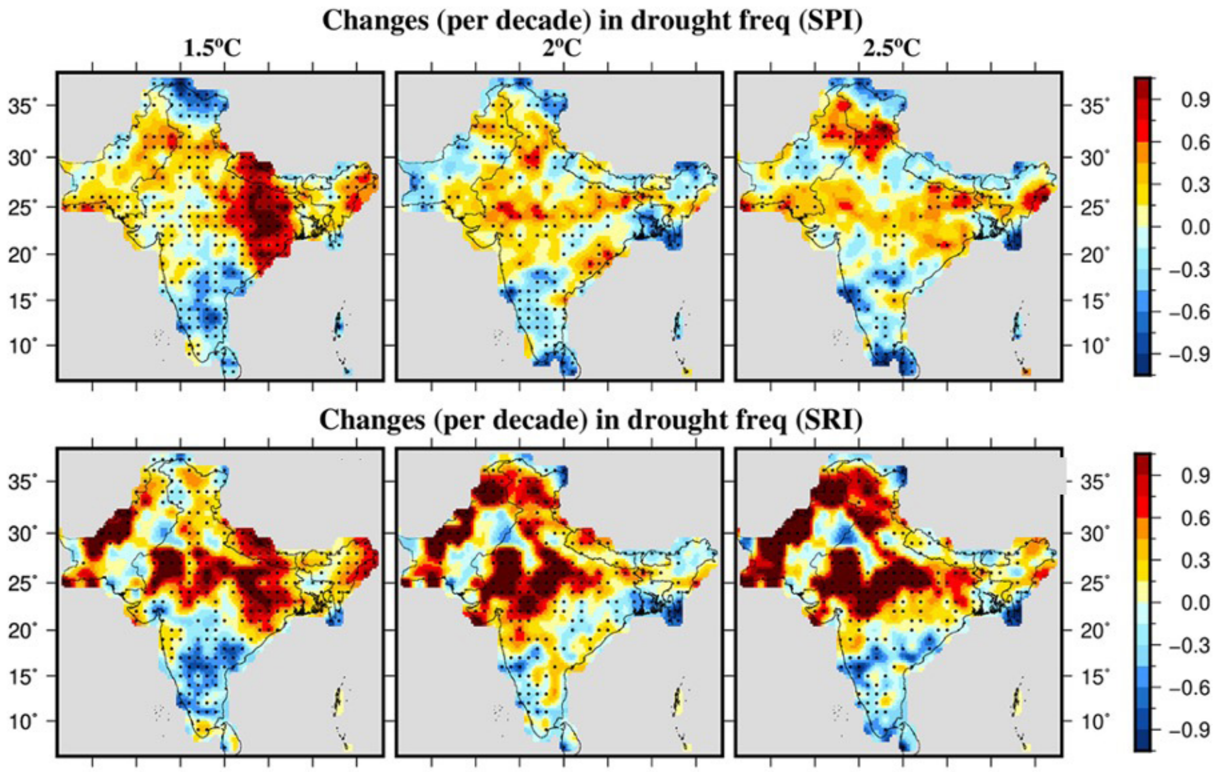

Figure 3.22: Change in drought frequency using standardised precipitation index (SPI, meteorological drought) and standardised runoff index (SRI, hydrological drought) under 1.5°C, 2.0°C, and 2.5°C based on best CMIP6 GCMs compared to the period 1985–20. Source: Aadhar & Mishra, 2019

Future climate projections indicate that these trends are likely to intensify, particularly under warming scenarios of 1.5°C, 2.0°C, and 2.5°C. BEST-GCM climate models indicate increased drought frequency across most parts of South Asia, with greater impacts projected under higher warming levels (Figure 3.22). At 2.5°C of warming, drought conditions could affect approximately two billion people in South Asia by the end of the century, with India being the most affected (Aadhar & Mishra, 2019). Even under a 1.5°C warming scenario, dryness is expected to increase in over half of South Asian countries. Projected declines in precipitation and runoff will likely exacerbate drought conditions and increase the frequency of both meteorological and hydrological droughts (Figure 3.22). Models predict that the most extreme drought events will not only become more frequent but will also cover larger areas with heightened severity. Consequently, droughts in India are anticipated to present greater challenges for water security and agricultural stability under future climate conditions.

3.2.2 Agriculture

The agro-climatic zone-wise assessment of hazard-aggregated climate risk for agriculture and allied sectors under the RCP 4.5 scenario for the year 2035 (covering the period 2026–2045), as illustrated in the figure 3.23, presents a clear spatial distribution of climate risks across regions.

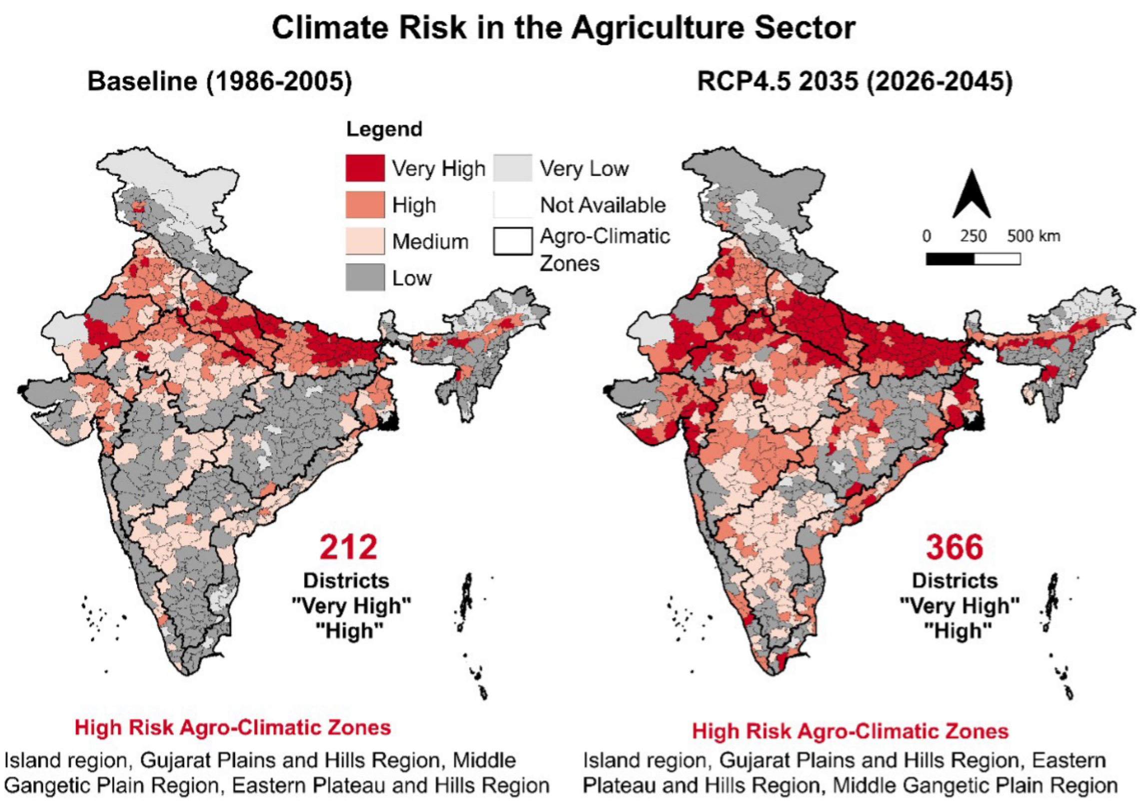

Figure 3.23: Composite climate risk in the Agriculture and Allied sectors. Source: National Adaptation Plan

The climate risk results for the RCP4.5 scenario indicate that the Gujarat Plains and Hills region, the Eastern Plateau and Hill region, the Middle Gangetic Plain, the Trans-Gangetic Plain region, and the Western Plateau and Hills region are the most prone to recurrent multi-hazards. Climate risk in the agricultural and allied sectors is expected to intensify further across agro-climatic regions over the next decade, with an estimated increase of 73% compared to the baseline.

The report on “Risk and Vulnerability Assessment of Indian Agriculture to Climate Change – NICRA, ICAR” (Rama Rao et al, 2019) presents a district-level analysis of climate risk to Indian agriculture as a revision of a previous 2013 assessment. It adopts the IPCC's risk-based framework, which reconceptualises vulnerability as a key component of overall climate risk alongside hazard and exposure and uses more recent socio-economic data and AR5 climate projections. The analysis uses an indicator-based approach to calculate a final risk index for 573 rural districts. The study's scope is limited to the rural districts defined in the 2001 census. The analysis of future hazards relies on climate projections from a single scenario, RCP 4.5 for the period 2020-49, which was chosen in consultation with stakeholders and is considered the most likely scenario.

The resulting risk index is relative (as are all vulnerability and risk assessment studies reported in this BTR) and is intended solely for comparison and ranking within India. A district categorised as high risk is only high in comparison to other Indian districts, not against a fixed or global benchmark.

The analysis identifies 109 districts with a very high climate change risk and 201 districts with a high climate change risk, which require priority attention for adaptation planning. These high-risk districts are concentrated in states such as Uttar Pradesh, Rajasthan, Bihar, and Madhya Pradesh. This risk profile is driven by a combination of factors across the country: very high exposure is found in 50 districts, primarily in densely populated agricultural states; high or very high vulnerability is present in 193 districts, particularly in Rajasthan and Jharkhand; and future climate is projected to become unfavourable for agriculture in 325 districts out of 573 districts.

To guide targeted interventions, the analysis identifies the primary local sources of risk for high-risk districts. The most prominent vulnerability-related driver was found to be low access to irrigation, affecting 116 districts. For future hazards, a rise in minimum temperature is the most widespread risk factor, impacting 271 districts. The report suggests a pragmatic strategy to prioritise interventions that reduce vulnerability. This approach is favoured because reducing exposure is more difficult, and over-reliance on uncertain climate projections could lead to maladaptation.

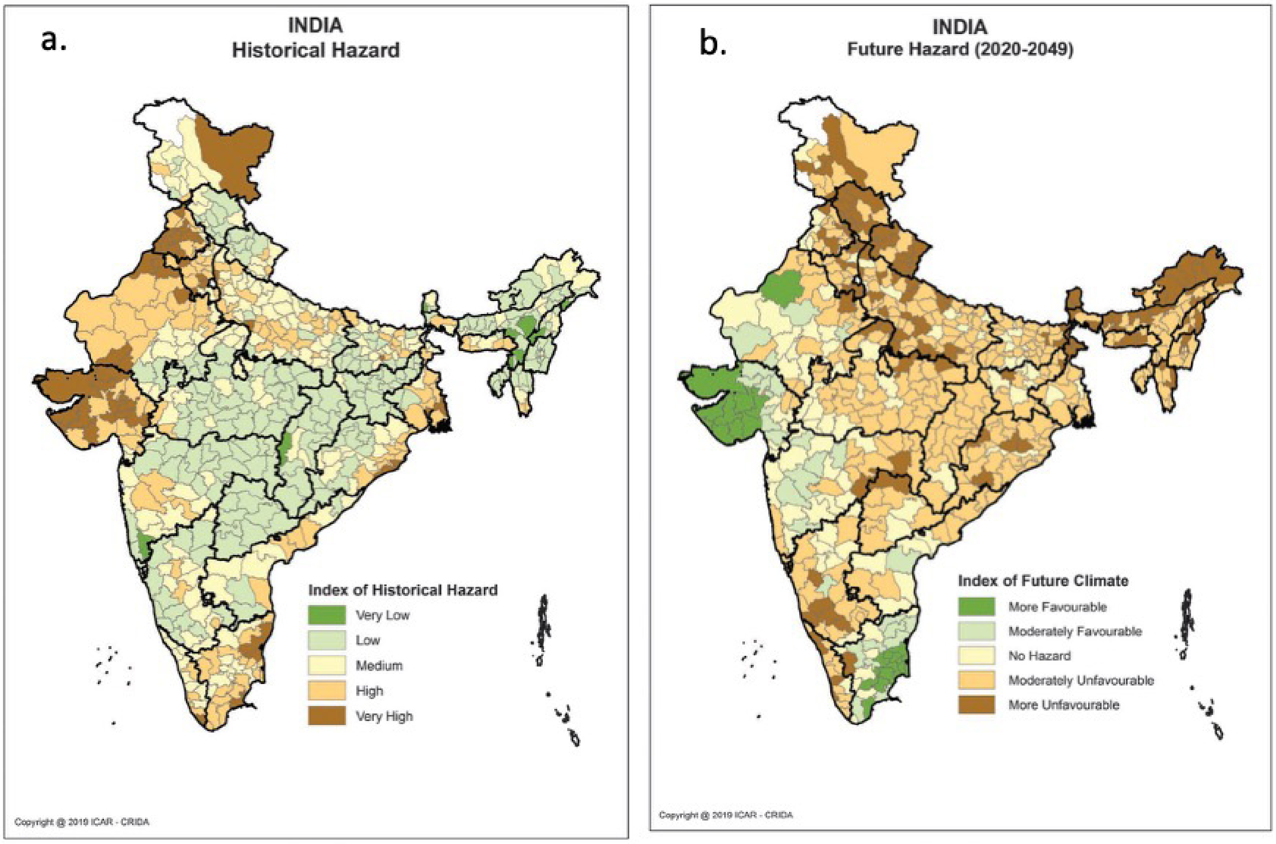

Figure 3.24: (a) Historical Hazard (b)Future Hazard (2020-2049). Source: Rama Rao et al (2019)

While these studies provide a broad overview of future climate risk compared to the base period pre-2020, more specific impacts are noted below.

Current and projected climate trends and hazards

For agricultural seasons, an analysis of ensemble probabilistic scenarios for India, derived from 33 CMIP5-GCMs data, for 2020, 2050 and 2080 in RCPs 2.6, 4.5, 6.0 indicated that 1) Rise in minimum temperatures is projected to be more than rise in maximum temperatures; 2) Rise in temperatures to be more during rabi than during kharif; 3) Rise in minimum temperatures likely be 0.15°C more than during kharif, which is more than the increase in maximum temperatures; 4) Rise in temperatures are projected to be more in the northern regions of India than in the southern region; 6) Rainfall projections, though less robust, indicate an increase during kharif and rabi seasons with more extreme rainfall events and increase in rabi season rainfall. Temperature variability, particularly that of maximum temperatures (in terms of coefficient of variation), is projected to be more for the rabi season (Naresh Kumar et al., 2019). This analysis indicated a progressive climate change and an increase in variability during the kharif and rabi seasons in India towards the end of the century.

Observed and potential impacts of climate change, including sectoral, economic, social and/or economic vulnerabilities

Climate extremes have been significantly affecting agricultural production in India. In recent years, for instance, the heat wave in March-April 2022 affected wheat production to the tune of about 4.5 MT (million tonnes) due to its coincidence with the grain-filling period of wheat (Naresh Kumar, 2023). Similarly, in March-April 2023, heavy rainfall and wind events caused lodging in wheat, causing a loss of about 1.5 MT in wheat productivity. The rainfall extremes and prolonged dry spells have been affecting crop productivity in several regions of India. Similarly, hailstorms have damaged the horticultural and agricultural crops in Maharashtra and other regions. There have been several such incidences of climate hazard-driven production losses in tomato, onion, fruit crops, and vegetables, resulting in significant impacts on producers and consumers alike due to production loss and an increase in market prices.

Projected impacts on major crops in India

Food grain production in India is dominated by cereal crops such as rice, wheat, maize, sorghum and pearl millet, which is about 91% of total food grain production. India's production of pulses and oil seeds falls short of the demand, prompting significant imports.

Other major crops include potato and cotton. Though sugarcane also assumes a major role, the studies on impacts of climate change have been initiated only recently.

The projected impacts on major agricultural crops (cereals, pulses, oil seeds, and commercial crops) are being presented from the studies conducted (Naresh Kumar et al., 2019; Naresh Kumar 2023), and the same are reported in India's Third National Communication to UNFCCC, 2023.

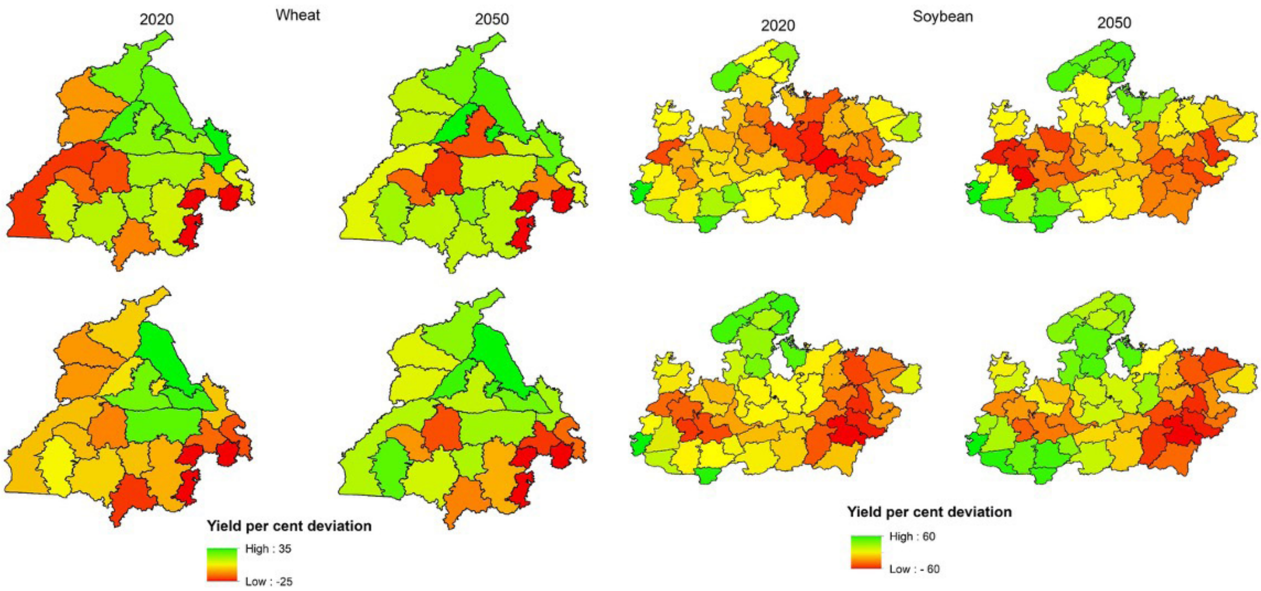

Figure 3.25: District-level impacts of climate change on wheat (in Punjab, on the left) and soybean (in Madhya Pradesh, on the right) in RCP 4.5 in 2020 and 2050 climate scenarios. Source: Naresh Kumar (2023)

A summary of the projected impacts of climate change on the major cereals, millets, pulses, oil seed crops and potato and cotton indicate that the impacts have been commodity-specific with significant spatio-temporal variations. The impacts of climate change basically fall in five large categories with respect to commodity, management, region and climate scenario viz., i) positive impacts even with current management ii) vulnerable with current management but can gain significantly with adaptation, iii) remain vulnerable despite adaptation, iv) gain in near future but may become vulnerable later despite adaptation, and v) gain in near future but get negatively impacted in later scenarios of climate, however can become good productive zones with adaptation (Naresh Kumar, 2023; TNC, 2023). A detailed account of the impacts of climate change on 11 crops is described in TNC (2023) and Naresh Kumar 2023). Briefly, by 2039 (2010-2039, 2020 climate scenario, 4.5 RCP), the climate change impacts are projected to be -9.1% (wheat), -12.3% (Kharif season irrigated rice), -18.4% (Kharif season irrigated maize) and -6.0% (Kharif season pearl millet) reduction in grain yield, while positive impacts (17.1%) are projected for sorghum. In case of pulses and oil seeds, the beneficial effects are projected for pigeon pea (14.9%) while chick pea may get marginally affected (-2.9%). Among oil seeds, the projected decrease in productivity is 2.1% for mustard and 3.2% for soybean, while marginally affecting the groundnut yield (0.5%). Potato productivity is projected to be affected up to 13.4% while the cotton productivity is projected to be benefited by 8.4% (Naresh Kumar, 2023; TNC, 2023).

The impacts, in general, are projected to be more in magnitude in 2050 (2040-2069) and 2080 (2070-2099) in climate scenarios of RCP 4.5. Additional analysis for this provides climate change impact information at the district level. To showcase an example, assessments on the impacts of climate change on wheat (irrigated -Rabi season) and soybean (rainfed -Kharif season) crops are carried out. A pictorial representation of wheat and soybean yields for 2020 and 2050 is depicted in Figure 3.25.

The analysis indicated that the magnitude and direction of impacts vary with the climate and emission scenarios in different ways. This study highlights the importance of having high-resolution analysis for Integrated Vulnerability Assessment (IVA) assessments.

Therefore, adaptation becomes extremely important. The analysis also indicated that adaptation of shifting sowing time, change in the duration of variety, and a slight improvement in nitrogen and water management can help improve the productivity levels of many crops mentioned above. However, some regions and commodities will still lose productivity because of the technological adaptation constraints as well as the limitations and limits of technologies that exist currently (Naresh Kumar, 2023; TNC, 2023). Many regions and commodities need significant adaptation technology innovations or improvements.

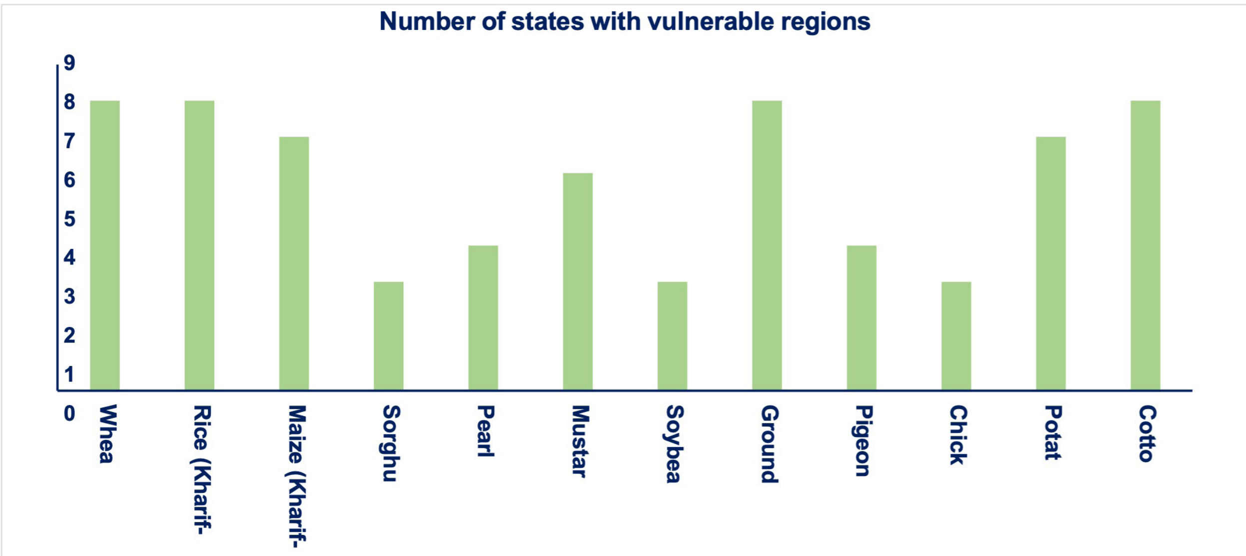

Figure 3.26: Number of States vulnerable to climate change for the productivity of major crops. Source: Naresh Kumar (2023)

Approaches, methodologies, tools, uncertainties, and challenges of these estimates

The approaches followed include i) past data analysis, ii) use of multi-location, multi-seasonal experiments data, iii) surveys, iv) data from controlled environment experiments, and v) meta-analysis. The database thus created was eventually assimilated into the simulation modeling framework (hydrological, crop modeling, crop-pest modeling, and economic modeling) for deriving the impacts and adaptation strategies.

The data used were 17 Regional Climate Models data (CORDEX ESGF node for South Asia) for RCP 4.5 for 2020 (2010-2039), 2050 (2040-2068), and 2080 (2070-2099); IMD gridded data for 1976-2005 as the baseline and used for bias correction; Soil data are taken from NBSSLUP, Nagpur and the varietal coefficients derived from several experimental data (Naresh Kumar, 2023).

The uncertainties arise due to the non-availability of input data in terms of spatio-temporal resolution, climate data uncertainties, uncertainties due to pests and disease, and irrigation water availability. The challenges of IVA analysis include data collection constraints, identification of quality data, data screening as well as computational facility limitations caused significantly long time to complete simulation analysis, which has about 3.12 billion simulations for 12 crops.

3.2.3 Forests

Observed and potential impacts of climate change on forests

Many models and projections are being developed and tested by many workers all over the country on the trends, and their impact on ecosystem processes, vegetation changes, and other biophysical environments (MoEF, 2010; MoEF, 2012; Chaturvedi et al., 2008, 2011 & 2012). MoEF (2010) while assessing the impact of climate change on different sectors concluded that by 2100, more than one-third of the forest cover will largely convert from one type to another type of forest. Climate combined with patterns of land-use change can result in the contraction or shift in species ranges.

Bala et al. (2013) reported increased net primary productivity over the Indian landmass in response to rising atmospheric carbon dioxide concentrations. (Chen et al., 2019) too noted the greening trend in Indian forests. These studies confirm the carbon dioxide fertilization effect associated with excessive build-up of carbon dioxide in the atmosphere. While this may look beneficial in the short run, in the long-term carbon dioxide fertilization effect will be overtaken by increased respiration losses and net ecosystem productivity may suffer due to nutrient and water-related limitations.

Climate change impacts, vulnerability and adaptation assessments were carried out for the forest sector in India for the Third National Communication. Outputs from the Coordinated Regional Climate Downscaling Experiment (CORDEX) (Giorgi et al., 2009) models were used for impact modelling. The dynamic global vegetation model used is the Lund-Postdam-Jena Model (LPJ) model (Smith et al., 2001) which is one of the most extensively used vegetation models globally and has been validated for India (Ravindranath et al., 2019).

According to the study by Ravindranath et al. (2019), among the forested regions, the Western Himalayan and North-western Indian regions are likely to be impacted by climate change. These regions include the Himalayan temperate forests, sub-tropical broad-leaved hill forests, and sub-tropical pine forests. Forested grids that are not projected to be significantly impacted by climate change in this scenario are the tropical deciduous forests in North-Eastern India and the tropical evergreen and deciduous forests in the Western Ghats regions. In the long term (2080s), under the RCP 4.5 scenario, 25% of India's forested grids are projected to be impacted by climate change. It can be observed that apart from the Himalayan and North-Western region, forested grids in the North-Eastern region and a few grids in the Western Ghats are projected to undergo vegetational change.

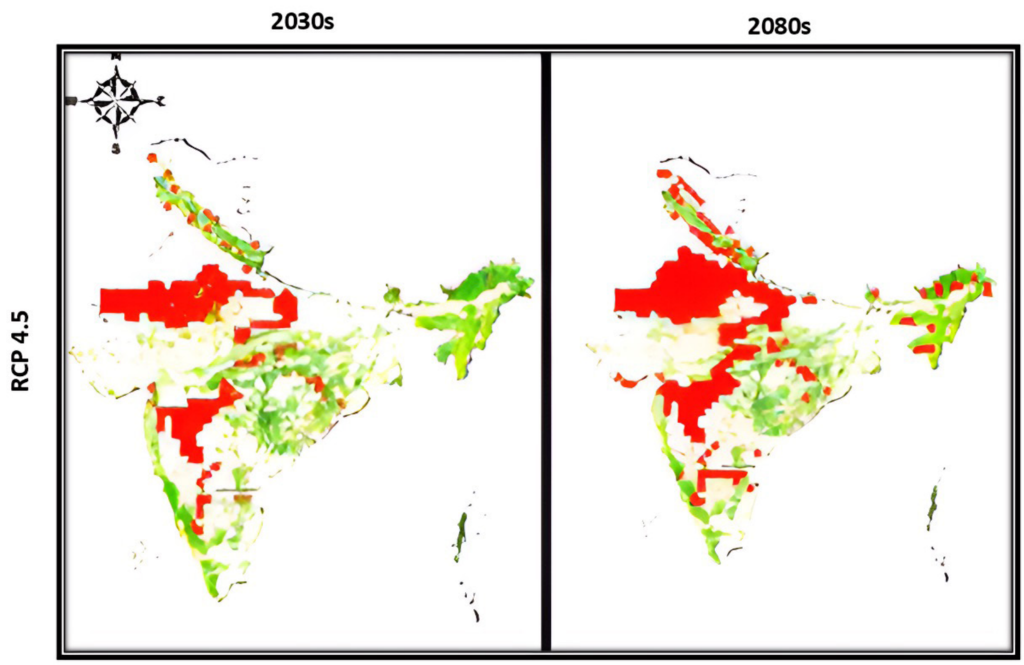

Figure 3.27: Proportion of forest projected to be impacted under RCP 4.5 scenario. Source: Ravindranath et al (2019).

Overall, the percentage of forested grids that will be impacted by climate change lies in the range of 18% to 25% under the RCP 4.5 scenario (including both short and long-term).

Das and Behera (2019) conducted a study on the relationship between forest cover and annual precipitation, concluding that only 0.02% of the total forest cover in India was estimated to be in the category of least resilient, located in the dry regions of the trans-Himalaya. The forest covers in the wet climate regimes such as the Western Ghats, Western Himalayas, Eastern Ghats and North-East India were predicted highly resilient. The forest cover resilience curve saturates at about 1400 mm in precipitation, indicating that the major part of the forest cover in India was extremely resilient and could withstand large precipitation alterations in addition to the shorter drought periods.

Mapping Climate Change Hotspots in Indian Forests based on Observed Climate Change and High-Resolution Climate Model Projections

A study to map the climate hotspots (an area which is likely to face severe impacts of climate change) in the forest areas of the country was conducted by the Forest Survey of India by using computer model-based projections of temperature and rainfall in three-time horizons, i.e., year 2030, 2050 and 2085 (FSI, 2021). The computer model-based projection analysis over scaled down (1°x1°) gridded temperature and rainfall data was carried out to generate National level hotspots database over forest grids based on the forest cover layer of India State of Forest Report, 2019. Forest cover in the country under different hotspot classes in different periods with Representative Concentration Pathway (RCP) 4.5 is given in Table 3.10.

Table 3.10: Forest cover area under hotspots in 2030/ 2050/ 2085 with RCP 4.5

Hotspots Classes	Forest Cover Area (sq km)		
	Year 2030	Year 2050	Year 2085
High	314969	367334	11804
Very High	698	330602	656094
Extremely High	0	6899	37196

Source: FSI (2021)

The classification of different hotspot classes is based on a combination of different levels of temperature increase above the 1860-1900 base levels and precipitation increase over the 1960-1990 base levels.

Vulnerability of forest ecosystems in India to projected climate change

Ravindranath et al. (2019), in the vulnerability assessment of forests to climate change in India, noted that about 40% of the assessed forested grids belong to 'high' and 'very high' vulnerability classes. Except in pockets, the forests in the biological diversity-rich hotspots in the Western Ghats in peninsular India, North-Eastern India, and the North Himalayas have low to medium inherent vulnerability. A 'very high' vulnerability is estimated for parts of southern Karnataka, Tamil Nadu, the eastern parts of Andhra Pradesh, and Rajasthan. The majority of the plantation forest area (65% of the area) is classified under high and very high inherent vulnerability classes. Plantations have higher vulnerability compared to natural forest types (except for tropical thorn forests, for which 100% of grid points have been classified under high and very high inherent vulnerability). For the dominant forest type in India, the dry deciduous forests, 35% and 19% of the area are classified under high and very high inherent vulnerability classes, respectively. None of the region's littoral and swamp forests, montane wet temperate forests, and Himalayan dry temperate forests show high or very high inherent vulnerability (Ravindranath et al., 2019). The percentage of area that is under high and very high inherent vulnerability classes for Himalayan moist temperate forests, sub-alpine and alpine forests, tropical wet evergreen forests, tropical moist deciduous forests, and tropical semi-evergreen forests is low. Low inherent vulnerability of these forests has important significance as most of the forest biological diversity and endemicity is hosted by these forest types in the biological diversity 'hotspots' of Western Ghats in peninsular India, Northern Himalayan region, and Northeast India (Ravindranath et al., 2019).

An indicator-based vulnerability assessment of forests in the Western Himalayan region comprising the states of Jammu & Kashmir, Himachal Pradesh and Uttarakhand was conducted by Kumar et al. (2019). Indicators of vulnerability in the form of biological richness index, disturbance index, forest canopy density, fire point intensity and forest extraction intensity of fringe forests were used for identification of the most prominent indicators of vulnerability, assigning weights to selected indicators using analytical hierarchy process and integration of the indicators to map the spatial extent of vulnerability for a forest ecosystem in the Western Himalaya. Vulnerability of forested areas was observed to be linked with the altitudinal variations in the three states of the Western Himalaya. It is observed that with increasing elevation, the percentage distribution of very high vulnerable regions decreases. The forested areas of the Western Himalaya have ten dominant forest type groups among which the highest percentage of areas under very high category is in Tropical moist deciduous forests (52.77%) followed by Subtropical pine forest (25.39%), Himalayan moist temperate forest (17.77%) and tropical dry deciduous forest (17.61%). The least percentage of very high vulnerable areas are in Dry alpine forests (3.11%), followed by Himalayan dry temperate forests (4.65%), Sub-alpine forests (5.12%) and Subtropical dry evergreen forests (6.28%). The extent of vulnerability of each forest type across different vulnerability classes is given in the table below.

Table 3.11: Indicator-based vulnerability of forested grids across different forest type groups in the Indian Western Himalaya

Forest Type Groups	Percent of forest grids under different vulnerability classes			
	Low	Medium	High	Very high
Tropical moist deciduous forests	8.69	18.31	20.23	52.77
Tropical dry deciduous forests	24.97	30.38	27.04	17.61
Subtropical pine forests	15.95	29.59	29.06	25.39
Subtropical dry evergreen forests	8.90	35.32	49.49	6.28
Himalayan moist temperate forests	14.83	30.61	36.79	17.77
Himalayan dry temperate forests	32.91	26.82	35.62	4.65
Sub-alpine forests	35.15	27.42	32.31	5.12
Moist alpine forests	35.69	19.72	33.50	11.09
Dry alpine forests	46.50	30.43	19.96	3.11
Plantation/ Tree outside the forest	32.57	34.16	17.59	15.68

Source: Kumar et al (2019)

Most recently, as part of the preparation of the NAP, the agro-climatic zone-wise assessment of hazard-aggregated climate risk for the forests sector under the RCP 4.5 scenario for the year 2035 (covering the period 2026–2045), as illustrated in the figure 3.28, was carried out. It presented a clear spatial distribution of climate risks across regions.

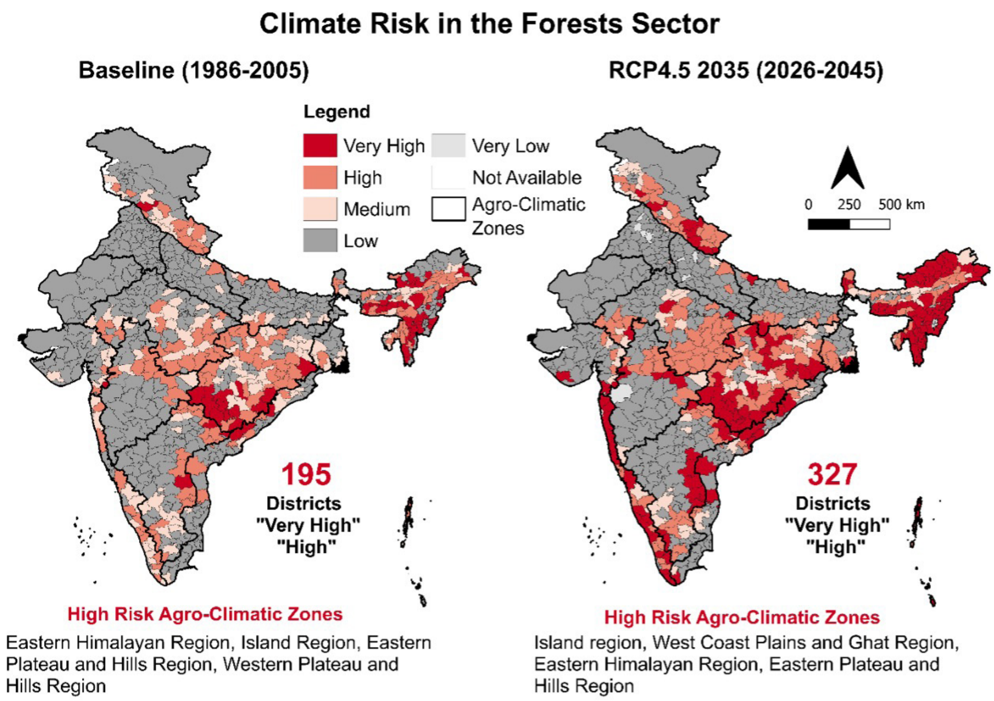

Figure 3.28: Composite climate risk in the Forests sector. Source: National Adaptation Plan

The climate risk results for the RCP4.5 scenario indicate that the Island region, West Coast Plains and Ghat Region, Eastern Himalayan Region, and Eastern Plateau and Hill region are most prone to recurrent multi-hazards. Climate risk in the forests sector is projected to increase across agro-climatic regions over the next decade, with an estimated 68% increase compared to the baseline.

3.2.4 Himalayan Ecosystem

Direct and indirect impacts of climate change on plant biodiversity in the Himalayan ecosystems

Climate change alters various phenological events, including germination, flowering, fruiting, and senescence, in the life cycle of plants (Gaira & Dhar, 2020). It is expected that due to climate change, IHR will lose the cooler climatic zones at mountain peaks, and there will be upward shift of tree lines (Wani & Pant, 2021). As the climate warms, lower-altitude forests will migrate to higher-altitude woods (Verma, 2021). However, some plant species will be able to adapt and shift, while others will be unable to do so and may face extinction. Alpine and endemic species are more prone to such extinctions, as these species are already growing at higher altitudes and have nowhere to shift (Verma, 2021).

Changes in key plant species (threatened and endemic) distributions in different future climatic scenarios

The vegetation over the IHR has shown altitudinal shifts in recent decades (Maharjan et al., 2023, Kumar et al., 2022, Hamid et al., 2020, Tripathi et al., 2022, Tiwari et al., 2023). There is growing concern that ongoing warming affecting upper ecotonal vegetation dynamics may lead to significant changes in the biodiversity of the fragile Himalayan ecosystem. However, studies conducted in the region, although limited, indicate that plant species' responses to recent climate change vary across different ecological settings (Schickhoff et al., 2015), warranting the need to investigate the colonization pattern of species across different ecological settings.

Age analyses of plants growing at 5,500 – 6,150 m Above Sea Level (ASL) in Ladakh, Western Himalaya, have indicated a vertical elevation shift of approximately 150 meters for various species between 2003 and 2013 (Dolezal et al., 2016). The treeline is reported to have moved 388 ± 80 m asl upslope in the IHR between 1970 and 2006 (Dahal et al., 2021). It was found that endemic plant species in the alpine region of the Sikkim Himalaya have shifted their elevational range margins by nearly 90%. Six species showed more than a 50% contraction compared to their historically recorded range extents, while four species showed range expansion by more than 100% of their historical range border (Telwala et al., 2013). The distribution of the three treeline species in the Nepal Himalaya indicates that climatic shifts will likely influence future habitat suitability. About 90% of the endemic species in the Sikkim Himalayas have been displaced at the rate of 27 - 22 m/ decade.

Many species found in the northwest Himalayas of eastern Ladakh, have moved upwards by about 150 m ASL above the plant distribution limit (Chaudhary et al., 2023). It is predicted that under future climate scenarios, the habitat of Rhododendron species in the Sikkim region will shrink. Another study on eleven multi-purpose tree species in the mid-hill zone of the northwestern Himalayas (1999-2017) revealed that phenological changes, particularly leaf emergence, advanced significantly from 1999 to 2006, with varying growth period extensions among species, which is expected to impact future ecosystem dynamics (Panda et al., 2021). The climatic scenario significantly affects the rate of species range expansion. As temperatures rise, the expansion rate increases, directly influencing growth rates and fecundity while reducing the risk of faunal mortality, as seen in species like P. mugo. It can be inferred that species differ in their growth rates in response to rising temperatures, as well as in their dispersal capacities and competitive abilities during their recruitment phase. Phenological changes have also been recorded in different Himalayan ecosystems/forest types, being primarily that of early flowering across flowering plants.

Observed and potential impacts of climate change, including sectoral, economic, social, and environmental vulnerabilities

1. Summary of Studies on Climate Change Impacts on Plant Diversity in the Indian Himalayan Region (IHR)

The following section outlines research on both direct and indirect impacts of climate change on plant diversity in the IHR, based on multiple scientific studies. The summary here focuses only on impacts that are particularly unique to the ecosystem, without including impacts are generally true for all flora and fauna in most ecosystems.

a. Direct Impacts

Alpine vegetation faces vulnerability to increasing temperatures due to its restricted geographic area and narrow elevation range (Thakur et al., 2024). Similarly, apple production has declined because these crops require specific chilling temperatures for quality production (Basannagari & Kala, 2013).

b. Indirect Impacts

- The decreasing productivity of alpine grasslands leads to resource conflicts due to higher temperatures and reduced precipitation (Negi et al., 2022). Climate change also causes changes in species composition, distribution, and phenological events of plants, while creating mismatches in pollination services due to fluctuations in pollinator populations, which affects ecosystem productivity and species composition (Negi et al., 2022; Gaira & Dhar, 2020).

- Additional indirect impacts include changes in ecotones and micro-environmental endemism, vertical species migration, decline in populations of rare and endemic species, facilitation of pest and infectious disease spread, reduced availability of medicinal plants for traditional health systems, and decline in forest-based livelihoods (Tse-ring et al., 2010; Negi et al., 2022).

2. Observed and Potential Impacts of Climate Change in the IHR

The following section is a summary of observed and projected climate change impacts across key sectors in the IHR, based on peer-reviewed research.

a. Agriculture

- Observed Impacts: The agricultural sector has experienced reduced crop production, particularly affecting traditional crops such as Eleusine coracana (finger millet) and Fagopyrum esculentum (buckwheat), due to rising temperatures, water scarcity, and irregular precipitation patterns. There has been a degradation of arable land quality and a decrease in both agricultural land area and production in specific regions, notably in the Garhwal region of Uttarakhand.

- Potential Impacts: Projections indicate a 30% reduction in crop production across Central and South Asia by the mid-21st century. Future impacts include increased uncertainties in meteorological conditions that will affect agricultural output and yield, along with significant impacts on agro-biodiversity and traditional crop varieties (Rautela & Karki, 2015; Bhagawati et al., 2017; Pandey et al., 2018).

b. Livelihoods

- Observed Impacts: Mountain communities dependent on natural resources are experiencing socio-economic impacts and increased vulnerability to climate-related hazards, including floods, droughts, landslides, and erratic rainfall patterns.

- Potential Impacts: Communities face increased vulnerability to climate hazards in the future, with anticipated disruption of traditional livelihoods and economic activities (Smadja et al., 2015; Maurer et al., 2019; Miner et al., 2020).

c. Water Resources

- Observed Impacts: The region has experienced decreased snowfall and increased intense rainfall, which impacts groundwater recharge and soil moisture levels. Changes in river flow patterns are affecting both hydroelectric power generation and aquatic ecosystems.

- Potential Impacts: Future scenarios suggest unpredictable consequences for water availability and aquatic species, with potential for energy insecurity due to variability in hydroelectric power generation (Pramanik & Bhaduri, 2016; Viviroli et al., 2020; Miner et al., 2020).

d. Plant and Forest Biodiversity

- Observed Impacts: There has been an increased frequency of forest fires due to elevated temperatures and reduced precipitation, resulting in both financial losses and significant ecological impacts from forest fire incidents.
- Potential Impacts: Projections indicate potential for further escalation in forest fire incidents and associated losses on an annual basis, leading to potential ecological degradation and loss of biodiversity (IPCC, 2007; Globalforestwatch (n.d.))

3. Observed and Potential Climate Change Impacts in the IHR: Extreme Weather Events and Slow-Onset Events

In IHR, observed climate change impacts include an increased temperature, resulting in glacier retreat and an increase in extreme precipitation events, leading to an increasing frequency of flash floods and landslides. Slow-onset events, such as phenological shifts and treeline rise (4–6 m/year), pose a threat to alpine ecosystems and biodiversity. Potential future impacts by 2100 include intensified monsoon variability, increased risks of glacier lake outburst floods (GLOFs), and diminished water availability, thereby exacerbating socio-economic vulnerabilities. The comprehensive summary documents both extreme weather events and slow-onset climate changes affecting the IHR, along with their observed and projected impacts.

a. Extreme Weather Events

i. Drought

Observed Impacts: There has been an increase in the number of dry days and dry spells, with expansion of drought-affected areas over the last 85 years. Decreasing precipitation due to climate change has been documented across the region.

Potential Impacts: Future scenarios predict high variability in flow patterns, shifting monsoon patterns, and altered river flow patterns that will lead to more frequent floods and droughts. These changes will significantly impact agriculture, environmental systems, and urban water supplies (Bhattacharyya et al., 2015; Garg & Mishra, 2019; Goyal et al., 2016).

ii. Floods and Landslides

Observed Impacts: An increase in extreme rainfall events is leading to heterogeneous flood patterns across India, with a notable increase in cloudburst events in the Central Himalayas. Variability with increasing rainfall trends has been observed in 35% of the Indian landscape since 1970.

Potential Impacts: Projections indicate an increase in maximum monthly rainfall and expanded flood-affected areas by 2100. The variability with increasing rainfall trends observed in 35% of the Indian landscape since 1970 is expected to continue (Guhathakurta et al., 2011; Donat et al., 2016).

iii. Precipitation

Observed Impacts: Average annual rainfall in the North-western Himalaya during 1866–2006 showed decreasing winter precipitation (1975–2006). The Western Himalaya has experienced increasing rainfall by approximately 6 mm, while the Eastern Himalaya has seen significant rainfall decreases.

Potential Impacts: Shifts in precipitation regimes will cause water scarcity and drying springs. There will be decreased snow cover and a significant decline in both snowfall and glacial area (Bhutiyani et al., 2010; Guhathakurta & Rajeevan, 2008; Dimri & Dash, 2012; Krishnan et al., 2019; Saikia et al., 2013; Ren et al., 2020; You et al., 2017; Kulkarni & Karyakarte, 2014; Wester et al., 2019).

iv. Forest Fires

Observed Impacts: Forest fires in the northeastern Himalayas have been increasing in frequency, with a total mean fire incidence of approximately 3,158.5 and an average area of 658,778.4 hectares being destroyed annually. In Uttarakhand, most forest fires result from human negligence, with over 4,500 fires recorded annually, affecting more than 0.6 million hectares of forest.

Potential Impacts: Forest fires will exacerbate climate change by releasing significant amounts of carbon dioxide and other greenhouse gases into the atmosphere, contributing to global warming and altering local climate patterns, potentially leading to more extreme weather events. Changes in fire regimes due to climate change could further affect biodiversity and ecological balance in the region (Wangyel Wang et al., 2021; Lim et al., 2024; Sharma et al., 2014; Sudhakar et al., 2014; Negi, 2019; Bargali et al., 2022).

v. Glacial Lake Outburst Floods (GLOFs)

Observed Impacts: Widespread glacier retreat impacts the frequency of GLOFs, especially in the eastern Himalayas.

Potential Impacts: There will be increased risk of GLOFs due to continued glacier shrinkage (Kothyari et al., 2022).

b. Slow-Onset Events

i. Glacier and Water Resources

Observed Impacts: Melting glaciers impact river discharge, water availability, and agricultural practices downstream. Glaciers in the eastern Himalayas are retreating faster than those in the western Himalayas.

Potential Impacts: Future changes will affect species diversity, create economic impacts, and alter water quality due to cryosphere changes. Decreasing snowpack and glacial volume will reduce freshwater availability, disrupting seasonal stream flows and the overall hydrological cycle (Smadja et al., 2015; Pramanik & Bhaduri, 2016; Viviroli et al., 2020; Miner et al., 2020; Kaushik et al., 2019; Rashid et al., 2015).

ii. Agricultural Impact

Observed Impacts: The region has experienced reduced agro-diversity, loss of productivity, and shifts in agricultural zones due to temperature changes. There have been decreases in yields of major crops such as Oryza sativa (rice), Zea mays (maize), and Triticum vulgare (wheat) in Sikkim. The transition from traditional Jhum cultivation to settled agriculture has occurred. Apple yields have declined due to increased temperatures affecting chilling requirements, leading to the relocation of apple orchards to higher altitudes. There has been an expansion of crops like Mangifera indica (mango), Carica papaya (papaya), and Musa spp. (banana), which are now cultivated up to 1,200 m altitude, previously limited to lower elevations.

Potential Impacts: These include the spread of pests and diseases affecting crop yields and food security. There is potential for further declines in yields of temperature-sensitive crops and increased vulnerability of traditional crops to new diseases and pests. Crops may need to be relocated or adjusted in their cultivation practices due to changing climatic conditions (Isaac & Isaac, 2017; Bhagwati et al., 2017; Negi et al., 2021; Vedwan & Rhoades, 2001; Sharma & Rai, 2012; Sharma et al., 2016; Raina et al., 2009).

iii. Water Resources

Observed Impacts: Changes in hydroelectric power generation and aquatic ecosystems are occurring due to temperature increases and water flow variability. Decreased snowfall and increased intense rainfall are impacting groundwater recharge and soil moisture levels. Changes in river flow patterns are affecting hydroelectric power generation and aquatic ecosystems.

Potential Impacts: Future scenarios suggest unpredictable consequences for water availability and aquatic species, with potential for energy insecurity due to variability in hydroelectric power generation (Smadja et al., 2015; Pramanik & Bhaduri, 2016; Viviroli et al., 2020; Maurer et al., 2019; Miner et al., 2020).

3.2.5 Coastal Ecosystem

Densely populated coastal zones of India are affected by various short- and long-term events including continuous coastal processes, rising sea levels, and human interventions. Mohanty et al (2017) examined at coastal vulnerability mapping index of the Indian coastline and estimated that the highest percentage of coastal erosion has taken place along the West Bengal coast at 70% followed by Kerala (65%), Gujarat (60%) and Odisha

(50%). The coastlines of the remaining states recorded less than 50% of coasts under erosion (Mohanty, et al 2017).

Further, the Coastal Vulnerability Map Index prepared by the INCOIS has analysed 6907.18 km long of the Indian coastline (1990 to 2018) and observed that 33.6% of the coastline has been under varying degrees of erosion for the past 28 years. The latest atlas of Coastal Vulnerability Index mapping is slated to be released soon, but the figure below provides the existing vulnerability index map of India's coastline from 2012.

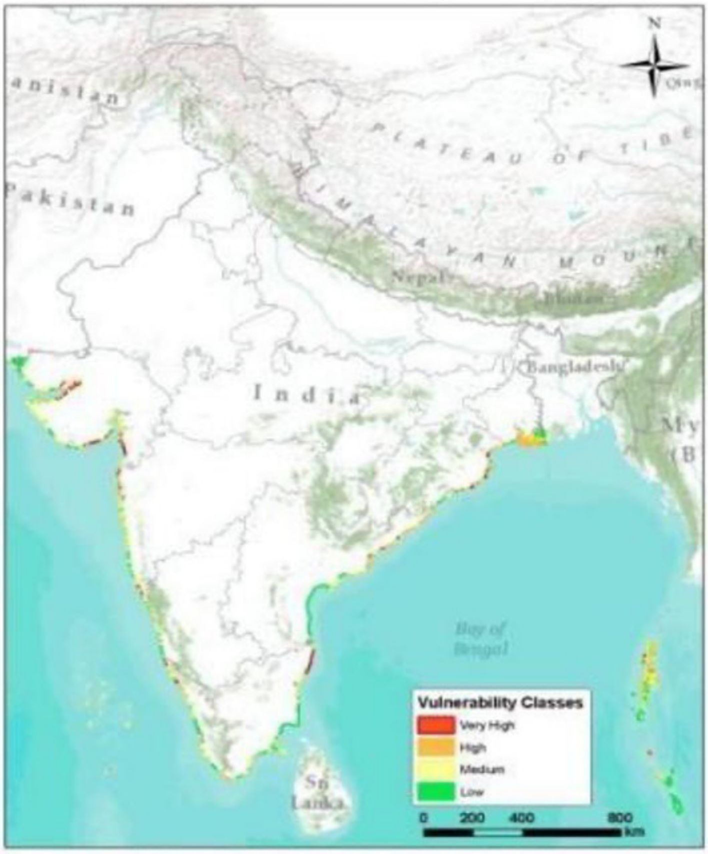

Figure 3.29: Coastal Vulnerability Index Atlas of India (2012). Source: INCOIS, (2012).

An additional threat that must be monitored in this regard is climate change-induced sea level rise. Sea level rise in the near and long-term future will affect populations including fisherfolk, salt pan workers, farmers in coastal agriculture, urban population and urban settlements. The coastal vulnerability of populations in India from climate change in India is a significant threat. A study conducted by INCOIS indicates that the current sea level rise along the Indian coast is about 1.7 mm/year (Nidheesh, et al 2020).)

Current Climate Trends and Impacts:

Warming of ocean waters is exerting a significant impact on fish diversity, distribution, abundance, and phenology, which in turn affects the ecosystem's structure and function. Even a 1°C rise in temperature can cause significant and rapid changes in the geographical distributions and mortality of some organisms, as well as prompt early metamorphosis in certain larval stages. In the Indian Ocean region, rapid ocean warming has led to enhanced surface stratification which inhibits vertical mixing of water and suppresses nutrient upwelling from the subsurface waters. This reduction in nutrient availability adversely impacts marine primary productivity, with cascading effects on higher trophic levels and overall ecosystem health.

Sea Level Rise

The studies show that sea level rise (SLR) is projected to increase under all Representative Concentration Pathway (RCP) scenarios, with RCP 2.6 showing the minimum rise with increasing rise for higher concentration pathways (Horton et al., 2020). Under RCP 2.6, the global mean sea level (GMSL) is projected to rise 0.43 m

(0.29–0.59 m, likely range) by 2100, relative to 1986–2005. For the Indian coast, SLR estimates range between 1.06 and 1.75 mm per year, with a regional average of 1.29 mm per year, consistent with the 1–2 mm per year global SLR estimates reported by the IPCC.

The Bay of Bengal shows a higher SLR trend compared to the Arabian Sea due to higher SST, river discharge, and precipitation, impacting the Indian marine and coastal ecosystem. SLR influences nutrient levels and productivity in coastal waters, exacerbates inundation and flooding of low-lying coastal areas, and increases coastal erosion. It affects coastal ecosystems like salt marshes, mangroves, and coral reefs, leads to saltwater intrusion into freshwater sources, alters sediment deposition along river channels, and may result in more typhoons and storms, impacting both the natural environment and human society. Mangroves, which act as natural barriers against coastal flooding and erosion, are at high risk of submergence due to SLR, as they cannot survive in environments with higher sea levels and salinity. Upwelling is crucial for the availability of large concentrations of commercially important pelagic fishes such as oil sardines, mackerel, and whitebait. Since India has a long coastline of 11,099 km, supporting millions of people for their livelihoods, the precise prediction of changes in future sea level and its impacts would be of utmost importance, as the rise in sea level could harm the lives and occupations of millions of people who live in coastal regions and islands.

The Indian National Centre for Ocean Information System (INCOIS) has carried out Coastal Vulnerability Index (CVI) mapping to prioritize vulnerable zones and to assess the probable implications of sea level rise along the Indian coast.

Coastal Erosion

In a study by MoES, Government of India, about 6031 km long coastline was mapped on a 1:25,000 scale to analyze the temporal shoreline changes from 1990 to 2016 using 9 data sets. The results are categorized into three categories: erosion, stable, and accretion. It is observed that 33.6% of the Indian coastline was vulnerable to erosion, 26.9% was under accretion (growing), and 39.6% was in a stable state. These figures highlight the widespread vulnerability of Indian coasts to dynamic coastal processes. The west coast of India (excluding Kerala) is mostly steady, with a few isolated areas of receding coastline. Land loss and gain investigations found that the West Bengal coast lost around 99 km^2 of land during the previous 26 years. The shoreline changes, along with infrastructure details, ports, industries, and anthropogenic activities, are also mapped. A total of 526 maps have been developed for the entire India to detect vulnerable coastal regions on a 1:25000 scale, coupled with 66 district maps and 10 state/UT maps.

Ocean Acidification

Over the past two to three decades, a decline in ocean interior pH has been observed in all major ocean basins. With rising global atmospheric CO_2 levels, it is critical to understand how the seas and coastlines are responding through changes in biogeochemistry and biological resources. Although there are a few coastal data on the temporal changes in pH available, there are no basin-scale observations to assess acidification in the Indian Ocean. The coastal Bay of Bengal has maintained the most extensive records of acidity measurements for over 10 years. The findings demonstrate a continuing decline in pH over time, consistent with the increased uptake of atmospheric CO_2 and the associated rise in Dissolved Inorganic Carbon (DIC) concentrations in surface waters.

Sea Surface Temperature

Changes in Sea Surface Temperature (SST) can disrupt marine ecosystems, leading to issues such as coral bleaching and altered fish migration patterns, which threaten biodiversity and fisheries. Rising SST due to climate change have far-reaching consequences for marine ecosystems and coastal communities. The impacts of rising sea surface temperatures extend beyond marine ecosystems, also affecting coastal communities. As the oceans expand due to thermal expansion, sea levels rise, putting low-lying coastal regions at risk of flooding and displacement.

Such an event poses a threat to both human populations and infrastructure. Additionally, the intrusion of saltwater into coastal aquifers and estuaries can disrupt freshwater supplies, impact agriculture, and alter the composition of aquatic environments.

The Indian Ocean has emerged as one of the most rapidly warming ocean basins, with significant implications for the region's climate and ecosystems. Over the past decades, the global average ocean surface temperature has risen by 0.7°C (0.11°C per decade), while the Tropical Indian Ocean (TIO) has experienced an even more pronounced warming of approximately 1.0°C on average (0.15°C per decade) (Krishnan et al., 2020). This trend is corroborated by a 138-year (1870–2007) monthly observed SST time series along a ship track extending from the Gulf of Aden through the Malacca Strait, which reveals a 1.4°C warming over the entire period (Chowdary et al., 2012). Climate models participating in the Coupled Model Inter-comparison Project (CMIP5), using observed CO_2 forcing rates, further support these findings. The models show warming trends of 0.1–0.18°C per decade during 1976–2005, with the northern Arabian Sea experiencing the maximum warming. This rapid warming of the Indian Ocean is a significant concern, as it can lead to changes in atmospheric circulation patterns, increased ocean stratification, and alterations in marine ecosystems.

3.2.6 Biodiversity

Observed and potential impacts of climate change

As part of the overall assessment conducted for the NAP referred to earlier, a combined vulnerability and climate risk assessment was carried out for the combined ecosystems and biodiversity sector, disaggregated to the level of agro-climatic zones and districts within them.

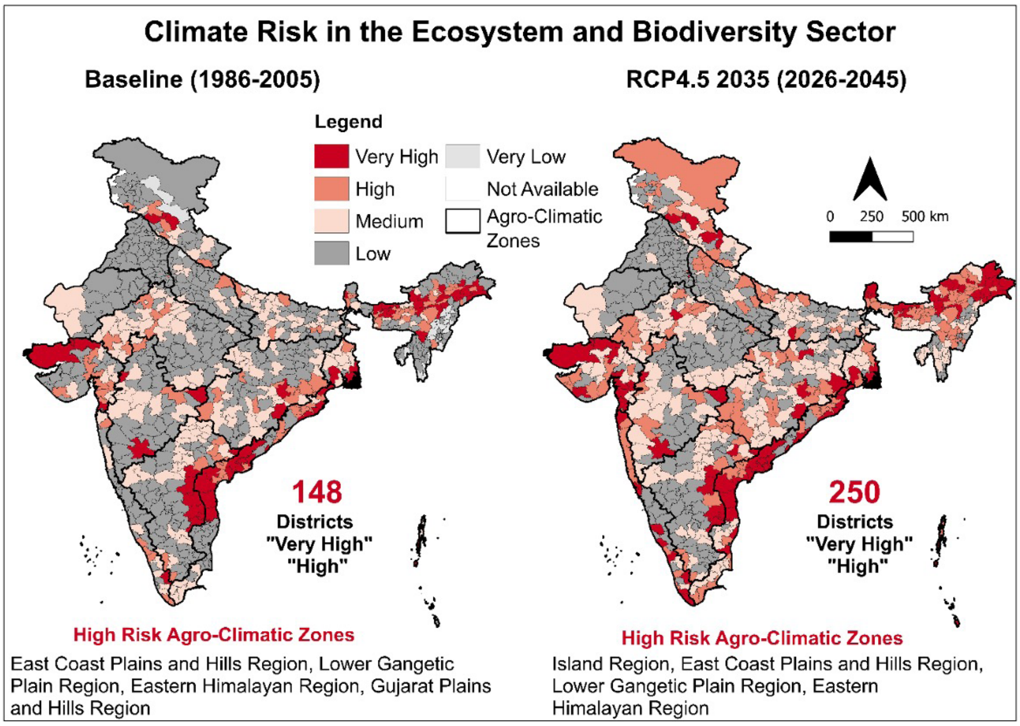

Figure 3.30: Climate risk in the Ecosystem and Biodiversity Sector. Source: National Adaptation Plan

The following map shows the historical and future climate risk of the combined sector under the RCP 4.5 scenario for the year 2035 (covering the period 2026–2045).

The results indicates that Island Region, East Coast Plains and Hills Region, Lower Gangetic Plain Region, Eastern Himalayan Region, and West Coast Plains and Ghat Region across India are projected to face highest levels of climate risk. Climate risk in the ecosystem and biodiversity sector is expected to intensify considerably across agro-climatic regions over the next decade, with a projected 69% increase compared to the baseline.

Observed impacts

i) **Marine ecosystems:** A reduction of up to 20% in marine phytoplankton and consequent decline in marine productivity was observed in the Indian Ocean during the past six decades, attributed to the rapid warming and the resultant enhanced ocean stratification suppressing nutrient mixing from subsurface layers. Future climate projections indicate further warming and subsequent reduction in marine productivity

(Roxy et al., 2015). The unfavourable conditions in the ocean ecosystem following El Niño Southern Oscillation (ENSO) events influence the growth and reproduction of oil sardine resources off the Kerala coast and since 2013 the sardine catch has witnessed a sharp decline (Rohit et al., 2018).

ii) **Mangroves:** Mangrove forests are under severe stress due to shoreline ingress and SLR (Thakur et al., 2021). Warm tropical mangroves thrive on their thermal limit, so a further increase in temperature can be devastating for the mangrove's physiological processes (Sardar and Samadder, 2023). A study conducted on shoreline changes in Sunderbans and its implication on the land use patterns reported that there is rampant erosion in parts of the island along with small amounts of accretion (Thakur et al., 2017). The habitat suitability for the two mangrove species *Rhizophora mucronata and Avicennia officinalis* is changing at local and regional levels due to an increase in precipitation and temperature (Samal et. al. 2022). Among these climatic factors, precipitation is found to have a more significant impact on the distribution of true mangroves compared to temperature. In the Indian Wetland Province (IWP), species like *Aegiceras ilicifolius, Excoecaria agallocha,* and *Avicennia corniculatum* show the highest potential for distribution. The distribution of these species is most strongly influenced by precipitation-related factors, highlighting the importance of future changes in precipitation patterns in shaping mangrove ecosystems in the region (Banerjee et al., 2022).

iii) **Forests and vegetation:** Warming-driven geographic range shift was recorded for 87% of the 124 endemic plant species studied in the Sikkim Himalayas during 1849–1850 and 2007–2010 (Telwala et al., 2013). Vegetation species such as *Betula utilis* (Himalayan birch) have shown a tendency to shift towards the Eastern Himalayas with declining trends in the western parts (Hamid et al., 2018). In Darjeeling, India, significant change in lichen community structure was shown in response to climate change and anthropogenic pollution (Bajpai et al., 2016). In semi-arid tropical scrublands of Andhra Pradesh, the flowering and fruiting phenology of trees and shrubs (native and non-native) and the phenology of animals have been mismatched and altered due to changes in seasonal variation, temperature, and precipitation (Ramaswami et al., 2018). The studies from the Mudumalai landscape in the Western Ghats indicate that the amount and seasonality of precipitation is a major driver of forest dynamics, through its effects on species diversity, tree growth, and mortality and influence on the frequency and intensity of fire (Das & Sukumar, 2018). The endemic plants of Western Ghats are shifting towards the southern parts, which experience a greater annual mean moisture index. Southern and south-eastern parts of Western Ghats experience higher annual rainfall and low mean monthly temperature, compared to other parts of the hotspot (Chitale et al, 2014).

iv) **Crops and pollinators:** Studies on the impact of temperature and precipitation on pollination services are very few and in a literature survey on the vulnerability of pollination services, only seven studies reported the impacts of temperature on pollination and the review highlighted severe paucity of data on the response of pollinators to climate change in India (Borges et al., 2020). Some studies investigating the role of altitude (as a proxy for future temperature changes) in determining pollinator composition of Sikkim Mandarin Orange, an alternative cash crop introduced in Sikkim Himalayas showed a gradual shift in pollinator species composition with an increase in altitudes. The lower altitudes were dominated by the common honeybee *Apis cerana* and higher altitudes by hover flies. Other modelling studies showed that hoverflies decrease in abundance when temperatures increase and therefore higher elevation farmlands which are pollinated by hoverflies are likely to be affected by warming leading to economic and livelihood loss to farmers (Devy et al., 2018).

v) **Ecosystem services:** A review of 102 studies published between the year 2000- 2018 on climate change impacts on ecosystem services in India showed that although the research on the topic is rapidly growing, the focus so far has primarily been on the effects of changing climate on two services – food production, and water supply and regulation. Studies on food production chiefly correspond to climate-induced changes in crop physiology, while studies on water supply and regulation mainly cover abiotic processes. At the same time, ecosystem services such as nutrient cycling and carbon storage, that arise out of complex ecological interactions remain understudied (Osuri et al., 2018).

Projected impacts

i) **Forestry, mangroves and vegetation:** Exploratory simulations of the possible evolution of the Indian Sundarbans mangroves to 2100 under a range of future sea-level rise scenarios, considering the effects of both inundation and shoreline erosion showed significant mangrove decline in all scenarios with greater losses predicted under higher sea level rises. Sundarban mangroves may lose 42-80% of their area under the BAU scenario by 2100 (Samanta et al., 2023). Chakraborty et al. (2016) indicate a shift in forest composition, with a decrease in Quercus spp. and an increase in the distribution of *Pinus roxburghii* (pine) over the progressive Representative Concentration Pathways (RCPs) for 2050 and 2070. This trend aligns with changes in climatic conditions, as precipitation and temperature fluctuations influence species distribution. Climate niches for Dipterocarp trees like Sal (*Shorea robusta*) and Garjan (*Dipterocarpus turbinatus*) are likely to come under increasing stress potentially resulting in range contraction and distribution shifts across the region. Climate change is projected to significantly impact the distribution of teak and Sal forests in India. By 2070, Sal (*Shorea robusta*) is expected to lose suitable climate space across key states, including Madhya Pradesh, Chhattisgarh, West Bengal, Odisha, and Jharkhand (Deb et al., 2017). Similarly, MaxEnt modeling indicates a future increase in suitable habitat for teak (*Tectona grandis*) but a decline for Sal under changing climate scenarios in central India (Patasaraiya et al., 2023). The habitat suitability of *Barringtonia acutangula*, a traditional community forest species is predicted to further decrease by 63.63% by 2050 in India due to changes in the precipitation pattern that can put the species under stress and lead to a high risk of population shrinkage (Hazarika et al., 2022). Climate change would promote the invasion of 11 invasive plant species in the western Himalayas (Thapa et al., 2018) and the Giant African Snail in India (Sarma et al., 2015), while another study has projected that climate change would inhibit the invasion of invasive plants *Chromolaena odorata* and *Tridax procumbens* in India (Panda and Behera, 2019). Additionally, species like *Prosopis juliflora* (Singh et al., 2021), *Ageratum conyzoides* (Lamsal et al., 2018), and *Parthenium hysterophorus* (Ahmad et al., 2019) are projected to experience a reduction in their suitable habitats under future climate scenarios, potentially shrinking their current ranges.

ii) **Pollinators and insects:** A warming climate and changing precipitation regimes are likely to have variable responses from plant-pollinator systems. A study simulating the effects of unseasonal rain during the dry season on *Cullenia exarillata*, a key stone species in tropical forests showed the incidence of fungal infections and no fruit set from lack of pollinator visits (Devy, et al., 2018). Climate change can result in poleward and upward shifts in the distributional ranges of butterflies, changes in breeding phenology and survival of different life stages and reproduction, reduce available habitat for the species, and cause local population extinctions (Kunte, 2018).

iii) **Amphibians and reptiles:** Four species of Himalayan amphibians studied are expected to reduce their geographic distributions, indicating increased extinction risk (Subba et al., 2018). Habitat suitability models in conjunction with future climate models predict several endemic herpetofauna including the Indian Golden Gecko (*Calodactylodes aureus*) of southern India to shrink or shift their geographic ranges in response to increasing temperatures, with up to 73.48% reduction in climatically suitable habitat for some species by the year 2050 (Srinivasulu and Srinivasulu, 2016; Srinivasulu et al., 2021). While *Tylototriton verrucosus* is projected to have range expansion in the future (Das et al., 2022).

iv) **Birds:** A study using maximum entropy-based species distribution algorithms indicates that by 2070, 66–73% of bird species in India will shift to higher elevations or northward (Deomurari, 2023). At the end of the century (2081–2100), five species of Indian hornbills (family: *Bucerotidae*) will face >50% of climatic niche reduction. A north-east directional shift is observed in species like Rufous-necked hornbill (*Aceros nipalensis*), Austen's brown hornbill (*Anorrhinus austeni*), Wreathed hornbill (*Rhyticeros undulatus*) (Sarkar and Talukdar, 2023).

v) **Mammals:** Habitat generalist species such as the golden jackal and jungle cat that can tolerate human-modified landscapes may be better buffered against future climate- driven changes compared to habitat specialists such as the Indian fox that require native grasslands that are already dwindling in status (Katna et al., 2021). Krishnamani and Kumar (2018) attribute the rarity of the lion-tailed macaque (Macaca silenus), a highly endangered species, to the distribution of its food plants - mainly comprising Ficus species. An increase in ENSO-related drought events in India will make fig wasps vulnerable to extinction producing a cascading effect on fruit-eating communities, including that of the lion-tailed macaque (Gergis and Fowler, 2009). Additionally, the distribution of Asiatic elephants (*Elephas maximus*) is projected to shift due to climate change, mostly driven by changes in climatic water balance, followed by temperature fluctuations and ongoing human-induced disturbances (Kanagaraj et al., 2019). While most mammals are expected to experience range contraction under various future climate scenarios, some species, such as the Himalayan musk deer (*Moschus leucogaster*) (Khadka and James, 2017), Indian fox (*Vulpes bengalensis*), golden jackal (*Canis aureus*), Asiatic wildcat (*Felis lybica ornata*), and jungle cat (*Felis chaus*), are projected to expand their ranges (Rather et al., 2020; Sarkar et al., 2024).

Approaches, methodologies, and tools, and associated uncertainties and challenges

A wide range of approaches and indicators have been used to assess the risk and vulnerability associated with the impact of climate change on biodiversity.

Species Distribution Modelling (SDM) is used to identify a species' potential current and future distribution (Sarkar et al. 2024) for predicting species distribution across different temporal and spatial scales. SDMs can project future climatic niches of a species using species presence points and different environmental layers, mainly climate change scenarios based on Global Circulation Models (GCMs).

Under the **Indicator-based Approach for Inherent Vulnerability Assessment**, the present state of forests and biodiversity is analyzed using appropriate indicators to assess their propensity to suffer losses under various disturbances (Brooks, 2003; Sharma et al., 2015). The results of the assessment are finally expressed in terms of a vulnerability index value. Indicators for forest vulnerability assessment include species richness, canopy density, slope, forest dependency disturbance index, etc. Weights are assigned to these factors based on the information gathered during stakeholder consultation and expert review using the Analytical Hierarchy Process (AHP).

The **Forest Tree Genetic Risk Assessment System (FTGRAS)** was applied to assess the inherent vulnerability of the forest floral species and provides a framework to rank the relative risk of genetic degradation for multiple forest tree species present in an area (Potter & Crane, 2010). FTGRAS gives each species a rating for risk factors relating to its intrinsic attributes, such as population structure and seed dispersal mechanism that may increase its vulnerability when faced with change, external threats to its genetic integrity, and conservation modifiers (Table 3.12).

Table 3.12: Risk Factors and the Assessed Traits

Risk Factors	Traits
Intrinsic Risk Factors	Population structure, rarity/density, regeneration capacity, dispersal ability, habitat affinities, genetic variation.
External Risk Factors	Pest and pathogen threats, habitat shift pressure
Conservation modifiers	Endemism and conservation status

Source: compilation for the report

A trait-based Climate Change Vulnerability Assessment (CCVA) Toolkit was used to assess the vulnerability or resilience of faunal species to climate change (Advani, 2023), based on four factors: sensitivity, adaptive capacity, exposure, and other threats (Table 3.13).

Table 3.13: Vulnerability Factors and Assessed Traits

Vulnerability Factors	Traits
Sensitivity	IUCN Red List status, geographic range, population size, temperature tolerance, reliance on environmental cues for reproduction, reliance on ecological cues for migration, reliance on environmental cues for hibernation, symbiotic relationship with other species, diet, abundance of food sources, freshwater requirements, habitat specialization, disease susceptibility.
Adaptive Capacity	Dispersal ability, generation time, reproductive rate, genetic variation
Exposure	The degree of climate variability the species is exposed to
Other threats	Habitat destruction, poaching, human-wildlife conflict, etc.

Source: compilation for the report

Most studies investigating the impact of climate change on plant phenology are short-term studies, which hinders the accuracy of predictions of how they would change in response to future climatic changes. Further, tropical plant phenology is driven more by seasonality and amount of precipitation (Ramaswami et al. 2018, and references therein), rather than temperatures, making predictions even more difficult due to large uncertainties in projections of how rainfall and weather systems such as the ENSO, would change (IPCC 2013).

While studies in Protected Areas (in the absence of direct human influence) are useful to understand how such ecosystems respond to climate change, human influence is so pervasive in some ecosystems (e.g., freshwater) that it is necessary to account for the interactions of climate change with other anthropogenic drivers of change (e.g, construction of dams in rivers) to get useful information on how these ecosystems should be managed in a changing climate (Krishnaswamy et al. 2018).

3.2.7 Cities

Current Climate Impact Trends and Hazards

Nine Indian cities, supported by NGOs and other non-state actors, have conducted hazard, risk, and vulnerability assessments, following a key recommendation under the Climate Smart Cities Assessment Framework's (CSCAF) Cities Readiness Report to integrate spatial mapping and geospatial analysis for data-informed decision-making. As many as 96 out of 126 cities are still in the early stages of developing City Climate Action Plans (CAPs) and need to initiate vulnerability assessment preparation (MoHUA and NIUA 2021). In addition, 130 cities have prepared Heat Action Plans.

The National Institute of Urban Affairs (NIUA), under its Climate Smart Cities Assessment Framework 2.0, has published the latest Cities Readiness Report 2021, which contains a sophisticated ranking of climate readiness across 126 Indian cities and towns. The CSCAF 2.0 framework captures the contribution of cities to national and international initiatives like INDCs and SDGs via five categories: (a) urban planning, green cover and biodiversity, (b) energy and green buildings, (c) mobility and air quality, (d) water management and (e) waste management. These assessments primarily concentrate on environmental and physical infrastructure factors and governance. While ideal in its coverage, NIUA's assessment does not account for meteorological indicators or other extreme events.

For this report, a methodology for urban vulnerability assessment was developed based on the existing studies by the DST, NIUA, IMD, WRI India, and CEEW. It contains 153 indicators across 12 categories. and each state was assigned vulnerability index predicated on the number of urban districts that fall under identified vulnerability categories. It reveals a more nuanced picture of state vulnerabilities, highlighting states such as Assam, Maharashtra, Bihar, Karnataka, and Andhra Pradesh are highly vulnerable. Conversely, Punjab, Meghalaya, Tripura, Arunachal Pradesh, and Sikkim are identified as the least susceptible.

Key States:

Assam: Assam emerges as the most vulnerable state, as out of its 14 urban districts, 9 fall under the very high category, 4 under high, and 1 under moderate. This finding aligns with the composite ranking, where Assam is ranked as the most vulnerable state. The high concentration of districts in the very high and high categories underscores the significant exposure and sensitivity of Assam's urban areas, necessitating urgent adaptive measures.

Maharashtra: Our analysis places Maharashtra second in the urban district-based vulnerability index. Of its 20 urban districts, 6 are categorized as very high, 5 as high, and 6 as moderate, with none in the low or very low categories. This distribution highlights Maharashtra's considerable vulnerability, particularly in its urban centers, reflecting a substantial need for targeted resilience strategies to mitigate these vulnerabilities effectively.

Andhra Pradesh: A notable disparity exists between the composite ranking and the urban-centric ranking. Andhra Pradesh is ranked as the second most vulnerable state in the composite ranking but fifth in the urban-specific ranking. This is attributed to the distribution of its 7 urban districts: 2 in the very high category, 3 in the high, and 2 in the low. This discrepancy indicates that although Andhra Pradesh has a significant number of high-vulnerability districts, its overall vulnerability is mitigated by districts in lower categories.

Exposure to extreme weather events

The analysis indicates drought is the predominant hydrological climate hazard, impacting the highest share of urban districts (39.1%). This shows a significant vulnerability, necessitating urgent measures to mitigate drought effects in urban areas. Following closely is the combined threat of flood and drought, which affects 26.8% of urban districts. This dual threat poses compounded challenges, highlighting the need for integrated disaster response and resource allocation strategies. Floods affect 17.4% of urban districts, with specific areas highly vulnerable. In particular, the states of Assam (7 districts), Bihar (2 districts), and Haryana (1 district) are severely affected. These regions will likely experience significant flooding impacts, underscoring the need for targeted flood mitigation and adaptation strategies. Furthermore, the combination of flood, drought, and cyclone impacts 9.8% of urban districts, indicating areas exposed to multiple hazards. This necessitates comprehensive risk management plans to address these combined threats effectively. On the other end of the spectrum, the combination of drought and cyclone affects the smallest percentage of urban districts, at 2.6%, suggesting relatively lower vulnerability compared to other climate exposures. Similarly, the combination of flood and cyclone affects 4.3% of urban districts, indicating a moderate level of impact. Besides these, at the city level, the most identified vulnerability is Urban Heat Island (UHI). Table 3.14 provides the proportion of urban districts affected of individual or combined hydrological climate hazards.

Table 3.14: Share of urban districts by hydrological extreme weather events

Exposure	District	Urban District	Urban district percentage
Flood	90	41	17.40%
Drought	182	92	39.10%
Drought & Cyclone	12	6	2.60%
Flood & Cyclone	18	10	4.30%
Flood & Drought	108	63	26.80%
Flood & Drought & Cyclone	40	23	9.80%
Total District	450	235	100.00%

Source: Compilation prepared for this chapter based on data as indicated in text

The assessment underscores the critical need to address urban district vulnerabilities specifically to develop more targeted and effective resilience strategies. It illustrates that a state's vulnerability cannot be solely determined by the number of its urban districts but rather by the concentration of districts within the very high and high vulnerability categories. This nuanced approach provides a deeper understanding of state vulnerabilities, enabling more precise policy formulation and resource allocation for enhancing urban resilience.

Heat waves:

Heat waves are one of the key threats to human welfare in cities under global warming, and considerable efforts are underway with multiple studies on this issue for India as well. These studies have considerably evolved over time with increasing detail and sophistication.

A recent study (CSE, 2024) of the six cities of Delhi, Mumbai, Kolkata, Hyderabad, Bengaluru and Chennai from summer of January 2001 to April 2024 focussing on rends in day and night temperature, humidity levels, seasonal variations, land surface temperature trends, and built-up areas indicated the following: Decadal summer-time average ambient temperature has risen by about 0.5°C in Mumbai, Bengaluru, and Chennai compared to 2001-10. Kolkata's decadal average is also up by 0.2°C. Delhi and Hyderabad, two metros located in composite climate zones known for the driest and harshest summers, have registered lower decadal averages compared to 2001-10. Decadal summer-time average for Delhi is down by 0.6°C and for Hyderabad, by 0.9°C, compared to 2001-10.

Relative humidity has increased in all zones, which has made heat stress worse in warm-humid and moderate climate zones, while it has nullified the fall in air temperatures in composite and hot-dry climate zones, especially during monsoons. The average Relative Humidity (RH) has increased significantly over the last 10 summers compared to the 2001-2010 average. Barring Bengaluru, the decadal summer-time average RH has increased by 5-10 percent in the other five mega cities. The last 10 summers of Hyderabad have been, on average, 10 percent more humid compared to 2001-10. Similarly, Delhi's last 10 summers have been 8 percent more humid. Mumbai's relative humidity is up by 7 percent, while summers in Kolkata and Chennai are 5 percent more humid on average. Bengaluru has seen no change in humidity levels during summer.

The heat index (HI) has risen among these mega cities due to relative humidity during summers. Chennai's summer average heat index stood at 37.4°C (impact of humidity: 6.9°C), making it the hottest among the megacities. Kolkata, with a summer HI average of 36.5°C (impact of humidity: 6.4°C), and Mumbai, with 34.3°C (impact of humidity: 5°C), was almost equally hot. Delhi's summer HI average stood at 32.2°C (impact of humidity: 3.3°C), and Hyderabad's at 29.3°C (impact of humidity: 1.2°C). Bengaluru was the least hot among the megacities with a summer HI average of 26.9°C (impact of humidity: 0.8°C). (CSE , 2024)

Projected Climate Trends and Hazards

Heat waves under future warming:

A study by Rohini et al (2019) using observational data suggested an increase in day time temperatures and frequency and duration of heat waves over India during the pre-monsoon season (April–June). The characteristics (frequency and duration) of heat waves over India in future warming scenario were examined using nine CMIP5 models.

The study noted that the RCP4.5 scenario and the period 2020–2064 were used for the analysis to examine the possible changes in the characteristics of heat waves. In spite of moderate biases in daytime temperatures, the CMIP5 models showed only modest skill in the realistic simulation of observed heat waves in terms of spatial pattern and frequency. The models suggest an increase of about two heat waves and an increase of 12–18 days in heat wave duration during the period 2020–2064. In the future climate change scenario, the southern parts of India and the coastal parts of India, which are presently unaffected by heat waves, are likely to be affected by heat waves.

Further, the study noted that the spatial trend analysis of Heat Wave frequency (HWF) and Heat wave Duration (HWD) suggested that both the HWF and HWD will increase significantly over central and northwest India by 0.5 events per decade and 4–7 days per decade, respectively. The study also suggests that the future increase in heat waves is caused by the strengthening of the mid-tropospheric high and associated subsidence over central and northwest India. Land surface processes like depletion of soil moisture and increased sensible heat fluxes are also responsible for the increase in heat waves. The CMIP5 models also suggest that El Nino Modoki events may be responsible for the prolonged and more frequent future heat waves over India in the future climate scenario.

3.2.8 Health

Current and Future Climate Related Impacts and Hazards

As part of the vulnerability and risk assessment for the NAP, the combined (under multiple hazards) risk for the climate risk assessment for historical and the future up to 2035 under RCP4.5 warming trajectory was estimated. The main result, district wise, and aggregated by agro-climatic zones is provided in the following maps (Figure 3.31):

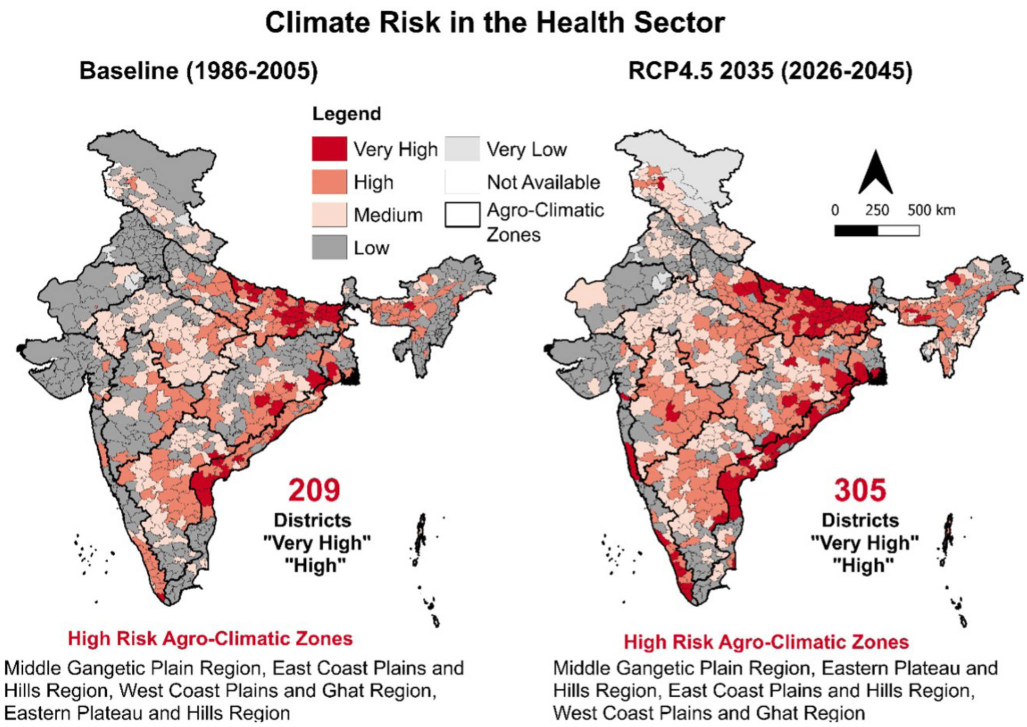

Figure 3.31: Climate risk in health sector. Source: National Adaptation Plan

The climate risk results indicate that the Middle Gangetic Plain Region, Eastern Plateau and Hills Region, East Coast Plains and Hills Region, West Coast Plains and Ghat Region, and Upper Gangetic Plain Region are projected to experience the highest levels of climate risk across India in the Health sector. Climate risk in the health sector is projected to increase across agro-climatic regions over the next decade, with an estimated 46% increase compared to the baseline.

Climate Change-related human health impact assessment

Assessment of the human health-related impacts of a changing climate on the Indian population is crucial to adaptation against climate change. Since many research studies have been conducted over the years in the country estimating the health impacts, a comprehensive synthesis of this evidence specific to India was conducted. A systematic approach was utilized following the standard methodology of systematic evidence mapping, focusing on the human health effects of climate change-associated long-term/short-term variations in temperature, humidity, precipitation, and the occurrence of climate extremes.

Through a search of published literature, 261 published reports/articles were identified that investigate the human health impacts of climate change on the Indian population. The majority (80%) of these studies have been published in the last decade. The climate-related aspects assessed by the published reports are mostly related to temperature (including extremes such as heat and cold waves), changes in rainfall intensity/duration/extreme precipitation events, and climate extremes. Health outcomes range from the investigation of the burden (incidence/prevalence or morbidities caused; n=107) and mortality (n=3) caused by infectious diseases (including vector-borne diseases like Malaria, Dengue, Leishmaniasis, etc. and water/food-born infections), heat-related illnesses (41 mortality & 25 morbidity studies), and other miscellaneous health effects (n=85, including climate extreme-induced mortalities, childhood undernutrition and developmental anomalies, reproductive & maternal health issues, mental health effects, cardiorespiratory diseases and exacerbations of existing chronic disease).

A number of studies investigated the relationship between climatic factors and infectious diseases. The authors reported that the incidence of vector-borne diseases has shifted in many parts of India. While malaria incidence has gradually declined in the country as compared to the 1990s (Roy, 2023), there is a change in the spatial distribution of malaria outbreaks in India, and it has been predicted that non-endemic regions might face a higher burden with a changing climate (Bhattacharya et al., 2005). In contrast, dengue incidence was shown to have increased over time in the country, and climatic factors like temperature and rainfall appear to play a significant role (Kakarla et al., 2019; Singh G. et al., 2023). The quantity of evidence varies regionally and by the subject of the study. Published correlation analysis has shown that the strongest correlation between meteorological variables like precipitation/temperature and the incidence of malaria is found in the northern and northeastern parts of India (Roy, 2023; Singh G. et al., 2023).

Studies have also explored the correlation between climatic variables and other vector-borne diseases like Visceral Leishmaniasis (VL) and chikungunya outbreaks. A recent study conducted in endemic and non-endemic blocks of Bihar and Jharkhand states (which are two of the four states in the country that are known to be endemic to VL reiterated the relationship between climatic factors and VL occurrence that was also previously reported by older pan-India research (Palaniyandi et al., 2014; Subramanian et al., 2024). Similar analyses for Chikungunya and climatic factors conducted through pan-India analysis of incidence data showed a strong correlation between rainfall and disease incidence, particularly in states that had maximal disease burden (i.e., West Bengal, Karnataka, and Maharashtra) during 2010– 2014 (Shil et al., 2018).

Other infectious diseases like gastrointestinal diseases (including diarrhoea, cholera, and enteric fever), as well as skin and respiratory infections, have also been explored in the context of changing climatic conditions in India. These studies varied significantly in terms of the study design. All fifteen studies reported an association/correlation between temperature or rainfall and diarrhoea incidence/prevalence. Additionally, another eight studies, mainly focussing on the adult population, investigating cholera and enteric fever, also reported evidence in favour of the effect of climatic variables like temperature and precipitation. In contrast, highly heterogeneous and sparse evidence (n=7) exists for other infectious diseases affecting the respiratory tract (for example, pneumonia, Tuberculosis) and skin.

Evidence on Heat-related morbidities and mortalities

The major part of Indian research on heatwave-related mortalities is based on populations in the western parts of the country. Pan-India analyses included in the current review documented a change in the spatial occurrence pattern of heatwave events in the country, with increasing burden in the northwestern, central, and south-central parts of the country as opposed to the decreasing trend noted from the eastern part of India (Singh et al., 2021). Research is also identifying relevant solutions to mitigate the adverse health effects of heat. An interventional study reported the benefits of awareness campaigns using different media platforms in reducing heatstroke-related deaths in Odisha (S. Das, 2016).

Twenty-five published reports have shown associations/correlations between exposure to high ambient temperatures with or without high humidity and the increased probability of morbidities

Evidence on Climate Extreme-related morbidities and mortalities

The current review identified 84 reports investigating the health effects associated with climate extremes. In contrast to other climate-health research in India, the proportion of studies focusing on the pediatric population was significantly more in this context with 38 studies specifically exploring health effects on children and another 21 studies including data for all population groups, including children. Most of these studies conclude that long-term exposure (particularly during early life) to precipitation shocks (drought and floods) can adversely affect child growth (Dimitrova & Bora, 2020; Kishore, 2023; Muttarak & Dimitrova, 2019). However, the ecological design adopted by most of these studies precludes the drawing of any accurate conclusion and instead warrants the future need for high-quality primary studies using cohort or even quasi-experimental approaches.

Finally, many pan-India datasets included in this review showed that the northern and eastern regions of India experience a higher burden due to climate extremes necessitating the implementation of specific preventive interventions to reduce the public health burden (Figure 3.32). Deployment of government initiatives to manage the impact of climate extremes is clearly evident from the fact that while the occurrence of extreme weather events such as extreme precipitation events, cyclones, lightning, and other storms have significantly increased in the country since the 1980s, their adverse health effects (especially attributable mortalities) have significantly reduced except in the case of lightning (Ray et al., 2021).

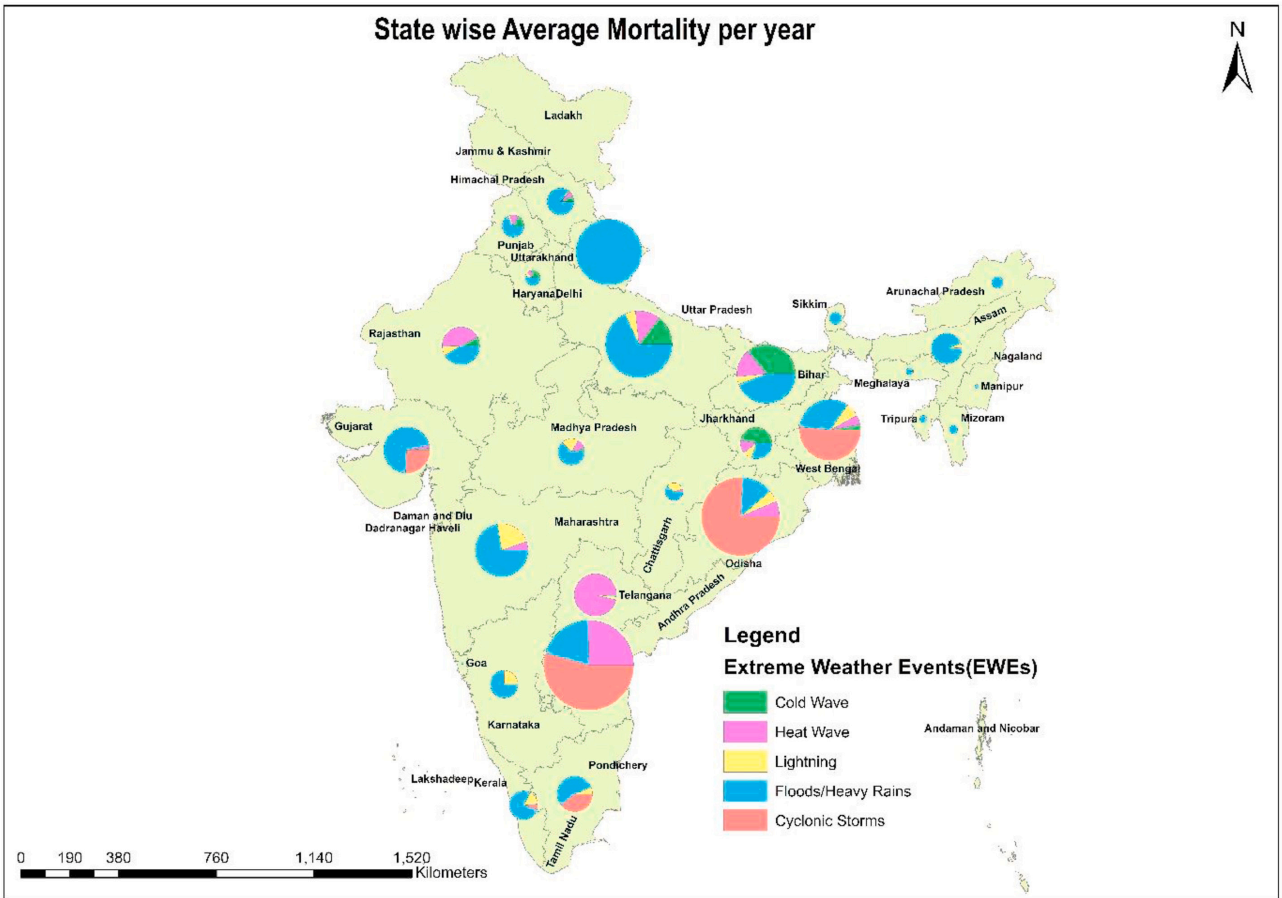

Figure 3.32: An overview of the spatial heterogeneity in the public health burden posed by extreme weather events in India
Source: Ray et al., 2021

3.2.9 Gender

Current and Projected Climate Change Impact Trends and Hazards

As part of India's Third National Communication to the UNFCCC, a Gender-based Climate Risk Index (GCRI) was developed that quantifies the vulnerability/risks faced by men and women to climate change at multiple scales. The index follows the IPCC AR5 Risk Assessment Framework. While examining women's vulnerability and risk to climate change and extremes, the holistic index considers the various roles played by women in different domains, such as household work, income generation, childcare, as well as participation in leadership roles in family and community. The index comprises four sub-indices dealing with hazards, exposure, sensitivity, and lack of adaptive capacity and uses 54 indicators.

This index was deployed to examine the male-female differentials in vulnerability and risk to climate change. The index has shown that despite facing the same climate-related hazards and exposure, there were substantial differences in vulnerability and risk faced by males and females. The weighted average for different states in India shows that women were 70% more vulnerable as compared to men and 30% more prone to climate-related risks. This was because of the greater sensitivity and limited adaptive capacity of women owing to their poorer health and reproductive health, low or no ownership of assets, much less participation in secondary and tertiary sectors of employment, decision making, and leadership at both the family and community level. Women also had very limited adaptive capacity because of lower literacy, education or training opportunities, poorer economic capacity, limited awareness about important issues, and very limited participation in decision-making in governance.

The index (GCRI) was also used to assess the risk faced by women in future climate scenarios (2030, 2050 and 2080) for RCP 8.5 (Figure 3.33). (Despite the exclusion of RCP 8.5 in this BTR, the significance of the outcomes on the specific issue of gender merits the exception made here.)

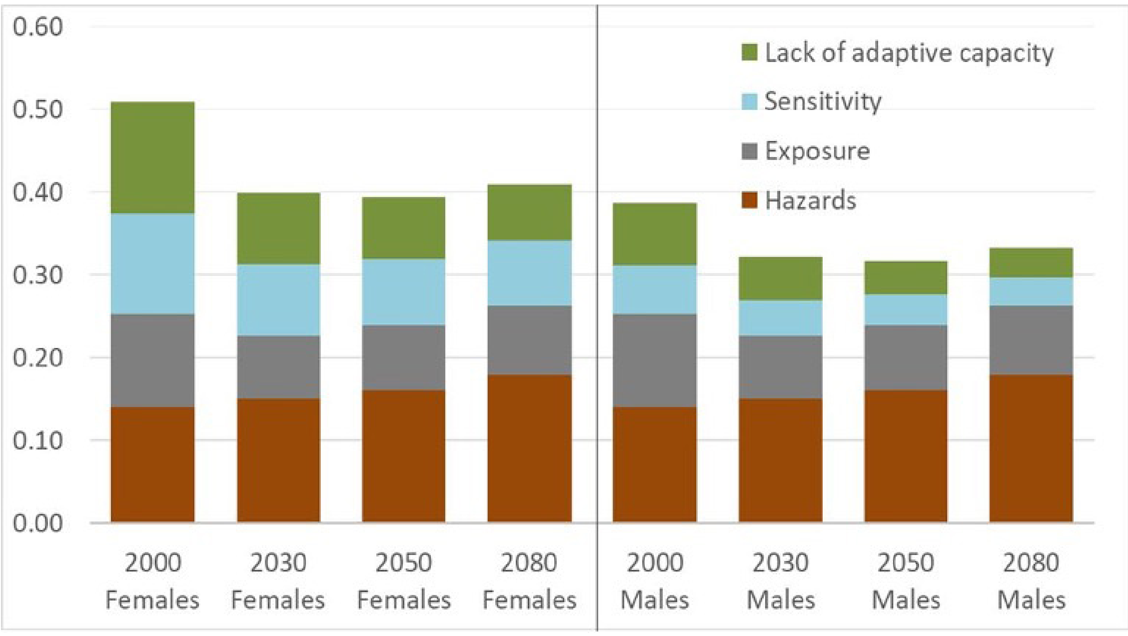

Figure 3.33: GCRI and its components for females and males for different climate change scenarios of RCP 8.5.
Source: Background paper on Gender for India's Third National Communication.

A total of 42 indicators were used for the computation; however, some indicators had to be dropped due to a lack of data availability for future scenarios. The climate projections for different time slices were computed using an ensemble mean of 11 Global Climate Models. The GCM baseline was corrected using the IMD baseline, and the correction was also incorporated into the climate data for future climate.

The socio-economic data for future scenarios was also required. While population projections and fertility rates were obtained from the Registrar General of India (2025) and the Population Foundation of India (2050 and 2080), the data for several other indicators were computed using the same rate of change as between 2001 and 2011. For a few indicators, such as the level of violence faced and participation in decision-making, the current values (2015-16) were used in the absence of clear trends. The results showed, as expected, that the hazards index increased in future from 0.42 in 2000 to 0.45, 0.48 and 0.54 in 2030, 2050 and 2080 respectively. The increase in the hazard proneness of different states and UTs is expected due to variations in rainfall patterns, temperature trends and the occurrence of climatic extremes.

The susceptibility of different states in India to 'exposure' to climate change-related events is expected to decrease substantially, from 0.36 in 2000 to 0.25-0.26 in 2030. This reduction is expected due to overall development in the country and consequent improvement in several indicators such as the percentage of people living below the poverty line, population living in kutcha houses, and reduction in the rate of forest degradation. However, the slight increase in the susceptibility to exposure from 2030 to 2080 was due to a higher percentage of areas affected by floods and droughts, rapid migration, and urbanization, leading to increased proliferation of slums in some states.

Despite the increase in the Hazard component, it is interesting to note that there is likely to be a reduction in the climate-related risk faced by both males and females. The GCRI for females is likely to decline from 0.51 in 2000 to 0.40-0.41 from 2030 onwards (Figure 3.33). The corresponding male values will reduce from 0.40 in 2000 to 0.32-0.34 in the same period. Thus, it can be inferred that improvements in different sectors, such as better health services, nutrition, per capita income, and overall development, are likely to be partially offset by rising temperatures, variations in rainfall patterns, and a higher proportion of flood and drought-prone areas. However, it is also important to note that despite the socio-economic development in the coming decades, the vulnerability of women to climatic risks would still be 28% higher than that of men.

3.3 Adaptation Priorities and Barriers

3.3.1 Water

As noted in the section on National Circumstances, a number of schemes, initiatives, and programs of the GoI and the various State governments in the water sector have a significant adaptation component. These include, inter alia, assuring access to water that reduces vulnerability and exposure, the provision of modern sanitation and safe drinking water whose health outcomes are a critical aspect of adaptation in climate and health, and the development of infrastructure that ensures climate resilience in response to climate shocks.

Domestic Priorities and Progress towards those Priorities

The current adaptive actions in the water resource sector are identified from the NAPCC, SAPCCs, union budgets, and India's five-year plans. NAPCC addresses nine sectoral missions, including NWM, which was established in 2011 with the objective of "conservation of water, minimizing wastage and ensuring its more equitable distribution both across and within States through integrated water resources development and management". National Water Mission has been working on the five goals which are as follows:

1. Comprehensive water database in the public domain
2. Assessment of the impact of climate change on water resources
3. Promotion of citizen and State action for water conservation, augmentation, and preservation with a focus on vulnerable and over-exploited areas
4. Increasing water use efficiency by 20%
5. Promotion of basin-level integrated water resources management

Following are some of the schemes pertaining to water:

a. Jal Jeevan Mission

The JJM, launched on August 15, 2019, aims to provide safe drinking water to all rural households in India by 2024. As on April 26, 2024, out of 192.7 million rural households in the country, more than 142.8 million (76.80%) households are reported to have tap water supply in their homes (Jal Jeevan Mission, 2025). This contributes directly to reducing vulnerability,

b. Ground Water Management & Regulation (GWMR)

GWMR Scheme, operated by the CGWB since 2007-08, focuses on providing scientific insights for sustainable groundwater management. One of its key initiatives is the National Aquifer Mapping & Management (NAQUIM) Programme, which aims to delineate, characterize, and develop management plans for aquifers across the country, covering the entire mappable area of 2.5 million sq.km. Another crucial aspect is the Groundwater Resource Assessment, conducted periodically to quantify groundwater availability and utilization. Starting from 2023, these assessments are conducted annually to ensure more up-to-date data for effective management.

These are critical to water management for adaptation.

c. Atal Bhujal Yojana

ATAL JAL is a World Bank aided Central Sector Scheme of the GoI with an outlay of INR 60 billion, with focus on community participation and demand side interventions for sustainable ground water management in identified water stressed areas. The scheme is being implemented from year 2020 in select areas in water stressed Gram Panchayats (GPs) of 229 administrative Blocks/ Talukas in 80 districts, 229 administrative blocks, and 8,220 water-stressed Gram Panchayats of seven states, viz. Haryana, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan and Uttar Pradesh (IBEF, 2025a).

d. Dam Rehabilitation and Improvement Programme (DRIP)

The Department of Water Resources, River Development, and Ganga Rejuvenation through CWC is coordinating and supervising the implementation of the Dam Rehabilitation and Improvement Project (DRIP) Phase II and III, with financial assistance from the World Bank and Asian Infrastructure Investment Bank. The Project Development Objective is to increase the safety of selected dams in participating States and to strengthen dam safety management in India through institutional strengthening.

The objectives of DRIP Phase II &III are to be achieved through investments in physical and technological dam improvements, managerial upgrading of dam operations, management and maintenance, with accompanying institutional reforms. With increasing extreme rainfall events, management of dam storage in safe and efficient manner is essential.

e. Jal Shakti Abhiyan

The Jal Shakti Abhiyan, launched in 2019 across 256 water-stressed districts, aimed to enhance water recharge and conservation while addressing depleting water levels to ensure water security (Jal Shakti Abhiyan, n.d.). This initiative included establishing structures for water storage and conservation, along with intensive afforestation activities that resulted in planting about 123 million saplings, contributing to India's carbon sinks.

f. Bureau of Water Use Efficiency

The establishment of the Bureau of Water Use Efficiency (BWUE) under the National Water Mission in October 2022 aims to achieve a 20% increase in water use efficiency, counteract the negative effects of rainfall variability, and alleviate water stress (BWUE, n.d.). Additionally, the NWM has initiated the "Sahi-Fasal" campaign to encourage the cultivation of crops that utilize water more efficiently, offer high nutritional value, and are economically beneficial to farmers.

g. Flood Management Program (FMP)

The GoI executes the "Flood Management and Border Area Programme" to assist State Governments in mitigating flood and erosion risks through structural measures, including anti-erosion efforts in vulnerable regions. This initiative aims to safeguard valuable land nationwide and foster cooperation on water resources with neighboring countries, incorporating hydro-meteorological monitoring, flood prediction, and management initiatives.

h. Water resource planning and flood forecasting

CWC has a network of 1,543 hydrological observation stations in all river basins for water resource planning and flood forecasting. The water data thus monitored is uploaded to WIMS/ India-WRIS to have a comprehensive water database in the public domain.

The CWC is the nodal Organisation entrusted with the task of flood forecasting & early flood warnings in the country. Presently, CWC issues flood forecasts for 338 forecasting stations (138 Inflow Forecast

Stations & 200 Level Forecast Stations) which include 25 States and UTs. This is a major paradigm shift from the conventional Gauge-to-Gauge correlation to a more scientific modelling technique for flood forecasting (Central Water Commission, 2024).

i. Swachh Bharat Mission

SBM was launched in October 2014 and aimed to achieve universal sanitation coverage, leading to improved water security by reducing contamination in surface and groundwater sources. SBM, comprising SBM-Grameen (SBM-G) and SBM-Urban (SWM-U), has revolutionized India's sanitation sector.

Urban India has achieved significant milestones under the SBM (Urban) program. waste processing in India has significantly increased from 14-15% in 2014 to 77% by 2023, with nearly 95% of urban areas practicing door-to-door waste collection, 89% segregating waste at the source, and 77% of waste being processed (MOHUA, 2024).

Similarly, SBM Grameen, launched on October 2, 2014, mobilized over a billion people for a cleaner India. It raised sanitation coverage from 39% in 2014 to 100% in 2019 (MoJS, 2024).

3.3.2 Agriculture

Domestic priorities and progress towards these priorities

The Government has undertaken initiatives to deal with the impact of climate change in the agriculture sector through the National Mission for Sustainable Agriculture (NMSA), which is one of the Missions within the NAPCC. The mission aims to evolve and implement strategies to make Indian agriculture more resilient to the changing climate. Awareness/capacity building of farmers is an important part of the NMSA strategy. Initially, NMSA was approved for three major components comprising, RAD; On-Farm Water Management (OFWM); and Soil Health Management (SHM). Subsequently, new programmes such as Soil Health Card (SHC), PKVY, Mission Organic Value Chain Development in North Eastern Region (MOVCDNER), Per Drop More Crop, NBM, etc. were also included (MoA&FW, 2024).

The focus in agriculture is on adaptation to climate change and building resilience, with co- benefits of mitigation, if any. The ICAR, under the Ministry of Agriculture and Farmers Welfare, Government of India, with its network of more than 100 research institutions, more than 100 State Agricultural Universities and about 650 Krishi Vigyan Kendras (Agricultural Knowledge Centres) have developed and released more than 2000 climate-resilient varieties of several crops in recent times. Similarly, several tolerant breeds of livestock are identified. The location-specific agronomic practices, including soil, water, nutrient, and energy management technologies, are developed and deployed in farmers' fields.

The ICAR has launched a flagship network project namely NICRA. The project aims to study the impact of climate change on agriculture including crops, livestock, horticulture and fisheries and to develop and promote climate-resilient technologies in agriculture, particularly in vulnerable areas. The project is helping to improve the resilience of farming communities in regions prone to extreme weather conditions like droughts, floods, frost, heat waves, etc. The salient achievements of ICAR are as follows:

- During the last 10 years (2014-2024), a total of 2593 varieties of various crops have been released by ICAR, out of these 2177 varieties are tolerant to one or more biotic and/or abiotic stresses.
- District-level assessments on the risk and vulnerability of agriculture to climate change are carried out for 651 predominantly agricultural districts following the IPCC protocols. Out of these, 109 districts are categorized as 'very highly' and 201 districts as 'highly' vulnerable.
- Impacts of climate change on major agricultural crops (rice, wheat, maize, sorghum, pearl millet, soybean, mustard, chickpea, pigeon pea, potato and cotton as well as plantation crops such as coconut are mapped as well as that of adaptation gains. Results indicated significant production loss in wheat, maize, mustard, rice, and potato. However, adaptation can significantly improve productivity by up to 60% from the mean productivity of the 2010-2015 year. Details are given in this report.
- District Agriculture Contingency Plans (DACPs) for 651 districts have been prepared covering extreme weather events like drought, floods, unseasonal rainfall, heatwaves, cold waves, frost, hailstorms, cyclones,

etc., with recommendations of location-specific climate resilient crops and varieties and management practices for use by the State agricultural departments and farmers.

- To enhance the resilience and adaptive capacity of farmers to climate variability, the "Climate Resilient Villages" (CRVs) have been initiated and developed under NICRA.
- Location-specific climate resilient technologies were demonstrated in 448 CRVs of 151 climatically vulnerable districts in 28 states/UTs for adoption by the farmers.
- Capacity building programmes are being conducted to educate the farmers on various aspects of climate change for the wider adoption of climate resilient technologies.

Adaptation gains in agricultural crops

Adaptation is extremely important to sustain food security in India. Climate change impacts on major crop productivity make it imperative to look for adaptation options to not only reduce the negative impacts but also to improve productivity in future climate scenarios. The location specific adaptation interventions such as adjusting sowing time, suitable variety with terminal heat tolerance, nutrient and irrigation management can significantly improve the productivity of major crops such as wheat (up to ~60%), rice (up to ~38%), maize (up to ~20%), sorghum (up to ~57%), Kharif pearl millet (up to ~47%), mustard (up to ~40%), soybean (up to ~38%), chickpea (up to ~40%), pigeon pea (up to ~53%), potato (up to 12-16%) and cotton (up to 16- 24%)p in 2020 scenario (Naresh Kumar, 2023; TNC, 2023). Each of the crops has specific adaptation requirements. For example, in the case of mustard, due to the reduction in climatically suitable period for mustard cultivation in future climates, short-duration (<130 days) cultivars with 63 % pod filling period will become more adaptable (Naresh Kumar et al., 2014).

Adaptation challenges, gaps and barriers

Despite several positive outcomes due to adaptation efforts, there exist issues related to granular impacts and adaptation costs, particularly for small and marginal farmers (Naresh Kumar et al., 2014; 2016). For instance, the crop insurance scheme, the Pradhan Mantri Fasal Bima Yojana (PMFBY) was introduced in the country in the Kharif 2016 season. The States that implement have significant interannual variation in coverage. This indicates the need to attract more farmers to opt for PMFBY, which acts as a safety net against crop loss.

The adaptation gaps arise from the lack of precise seasonal weather forecasts for providing reliable agro-advisories. Although currently available precise weather forecasts for 14 days are being used to provide district-level contingency plans to farmers by the ICAR and IMD, this is insufficient.

More importantly, the lack of awareness of climatic stresses and/or financial capacity for adaptation is a major constraint. Though the NICRA scheme and several other projects such as the DST- Mega Research and Development project, and the National Mission for Sustainable Himalayan Agriculture-Task Force-Agriculture have been providing technological support for adaptation, the cost of adaptation incurred by the small and marginal farmers is significant (Naresh Kumar et al., 2014; 2016).

In addition, significant yield gaps as noted earlier. Moreover, inadequate rural infrastructure such as threshing floors, and storage facilities exposes the produce to extreme rainfall events leading to post-harvest losses. Even though there has been a reported reduction in post-harvest losses since 2012, the country still suffered a staggering loss of approximately INR 1.53 trillion (USD 20.13 billion) annually in 2020-21 due to Post Harvest Loss (PHL) of crops and agri-allied produce (NABCONS, 2022).

3.3.3 Forests

Domestic priorities and progress towards adaptation priorities:

Structure and functioning of forest ecosystems are likely to be altered by the changes in climate as climate exerts a significant influence on the distribution, structure and ecology of forests. It was projected that climate change has adverse impacts on forest ecosystems and this in turn will affect the forest biological diversity, biomass and regeneration (Ravindranath and Chaturvedi, 2012; ICFRE, 2013; Bahuguna et al, 2016). There is a close association between forests and community adaptation. Forests are known to play a key role in the adaptive capacity of local communities by providing various ecosystem goods and services, while actions of the community can enhance or reduce the adaptive capacity of forests to a changing climate.

Adaptation to climate change in forests is also characterized by long gestation periods that necessitate preparation, execution, and oversight in advance. Adaptation to climate change in forest sector required to address current stresses such as causes of deforestation and forest degradation, forest fragmentation, cattle grazing and non-sustainable extraction etc. Ravindranath (2007) highlighted some strategies and practices to reduce the vulnerability of forests and plantations that include (i) forest and biological diversity conservation, (ii) expansion of protected areas, (iii) sustainable logging and management of forests, (iii) mixed species forestry, (iv) planting in advance and facilitating natural migration of some species by transplanting and (v) adoption of sound silvicultural practices to lessen the impact of climate change.

Adaptation practices include: (i) modifying the forest working plan preparation process and incorporating the projected climate change and likely impacts, (ii) initiating research on adaptation practices, covering both conservation and forest regeneration practices, (iii) linking Protected Areas and forest fragments, (iv) anticipatory planting of species along the altitudinal and latitudinal gradient, (v) in-situ conservation, (vi) adopting mixed species forestry in all afforestation programmes, (vii) incorporating fire protection and management practices and implementing advance fire warning systems. Developing a framework for the adaptation of forests and forest plantations to climate change is fundamental to the conservation of forests. This should be undertaken with due regard to the time needed for adaptation measures to become effective (Ravindranath et al., 2019).

Some of the adaptation measures as per the Version 2.0 of the SAPCC are highlighted as under:

i. **Effective implementation of existing policies, acts, and guidelines:** There is a need to improve and ensure effective implementation of existing policies, acts and guidelines such as the Forest (Conservation) Act of 1980; the Wildlife (Protection) Act, 1972 and 2002; and wildlife conservation programmes such as the Project Tiger and Project Elephant.

ii. **Expand Protected Areas:** There is a need to increase the area under Protected Areas and to link Protected Areas, Reserve Forests and Wildlife Reserves. There is also a need to enhance the area under Protected Areas in mountainous regions, ideally spanning an elevation gradient to facilitate species migration with increasing temperature. Expansion of protected areas again requires working with communities residing close to forest areas and providing alternatives for their livelihoods, given the large dependence of communities on forests for subsistence and livelihood.

iii. **Provision of natural corridors:** There is a need to ensure the natural corridors, needed for migration of both plant and animal species under a changed climate situation, are maintained. This can be possible only by reducing the fragmentation of forests and other ecosystems.

iv. **Adaptation plans for wildlife species:** The impacts of climate change on wildlife are less understood. There is a need to formulate specific plans to help wildlife, including flagship species and endangered species such as the elephant, rhino, tiger, and lion, migrate and adapt. These plans should be prepared based on existing knowledge of the ecology and distribution of species and the anticipated climate change in the regions of their present-day distribution.

v. **Afforestation and reforestation under climate change:** India has a target of bringing one-third of its geographic area under forest cover. Given the large thrust for afforestation, there is a need to incorporate adaptation practices and adopt strategies such as mixed species forestry, planting of ecologically compatible and locally valued species, coupled with soil restoration and anticipatory planting of species. Afforestation and reforestation should be taken up in the light of climate impact studies, i.e., plant species that are likely to survive under the projected climate.

vi. **Improved silvicultural practices:** The current silvicultural practices adopted in plantations, dominated by exotics and monocultures, are enhancing the vulnerability of forests. There is a need to develop and adopt silvicultural practices that would reduce vulnerability and enhance resilience. This requires research to identify practices that reduce the vulnerability of plant species and forest types to changing climate parameters. Some of the potential silvicultural practices are:

- Promotion of natural regeneration in degraded forest lands
- Promotion of mixed species forestry on degraded non-forest lands
- Anticipatory planting of species along the altitudinal and latitudinal gradient

- In-situ and ex-situ conservation of floral and faunal species
- Adoption of sustainable harvest practices for timber and non-timber products

vii. **Promoting community forestry:** Involvement of communities in raising, protecting, maintaining, and managing plantations and forests, coupled with soil moisture conservation activities and soil restoration works, will significantly help adaptation. The Joint Forest Management model could be adopted for promoting community forestry.

viii. **Decrease pressure on natural forests:** There is need to enhance support to afforestation and reforestation programmes and increase area covered to meet the demand for timber and fuelwood, to reduce pressure on primary forests. Widespread dissemination and awareness building on fuelwood conservation programmes and devices that help reduce the dependence of communities on forests for fuelwood.

ix. **Forest fire management:** Innovative and region-specific fire management strategies need to be formulated as opposed to measures generally adopted for the prevention of fire.

x. **Managing forests for climate change adaptation:** Good silvicultural practices, including maintenance of optimum stocking levels and selection of trees which are best adapted to existing sites should ensure that forests remain vigorous and relatively free of site and stand related stress. These practices should help forests adapt to climate change. Practices which could help forest adapt to climate change are:

- Shorter rotation length, which would reduce the possibility of senescence-related stresses and the related hazard of damage by pests and diseases.
- Control of competition for available moisture, light and soil nutrients.
- Selection of species and provenances best adapted to site conditions.
- Properly scheduled thinning to maximise growth and increase resistance to damage from high winds, insects, and diseases.
- Tree improvement programme to create planting stock from broad genetic base with high growth rates, better form and adapted to a varied range of site conditions.
- Create both in-situ and ex-situ reserves of important forest tree species with gene pools of wide variability that can adapt to climate change.
- Reduce reliance on one or two tree species in afforestation and reforestation programmes. Instead include several species, where feasible in mixed species plantings, which are well adapted to local sites and climatic conditions and meet national needs for forest products and services.
- Protection from the destructive effects of fire, pests, and diseases.
- Periodic inventories and stand examination to provide the basis for silvicultural prescriptions and harvest scheduling.
- Accelerate timber salvage and fuel management programmes to reduce the hazard of wildfire in forests, especially those which have suffered from high levels of pest and disease damage or forest decline events.

Design insect and disease monitoring programmes which are capable of capturing forest decline and in the active presence of new pests and diseases in addition to those which have historically caused losses

Adaptation challenges and gaps, and barriers to adaptation:

There are numerous gaps and constraints, which hamper the undertaking of activities for climate change mitigation and adaptation with respect to forests (Singh et al., 2014). Some of these are summarized below:

(i) **Knowledge gaps:** Though climate change is a global issue, there are still some gaps and constraints visible in the knowledge of adaptation and mitigation from the point of view of forestry. Key knowledge gaps include linkages between impacts of climate change and adaptation and mitigation options. More research is required to better understand climate change challenges and cost-effective solutions at the local levels and to fill knowledge gaps. Despite the emergence of more and more regional and country-specific studies on climate change in India in recent years, knowledge gaps remain. Hence, there is an urgent need for undertaking more research at regional level to better understand climate change and its impact, risks and vulnerability, adaptation needs, and mitigation potential at local levels.

(ii) **Financial gaps:** The lack of climate finance, especially for adaptation, is felt since resources with the Government at any time are finite and development considerations especially for poverty eradication require substantial public investment.

(iii) **Research gaps:** There is a considerable gap in our knowledge of the natural resources of India. A study undertaken by the International Centre for Integrated Mountain Development in the Eastern Himalaya and its vulnerability to climate change indicated that there is a need for enhancing monitoring, documentation, or research to check the status of biological diversity in the region. Across the entire region, most of the limited research that is available focuses on the adverse impacts of climate change and needs to examine further the adaptation mechanisms that local people have developed themselves, and the potential new opportunities.

A strategic approach is needed for detailed research on different ecosystem services and functions to estimate the potential impacts of climate change. Such research could develop adaptation mechanisms and/ or highlight mechanisms that have already been implemented by local people in response to the changing environment.

(iv) **Gaps and constraints at the policy level:** India was among the first few countries in the world to provide for the protection and improvement of the environment in the national constitution, and it has taken several steps in designing policies and legislation to overcome environmental problems. Cumulatively, over a period of years, the missions could help in gradual removal of bottlenecks at the policy level, as well as provide a strategic shift to enhance adaptation and mitigation activities. There is also a need to develop sector-specific climate policies, measures and regulations that could help in adaptation and mitigation activities.

3.3.4 Himalayan Ecosystem

Domestic priorities and progress

The following strategies and best practices are identified, based on the Indian experience and scientific research, to mitigate the impact of climate change on Himalayan biodiversity:

- Community-Based Conservation: Community-based conservation in the Indian Himalayan region leverages the rich traditional knowledge of local communities accumulated over generations. This knowledge encompasses sustainable agriculture, forestry, and resource management practices, which are crucial for conserving biodiversity in the face of climate change. Traditional agricultural practices, such as terracing and crop rotation, help maintain soil fertility and prevent erosion. Traditional forest management techniques, like selective logging and sacred groves, contribute to the preservation of forest biodiversity (Kumar & Nautiyal, 2018). By integrating this traditional knowledge with modern scientific approaches, community-based conservation efforts can enhance the resilience of both human and natural systems. For instance, Joint Forest Management (JFM) programs in the Indian Himalayas have successfully involved local communities in the sustainable management of forests, leading to improved forest health and increased biodiversity (Sundar, 2017).
- Ecosystem-Based Adaptation (EbA): EbA approaches utilize biodiversity and ecosystem services to help communities adapt to climate change. In the Himalayas, this can involve the restoration of degraded habitats, reforestation, and sustainable land management practices that enhance ecosystem resilience.
- Integrating Climate Science into Conservation Planning: Using climate models to predict future species distributions and habitat suitability changes can inform conservation planning and management. This proactive approach allows for identifying future refugia and implementing measures to protect these areas. Apart from the above habitat restoration, rewilding, and reintroduction are also identified as integral components of adaptation measures.

3.3.5 Coastal Ecosystem

Ecosystem-based Adaptation:

India has increasingly recognized the role of EbA in addressing the vulnerabilities of its extensive coastline and marine ecosystems. Under this approach through the National Coastal Mission Programme, a Central Sector

Scheme for the conservation of mangroves and coral reefs has been launched. Each year, Management Action Plans (MAPs) are prepared and implemented by coastal states and union territories. These MAPs typically include activities such as ecological surveys, boundary demarcation, afforestation of degraded sites, promotion of alternative livelihoods, and awareness programmes for local communities. Such initiatives highlight India's emphasis on combining ecological protection with socio-economic resilience.

At the state level, Maharashtra has pioneered institutional innovation in EbA. The Mangrove Cell, established by the Government of Maharashtra, is the first of its kind in the country. It has subsequently expanded into the Mangrove and Marine Biodiversity Conservation Foundation, a dedicated body that supports mangrove protection, community-based ecotourism, and livelihood programmes for fishing communities. This model of state-led institutional support has since been studied by other coastal states as an example of effective ecosystem governance.

Beyond mangroves, coral reef conservation has also been prioritized, particularly in regions such as the Andaman and Nicobar Islands, Lakshadweep, and the Gulf of Mannar. These efforts often combine restoration activities with the promotion of sustainable fisheries and community-based monitoring systems. By safeguarding biodiversity hotspots, India is investing in "natural infrastructure" that provides coastal protection against cyclones and storm surges while enhancing fishery-based livelihoods.

India's EbA efforts, therefore, reflect a strategic balance between ecological resilience and socio-economic security. By institutionalizing mangrove and coral reef conservation, engaging communities in decision-making, and integrating EbA into national programmes, India has demonstrated that ecosystems can serve as powerful, cost-effective buffers against climate risks while supporting sustainable development.

Sector-based Adaptation

India's sector-based adaptation efforts with coastal ecosystems target agriculture, fisheries, and aquaculture—sectors that are particularly vulnerable to climate change but central to food security and livelihoods. The Ministry of Agriculture and Farmers Welfare, together with state governments, has introduced adaptation measures in agriculture that include promoting saline-tolerant crop varieties, shifting cropping calendars, and adopting water-efficient cultivation techniques. For example, research institutions have developed rice varieties that can withstand saline conditions, which are increasingly being cultivated in West Bengal and Odisha to address saltwater intrusion. Farmers are also adopting techniques such as the System of Rice Intensification (SRI), which improves yields while reducing water use.

In fisheries and aquaculture, sector-based adaptation has emphasized diversification and sustainability. Brackish water aquaculture has been encouraged in Andhra Pradesh and Tamil Nadu, with polyculture systems integrating shrimp, finfish, and molluscs to reduce disease risks while improving productivity. Community-based aquaculture practices have also been piloted, aligning adaptation with livelihood diversification. These initiatives are often supported by the Indian Council of Agricultural Research (ICAR) and implemented through state fisheries departments, ensuring scientific backing and policy alignment.

SAPCCs across coastal states integrate these sectoral measures within broader adaptation frameworks. For instance, Odisha's SAPCC highlights aquaculture diversification and the cultivation of salt-tolerant crops as priority strategies. Tamil Nadu has focused on promoting integrated farming systems that combine crops, livestock, and aquaculture to enhance resilience. Such approaches reduce the vulnerability of smallholder farmers and fishers to climate shocks.

The National Adaptation Fund on Climate Change (NAFCC) has played a key role in funding pilot projects, including sustainable aquaculture in Andhra Pradesh and saline-tolerant agriculture in West Bengal. By embedding sectoral adaptation into state-level planning and national funding, India ensures that food production systems are climate-resilient.

Engineering-based Adaptation

India's engineering-based adaptation measures address the significant risks of erosion, flooding, and storm surges faced by its coastal population, which includes nearly 20 percent of the national population. With urban centres such as Mumbai, Chennai, Kolkata, Kochi, and Visakhapatnam highly exposed, the MoEFCC, along with state governments, has prioritized structural interventions.

In Gujarat, coastal protection projects include seawalls at Nani Danti–Moti Danti and gabion structures at Tithal Beach, safeguarding not only residential areas but also culturally significant sites like the Swaminarayan Temple. Maharashtra has invested in rubble stone bunds and seawalls, including those that protect Mumbai's Nariman Point, Chowpatty, Haji Ali Tomb, and Worli Sea Face. Goa has implemented retaining walls at Campal, Guddem Siolim, and Reis Magos, while Tamil Nadu constructed rubble mound seawalls along the Ennore Expressway and installed groynes near Royapuram fishing harbour. In Kerala and Puducherry, the MoEFCC has demonstrated innovative erosion mitigation approaches, such as restoring lost coastlines at Puducherry and protecting fishing villages like Chellanam.

India's engineering-based adaptation highlights the interplay between modern infrastructure and local needs, by protecting both cultural landmarks and critical urban infrastructure, while simultaneously investing in inland flood control systems. These projects illustrate that while engineering solutions are resource-intensive, they remain essential for safeguarding vulnerable populations and assets from escalating climate risks.

India's adaptation projects illustrate how locally grounded initiatives can deliver tangible ecological and socio-economic benefits. One of the earliest large-scale adaptation interventions was mangrove afforestation in the 1980s and 1990s. Implemented across West Bengal, Odisha, Gujarat, Maharashtra, Andhra Pradesh, and Tamil Nadu, these plantations stabilized shorelines, provided breeding habitats for fisheries, sequestered carbon, and improved community livelihoods. These projects were often implemented through collaborations between state forest departments, local communities, and research institutions, demonstrating a participatory model of ecosystem restoration.

The Puducherry Coastal Restoration Project (2003–2005) is another landmark example. Following severe erosion triggered by harbour construction, MoEFCC and the Government of Puducherry implemented offshore breakwaters to restore lost beaches. This project not only rejuvenated coastal tourism but also re-established traditional fishing livelihoods. It is widely cited as an example of combining engineering solutions with ecological and social goals.

In 2009, Kerala launched a pilot mangrove-based fishery enhancement project in Cochin. This integrated restoration of degraded mangrove patches, with the improvement of local fisheries, demonstrates that EbA measures can directly enhance productivity while conserving biodiversity. Fish catches improved, biodiversity indices rose, and community awareness of mangrove functions increased significantly.

Adaptation challenges and gaps, and barriers to adaptation

Barriers to adaptation in organizations include inadequate capacity, insufficient financial resources, and a work process and decision-making culture that needs capacity building to cope with the need for adaptation. In particular,

- Insufficient financial, technical, and human resources hinder the implementation of climate change adaptation strategies.
- Uncertainty about climate risks necessitates a planning approach that accommodates uncertainty.
- A lack of locally relevant information and technical expertise can stall planning efforts.
- Small to medium-sized organizations often have limited funds and prioritize immediate issues.
- Climate change planning may be treated as an environmental issue rather than a holistic concern.

3.3.6 Biodiversity

Adaptation challenges and gaps, and barriers to adaptation

Lack of climate information, limited knowledge, lack of local experts, gaps in the implementation of policies, low capacity of actors and institutions, weak inter-institutional networks, non-availability of data, limited financial and human resources, and local geographical challenges constitute barriers to adaptation in India (Dhanapal et al, 2023; Azhoni et al, 2017, 2018, 2018a).

3.3.7 Cities

Six types of plans have been identified that address resilience, climate, environment, heatwaves, air pollution, and disasters. These plans are:

- City Resilience Climate Action Plans (CRCAPs): It is a comprehensive, step-by-step strategy developed to help local governments address both climate change mitigation and adaptation. These plans serve as a detailed roadmap for cities to reduce their GHG emissions and build resilience against the impacts of a changing climate, such as floods, heatwaves, and water scarcity.
- The CapaCITIES project, an initiative supported by the Swiss Agency for Development and Cooperation, has been instrumental in creating these plans for several Indian cities, including Rajkot, Udaipur, Siliguri, and Coimbatore (ICLEI, 2025).
- City Resilience Strategy: Many cities have come up with a comprehensive strategy resulting from a strong multi-stakeholder consultation process addressing the city's climate concerns with relevant actions and recommendations to collectively address as a society (Resilient Chennai, 2019).
- City Heatwave Action Plans: helps to mitigate the health impacts of rising temperatures. These plans typically follow a multi-pronged approach that includes an early warning system from the India Meteorological Department (IMD) to alert residents and agencies of impending heat waves, and a robust public awareness campaign on how to stay safe (NDMA , 2019).
- City Clean Air Action Plan (CAAP): City Clean Air Action Plan: is a core component of the national-level National Clean Air Programme (NCAP), which is overseen by the Ministry of Environment, Forest and Climate Change. These plans are specifically designed for 131 non-attainment cities and million plus cities that do not meet the National Ambient Air Quality Standards. The CAAPs are a multi-sectoral strategy that identifies major local pollution sources, such as vehicular emissions, road dust, industrial pollution, and biomass burning, and outlines both short- and long-term measures to mitigate them. Source: (MoEFCC, 2023).
- City Disaster Management Strategy: Cities across India are mandated to develop their own multi-hazard Disaster Management Plans to prepare for, respond to, and recover from a range of natural and human-induced disasters. These plans are prepared in accordance with the national framework set by the NDMA and its parent ministry, the Ministry of Home Affairs. The city's plan typically includes a detailed vulnerability assessment to identify specific risks, such as earthquakes, floods, heatwaves, or industrial accidents. It also outlines the roles and responsibilities of various municipal departments, establishes a command and control structure for emergencies, and details protocols for public warning, search and rescue operations, and resource mobilization (NDMA, 2019).

Of the 133 cities that have some kind of urban climate action plans, the distribution of plan types among these cities is as follows in Table 3.15.

Table 3.15: Available Urban Climate Change Action Plans

City (metro cities/ state capital)	City Resilience Climate Action Plans (CRCAPs)	City Resilience Strategy	City Heatwave Action Plans	City Clean Air Action Plan	Climate Change and Environment Action Plan	City Disaster Management Strategy
Total	12	24	22	75	51	76

Source: Compilation prepared for this report from data indicated in the text.

From the list of 133, 24 were selected for detailed assessment (Table 3.16). Five cities have prepared four plans, nine cities have prepared three, seven cities have prepared two, and three cities have prepared one plan. These plans are assessed for their proposals related to seven urban components, (i) housing, (ii) buildings/ building codes, (iii) streets/ street design, (iv) transport, (v) green infrastructure, (vi) blue infrastructure, and (vii) energy and other infrastructure. Again, not all the plans have proposals related to each of the urban components listed.

Table 3.16: Available Climate Change Action Plans in Select Cities

	City	City Resilience Climate Action Plans (CRCAPs)	City Resilience Strategy	City Heatwave Action Plans	City Clean Air Action Plan	Climate Change and Environment Action Plan	City Disaster Management Strategy	Total number of plans available out of 6
1	Ahmedabad	Available		Available	Available	Available		4
2	Bengaluru	Available	Available		Available	Available		4
3	Bhopal		Available		Available	Available	Available	4
4	Chennai		Available		Available	Available	Available	4
5	Pune		Available		Available	Available	Available	4
6	Bhubaneshwar			Available	Available	Available		3
7	Guwahati		Available		Available		Available	3
8	Indore		Available		Available		Available	3
9	Mumbai				Available	Available	Available	3
10	Rajkot	Available		Available	Available			3
11	Srinagar	Available		Available	Available			3
12	Surat		Available	Available	Available			3
13	Udaipur	Available	Available		Available			3
14	Vishakhapatnam		Available		Available		Available	3
15	Jaipur				Available		Available	2
16	Jodhpur			Available	Available			2
17	Hyderabad					Available	Available	2
18	New Delhi			Available	Available		Available	2
19	Raipur				Available		Available	2
20	Shimla		Available				Available	2
21	Ujjain		Available		Available			2
22	Lucknow				Available			1
23	Patna				Available			1
24	Ranchi				Available			1
	Total	5	11	7	22	8	12	-

Source: Compiled for this report from data sources indicated in the text

Table 3.17: Sectoral Coverage of the Plans by Select Cities

Plan	Housing	Buildings/ Building Codes	Streets/ Street Design	Transport	Green Infrastructure	Blue Infrastructure	Energy and Other Infrastructure
City Resilience Climate Action Plans (CRCAPs)	Ahmedabad Bangalore Srinagar Udaipur	Ahmedabad Bangalore Rajkot Srinagar Udaipur	Ahmedabad Bangalore Rajkot Srinagar Udaipur	Ahmedabad Rajkot Srinagar Udaipur	Ahmedabad Bangalore Rajkot Srinagar Udaipur	Ahmedabad Bangalore Rajkot Srinagar Udaipur	Ahmedabad Bangalore Rajkot Srinagar Udaipur
City Resilience Strategy	Bhopal Chennai Indore Pune Shimla Surat Udaipur Ujjain Vishakhapatnam	Bangalore Bhopal Chennai Guwahati Indore Shimla Surat Udaipur	Bangalore Bhopal Chennai Guwahati Indore Pune Shimla Vishakhapatnam	Bangalore Guwahati Indore Pune Shimla Surat Ujjain	Bangalore Bhopal Chennai Guwahati Indore Pune Shimla Surat Udaipur Ujjain Vishakhapatnam	Bhopal Chennai Guwahati Indore Pune Shimla	Bangalore Bhopal Guwahati Indore Pune Shimla Surat Udaipur Ujjain Vishakhapatnam
City Heatwave Action Plans	Ahmedabad Bhubaneswar Jodhpur New Delhi Rajkot Srinagar Surat	Ahmedabad Bhubaneswar Jodhpur New Delhi Rajkot Srinagar Surat	Ahmedabad Bhubaneswar Jodhpur New Delhi Rajkot Srinagar Surat	Ahmedabad Bhubaneswar Jodhpur New Delhi Rajkot Srinagar	Ahmedabad Bhubaneswar Jodhpur New Delhi Rajkot Srinagar Surat	Ahmedabad Bhubaneswar Jodhpur New Delhi Rajkot Srinagar	Ahmedabad Bhubaneswar Jodhpur New Delhi Rajkot Srinagar Surat

Plan	Housing	Buildings/ Building Codes	Streets/ Street Design	Transport	Green Infrastructure	Blue Infrastructure	Energy and Other Infrastructure
City Clean Air Action Plan	Bhubaneshwar Bhopal Chennai Guwahati Indore Jodhpur Lucknow Mumbai New Delhi Patna Raipur Vishakhapatnam	Ahmedabad Bhubaneshwar Bhopal Chennai Guwahati Jaipur Jodhpur Lucknow Mumbai New Delhi Ranchi Patna Pune Raipur Rajkot Surat Vishakhapatnam	Ahmedabad Bangalore Bhubaneshwar Bhopal Chennai Guwahati Indore Jaipur Jodhpur Lucknow Mumbai New Delhi Patna Raipur Surat Vishakhapatnam	Ahmedabad Bangalore Bhubaneshwar Bhopal Chennai Guwahati Indore Jaipur Jodhpur Lucknow Mumbai New Delhi Ranchi Patna Pune Raipur Srinagar Surat Udaipur Ujjain Vishakhapatnam	Bangalore Bhubaneshwar Bhopal Chennai Guwahati Indore Jaipur Jodhpur Lucknow Mumbai New Delhi Vishakhapatnam	Bangalore Chennai Indore Jodhpur Lucknow Vishakhapatnam	Ahmedabad Bangalore Bhubaneshwar Bhopal Chennai Guwahati Indore Jaipur Jodhpur Lucknow Mumbai New Delhi Ranchi Patna Pune Raipur Rajkot Srinagar Surat Udaipur Ujjain Vishakhapatnam
Climate Change and Environment Action Plan	Bangalore Bhubaneshwar Bhopal Chennai Mumbai Hyderabad	Ahmedabad Bhopal Chennai	Bhopal	Ahmedabad Bangalore Bhopal Chennai Mumbai Pune	Ahmedabad Bangalore Bhubaneshwar Bhopal Chennai Mumbai Hyderabad Pune	Ahmedabad Bangalore Bhubaneshwar Chennai Mumbai Hyderabad	Ahmedabad Bangalore Bhubaneshwar Bhopal Chennai Mumbai Hyderabad Pune
City Disaster Management Strategy	Indore Jaipur	Chennai Hyderabad Indore Jaipur	Chennai Guwahati Hyderabad Indore	Chennai Guwahati Hyderabad Indore Jaipur	Chennai Guwahati Hyderabad Indore	Chennai Guwahati Indore	Chennai Guwahati Hyderabad Indore Jaipur

Source: Compiled for this report from data sources indicated in the text

This detailed analysis provides a quick overview of the complexity of evolving multiple action plans that cities require in order to cope comprehensively with climate action and specific features of climate impacts.

3.3.8 Health

Domestic Priorities and progress towards them

The adaptation priorities specific to climate change and health in India have been set under the National Programme on Climate Change and Human Health (NPCCHH) launched by the Indian Ministry of Health & Family Welfare (MoHFW) (Kumar et al., 2020; *National Action Plan for Climate Change & Human Health,* 2018). These priorities have been focused on "Climate Sensitive Diseases" (CSDs) which are in line with the health impact of changing climate in the country. Overall, at the national level, 17 CSDs have been identified for focused action under NPCCHH (National Centre for Disease Control (NCDC), 2022).

The national programme, based on the identified adaptation objectives has prioritized actions across the areas of –

1. Heat related illnesses
2. Air Pollution Related Illness
3. Extreme Weather Events
4. Green and Climate Resilient Infrastructure
5. Vector borne diseases

As a part of NAPCCHH, adaptation priorities are directed towards:

- Building capacity and awareness among healthcare workers, and communities to better understand and respond to climate-induced health threat.
- Conducting health vulnerability and adaptation assessments to map region-specific climate risks and guide localized interventions.
- Enhancing disease surveillance systems for CSDs, such as air pollution and heat-related illnesses.
- Strengthening health system resilience to manage climate-related risks through improved infrastructure, service delivery, and emergency preparedness.
- Integrating climate and health considerations into existing public health programs and planning processes at the national, state, and district levels.
- Strengthen collaborative engagement and interdisciplinary research with critical sectors to ensure the systematic integration of climate–health linkages into policy and programmatic priorities.

The states have included health adaptation plans for climate sensitive issues such as heat related illnesses, vector borne diseases and green and climate resilient health systems in their SAPCCHH. The programme is being implemented to address the impacts of climate change on health which include awareness generation, capacity building, and health systems strengthening measures. Community engagement and community resilience development is being prioritized under the programme. Further, training health care professionals and community health workers to address climate-related challenges, such as heat stress, air pollution related illnesses and mental health impacts, further strengthens health systems' ability to deliver patient-centered care. Climate resilient healthcare infrastructure with energy efficiency and renewable power supply is another intervention being undertaken at the state and district level to strengthen healthcare services.

As incidences of climate shocks and extreme weather are increasing in the country the program's goal is to reduce the mortality, morbidity, injuries and health vulnerability to climate change.

Adaptation barriers

India's adaptation response to climate change focusing specifically on the human health aspect is a recent phenomenon starting with the launch of the national program. Since these efforts are still in their initial stages, field-level barriers will become evident subsequently through experience. However, some barriers can be anticipated and tackled proactively. Learning from international experience reported by researchers based outside India (Dodd et al., 2023; Gould & Rudolph, 2015) as well as the recent UNEP report detailing the reasons behind global adaptation failure (United Nations Environment Programme, 2022), Indian researchers have considered the potential barriers to climate and health action in India, including access to finance (Shrikhande et al., 2023, Anjanappa, 2023).

Having considered the potential barriers some preventive actions have also been incorporated in the national action plan.

3.4 Adaptation Strategies, Policies, Plans, Goals and Actions to Integrate Adaptation into National Policies and Strategies

3.4.1 Institutional Framework of Adaptation Actions

India has thus far submitted its First National Adaptation Communication alongside its Third National Communication. Currently India is undertaking the development of its NAP. However, adaptation actions in a coherent policy framework commenced early on in the post-Bali context with India's NAPCC.

The National Environment Policy (Government of India, MoEFCC, 2006) envisaged identifying key vulnerabilities of India to climate change and assessing the need for adaptation to future climate change and the scope for incorporating these in relevant programmes. The formal framework for guiding action on climate change was established in 2007, with the setting up of the Prime Minister's Council on Climate Change (PMCCC). In 2008, India launched its NAPCC with a focus on low-carbon pathways and climate-resilient development and identified several measures that simultaneously advance the country's development and climate change-related objectives through focused national missions. Six out of nine missions under NAPCC focus on adaptation and/or adaptation co-benefits, such as the sectors of agriculture, water, forestry, health and the Himalayan ecosystem.

NAPCC outlines the following principles in this regard:

i. Protecting the poor and vulnerable sections of society through an inclusive and sustainable development strategy sensitive to climate change.

ii. Achieving national growth objectives through a qualitative change in direction that enhances ecological sustainability, leading to further mitigation of GHG emissions.

iii. Devising efficient and cost-effective strategies for end use demand side management.

iv. Deploying appropriate technologies for both adaptation and mitigation of GHGs emissions extensively as well as at an accelerated pace.

v. Engineering new and innovative forms of market, regulatory and voluntary mechanisms to promote sustainable development.

vi. Effecting implementation of programmes through unique linkages, including with civil society and local Government institutions and through public-private-partnership.

vii. Welcoming international cooperation for research, development, sharing and transfer of technologies enabled by additional funding and a global Intellectual Property Rights regime that facilitates technology transfer to developing countries under the UNFCCC.

To decentralize the NAPCC, the GoI advised all states and UTs to submit their respective SAPCCs in 2010. All the thirty-four States and UTs have prepared and submitted their respective SAPCCs using a common framework prepared by the MoEFCC, GoI.

The sectoral missions under the NAPCC are under the jurisdiction of various Ministries of the GoI. Similarly, SAPCCs are operated by the respective State Governments. The district administrative authorities ensure that the national missions under NAPCC and SAPCCs are implemented on the ground. The plans and policies thus formulated are implemented at the sub-national level through the State Government's line departments and district authorities to achieve the desired goal of enhancing resilience and improving the adaptive capacities of the communities and ecosystems.

The Central Government constituted the 'Apex Committee for Implementation of the change. This intricate network of Ministries at the Central level, State Governments, research institutes, think tanks and NGOs and corporates, institutionalizes the directional shift of the India's developmental pathway towards an operational mechanism which enhances resilience and improves the country's adaptive capacity. India has also submitted its third Biennial Update Report to the UNFCCC, along with sharing an ambitious set of objectives for the country under the Nationally Determined Contribution (NDC), in which adaptation is a crucial component. India's NDC categorically stated - "To better adapt to climate change by enhancing investments in development programmes in sectors vulnerable to climate change." Paris Agreement' AIPA in 2020 with the aim to ensure a coordinated national response to climate

One of the key recent initiatives undertaken by the GoI has been the LiFE (campaign, launched by the Hon'ble Prime Minister, which calls for embracing a sustainable lifestyle at the individual level by replacing mindless consumption patterns with mindful utilization. It aims to create a global network of individuals who can work towards improving the health of the planet. The LiFE Principles collectively define a new sustainable and resilient development paradigm to support livelihoods, create investment opportunities to promote growth, improve standards of nutrition, healthcare, education, and living, and meet the socioeconomic aspirations of the population.

3.4.2 Adaptation Priorities

The adaptation priorities for the country stem from three sources – one, from an understanding of potentially high consequences and highly likely climate risks facing the country; two, from the socioeconomic context and the development needs of the country; and three, from addressing the constraints to adaptation.

This section describes the three broad categories of adaptation priorities for the country –

i. priorities related to knowledge systems on climate change risks and adaptation.

ii. priorities related to a reduction of exposure to climate risk, and

iii. priorities related to building resilience and adaptive capacity.

Priorities to Strengthen of Knowledge Systems and Amalgamating them to Planning and Implementation

Key areas that would strengthen systems of knowledge development and lead to the generation of new knowledge are:

i. Enhancing high-resolution climate modelling for local-level assessments of vulnerability and risks.

ii. Enhancing ground observation and data gathering networks for various hydro-meteorological phenomena for improvements in data collection and data quality.

iii. Vulnerability assessments and risk profiling: India has many development schemes suited for different regions (e.g. north east hill regions, rain-fed areas, coastal areas), underdeveloped communities (e.g. those below the poverty line, belonging to scheduled castes and tribes, women), and farmers with smaller holdings (small and marginal farmers). Strengthening this further is needed by conducting vulnerability assessments at the grassroots levels. Such assessments help decision makers and policy planners prioritize areas that need urgent adaptation actions. This can be further aided by a comprehensive localized risk profiling of the country through a bottom-up approach capturing the intricacies of the local ecosystem.

iv. Facilitating two-way Communication: In this regard, a key priority is to translate climate change relevant information to the local context in a way that is understood by the communities. Equally important is gathering ground-level information to assess the intensity of weather events and their socioeconomic impacts on the local community, guiding adaptation priorities.

v. Establishing mechanisms and institutions to couple the knowledge systems to planning and implementation systems.

Priorities to Reduce the Exposure to Climate Risks:

The multifaceted nature of the adaptation challenge requires putting in place physical and institutional infrastructure and a range of activities that would reduce exposure and vulnerability to climate risks. These include, inter alia:

i. Enhancing Climate Services and Early Warning Systems to reach the target recipients is a priority to address constraints of low capacity, inadequate institutions, and difficulties in maintaining systems beyond the pilot project stage.

ii. Addressing Floods: One of the approaches is improving the stormwater infrastructure in cities, as urban floods have become a new form of disaster plaguing Indian cities in recent times and resulting in extensive losses and damages. Other ways of addressing the issue include surplus floodwater capture mechanisms that must be installed at the local level. Concerning rural areas, there is a need to use river plans that can help to manage the flood situation and reduce losses and damages effectively. Coastal flooding is also a climate risk being faced in the country. Measures to create physical and biological barriers between the sea and land through afforestation, improved embankments, soft-hard-hybrid shoreline protection structures, seawalls and de-siltation of channels may be prioritized.

iii. Ecosystem-based approaches: Ecosystem-based approaches such as sustainable watershed management, coastal area protection, mangroves and seagrass restoration and strengthening, coastal area protection, coral reef conservation and restoration, etc., which require concerted action at a larger spatial scale, are important ways of adaptation that need to be scaled up in the country.

iv. Long-term relocation of communities along the long coastline would reduce the exposure of coastal communities to impacts of sea level rise, cyclones, storm surges, and coastal flooding.

Priorities to Enhance Resilience and Adaptive Capacity

Strengthening existing systems and developing new ones to enhance adaptive capacity and resilience is a crucial part of the country's adaptation planning agenda. Broad domains are discussed below:

i. Promoting research and innovation on technologies that help address climate risk:

ii. Considering the challenges of technology transfer from developed countries, there is an urgent need to develop technologies in India, along with the vision of "Make in India" of the Hon'ble Prime Minister Shri Narendra Modi, which minimize the adverse impacts of climate change and develop the adaptive capacities of vulnerable communities. A systematic approach to research and innovation for adaptation technologies across various sectors, at both national and sub-national levels, is required.

iii. Ensuring credit supply in rural India: Recognizing the disparities within rural areas in terms of the risks and vulnerabilities, the GoI has identified 184 credit-starved districts to reduce the regional disparities and assure better credit supply. Better credit access in these districts through private sector engagement would enhance their resilience and improve their capacities to respond to climate risks.

iv. Livelihood diversification and inclusion of marginalized communities: The climate-sensitive regions like the Indian Himalayas, coasts and islands, and arid and semi-arid regions are usually inhabited by low-income marginalized communities that are excluded from protection and services. The priority is to provide diversified livelihood options in the face of fast-evolving climate risks.

3.4.3 Adaptation Goals

In the following, some of the key adaptation goals are listed, sector-wise, that have been identified in the process of preparing the NAP.

Water

Goal 1: Improve climate-related data collection, monitoring, and early warning systems

- Enhance real-time monitoring and information dissemination systems for accurate predictions of floods, GLOF, rainfall-induced landslides, droughts, cyclones, and coastal salinity ingress.

- Develop and implement advanced flood early warning systems and improve flood hazard atlas coverage.
- Improve prediction systems for rainfall variability using advanced modeling and data analytics technologies.
- Develop city-specific flood risk management indices to guide urban planning, preparedness, and progress monitoring.
- Develop effective communication among institutions and establish systematic protocols for collecting spatial and temporal hydro-meteorological data within a GIS framework for efficient urban flood management.
- Establish a national portal/grid for integration of flood, drought, sea-level rise, cyclone, etc. forecasts with various digital platforms for real-time updates.
- Enhance water quality monitoring and surveillance networks.

Goal 2: Develop and strengthen climate-resilient water infrastructure

- Invest in and expand water storage infrastructure, including dams, reservoirs, irrigation and canal systems, artificial groundwater recharge systems, and rainwater harvesting systems.
- Develop climate-resilient infrastructure for floods, droughts, cyclones, and sea-level rise, such as improved drainage systems, permeable pavements, stormwater collection tanks, rainwater collection systems, and desalination plants.
- Strengthen implementation of infrastructure-related rules and regulations
- Promote private investment in desalination plants, advanced distribution networks, and wastewater recycling.
- Mainstream ecosystem-based solutions for flood mitigation

Goal 3: Promote efficient, equitable, and sustainable water management practices

- Develop decision support systems for Integrated Water Resource Management (IWRM) frameworks incorporating climate projections.
- Enhance effective government/private and inter-departmental coordination for location-specific sustainable water management and optimal recycling.

Goal 4: Strengthen community engagement and build capacity for climate-resilient water management

- Raise awareness among farmers, communities, and stakeholders to promote sustainable water use and flood preparedness, supported by water conservation campaigns and educational programs on water quality.
- Implement community-based initiatives for conservation and sustainable water management (e.g., advanced water distribution networks, water quality measurement kits for community leaders, detailed mapping of affected regions, testing water from tube wells).
- Promote and fund research and development initiatives focused on site-specific, multi-component adaptation strategies.

Agriculture:

Goal 1: Enhanced climate-resilience of agricultural production and livelihoods

- Encourage the use of climate-resilient crop and livestock varieties while promoting integrated farming through crop diversification and agroforestry
- Implement micro-irrigation techniques (drip and sprinkler systems), soil-test-based fertilizer applications, and water-efficient rice cultivation methods
- Enhance livestock resilience through better shelter management, nutrition practices with mineral mixtures, and fodder scarcity management (e.g., silage making)

- Strengthen agricultural supply chains through post-harvest support by improving storage facilities, transportation logistics, and market access
- Support conservation agriculture and organic farming, promote improved fishing technologies, and advance ecosystem-friendly practices
- Support private sector/MSME R&D in agricultural technology (pest diagnostics, solar irrigation, clean cold chains, resilient supply chains, precision farming, blockchain)

Goal 2: Improved natural resource management

- Promote integrated soil and water conservation through in situ conservation measures, on-farm and community-based rainwater harvesting systems, check dams, and groundwater recharge initiatives.
- Develop and promote climate-resilient watershed management and ecosystem-based adaptation approaches to manage water resources effectively.
- Enhance soil health through precision nutrient management, balanced use of fertilizers, and integration of organic manures via Integrated Nutrient Management (INM).
- Encourage practices that promote ecosystem resilience, biodiversity, and environmental health.

Goal 3: Enhanced institutional capacity

- Create and strengthen local organizations (Self-Help Groups (SHGs), women SHGs, Water User Associations, Farmer Producer Organizations) to empower community-level adaptation initiatives
- Conduct targeted programs to build the capacities of government agencies, NGOs, Panchayati Raj Institutions (PRIs), women groups, and farmers, ensuring knowledge of climate adaptation needs and innovations
- Promote cross-sectoral coordination and collaboration among government departments, NGOs, civil society, and the private sector to streamline adaptation efforts
- Establish institutional arrangements like custom hiring centers to facilitate access to farm machinery and technology, ensuring gender-responsive adaptation planning
- Strengthen early warning systems and develop agrometeorological advisory platforms for accurate, timely decision-making.

Goal 4: Increased access to risk management instruments

- Increase access to institutional credit through innovative solutions (microfinance, group credit schemes) to enhance farmers' financial resilience
- Develop and promote diverse insurance products (crop, livestock, weather-based, disaster-linked) to mitigate agricultural risks
- Create and strengthen mechanisms providing financial and social safety nets for farmers and agricultural labor
- Offer skill-building programs for farmers and agricultural labor to pursue non-farm employment opportunities, diversifying income sources

Forests:

Goal 1: Restore degraded forests

- Restore forested landscapes using native species in Trees Outside Forests (TOF) and agroforestry systems, enhancing biodiversity and carbon sequestration
- Promote climate-resilient afforestation and reforestation practices, including soil and water conservation, planting of indigenous species suited to local climatic conditions across altitudinal and latitudinal gradients
- Expand mangrove plantations and restore wetlands to enhance biodiversity, hydrological resilience, and mitigate impacts of sea level rise, salinity intrusion, and storm surges

- Align initiatives like Green India Mission, CAMPA, and Green Credit Program (GCP) to incentivize ecological afforestation and restoration and achieve convergence of adaptation measures with ongoing schemes
- Use geospatial technologies, including drone technologies for real-time monitoring, spatial analysis, and mapping degraded forests for targeted restoration efforts

Goal 2: Conserve forest habitats

- Substitute pure stands of species such as teak and eucalyptus from wildlife protected areas with native species of trees, shrubs, and grasses to improve the habitat and provide livelihood opportunities to locals
- Strengthen area-based measures, for example: Community Conserved Areas (CCAs), Biodiversity Heritage Sites (BHS), and Sacred Groves ensuring ecological representation and habitat continuity
- Promote ecosystem connectivity through the creation and maintenance of wildlife corridors and migration pathways
- Inclusion of traditional knowledge and practices under conservation strategies

Goal 3: Enhance the adaptive capacity of forest ecosystems

- Institutional capacity development for forest landscape restoration (preparedness of forestry institutions to address emerging climate challenges)
- Strengthen women's roles through leadership training and participation in forest governance, and support community capacity building for diversified livelihoods
- Establish multi-institutional collaborative Long Term Ecological Observatories (LTEO) networks to generate data, and create interoperable, open-access ecological databases to support adaptive forest governance and actions
- Improved fire management through maintenance of fire lines, bamboo harvesting to reduce the fuel load, fire suppression, and post-fire recovery

Goal 4: Reduce the risk of climate change for forest ecosystems and dependent communities

- Establish clean energy solutions to minimize reliance on fuelwood
- Collaborate with the Coalition for Disaster Resilient Infrastructure (CDRI) to develop climate-resilient infrastructure in forested and adjoining regions
- Develop infrastructure to enhance water availability by combining water harvesting and storage systems, and watershed management to alleviate women drudgery on water collection, improve drainage, and prevent soil erosion in vulnerable areas
- Strengthen community safety networks and legal protection against gender-based violence in resource collection areas
- Enhance infrastructure and capacity for early warning systems such as AI-powered predictive tools for response, and recovery from climate-induced disasters such as forest fires, pest outbreaks, droughts, landslides, and floods
- Explore risk sharing instruments and insurance mechanisms for forest-dependent communities to reduce economic vulnerabilities caused by climate-induced changes
- Provide women with access to microfinance, skill training, and cooperatives, and support private investment in NTFP-based enterprises to create jobs, diversify income sources, reduce dependence on degrading forests, and minimize overextraction for forest-dependent households

Ecosystems and Biodiversity

Goal 1: Enhance ecosystem resilience and climate buffering capacity

- Implement proactive and sustained measures to control and reduce Invasive Alien Species, minimizing their impact on native biodiversity and ecological stability

- Apply ecological principles and promote adaptive management tools to restore and maintain ecosystems, aligning with changing climatic conditions and biodiversity needs
- Safeguard natural processes and habitat linkages critical for species movement, hydrological balance, and long-term ecosystem functionality
- Expand the network of conserved areas with a focus on climate-resilient planning and dynamic wildlife corridors to support species migration
- Promote the development and retrofitting of green infrastructure and restoration facilities to enhance resilience against climate change impacts
- Develop innovative financing models to sustain biodiversity adaptation by leveraging blue carbon and biodiversity credits, insurance for vulnerable communities, and payments for ecosystem services

Goal 2: Mainstream ecosystem-based approaches (EbA) into climate adaptation and development planning

- Implement climate-resilient land-use planning, ecological zoning, and augment it with satellite-aided land surveillance
- Establish Regional Ecosystem Partnerships: Collaborate with South Asian countries on regional biodiversity conservation efforts
- Deploy precision methods to assess risks & vulnerabilities: Early warning systems, remote sensing tools, AI and machine learning tools, and advanced modeling techniques for developmental works
- Build capacity for management authorities by enabling participatory scenario planning to co-design future adaptation pathways
- Establish robust monitoring systems and research networks on climate-biodiversity interactions for evidence-based decisions, tracking ecological change, and improving adaptive responses
- Encourage integration of valuation of ecosystem services into planning processes
- Leverage existing schemes/initiatives such as the Global Biodiversity Framework Fund (GBFF) and BIOFIN to direct funds towards ecosystem and biodiversity-centric adaptation actions
- Promote private investment opportunities through innovative market instruments including PES, credits and bonds

Goal 3: Enhance climate resilience for ecosystem dependent communities

- Promote climate-resilient livelihood practices, enterprise and market linkages: Eco-tourism, women-led craft livelihoods, climate-resilient livestock and traditional livelihoods
- Ensure gender mainstreaming by actively including women in adaptation planning, decision-making, and benefit-sharing
- Mobilize and support local communities in ecosystem stewardship through participatory governance, education, and equitable benefit-sharing mechanisms
- Promote and invest in indigenous and traditional knowledge for ecosystem-based solutions

Health:

Goal 1: Enhance awareness and engagement among general population (vulnerable communities), health-care providers, and Policy makers regarding impacts of climate change on human health

- Climate and health advisories for communities and health departments
- Development and implementation of Climate Health Communication materials for sensitization of the general population (vulnerable communities), health-care providers, and Policy makers
- Integration of climate in National Health Programmes

Goal 2: Strengthen health system resilience and responsiveness to Climate Sensitive Diseases (CSDs) through comprehensive capacity strengthening of health care providers

- Climate and Health Risk Assessment for priority climate-sensitive hazards
- Integrate the health impacts of climate change into the curriculum of medical and allied sciences
- Capacity strengthening of health workforce through training and sensitization activities

Goal 3: Strengthen climate-health surveillance and response system at national, state, district, and facility levels

- Strengthen the surveillance mechanism for climate and health
- Improve access and utilization of early warning systems/alerts for Health sector preparedness and response
- State/ region-specific action plan on climate change and human health, informed by climate-related health risk assessments

Goal 4: Enhancing climate-resilient and sustainable health infrastructure and services for extreme weather events (including heat, flood, and cyclone) preparedness and response

- Develop climate resilient healthcare guidelines and monitoring tools
- Proper management of Health care waste as per recommended waste management protocols
- Improving climate resilience healthcare infrastructure for better preparedness and response for including heat, flood, and cyclone

Goal 5: Foster collaboration and research with other critical sectors to integrate climate related health concerns as a priority agenda

- Develop joint action plan with other relevant ministries, departments, and organizations to advance health adaptation measures
- Strengthen leadership, governance, and decentralized actions through task forces at state and district administrative levels
- Enhance research and development on climate and health to support evidence-informed activities
- This list of adaptation goals is not exhaustive.

3.4.4 Gender Responsiveness of Adaptation Efforts in the Country

While the climate risks and hazards faced across the country affect all its citizens, the impacts do not affect all groups equally. The impacts of climate change and disasters affect weaker socio-economic groups with much higher intensity. Women, especially those from lower economic backgrounds, face some of the most severe effects of climate change. Recurring incidences of erratic rainfall and increasing possibilities of extreme events can result in the loss of agricultural produce. Women are exposed to harvest losses, which are often their sole source of food and income. Climate change may, thus, result in a consequent shrinkage of work opportunities and would inflict a blow to the socio-economic edifice of the rural womenfolk. Second, climate variability usually impacts sectors that are traditionally associated with women, such as paddy cultivation, cotton and tea plantations, and fishing. A multitude of factors leads to a situation in which women bear a disproportionate share of the burden for adaptation, despite their limited ability to adapt. Thus, it becomes imperative to devise appropriate adaptation measures, with a special focus on women. The GoI recognizes that women involved in agriculture and other such climate-sensitive sectors are more exposed to vulnerabilities due to climate risks, as lack of access to tools and machinery makes them more exposed and sensitivity to climate risks and extreme events. In India, about 65 percent of the total female workers are engaged in one of the most climate-sensitive sectors – agriculture, thereby constituting 30 percent of the total cultivators and about 43 percent of the total agricultural labourers in the country. Women can play important roles in the adaptation process due to their involvement in climate-sensitive livelihoods. In addition, they are the ones who have a major role in decisions at the household level on the types of chulla (cook-stove) used for cooking, as also in decisions related to the sanitation norms at household level. They need to be readily involved in the micro-level strategy action to combat climate change.

The GoI has made significant strides in empowering women, particularly over the past few years. A number of initiatives have been introduced to improve gender parity and women's participation in the workforce thereby enabling greater access to as well as ownership of resources. A significant step forward in gender equality was the introduction of Clause (3) under Article 243 D of the Constitution, which ensures the participation of women in Panchayati Raj Institutions by mandating at least one-third reservation for women out of a total number of seats to be filled by direct election and the number of offices of chairpersons of Panchayats. Recognizing that national budgets benefit women and men differently, India formally adopted Gender-Responsive Budgeting (GRB) in 2005-2006. GRB does not merely involve earmarking funds for women; it is an exercise that scrutinizes the budget through a gender lens. The Gender Budget Statement comprises two parts: Part A reflects women-specific schemes with a 100 per cent allocation for women, and Part B is composed of pro-women schemes wherein at least 30 per cent of the allocation is for women.

The guidelines for preparation of SAPCCs urge the States and UTs to address the needs of vulnerable groups such as women, because the "poorest of the poor, especially the marginalized groups, will be the most affected by these changes". Additionally, under the Agriculture Technology Management Agency (ATMA) scheme, for instance, there are provisions for women's Food Security Groups (FSGs), a gender coordinator and representation of women in decision-making bodies. The Sub-Mission on Agricultural Mechanization (SMAM) also provides training programmes on gender-friendly farming equipment for women farmers and gives additional subsidies to women farmers for buying farming machinery and equipment.

Gender has been made an integral component of developmental planning in the country, with key schemes of the GoI highlighting the priorities of women. In order to address the heightened vulnerabilities faced by women in rural parts of the country, schemes such as Mahila Shakti Kendra, Mahila E-Haat, and STEP (Support to Training and Employment Program for Women) have been undertaken. These schemes acknowledge the vulnerabilities faced by women who carry out the minor tasks of climate-sensitive sectors, such as agriculture, or gather firewood and other materials from forests. The schemes address such concerns through enabling the empowerment of women by providing training and skill development courses to facilitate alternative livelihood opportunities. Thus, women-related issues are being mainstreamed in developmental programmes of the Government of India.

The table below shows a few such schemes and their impact on strengthening women's capacity by reducing their exposure and sensitivity and strengthening their adaptive capacity against climatic risks. Widespread and effective implementation of these initiatives, coupled with a greater emphasis on meeting the Strategic Gender Needs of women pertaining to income, employment, and control over financial and other resources, can be instrumental in enhancing the adaptive capacity of women to meet the challenges of climate change.

Table 3.18: Impacts of Government schemes and programs on the vulnerability of women to climate related risks in India

Scheme/program	Impact on women's climate risk reduction
Pradhan Mantri Ujjawala Yojana Started in 2016 to provide cooking gas in women's name and to develop a smoke-free rural India	Increased adaptive capacity by enhanced access to clean fuel, which reduces drudgery and the time spent on collecting firewood; improved respiratory and eye health; reduced GHG emissions and pollution.
Nal Se Jal and Jal Jeevan Mission Started in 2019 to enhance the water and sanitation security of households	Reduced sensitivity to climatic risks through enhanced access to safe and adequate drinking water leading to less workload and diseases
Swaccha Bharat Mission Started in 2014 for improved hygiene and sanitation	Reduced sensitivity to climatic change through improved access to sanitation leads to better hygiene and health.
Pradhan Mantri Awas Yojana Started in 2015 to provide safe housing to the poor	Climate-proof housing for poor families reduces exposure to climatic extremes, leading to increased resilience and improved quality of life.

Scheme/program	Impact on women's climate risk reduction
Janani Shishu Suraksha Karyakram, and Mother and Child tracking system of National Health Mission Started in 2005 to support the reproductive health of Women	Reduced infant and maternal morbidity and mortality rates by facilitating pre- and post-natal check-ups, institutional deliveries and immunization reducing sensitivity to climatic risks
Mahatma Gandhi National Rural Employment Guarantee Act Started in 2005 to provide livelihood security to families with one-third of jobs for women	Access to paid employment; reduction in the gender gap in the labour force and poverty increases the adaptive capacity of women to climate change.
Beti Bachao Beti Padhao Started in 2015 to encourage the growth and educational advance of girls.	Enhanced educational level of girls leading to better status and employment opportunities, strengthens the adaptive capacity of women to climate change.

Source: Compiled from various sources for the report

New databases on hazards, exposure, and vulnerability indicators are now available to assist in improving the understanding of granular, gendered risks. In the Fourth National Communication, the GCRI will be improved further by considering the recent progress in other similar indices developed. The GCRI will be further updated later. Factors such as 'human capital', 'economic capital', 'social capital', 'access and availability', as well as 'women's role in decision-making processes' will also be considered, which impact the gender differentiated vulnerability and risk, as well as the capacity to adapt to climate change. Further evidence on the risks and vulnerabilities faced by women at a granular scale - district and block level will also be considered. Since empowering girls and women will be a significant factor in meeting the climate challenge, the government's various policies, programs, and schemes will be analysed using suitable Gender Analysis Frameworks to examine how far they are gender-positive, responsive and inclusive and how far they contribute to building the adaptive capacity of women to climate change.

3.4.5 Traditional and Local Knowledge Systems Relevant to Adaptation

Traditional knowledge systems include practices, innovations, and customary laws that indigenous groups and communities have been using for generations for multiple purposes, the main among which include farming techniques, resource management, and medicinal purposes. India is one of the few ancient civilizations and cultures that encompasses a multitude of traditions that are practiced across its length and breadth but are tied together with certain core values that have been observed to be in complete consonance with the need for sustainability. The heart of Indian culture and tradition lies in its diversity. Different lifestyles that match the local climatic and geographical conditions can be found across the country, ranging from the deserts of Rajasthan to the forests of the Northeast. Traditional and local knowledge systems are an integral part of India's way of life. This is not only the case for the tribal and forest-dwelling communities, but across the country. Different communities have adopted a myriad of practices and systems, the core of which is ingrained in sustainability. India, with over 700 Scheduled Tribes that comprise approximately 8.6 percent of the country's total population, has several pockets of tribal population in rural and forest areas where rich traditional knowledge exists and is passed on from one generation to another through folklore and oral traditions. The immense potential of traditional knowledge systems that have supported local societies in organizing lifestyles successfully in remote and fragile areas of the country has been acknowledged and appreciated by integrating them into the formal sector policies and practices. The country's history is replete with the use of traditional knowledge and practices that have been recognized globally for healthcare and includes Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homeopathy. The GoI, has made great efforts to preserve the traditional knowledge of medicines and improved healthcare, forming the Ministry of AYUSH in 2014 that promotes research and education in these fields to integrate traditional knowledge and practices into medical research. Traditional knowledge systems, in recent years, have been encountering several challenges in the face of modernization, outmigration of youth impacting the process of knowledge transfer, urbanization, etc. Therefore, recognizing the increased vulnerability of such communities and addressing these challenges, the GoI has initiated the Pradhan Mantri Van Dhan Yojna, an initiative that targets livelihood generation for tribal and forest-dwelling communities by harnessing the wealth of forests. It aims to tap into the traditional knowledge and skill sets of these communities by adding technology and IT to transform them at each stage and to convert the tribal wisdom into a viable economic activity through value-added products, thereby also addressing the outmigration of the younger generation to sustain the process of vernacular knowledge transfer among these communities.

3.4.6 Adaptation in the State Action Plans on Climate Change

One of the important features of India's institutional arrangements for climate action is the requirement of the States to formulate their own SAPCC as the basis for State-level climate action. Formulated by the States themselves through a multi-stakeholder process, led by the Government, these SAPCCs have been upgraded to a second version in 14 States. These SAPCCs cover both mitigation and adaptation dimensions of climate action.

In the adaptation strategies and targets set in the SAPCC 2.0 by these fourteen states, the following sectors have been covered: water, agriculture, health (except Karnataka), biodiversity (except Karnataka), infrastructure and human settlement (except WB, Himachal, Tripura, Odisha, and Chhattisgarh). As reporting the details of all the adaptation strategies and targets would be too lengthy, the following assessment is provided, sector-wise, based on select parameters.

For the water sector — whether the strategies aimed to enhance climate resilience towards water-related hazards, address climate-resilient water scarcity, ensure access to safe and affordable potable water for all, and climate-resilient sanitation.

For agriculture, the parameters — whether the strategies ensured climate-resilient food and agriculture, looking closely at all three stages of supply, production and distribution and also if the strategies addressed equitable access to adequate food and nutrition.

In the health sector, the strategies aimed at increasing resilience against climate change related health impacts, promoted climate-resilient health services, and attempted to reduce climate-related morbidity and mortality (particularly in the most vulnerable communities).

In the biodiversity sector, whether the strategies aimed at reducing climate impacts on ecosystems and biodiversity, accelerating the use of ecosystem-based adaptation and nature-based solutions, Ensuring management, enhancement, restoration and conservation of ecosystem and biodiversity along with protection of terrestrial, inland water, mountain, marine and coastal ecosystems.

For infrastructure and human settlement, whether the strategies attempted to minimize climate-related impacts and increase the resilience to climate change impacts to ensure basic and continuous essential services.

A brief sector-wise summary is provided of the adaptation strategies and targets of the States based on these parameters.

Agriculture: Based on these parameters, the assessment shows that most states have acknowledged the need to improve the current flood control initiatives by mapping the vulnerable areas, enhancing forecasting, ensuring proper drainage and simultaneously encouraging research to create real-time data for the same thereby enabling better monitoring of the affected areas. Further investment in flood control infrastructures and capacity building is among the crucial strategies that have been proposed by certain States. Assessment of the sustainability of the water resources has also been proposed along with Integrated Water Resource Management and an enhanced monitoring system to provide a climate-resilient water supply. Adaptation strategies like micro-irrigation (drip irrigation) are being promoted across States to deal with water scarcity in the agriculture sector along with watershed management. Strategies to reclaim wastewater and reuse it for different purposes (non-drinking and non-irrigational) to deal with scarcity of potable water are being adopted. Besides the formation and strengthening of groundwater measures are being undertaken. In addition to these, strategies are designed to increase the water use efficiency through rainwater harvesting, construction of anicuts, and revamping of the existing water supply. To augment the availability of potable water, states are planning to improve the current infrastructure to ensure water supply to households. Further measures to ensure the safety of water will be undertaken by providing water quality testing kits or water testing infrastructures by some states. For sanitation, strengthening of stormwater, floodwater drainage along with sewerage management have been proposed.

In the agriculture sector, the proposed adaptation strategies aim to transition to climate-resilient food production by increasing the productivity of the crops, livestock, and fisheries.

Ten out of the fourteen States have emphasized the need for capacity building and training of farmers. Several States have proposed measures to build soil fertility, use comparatively fewer inputs (fertilizers) and simultaneously build the resilience of the agriculture system.

Strengthening of early warning systems, weather forecasting, and climate-related information is to be made available to the farmers. Activities to promote soil health management are to be undertaken along with more attention on soil health, while some States have also emphasized the need to prevent soil erosion. In order to increase the productivity of fisheries, some States have emphasized the need to improve the infrastructure. Among the States covering animal husbandry, most of them have proposed strategies to promote the breeding of species, with one State emphasizing the need for higher milk-yielding cattle, while a couple of the States emphasized the breeding of climate-resilient species. A few states have also put forth strategies to enhance fodder production. On irrigation, while a few States like Himachal Pradesh and Madhya Pradesh have emphasized the need for participatory irrigation management, it is important that such strategies are implemented across states in the country. With respect to specific crops, while the State of Tamil Nadu aims at the revitalization of millets for nutritional security, some other States aim to enhance the production of pulses (legumes).

Six States have proposed strategies promoting the supply of quality seeds for production, particularly for certified seeds to be sold to the farmers, while one State has emphasized the need for a timely supply of seeds (West Bengal).

Most of the states have strategized to strengthen the market linkage to enhance distribution. Some states have aimed to strengthen and promote FPOs (Farmer-Producer Organizations) in order to strengthen the market linkage. While some states have strategized measures for post-harvest value addition of crops and horticulture products, some have proposed. Very few states have proposed strategies to minimize post-harvest losses and provide accessible information on market trends, as a couple highlight the need to improve storage facilities.

Biodiversity: Eight States have proposed strategies that aim to enhance forest protection and cover, for which measures like afforestation and restoration of degraded land will be undertaken. To protect biodiversity, some states are taking measures to conserve their wetlands. Solutions like ecotourism are being promoted by some States to ensure harmony between livelihood security and sustainable ecosystems. Six States have proposed agroforestry. Ten out of twelve States have proposed strategies for the management, enhancement, restoration and conservation of ecosystems and biodiversity. Seven States have proposed strategies that aim to restore, rejuvenate, and protect the inland water resources. Besides these strategies, some important adaptation strategies proposed by a few States include strategies for forest fire management, mangrove conservation, nursery development and addressing problems related to invasive species.

Health: States through various strategies have proposed the need to ensure proper surveillance, monitoring and assessment of disease outbreaks. Some States have highlighted the need to map the vulnerable areas where it is necessary to detect vector and waterborne diseases, as early detection would enable prevention. Six States have proposed sensitizing the health staff on treatment protocols to deal with heat stress. Most of the States have strategized an improved accessibility to health care facilities, while two States have also aimed at providing rapid response teams. Kerala has proposed eHealth for people and has highlighted the need to increase access to healthcare facilities for tribal hamlets. Some States have strategized measures to enhance climate change knowledge and create more awareness. The State of Uttar Pradesh plans to incorporate 'Climate and Health' in the curriculum of school students. A few States are making an attempt to enable real-time data that people can access to know about any disease outbreak. Some States have also focused on the health of the livestock via surveillance of disease outbreaks on the livestock, vaccine coverage and development of science and technology for the same.

Infrastructure and Human Settlement: In order to minimize the climate-related impacts some States have proposed the identification of low-lying areas which are prone to floods. Some States have proposed green buildings. Among the other strategies proposed by different States are rainwater harvesting and proper sanitation to ensure the continuation of basic essential services. Few States have strategized measures to make the coastal communities more resilient to climate change including multipurpose cyclone shelters, safe housing in coastal areas, rescue, relief and rehabilitation during hazards and sea protection walls.

Most States have proposed crop insurance as a strategy to promote livelihood security along with training and skill development or create opportunities for an alternative livelihood, especially for the fishing community.

3.5 Progress and Implementation of Adaptation

Key Adaptation and Adaptation-Related Schemes and Programmes

The GoI has been undertaking several initiatives to mainstream adaptation efforts while furthering developmental requirements. The Table below highlights some of the significant schemes/ projects and programmes pursued by the GoI, either designed as climate change adaptation strategies or to help improve adaptive capacities. These plans, schemes, policies, programmes, and projects have been mapped as per the adaptation typology presented in IPCC's fifth assessment report (WG II AR5) to provide an outline of the different kinds of adaptation actions being undertaken in the country. The mapping indicates the climate risks and vulnerabilities at the national level that have emerged from an assessment of climate impacts, risks, and vulnerabilities facing the country.

Adaptation actions may be classified following the typology established by the IPCC AR5 Working Group II Report in the following three categories:

Structural and Physical Options: This category highlights discrete adaptation options, with clear outputs and outcomes that are well defined in scope, space, and time. They include structural and engineering options (e.g. seawalls, dykes, slope revetments and other coastal protection structures); the application of discrete technologies (e.g. water-saving technologies); the use of ecosystems and their services to serve adaptation needs (e.g. mangrove conservation and replanting); and the delivery of specific services at the national, regional, and local levels (e.g. social safety nets and social protection).

Social Options: This category includes various adaptation options that target the specific vulnerability of disadvantaged groups, including targeted vulnerability reduction and social inequities. Included in this category are Education (e.g. awareness raising, extension, outreach, community meetings, and other educational programs); Informational strategies (e.g., early warning systems, climate services); and Behavioural measures (e.g. Household preparation and evacuation planning).

Institutional Options: Numerous institutional measures can be used to foster adaptation. These range from Economic instruments (e.g. taxes, subsidies, and insurance arrangements) to Policies, Plans and Regulations (e.g. Land zoning laws; Building standards and practices; Laws to support disaster risk reduction).

Even before the NAPCC came into being, the GoI had several individual programmes and schemes that contributed to developing adaptive capacities. Table 3.19 provides an overview of the missions, plans, programs and schemes, that are directly formulated for adaptation or provide increase in specific adaptive capacities (Government of India, 2023a).

Table 3.19: Mapping of adaptation relevant plans, schemes, programs and projects of the GoI

Sectors	National Government plans, programs and missions	Sub-programmes, Schemes, and projects	Structural				Social			Institutional	
			Engineering	Technological	Ecosystem	Services	Educational interventions	Informational strategies	Behavioral measures	Economic instruments	Policies and Plans
Water	National Water Mission	Jal Shakti Abhiyan	√								
		Sahi Fasal		√						√	
		R&D Projects						√			
		Baseline studies						√			
		Training and Capacity Development Workshop					√				
		State Specific Action Plan	√	√			√	√			
	The Dam Rehabilitation and Improvement Programme		√								
	The Jal Jeevan Mission		√	√		√	√				
	Namami Gange/ National Mission for Clean Ganga				√						
	National River Conservation Programme				√						
	National Plan for Conservation of Aquatic Ecosystem				√						
	Atal Bhujal Yojna	Institutional Strengthening & Ca- pacity Building									√
		Incentive Component								√	
	National Aquifer Mapping and Management Programme				√			√			
Agriculture	National Mission for Sustainable Agriculture (NMSA)	Rainfed Area Development (RAD)			√					√	
		Sub-Mission on Agroforestry (SMAF)			√					√	
		National Bamboo Mission (NBM)			√					√	
		Soil Health Management (SHM). This includes Paramparagat Krishi Vikas Yojana (PKVY).			√	√					
		Monitoring, Modeling and Networking (CCSAMMN)			√			√			
	National Innovations in Climate Resilient Agriculture (NICRA)		√	√	√		√	√			

Sectors	National Government plans, programs and missions	Sub-programmes, Schemes, and projects	Structural				Social			Institutional	
			Engineering	Technological	Ecosystem	Services	Educational interventions	Informational strategies	Behavioral measures	Economic instruments	Policies and Plans
Agriculture	Rashtriya Krishi VikasYojana (RKVY)- RAFTAAR			√							
	National Rural Livelihood Mission – Deendayal Antyodaya Yojana– This includes Mahila Kisan Sashaktikaran Pariyojna.					√					
	Agriculture Technology Management Scheme			√							
	National Mission on Agricultural Extension and Technology (NMAET)	SMAE: Sub-Mission on Agricultural Extension		√							
		SMSP: Sub-Mission on Seed and Planting Material		√							
		SMAM: Sub-Mission on Agricultural Mechanization		√							
		SMPP: Sub-Mission on Plant Protection and Plant Quarantine		√							
	Pradhan Mantri Fasal Bima Yojana or the Prime Minister Crop Insurance Scheme									√	
	Pradhan Mantri Kisan Samman Nidhi(PM-Kisan)									√	
	Pradhan Mantri Krishi Sinchayee Yojana (PMKSY)	Accelerated Irrigation Benefit Programme (AIBP)	√								
		Command Area Development and Water Management (CAD&WM)	√								
		Her Khet ko Pani	√	√							
		Per Drop More Crop (Micro Irrigation)									
Horticulture	Mission for Inte- grated Development of Horticulture (MIDH)	National Horticultural Mission (NHM)		√						√	
		Horticulture Mission for North East and Himalayan States (HMNEHS)		√						√	

Sectors	National Government plans, programs and missions	Sub-programmes, Schemes, and projects	Structural				Social			Institutional	
			Engineering	Technological	Ecosystem	Services	Educational interventions	Informational strategies	Behavioral measures	Economic instruments	Policies and Plans
Livestock	National Livestock Mission (NLM)	Rastriya Gokul Mission (RGM)		√						√	
		Breed Development of Livestock & Poultry		√						√	
		Feed and Fodder development		√						√	
		Extension and Innovation		√			√				
		Livestock Health and Disease Control	√								
		National Programme for Dairy Development								√	
		Livestock Census and Integrated sample Survey						√			
		National Animal Disease Control Programme		√							
		Dairy Infrastructure Development Fund	√								
		Animal Husbandry Infrastructure Development Fund	√								
Fisheries	Pradhan Mantri Matsya Sampada Yojana (PMMSY)									√	√
Forestry	CAMPA 2016					√					
	GIM				√						
	Nagar Van UdyanYojana				√						
	Intensification of Forest Management Scheme (IFMS)				√						
	Pradhan Mantri Van Dhan Yojana									√	
	Green Skill Development Programme (GSDP)						√				
Coastal Zones	National Coastal Mission	Integrated Coastal Zone Management Project (Phase I)		√	√			√	√	√	
		Beach Environment and Aesthetics Management System (BEAMS)			√	√	√				
		Blue Economy: Integrated Development and Management of Fisheries	√	√	√	√	√	√	√	√	√
	Coastal and Marine Protected Areas							√			√

Sectors	National Government plans, programs and missions	Sub-programmes, Schemes, and projects	Structural				Social			Institutional	
			Engineering	Technological	Ecosystem	Services	Educational interventions	Informational strategies	Behavioral measures	Economic instruments	Policies and Plans
Himalayan Ecosystems	National Mission for Sustaining the Himalayan Ecosystem (NMSHE)		√	√	√	√	√	√	√		
	Hill Area Development Plan		√	√			√				
	National Mission on Himalayan Studies (NMHS) MoEFCC						√	√			
		Mid-Himalayan Watershed Development project*	√	√							
		Assam Agricultural Competitiveness Project *								√	
		Securing Livelihoods in the Himalayas*								√	
		The Meghalaya Community Led Landscape Management Project *			√		√	√			
Disaster risk reduction and resilient infrastructure	Aapda Mitra (Friends in Emergency)						√				
	Coalition for Disaster Resilient Infrastructure (CDRI)		√				√	√		√	
	National Disaster Management Policy 2009 & DM Act 2005 & NDMP-2019		√	√	√	√				√	√
	National Health Mission	National Vector Disease Control Programme				√		√			
	Village Disaster Management Plans					√					√
	National Cyclone Risk Mitigation Project1	Early Warning Dissemination Systems	√	√		√	√				
		Cyclone risk mitigation infrastructure	√				√	√			
		Technical Assistance for Multi-hazard Risk Management		√			√				
	National Mission for Sustainable Habitat (NMSH)	Atal Mission on Rejuvenation and Urban Transformation (AMRUT)		√							
		Swachh Bharat Mission (Rural and Urban)			√	√					
National Health Mission	National Programme on climate Change and Human Health (added) National Vector Disease Control Programme					√		√			

Source: Government of India, 2023a

** Refers to projects funded by multi-lateral agencies like World Bank and GEF but coordinated by the Central Ministries of GoI*

India's Direct and Indirect Adaptation Relevant Expenditure

India's adaptation relevant expenditure cannot be separately demarcated immediately as much of it is embedded within development expenditure. Given the very low levels of climate finance for adaptation, much of India's expenditure on adaptation arises from the indirect development of adaptive capacities, as noted in the previous section.

A study undertaken for India's first Adaptation Communication by ICRIER (Goldar et al., 2023) noted the following, as in Table 3.20 below

Table 3.20: Total Adaptation Relevant Expenditure as Percentage of Total Expenditure and GDP

	Total Actual 2015-16 spending (in INR billion)	Total Actual 2021-2022 spending (in INR billion)	Total Actual 2015-16 spending (in USD billion)	Total Actual 2021-2022 spending (in USD billion)
Total Adaptation Relevant Expenditure	5,059.54	13,351.87	77.28	179.22
Grand Expenditure Budget Total	17,907.83	37,938.01	273.53	509.24
Adaptation Relevant Expenditure as a % of Total Expenditure	28.3%	35.2%	28.3%	35.2%
GDP 2015-16 at Current Prices	1,37,718.74		2103.59	
GDP 2021-22 at Current Prices (in billion) [Provisional Estimates; PE]		2,36,646.37		3176.46
Adaptation Relevant Expenditure as a % of GDP	3.7%	5.6%	3.7%	5.6%

Source: Goldar et al, (2023) and calculations therein.

Data Sources:

For basic data: Demand for Grants, 2023-2024, Union Budget 2023-2024, GoI

Demand for Grants, 2017-2018, Union Budget 2017-2018, GoI

For GDP data: Economic Survey 2022-23, GoI, Statistical Appendix, Table 1.6 Components of Gross Domestic Product at Current Prices; for GDP 2021-22 estimate

Economic Survey 2021-22, GoI, Statistical Appendix, Table 1.6 Components of Gross Domestic Product at Current Prices; for GDP 2015-16 estimate an annual average exchange rate of 1 USD= 65.47 Rs is used; for GDP 2021-2022 estimate an annual average exchange rate of 1 USD= 74.5 Rs. is used

These figures show the considerable impact that adaptation to global warming already has on India's development trajectory.

As noted in India's Adaptation Communication, the cumulative expenditure needed for adaptation in a BAU scenario, without any additionality, is estimated to be INR 56.68 trillion till 2030, assuming 2023-24 as the base year of analysis. This estimate, based on an "infrastructure needs" approach, is developed for select sectors that are most relevant for enhancing adaptive capacity and building resilience. These sectors include agriculture, water supply and sanitation, housing, health, education, poverty alleviation, forestry and wildlife, and disaster management.

Climate impacts could lead to an incremental cost of INR 15.5 trillion by 2030, and the total requirements for building adaptation capital stock could be as high as INR 72 trillion after accounting for the country's developmental needs and climate-induced pressures. It comprises of both, the additional expenditures required due to developmental pressures as it traverses in the BAU pathways as well as addressing future climate change-induced impacts. Regarding the latter point, building a climate-resilient infrastructure stock would prove to be a more preferred option as the degree of climate damage is expected to exacerbate in the future. While the extent of climate damage has been taken as 3 to 6 per cent of the investments needed for building infrastructure resilience and accounting for climate-induced damages in the current context in different sectors, i.e., till 2030, these would in all probability increase in the coming decades. Hence, the amount of INR 72 trillion, is considered to be the adaptation gap that the GoI needs to bridge in the future.

It however needs to be stated that this adaptation gap cannot be met only through governmental resources and the financing requirements. Considering the increase in the adverse impacts of climate change as well as costs of resilience measures, significant contributions need to be channelized through bilateral and multilateral public finance and private investments.

Estimating the cost of adaptation involves many technical and empirical limitations. The estimates are based on several assumptions. Although the spending on certain key sectors, such as agriculture, water, coastal, energy, and disaster management, are considered, there may still be many missing and unknown aspects. Therefore, the estimate should be taken as conservative and indicative. While individual estimates are subject to uncertainty, it is clear that the adaptation finance required is significantly higher than the current adaptation finance estimation. Urgently increasing adaptation finance flows to India is a crucial requirement for India to be able to meet its long-term sustainable development and low-emission growth goals. India's adaptation finance needs are challenging to quantify.

3.6 Monitoring and Evaluation of Adaptation Actions and Processes

The Monitoring and Evaluation (M&E) mechanisms, to measure the physical and financial progress of programmes, are an integral part of each Ministry of the GoI. There exists a robust M&E framework at the national and State levels to measure the developmental and climate benefits of projects supported through bilateral and multilateral agencies and national and international climate funds NAFCC, Adaptation Fund (AF), GCF and GEF. Consistent with the NAPCC, all the States and UTs in the country have developed SAPCCs with some inbuilt M&E arrangements to ensure better measurement of adaptation impacts and to promote accountability and effective learning. However, the mainstreaming of the climate change agenda into the State level planning and sectoral line Departments has just been initiated and capacity building of actors for M&E of SAPCC activities is currently evolving in the country.

3.7 Information related to averting, minimizing and addressing loss and damage associated with climate change impacts

3.7.1 Observed and potential climate change impacts, including those related to extreme weather events and slow onset events, drawing upon the best available science

In the following, a brief overview of the key natural hazards in the Indian context is presented.

While heat waves, floods, and droughts in the hydrometeorological context are also discussed in detail elsewhere in the report, they are included here for completeness. It may be noted that loss and damage, under the rubric of disaster management, is a subject that is very actively studied with reference to India, which would be difficult to capture in its entirety in this chapter, except to note some key highlights and provide an overview.

To provide an authoritative account, in the following, relevant information is compiled from the web pages of the NDMA (NDMA, n.d.) and other related institutions, which is the statutory authority within the GoI and the nodal agency for disaster management in the country.

Heat Waves

A Heat Wave is defined as a period of abnormally high temperatures exceeding the normal maximum temperature typically observed during the summer season in the north-western parts of India. Heat Waves generally occur between March and June and, in some rare instances, extend up to July. The elevated temperatures and associated atmospheric conditions negatively impact the population in these regions by causing physiological stress, which can sometimes lead to fatalities.

The IMD has established the following criteria for declaring Heat Waves:

- A Heat Wave is not considered until the maximum temperature at a station reaches at least 40°C in plains and at least 30°C in hilly regions.
- When the normal maximum temperature of a station is less than or equal to 40°C, a Heat Wave is declared if the departure from normal temperature is between 5°C and 6°C; a Severe Heat Wave is declared if the departure from normal is 7°C or more.
- When the normal maximum temperature of a station exceeds 40°C, a Heat Wave is declared if the departure from normal temperature is between 4°C and 5°C; a Severe Heat Wave is declared if the departure is 6°C or more.
- A Heat Wave is also declared when the actual maximum temperature reaches or exceeds 45°C, irrespective of the normal maximum temperature.

Globally, higher daily peak temperatures and longer, more intense heat waves are becoming increasingly frequent due to climate change. India is experiencing this trend, with increasing instances of more intense heatwaves each year, resulting in severe health impacts and a higher number of heatwave-related casualties.

This pattern of rising temperatures and intensifying heat waves continues to affect India, causing considerable adverse effects on human health and increasing the frequency of heat-related mortality.

Floods

Several regions in India are significantly vulnerable to flooding. Of the total geographical area of 329 million hectares, more than 40 million hectares are considered flood prone. Floods are a recurring phenomenon that result in significant loss of life and cause extensive damage to livelihood systems, property, infrastructure, and public utilities. There is cause for concern as flood-related damages have shown an increasing trend over time. For instance, the average annual flood damage during the decade from 1996 to 2005 was INR 47.45 billion, considerably higher than the average of INR 18.05 billion recorded over the preceding 53 years. This increase can be attributed to multiple factors, including rapid population growth, accelerated urbanization, expanding development and economic activities in floodplains, and the possible effects of global warming.

On average, floods affect approximately 7.5 million hectares annually, resulting in the loss of around 1,600 lives each year and causing damage to crops, housing, and public utilities estimated at INR 18.05 billion. The highest number of fatalities occurred in 1977, with 11,316 lives lost. Major floods tend to occur more frequently than once every five years. In recent times, floods have also affected areas previously not recognized as flood prone.

Approximately 80 percent of annual precipitation occurs during the monsoon months, from June to September. Rivers transport heavy sediment loads from their catchment areas, which, in conjunction with the reduced carrying capacity of the rivers, contribute to flooding, drainage congestion, and riverbank erosion. Cyclones, cyclonic circulations, and cloudbursts trigger flash floods, causing substantial losses. Moreover, some rivers are responsible for flood damage in India originate in neighbouring countries, which adds complexity to flood management efforts.

The following table provides data on the flood-affected area at the State level during the period 1998-2022 (NRSC, 2023).

Table 3.21: Flood affected area at state level during period 1998-2022

State	No. of districts affected	Flood affected area (Ha)
Andhra Pradesh	24	738,200
Arunachal Pradesh	5	3373
Assam	35	2,464,958
Bihar	38	3,976,861
Chhattisgarh	12	12,029
Delhi	7	5,848

State	No. of districts affected	Flood affected area (Ha)
Gujarat	16	517,770
Haryana	9	67,852
Jammu & Kashmir	10	43,022
Jharkhand	2	2,966
Karnataka	26	280,156
Kerala	10	79,377
Madhya Pradesh	30	210,809
Maharashtra	20	233,590
Manipur	9	88,352
Meghalaya	2	8,787
Odisha	23	1,424,313
Rajasthan	10	155,144
Tamil Nadu	24	552,010
Telengana	24	102,318
Uttar Pradesh	72	2,662,942
Uttarakhand	2	7,604
West Bengal	20	1,969,750
TOTAL	435	15,750,723

Source: NRSC, 2023

Urban Floods

Urban flooding differs significantly from rural flooding because urbanization leads to developed catchments that increase flood peaks by a factor of 1.8 to 8 times and flood volumes by up to 6 times. This results in flooding occurring very rapidly, often within minutes, due to shorter flow times. Urban areas tend to be densely populated, and residents in vulnerable locations suffer from flooding, sometimes resulting in loss of life. Beyond the immediate flooding, secondary effects such as increased exposure to infections also contribute significantly to human suffering, loss of livelihood, and, in severe cases, mortality.

In recent years, urban flood disasters have shown an increasing trend across India, greatly affecting major cities. Some of the most notable incidents include flooding in Hyderabad (2000), Ahmedabad (2001), Delhi (2002 and 2003), Chennai (2004), Mumbai (2005), Surat (2006), Kolkata (2007), Jamshedpur (2008), Delhi again in 2009, and both Guwahati and Delhi in 2010.

A distinctive feature of India's climate is the heavy rainfall during the monsoon season. Besides monsoons, other weather systems also contribute considerable rainfall, while storm surges frequently impact coastal cities and towns. The sudden or uncontrolled release of water from dams can also cause severe flooding. Furthermore, the urban heat island effect has led to increased rainfall over urban areas. Changes in weather patterns due to global climate change have resulted in more frequent episodes of intense rainfall over shorter durations. Additionally, the threat of sea-level rise endangers all coastal cities. Cities and towns located along the coast, on riverbanks, upstream or downstream of dams, inland urban centres, and those in hilly areas are all susceptible to flooding.

Historically, stormwater drainage systems were designed to handle rainfall intensities of 12 to 20 millimeters per hour. However, these capacities are frequently overwhelmed during events of higher intensity rainfall. Moreover, drainage systems often fail to perform at designed capacities due to inadequate maintenance. Encroachments have also become a significant issue in many cities and towns. Natural streams and watercourses have formed over thousands of years due to the flow of water within their watersheds. As human settlements expanded into towns and cities alongside rivers and watercourses, the volume of runoff increased in proportion to urbanization. Ideally, natural drains should have been widened to accommodate the increased stormwater flows, much like roads are widened to handle greater traffic. Contrary to this, large-scale encroachments on natural drains and river floodplains have occurred, reducing the capacity of drainage channels and leading to increased flooding. Improper disposal of solid waste, including domestic, commercial, and industrial refuse, along with the dumping of construction debris into drains, significantly contributes to the reduction of their capacity. Therefore, improved operational and maintenance measures are imperative to address these challenges.

Landslides

Landslides and avalanches represent significant hydro-geological hazards that impact extensive regions of India, including the Himalayas, the Northeastern hill ranges, the Western Ghats, the Nilgiris, the Eastern Ghats, and the Vindhyas, collectively covering approximately 15 percent of the country's land area. The Himalayas experience landslides of varying types and scales, ranging from large to small, rapid to slow-moving, and including both ancient and recent occurrences. The Northeastern region faces a diverse array of landslide challenges. Specific areas such as the Darjeeling district in West Bengal, along with Sikkim, Mizoram, Tripura, Meghalaya, Assam, Nagaland, and Arunachal Pradesh, encounter persistent landslide issues that cause recurring economic losses amounting to billions of rupees. In the Western Ghats and Nilgiris, a distinct category of landslides characterized by a lateritic cap consistently threatens these areas, particularly on steep slopes overlooking the Konkan coast.

Several prominent landslide events have been documented, including the Varnavat landslide in Uttarkashi District, the Malpha landslide in Pithoragarh District, the Okhimath landslide in Chamoli District, and occurrences in the Darjeeling District as well as in Sikkim and Aizawl, Mizoram. These examples illustrate some of the more recent landslide incidents. Addressing this issue effectively requires targeted mitigation and management efforts, starting with the identification of landslide hazard zones. Specific landslides need to be stabilized and managed through appropriate interventions, complemented by the establishment of monitoring systems and early warning mechanisms at selected vulnerable sites.

A general landslide hazard map for India delineates various hazard zones across different states, demonstrating notably high vulnerability in the Northwestern and Northeastern Himalayas, as well as the Western Ghats, which are recognized as regions highly susceptible to landslides.

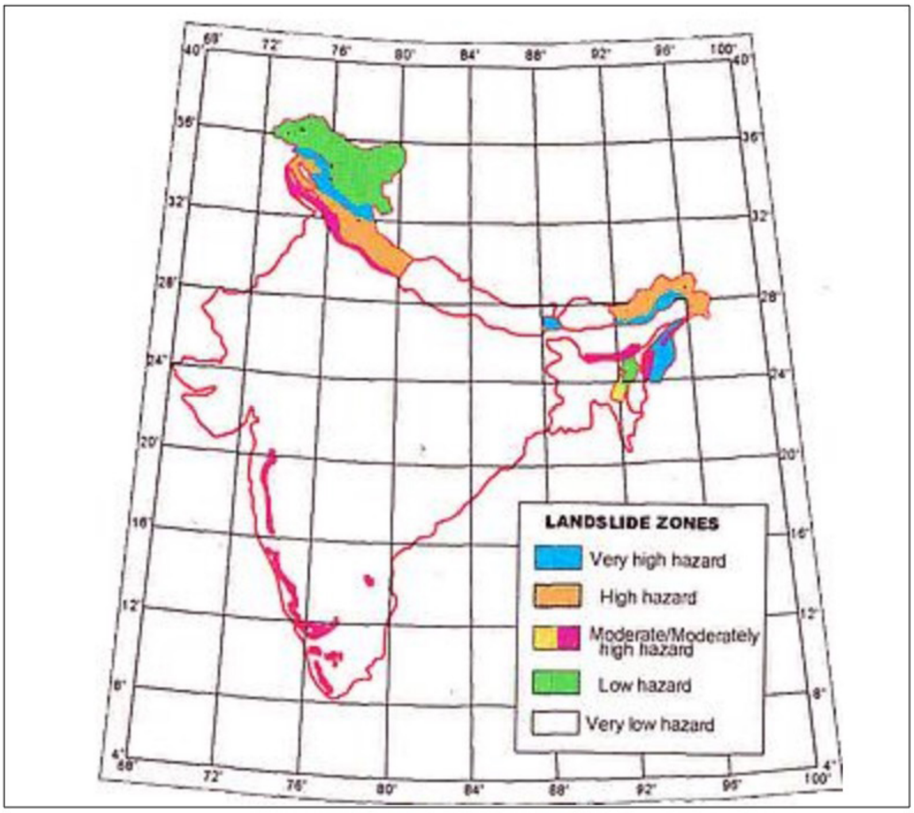

Figure 3.34: Landslide hazard map. Source: NDMA (n.d)

The NDMA guidelines are employed for the preparation of Landslide Hazard Zonation (LHZ) maps, which are produced at a scale of 1:50,000 and at progressively larger scales for specific high-risk areas. Multiple institutions, including the National Remote Sensing Centre (NRSC), the DST, the CSIR, Indian Institutes of Technology (IITs), and various universities, have made significant contributions in this domain. The NRSC has developed a detailed atlas covering selected corridors in Uttarakhand and Himachal Pradesh, providing valuable resources for landslide assessment and management. Furthermore, the DST has supported over 30 research projects across India through different academic institutions; reports from these projects can be obtained from the DST, as referenced by the NDMA.

Cyclones

The Indian subcontinent is one of the most cyclone-affected regions globally. With an extensive coastline measuring 11,099 km, it is exposed to nearly 10 percent of the world's tropical cyclones. A majority of these cyclones originate over the Bay of Bengal and predominantly make landfall along the eastern coast of India. On average, five to six tropical cyclones form each year, of which two or three may reach severe intensity. Cyclones occur more frequently in the Bay of Bengal than in the Arabian Sea, with an approximate ratio of 4:1. Both the western coast (Arabian Sea) and the eastern coast (Bay of Bengal) experience cyclonic activity regularly. An analysis of cyclone frequency between 1891 and 1990 indicates that around 262 cyclones affected a 50-kilometer-wide strip along the eastern coast, with 92 classified as severe. In comparison, the western coast experienced 33 cyclones during the same period, including 19 severe events.

In India, cyclones are classified based on three parameters: the strength of associated winds, storm surges, and exceptional rainfall occurrences. The IMD has formulated criteria for classifying low-pressure systems in the Bay of Bengal and Arabian Sea, which is adopted by the World Meteorological Organization (WMO). These classifications are as follows:

Table 3.22: Criteria for classifying low-pressure systems in Bay of Bengal and Arabian sea

Type of Disturbances	Wind Speed in Km/hr	Wind Speed in Knots
Low Pressure	Less than 31	Less than 17
Depression	31-49	17-27
Deep Depression	49-61	27-33
Cyclonic Storm	61-88	33-47
Severe Cyclonic Storm	88-117	47-63
Super Cyclone	More than 221	More than 120

Source: NDMA (n.d.)

Tropical cyclones generally occur during the months of May-June and October-November. In the North Indian Ocean, cyclones of severe intensity and frequency exhibit a bi-modal distribution pattern, with a primary peak in November and a secondary peak in May. The disaster potential is particularly high during landfall in this region, which includes the Bay of Bengal and Arabian Sea, due to the combined effects of destructive winds, storm surges, and torrential rainfall. Of these, storm surges contribute the most damage by flooding low-lying coastal areas with seawater, leading to extensive floods, erosion of beaches and embankments, destruction of vegetation, and degradation of soil fertility.

Cyclones vary in diameter from 50 to 320 kilometers but can impact thousands of square kilometers of ocean surface and the lower atmosphere. While their perimeter may extend to 1,000 kilometers, the core energy, or "powerhouse," is generally confined within a 100-kilometer radius. Near the eye of the cyclone, wind speeds can reach up to 320 kilometers per hour. Tropical cyclones, characterized by these destructive winds, heavy rainfall, and storm surges, disrupt normal life and are commonly accompanied by floods resulting from exceptional rainfall and storm surge penetration into inland areas. These cyclones have significant destructive potential, damaging structures such as houses, lifeline infrastructure including power and communication towers, hospitals, food storage facilities, roads, bridges, culverts, and crops. The majority of fatalities related to cyclones result from storm surges and the flooding of low-lying coastal regions caused by torrential rains.

The map below shows the cyclone zones in India categorized by damage risk.

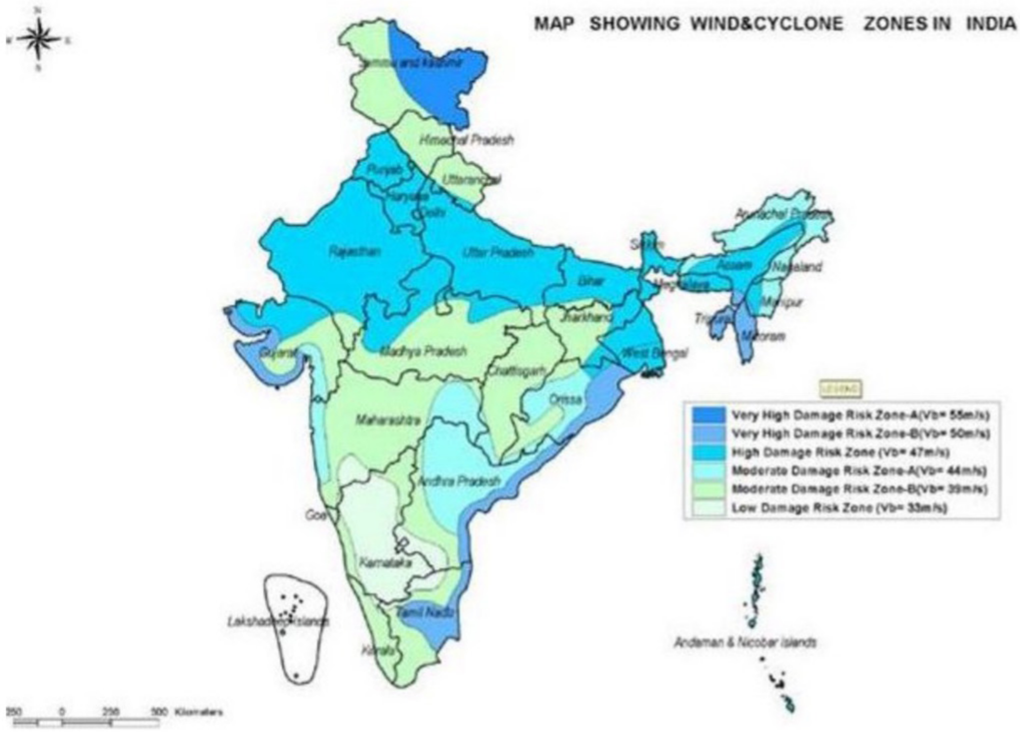

Figure 3.35: Wind, Cyclone zones in India Source: NDMA (n.d.)

Estimates of damages from hydrometeorological disasters

The table below gives the estimates of damages from weather disasters during the period 2022-2024 (DTE, 2025). The disasters considered are heavy rains, floods, landslides, lightning & storms, heatwaves, cold waves, cloudbursts, snowfall, and cyclones.

Table 3.23: Estimates of damages from weather disasters (2022-2024)

State/Union Territory	Human Deaths (2022-2024)	Crop Area Affected (ha) (2022-2024)	Property Damaged (2022-2024)	Animal Deaths (2022-2024)
Andhra Pradesh	147	4,24,686	85,998	532
Arunachal Pradesh	55	105	1,406	60
Assam	554	3,42,433	3,85,578	56,515
Bihar	1,093	3,37,000	1,486	0
Chattisgarh	331	18,180	4,798	832
Delhi	7	30	216	3
Goa	8	175	364	0
Gujarat	224	40,000	20,500	100
Haryana	55	2,500	2,000	20
Himachal Pradesh	675	500	150	35
Jammu & Kashmir	400	15,000	6,000	150
Jharkhand	260	15,000	1,500	450
Karnataka	190	60,000	30,000	900
Kerala	520	70,000	28,000	320
Madhya Pradesh	430	25,000	5,000	480

Maharashtra	380	1,00,000	40,000	1,200
Manipur	45	300	800	20
Meghalaya	60	2,000	900	40
Mizoram	25	150	700	10
Nagaland	40	100	600	15
Odisha	800	1,10,000	50,000	1,000
Punjab	55	1,200	800	25
Rajasthan	300	7,000	2,200	100
Sikkim	30	70	400	5
Tamil Nadu	140	33,000	18,000	700
Telangana	90	25,000	14,000	300
Tripura	35	200	800	15
Uttar Pradesh	500	50,000	10,000	150
Uttarakhand	250	15,000	3,500	120
West Bengal	750	1,20,000	55,000	1,000

Source: DTE, 2025

3.7.2 Activities related to averting, minimizing and addressing loss and damage associated with the adverse effects of climate change

India's disaster risk reduction (DRR) framework is anchored in the Disaster Management (DM) Act, 2005, which provides the legal and institutional basis for a comprehensive and coordinated approach to disasters. The Act mandates the preparation of the National Disaster Management Plan (NDMP), first formulated in 2016 and subsequently revised in 2019, which integrates prevention, preparedness, response, recovery, and reconstruction. The NDMP provides a comprehensive strategy for all phases of the disaster management cycle and is aligned with the Sendai Framework for Disaster Risk Reduction, the SDGs, the Paris Agreement (2015), and the Prime Minister's 10-Point Agenda. It brings together ministries, departments, and agencies across central, state, and district levels, clearly defining their roles and responsibilities to minimise ambiguity and strengthen disaster-resilient efforts. Complementing this, the National Policy on Disaster Management (NPDM) of 2009 envisions building a safe and disaster-resilient India through a holistic, multi-disaster and technology-driven approach based on prevention, mitigation, preparedness, and response.

Additionally, India established the National Platform for Disaster Risk Reduction (NPDRR) in 2013 as a multi-stakeholder, multi-sectoral mechanism to enhance participatory decision-making in disaster management. NPDRR brings together the Central and State Governments, local authorities, civil society, private sector, academia, and community representatives. Its functions include reviewing the progress of disaster management, appraising the implementation of policies, and advising on coordination among governments and stakeholders. The third session of NPDRR, held in 2023 on the theme "Building Local Resilience in Changing Climate", highlighted priorities such as mainstreaming DRR into social and economic sectors, improving risk governance, building a national integrated response system, capacity building, strengthening local resilience, and fostering technology & innovation in DRR.

The NDMA is the apex body responsible for policy, planning, and coordination. It issues guidelines, frameworks, and oversight. So far, NDMA has issued 38 guidelines for the management of hazard-specific disasters on various thematic and cross-cutting issues. Additionally, the NIDM supports research, capacity building, training, risk/vulnerability assessments and development of DRR and climate change adaptation integration tools. The subsequent section summarises key activities, measures, initiatives and schemes in this domain that are currently in place.

Measures, Initiatives and Activities:

1. **Technology, Data and Early Warning Dissemination Systems (EWDS):** Technology has been integrated into India's disaster preparedness framework through tools such as the Web-based Dynamic Composite Risk Atlas (Web-DCRA) and Decision Support System (DSS), which has been used effectively in planning for cyclones such as Biparjoy (June, 2023) and Michaung (December, 2023), improves risk assessment and overall response planning for cyclones in advance. The India Disaster Response Network (IDRN) maintains an updated database of disaster response equipment at the district level to facilitate quick mobilisation. Early warning systems have also been significantly upgraded under NCRMP, providing timely alerts to coastal communities. Early warning and technological innovations have been prioritised through initiatives such as the Common Alerting Protocol (CAP)-based Integrated Alert System (SACHET) developed by Centre of Development of Telematics (C-DOT), which modernises disaster alerts and ensures last-mile reach by integrating multiple agencies and disseminating of geo targeted early warnings/alerts related to disasters to the citizens of India for all 36 States/UTs in regional languages using various disseminating medium like SMS, TV, Radio, Indian Railways, Costal Sirens, Cell broadcast, Internet (RSS feed & Browser Notification), Satellite Receiver of GAGAN & NavIC etc.

2. **Institutional Strengthening and Response Capacity through National Disaster Response Force (NDRF):** India has progressively built its disaster response capacity by expanding the NDRF, which now has 16 fully operational battalions for immediate response. NDRF regularly conducts mock drills in all 36 states/UTs on disaster awareness. To ensure a systematic approach to training, the foundation stone for an NDRF Academy was laid in 2020. Additionally, the government has also institutionalised the practice of deploying Inter-Ministerial Central Teams (IMCTs) immediately after a natural calamity, ensuring quicker assessments and support without waiting for a formal memorandum from affected states. In case of a disaster of a 'severe nature', additional financial assistance is extended from the National Disaster Response Fund, based on the visit and assessment by IMCT.

3. **International cooperation through Coalition for Disaster Resilient Infrastructure (CDRI):** A major initiative in strengthening resilience has been the establishment of the CDRI, launched by India at the United Nations General Assembly (UNGA) Climate Action Summit in 2019. It is a collaborative effort of various national governments, international organisations, and the private sector that aims at enhancing the resilience of infrastructure systems to climate and disaster risks. With 39 countries and 7 international organisations as members, the CDRI has developed specialised programmes, such as the Infrastructure for Resilient Island States (IRIS), to deliver resilience and climate adaptation solutions to Small Island Developing States (SIDS), launched at COP-26 in 2021.

4. **Capacity Building, Training and Community Awareness:** Training and capacity building are central to India's disaster risk reduction efforts. Under the National Cyclone Risk Mitigation Project (NCRMP), through 925 capacity building trainings, nearly 24,007 government officials across priority sectors such as health, education, Panchayat Raj Institutions, Urban Local Bodies, and Rural Development, as well as 68,988 community representatives, have been trained in critical disaster response skills, including first aid, search and rescue, and shelter management. The NDRF regularly conducts mock exercises in all states and union territories, covering hazards such as floods, cyclones, earthquakes, landslides, and other emergencies. Additionally, special School Safety Programmes are carried out to impart training on disaster response to children in vulnerable schools.

5. **Knowledge and Research Networks:** Recognising the role of education and research, the Indian Universities and Institutions Network for Disaster Risk Reduction (IUINDRR-NIDM) was established under the National Institute of Disaster Management. It now brings together over 300 universities and institutions to develop curricula, training modules, and collaborative research on disaster resilience. It also provides a platform and opportunities for dialogue between the government, experts, and community representatives.

6. **Relief and Financial Assistance Mechanisms:** Financial assistance for disasters is primarily provided through the State Disaster Response Fund (SDRF), which covers relief for twelve notified disasters. In situations of 'severe nature' of disasters, additional support is extended through the NDRF, based on assessments by IMCT after visiting the disaster-affected region. These funds are designed to provide immediate relief rather than compensation.

7. **Recognition and Motivation:** To encourage excellence in disaster management, the GoI instituted the Subhash Chandra Bose Aapda Prabandhan Puraskar in 2018–19. This annual award recognises outstanding contributions by individuals and institutions in the field of disaster management, and is announced on 23rd January, the birth anniversary of Netaji Subhash Chandra Bose.

Schemes for Disaster Risk Reduction and Response:

1. **Aapda Mitra Scheme:** The Aapda Mitra Scheme focuses on building community-level capacity by training one lakh volunteers across 350 multi-hazard prone districts across all States and UTs. These volunteers, known as Aapda Mitra or Aapda Sakhi, undergo two weeks of intensive training, receive Emergency Responder Kits (ERK), and are provided with insurance cover for five years. Each district also provided with an Emergency Essential Resource Reserve (EERR) to support these volunteers during disasters.

2. **National Landslide Risk Mitigation Programme (NLRMP) & Landslide Risk Mitigation Scheme (LRMS):** The NLRMP has been approved with an outlay of INR 10 billion to support 15 landslide-prone states/UTs in implementing landslide risk mitigation projects/activities. This programme enables states to develop area-specific measures to reduce risks, with priority given to highly vulnerable regions such as Kerala's Wayanad district. In addition, the Government had also initiated the Landslide Risk Mitigation Scheme (LRMS) in 2019 with a total financial outlay of INR 439.1 million, which provides central assistance to four vulnerable States, viz. Sikkim, Mizoram, Nagaland and Uttarakhand, for disaster preparedness and build their capacity to take up other landslide mitigation projects in future.

3. **National Cyclone Risk Mitigation Project (NCRMP):** The NCRMP is a major initiative to undertake suitable structural and non-structural measures to mitigate the effects of cyclones as well as reduce cyclone-related risks in cyclone-prone coastal states of India. Implemented in multiple phases, it includes four major components, namely, the Early Warning Dissemination System (EWDS), Cyclone Risk Mitigation Infrastructure (CRMI), Technical Assistance for Capacity Building on Disaster Risk Management and Project Management and Monitoring.

4. **Common Alert Protocol (CAP) Scheme:** The CAP scheme with an initial financial outlay of INR 3.5483 billion in March 2021, provides geo-targeted disaster alerts to citizens, including in regional languages, through various disseminating medium like SMS, television, radio, Indian Railways, coastal sirens, internet feeds, and satellite receiver of GAGAN and NavIC, across all States/UTs of India. By mid-2025, more than 43 billion alerts have been disseminated successfully, enhancing India's ability to provide timely warnings.

5. **Emergency Response Support System (ERSS – Dial 112):** The ERSS offers a single nationwide emergency number (112) to handle all types of distress calls, including those related to disaster emergencies. The system leverages technology for quick response, thereby reducing potential loss of life and property.

6. **National Disaster Response Reserve (NDRR):** Set up with a corpus fund of INR 2.5 billion, on the recommendation of the 13th Finance Commission in 2014, the NDRR maintains essential relief materials to provide immediate assistance to up to 0.4 million affected people, ensuring rapid availability of critical resources in disaster-hit areas. Its main aim is to maintain an inventory of necessary relief equipment from Central resources for at least a population of 0.25 million in the plain areas and for a minimum of 0.15 million population in hilly areas.

7. **National Disaster Mitigation Fund (NDMF) and State Disaster Mitigation Fund (SDMF):** Constituted in 2021 as a part of the 15th Finance Commission Grants, the NDMF and SDMF provide dedicated financial resources for proactive mitigation. With allocations of INR 136.93 billion and INR 320.31 billion for NDMF and SDMF, respectively, these funds support structural and non-structural measures aimed at reducing disaster risks. The fund is mainly designated for planning and executing hazard-specific mitigation projects and programs, focusing on local and community-level initiatives to enhance resilience within communities.

8. **Modernisation of Fire Services Scheme:** To strengthen state fire services, the Government has allocated INR 50 billion for their expansion and modernisation. This scheme, supported under the preparedness and capacity-building window of the NDRF, ensures better equipment, training, and resources for managing urban and industrial hazards. In this context, the Model Fire Bill was circulated in 2019 to amend fire safety legislation across all States/UTs.

9. **National Disaster Management Information System (NDMIS):** The NDMIS is an integrated online platform that tracks expenditure under SDRF and NDRF, monitors contributions from both the Centre and States, and captures disaster damage and loss data. It also facilitates monitoring of targets A, B, C and D under the Sendai Framework for Disaster Risk Reduction, as well as implementation progress of the Sendai Framework for Disaster Risk Reduction across all States/UTs.

3.7.3 Institutional Arrangements to Facilitate Implementation of Loss & Damage Activities

As noted in the opening paragraphs of 3.7.2 above, India's institutional framework for disaster management operates through a multi-level structure established under the Disaster Management Act, 2005 (GOI, 2005), which provides the institutional foundation for addressing loss and damage from disasters and climate impacts. Within this framework, DRR constitutes a core aspect, aimed at minimising loss and damage, while response and recovery mechanisms address residual impacts. The institutional mechanism operates through national, state, district, and local levels with defined roles and responsibilities at each tier as specified in the DM Act 2005. This structure has evolved significantly since its inception to facilitate both ex-ante preventive measures and ex-post response and recovery activities for addressing loss and damage. Together, these arrangements mean that the institutional structure created under the DM Act serves as the primary channel through which India operationalises its commitments to minimising and addressing loss and damage, with the national, state, and district authorities functioning as the key implementing arms.

National Level Institutional Mechanisms

The overall coordination of disaster management is vested with the Ministry of Home Affairs, while the Cabinet Committee on Security and the National Crisis Management Committee function as key committees for top-level decision-making (NDMA, 2019). The NDMA, established under Section 3 of the DM Act 2005 with the Prime Minister as Chairperson and up to nine nominated members, serves as the apex body responsible for laying down policies, plans, and guidelines for disaster management (GOI, 2005). The NDMA approves the NDMP and disaster management plans of central ministries and departments, coordinates their enforcement and implementation, and takes measures for prevention, mitigation, preparedness and capacity building for disaster situations (NDMA, 2019). The institutional structure represents coordination for decision-making and communication with central agencies participating on request from state governments.

The National Executive Committee, chaired by the Union Home Secretary, comprises secretaries from ministries including Agriculture, Atomic Energy, Defence, Drinking Water and Sanitation, Environment Forests and Climate Change, Finance, Health and Family Welfare, Power, Rural Development, Science and Technology, Space, Telecommunications, Urban Development, and Water Resources, along with the Chief of Integrated Defence Staff (GOI, 2005). The NEC assists NDMA in the discharge of its functions, coordinates and monitors implementation of the National Plan and policies, ensures compliance with central government directions, and coordinates response during disaster situations (NDMA, 2019). The NEC directs relevant ministries, departments, and state governments regarding measures for disaster response, coordinates with armed forces, Central Armed Police Forces (CAPF), and NDRF for response operations, and ensures coordination with scientific institutions for early warning and monitoring.

The NIDM, constituted under Chapter VII of the DM Act 2005, functions as the institute for capacity development with nodal responsibilities for human resource development, capacity building, training, research, documentation, and policy advocacy in disaster management (GOI, 2005). NIDM operates within the framework of policies and guidelines laid down by NDMA, provides technical support to state governments through Disaster Management Centres in Administrative Training Institutes, and maintains strategic partnerships with central, state, and local governments, academic institutions, and international agencies (NIDM, 2023). The institute designs and implements training programmes, undertakes research, formulates human resource development plans, develops educational materials for dissemination, and assists in national policy.

State and Local Level Arrangements

According to the DM Act 2005, each state and Union Territory shall establish its own institutional framework for disaster management, with a nodal department for coordinating disaster management, referred to as the

DM department, although the name varies across states (NDMA, 2019). The Act mandates that each state/ UT shall take necessary steps for the preparation of disaster management plans, integration of measures for prevention or mitigation into development plans, allocation of funds, and establishment of early warning systems (GOI, 2005). Each state prepares its own State Disaster Management Plan aligned with national guidelines while incorporating state-specific requirements.

State Disaster Management Authorities function under Chapter III of the DM Act with the Chief Minister as Chairperson, except in Union Territories where the Lieutenant Governor or Administrator serves as Chairperson (GOI, 2005). For the UT of Delhi, the Lieutenant Governor and Chief Minister serve as Chairperson and Vice-Chairperson, respectively, while in UTs with a Legislative Assembly except Delhi, the Chief Minister chairs the Authority (NDMA, 2019). The SDMA lays down policies and plans for disaster management in the state, approves dis- aster management plans prepared by departments, approves the State Plan in accordance with NDMA guidelines, coordinates implementation of the State Plan, recommends provision of funds for mitigation and preparedness measures, and reviews developmental plans of different departments to ensure integration of prevention, preparedness and mitigation measures (GOI, 2005).

State Executive Committees (SEC) assist SDMAs in the performance of their functions, headed by the Chief Secretary to the State Government (NDMA, 2019). The SEC coordinates and monitors implementation of the National Policy, National Plan, and State Plan while providing information to NDMA relating to different aspects of disaster management (GOI, 2005). These committees ensure coordination across state departments and facilitate integration of disaster risk reduction into state development planning processes.

District Disaster Management Authorities, established under Chapter IV of the DM Act for every district, are headed by the District Collector, Deputy Commissioner, or District Magistrate with the elected representative of the local authority as Co-Chairperson (GOI, 2005). The State Government appoints an officer not below the rank of Additional Collector, Additional District Magistrate, or Additional Deputy Commissioner as Chief Executive Officer of the District Authority (NDMA, 2019). The DDMA acts as the planning, coordinating, and implementing body for disaster management at the district level, takes all necessary measures for disaster management in accordance with guidelines laid down by NDMA and SDMA, prepares the disaster management plan for the district, and monitors implementation of all relevant national, state, and district policies and plans (GOI, 2005). DDMAs ensure that guidelines for prevention, mitigation, preparedness, and response measures laid down by NDMA and SDMA are followed by all district-level offices of various departments of the State Government.

Sectoral Integration Mechanisms

The institutional framework recognizes that disasters impact multiple sectors and therefore requires sectoral integration for effective loss and damage minimization. Key ministries have established dedicated disaster management cells that develop sector-specific contingency plans and coordinate with NDMA for an integrated response. The Ministry of Agriculture's Crisis Management Plan (MoAFW, 2021) addresses drought and pest attacks that affect agricultural production and farmer livelihoods. The Ministry of Water Resources, through the Central Water Commission, manages flood forecasting and warning systems covering major river basins (Central Water Commission, 2024). The Ministry of Earth Sciences coordinates multiple technical agencies, including the India Meteorological Department for meteorological disasters and the Indian National Centre for Ocean Information Services for coastal system warnings (INCOIS, 2022).

Scientific and technical institutions play an important role in providing the knowledge base for disaster risk reduction activities. The IMD operates early warning systems for cyclones, extreme weather events, and climate-related hazards with increasing accuracy and lead time (IMD, 2024a). The CWC maintains a network of flood forecasting stations (Central Water Commission, 2024), providing real-time information for flood management. The Geological Survey of India conducts landslide susceptibility mapping in hilly regions, while the Indian Space Research Organization provides critical support through emergency communication systems and satellite-based damage assessment capabilities, enabling rapid response and recovery planning.

Financial Institutional Mechanisms

The financial framework for disaster management in India is shaped both by statutory provisions under the DM Act 2005, and by successive recommendations of the Finance Commissions. The Act provides for the creation of dedicated response and mitigation funds at both national and state levels, while the Finance Commissions determine the size of these funds and the Centre–State sharing patterns.

For the 2021–26 period, the 15th Finance Commission recommended a total corpus of INR 1.60153 trillion for the State Disaster Risk Management Fund (SDRMF) (Fifteenth Finance Commission, 2021a). This corpus is divided into the SDRF with 80% of the allocation and the SDMF with the remaining 20%. Funding for the SDRMF follows a cost-sharing pattern in which the GoI contributes 75% for general category states and 90% for special category states, with the balance provided by the states (Fifteenth Finance Commission, 2021b). SDRFs are managed by the SEC, chaired by the Chief Secretary, and serve as the primary resource for providing relief to affected populations. If the scale of a disaster exceeds the coping capacity of a state, additional assistance may be sought from the national-level funds.

At the national level, the current Finance Commission recommended a separate allocation of the National Disaster Risk Management Fund (NDRMF), to be split in the same 80:20 ratio between the NDRF and the NDMF (Fifteenth Finance Commission, 2021c). The NDRF is constituted under Section 46 of the Disaster Management Act and is operated by the Ministry of Home Affairs (MHA). Releases are made on the recommendations of the MHA and with the approval of a High-Level Committee chaired by the Union Home Minister (GOI, 2005; MHA, 2012). Financing of NDRF is through budgetary provisions of the GoI, with the Ministry of Finance facilitating the release of funds as grants-in-aid once approval is accorded.

The creation of dedicated mitigation funds (SDMF and NDMF) is an important policy shift toward proactive investment in risk reduction, complementing the traditional focus on relief and response. While the NDMF has not been fully operationalised, mitigation projects are supported through allocations recommended by successive Finance Commissions and approved by the Empowered Committee under the MHA (MHA, 2022). This integrated system of response and mitigation funds ensures that resources are available for both immediate disaster relief and long-term resilience building.

Implementation of Sendai Framework for Disaster Risk Reduction

India implements the Sendai Framework for Disaster Risk Reduction 2015–2030 through institutional arrangements led by the Ministry of Home Affairs and coordinated with the National Disaster Management Authority, states, and sectoral ministries. The national focal point for Sendai reporting is the Ministry of Home Affairs (UNDRR, 2023a), and India has documented its progress in the Voluntary National Report for the Sendai Midterm Review, which outlines institutional responsibilities for monitoring and data flows (GOI, 2024). Progress in Sendai is reported through the Sendai Framework Monitor (SFM), UNDRR's online platform for tracking the seven global targets (UNDRR, 2023b). Within India, the MHA and NDMA coordinate inputs from central ministries and states, supported by the National Database for Emergency Management (NDEM), operated by NRSC–ISRO, which provides geospatial data layers and decision-support tools across all disaster phases (ISRO, 2023; NRSC, 2023). States and line departments submit administrative statistics through systems such as the NDMIS and State Emergency Operation Centres, with central consolidation by MHA/NDMA as described in official training and reporting materials (GOI, 2024; NDMA, 2023a).

Indicator production under the Sendai Framework relies on multiple sources. Mortality statistics (Target A) are derived from the Health Management Information System maintained by the MoHFW (GOI, 2024; MoHFW, 2022). Data on affected populations (Target B) are compiled from state-level submissions and consolidated centrally, supported by geospatial layers from NDEM (GOI, 2024; NRSC, 2022). Economic loss and infrastructure damage (Targets C and D) are estimated in consultation with the Ministry of Finance and relevant infrastructure ministries, following United Nations Office for Disaster Risk Reduction (UNDRR's) indicator methodology, while NDMA guidance standardises field protocols for rapid damage assessments (GOI, 2024). NDMA also oversees the monitoring of national, state, and local disaster risk reduction strategies (Target E) and reports these through the SFM (GOI, 2024). International cooperation and early warning capacities (Targets F and G) are coordinated by MHA and NDMA with the Ministry of External Affairs.

Finally, alignment with the SDGs is ensured through India's SDG monitoring framework, led by NITI Aayog via the SDG India Index, which provides a bridge between Sendai indicators and national development priorities (NITI Aayog, 2024a). Together, these arrangements demonstrate that India's implementation of the Sendai Framework is based on an integrated system combining administrative statistics, geospatial tools such as NDEM, and the UNDRR's global monitoring platform, enabling consistent progress tracking and policy course-correction.

Coordination Mechanisms for L&D Activities

The effectiveness of institutional arrangements depends significantly on coordination mechanisms operating both vertically and horizontally. Vertical coordination ensures the flow of information and resources from national to state to district to local levels (NDMA,2019). The top-down flow involves translation of national guidelines into state-specific implementation strategies, cascading of financial resources through established channels, and provision of technical support from specialised agencies to field-level functionaries. Conversely, the bottom-up flow ensures that damage, loss and needs assessments initiated at village and block levels are aggregated through district and state authorities and, when required, compiled into a state relief plan for consideration by central government agencies (NDMA,2020), thereby enabling evidence-based resource allocation and policy adjustments grounded in local realities.

Horizontal coordination mechanisms are critical for integrating disaster management efforts across ministries, states, and non-governmental stakeholders. At the national level, inter-ministerial coordination is led by the National Executive Committee, chaired by the Union Home Secretary, which brings together senior officials from key ministries to ensure coherence of disaster response and preparedness measures. In the event of major calamities, the Cabinet Secretariat, under the Prime Minister's Office, provides high-level coordination to align the actions of central ministries with national priorities. This arrangement ensures that disaster management responsibilities are shared across all relevant departments rather than concentrated in a single agency. Inter-state coordination is facilitated by mechanisms supported by the Inter-State Council Secretariat, which help states address transboundary disasters such as floods and cyclones that cut across administrative boundaries.

Beyond the public sector, the private sector contributes through public–private partnerships and initiatives under corporate social responsibility. NDMA guidelines on private sector engagement provide a framework for mobilising resources, technical expertise, and innovation, thereby expanding the national capacity for disaster risk management

Strengthening Measures and Way Forward

India's disaster management system has evolved considerably since the enactment of the DM Act, 2005, but important challenges remain. Capacity gaps at local levels, particularly in remote and rural areas, continue to limit effective implementation of disaster risk reduction measures, as acknowledged in recent policy discussions (MHA,2023). Mainstreaming disaster risk reduction into development planning has been a stated national priority since the NDMP 2019, and India's Sendai Midterm Review (2024) highlights that this remains an ongoing area requiring further strengthening across sectors. There are budgetary and implementation shortfalls in the disaster management domain, underscoring the need for stronger institutional follow-through (PSC, 2023). In addition to these resource and delivery constraints, there is insufficient attention to non-economic losses, such as losses not captured by market valuation, which also restricts comprehensive impact assessments. The Sikkim Conclave "Loss and Damage" document of NDMA defines non-economic losses as "items that are not commonly traded in markets" and calls for better inclusion of these in assessments (NDMA,2023b). In many cases, private sector engagement in India's disaster risk management has been largely via corporate social responsibility programs. This constrains the use of private capital and specialist expertise in preparing for disasters.

To address the gaps, several measures are underway. The Aapda Mitra programme currently aims to train around 6,000 community volunteers (200 per district in 30 particularly flood-prone districts) to strengthen local-level preparedness. A scheme launched more recently Yuva Aapda Mitra, seeks to train 237,326 youth volunteers in 315 districts to act as first responders (PIB, 2024). Disaster risk reduction and climate change adaptation are also being mainstreamed into flagship development programmes such as the Smart Cities Mission, AMRUT, and Pradhan Mantri Awas Yojana, as shown in the MHA-UNDP study on flagship schemes (MHA & UNDP, 2019). Additionally, frameworks for climate risk assessment, such as the District-Level Climate Risk Assessment (DST) and the "Framework for India Climate Risk Management" developed by NIDM, help to better integrate disaster and climate risks into planning and policy (Dasgupta et al, 2024).

These initiatives reinforce India's multi-level institutional framework and connect national disaster risk reduction measures with global commitments under the Sendai Framework. Going forward, sustained investment in local capacities, systematic integration of DRR into sectoral development policies, explicit accounting of non-economic losses, stronger financial dissemination to frontline institutions, and deeper private sector participation beyond corporate social responsibility will be critical for minimising and addressing loss and damage in the context of intensifying climate and disaster risks.

3.8 Cooperation, Good Practices, Experiences and Lessons Learned

India has made substantial progress in climate adaptation through both international and national cooperation. At the international level, India aligns its climate adaptation goals with the Paris Agreement, particularly its NDCs, which emphasize sustainable development and climate resilience. India also works closely with global partners, receiving funding and technical assistance from entities such as the GEF to implement climate-resilient initiatives, including water resource management and agriculture diversification. Additionally, India collaborates through South-South Cooperation, sharing its climate adaptation knowledge with other developing countries. Bilateral partnerships with countries like Germany, Japan, and the UK are instrumental in implementing climate adaptation strategies in areas like disaster risk management and sustainable urban development.

Coalition for Disaster Resilient Infrastructure (CDRI)

The range of adaptation efforts in the domestic sectors has been highlighted in previous sections. This section focuses on India's key initiative in adaptation in the international arena, the CDRI.

An India-led initiative launched in September 2019 at the New York Climate Action Summit, the CDRI, is a partnership of national governments, UN Agencies and programmes, Multilateral development banks and financing mechanisms, the private sector, and knowledge institutions that aim to promote the resilience of new and existing infrastructure systems to climate and disaster risks in support of sustainable development (CDRI, 2023). While at the time of inception, 12 countries were the founding members, and as of August 2023, this membership has increased to 31 nations, 6 international organizations, and two (2) private sector organizations. The following are the initiatives being undertaken by CDRI for building resilience:

Infrastructure for Resilient Island States (IRIS)

Serving as a 'knowledge centre', this initiative gives priority to the small island nations for the creation of resilient infrastructure by providing technical support to 58 SIDS across the Caribbean, the Pacific Ocean, the Atlantic, the Indian Ocean, the Mediterranean and the South China Sea. Through its work, IRIS predominantly seeks to deliver and achieve the following outcomes:

i. Improved Resilience of SIDS Infrastructure to Climate Change and Disaster Risks

   This outcome focuses on addressing any existing bottlenecks of SIDS infrastructure planning, design, delivery, operations, maintenance, and decommissioning to increase the resilience of SIDS infrastructure to climate change disaster risks. The strategic interventions designed for this outcome promote the strengthening of institutional and regulatory frameworks for policy, planning, execution, operation, regulation, and maintenance of resilient infrastructure; identification and strengthening of mechanisms, tools, and frameworks to implement an integrated disaster risk reduction strategy; and provide assistance for the access to innovative finance mechanisms, funding and investment opportunities.

ii. Strengthened knowledge and partnerships for integrating resilience in SIDS infrastructure.

   This outcome seeks to support SIDS in expanding knowledge and broadening partnerships through the interventions of peer learning and knowledge exchange, developing capacities through technical training programmes, and establishing dedicated partnerships with multiple stakeholders such as financial institutions, international organisations, academia, private sector organisations etc.,

iii. Gender equality and disability inclusion promoted through resilient SIDS infrastructure.

   This third outcome seeks to ensure that the SIDS infrastructure provides accessible, affordable and equitable services in order to integrate gender equality into climate resilience. This is sought to be done through the interventions of people-centered policy and advocacy approaches for inclusive infrastructure, investment in initiatives that support innovation, piloting and replication of scalable good practices and facilitate knowledge exchange and capacity development on global practices, policies and technical expertise that promote climate resilient infrastructure.

Resilience Programmes

i. Power Sector Infrastructure Resilience Programme initiated a power sector resilience study with Chile and Brazil on systematic resilience and redundancy, and hydel power, respectively.

ii. The Transport Sector Infrastructure Resilience Programme currently focuses on airport and seaport resilience.

iii. The Telecommunications Sector Infrastructure Resilience Programme studying the Indian States of Assam, Odisha, Himachal Pradesh, Gujarat and Tamil Nadu.

iv. The Health Sector Infrastructure Resilience Programme seeks to promote systemic preparedness, response, and recovery capabilities to enable the continuity of healthcare services during disasters.

v. The Urban Sector Infrastructure Resilience Programme has conceptualized a global study on urban infrastructure resilience in 20 cities in partnership.

vi. The Finance for Resilient Infrastructure Programme has initiated a study on the fiscal risk assessment of power and transport sectors in four member countries (India, Fiji, Mauritius, and Nepal) (Sablok, 2023).

Disaster Resilient Infrastructure (DRI) Connect

It is a digital stakeholder learning, engagement, and co-creating platform working on creating a knowledge product envisioned as a one-stop online space for DRI stakeholders to connect, learn, and collaborate towards improved practices, processes, and policies for resilient infrastructure systems (Sablok, 2023).

Biennial Global Infrastructure Resilience Report

With UNDP as the coordinating agency, the first edition of the biennial Global Infrastructure Resilience Report was launched in September 2023 with a thematic focus on nature-based infrastructure solutions. The report has been envisioned as the first ever fully probabilistic risk assessment covering global infrastructure sectors, which can inform planning, decision-making, and investment in disaster and climate resilient infrastructure.

Infrastructure Resilience Accelerator Fund (IRAF)

Launched at the India Pavilion at CoP27 in 2022, the IRAF is a CDRI Multi-Partner Trust Fund, established with the support of UNDP and the UNDRR to support global action on disaster resilience of infrastructure systems, particularly in developing countries and SIDS. IRAF is expected to play a critical role in the delivering of an improved and inclusive infrastructure governance. Poised for an initial duration of five years, USD 50 million in financial commitments have been announced by countries, including India, the United Kingdom, Australia, and the European Union.

CDRI Fellowship

Launched in September 2020, the CDRI fellowship continues to award a 12-month seed grant, in addition to peer learning and capacity development opportunities for creating transforming, actionable, and scalable solutions for disaster resilience of infrastructure.

Finance for Resilient Infrastructure Programme (FRIP)

The FRIP supports member countries of the CDRI in the development of a disaster risk financing strategy in order to address the financing needs for the rebuilding of resilient infrastructure. As of 2022-23, two Fiscal Risk Assessment Studies and Policy Guideline Appraisal of National Infrastructure Pipeline (NIP) of India study has been conceptualized in collaboration with the Department of Economic Affairs (DEA), other key infrastructure ministries of the GoIand NITI Aayog (CDRI, 2023).

The CDRI Annual Report 2023-24 notes that in the financial year 2023-24, CDRI incurred total expenses of INR 479.9 million (approximately USD 5.76 million). Approx. 82% of this expenditure was incurred towards the achievement of the programmatic activities of CDRI and the remaining 18% was allocated towards Secretariat Operations & Management including Institutional Media & Communications.

Finance details related to programme activities –

1. The first cohort of funded projects under CDRI worth USD 5.8 million is supporting 11 projects across 13 SIDS, including development of an early warning systems in Fiji and Dominican Republic; resilient housing in Dominica and Haiti; and health and coastal infrastructure in the Marshall Islands.
2. During COP29, the CDRI announced USD 8 million of funding for 12 projects across 18 Small Island Developing States under its Infrastructure for Resilient Island States initiative. The 12 projects announced will support Antigua & Barbuda, Bahamas, Belize, Comoros, Dominican Republic, Grenada, Haiti, Jamaica, Kiribati, Maldives, Mauritius, Saint Kitts and Nevis, Seychelles, St. Lucia, St. Vincent and the Grenadines, Timor-Leste, Tonga, and Vanuatu.
3. CDRI's Infrastructure for Resilient Island States initiative is funded by Australia, India, the UK, and the EU through donations totaling USD 40 million to CDRI's IRAF Multi-Partner Trust Fund. This announcement brings the total number of SIDS projects funded by CDRI under this initiative to 23.
4. CDRI's Urban Infrastructure Resilience Programme is offering funding of USD 2.5 million to strengthen infrastructure resilience in cities across Low- and Middle-Income countries (LMICs).

3.9 Any Other Information Related to Climate Impacts and Adaptation Under Article 7 of the Paris Agreement

The GCF was set up under the UNFCCC at the 16th Conference of the Parties (COP-16) in 2010 to support developing countries in reducing GHG emissions and strengthening capacity to adapt to climate change. The GCF has started approving projects/programmes to developing countries from 2015 onwards.

The GoI has been engaging with the GCF and so far, eleven (11) projects/ programmes have been approved to India with a total allocation of USD 782.4 million to mitigate and adapt to climate change in sectors including water, clean energy, coastal, livelihood, transport, medium and small enterprises and climate start-ups.

Table 3.24: List of projects under Green Climate Fund (GCF)

Sr. No.	Project/ Programmes	Year of approval	GCF Funding (in Million USD)
1	Ground Water Recharge and Solar Micro Irrigation to Ensure Food Security and Enhance Resilience in Vulnerable Tribal Areas of Odisha	2017	34.357 (Grant)
2.	Line of Credit for Solar rooftop segment for Commercial, Industrial and Residential Housing	2018	100 (Concessional Loan)
3.	Enhancing Climate Resilience of India's Coastal Communities	2018	43.418 (Grant)
4.	Green Growth Equity Fund (GGEF)	2021	137 (132.5 Equity, 4.5 Grant)
5.	India E-Mobility Financing Program	2022	200 (Equity)
6.	Climate Investor Two	2022	145 (multi-country) (Grant)
7.	Green Guarantee Company ("GGC")	2022	40.5 (multi-country) (Equity)

Source: Compilation prepared for this report

The Economic Survey 2024-25 highlights India's progress in climate adaptation under the Paris Agreement while addressing the challenges of balancing developmental needs with environmental commitments. The survey notes a significant rise in adaptation investments, which grew from 3.7% of GDP in 2015-16 to 5.6% in 2021-22, focusing on protecting vulnerable regions, such as coastal and flood-prone areas, through measures like expanding Ramsar sites to conserve wetlands.

The survey also underscores the insufficient international climate finance for adaptation, advocating for developed nations to fulfill their financial commitments to support the estimated USD 5.8-11.5 trillion required by 2030 for developing countries to transition to low-carbon pathways.

The Initial Adaptation Communication of India estimates that total adaptation-relevant expenditure in 2021-22 was INR13.35 trillion, compared to INR 5.06 trillion in 2015-16. The total adaptation relevant expenditure was 5.60 per cent of the GDP in 2021-2022, growing from a share of 3.7 per cent in 2015-16, indicating integration of climate resilience and adaptation into development plans. This reflects the importance that the Government is placing on adaptation action and, at the same time, is reflective of the significant pressure on domestic resources. An increase in adaptation finance flows to India is a necessity to ease the resource constraint and enable the country to meet its over-riding priorities of poverty eradication and sustainable development, and is a responsibility and commitment owed to it by developed countries under the UNFCCC and its Paris Agreement.

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CHAPTER-4

FINANCIAL, TECHNOLOGY DEVELOPMENT AND TRANSFER AND CAPACITY-BUILDING SUPPORT NEEDED AND RECEIVED UNDER ARTICLES 9–11 OF THE PARIS AGREEMENT

FINANCIAL, TECHNOLOGY DEVELOPMENT AND TRANSFER AND CAPACITY-BUILDING SUPPORT NEEDED AND RECEIVED UNDER ARTICLES 9–11 OF THE PARIS AGREEMENT

4.1 Introduction

In alignment with the Enhanced Transparency Framework (ETF) established under Decision 18/CMA.1 and guided by Articles 9, 10, and 11 of the Paris Agreement, this chapter provides updated and detailed information on India's current needs and the support received in financial resources, technology transfer, and capacity-building to meet its climate action commitments. The information presented is provisional, partial, and non-exhaustive, highlighting the ongoing and critical need for financial, technical, and capacity-building support.

India's updated Nationally Determined Contributions (NDCs) set ambitious climate targets aligned with its sustainable development objectives. These objectives encompass poverty alleviation, economic growth, and job creation, intertwined with climate adaptation and mitigation strategies. Achieving these goals necessitates substantial financial, technological, and capacity-building support, underscoring the critical role of international assistance. While India has made significant progress in domestic policy and action, challenges persist in accessing adequate external resources. There is limited availability of concessional finance, advanced technologies, and tailored capacity-building programs. In light of these challenges, this chapter emphasizes India's needs in these areas, inviting further international collaboration to bridge existing gaps.

To emphasize transparency, the chapter begins by outlining India's national circumstances and institutional arrangements. It then delves into India's strategic priorities, assessing the received support from multilateral and bilateral sources and highlighting unmet requirements. Common Tabular Formats (CTFs) are provided for structured data presentation, complementing the narrative. This chapter should be read in conjunction with the information furnished by the Government of India to the UNFCCC since 2004.

4.2 National Circumstances, Institutional Arrangements, and Strategies

Financial support is a crucial enabling pillar for India's climate action under the United Nations Framework Convention on Climate Change (UNFCCC) and its Paris Agreement. However, fundamental gaps exist between the pledges made by developed countries and the actual funding provided to developing nations like India. The first Global Stock take (2023) highlighted this gap, estimating that developing countries require USD 5.8–5.9 trillion by 2030 to achieve their climate goals, with annual adaptation finance needs ranging from USD 215 to 387 billion until 2030. For India, a nation of over 1.4 billion with a fast-growing economy, balancing development and sustainability is a formidable challenge, compounded by its vulnerability to climate-induced disasters like floods, droughts, and cyclones that disproportionately threaten its rural, agriculture-reliant population. Notwithstanding these challenges, India has demonstrated a strong commitment to climate action, setting ambitious non-fossil fuel-based energy targets and implementing nationwide initiatives to enhance climate resilience. However, the current scale, scope, and speed of finance for climate action falls short in comparison to what is required to meet these targets. The inadequacy of financial support hinders India's ability to fully realize its potential to address climate change consequences and therefore re-emphasize the urgent need for adaptation and mitigation measures.

India has developed a comprehensive institutional framework to effectively combat climate change, with the Ministry of Environment, Forest and Climate Change (MoEF&CC) taking the lead in shaping and executing national climate policies. The MoEF&CC works closely with state agencies to weave climate priorities into India's development agenda and represents the country's interests on the global stage, while the Prime Minister's Council on Climate Change provides strategic direction and ensures high-level coordination across sectors. The core of this framework lies on the National Action Plan on Climate Change (NAPCC), introduced in 2008, which guides India's climate strategy through nine targeted missions . These missions include the National Solar Mission, overseen by the Ministry of New and Renewable Energy to boost solar power. The National Mission for Enhanced Energy Efficiency, managed by the Ministry of Power to promote energy savings, and the National Mission for Green India, led by the MoEF&CC to enhance forest cover and biodiversity. Each mission aligns with international climate commitments and plays a vital role in advancing India's sustainable development goals. Complementing these national efforts, many states have crafted their own climate action plans to tackle region-specific challenges, such as floods or droughts, ensuring a localized response. The Department of Science & Technology also contributes by spearheading research-focused missions like the National Mission on Strategic Knowledge for Climate Change. Despite this strong setup, the realization of India's bold climate targets depends heavily on receiving sufficient and timely financial support from developed countries under the UNFCCC and its Paris Agreement. Without this critical funding, the execution of these well-designed initiatives faces significant obstacles, limiting India's ability to respond effectively to climate change.

India recognizes that the obligations and commitments of developed countries under the UNFCCC and its Paris Agreement have not been met satisfactorily. The persistent shortfall in finance for climate action, particularly the unmet goal of mobilizing USD 100 billion per year by 2020, poses significant challenges to executing developing countries' climate action plans. Reports indicate that while developed countries claim to have met this goal in 2022, the methodologies used to calculate these figures have been widely contested. Issues such as the overestimation of climate-specific finance, lack of an agreed definition of climate finance, and the predominance of loans over grants undermine the efficacy of the reported support. In this context, India advocates for scaling up new and additional grant-based highly concessional finance and non-debt financial instruments. India strongly advocates financial support for climate action that is affordable, predictable, accessible, and commensurate with the articulated needs and development aspirations of developing nations.

India's strategic priorities are centered on achieving its ambitious climate targets as outlined in its updated NDCs, which include reducing the emissions intensity of its GDP by 45% by 2030 from 2005 levels, achieving about 50% cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030, and creating an additional carbon sink of 2.5 to 3 billion tonnes of CO_2 equivalent through additional forest and tree cover by 2030. This update to India's existing NDC is a step forward towards our long term goal of reaching net-zero by 2070. To realize these commitments, India has identified key areas where external support is essential. Initiatives like the National Green Hydrogen Mission aim to position India as a global hub for green hydrogen production, promoting clean energy alternatives. Climate-resilient agriculture, sustainable urban development, disaster resilience, energy efficiency programs, and afforestation efforts are also critical components of India's climate strategy. However, the successful implementation of these strategies is dependent upon the mobilization of adequate finance for climate action. India has continued to lead global initiatives such as the International Solar Alliance, One Sun One World One Grid, and the Coalition for Disaster Resilient Infrastructure, emphasizing its dedication to global climate leadership and technological collaboration.

4.3 Underlying assumptions, definitions and methodologies

For the preparation of India's first Biennial Transparency Report, attempts have been made to provide a more transparent and broader overview of the country's financial, technological and capacity building support needs and support received. With reference to Table III.6 of Annex III, identified needs pertain to the period up to the year 2030, as this information was available in the context of NDC implementation and reflects official estimates for the kind of support required.

With reference to Table III.7 of Annex III, it is to be noted that the projects included are an indicative list of disbursements received by the country in the calendar years 2021 and 2022 for projects with a climate objective as well as other developmental activities with a minor climate component.

With reference to Table III.8 of Annex III, the identified technology needs span over multiple sectors and represent official estimates of support required through 2030 to achieve India's Nationally Determined Contributions (NDCs) and broader climate goals. These estimates assume that technology transfer includes not only the provision for hardware but also the associated know-how, training, and adaptation to local conditions, consistent with India's emphasis on building endogenous capacities. The methodologies for identifying these needs draw from national assessments, sector-specific consultations, and prior submissions like Biennial Update Reports (BURs) and National Communications, reflecting both immediate deployment requirements and long-term innovation priorities. However, the absence of operational technology transfer mechanisms under Article 10 to date has constrained the ability to quantify potential support, leading to a reliance on projected sectoral demands rather than realized transfers.

Technology transfer through the mechanism established under Article 10 of the Paris Agreement is yet to be operationalized for India. While technology needs across various sectors have been identified in this report, as well as in the previously submitted BURs and National Communications, no relevant technology transfer has taken place. Therefore, there is no information to be reported in Table III.9 with respect to India.

Table III.10 of Annex III provides a detailed and transparent overview of the capacity building support needed under Article 11 of the Paris Agreement to strengthen India's climate action framework. The assumptions underlying these needs include the necessity of enhancing institutional, technical, and community-level capabilities to implement NDCs effectively, with a focus on training, knowledge transfer, and policy development across sectors like energy, transportation, agriculture, and disaster management. The definitions of capacity building encompass both skill development (e.g., training for solar technicians) and systemic improvements (e.g., policy alignment with global goals), as derived from national priority assessments and stakeholder inputs. Methodologies for identifying these needs involve a combination of gap analyses, sectoral consultations, and reviews of existing capacity constraints outlined in previous BURs and National Communications.

The lack of a common reporting framework on the capacity building activities, conducted under the internationally funded projects, has led to the unavailability of documentation regarding the specific contribution to capacity building objectives. Accordingly, there is no information to report in Table III.11 pertaining to India.

With reference to Table III.12, an attempt has been made to indicate the needs of the country in implementing Article 13 of the Paris Agreement and enlists the funding that the country expects to receive in the form of grants and grant equivalents to enhance its transparency reporting framework. Similarly, Table III.13 of the same annexure highlights the grant amounts approved for the country for reporting in the current period. The tables of Annex III, as referred to above, are provided in Appendix IV.

4.4 Information on financial support needed by India under Article 9 of the Paris Agreement

Article 9.1 of the Paris Agreement mandates developed country parties to "provide financial resources to assist developing country Parties with respect to both mitigation and adaptation in continuation of their existing obligations under the Convention". Article 9.3 further urges developed country parties to "continue to take the lead in mobilizing climate from a wide variety of sources, instruments and channels, noting the significant role of public funds, through a variety of actions, including supporting country-driven strategies, and taking into account the needs and priorities of developing country Parties. Such mobilization of climate finance should represent a progression beyond previous efforts" (UNFCCC, 2024). India with its massive population and growing economy is one such party at the receiving end which needs substantial financial support from all multilateral and bilateral channels across sectors coupling it with efforts and contributions from the country itself.

India's Intended Nationally Determined Contribution shared a preliminary estimate that at least USD 2.5 trillion (at 2014-15 prices) will be required for meeting India's climate change actions till 2030 (INDC, 2015).

Similarly, India's Initial Adaptation Communication estimates that cumulative expenditure needed for adaptation till 2030 in a business as usual (BAU) scenario, without any additionality, is INR 56.68 trillion (Economic Survey, 2023-24), assuming 2023-24 as the base year of analysis. Climate induced damages could lead to an incremental cost of INR 15.5 trillion by 2030 and the requirements for building adaptation and capital stock could be as high as INR 72 trillion after accounting for the country's developmental needs and climate-induced pressures.

Another important aspect to focus on is the sectoral needs when discussing finance for climate action. For instance, India's growing demand in the energy sector requires considerable financial assistance for carrying out the scaling up of non-fossil fuel-based energy capacity installations, modernizing infrastructure and in improving energy efficiency across sectors. To meet its ambitious updated target of generating 50% of the country's cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030, it will require investment in solar, wind, hydro and other clean energy supporting technologies.

4.5 Information on financial support received by India under Article 9 of the Paris Agreement

This section provides a summary of the fund flow received by India through multilateral funds, multilateral development banks and bilateral channels across sectors and areas of support. With a more detailed approach of reporting project components as compared to the country's previous transparency framework related reports, an effort has been made to provide an indicative, not exhaustive, list of projects which include some components of finance for climate action. While details have been provided in Table III.7 of Annex III, some specifications remain uncertain due to lack of transparency in reporting by the concerned authorities.

To facilitate the provision of climate finance, UNFCCC established a financial mechanism to provide resources to developing country parties. The Global Environment Facility (GEF) has served as an operating entity of this mechanism since 1994 and in 2011 with the establishment of the Green Climate Fund, it was designated as the second operating entity. Additionally, the Special Climate Change Fund (SCCF) and the Least Developed Countries Fund (LDCF) were established and managed by GEF, and the Adaptation Fund was ordained under the Kyoto Protocol. All these funds and facilities are supposed to act as channels of multilateral climate fund flows to developing countries like India. There also exist sector specific multilateral funds such as the International Fund for Agricultural Development (IFAD) created by the United Nations to provide grants and low interest loans to support agricultural development projects in developing countries.

Table 7 of Annex III includes disbursements received by India in the calendar years 2021 and 2022 for projects with some climate component approved in these years and the years prior to them. The projects included should be seen as an indicative list of climate-related funding received by the country and may include development finance with only a small climate component. The table covers projects by multilateral and bilateral agencies, namely the GEF, ADB, IBRD, and IFAD at the multilateral level and support from Germany at the bilateral level. Table III.7 reveals that almost all of the funds received are debt-creating in nature, with a very small share of grants. As a cumulative total of the projects listed in Table III.7 of Annex III, India has received only USD 5.39 million in the form of grants as components of these projects in the years 2021 and 2022, whereas loan disbursements amounted to USD 783.72 million for the same period. Out of these loans, only 40.9% amounting to USD 321.23 million, were provided as concessional loan support, received entirely from Germany under bilateral cooperation.

4.6 Information on technology development and transfer support needed by India under Article 10 of the Paris Agreement

India's climate strategy under Article 10 of the Paris Agreement (paras. 135–136, MPGs) hinges on the effective transfer of advanced technologies to achieve its mitigation and adaptation goals, yet no significant technology development and transfer support has materialized from developed countries through the UNFCCC regime, leaving critical gaps in its climate action framework. India urgently requires cutting-edge solutions across key sectors including renewable energy (ultra-efficient solar cells, offshore wind, hydrogen storage), energy storage (advanced batteries), agriculture (precision farming tools, climate-resilient crops), industry (carbon capture, utilization, and storage [CCUS] for cement and steel), and water and waste management (solar-powered desalination, waste-to-energy systems) to drive low-carbon growth, enhance resilience, and ensure sustainable resource use. High costs, restrictive intellectual property rights (IPR), and limited funding obstruct access, forcing India to divert scarce domestic resources from vital areas like healthcare and education to meet its ambitious climate action targets. Beyond acquisition, India seeks to build endogenous capacity through local skill development, infrastructure upgrades, and innovation ecosystems, as seen in initiatives like Mission Innovation 2.0, the International Solar Alliance (ISA), and the National Green Hydrogen Mission, which underscore its leadership in clean energy and resilience-building. The escalating climate crisis amplifies the need for rapid advancements in CCUS, green hydrogen, energy storage, precision agriculture, and water-efficient systems, yet these remain out of reach without enhanced international cooperation. Meeting global climate objectives demands that developed nations ensure these technologies are not only affordable and accessible but also suited to local contexts. India has shown proactive leadership in embracing climate-friendly technologies, yet the full realization of its climate ambitions hinges on timely and robust international cooperation, which remains conspicuously absent.

4.7 Information on technology development and transfer support received by India under Article 10 of the Paris Agreement

Technology transfer is a critical component of climate change mitigation and adaptation efforts, yet it faces significant supply-side challenges. Under the UNFCCC, Kyoto Protocol, and Paris Agreement (Article 10), developed nations are obligated to provide technology and financial resources to developing countries, guided by the principle of Common but Differentiated Responsibilities and Respective Capabilities (CBDR-RC). The establishment of the Technology Mechanism, consisting of the Technology Executive Committee (TEC) and the Climate Technology Centre and Network (CTCN), was intended to facilitate this process. However, despite long standing commitments, actual technology transfer from developed nations to India remains effectively nil. This lack of meaningful support has forced India to rely on its own limited resources, diverting funds that could be utilized for other essential development needs..

4.8 Information on capacity-building support needed by India under Article 11 of the Paris Agreement

India urgently requires comprehensive capacity-building support under Article 11 of the Paris Agreement to execute its climate action plans and meet its commitments, empowering government, private sector, and local communities to address climate challenges effectively. This includes training policymakers to develop and implement climate policies aligned with global goals, equipping technicians with skills for solar and wind energy system installation, operation, and maintenance, and conducting workshops on advanced energy storage technologies to integrate them into the grid, alongside specialized nuclear safety and regulatory training. In transportation, India needs programs for electric vehicle (EV) manufacturing and maintenance, as well as capacity enhancement for urban planners to design sustainable mass transit systems such as metro rail and integrated multi-modal transport networks. Agriculture demands farmer training in precision agriculture, organic farming, and micro-irrigation system implementation (e.g., drip and sprinkler systems), while water resources require technical expertise in operating advanced sewage treatment plants and solar-powered desalination systems to combat scarcity. Waste management calls for training municipal staff in waste-to-energy projects, recycling (e.g., plastics and e-waste), and segregation techniques, and industry professionals need energy auditing and management skills to boost efficiency. Forestry and land use initiatives necessitate community education in sustainable forest management and agroforestry, complemented by disaster preparedness training for early warning systems and emergency response. Health sector capacity must expand to monitor climate-related risks like heat stress and vector-borne diseases, urban development requires architects and builders to master green building practices supporting the Smart Cities Mission, and ICT training in climate data analysis and Geographic Information Systems (GIS) is essential for planning. Education efforts focus on training educators to integrate climate topics into curricula, while coastal zone management needs community training in mangrove restoration and sustainable resource use. Financially, India seeks capacity to access climate funds and plan investments, empowering women through climate-smart agriculture and renewable energy entrepreneurship, and enhancing research in climate technology innovation. These elements are critical to bridge gaps and achieve resilience and sustainability.

4.9 Information on capacity-building support received by India under Article 11 of the Paris Agreement

According to Article 11 of the Paris Agreement, developed country Parties were directed to "enhance support for capacity-building actions in developing country Parties". This includes, but is not limited to, the implementation of adaptation and mitigation measures, the facilitation of technology development, dissemination and deployment, access to finance for climate action, relevant aspects of education, training, and public awareness, and the transparent, timely, and accurate delivery of information.

More projects may be designed to foster capacity building. However, there is a lack of public information regarding the precise allocation of project finance for these activities and the status of their implementation.

4.10 Information on support needed and received by India for the implementation of Article 13 of the Paris Agreement and transparency-related activities including transparency related capacity building

India has made significant progress towards fulfilling its obligations under Article 13 of the Paris Agreement. However, several critical areas require additional support. Firstly, there is a pressing need to enhance capacity for data collection and data management. Improved systems and tools are necessary to enable consistent data collection, especially in complex sectors such as agriculture, waste, and forestry. Financial assistance would be instrumental for procuring and implementing advanced data collection tools, including remote sensing technologies and regional data platforms for integrated and accurate reporting.

Secondly, technical capacity building is of utmost priority. Comprehensive training programs are needed to upskill personnel in greenhouse gas inventory methodologies, emissions projections, and climate finance reporting. Financial assistance from international agencies would support specialized training programs focused on climate science, impact assessment, emissions modeling, and data analysis. Another area requiring support is the development of metrics for adaptation and mitigation. India faces challenges in establishing metrics that can effectively measure and report adaptation outcomes, as adaptation reporting methodologies are still evolving. Support from international organizations is crucial to develop metrics and methodologies that align with the guidelines of the United Nations Framework Convention on Climate Change (UNFCCC).

Finally, India requires sustained access to financial support to continue implementing and maintaining its climate transparency efforts. Financial support is particularly needed for expanding institutional capacity, and managing ongoing operational costs. Enhanced access to international climate funds, such as the Green Climate Fund, would help fulfill these long-term financial needs, supporting India's actions under Article 13.

In relation to these needs, the Global Environment Facility (GEF) has provided support to India through two projects approved in 2022. These are the preparation of India's First Biennial Transparency Report (BTR) and Capacity-building for establishing an integrated and Enhanced transparency framework for climate actions and support measures (CBIT-1) . The objective of these projects is to effectively implement the Enhanced Transparency Framework under the Paris Agreement by fulfilling India's reporting commitments to the UNFCCC in an efficient way. For a detailed description and more insights into these projects, please refer to Table III.13 of Annex III. However, while this support is a significant step forward, India recognizes that additional and enhanced assistance is essential to meet the requirements of Article 13. The complexity and scale of the challenges necessitate sustained and increased support to address gaps in capacity, technology, and finance.

Potential future activities have been planned for sector-wise GHG inventory improvement. The primary objective of this plan is to strengthen institutional and technical capacities, develop country-specific emission factors, and improve the quality of activity data across key sectors including Energy, IPPU, Agriculture, LULUCF, and Waste. These activities are planned to reduce estimation uncertainties, enhance data quality, and implement methodological refinements in line with IPCC guidelines and national circumstances. They also aim to ensure comprehensive data coverage across all inventory sectors. Implementation of these planned interventions will require dedicated financial and technical assistance, through Capacity-Building Initiative for Transparency (CBIT-2) project.

In line with this, the country enlists its project wise requirements of funds to fulfill criteria of Article 13 in Table III.12 of Annex III. The country's financial needs for these efforts are provided in Table III.12 of Annex III. India requires approximately USD 2.5 million each for the preparation of its second (BTR-2), third (BTR-3), and fourth (BTR-4) Biennial Transparency Reports, respectively. Additionally, India requires funding of USD 7.5 million for the preparation and implementation of its Second Capacity-Building Initiative for Transparency (CBIT-2). The project will support India in achieving its climate actions and commitments. It will help strengthen national institutions for transparency-related activities in line with national priorities; provide relevant tools, training and assistance in line with Article 13 of the Paris Agreement; and assist in the improvement of transparency over time.

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Appendix IV: Common Tabular Formats (CTFs)

Table III.6: Information on financial support needed by developing country Parties under Article 9 of the Paris Agreement

Exchange Rate Used: 1 USD = INR 76.34

Sector	Sub -sector	Title of activity, programme, project or other	Programme / Project Description	Domestic Currency (INR Crore)	USD Million	Expected Time Frame	Expected Financial Instrument	Type of Support	Contribution to technology development and transfer objectives	Contribution to capacity - building objectives	Whether the activity is anchored in a national strategy and/ or an NDC	Expected use, impacts, and results	Additional Information
NA	NA	NA	NA	19085000	2500000	till 2030	UA	Cross-Cutting	UA	UA	1	India's Intended Nationally Determined Contribution provided a preliminary estimate that at least USD 2.5 trillion (at 2014-15 prices) would be required to implement its climate change actions through 2030.	UA
NA	NA	NA	NA	5668000	742508	till 2030	UA	Adaptation	UA	UA	UA	India's Initial Adaptation Communication estimates this to be the cumulative expenditure needed for adaptation in a Business as Usual (BAU) scenario, without any additionality, assuming 2023-24 as the base year of analysis.	Climate-induced damages could lead to an incremental cost of INR 15.5 trillion by 2030, and the requirements for building adaptation capital stock could be as high as INR 72 trillion after accounting for the country's developmental needs and climate-induced pressures.

Notations: NA = Not applicable; UA = Information not available at the time of reporting

Table III.7: Information on financial support received by developing country Parties under Article 9 of the Paris Agreement

Exchange Rate Used: 1 USD = INR 76.34

(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)
Title of activity, programme, project or other	**Programme / Project Description**	**Channel**	**Recipient Entity**	**Implementing Entity**	**Domestic Currency (INR Crore)**	**USD Million**	**Time Frame**	**Financial Instrument**
Himachal Pradesh Clean Energy Transmission Investment Program - Tranche 3	This tranche is 3rd phase of Multitranche Financing Facility (MFF) to funded construction of transmission lines and substations to increase the transmission system capacity due to increase in the hydropower generating capacity in Himachal Pradesh. The proposed tranche 3 will fund (i) physical investments in transmission infrastructure, including high-voltage lines and transmission substations; and (ii) investments in upgrading the enterprise resource planning (ERP) system and related components.	Multilateral	Himachal Pradesh Power Transmission Corporation Limited	Himachal Pradesh Power Transmission Corporation Limited	609.93	79.9	06 November 2018 - 10 February 2022	Other - Loan
Green Energy Corridor	In the year 2012, a study was conducted by Power Grid Corporation of India Limited (PGCIL) wherein it was found that power evacuation and transmission infrastructure in near vicinity of potential sites was less and therefore, dedicated transmission infrastructure for large scale solar and winf power plants was planned. Green Energy Corridor (GEC) comprises of both Inter State Transmission System (ISTS) and Intra State Transmission System (InSTS) along with the setting up of Renewable Energy Management Centre (REMC) and the control infrastructure like reactive compensation, storage systems etc. The scheme is currently under implementation by the State Transmission Utilities (STUs) of 8 renewable energy rich states i.e, Andhra Pradesh, Gujarat, Himachal Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan and Tamil Nadu.	Bilateral	PGCIL (EUR 500 m) and another EUR 500 million to DEA, GoI (for State Transmission Utilities namely APTransco, GETCO, HPPTCL & HPSEBL, MPPTCL, MSETCL, RVPN & TanTransco. (Note: KPTCL has not availed loan from KfW)	State Transmission Utilities of the 8 states (PGCIL + 7 STUs + KPTCL)	1043.88	136.75	2015 - N/A	Concessional Loan

(x)	(xi)	(xii)	(xiii)	(xiv)	(xv)	(xvi)	(xvii)	(xviii)
Status	**Type of Support**	**Sector**	**Sub sector**	**Contribution to technology development and transfer objectives**	**Contribution to capacity - buidling objectives**	**(l) Status of Activity**	**Use, impacts and results**	**Additional Information**
Received	Mitigation	Energy	Electricity transmission and distribution	NA	NA	Completed	Impact: Clean energy transmitted to end users in Himachal Pradesh and India increased. Outcome: Capacity of Himachal Pradesh Power Transmission Corporation Limited to transmit electricity from hydropower generation sources within and outside of Himachal Pradesh and to manage its operations improved.	The multilateral support has been provided by the Asian Development Bank. The project has helped to strengthen the grid, increase availability and reliability of electric power, and development of economic activities in the state of HP. The project has also supported to strengthen the capacity of HPPTCL by the way of training, consultant support, and operationalization of Enterprise Resource Planning (ERP) system. Due to impact of coronavirus pandemic (COVID-19), the physical implementation of subprojects was critically impacted resulting in spillover of substantial works beyond closure of the loan, which is being completed by HPPTCL through own resources.
Received	UA	Energy	Transmission	NA	NA	Ongoing	Under InSTS, as of 30/06/2024, 9135 km of transmission lines have been constructed and 21313 MVA substations have been charged. Out of the 8 states, 4 have completed all projects i.e, Rajasthan, Madhya Pradesh, Karnataka and Tamil Nadu. The remaining states have been granted extension because of delays owing to delay in land acquisition, Right of Way (RoW) issues and forest clearances.	The bilateral support has been provided by Germany to PGCIL and 7 State Transmission Utilities (other than Karnataka) namely APTransco, GETCO, HPPTCL & HPSEBL, MPPTCL, MSETCL, RVPN & TanTransco.

(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)
Title of activity, programme, project or other	**Programme / Project Description**	**Channel**	**Recipient Entity**	**Implementing Entity**	**Domestic Currency (INR Crore)**	**USD Million**	**Time Frame**	**Financial Instrument**
Climate Change Adaptation in the Himalaya - Component I	Introduce sustainable climate-adaptive and participative management of natural resources, particularly forests, in several Indian states in the catchment area of the Himalaya, specifically Manipur	Bilateral	Govt of India/ Govt of Manipur	Manipur Forest Dept	11.62	1.52	1 December 2017 - 31 December 2024	Concessional Loan
Climate Loan Kerala	Support targeted policy and institutional reform efforts through Policy Based Lending (PBL) to enhance Kerala's resilience to natural disasters and climate change.	Bilateral	Govt of India/ Govt of Kerala	Rebuild Kerala Initiative, Govt of Kerala	868.45	113.77	22 December 2020 - 31 May 2022	Concessional Loan
Climate-Friendly Urban Mobility I	Support for an integrated water metro transport system for Kochi	Bilateral	Govt of India/ Govt of Kerala	Kochi Metro Rail Ltd	122.7	16.07	17 June 2016 - 30 June 2025	Concessional Loan
PV Solar Power Plant Sakri, India	The project involved the construction of a 125 - MW large-scale photovoltaic power plant at the Shivajinagar site near Sakri in the Indian State of Maharashtra	Bilateral	Govt of India/ Govt of Maharashtra	Maharashtra State Power Generation Co. Ltd.	93.05	12.19	August 10, 2011 to June 30, 2024	Concessional Loan
Himachal Pradesh Forest Ecosystem Climate Proofing Project	Support for the rehabilitation, protection and sustainable use of selected forest areas in order to increase its resilience against climate change impacts	Bilateral	Government of India/ Government of Himachal Pradesh	Himachal Pradesh Forest Department	15.7	2.06	29 December 2015 - 31 March 2026	Grant
Andhra Pradesh Community Managed Natural Farming Programme	The aim of the project is to promote the expansion of Community managed Natural Farming (CNF) in the Indian state of Andhra Pradesh.	Bilateral	Government of India/ Government of Andhra Pradesh	Rythu Sadhikara Samstha (RYSS), Dept of Agriculture	101.71	13.32	19 December 2019 - 31 March 2025	Concessional Loan

(x)	(xi)	(xii)	(xiii)	(xiv)	(xv)	(xvi)	(xvii)	(xviii)
Status	Type of Support	Sector	Sub sector	Contribution to technology development and transfer objectives	Contribution to capacity - buidling objectives	(l) Status of Activity	Use, impacts and results	Additional Information
Received	UA	Forestry	UA	NA	NA	Ongoing	Only 4 out of 50 micro plans have been approved so far and the area covered under the forestry measures is 667 ha as against the target of 12650 ha	The bilateral support has been provided by Germany to the Government of Manipur
Received	UA	UA	UA	NA	NA	Completed	UA	The bilateral support has been provided by Germany to Govt of Kerala
Received	UA	Transport	Water metro	NA	NA	Ongoing	UA	The bilateral support has been provided by Germany and is focused on the Indian city of Kochi.
Received	UA	Energy	Solar Energy	NA	NA	Ongoing	Impact: The overarching development goal was to contribute to the further expansion of solar power, and thus to an ecologically sustainable and climate friendly energy supply in India. Outcome: The measure aimed to support the restructuring of the energy supply in the State of Maharashtra towards an increased use of solar power. Output: This was achieved by implementing the first major grid-connected photovoltaic project.	The bilateral support has been provided by Germany.
Received	UA	Forestry	UA	NA	NA	Ongoing	The physical achievement of is nearing the target (12,196 ha through 315 microplans as against 15000 ha through 326 micro plans)	The bilateral support has been provided by Germany to Govt of Himachal Pradesh
Received	UA	Agriculture	Agroecology/ Natural Farming	NA	NA	Ongoing	UA	The bilateral support has been provided by Germany to Government of Andhra Pradesh

(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)
Title of activity, programme, project or other	**Programme / Project Description**	**Channel**	**Recipient Entity**	**Implementing Entity**	**Domestic Currency (INR Crore)**	**USD Million**	**Time Frame**	**Financial Instrument**
Maharashtra Project on Climate Resilient Agriculture	The development objective of Maharashtra Project on Climate Resilient Agriculture Project for India is to enhance climate resilience and profitability of smallholder farming systems in selected districts of Maharashtra.	Multilateral	Republic of India	Department of Agriculture, Government of Maharashtra	1647.4	215.81	27 February 2018 - 30 June 2024	Other - Loan
Odisha Integrated Irrigation Project for Climate Resilient Agriculture	The objective of the Odisha Integrated Irrigation Project for Climate Resilient Agriculture in India is to intensify and diversify agricultural production and enhance climate resilience in selected districts of Odisha.	Multilateral	UA	Odisha Community Tank Development and Management Society, Department of Water Resources, Agricultural Promotion and Investment Corporation of Odisha Limited	96.92	12.7	30 September 2019 - 31 December 2025	Other - Loan
Integrated Project for Source Sustainaility and Climate Resilient Rain-fed Agriculture in Himachal Pradesh	The development objective of the program is to improve upstream watershed management and increase agricultural water productivity in selected Gram Panchayats in Himachal Pradesh.	Multilateral	Department of Economic Affairs	Department of Forest, Government of Himachal Pradesh	129.1	16.91	18 February 2020 - 31 March 2025	Other - Loan

(x)	(xi)	(xii)	(xiii)	(xiv)	(xv)	(xvi)	(xvii)	(xviii)
Status	Type of Support	Sector	Sub sector	Contribution to technology development and transfer objectives	Contribution to capacity - buidling objectives	(I) Status of Activity	Use, impacts and results	Additional Information
Received	Cross-Cutting	Agriculture	UA	NA	NA	Completed	Outcomes and Goals: 1. A more climate - resilient agriculture sector. 2. Enhanced agricultural productivity. 3. Household food and income security. 4. Agricultural sector growth. 5. GHG emission reduction and climate co-benefits. 6. Contribution to India's Nationally Determined Contributions at COP21. 7. Contribution to the World Bank Group's commitment to increase the climate-related share of its portfolio (CCAP).	The multilateral support has been provided by the International Bank for Reconstruction and Development.
Received	Cross-Cutting	Agriculture	UA	NA	NA	Ongoing	The project is expected to lead to increased average yields, increases in the range, volume and value of marketed agricultural output, more productive and efficient use of scarce water resources, a more reliable supply and a better quality of irrigation service delivery, and improvements in farmers' capacity to adapt to climate change.	The multilateral support has been provided by the International Bank for Reconstruction and Development.
Received	Cross-Cutting	Agriculture	UA	NA	NA	Ongoing	Proposed Result Indicators: 1. Increased sustainability of perennial water sources in targeted watersheds. 2. Selected upland areas managed in accordance with site-specific management plans. 3. Increased agricultural water productivity among participating farmers. 4. A more institutionally integrated approach to multi-sectoral watershed-level decision making. 5. Increased adoption of climate-smart technologies among participating farmers.	The multilateral support has been provided by the International Bank for Reconstruction and Development.

(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)
Title of activity, programme, project or other	**Programme / Project Description**	**Channel**	**Recipient Entity**	**Implementing Entity**	**Domestic Currency (INR Crore)**	**USD Million**	**Time Frame**	**Financial Instrument**
Fostering Climate Resilient Upland Farming Systems in the Northeast (FOCUS)	The overall goal of the project is to increase agricultural income of 201,500 households, and to enhance their resilience to climate change. This would be achieved through the development objective of increasing the environmental sustainability and profitability of farming systems practiced by highland farmers.	Multilateral	UA	Society for Climate Resilient Agriculture of Nagaland and Mizoram (separate for both states)	110.39	14.46	11 December 2017 - 2024	Other - Loan
Securing Livelihoods, Conservation, Sustainable Use and Restoration of High Range Himalayan Ecosystems (SECURE) Himalayas	The project will adopt a landscape approach to conservation and management, by ensuring that key biodiversity areas, buffer zones, corridors and areas outside traditional protected areas that are critically important for conservation of endangered snow leopard, wild prey and their associated and threatened species and habitats are managed in tandem with the sustainable use of these resources and improvement and diversification of livelihoods of a large number of local communities living in this region.	Multilateral	UA	Ministry of Environment, Forest and Climate Change	16.17	2.12	1 April 2017 - 30 March 2024	Grant
Climate Urban Mobility (I & IV: Accompanying Measure)	Support for the modernisation of bus services in major cities of Tamil Nadu through the replacement of old buses with new and the introduction of electric buses in the state	Bilateral	Government of India/ Government of Tamil Nadu	Tamil Nadu State Transport Department	5.75	0.75	30 August 2019 - 31 December 2026	Grant
Climate Adaptation in Vennar Subbasin in Cauvery Delta Project	The Climate Adaptation in Vennar Subbasin in Cauvery Delta Project aims to protect coastal districts from cyclones and flooding that is being made worse by climate change. The project is upgrading infrastructure and resectioning and strengthening embankments of six main channels totaling 235 kilometers. More robust flood control structures will reduce the frequency and impact of flooding. Thirteen pump stations are also being upgraded. The management systems of the Water Resources Department will also be strengthened, with greater participation by stakeholders in the planning and delivery of water services, better assessment of water resources, development of a decision support system, and training of officers.	Multilateral	UA	Water Resources Department, Public Works Department, Government of Tamil Nadu	85.29	11.17	7 June 2016 - 5 April 2022	Other - Loan

(x)	(xi)	(xii)	(xiii)	(xiv)	(xv)	(xvi)	(xvii)	(xviii)
Status	Type of Support	Sector	Sub sector	Contribution to technology development and transfer objectives	Contribution to capacity - buidling objectives	(l) Status of Activity	Use, impacts and results	Additional Information
Received	UA	Other - Marketing/ Storage/ Processing	UA	NA	NA	Ongoing	Expected Outcomes: 1. Improved farmers' capacities to manage upland farming sustainably. 2. Increased volume of marketed crops and livestock, with improved returns to producers. 3. Improved access to markets.	The multilateral support has been provided by the International Fund for Agricultural Development.
Received	UA	Other - Biodiversity & Land	UA	NA	NA	UA	Project Targets: 1. Maintain globally significant biodiversity and the ecosystem goods and services that it provides to society. 2. Sustainable land management in production systems (agriculture, rangelands, and forest landscapes) 3. Support for transformational shifts towards a low-emission and resilient development path.	The multilateral support has been provided by the Global Environment Facility.
Received	UA	Transport	Urban Transport (Buses)	NA	NA	Ongoing	UA	The bilateral support has been provided by Germany to Government of Tamil Nadu
Received	Adaptation	Agriculture	Agricultural policy, institutional and capacity development - Irrigation	NA	NA	Completed	Intended Impact: 1. Coastal districts are protected from cyclones and flooding exacerbated by climate change. 2. Innovative and inclusive economic growth, including agricultural growth, in Tamil Nadu is accelerated. Outcome: Climate - resilient water management in the Vennar System improved.	Output 1: Flood risk management and irrigation infrastructure upgraded. One output indicator was exceeded and three were achieved, as follows: (i) 354 kilometers (km) of embankments were rehabilitated to climate-resilient standards, exceeding the target of 200 km; (ii) 4 new regulators were constructed, meeting the target of 4; 14 regulators were replaced, exceeding the target of 10; 12 regulators were upgraded, versus a target of 13; and 136 head sluices were upgraded, exceeding the target of 133; (iii) all 13 irrigation pumping schemes were rehabilitated and functioning with 85% efficiency; and (iv) cumulative seawater ingress along the channels decreased to 4 km as planned, from a baseline of 37 km.

(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)
Title of activity, programme, project or other	**Programme / Project Description**	**Channel**	**Recipient Entity**	**Implementing Entity**	**Domestic Currency (INR Crore)**	**USD Million**	**Time Frame**	**Financial Instrument**
Bengaluru Smart Energy Efficient Power Distribution Project	The project will (i) convert overhead distribution lines to underground cables, with parallel installation of optical fiber cables; and (ii) install automated ring main units adapted with a distribution automation system (DAS) in six divisions, spanning 52 subdivisions, in urban Bengaluru city in the state of Karnataka. As a result of this project, the efficiency, reliability, and safety of the power distribution system in urban areas of Bengaluru will be enhanced.	Multilateral	UA	Government of Karnataka, Bangalore Electricity Supply Company Limited (BESCOM)	523.49	68.58	4 December 2020 - 30 June 2026	Other - Loan
Uttarakhand Integrated and Resilient Urban Development Project	The Uttarakhand Integrated and Resilient Urban Development Project (UIRUDP) supports the improvement of universal and equitable access to safe and affordable drinking water, and access to adequate and equitable sanitation and hygiene for all ending open defecation, in support of Uttarakhand Vision 2030.	Multilateral	UA	Government of Uttarakhand	88.62	11.61	26 November 2021 - 30 June 2029	Other - Loan
Climate-Resilient Reconstruction after Flooding in Kerala	Reconstruction of around 400 km of roads with climate resilience elements which were impacted during the event of flood	Bilateral	Government of India/ Government of Kerala	Public Works Dept	179.79	23.55	October 30, 2019 -December 30, 2026	Concessional Loan

(x)	(xi)	(xii)	(xiii)	(xiv)	(xv)	(xvi)	(xvii)	(xviii)
Status	Type of Support	Sector	Sub sector	Contribution to technology development and transfer objectives	Contribution to capacity - buidling objectives	(l) Status of Activity	Use, impacts and results	Additional Information
								Output 2: Improved water and flood risk management systems established. One indicator was exceeded, three were achieved, and one will likely be achieved, as follows: (i) a decision support system (DSS) is installed and WRD staff trained; (ii) 24-hour advanced flood warnings are issued by the District Collector; (iii) channel stakeholder groups (CSGs) were established with females accounting for 22% of members, exceeding the target of 20% female members; (iv) 630 WRD staff members were trained in water resource management, including 23.9% women, exceeding the target of 140 WRD staff trained and 10% women; and (v) the feasibility study for phase 2 of the climate adaptation project was completed and a report submitted to the central government
Received	Cross-Cutting	Energy	Electricity transmission and distribution	NA	NA	Ongoing	Outputs: 1. Smart and climate and disaster resilient power distribution system established in 6 divisions in urban areas of Bengaluru. 2. Institutional capacity of implementing agency improved. Overall Output: Energy efficiency, relaibility, and safety of power supply system in Bengaluru urban areas improved.	The multilateral support has been provided by the Asian Development Bank.
Received	Cross-Cutting	Water and Sanitation	Urban flood protection - Urban policy, institutional and capacity development, Urban sewage, Urban water supply	NA	NA	Ongoing	Project Outputs: 1. Resilient water supply system and service in Dehradun, Haldwani and Tanakpur improved. 2. Integrated and resilient sanitation systems and drainage established in Dehradun, Haldwani and Nainital. 3. Citywide computerised maintenance and management systems (CMMSs) for water and sanitation developed and implemented in Dehradun, Haldwani, Nainital and Tanakpur. 4. Institutional capacity and knowledge strengthened.	The multilateral support has been provided by the Asian Development Bank.
Received	UA	Transport	Road reconstruction	NA	NA	Ongoing	UA	The bilateral support has been provided by Germany to Government of Kerala

(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)
Title of activity, programme, project or other	Programme / Project Description	Channel	Recipient Entity	Implementing Entity	Domestic Currency (INR Crore)	USD Million	Time Frame	Financial Instrument
Himachal Pradesh Forest Ecosystems Climate Proofing Project	The objective is to provide support for the rehabilitation, protection and sustainable use of selected forest areas in order to increase its resilience against climate change impacts.	Bilateral	Government of India/ Government of Himachal Pradesh	Himachal Pradesh Forest Department	22.78	2.98	29 December 2015 - 31 March 2026	Concessional Loan
Climate Change Adaptation in the Himalaya (Tripura)	Improve the climate resilience of the treated ecosystems and communities in the selected watersheds, benefiting the rural and largely indigenous population in the project areas.	Bilateral	Government of India/ Government of Tripura	Tripura Forest Department	2.6	0.34	19 June 2020 to 30 December 2028	Concessional Loan
Climate Friendly Urban Mobility IV	The objective is to provide support to selected federal states and cities in the development of energy-efficient and sustainable mobility solutions.	Bilateral	Government of India/ Government of Tamil Nadu	Tamil Nadu State Transport Department	5.65	0.74	26 August 2019 - 30 June 2026	Concessional Loan
The Resilient Kerala Program	The development objective of the Resilient Kerala Program Program-for-Results Project in India is to enhance Kerala's resilience against the impacts of climate change and natural disasters, including disease outbreaks and pandemics. The Program consists of the following activities: Area 1, strengthening transversal systems for resilience includes: (1.1) sustainable fiscal and debt management; (1.2) comprehensive disaster risk finance and social protection system; (1.3) risk-informed urban master plans for cities and towns; and (1.4) risk-informed local disaster risk management plans. Area 2, embedding resilience in key economic sectors includes: (2.1) resilient public health systems; (2.2) integrated and sustainable water resources management; (2.3) sustainable and resilient agriculture systems; (2.4) climate resilient road infrastructure.	Multilateral	Department of Economic Affairs	State of Kerala	239.34	31.35	24 June 2021 - 30 June 2028	Other - Loan
Climate Change Adaptation in The Himalayan - Grant Component	Improve the climate resilience of the treated ecosystems and communities in the selected watersheds, benefiting the rural and largely indigenous population in the project areas.	Bilateral	Government of India/ Government of Tripura	Tripura Forest Department	0.62	0.08	19 June 2020 to 30 December 2028	Grant
Andhra Pradesh Community Managed Natural Farming Programme	The objective of the project is to promote the expansion of Community managed Natural Farming (CNF) in the Indian state of Andhra Pradesh.	Bilateral	Government of India/ Government of Andhra Pradesh	Rythu Sadhikara Samstha (RYSS), Dept of Agriculture	2.89	0.38	19 December 2019 - 30 April 2026	Grant

Notations: NA = Not applicable; UA = Information not available at the time of reporting

(x)	(xi)	(xii)	(xiii)	(xiv)	(xv)	(xvi)	(xvii)	(xviii)
Status	Type of Support	Sector	Sub sector	Contribution to technology development and transfer objectives	Contribution to capacity - buidling objectives	(l) Status of Activity	Use, impacts and results	Additional Information
Received	UA	Forestry	UA	NA	NA	Ongoing	The physical achievement of is nearing the target (12,196 ha through 315 microplans as against 15000 ha through 326 micro plans)	The bilateral support has been provided by Germany to the Government of Himachal Pradesh
Received	UA	Forestry	UA	NA	NA	Ongoing	UA	The bilateral support has been provided by Germany to Govt of Tripura
Received	UA	Transport	Urban Transport (Buses)	NA	NA	Ongoing	UA	The bilateral support has been provided by Germany to the Govt of Tamil Nadu
Received	Cross-Cutting	Other - Urban, Resilience and Land	UA	NA	NA	Ongoing	Result Areas: 1. Building systems and institutional capacities for managing shocks from climate change, natural disasters and disease outbreaks. 2. Supporting effective COVID-19 response and disease outbreak preparedness. 3. Demonstrating integrated approaches to multidimensional resilience at the local level.	The multilateral support has been provided by the International Board for Reconstruction and Development (INR 127.96 crore) and by the Asian Infrastructure Investment Bank (INR 111.38 crore).
Received	UA	Forestry	UA	NA	NA	Ongoing	UA	The bilateral support has been provided by Germany to Govt of Tripura
Received	UA	Agriculture	Agroecology/ Natural Farming	NA	NA	Ongoing	UA	The bilateral support has been provided by Germany to Govt of Andhra Pradesh

Table III.8: Information on technology development and transfer support needed by developing country Parties under Article 10 of the Paris Agreement

Sector	Subsector	Title of Activity, Programme, Project or Other	Programme/ Project Description	Type of Support	Type of Technology	Expected Time Frame	Expected Use, Impact, and Estimated Results	Additional Information
Energy	Coal Mining (Undeground)	Mitigation of ventilation air methane from underground coal mines	Capacity building for mitigation of low concentration methane emissions from underground coal mines through catalytic/oxidative conversion	Mitigation	Advanced modular facility for catalytic/oxidative conversion of methane to CO_2 at pit head or mine mouth	Short-term to Mid-term	Methane emission reduction from underground coal mine	Includes onsite installation/ demonstration on advanced modular facility and financial support for technology acquisition
Energy	Solar Energy	Expansion of Solar PV and Solar Thermal Power Generation	Implementation of large-scale solar PV and solar thermal power plants to increase the share of renewable energy in the grid through advanced technologies and storage integration.	Mitigation	Advanced PV Technologies, Solar Thermal Systems, Energy Storage Integration	Mid-term	Expands renewable energy capacity tending to reduce, reduces dependency on fossil fuels, mitigates emissions, and supports energy security goals.	Supports India's NDC goals; addresses intermittency challenges in solar energy generation.
Energy	Wind Energy	Development of Onshore and Offshore Wind Farms	Establishing new onshore and offshore wind farms to harness wind energy potential, contributing to renewable energy targets.	Mitigation	High-Capacity Wind Turbine technologies, Offshore Wind Technology, Advanced technologies like sensors, data analytics, and machine learning to develop Predictive Maintenance Systems for wind energy which are utilised to anticipate potential equipment failures and to schedule maintenance proactively.	Long-Term	Enhances renewable energy contribution, supports grid stability, creates green jobs, and reducing greenhouse gas emissions.	Requires substantial investments in offshore wind infrastructure

Sector	Subsector	Title of Activity, Programme, Project or Other	Programme/ Project Description	Type of Support	Type of Technology	Expected Time Frame	Expected Use, Impact, and Estimated Results	Additional Information
Energy	Small and Micro Hydropower	Promotion of Small and Micro Hydropower Projects	Development of small and micro hydropower plants in hilly and remote areas to provide decentralized energy solutions.	Mitigation	Technologies dealing with Low-Head Turbines, Run-of-the-River Systems, Hybrid Renewable Systems	Mid-term	Provides decentralized energy, supports rural electrification, reduces emissions, and ensures eco-friendly energy generation.	Addresses co-friendly and decentralized energy solutions; important for remote and rural electrification.
Energy	Biomass Energy	Biomass Gasification and Combustion Projects	Utilization of agricultural residues and biomass waste for energy production through gasification and combustion technologies.	Mitigation	Co-combustion Technology, Technologies for efficient Biomass Gasification Technologies for, Biogas Upgradation Systems, and methodologies for Supply Chain Optimization	Short-Term	Utilizes agricultural residue and biomass waste for clean energy development, supports rural income generation, reduces emissions, and addresses waste issues.	Addresses waste management challenges; enhances rural income through gathering and delivery of resource materials for biomass-based energy projects.
Energy	Geothermal Energy	Exploration and Development of Geothermal Resources	Identification and development of geothermal energy sites for electricity generation and direct heat applications.	Mitigation	Exploration Technologies, Technologies dealing with Enhanced Geothermal Systems (EGS), and Direct Use Applications	Long-Term	Unlocks sustainable geothermal energy potential, diversifies renewable energy mix, and reduces emissions from energy production.	Explores India's geothermal potential for sustainable heating applications and electricity generation.

Sector	Subsector	Title of Activity, Programme, Project or Other	Programme/ Project Description	Type of Support	Type of Technology	Expected Time Frame	Expected Use, Impact, and Estimated Results	Additional Information
Energy	Nuclear Energy	Expansion of Nuclear Power through Advanced Reactors (PHWRs, FBRs, AHWRs)	Enhancement of nuclear power capacity by deploying advanced reactors, enhancing low-carbon electricity generation and energy security.	Mitigation	Advanced Reactor Technologies (PHWRs, FBRs, AHWRs (Thorium based)), Small Modular Reactor (SMR) Technology	Long-Term	Provides reliable and low-carbon energy, supports baseload power requirements, reduces emissions	Addresses energy security and low-carbon energy needs
Energy	Energy Storage	Deployment of Advanced Energy Storage Systems (Long Duration Energy Storage)	Implementation of various long duration energy storage technologies to support renewable energy integration and to enhance grid stability, including batteries, pumped hydroelectricity, and other thermal & mechanical storage systems.	Cross-Cutting	Technologies dealing with Advanced Battery Energy Storage Systems, Thermal Energy Storage, Solid-State Batteries, Hydrogen Storage Systems, Flow Batteries	Mid-term to Long Term	Ensures grid stability, addresses renewable intermittency issues, enhances energy security, and supports sustainable renewable adoption.	Enhances renewable energy adoption, addresses intermittency challenges leading to grid stability, and provides grid reliability.
Energy	Energy Efficiency	Promotion of Energy-Efficient Appliances and Buildings	Implementation of energy-efficient technologies and systems across the power sector, including high-efficiency motors, waste heat recovery systems, advanced transmission technologies, and smart distribution systems to minimize operational losses and strategies to reduce energy consumption	Mitigation	Technologies dealing with High-Efficiency Motors, Waste Heat Recovery Systems, Smart Distribution Systems, and Energy Monitoring Tools (IoT-based).	Mid-Term	Reduces energy consumption, lowers operational costs, enhances building thermal performance, and decreases carbon emissions.	Aligns with national energy efficiency targets, promotes operational cost savings, and reduces emissions from the power sector.

Sector	Subsector	Title of Activity, Programme, Project or Other	Programme/ Project Description	Type of Support	Type of Technology	Expected Time Frame	Expected Use, Impact, and Estimated Results	Additional Information
Energy	Clean Coal Technologies	Deployment of Advanced Clean Coal Technologies	Upgradation of coal-based power plants with advanced ultra-supercritical (AUSC) boilers and integrated gasification combined cycle (IGCC) systems to improve efficiency and reduce emissions.	Mitigation	Advanced Ultra-Supercritical (AUSC), Technology and Integrated Gasification Combined Cycle (IGCC) Technology	Medium-Term	Improves efficiency in coal-based power generation, reduces emissions from coal use, and thereby transforming cleaner energy production.	Supports efficient and cleaner coal-based power generation while reducing carbon intensity.
Energy	Carbon Capture, Utilization, and Storage (CCUS)	Development, Deployment and integration of Carbon Capture, utilisation and Storage (CCUS)	Implementation of carbon capture, utilization, and storage (CCUS) technologies in coal based thermal power plants and industrial plants to capture CO_2 emissions and to materialize its reuse or permanent storage.	Cross-cutting	Technologies dealing with Advanced Amine Solvents, Cryogenic CO_2 Separation, and Modular CCUS Systems	Mid-term to Long Term	Captures CO_2 emitted from industrial and energy sectors, facilitates utilization, and supports global decarbonization efforts.	Enables significant emissions reductions in hard-to-abate sectors and supports the transition to coal based cleaner energy production.

Sector	Subsector	Title of Activity, Programme, Project or Other	Programme/ Project Description	Type of Support	Type of Technology	Expected Time Frame	Expected Use, Impact, and Estimated Results	Additional Information
Energy	Grid Infrastructure	Development and Modernization of Grid Infrastructure	Implementation of advanced grid technologies such as Smart Grid Technologies (AMI, smart meters, demand response systems), Renewable Energy Integration (HVDC links, FACTS), Solid-State Power Substations, and Transmission, etc. Also, implementation of Distribution Loss Reduction technologies to enhance efficiency, stability, etc. and the implementation of grid-integration with renewable energy.	Cross-cutting	Technologies related to Smart Grid, Power Electronics (Inverters, HVDC, FACTS), Solid-State Power Substations (SSPS), Superconducting Cables, Advanced Conductor Materials, and Voltage Optimization Devices (SVC, STATCOM), etc.	Short-term to Mid-term	Improves grid reliability, enhances renewable energy integration, reduces transmission losses, ensures reliable power distribution, and improves energy management systems.	Focus required on secure, scalable solutions, promotion of R&D, and deployment of pilot projects to reduce energy losses and to enhance operational efficiency.

Sector	Subsector	Title of Activity, Programme, Project or Other	Programme/ Project Description	Type of Support	Type of Technology	Expected Time Frame	Expected Use, Impact, and Estimated Results	Additional Information
Transportation	Electric Mobility	Promotion of Electric Vehicle (EV) Adoption	Accelerate adoption of EVs across passenger, freight, and public transport segments with a focus on building charging infrastructure, manufacturing advanced batteries, and promoting battery-swapping systems for motor vehicles	Mitigation	Advanced Batteries (LFP, NMC, Solid-State), High-Power DC Chargers, Battery Swapping Stations	Short-term to Mid-term	Reduces transportation emissions, improves urban air quality, supports energy efficiency, and promotes sustainable urban mobility.	Promotes decarbonization of the transport sector and aligns with India's EV targets.
Transportation	Mass Transit Systems	Development of Electrified Mass Transit Systems	Electrification of urban and inter-city transit systems like metro rails, light rail, and buses integrated with renewable energy sources. Enhancement of efficiency with regenerative braking and driverless systems.	Mitigation	Hybrid Electric Systems (Pantograph + Battery Backup), Driverless Metro Systems	Mid-term	Decreases traffic congestion, reduces per capita emissions, improves energy efficiency, and enhances accessibility to public transport.	Promotes sustainable urban mobility and reduces dependency on road-based passenger transport.

Sector	Subsector	Title of Activity, Programme, Project or Other	Programme/ Project Description	Type of Support	Type of Technology	Expected Time Frame	Expected Use, Impact, and Estimated Results	Additional Information
Transportation	Alternative Fuels	Development of commercial scale Hydrogen, Biofuel Technologies and carbon neutral fuel	Scaling up of green hydrogen production and promoting biofuels for long-haul freight, aviation, and shipping with a focus on waste-based biofuel production and hydrogen fuel cell deployment for public transport and logistics.	Cross-cutting	Hydrogen Fuel Cells, Electrolyzers, Waste-Based Biofuels, Non-Edible Oilseed Biofuels, e-Methanol, e-Diesel, and Ammonia using renewable power and CO_2 capture technologies, Sustainable Aviation Fuels (SAFs) attempting CO_2 capture and use of renewable power.	Mid-term to Long-term	Diversifies energy sources, reduces dependency on fossil fuels, lowers emissions in hard-to-decarbonize sectors, and supports energy security.	Reduces fossil fuel dependency, supports net-zero emissions in hard-to-abate sectors like aviation and shipping.
Transportation	Smart Traffic Management and Connected Vehicles	Development of Smart Traffic Management and Connected Vehicle Technologie	Implementation of IoT-enabled adaptive traffic signals integrated with AI for traffic optimization, and deployment of V2X communication systems (V2V, V2I, V2G) for real-time data exchange to enhance road safety, reduce congestion, and integrate EVs with the grid.	Mitigation	IoT Adaptive Traffic Signals, AI-Driven Analytics, V2X Communication (V2V, V2I, V2G)	Short-term to Mid-term	Optimizes traffic flow, reduces fuel consumption, minimizes urban air pollution, and enhances road safety through connected technologies.	Enhances traffic flow, reduces urban emissions, improves road safety, and supports EV energy grid integration.

Sector	Subsector	Title of Activity, Programme, Project or Other	Programme/ Project Description	Type of Support	Type of Technology	Expected Time Frame	Expected Use, Impact, and Estimated Results	Additional Information
Industry	Energy Efficiency	High-Efficiency Motor Program, Waste Heat Utilization Program	Replacement of inefficient motors with VFDs/PMMs; implementation of modular WHRUs and thermoelectric generators to capture and reuse heat.	Mitigation	VFDs, PMMs, WHRUs, Thermoelectric Generators	Short-term to Mid-term	Reduces energy consumption across sectors, lowers operational costs, and supports sustainability goals by improving process efficiency.	Targets Small Medium Enterprises; focuses on retrofitting legacy systems and mobilizing new technology adoption.
Industry	Process Optimization	Integration of Advanced Catalytic and Enzymatic Processes	Utilization of heterogeneous catalysts for chemical synthesis and enzymatic bleaching in pulp and textile industries to enhance process efficiency and lower environmental impact.	Mitigation	Advanced Catalysts, Enzymatic Pre-treatment Systems, Inert Anode, Advanced Pot Controller, Solar MVR, LC3 Cement	Mid-term	Enhances resource efficiency, reduces energy waste, improves productivity, and lowers emissions in industrial and operational processes.	Promotes sustainable industrial practices; alters chemical use pattern and reduces energy intensity in industrial sectors.
Industry	Renewable Energy Integration	Deployment of On-Site Renewable and Hybrid Energy Systems	Integration of solar PV, small wind turbines, and hybrid systems into industrial estates for energy self-sufficiency and emission reductions.	Mitigation	Solar PV Systems, Small Wind Turbines, Battery Storage for Hybrid Systems	Mid-term	Enhances energy resilience, increases the share of renewables in the energy mix, reduces grid dependency by promoting decentralised power generation, and mitigates greenhouse gas emissions	Promotes energy security for industries through decentralised power production and reduces dependence on fossil fuels.

Sector	Subsector	Title of Activity, Programme, Project or Other	Programme/ Project Description	Type of Support	Type of Technology	Expected Time Frame	Expected Use, Impact, and Estimated Results	Additional Information
Industry	Digitalization	Digital Energy Monitoring Program, Fault Prediction in Industrial Equipment	IoT-enabled real-time energy monitoring; AI-driven fault detection systems to reduce downtime and optimize operations.	Mitigation	IoT, AI for Energy Optimization, Predictive Maintenance Tools	Short to Mid-Term	Improves process monitoring and optimization, reduces inefficiencies, enhances productivity, and supports decision-making with real-time data.	Promotes SME digitalization & energy efficiency improvement; reduced operational inefficiencies and increase in equipment lifespan.
Industry	Industrial Symbiosis	Scrap Steel Recycling Initiative, Waste Sharing Across Industries	Expanding EAF capacities for steel recycling; establishing industrial networks for sharing waste heat, by-products, and resources.	Cross-Sectoral	Electric Arc Furnaces (EAF), Heat Sharing Technologies, Advanced By-Product Recycling technologies	Mid to Long	Promotes resource sharing, reduces industrial waste, enhances energy efficiency, and minimizes environmental impacts in industrial clusters.	Enables decarbonization of hard-to-abate sectors like steel, cement, and refining.
Industry	Cement & Iron Sector	Clinker Substitution Program, Hydrogen-Based Ironmaking	Promoting blended cements with SCMs; implementing hydrogen-based DRI systems to replace coke in steelmaking	Mitigation	Blended Cements, Hydrogen Reduction Processes	Mid to Long Term	Reduces carbon emissions through alternative materials and energy efficiency, supports circular economy practices, and enhances sustainability.	Focuses on alternative materials in cement; integrates hydrogen-ready infrastructure with renewable hydrogen hubs.

Sector	Subsector	Title of Activity, Programme, Project or Other	Programme/ Project Description	Type of Support	Type of Technology	Expected Time Frame	Expected Use, Impact, and Estimated Results	Additional Information
Industry	Circular Economy	Advancement of Recycling and Waste Management Systems	Promoting advanced recycling technologies for metals and plastics. Implementation of zero liquid discharge (ZLD) systems and wastewater management for sustainable industrial practices.	Cross-cutting	Advanced Recycling Technologies, Membrane-Based ZLD Systems	Mid-term	Reduces resource extraction, promotes material reuse and recycling, minimizes waste, and supports sustainable production and consumption.	Reduces waste and supports resource recovery in industries while addressing water scarcity.
Industry	Bio-Refinery Plant	Biomass-Based Bio-Refinery	Development of bio-refineries to produce bio-based value-added products from biomass for industrial use.	Cross-cutting	Bio-Refinery Technologies	Mid to Long Term	Converts biomass into value-added products, supports renewable energy goals, reduces dependency on fossil fuels, and creates rural livelihoods.	Significant reduction in fossil-based raw materials; creation of diverse bio-based product lines.
Industry	Advanced Materials	Development of Low-Impact Materials	R&D into advanced materials with lower environmental impacts to reduce energy consumption and emissions across industries.	Cross-cutting	Advanced Materials	Short to Mid-Term	Promotes lightweight, durable, and energy-efficient materials, reduces embodied carbon, and supports innovation in industrial and building sectors.	Promotes adoption of materials with higher energy efficiency and lower lifecycle emissions.

Sector	Subsector	Title of Activity, Programme, Project or Other	Programme/ Project Description	Type of Support	Type of Technology	Expected Time Frame	Expected Use, Impact, and Estimated Results	Additional Information
Industry	Refrigeration and Airconditioning	Low GWP and natural refrigeration technologies to replace use of HFCs	R&D and commercialisation of low GWP and natural refrigeration technologies leading to lower and no GHG emissions	Mitigation	Mainstreaming the use of natural refrigerants such as ammonia, carbon dioxide, and hydrocarbons; and synthetic alternatives like Hydrofluoroolefins (HFOs	Short to Mid term	Supports India's commitment to Kigali amendment in addition to mitigating warming due to HFC use	Promotes adoption of refrigerants with low or no GWP refrigerants and higher energy efficient cooling systems
Building and Habitat	Alternative Building Materials	Engineered Wood Products, Geopolymer Concrete	Eco-friendly substitutes to reduce embodied carbon in construction and for thermal control in buildings	Mitigation	Engineered Wood, Cement-Free Concrete	Mid-term	Reduces reliance on high-carbon materials like cement and steel, supports eco-friendly construction, and promotes sustainable infrastructure development.	Promotes local manufacturing hubs for engineered wood; Encourages Geopolymer concrete adoption.
Building and Habitat	Passive Housing Designs & High-Performance Building Envelopes	Promotion of Passive Housing Designs & High-Performance Building Envelopes	Incorporation of natural ventilation, thermal insulation, double-glazed windows, and cool roofs to reduce heating and cooling demands.	Mitigation	Passive Design, Insulated Envelopes	Mid-term	Improves thermal comfort, reduces heating and cooling energy requirements, supports energy-efficient construction, and lowers operational emissions.	Mandate inclusion of passive elements in building codes; subsidies for retrofitting.
Building and Habitat	Prefab and Modular Construction Systems	Promotion of Prefabricated Sandwich Panels, Precast Concrete, Monolithic Formwork	Factory-produced components for high-rise residential buildings, industrial warehouses, and schools to enhance efficiency.	Mitigation	Prefabricated Systems, Modular Techniques	Mid to Long Term	Speeds up construction timelines, reduces material waste, enhances cost efficiency, and supports low-carbon infrastructure development.	Establishing regional prefabrication hubs; incentivizing advanced modular systems and recycling of high-carbon components.

Sector	Subsector	Title of Activity, Programme, Project or Other	Programme/ Project Description	Type of Support	Type of Technology	Expected Time Frame	Expected Use, Impact, and Estimated Results	Additional Information
Waste	Sustainable Waste Management Technologies	Sustainable Waste Collection, Transportation & Treatment	Deployment of modern collection and transport systems (smart bins, GPS routing, EV vehicles) along with decentralized and centralized treatment facilities (composting, biomethanation, RDF, waste-to-energy).	Cross-Sectoral	Deployment of modern collection and transport systems (smart bins, GPS routing, EV vehicles) along with decentralized and centralized treatment facilities (composting, biomethanation, RDF, waste-to-energy).	Short to Mid-Term	Reduced landfill dependency, energy recovery, improved collection efficiency, reduced emissions	Supports smart cities, renewable energy, and waste diversion goals
Waste	Solid Waste	Advanced Recycling, Resource Recovery & Monitoring Systems	Establishment of MRFs, advanced mechanical/ chemical recycling, co-processing, along with digital monitoring, GIS/ IoT-based waste tracking, and MRV frameworks.	Financial, Technical, Capacity-building	Advanced recycling, chemical recovery, GIS/IoT systems, AI-based analytics, EPR models	Mid to Long Term	Promotes circular economy, resource efficiency, accurate GHG reporting, reduced plastic leakage, climate resilience	Supports Plastic Waste Management Rules, SDG 12, SDG 13, and transition to circular economy
Water	Water Treatment and Distribution	Deployment of Advanced Membrane Filtration, Smart Water Grids, and Reverse Osmosis (RO) with Energy Recovery	Integrating advanced filtration, IoT-enabled grids, and energy-efficient desalination systems to optimize water treatment and distribution.	Cross-Sectoral	Nano-Membranes, IoT Pressure Sensors, PX Devices	Short to Mid-Term	Ensures clean water access, reduces energy use in water treatment, enhances distribution efficiency, and mitigates water scarcity challenges.	Targets modular small-scale applications; incentivizes IoT upgrades for water grids and renewable energy integration in RO plants.

Sector	Subsector	Title of Activity, Programme, Project or Other	Programme/ Project Description	Type of Support	Type of Technology	Expected Time Frame	Expected Use, Impact, and Estimated Results	Additional Information
Water	Wastewater and Circular Water Economy	Portable Solar Water Treatment, Advanced Oxidation Processes (AOPs), and Zero Liquid Discharge (ZLD) in Industries, energy recovery in industrial wastewater treatment	Promoting energy-efficient wastewater treatment systems and achieving full water recycling through decentralized systems and advanced ZLD technologies. Advanced anaerobic reactors to exploit organic wastewater generation in Indian industries,	Cross-Sectoral	Energy efficient aeration systems, Membrane Bioreactors (MBRs), AOPs based on wet oxidation, UV Led, crystallizers Microbial fuel cell-based wastewater treatment	Mid to Long Term	Reduced sludge production of organic nature. Promotes wastewater recycling, reduces pollution in water bodies, supports industrial water reclamation, and ensures sustainable water management. MFCs minimize sludge production compared to conventional methods, thus reducing waste and associated disposal challenges. Their operation supports decreased emissions and a more eco-friendly treatment infrastructure	Supports in promotion of modular setups for smaller communities and incentives for ZLD adoption in high water-use industries. MFC can treat a variety of wastewaters—domestic, industrial (e.g., sulfate-laden, nutrient-rich, or even heavy-metal-containing waste streams)—and can be tailored for specific recovery goals such as elemental sulfur or biogas production.

Sector	Subsector	Title of Activity, Programme, Project or Other	Programme/ Project Description	Type of Support	Type of Technology	Expected Time Frame	Expected Use, Impact, and Estimated Results	Additional Information
Agriculture	Smart Agriculture/ precision farming	Smart Irrigation, Precision Farming	Adopting IoT-enabled sensors, Drone based management, AI-based crop analysis, and data driven decision for improved water and nutrient use efficiency and resilience to climate variability.	Adaptation	IoT Soil Sensors, AI Crop Analysis, Smart Weather Monitoring	Short to Mid-Term	Optimizes water, fertilizer, and pesticide use, improves crop yields, reduces resource wastage, and enhances climate resilience in farming.	Promotes adoption of precision agriculture tools
Agriculture	Enteric emission	Feeding interventions for reducing enteric emission	Balanced feeding and feed additives to improve feed efficiency, selection of feed efficient animals and carbon footprint	Mitigation	Precision feeding	Short to mid term	Improving feed efficiency will reduce carbon footprint for milk production	Requires policy to implement under field condition
Agriculture	Manure management	Biogas production/ bio fuel production	Management of manure for biogas/ bio fuel production at small scale	Adaptation	Smart animal agriculture	Short to long term	Improving manure management will reduce emission and reduce dependency on fossil fuel/ conventional energy source	Requires policy to implement under field condition

Sector	Subsector	Title of Activity, Programme, Project or Other	Programme/ Project Description	Type of Support	Type of Technology	Expected Time Frame	Expected Use, Impact, and Estimated Results	Additional Information
Forestry	Sustainable Forest Monitoring	Establishment of Integrated Smart Forest Monitoring System	Establishing and upgrading forest inventory plots into smart inventories using LiDAR for biomass estimation and growth tracking, and Phenological monitoring using PhenoCams, supported by IoT sensors, automated data collection, and weather stations linked to each plot for climate–forest interaction studies.	Adaptation and Mitigation	LiDAR, IoT Sensors, Smart Monitoring Platforms, Weather Stations, Data Analytics Tools	Mid- to Long-term	Provides accurate biomass estimates, improves carbon stock assessments, enhances climate resilience strategies and carbon credit mechanisms, enables real-time monitoring of forest health, and strengthens sustainable forest management practices.	Facilitates integration of ground-based inventory with remote sensing; supports policy-making through high-resolution data; strengthens collaboration between local communities, researchers, and forest managers.
Forestry	Sustainable Forest Monitoring for Disaster Management	AI-Enabled Early Warning and Forest Health Monitoring System	Developing a real-time disaster management system for forests by integrating AWS (Automatic Weather Stations) with AI and ML-based models to predict and detect forest fires, pest/disease outbreaks, and forest degradation.	Adaptation and Mitigation	AI/ML Models, Automatic Weather Stations, IoT Sensors, Remote Sensing, Smart Analytics Platforms	Mid-term	Enables real-time forest fire prediction and detection, supports rapid response to disasters, minimizes biodiversity loss, and enhances the resilience of forest ecosystems. Provides early warnings to authorities and communities, thereby reducing economic losses and safeguarding carbon stocks.	System integrates climatic, ecological, and satellite data; leverages AWS networks for localized forecasting; supports national forest protection policies and strengthens community-based disaster preparedness.

Sector	Subsector	Title of Activity, Programme, Project or Other	Programme/ Project Description	Type of Support	Type of Technology	Expected Time Frame	Expected Use, Impact, and Estimated Results	Additional Information
Forestry	Sustainable Forestry Management	Deployment of Precision Forestry, Agroforestry Systems, and Forest Monitoring Technologies	Utilising satellite imagery, drones, and GIS tools for forest monitoring and integrating agroforestry for enhanced productivity and ecosystem restoration.	Adaptation	Remote Sensing, Agroforestry Systems, GIS Tools	Mid-term	Protects biodiversity, enhances carbon sequestration, supports sustainable timber production, and promotes ecosystem restoration.	Encourages local community engagement in agroforestry projects; integrates GIS for data-driven decision-making in forest management

Table III.10: Information on capacity-building support needed by developing country Parties under Article 11 of the Paris Agreement

Sector	Subsector	Title of Activity, Programme, Project or Other	Programme/Project Description	Type of Support	Expected Time Frame	Expected Use, Impact, and Estimated Results	Additional Information
Energy	Inventory Reporting	Development of Advanced GHG Inventory Systems	Improvement of inventory methodologies, development of country specific emission factors and Expansion of activities for the new categories like fugitive emissions.	Mitigation	Mid-term	Improved accuracy and transparency in GHG inventory reporting.	Focus on updating coal and fuel metrics, with new methods for dispersed industrial activities.
Energy	Oil and Gas	Training for Fugitive Emissions Monitoring	capacity building for detecting and quantifying methane leaks in oil and gas operations using advanced monitoring technologies.	Mitigation	Short-term to Mid-term	Enhanced capability to capture and mitigate methane emissions.	Includes training on advanced equipment and financial support for technology acquisition.
Energy	Coal Mining (Opencast)	Measurement of methane flux in opencast coal mines	Capacity building for methane flux measurement in opencast coal mines	Mitigation/ Inventory	Short-term to Mid-term	Enhance capability for measurement of low concentration methane emissions	Financial support for technology acquisition
Energy	Coal Sector	Establishment of Coal Quality Metrics	Develop systems for comprehensive coal quality tracking, including monitoring for all coals in the country's economy including imported coals imported coals for determination of NCVs and CEFs for various coal- categories.	Mitigation	Mid-term	Time to time refinement of the NCVs and CEFs to be used for emission estimations for the energy and industrial sectors.	Requires collaboration between government agencies and coal producers/ suppliers / users
Energy	Data Collection	Centralized Data Infrastructure Development	Establishment of a centralized platform for data collection, storage and delivery to concerned agency, ensuring consistency and transparency.	Cross-Cutting	Short-term	Improved data availability and reduced uncertainty in sectoral emissions.	Develop a real-time data integration framework with advanced analytics tools.
Energy	Renewable Integration	Training for Advanced MRV and Grid Stability Techniques	Enhancement of capacity in integrating renewables, handling grid variability, and implementing advanced MRV techniques.	Cross-Cutting	Short-term	Improved accuracy in emissions reporting and grid resilience.	Includes financial incentives for renewable adoption and grid modernization.

Sector	Subsector	Title of Activity, Programme, Project or Other	Programme/Project Description	Type of Support	Expected Time Frame	Expected Use, Impact, and Estimated Results	Additional Information
Energy	Grid Management	Research on Grid Modernization and Storage Technologies	Setting up of benchmarks for energy-saving technologies and innovation in battery storage for renewable integration.	Mitigation	Short-term to Mid-term	Enhanced grid stability and renewable energy adoption.	Includes pilot studies for rural electrification using resilient technologies.
Energy	Capacity Building	Training Programs for Industry Personnel	Conducting training on inventory reporting, emissions monitoring, and data management for industry personnel and government officials.	Cross-Cutting	Short-term	Improved skills for accurate and timely emissions reporting across energy sub-sectors.	Includes periodic workshops, digital modules, and certification programs.
Transportation	EV and Sustainable Systems	R&D for EV and Low-Emission Public Transport Systems	Increased investments in EV technology innovation, sustainable charging infrastructure, and resilient transport solutions.	Cross-Cutting	Short-term to Mid-term	Accelerated adoption of EVs and development of sustainable public transport systems.	Behavioral studies for promoting non-motorized transport adoption.
Transport sector	Road transportation, Aviation, navigation and railways	Development of India specific models to estimate the GHG emissions for capturing the changing scenario in road transportation, navigation (marine and inland) and aviation	The project will capture the year-on-year GHG emission trends resulting from energy savings due to multimodal transportation, improved road infrastructure, use of alternative fuel, penetration of EVs, and energy efficiency technologies amongst other initiatives.	Mitigation	Mid- long term	Higher tier reporting of emissions leading to an emissions inventory from this sector that is representative of actual scenario on the ground.	Would lead to formation of network of institutions across India working on various aspects of transportation that would generate the spatial data on transportation on land, sea and air.
Buildings	Climate-Resilient Construction	Research in Energy-Efficient Materials and Urban Planning	Development of climate-resilient architecture and urban planning frameworks for sustainable development.	Adaptation	Mid-term	Increased adoption of energy-efficient building practices and urban sustainability.	Collaboration with urban planning agencies and private builders.

Sector	Subsector	Title of Activity, Programme, Project or Other	Programme/Project Description	Type of Support	Expected Time Frame	Expected Use, Impact, and Estimated Results	Additional Information
IPPU	Emission Factors	Development of Updated Country-Specific Emission Factors Sector-Specific Emission Factor Libraries	development of technology-specific and country-specific EFs for cement, ammonia, iron & steel, and for industrial processes and product use in electronic industries, air conditioning and refrigeration, production of chemical and metals, and used in other product manufacturing and use to enhance emissions accuracy. IPCC could compile /Update comprehensive libraries of emission factors for diverse industrial processes and products under the IPPU sector, reflecting regional and technological variations.	Mitigation	Mid-term	Improved accuracy and relevance of emissions data for key industrial sectors.	Collaboration with research institutions and international experts is essential.
IPPU	Data Collection	Strengthening Industrial Data Collection Systems	Building up of centralized systems for real-time emissions data collection from industries, ensuring alignment with IPCC guidelines. Systematic collation of activity data across all categories in the IPPU sector from related industries to ensure a comprehensive reporting of GHG emissions from this sector.	Mitigation	Short-term	Enhanced consistency and granularity in industrial emissions reporting.	Focus on data collection tools and training for industry personnel.

Sector	Subsector	Title of Activity, Programme, Project or Other	Programme/Project Description	Type of Support	Expected Time Frame	Expected Use, Impact, and Estimated Results	Additional Information
IPPU	Capacity Building	Training Programs for Emissions Inventory Compilers	Capacity building for the compilers and industry personnel in Tier 2/3 methodologies, direct measurement techniques, and advanced emissions modelling. Facilitate access to case studies, success stories, and lessons learned from other countries' experiences in IPPU inventory development to inform and inspire improvements. Support creation of interactive web-based platforms for real-time knowledge exchange, FAQs, and troubleshooting related to IPPU inventory challenges.	Mitigation	Short-term	Improved capacity for accurate and transparent emissions reporting.	Includes workshops, digital tools, and international knowledge-sharing forums.
IPPU	Policy and Standards	Institutional Strengthening for Emissions Reporting	Policy- making mandating regular updates to industrial emissions data and aligning sectoral reporting with international standards.	Mitigation	Mid-term to Long-term	Improved alignment of India's emissions inventory with international climate commitments.	Requires inter-agency coordination and stakeholder engagement for implementation.
IPPU	MRV Systems	Establishing Robust MRV Frameworks	Creation of robust MRV frameworks to integrate industrial emissions data into national inventories effectively and transparently.	Mitigation	Mid-term	Enhanced transparency and accountability in emissions reporting.	Focus on linking industrial MRV systems with national GHG inventory databases.
IPPU	Low-Carbon Technologies	R&D for CCS and Cleaner Production Technologies	Development of expertise in CCS, process optimization, and energy efficiency for hard-to-abate industries.	Mitigation	Mid-term	Reduced industrial emissions and enhanced adoption of low-carbon technologies.	Collaboration with research institutes and industries for cost-effective technology adoption.

Sector	Subsector	Title of Activity, Programme, Project or Other	Programme/Project Description	Type of Support	Expected Time Frame	Expected Use, Impact, and Estimated Results	Additional Information
IPPU	Low-Carbon Technologies	R&D in CCS and Cleaner Production Processes	Promotion of research in the area of advanced CCS and sector-specific low-carbon manufacturing technologies.	Mitigation	Mid-term	Reduced industrial emissions and improved process efficiencies.	Focus on cement, steel, and chemical industries.
Agriculture	Data Collection	Development of Comprehensive Agricultural Data Systems	Establishment of systems to gather detailed sub-national data on crop production, fertilizer use, and water regimes.	Mitigation	Mid-term	Improved accuracy in GHG estimates; reduced uncertainty in CH_4 and N_2O emissions.	Includes remote sensing tools and integration of precision agriculture technologies.
Agriculture	Emission Factors	Development of Country-Specific Emission Factors	development of EFs for activities like rice cultivation, agricultural soils, manure management, and residue burning to enhance emission accuracy.	Mitigation	Mid-term	Enhanced reliability and granularity in agricultural GHG reporting.	Collaboration with research institutions for field-level measurements.
Agriculture	Sustainable Practices	Training in Climate-Resilient Agriculture Practices	Imparting training to the farmers on conservation agriculture, organic farming, and water- and nutrient efficient practices to promote sustainable agriculture.	Adaptation	Mid-term	Increased adoption of SAPs; reduced emissions from agricultural activities.	Focus on training extension workers and farmers at the village level.
Agriculture	MRV Systems	Strengthening MRV Systems for Rural Agriculture	Development of MRV systems to monitor CH_4 and N_2O emissions in rural areas, supported by advanced modeling and monitoring tools.	Mitigation	Short-term to Mid-term	Improved transparency and accuracy in agricultural emissions reporting.	Includes field validation, real-time reporting, and integration with national inventory systems.
Agriculture	Policy and Governance	Policy Support for SAP Adoption	Strengthening policies for organic farming, fertilizer efficiency, and precision irrigation through financial and technical incentives.	Cross-Cutting	Mid-term to Long-term	Increased adoption of mitigation strategies and reduced GHG emissions.	Requires collaboration between policymakers, researchers, and agricultural cooperatives.
Agriculture	Sustainable Practices	Training for SAPs and Data Collection	Capacity Building. for data collection and SAP adoption, focusing on precision agriculture and emissions modeling.	Mitigation	Short-term to Mid-term	Improved agricultural efficiency and reduced CH_4 and N_2O emissions.	Includes workshops for farmers and extension officers on SAP benefits.

Sector	Subsector	Title of Activity, Programme, Project or Other	Programme/Project Description	Type of Support	Expected Time Frame	Expected Use, Impact, and Estimated Results	Additional Information
LULUCF	Data Collection	Development of Comprehensive Land Use Data Systems	Building up frameworks for consistent time-series data collection on biomass, SOC, and wetland carbon emissions and HWP Domestic Production, Import and Export.	Mitigation	Mid-term	Improved carbon flux monitoring and accuracy in LULUCF emissions reporting.	Includes geospatial tools and harmonized inter-agency reporting mechanisms.
LULUCF	MRV	Enhancing QA/QC process	Development of a clear MRV framework specific to the sector, with integration across field, satellite, and institutional data, to enhance transparency	Cross-cutting	Short-term to Mid-term	Enhanced accuracy in the GHG inventory	Include workshops and trainings
LULUCF	Methodology	Advancing Process-Based Carbon Stock Modeling	Developing Tier 3 methodologies for SOC and biomass flux estimation using advanced process-based modeling techniques.	Mitigation	Mid-term to Long-term	Higher accuracy in carbon stock assessment and alignment with IPCC guidelines.	Includes training in model-based tools for SOC and biomass flux calculations.
LULUCF	Capacity Building	Training for LULUCF Professionals in Gain-Loss Approaches	Capacity building in carbon stock estimation, remote sensing, and model-based indicators for enhanced data accuracy.	Cross-Cutting	Short-term to Mid-term	Improved technical skills and standardized data collection practices.	Include workshops, certification programs, and international collaboration platforms.
LULUCF	Carbon Dynamics	Developing Country-Specific Emission Factors (EFs)	Developing EFs for above-ground biomass, soil organic carbon, deadwood, and litter across diverse land categories and Half Life and Conversion Factors for HWP.	Mitigation	Mid-term	Enhanced relevance and reliability of LULUCF emissions reporting.	Collaboration with international experts and research institutions for EF development.
LULUCF	Reporting Systems	Standardization of LULUCF Reporting Protocols	Establishing standardized reporting mechanisms to align with international transparency frameworks (e.g., UNFCCC, Paris Agreement).	Cross-Cutting	Mid-term to Long-term	Improved transparency and consistency in LULUCF data for national and international commitments.	Focus on integrating tools for annual land cover and change estimation.

Sector	Subsector	Title of Activity, Programme, Project or Other	Programme/Project Description	Type of Support	Expected Time Frame	Expected Use, Impact, and Estimated Results	Additional Information
LULUCF	Land-Use Modeling	Training in Geospatial and Carbon Estimation Techniques	Capacity building for geospatial modeling, carbon stock assessment, and standardized reporting in the LULUCF sector.	Cross-Cutting	Mid-term	Improved transparency and accuracy in LULUCF data for national inventories.	Focus on community-driven conservation and reforestation initiatives.
Waste	Data Collection	Establishment of National Waste Data Systems	Development of comprehensive systems for collecting data on waste volumes, generated, treatment methods, and disposed with emissions potential and across regions	Cross-Cutting	Short-term	Improved accuracy and consistency in national waste management reporting.	Integration of informal sector contributions and use of automated data collection tools.
Waste	Advanced Technologies	Promotion of Methane Capture and Waste-to-Energy Systems	Implementation of technologies like anaerobic digesters, landfill gas recovery, and waste-to-energy plants to reduce emissions.	Mitigation	Mid-term	Reduced methane emissions and increased energy recovery from waste.	Focus on urban areas and high-emission waste streams such as MSW, industrial effluents and hazardous waste.
Waste	Reporting Frameworks	Standardization of Waste Reporting Protocols	Development of uniform reporting methodologies across states and agencies for consistent and reliable GHG emissions estimates and development of emission factors across the reporting requirements and for Tier 3 methodologies.	Cross-Cutting	Short-term to Mid-term	Improved transparency and alignment with international GHG reporting standards.	Requires inter-agency collaboration and integration with national GHG inventories.
Waste	Capacity Building	Training Programs for Waste Management Professionals on methods for development of emissions factors and measurement methods as reported for the NDCs and BTRs	Skill development in emissions measurement, emissions factor database across geographical context, waste treatment technologies, and inventory reporting for municipal and industrial personnel.	Cross-Cutting	Short-term	Enhanced technical capacity and reduced uncertainties in emissions reporting.	Includes periodic workshops and certification programs targeting waste sector stakeholders.

Sector	Subsector	Title of Activity, Programme, Project or Other	Programme/Project Description	Type of Support	Expected Time Frame	Expected Use, Impact, and Estimated Results	Additional Information
Waste	Informal Sector	Integration of Informal Sector into Waste Management	Development of frameworks to include informal waste collectors in formal systems through training and incentivization. Include other industries where effluents have potential for methane extraction.	Cross-Cutting	Mid-term	Improved emissions reporting and waste management efficiency.	Focus on creating livelihood opportunities and promoting sustainable waste management.
Waste	Reporting and Methane Capture	Standardizing Waste Reporting and Promoting Methane Capture	Development of consistent reporting frameworks and adopt advanced methane capture technologies for landfills.	Mitigation	Mid-term	Reduced landfill methane emissions and improved compliance with international standards.	Includes integration of informal sector workers into formal waste systems.
Water	Regional Models and Bioresources	Research on Hydropower Emissions and Marine Sequestration	Studies on hydropower-related emissions, scalable algal biofuels, and carbon sequestration in marine ecosystems.	Mitigation	Mid-term to Long-term	Improved climate resilience of water resources and marine ecosystems.	Includes partnerships with academic institutions and NGOs.
Cross-cutting	Training & Institutional Strengthening	Gender-Sensitive Capacity Building and Cross-Sectoral Linkages	To integrate gender-sensitive training and equity considerations into climate action programmes while fostering stronger cross-sectoral linkages with agriculture, water, and livelihood sectors. This holistic approach ensures inclusivity, knowledge-sharing, and enhanced community resilience.	Cross-Cutting	Short-term to Mid-term	Strengthen institutional capacities, mainstream gender equity in climate action, and promote integrated approaches across agriculture, water, and livelihood sectors.	This cross-cutting initiative emphasizes gender-sensitive training, equity dimensions, and stronger sectoral linkages.
Cross-cutting	MRV Systems	Development of Centralized MRV Frameworks	Upgradation of standardized reporting methodologies and integrating state-level data into a unified national platform.	Cross-Cutting	Mid-term	Improved consistency, transparency, and accuracy in GHG inventory reporting.	Includes training for state-level agencies and digitization of reporting processes.
Cross-cutting	Climate Finance	Capacity Building for Securing Climate Finance	Capacity Building of the stakeholders in proposal writing, financial planning, and grant management to enhance access to international funds.	Cross-Cutting	Short-term	Increased funding for mitigation and adaptation projects, especially in vulnerable sectors.	Collaboration with financial institutions to support grant-based funding.

Sector	Subsector	Title of Activity, Programme, Project or Other	Programme/Project Description	Type of Support	Expected Time Frame	Expected Use, Impact, and Estimated Results	Additional Information
Cross-cutting	Technology Transfer	Promoting Domestic Manufacturing and Deployment of Technologies	Development of the policies to address IP barriers and incentivize local manufacturing of renewable energy and adaptation technologies.	Mitigation	Mid-term to Long-term	Faster deployment of advanced climate technologies, reducing dependency on imports.	Leverage PPPs to build domestic capacity in climate-resilient technologies.
Cross-cutting	Public Awareness	Nationwide Education and Awareness Campaigns	Launching campaigns to promote sustainable practices, behavioral changes, and energy conservation at individual and community levels.	Cross-Cutting	Short-term	Increased public participation in climate actions and adoption of sustainable practices.	Utilize digital platforms and local networks for maximum outreach.
Cross-cutting	Livelihood Resilience	Livelihood Diversification Programs	Development of programs for agroforestry, aquaculture, and eco-tourism to reduce reliance on climate-sensitive sectors.	Adaptation	Mid-term	Enhanced adaptive capacity of vulnerable communities and reduced socio-economic impacts.	Focus on integrating traditional knowledge with modern practices for climate resilience.
Cross-cutting	Transparency and Reporting	Enhanced Climate Finance Transparency	Development of tools to monitor and report on the allocation and impact of climate finance, ensuring alignment with capacity-building goals.	Cross-Cutting	Short-term to Mid-term	Improved accountability and efficiency in climate finance utilization.	Public dashboards for real-time updates on project funding and outcomes.
Cross-cutting	Public Awareness and Behavior	Behavioral Studies for Sustainable Practices	Conducting research to identify barriers to adoption of sustainable practices and effective awareness strategies.	Adaptation	Short-term	Increased community participation and adoption of sustainable lifestyles.	Focus on outreach programs and localized campaigns.
Cross-cutting	Policy and Governance	Strengthening Institutional Frameworks for Climate Action	Training for the policymakers in risk assessment, financial planning, and multi-sectoral coordination for climate resilience.	Adaptation	Short-term to Mid-term	Enhanced alignment of national strategies with international commitments (e.g., Paris Agreement).	Focus on inter-departmental collaboration and integration of SAPCCs into national plans.
Cross-cutting	Resilience Building	Livelihood Diversification Programs	Promotion of programmes in agroforestry, aquaculture, and eco-tourism to enhance adaptive capacity for vulnerable communities.	Adaptation	Mid-term	Reduced dependency on climate-sensitive sectors and increased community resilience.	Includes capacity building for alternative livelihoods and financial literacy training.

Table III.12: Information on support needed by developing country Parties for the implementation of Article 13 of the Paris Agreement and transparency-related activities, including for transparency-related capacity-building

Exchange Rate used: USD 1 = INR 76.34

Title of activity, programme, project or other	Objectives and description	Expected time frame	Recipient Entity	Channel	Domestic Currency (INR Crore)	USD Million	Status of Activity	Expected use, impact and estimated results	Additional Information
Preparation of India's Second Biennial Transparency Report (BTR -2)	The objective of this project is to assist India in preparation and submission of its second BTR for the fulfilment of the obligations under the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement, in line with the modalities, procedures and guidelines (MPGs) for the transparency framework for action and support referred to in Article 13 of the Paris Agreement (Decision 18/ CMA.1) and the guidance on operationalising the MPGs as per Decision 5/CMA.3.	2025-2026	Ministry of Environment, Forest and Climate Change	NR	19.09	2.50	Planned	The project will support India in achieving its global environment concerns and commitments to international conventions, and to integrate climate change considerations in national development planning and policy through ensuring continuity of the institutional and technical capacity building, partly initiated and consequently sustained by reporting instruments under the UNFCCC.	NA
Second phase of Capacity-building for establishing an integrated and Enhanced transparency framework for climate actions and support measures (CBIT - 2)	The objective of this project is to assist India towards strengthening and expanding its current technical capacities regarding methodologies and tools to enhance transparency, as outlined in Article 13 of the Paris Agreement. The potential future activities have been planned for sector-wise GHG Inventory improvement.The primary objective of the sector-wise GHG inventory improvement plan is to strengthen institutional and technical	2028-2032	Ministry of Environment, Forest and Climate Change	NR	57.26	7.5	Planned	The project will support India in achieving its global environment concerns and commitments to international conventions. It will help strengthen national institutions for transparency-related activities in line with national priorities; provide relevant tools, training and assistance for meeting the provisions stipulated in Article 13 of the Paris Agreement; and assist in the improvement of transparency over time.	NA

Title of activity, programme, project or other	Objectives and description	Expected time frame	Recipient Entity	Channel	Domestic Currency (INR Crore)	USD Million	Status of Activity	Expected use, impact and estimated results	Additional Information
	capacities, develop country-specific emission factors, and improve activity data quality across key sectors such as Energy, IPPU, Agriculture, LULUCF, and Waste. The planned activities outline targeted interventions aimed at reducing uncertainties, enhancing methodological robustness, and ensuring comprehensive data coverage across all inventory sectors. The details of the activities are given at Chapter 5.8 of BTR								
Preparation of India's Third Biennial Transparency Report (BTR-3)	The objective of this project is to assist India in preparation and submission of its third BTR for the fulfilment of the obligations under the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement, in line with the modalities, procedures and guidelines (MPGs) for the transparency framework for action and support referred to in Article 13 of the Paris Agreement (Decision 18/CMA.1) and the guidance on operationalising the MPGs as per Decision 5/CMA.3.	2027-2028	Ministry of Environment, Forest and Climate Change	NR	19.09	2.50	Planned	The project will support India in achieving its global environment concerns and commitments to international conventions, and to integrate climate change considerations in national development planning and policy through ensuring continuity of the institutional and technical capacity building, partly initiated and consequently sustained by reporting instruments under the UNFCCC.	NA

Title of activity, programme, project or other	Objectives and description	Expected time frame	Recipient Entity	Channel	Domestic Currency (INR Crore)	USD Million	Status of Activity	Expected use, impact and estimated results	Additional Information
Preparation of India's Fourth Biennial Transparency Report (BTR -4)	The objective of this project is to assist India in preparation and submission of its fourth BTR for the fulfilment of the obligations under the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement, in line with the modalities, procedures and guidelines (MPGs) for the transparency framework for action and support referred to in Article 13 of the Paris Agreement (Decision 18/CMA.1) and the guidance on operationalising the MPGs as per Decision 5/CMA.3.	2029-2030	Ministry of Environment, Forest and Climate Change	NR	19.09	2.50	Planned	The project will support India in achieving its global environment concerns and commitments to international conventions, and to integrate climate change considerations in national development planning and policy through ensuring continuity of the institutional and technical capacity building, partly initiated and consequently sustained by reporting instruments under the UNFCCC.	NA

Notations: NA = Not applicable; UA = Information not available at the time of reporting

Table III.13: Information on support received by developed country Parties for the implementation of Article 13 of the Paris Agreement and transparency-related activities, including for transparency-related capacity building

Exchange Rate Used: 1 USD = INR 76.34

(i)	(ii)	(iii)	(iv)	(v)
Title of activity, programme, project or other	**Objectives and description**	**Time Frame**	**Recipient Entity**	**Channel**
Preparation of India's first Biennial Transparency Report (BTR)	To appropriately implement the Enhanced Transparency Framework (ETF) under the Paris Agreement by fulfilling India's reporting commitments to the UNFCCC of submitting a Biennial Transparency Report in an efficient way.	2023-2025	Executing Agency: Ministry of Environment, Forest and Climate Change; GEF Agency: United Nations Development Program	Multilateral
Capacity-building for establishing an integrated and Enhanced transparency framework for climate actions and support measures	To appropriately implement the Enhanced Transparency Framework (ETF) under the Paris Agreement by fulfilling India's reporting commitments to the UNFCCC of submitting a Biennial Transparency Report in an efficient way.	Oct 2023- Sep 2028	Executing Agency: Ministry of Environment, Forest and Climate Change; GEF Agency: United Nations Development Program	Multilateral

(vi)	(vii)	(viii)	(ix)	(x)
Domestic Currency (INR Crore)	USD Million	Status of Activity	Use, impact and estimated results	Additional Information
13.86	1.82	Ongoing	1. National inventory report of anthropogenic emissions by sources and removals by sinks of GHGs prepared for the period 2000-2022. 2. Information necessary to track progress made in implementing and achieving NDCs under Article 4 of the Paris Agreement compiled and the progress in the achievement of NDC presented. 3. Information related to climate change impacts and adaptation under Article 7 of the Paris Agreement compiled and presented. 4. Information on financial, technology development and transfer and capacity building support needed and received compiled and presented.	The multilateral support has been provided by the Global Environment Facility.
29.01	3.80	Ongoing	The project is facilitating the development of national capacities for meeting the reporting requirements under the Enhanced Transparency Framework (ETF) of the Paris Agreement. Its implementation is building technical expertise and supporting the preparation of comprehensive Biennial Transparency Reports (BTRs). The project is developing a robust system for data collection, validation, management, and reporting across key sectors such as energy, industry, agriculture, LULUCF, and waste. It is also enhancing institutional coordination among ministries, technical agencies, and state-level entities to ensure the consistency, accuracy, and quality of climate-related data. In addition, the project is facilitating the improvement of emission factors and the adoption of higher-tier methodologies, leading to more precise and country-specific greenhouse gas (GHG) estimates.	The multilateral support has been provided by the Global Environment Facility.

CHAPTER-5

INFORMATION ON FLEXIBILITY

INFORMATION ON FLEXIBILITY

5. Information on flexibility

Enhanced Transparency Framework (ETF), established as per Article 13 of the Paris Agreement, aims to promote transparency and accountability in global efforts to combat climate change. To ensure consistency and comparability in climate data, Parties are required to submit their GHG inventory data using Common Reporting Tables (CRTs) and tracking of Nationally Determined Contributions (NDCs) using Common Tabular Formats (CTFs). With the adoption of the modalities, procedures, and guidelines (MPGs) for the ETF, along with the corresponding CRTs and CTFs, India has transitioned to the new reporting system. These MPGs outline the specific information countries must report, the format for presenting it, and the process for reviewing the data. These agreements were formalized at COP24 in 2018 and finalized at COP26 in 2021.

India has availed flexibilities in specific areas of reporting, in light of its capacity constraints and national circumstances. Where flexibility has been availed, it has been clearly identified and justified and are consistent with the reporting provisions of the MPGs. The application of flexibility by India reflects the principle of common but differentiated responsibilities and respective capabilities (CBDR-RC), while also reaffirming its commitment to progressively enhance the transparency, accuracy, and completeness of its climate reporting over time.

India's vast geographical size, diverse agro-climatic zones, and complex institutional structure make gathering timely and precise data across various sectors and sub-sectors a difficult task. The challenge is compounded by the need to coordinate among multiple government departments and organizations to collect the necessary information. Additionally, employing the more advanced Tier II and Tier III methodologies for GHG estimations demands substantial resources, time, technical expertise, and institutional capacity.

Further, due to the delayed disbursement of Global Environment Facility (GEF) funds, India was left with less than two years to prepare its first Biennial Transparency Report (BTR-1). Despite these constraints, India, as a developing country, has exercised a minimum/limited number of flexibilities available to the developing countries under the MPGs. Moreover, India has made concerted efforts to adhere to the transparency, accuracy, completeness, consistency, and comparability (TACCC) principles ensuring transparency, accuracy, consistency, completeness, and comparability while preparing its national GHG inventory. The specific flexibilities availed by India and their details are provided below.

Table 5.1: Summary of flexibilities availed by India

SN	MPG paragraph	Flexibility	Timeline for improvement*
		GHG inventory	
1.	25	Each Party shall identify key categories for the starting year and the latest reporting year, including and excluding land use, land-use change and forestry (LULUCF) categories, for both level and trend assessment, by implementing a key category analysis consistent with the 2006 IPCC guidelines; those developing country Parties that need flexibility in the light of their capacities with respect to this provision have the flexibility to instead identify key categories using a threshold no lower than 85 per cent in place of the 95 per cent threshold defined in the 2006 IPCC guidelines, allowing a focus on improving fewer categories and prioritizing resources.	10 years

SN	MPG paragraph	Flexibility	Timeline for improvement*
2.	57	Each Party shall report a consistent annual time series starting from 1990; those developing country Parties that need flexibility in the light of their capacities with respect to this provision have the flexibility to instead report data covering, at a minimum, the reference year/period for its NDC under Article 4 of the Paris Agreement and, in addition, a consistent annual time series from at least 2020 onwards.	10 years
		Mitigation policies and measures, actions and plans	
3.	85	Each Party shall provide, to the extent possible, estimates of expected and achieved GHG emission reductions for its actions, policies and measures in the tabular format; those developing country Parties that need flexibility in the light of their capacities with respect to this provision are instead encouraged to report this information.	5 years
		Projections	
4.	95	Projections shall begin from the most recent year in the Party's national inventory report and extend at least 15 years beyond the next year ending in zero or five; those developing country Parties that need flexibility in the light of their capacities with respect to this provision have the flexibility to instead extend their projections at least to the end point of their NDC under Article 4 of the Paris Agreement.	5 years
5.	98	Each Party shall include projections on a sectoral basis and by gas, as well as for the national total, using a common metric consistent with that in its national inventory report, those developing country Parties that need flexibility in the light of their capacities are instead encouraged to report these projections.	10 years

*Self-determined timeline for improvement from the year of submitting India's first BTR

1. India has availed the flexibility to identify key categories using a threshold no lower than 85 percent in place of the 95 percent threshold defined in the IPCC guidelines (Para 25 of MPGs). This is due to the unavailability of important data/information at granular level and lack of adequate funding. One such example is the calculation of GHG emissions from the road transport sector which is the 2nd largest contributor to India's total inventory using tier I methodology. This is primarily due to insufficient funds to carry out exhaustive experimental studies for developing country specific emissions factors (EFs) to move to a higher tier. Apart from financial resources, development of EFs requires significant time and technical expertise. Moreover, adopting higher-tier methodologies (i.e., Tier II or III) as recommended by the 2006 IPCC Guidelines and its 2019 Refinement Guidelines to calculate GHG emissions in certain sectors has been proven difficult and sometimes ineffective due to lack of high-quality granular data. Therefore, India plans to avail this flexibility provision for an additional 10 years, during which it will aim to improve data availability and apply higher-tier methodologies to key sectors, currently being estimated using the Tier I approach.

Table 5.2: Methodologies of key categories (without LULUCF) used for the preparation of national GHG inventory BTR-1

Sub-sectors, Gas	BTR-1
1A1a Electricity production, CO_2	T1/T2/T3
1A3b Road transport, CO_2	T1
3A1 Enteric Fermentation, CH4	T1/T2
1A2gviii Other (Nonspecific Industries), CO_2	T1/T2
1A2a Iron & steel, CO_2	T1/T2/T3
2A1 Cement production, CO_2	T2
1.A.4.b.i. Stationary combustion, CO_2	T1

Sub-sectors, Gas	BTR-1
3C7 Rice Cultivation, CH4	T2
1.A.1.b. Petroleum refining, CO_2	T1
3.D. Agricultural soils	T2
1A2f Non-metallic Minerals (Cement and Bricks) CO_2	T2

2. India has availed the flexibility in reporting time-series calculation of greenhouse gas inventory for four years – 2005, 2020, 2021, and 2022 (Para 57 of MPGs). This flexibility was adopted due to the unavailability of data for certain time periods and financial constraints to carry out estimations for all these years, following the BTR requirements. For data between 1990 and 2005, India, like many other developing nations, needed more advanced data collection, data-recovery infrastructure and methodologies to track GHG emissions across all sectors accurately. There were gaps in institutional capacities, technological limitations, and data governance frameworks, making it difficult to maintain consistent, reliable inventories. In next 10 years, India aims to report time-series calculations starting 1990 onwards.

3. In line with paragraph 85, India has exercised the flexibility to report only the achieved GHG emission avoided, rather than the expected emission avoided for its actions, policies, and measures in CTF-5. India, like many other developing countries, faces challenges in accurately forecasting the outcomes of its mitigation actions due to the complexity of its socio-economic systems in which these policies operate. Moreover, the mitigation actions are implemented through various national and state-level schemes that depend on budgetary allocations, which can vary every year. Forecasting expected emission avoided is especially challenging when future funding is uncertain. Additionally, many a times these schemes are merged or amalgamated with others, further making it challenging to accurately track and forecast their outcomes. Hence, in future, key schemes with highest GHG avoidance potential may be identified and information on expected avoided emissions from these schemes may be reported in next 5 years.

4. India's projected emissions is for the year 2030 which is the end date of implementation of the existing NDC (Para 95). This is due to the constraints in technical and modeling capacity required for future projections. Limited financial resources restrict the ability to upgrade data collection infrastructure and invest in new technologies needed for precise GHG monitoring and projections. Due to these capacity constraints, India has relied on flexibility mechanisms in its first BTR to meet reporting requirements and will avail for the next 5 years.

5. In line with paragraph 98, India reports projections only on a sectoral basis and not for individual GHGs. Generating gas-specific projections requires detailed and segregated data at the category and sub-category level for each greenhouse gas, which is presently not available. Additionally, domestic technical capacity constraint is another reason for adopting this flexibility. There is a need for capacity building through trainings and workshops with bilateral and/or multi-lateral partners. India will avail this flexibility for the next 10 years.

As a developing country, India has judiciously exercised the flexibility provisions available under the ETF to ensure transparency, accuracy, and consistency in its national GHG inventory. Moving forward, India aims to further enhance its reporting capabilities, gradually reducing its reliance on these flexibilities as its data collection systems and institutional capacities strengthens.

CHAPTER-6

IMPROVEMENTS IN REPORTING OVER TIME

IMPROVEMENTS IN REPORTING OVER TIME

6. Improvements in reporting over time

Pursuant to the modalities, procedures, and guidelines (MPGs) under the Enhanced Transparency Framework (ETF), this chapter outlines India's responses to areas of improvement, those related to the flexibilities exercised in the preparation of this BTR. It highlights steps taken to enhance transparency, accuracy, and completeness of reporting, as well as identifies capacity-building efforts and institutional strengthening measures. Additional potential future activities planned for GHG inventory improvement may be referred to in the National Inventory Document (NID).

Based on the flexibilities availed, India has identified various improvement plans which will further help to increase its capacity to report more transparently with greater accuracy.

1. India has availed the flexibility to identify key categories using a threshold no lower than 85 percent defined in the MPGs due to challenges in applying higher tier methodologies, primarily because of unavailability of disaggregated data across sectors. To address this, India will focus on strengthening institutional and technical capacity across relevant sectors. This includes enhancing the capabilities of line ministries, specialised agencies, and technical institutions to collect, manage, and report granular level activity data. As part of the improvement plan to enhance the robustness of India's GHG inventory, emphasis will be placed on the development of country-specific emission factors for key categories. Currently, the use of IPCC default values limits the precision and representativeness of national estimates. To address this, India aims to undertake sector-specific research studies and field measurements, in collaboration with research institutions, universities, and technical agencies, by utilizing the funds of Capacity-building Initiative for Transparency (CBIT) project.

2. In line with the flexibility availed by India for time series consistency, as per paragraph 57 of the MPGs, India plans to progressively extend its GHG inventory time series with the aim of covering the period back to 1990 over the next ten years in a phased manner. To address this gap, India plans to invest in strengthening relevant institutions and will implement advanced statistical methods and computational techniques to reconstruct missing data from 1990 onwards. These methods include interpolation, extrapolation and surrogacy techniques to fill in missing data points using available data from adjacent years and proxy data to estimate emissions for periods where direct activity data related to GHG estimation is unavailable. With the strengthening of institutions and implementation of new methodologies, India plans to transition away from this flexibility provision in next 10 years.

3. In accordance with paragraph 85 of the MPGs, India has currently exercised flexibility to report only the achieved GHG avoided emissions, rather than the expected avoided emissions from its policies and measures. As part of its improvement plan, India will develop a robust Monitoring, Reporting, and Verification (MRV) system specifically designed to track the emission reduction impacts of government schemes. This system will include the formulation of standardized indicators for mitigation actions and establish clear methodologies for quantifying expected GHG avoided emissions. Over the next five years, India aims to identify around five key mitigation schemes with the highest GHG avoidance potential and begin providing information on expected reductions from these schemes. Additionally, a comprehensive performance review of ongoing mitigation schemes will be conducted to assess their effectiveness, scalability, and potential for emission reduction. This process will be supported by extensive stakeholder consultations with all relevant ministries and implementing agencies to ensure improved data coordination and institutional capacity. Moreover, India plans to enhance and build its domestic modelling capacities.

4. India has opted for the flexibility provision for projections, as outlined in para 95 of the MPGs. To enhance its projection capabilities, India requires advanced modeling tools and GDP projections to correlate with GHG emissions. To strengthen this capacity, a 5-year plan will be developed to improve India's modeling capabilities through various capacity-building programs, collaboration with relevant international and national organizations, enhance sectoral data collection, and develop advanced domestic modeling tools or methodologies specific to Indian conditions.

5. In accordance with paragraph 98 of the MPGs, India currently reports only projections on a sectoral basis and not at individual greenhouse gases, in line with the flexibility available to developing countries facing technical capacity constraints. As part of its improvement plan, India aims to strengthen national technical capacity through targeted training programmes, workshops, and technical collaborations with bilateral and multilateral partners. These efforts will focus on enhancing the modelling capabilities and data systems required for gas-wise projections.

CHAPTER-7

ADDITIONAL INFORMATION

ADDITIONAL INFORMATION

7.1 Introduction

This chapter details with information that is additional to what is provided in the preceding chapters of the report. The chapter encapsulates essential initiatives of the Government of India focused on greening the financial sector of the country, unconventional initiatives that have spurred individual action against climate change, institutional initiatives that have enabled the preparation of this BTR, and other allied efforts to ensure that India achieves its NDCs and the net zero pledge.

7.2 Institutional Arrangement

The Ministry of Environment, Forest and Climate Change (MoEFCC), Government of India (GoI), is the executing and implementing agency for preparation of National Communication NC. NATCOM Cell's Integrated Project Management Unit (IPMU) headed by National Project Director (NPD), under GEF-UNDP-GoI Project has been established in MoEFCC for the preparation of National Communications and BTRs.

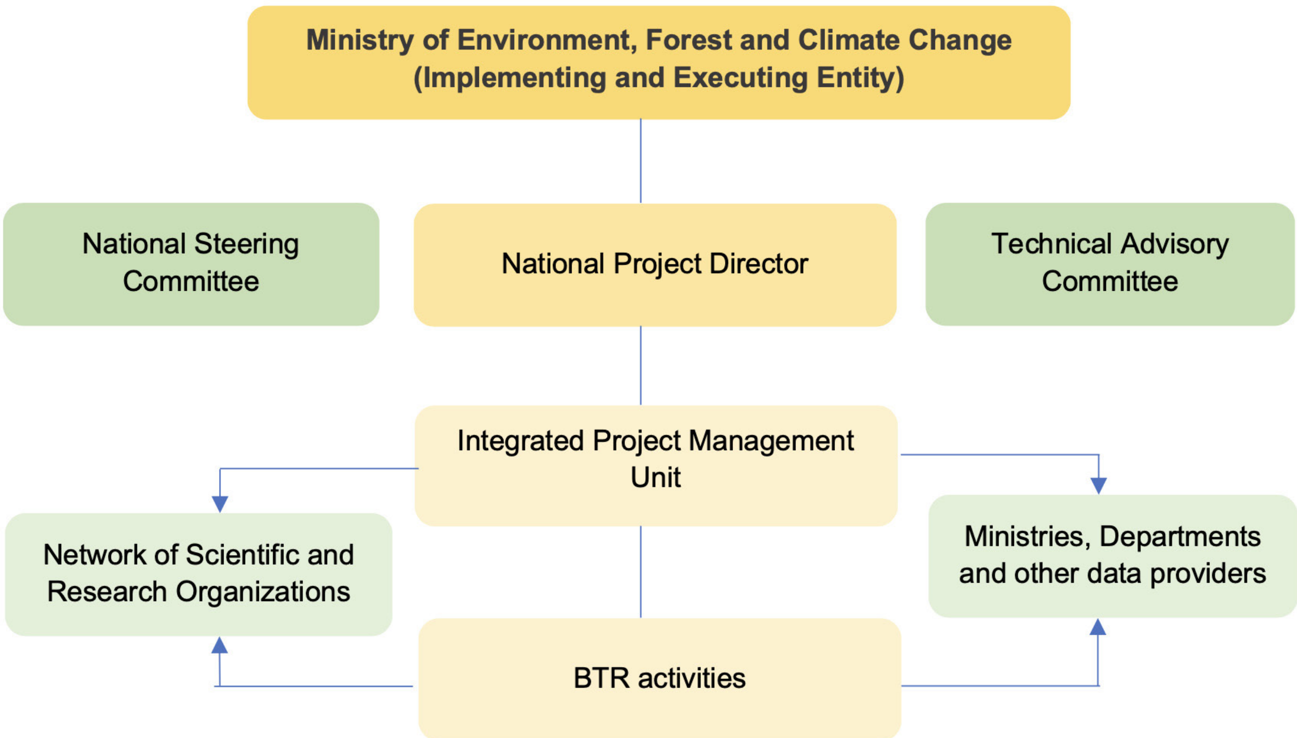

Figure 7.1: Implementation Arrangement for the First Biennial Transparency Report

The IPMU coordinates with the line Ministries, Organizations and Departments of GoI, network of Scientific and Research Organisations including data providers. The activities are supervised by National Steering Committee (NSC), comprising representatives from various line Ministries and Departments, under the technical guidance of Technical Advisory Committee (TAC), comprising representatives from various Scientific and Research Organisations of the country. The schematic diagram in Figure 7.1 depicts the implementation arrangement and responsibilities of various committees/institutes for BTR-1 preparation.

The National Steering Committee, chaired by the Secretary of MoEFCC, is responsible for overseeing the implementation of the BTR, providing strategic guidance and recommendations, and reviewing its content. The National Project Director (NPD) ensures overall supervision and management of the BTR preparation process. The Integrated Project Management Unit (IPMU) is tasked with coordinating and managing activities, facilitating engagement with expert institutions, implementing the work programme, tracking progress, consolidating information from various reports, and supporting the NPD in preparing the BTR. Lead Institutions coordinate with their network of institutions, compile inventory data and mitigation actions, and prepare sector-specific reports. Network Institutions are responsible for collecting activity data and emission factors, conducting field and laboratory studies, estimating inventories, tracking progress on NDC implementation, assessing climate change impacts and adaptation efforts, and preparing reports on their respective studies.

For the preparation of the 1st BTR, Government of India has taken steps and made efforts towards creating a sustainable institutional structure. Preparation of the BTR-1 required a comprehensive study, and technical as well as administrative arrangements, in addition to stakeholder's participation in various tasks and activities. To ensure adequate attention and participation, elaborate implementation arrangements have been formulated.

Technical consultations on multiple and multidisciplinary aspects of information related to the compilation of GHG inventory and mitigation actions were held during the process. Considering the range of requirements, it was deemed practical to have a Technical Advisory Committee (TAC) (refer to table 7.1) to provide technical guidance to the preparation of BTR-1. This committee which comprises members from the Government, Academia and Society. Moreover, National Steering Committee (NSC) under the Chairmanship of the Secretary, Ministry of Environment, Forest and Climate Change (MoEFCC) is in place to oversee the preparation and implementation of the work programme of the BTR-1. Various line Ministries and Government Departments that are concerned with providing different types of information required for the compilation of this report have representation in the NSC (refer to table 7.1).

Table 7.1: Composition of National Steering Committee and Technical Advisory Committee

Composition of National Steering Committee (NSC)		Composition of Technical Advisory Committee (TAC)	
S.No.	**Designation**	**S.No.**	**Designation**
Chairman			
1.	Secretary, Ministry of Environment, Forest and Climate Change (MoEFCC)	1.	Additional Secretary, MoEFCC
Members			
2.	Additional Secretary, MoEFCC	2.	Advisor (Energy), National Institution for Transforming India (NITI) Aayog
3.	Chief Executive Officer (CEO), NITI Aayog	3.	Representative of Indian Space Research Organisation(ISRO)
4.	Secretary, Department of Agricultural Research and Education (DARE), Ministry of Agriculture and Farmers Welfare (MoAFW)	4.	Representative of Ministry of Earth Sciences
5.	Secretary, Department of Agriculture Co-operation and Farmers Welfare (DACFW), MoAFW	5.	Representative of Indian Council of Agricultural Research (ICAR)
6.	Secretary, Department of Economic Affairs (DEA), Ministry of Finance (MoF) or his representative	6.	Representative of Department of Science and Technology (DST)
7.	Secretary, Ministry of New and Renewable Energy (MNRE) or his representative	7.	Representative of Council of Scientific and Industrial Research (CSIR)
8.	Secretary, DST or his representative	8.	Representative of MNRE

Composition of National Steering Committee (NSC)		Composition of Technical Advisory Committee (TAC)	
S.No.	Designation	S.No.	Designation
9.	Secretary, Ministry of Coal (MoC) or his representative	9.	Representative of Forest Survey of India (FSI)
10.	Secretary, Ministry of Power (MoP) or his representative	10.	Representative of Central Electricity Authority (CEA)
11.	Chairman, Railway Board, Indian Railways or his representative	11.	Representative of Directorate of Health Services
12.	Secretary, Ministry of Road Transport & Highways (MoRTH) or his representative	12.	Representative of The Energy and Resources Institute
13.	Secretary, Ministry of Ports, Shipping and Waterways (MOPSW) or his representative	13.	Representative of Integrated Research and Action for Development
14.	Secretary, Ministry of Petroleum & Natural Gas (MoPNG) or his representative	14.	Dr. L. S. Rathore, Former Director General, IMD
15.	Secretary, Department of Water Resources, River Development and Ganga Rejuvenation (DoWR, RD & GR) or his representative	15.	Prof. K. S. Kavi Kumar, Madras School of Economics (MSE)
16.	Secretary, Ministry of Health & Family Welfare (MoHFW) or his representative	16.	Prof. A. K. Gosain, Indian Institutes of Technology (IIT) Delhi
17.	Secretary, Ministry of Earth Sciences (MoES) or his representative	17.	Prof. N. H. Ravindranath, Indian Institute of Science (IISc)
18.	Secretary, Department of Rural Development (DoRD) or his representative	18.	Dr. R. Srikanth, National Institute of Advanced Studies (NIAS)
19.	Secretary, Ministry of Housing and Urban Affairs (MoHUA) or his representative	19.	Prof. Raman Sukumar, IISc
20.	Secretary, Department of Industrial Policy & Promotion (DIPP), Ministry of Commerce and Industry (MoCI) or his representative	20.	Prof. Amit Garg, Indian Institute of Management (IIM) Ahmedabad
.21	Secretary, Ministry of Steel (MoS) or his representative	21.	Prof. Anamika Barua, IIT Guwahati
22.	Secretary, Ministry of Civil Aviation (MoCA) or his representative	22.	Prof. T. Jayaraman, M.S. Swaminathan Research Foundation (MSSRF)
23.	Secretary, Ministry of Statistics and Programme Implementation (MoSPI) or his representative	23.	Dr. Sumana Bhattacharya, NIAS
24.	Director General, India Meteorological Department (IMD) or his representative	24.	Dr. Tejal Kanitkar, NIAS
25.	Joint Secretary, Ministry of External Affairs (MEA) or his representative	25.	Joint Secretary (Climate Change), MoEFCC
26.	Joint Secretary (Climate Change) MoEFCC	26.	Member Secretary, Scientist 'G'(NATCOM Cell), MoEFCC
27.	Member Secretary, Scientist 'G'(NATCOM Cell),MoEFCC		

This report encompasses information on India's National GHG Inventory for 2005, 2020, 2021 and 2022, tracking progress made on NDCs, climate change impacts and adaptation, information on financial, technology development and transfer and capacity building support needed and received, information on flexibility, areas of improvement and some additional information. Several studies were launched to accommodate the requisites of the BTR-1. These studies were carried out by Scientific and Research Institutions having sector-specific expertise. Besides, various Ministries, Government Departments, and Public-Sector Units (PSUs) and industrial associations provided inputs for preparation of this BTR (refer to table 7.2).

Table 7.2: Data providers (Ministries/Departments/Institutions/Organisations) for the preparation of BTR-1

Ministries/Departments of Government of India	Institutions/Organisations
Department of Health and Family Welfare (DoHFW)	All India Glass Manufacturers' Federation (AIGMF)
Department for Promotion of Industry and Internal Trade (DPIIT)	Bureau of Energy Efficiency (BEE)
Department of Agricultural Research and Education (DARE)	Cement Corporation of India (CCI) Limited
Department of Agriculture and Farmers Welfare (MoAFW)	Cement Manufacturers Association (CMA)
Department of Animal Husbandry and Dairying (DAHD)	Central Electricity Authority (CEA)
Department of Chemicals and Petrochemicals (DCPC)	Central Electricity Regulatory Commission (CERC)
Department of Economic Affairs (DEA)	Central Pollution Control Board (CPCB)
Department of Fertilizers (DoF)	Credit Rating Information Services of India Limited (CRISIL)
Department of Fisheries (DoF)	Directorate General of Mines Safety (DGMS)
Department of Space (DoS)	Energy Efficiency Services Limited (EESL)
Department of Water Resources, River and Ganga Rejuvenation (DoWR, RD & GR)	Fertiliser Association of India (FAI)
Ministry of Civil Aviation (MoCA)	Forest Survey of India (FSI)
Ministry of Coal (MoC)	India Meteorological Department (IMD)
Ministry of Commerce and Industry (MoCI)	Indian Bureau of Mines (IBM)
Ministry of Earth Sciences (MoES)	Indian Council of Forestry Research and Education (ICFRE)
Ministry of Heavy Industry (MHI)	Indian Farmers Fertilizer Cooperative Limited (IFFCO)
Ministry of Housing and Urban Affairs (MoHUA)	Indian Space Research Organization (ISRO)
Ministry of Micro, Small & Medium Enterprises (MSME)	Mahalanobis National Crop Forecast Centre (MNCFC)
Ministry of Mines (MoM)	National Disaster Management Authority (NDMA)
Ministry of New and Renewable Energy (MNRE)	National Institute of Solar Energy (NISE)
Ministry of Petroleum and Natural Gas (MoP&NG)	National Institution for Transforming India Aayog (NITI-Aayog)
Ministry of Power (MoP)	Ozone Cell, Ministry of Environment, Forest and Climate Change
Ministry of Railways (MoR)	Petroleum Planning and Analysis Cell (PPAC)
Ministry of Road Transport and Highways (MoRTH)	Refrigeration and Air Conditioning Manufacturers Association (RAMA)
Ministry of Statistics and Programme Implementation (MoSPI)	Society of Indian Automobile Manufacturers (SIAM)
Ministry of Steel (MoS)	

The Ministry of Environment, Forest and Climate Change, being the implementing and executing entity assigns several research and scientific studies and conducts activities including workshops and national consultations for the preparation of BTR-1 (refer to table 7.3). Many independent experts and think tanks also provided their inputs, comments and feedback for preparation of BTR-1.

Table 7.3: Network of scientific and research institutes for preparation of BTR-1

Chapters of BTR-1	Network of Scientific and Research Institutes
Chapter 1: National inventory report of anthropogenic emissions by sources and removals by sinks of greenhouse gases	IIM-A: Indian Institute of Management, Ahmedabad
	CSIR-CIMFR: Council of Scientific and Industrial Research-Central Institute of Mining and Fuel Research, Dhanbad
	CSIR-IIP: Council of Scientific and Industrial Research - Indian Institute of Petroleum, Dehradun
	CSIR-CRRI: Council of Scientific and Industrial Research -Central Road Research Institute, New Delhi
	NIAS: National Institute of Advanced Studies, Bengaluru
	IISc: Indian Institute of Science, Bangalore
	ICAR-IARI: Indian Council of Agricultural Research -Indian Agricultural Research Institute, New Delhi
	ICAR-NDRI: Indian Council of Agricultural Research -National Dairy Research Institute, Karnal
	CII: Confederation of Indian Industry, New Delhi
	FSI: Forest Survey of India, Dehradun
	ISRO NRSC: National Remote Sensing Centre, Hyderabad
	ICAR-NBSSLUP: Indian Council of Agricultural Research - National Bureau of Soil Survey & Land Use Planning, Nagpur
	CSTEP: Center for Study of Science, Technology and Policy, Bengaluru
	BITS Pilani - Goa: Birla Institute of Technology and Science
	CSIR-NEERI: Council of Scientific and Industrial Research - National Environmental Engineering Research Institute, Nagpur
Chapter 2: Information necessary to track progress made in implementing and achieving nationally determined contributions	IIM-A: Indian Institute of Management, Ahmedabad
	NIAS: National Institute of Advanced Studies, Bengaluru
	TERI: The Energy and Resources Institute, New Delhi
	ICAR-CRIDA: Indian Council of Agricultural Research-Central Research Institute of Dryland Agriculture, Hyderabad
Chapter 3: Information related to climate change impacts and adaptation	IIT-Delhi: Indian Institute of Technology, Delhi
	ICFRE: Indian Council of Forestry Research and Education, Dehradun
	GBPNIHE: G.B. Pant National Institute of Himalayan Environment, Almora
	IIFM: Indian Institute of Forest Management, Bhopal
	IISc: Indian Institute of Science, Bengaluru
	ICAR-CMFRI: Indian Council of Agricultural Research – Central Marine Fisheries Research Institute, Kochi
	NCSCM: National Centre for Sustainable Coastal Management, Chennai

Chapters of BTR-1	Network of Scientific and Research Institutes
	Ahmedabad University, Ahmedabad
	IHE: Institute of Home Economics, University of Delhi, New Delhi
	ICMR-NIREH: Indian Council of Medical Research – National Institute for Research in Environmental Health, Bhopal
	ICAR-IARI: Indian Council of Agricultural Research -Indian Agricultural Research Institute, New Delhi
	IIT-Gandhinagar: Indian Institute of Technology, Gandhinagar
	MSSRF: MS Swaminathan Research Foundation, Chennai
Chapter 4: Information on financial, technology development, and transfer, and capacity building support needed and received	NIPFP: National Institute of Public Finance and Policy, New Delhi
	TIFAC: Technology Information, Forecasting and Assessment Council, New Delhi
Chapter 7: Additional Information	EPTRI: Environment Protection Training & Research Institute, Hyderabad

7.3 Climate Change aligned finance strategy

7.3.1 India's Climate Finance Taxonomy

In pursuance of the Union Budget 2024-25 announcement to develop India's Climate Finance Taxonomy, the Department of Economic Affairs, Ministry of Finance, developed a draft Framework of the Climate Finance Taxonomy. It aims to facilitate greater resource flow to climate-friendly technologies and activities, enabling the country to achieve the vision of being Net Zero by 2070 while also ensuring long-term access to reliable and affordable energy. The Climate Finance Taxonomy will serve as a tool to identify activities consistent with a country's climate action goals and transition pathway. The framework outlines the approach, objectives, and principles that will guide the taxonomy. It also details the methodology for classifying activities, projects, and measures that contribute to India's climate commitments, while also taking into account goals associated with achieving Viksit Bharat by 2047.

India's taxonomy on climate finance will be a living document. It will be periodically reviewed to capture the evolving requirements and to progressively cover sectors, projects and activities reflecting the dynamic landscape of investments for climate finance. In the beginning, the following sectors shall be considered:

i. Power, Mobility, and Buildings in the context of climate mitigation and adaptation co-benefits.

ii. Agriculture, food and water security will be in the context of climate adaptation and resilience building.

iii. Addressing transition, in line with country circumstances, in hard-to-abate sectors. Iron & Steel and Cement shall be considered at the outset.

7.3.2 Framework for Acceptance of Green Deposits

Recognising the crucial role of the financial sector in mobilising and directing funds towards environmentally sustainable activities and projects in the face of climate change, the Reserve Bank of India (RBI) introduced the Framework for Acceptance of Green Deposits. This initiative marks a significant step in advancing the green finance ecosystem in India. The framework aims to encourage Regulated Entities (REs) to offer green deposit products to their customers, supporting them in meeting their sustainability goals while addressing the risks of greenwashing. Additionally, it seeks to enhance the flow of credit to environmentally beneficial projects and activities (RBI, 2023).

The funds collected through these green deposits are designated for specific categories of activities and projects (see Table 7.4, RBI 2023) that promote efficient use of resources, lower carbon emissions and greenhouse gas output, strengthen climate resilience and adaptation efforts, and support the restoration and conservation of natural ecosystems and biodiversity.

Table 7.4: List of activities which benefits from green deposits

Sectors	Description
Renewable Energy	• Solar/wind/biomass/hydropower energy projects that integrate energy generation and storage • Incentivising the adoption of renewable energy
Energy Efficiency	• Design and construction of Energy-efficient and energy-saving systems and installations in buildings and properties • Supporting lighting improvement (replacement with LEDs) • Supporting the construction of new low-carbon buildings as well as energy-efficient retrofits to existing buildings • Projects to reduce electricity grid losses.
Clean Transportation	• Projects promoting the electrification of transportation • Adoption of clean fuels like electric vehicles, including building charging infrastructure.
Climate Change Adaptation	• Projects aimed at making infrastructure more resilient to the impacts of climate change.
Sustainable Water and Waste Management	• Promoting water-efficient irrigation systems • Installation and upgradation of wastewater infrastructure, including transport, treatment and disposal systems • Water resources conservation • Flood defence systems
Pollution Prevention and Control	• Projects targeting reduction of air emissions, greenhouse gas control, soil remediation, waste management, waste prevention, waste recycling, waste reduction and energy/emission-efficient waste-to-energy.
Green Buildings	• Projects related to buildings that meet regional, national or internationally recognised standards or certifications for environmental performance
Sustainable Management of Living Natural Resources and Land Use	• Environmentally sustainable management of agriculture, animal husbandry, fishery and aquaculture • Sustainable forestry and management, including afforestation/reforestation • Support for certified organic farming • Research on living resources and biodiversity protection.
Terrestrial and Aquatic Biodiversity Conservation	• Projects relating to coastal and marine environments • Projects related to biodiversity preservation, including conservation of endangered species, habitats and ecosystems.

7.3.3 Disclosure Framework on Climate-Related Financial Risk

In February 2024, the Reserve Bank of India (RBI) issued a draft Disclosure Framework on Climate-Related Financial Risks to guide regulated entities (REs) in addressing climate-related financial impacts. The draft framework is consistent with global standards like TCFD and ISSB, promoting transparency and responsible climate finance in India's financial sector. (PIB 2024)

7.3.4 Union Bank of India - Partnership for Carbon Accounting Financials

The Union Bank of India, one of the largest government-owned banks of India also became the first major Indian bank to become a signatory to the Partnership for Carbon Accounting Financials (PCAF) in September 2024.

By virtue of becoming a signatory, the bank commits to measure and disclose the greenhouse gas emissions associated with their portfolio of loans and investments (PTI, 2024 ; PCAF, 2024).

7.3.5 Expansion of Sustainable Finance Framework

In December 2024, SEBI expanded the existing framework for sustainable finance in India by amending the SEBI (Issue and Listing of Non-Convertible Securities) Regulations, 2021, to include the definition of 'Environment, Social and Governance (ESG) Debt Securities'

Under the amendment notification, a circular was issued by SEBI on June 5, 2025, whereby a framework was prescribed for the issuance of ESG Debt Securities (other than green debt securities). These bonds and 'green debt security' are termed 'ESG Debt Securities'. This was aimed at covering a wider spectrum of sustainable finance instruments. This move is believed to provide issuers the necessary flexibility to raise funds for projects that align with ESG objectives.

Under the new framework, issuances of 'social bonds', 'sustainability bonds' and 'sustainability-linked bonds' must align with international standards such as ICMA's Bond Principles, the Climate Bonds Standard, or other SEBI-recognised frameworks. Issuers are required to provide detailed pre- and post-issuance disclosures, including use-of-proceeds, target beneficiaries, and fund-tracking mechanisms, all subject to mandatory third-party verification. For social bonds, eligible areas include affordable infrastructure, health, education, food security, employment support, and socioeconomic advancement. Regarding sustainability-linked bonds, issuers must set key performance indicators (KPIs) and sustainability performance targets (SPTs), disclose their ESG strategies, and ensure external review of the KPIs' relevance and ambition. (SEBI 2025).

7.3.6 Revision of Green Debt Securities

In March 2023, to enhance the sustainable finance ecosystem in India, and to align the country's green debt securities with the Green Bond Principles (GBP) recognised by International Organization of Securities Commissions, SEBI revised disclosure requirements for green debt securities (SEBI, 2023). The revised guidelines require the appointment of an independent third-party reviewer/certifier for pre and post -green bond issuance, resulting in the requirements to go further than the Capital Market Association (CMA) requirements (IEEFA, 2023). On June 5, 2025, SEBI released a new circular establishing a framework for Environment, Social & Governance (ESG) debt securities, encompassing but not limited to green bonds. This framework extends beyond green bonds to include social bonds, sustainability bonds, and sustainability-linked bonds.

7.3.7 Policy Initiatives by IFSCA

Banking Channel is critical for the economy to transition towards a low-carbon and climate-resilient future. International Financial Services Centres Authority (IFSCA) in April 2022 issued "Guidance framework on Sustainable and Sustainability-linked lending by financial institutions". The framework also mandates that banks in GIFT IFSC lend 5% of the incremental loan towards sustainable projects. In the first two years of its implementation, more than USD 4.8 bn green/sustainable loans have been disbursed from GIFT IFSC.

To encourage the growth of Green Bonds, Social Bonds, Sustainability Bonds, Sustainability-linked Bonds and other labelled bonds, IFSCA has specified the necessary regulatory framework initially in the IFSCA (Issuance & Listing of Securities) Regulations,2021 and subsequently subsumed in the IFSCA (Listing) Regulations, 2025. The listing of around USD 15.43 bn ESG-labelled debt securities, out of USD 65 Bn total debt listings, on IFSC exchanges, as of May 2025, showcases that GIFT IFSC is slowly emerging as a preferred platform for Indian corporates to raise sustainable capital from global investors.

To ensure that the instrument is true to its label, the issuers are mandated to provide various pre- and annual disclosures, such as ESG objectives, utilisation of proceeds of the issue, allocation report, impact report, etc.

7.3.8 Framework for Sovereign Green Bonds

To mobilise resources for green infrastructure, the Government of India announced the issuance of Sovereign Green Bonds as a part of the Government's overall market borrowings. To implement the same, the Department of

Economic Affairs of the Ministry of Finance envisaged a framework for sovereign green bonds that sets forth the obligations of the Government of India as a green bond issuer. The proceeds raised from these Sovereign Green Bonds are used to finance and/or refinance expenditures for green projects. The following are the categories and typologies of the projects (Table 7.5) for which the sovereign green bonds shall be applicable (DEA, 2022).

Table 7.5: Eligible categories of projects for Sovereign Green Bonds

S.No.	Green Project Category	Eligibility Criteria
1.	Renewable Energy	Investments in solar/wind/biomass/hydropower projects to integrate energy generation and storage. Incentivising the adoption of renewable energy.
2.	Energy Efficiency	Design and construct energy-efficient and energy-saving systems and installations in government buildings and properties Supporting public lighting improvements Supporting the construction of new low-carbon buildings and energy-efficient retrofits to existing buildings. Projects to reduce electricity grid losses.
3.	Clean Transportation	Promote public transportation, including its electrification and transport safety. Subsidies to adopt clean fuels like electric vehicles, including building charging infrastructure
4.	Climate Change Adaptation	Projects aimed at making infrastructure more resilient to the impacts of climate change, as well as investments in information support systems, such as climate observation and early warning systems
5.	Sustainable Water and Waste Management	Promoting water-efficient irrigation systems. Installation/upgradation of wastewater infrastructure, including transport, treatment and disposal systems Water resources conservation. Flood defence systems
6.	Pollution prevention and control	Projects targeting reduction of air emission, greenhouse gas control, soil remediation, waste management, waste prevention, waste recycling, waste reduction, and energy/emission-efficient waste-to-energy.
7.	Green Buildings	Projects related to buildings that meet regional, national or internationally recognised standards or certifications for environmental performance.
8.	Sustainable Management of Living Natural Resources and Land Use	Environmentally sustainable management of agriculture, animal husbandry, fishery and aquaculture. Sustainable forestry management, including afforestation/reforestation. Support to certify organic farming Research on living resources and biodiversity protection.
9.	Terrestrial and Aquatic Biodiversity Conservation	Projects relating to coastal and marine environments. Projects related to biodiversity preservation, including conservation of endangered species, habitats and ecosystems.

As of 29th January 2026, the Government of India has cumulatively issued sovereign green bonds amounting to ₹726970 million.

7.4 Business Responsibility and Sustainability Reporting by Listed Entities

To further mainstream sustainability in the corporate sector, the Securities and Exchange Board of India (SEBI) has mandated Business Responsibility and Sustainability Reporting (BRSR) for the top-1,000 listed entities (by market capitalisation) from FY 2022-23 onwards. BRSR is a foundational step in India's climate and sustainability-related disclosure ecosystem and contributes significantly to corporate practices' financial transparency, ESG integration, and climate risk mitigation.

SEBI's BRSR framework is a result of extensive public consultation. It is based on the needs of the Indian economy while also allowing for interoperability with global standards like the Global Reporting Initiative (GRI), the Task Force on Climate-related Financial Disclosures (TCFD), and the International Sustainability Standards Board (ISSB). These initiatives aim to improve the quality, consistency, and comparability of sustainability data disclosed by Indian corporates, thereby enhancing decision-making by investors and other stakeholders.

The BRSR framework requires companies to disclose their performance across environmental, social, and governance (ESG) parameters in a structured and comparable manner. For instance, BRSR seeks disclosure on greenhouse gas emissions, corporate policies on ESG issues, identification and mitigation of climate risks, etc.

In 2023, SEBI introduced the "BRSR Core", an assurance-based reporting mandate for key BRSR indicators, to improve the reliability of sustainability disclosures and reduce greenwashing. Disclosures for the value chain shall be made by the listed company as per BRSR Core, as part of its Annual Report. For this purpose, the value chain shall encompass the top upstream and downstream partners of a listed entity, individually comprising 2% or more of the listed entity's purchases and sales (by value), respectively. However, the listed entity may limit disclosure of the value chain to cover 75% of its purchases and sales (by value). On a voluntary basis, ESG disclosures for the value chain have also been introduced for top-250 listed entities (by market capitalisation) w.e.f. 2025-26.

7.4.1 ESG Ratings

The BRSR Core initiative has acknowledged the unique context of emerging markets by mandating that ESG Rating Providers (ERPs) incorporate India-specific and emerging market factors into their ESG assessments. To enhance the reliability of these ratings, ERPs are required to introduce a distinct category called the 'Core ESG Rating,' which is based exclusively on the assured parameters defined under BRSR Core (SEBI, 2023). The BRSR Core has 9 KPIs areas of reporting:

1. Greenhouse gas footprint
2. Water footprint
3. Energy footprint
4. Embracing circularity – waste management
5. Enhancing employee safety and wellbeing
6. Enabling gender diversity in business
7. Enabling inclusive development
8. Fairness in engaging with customers and suppliers
9. Openness of business

7.4.2 ESG Investing

To address and reduce the issues of mis-selling and greenwashing, the following mandates have also been incorporated for the promotion of ESG investing:

a. ESG schemes are to invest at least 65% of Asset Under Management (AUM) in listed entities, where assurance on BRSR core is undertaken.

b. Third party assurance and certification by the Board of Asset Management Companies (AMCs) on compliance with the objective of the ESG scheme is mandatory.

c. Enhanced disclosures on voting decisions with specific focus on environmental, social and governance factors is mandatory.

d. Disclosure of fund manager commentary and case studies which inter-alia highlight how the ESG strategy is applied on the fund/investments.

e. Introduction of a new scheme category, enabling the launch of multiple schemes on ESG related factors (SEBI, 2023).

7.5 Climate Change Education and Awareness

The National Education Policy (NEP), 2020 of India already places emphasis on the integration of environmental awareness and concepts of sustainable development in school curricula. Further, the concepts of climate change have been incorporated in the curriculum and textbooks that are developed by the National Council for Research and Training (NCERT). In addition to this, NCERT has been actively organizing in-service teacher's capacity building programmes in geography and social sciences where sensitization is enabled on issues related to climate change (PIB, 2022).

On the occasion of World Environment Day, the Government launched the Ek Ped Maa Ke Naam 2.0 campaign in New Delhi, along with special modules for schools, a dedicated web portal, and a microsite. The campaign, under the broader umbrella of Mission LiFE, promotes tree plantation in honour of one's mother and aims to instil environmental consciousness among students through experiential learning.

The special modules—developed for Preparatory, Middle, and Secondary levels—highlight the nurturing role of both mothers and Mother Earth. They guide students on the formation and functioning of Eco Clubs, Mission LiFE themes, and practical activities such as QR-coding flora and creating school nutrition gardens. These modules aim to nurture young "Eco-Warriors" through hands-on tasks and sustainability-driven assignments.

The newly launched multilingual portal enables over 1.47 million schools to track, upload, and monitor Eco Club activities, with each school provided a personalized dashboard. The integrated microsite allows students to upload a selfie taken while planting a sapling with their mother, generating an e-certificate as proof of participation. (PIB 2025).

7.6 Lifestyle for Environment (LiFE) Movement: Mission LiFE

LiFE (Lifestyle for Environment) is an India-led global movement launched by the Prime Minister at COP26 in 2021, promoting mindful and sustainable consumption to protect the environment. Officially launched as Mission LiFE in October 2022, it encourages behavioural change through simple daily actions. The initiative promotes 75 actions across seven themes including water and energy conservation, waste reduction, sustainable food, and healthy lifestyles.

On World Environment Day 2024, the 'Ek Ped Maa Ke Naam' (Plant4Mother) campaign was launched, aiming to plant 1400 million trees by March 2025. As of June 2025, more than 1420 million tree saplings had been planted.

Two portals—Mission LiFE and Meri LiFE—have been developed for outreach and progress tracking. The 'Ideas4LiFE' initiative invited citizen-led sustainability ideas, receiving over 1,000 entries. Mission LiFE has received global recognition, with India's resolution on sustainable lifestyles adopted at UNEA-6, and references in key international frameworks including the IPCC, G20, G7, and COP28.

7.7 Mission Innovation

India is a founding member of the Mission Innovation (MI), a global initiative that seeks to catalyze a decade of action and investment in research, development and demonstration to make clean energy affordable, attractive and accessible for all. In June 2021, Mission Innovation 2.0 was launched to accelerate progress towards the Paris Agreement goals and pathways to net zero. As a part of the mission, India has successfully led three MI challenges - Smart Grids, Off Grid Access to Electricity and Sustainable Biofuels. After having undertaken funding opportunity announcements under these MI challenges, India has invested extensively in research, development and demonstration in environmentally friendly, energy efficient clean energy technologies (Mission Innovation, 2022).

India highlighted Its BioE3 Policy and Integrated Biorefinery Initiatives at Mission Innovation Annual Gathering 2025 held during 9th to 11th April at Seoul, South Korea. At the Annual Gathering held in Seoul, the Department of Biotechnology (DBT) being an integral member of the Indian delegation, participated in discussions on collaborative opportunities among diverse MI missions and platforms. The focus has been to advance the biorefinery approach for fuels, chemicals, and materials. During the event, the DBT presented BioE3 (Biotechnology for Environment, Energy, and Economy) Policy and demonstrated its pivotal role in addressing climate challenges and aligning national priorities under the Integrated Biorefinery Mission were extensively discussed at roundtables and reviewed by Mission Innovation members as well as the Technical Advisory Groups associated with the Missions (PIB 2025).

7.8 India's Global Initiatives

7.8.1 The Global Biofuels Alliance (GBA)

GBA was launched by Hon'ble Prime Minister Shri Narendra Modi along with the leaders of USA, Brazil, Italy, Argentina, Singapore, Bangladesh, Mauritius and UAE on 9th September 2023, on the sidelines of the G20 Summit in New Delhi, as Chair's initiative.

GBA is a multi-stakeholder alliance of Governments, International Organizations and Industries, bringing together the biggest consumers and producers of biofuels. GBA is intended to facilitate capacity-building exercises, technical support for national programs, policy lessons-sharing, technology advancements, and implementation of internationally recognized standards & codes through participation of a wide spectrum of stakeholders. Since launch, GBA has garnered enormous support globally as its current membership has expanded to 24 members countries and 12 International Organizations with a trajectory of on-going growth.

GBA has also significantly enhanced its presence on the global pedestal by representation at international forums such as COP28 (Dubai), World Economic Forum (Switzerland), India Energy Week 2024 and World Biogas Summit 2024 (UK). GBA was also invited as an International Organization to the Energy Transitions Working Group (ETWG) meeting under the G20 presidency of Brazil and at International Forum on Sustainable Biofuels under the Italian G7 Presidency.

GBA aims at, inter alia, providing additional opportunities to Indian industries by positioning India as a knowledge base and as a production hub for biofuels including ethanol, Sustainable Aviation Fuel (SAF) and Compressed Bio Gas (CBG) etc. An active role in GBA helps elevate India's position in the global biofuels sector.(PIB 2024).

7.8.2 International Solar Alliance (ISA)

Conceived as a joint effort between India and France at the sidelines of CoP21, the International Solar Alliance (ISA) is successfully mobilising efforts against climate change through the deployment of solar energy solutions. As of 2023, ISA has undertaken 90 country level assessments to enable countries to develop an enabling policy and regulatory ecosystems for large scale solar deployment. For the financial years of 2022-23, 2023-24 and 2024-25, the Government of India provided an assistance of Rs. 1000 million per year to the ISA to aid in energy transition, particularly in developing and emerging economies (PIB, 2023). In November 2024, India hosted the seventh assembly of ISA at New Delhi with ministers from 29 member countries (PIB 2024). The 3rd edition of the World Solar Report series was released at the 7th Assembly of the International Solar Alliance focusing on global solar growth, investment trends, technological advancements, and Africa's green hydrogen potential were released. The newly launched 4 reports namely World Solar Market Report, World Investment Report, World Technology Report, and Green Hydrogen Readiness Assessment for African Countries each highlight a crucial area in the global shift towards sustainable energy (PIB 2024).

7.8.3 The Coalition for Disaster Resilient Infrastructure (CDRI)

CDRI is an India-led initiative launched in September 2019 at the New York Action Summit, which had 12 founding members, has now expanded to 47 member countries as of October 2024 (PIB, 2024).

CDRI seeks to become the platform for its Members and partners to collaborate, cooperate and advocate for achieving the following impact: By 2050, over US$10 trillion of new and existing infrastructure investments and services are resilient to natural hazards and climate change through enhanced capacity, informed policy, planning, and management leading to improved quality of environment, livelihood and life of over 3 billion people.

The governance arrangement of the Coalition comprises three principal bodies-the Governing Council (GC), the Executive Committee (EC), and the Secretariat. The GC is the highest policy-making body of CDRI and comprises all members of the Coalition. With India as Permanent Co-chair and France as Rotational Co-chair, April 2024 - March 2026. The EC comprises 10 members representing notional constituencies. It oversees the implementation of the decisions of the GC. (CDRI).

7.8.4 International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE)

India hosted the 41st Steering Committee Meeting of the International Partnership for IPHE in March 2024, whose Working Groups deliberated on 'Regulations, Codes, Standards and Safety' and 'Education and Outreach' and the Task Forces ideated and provided suggestions on 'Hydrogen Skills', 'Hydrogen Production Analysis', 'Hydrogen Certification Mechanisations' and 'Hydrogen Trade Rules' (PIB, 2024)

7.8.5 Leadership Group for Industry Transition (LeadIT 2.0)

The Leadership Group for Industry Transition (LeadIT)—an India-and-Sweden-led initiative launched at the UN Climate Action Summit in September 2019 and backed by the World Economic Forum—brings together countries and corporations committed to industrial decarbonisation in line with the Paris Agreement. At COP28 (1 December 2023) in Dubai, Prime Ministers Narendra Modi and Ulf Kristersson jointly inaugurated LeadIT 2.0, marking Phase II (2024–26), and launched the India–Sweden Industry Transition Platform (ITP) to accelerate low-carbon transformation in heavy industries (PIB 2023).

At COP29 in November 2024 (Baku), India and Sweden co-hosted the LeadIT Annual Summit, reiterating their commitment to public–private partnerships, North–South cooperation, and industrial decarbonisation in hard-to-abate sectors like steel and cement. LeadIT continues to operationalize its Phase II objectives through several key initiatives, including:

i. **Transition Tracker, Green Steel Tracker, Green Cement Technology Tracker:** tools to monitor industry progress.

ii. **Roadmap Planner:** providing decision-makers with detailed guidance on actors, actions, and steps for decarbonisation.

iii. **The India–Sweden ITP,** which held its second summit in May 2025 to review pilot green-industry projects under bilateral collaboration

Since its inception, LeadIT has grown to include 18 member countries and roughly 20–21 corporate partners, with Phase II reinforcing its commitment to net-zero industrial emissions by 2050 and delivering tangible outcomes by COP30 in 2025 (LeadIT2)

7.9 National Coastal Mission

The National Coastal Mission (NCM) is a scheme under the National Coastal Management Program that focuses on coastal conservation and management, including activities like mangrove plantation, coral transplantation, livelihood enhancement for coastal communities, and pollution abatement. Major components under the NCM are:

i. Management Action Plan on Conservation of Mangroves and Coral Reefs

ii. Research & Development in Marine and Coastal ecosystem

iii. Sustainable Development of Beaches under Beach Environment & Aesthetic Management Service

iv. Capacity Building / Outreach Programme of Coastal States/UTs on conservation of marine and coastal ecosystem including beach cleaning drive.

NCM is implemented by the State Governments of Coastal States and Union Territory (UT) Administrations. The funds are released to the coastal States/Union Territories based on the review of the proposals received from the States/UTs in the Ministry.

A sum of ₹79.4 million has been released from 2018-19 till 2023-24 under the EAP (Externally Aided Programme) and non-EAP component for the development of infrastructure facilities, pollution abatement, safety surveillance and beach cleaning in Andhra Pradesh. (PIB 2024)

7.10 Advancing Sustainable Infrastructure

The National Highways Authority of India (NHAI), demonstrated that large-scale infrastructure expansion can align with India's low-carbon and climate-resilient development goals. Despite a 20% increase in highway construction, NHAI achieved a reduction in greenhouse gas (GHG) emissions intensity from 1.0 $MTCO_2e$/km in FY 2022-23 to 0.8 $MTCO_2e$/km in FY 2023-24. The use of over 631 lakh metric tonnes of recycled materials such as fly ash, plastic, and reclaimed asphalt illustrates successful adoption of circular economy practices.

Water efficiency measures, including a 74% reduction in water use intensity in water-stress region and rejuvenation of 467 water bodies, contribute to ecosystem restoration, while 56 lakh saplings planted under the Green Highways Policy enhance carbon sequestration. The deployment of Data Lake 3.0 for project management and FASTag (98.5% coverage) has improved operational efficiency, transparency, and reduced vehicle idling emissions.

These measures collectively advance India's Nationally Determined Contributions NDCs by embedding sustainability, resource efficiency, and climate-smart practices in the transport sector (Sustainability Report, NHAI, 2023-24).

7.11 Ecomark Programme

MoEFCC has notified Ecomark Rules, 2024 on 26.09.2024 replacing Ecomark 1991 which aims to strengthen the institutional structure and implementation of the Ecomark to enable consumers to make informed purchase decision as well as encourage manufacturers to transition to production of environment friendly. products leading to promotion of green industries.

Ecomark intends to encourage the demand for environmentally friendly products that causes lesser adverse impacts on the environment, promote lower energy consumption, resources efficiency and conservation, circular economy and prevent misleading information on environmental aspects of products. (MoEFCC Annual Report, 2024-25).

7.12 Green Credit Program

The Green Credit Programme is a voluntary initiative of the Government of India to promote climate-positive actions through a market-based mechanism. Notified under the Environment (Protection) Act in October 2023, initially it focussed on tree plantation over degraded, waste, and watershed lands managed by State and UT forest departments. The programme is guided by an inter-ministerial Steering Committee and a Technical Committee, with the Indian Council of Forestry Research and Education (ICFRE) as the Administrator for implementation and monitoring. A digital portal has been created to maintain a land bank of degraded forest areas, where registered entities like PSUs, companies, NGOs, communities, and individuals can undertake plantation activities. After verification by designated agencies, participants receive tradable Green Credit certificates through an ICFRE-managed registry and trading platform. The programme supports forest cover expansion, restoration of degraded lands, and promotes pro-environmental behaviour among various stakeholders, in alignment with the MoEFCC's LiFE mission. Work is in progress to finalise standards for credit issuance and to identify additional suitable land parcels. (PIB 2023, 24, MoEFCC notifications and GCP Portal). As on 16th March 2026, a total of 4391 ha is available for Eco-restoration across 227 blocks PIB (2026).

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