सत्यमेव जयते

# INDIA
# FOURTH BIENNIAL UPDATE REPORT
## to the United Nations Framework Convention on Climate Change

LiFE Lifestyle for Environment

प्रकृतिः रक्षति रक्षितः
Nature Protects if She is Protected

Ministry of Environment, Forest and Climate Change
**Government of India**
December 2024

# INDIA

# FOURTH BIENNIAL UPDATE REPORT

to the United Nations Framework Convention on Climate Change

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**to the United Nations Framework Convention on Climate Change**



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# INDIA

# FOURTH BIENNIAL UPDATE REPORT

to the United Nations Framework Convention
on Climate Change

Nature Protects if She is Protected

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December 2024

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BHUPENDER YADAV

MINISTER
ENVIRONMENT, FOREST AND CLIMATE CHANGE
GOVERNMENT OF INDIA

## FOREWORD

Reaffirming its unwavering commitment to combating climate change, transparency and global cooperation India presents its Fourth Biennial Update Report (BUR-4) to the United Nations Framework Convention on Climate Change (UNFCCC). The Report meets the prescribed guidelines and ensured that India's BUR-4 is comprehensive, consistent and transparent, meeting the highest standards of international climate reporting. This report encapsulates the dedicated efforts of our Scientists, Policymakers and Officials from other concerned Ministries as well as those from the Ministry of Environment, Forest and Climate Change (MoEFCC).

The BUR - 4 builds up on the *Panchamrit* principles announced by Hon'ble Prime Minister, Shri Narendra Modi at COP26 in Glasgow. This approach underscores our comprehensive strategy to mitigate and adapt to climate change. India, despite having more than 17% of global population, contributes less than 4% of cumulative global emissions. However, we continue to face significant climate impacts and our ecosystems and communities are already bearing the brunt of these effects which threatens the livelihood of millions.

To overcome these challenges, India has chosen a path of proactive citizen centric climate action through a transformative India led global mass movement initiative known as *Mission LiFE* - **L**ifestyle for **E**nvironment which promotes environment friendly lifestyle or sustainable living at the individual level. The *LiFE* movement encourages citizens to make conscious, eco-friendly choices in daily life, underscoring that collective individual actions can drive significant global change. This initiative reinforces India's vision that environmental friendly responsibility begins at the individual level.

In yet another such initiative a nationwide campaign titled Plant4Mother or *Ek Ped Maa Ke Naam* ( Planting a Tree in the Name of one's own Mother and Mother Earth) encourages citizens to plant a tree as a mark of respect and honour of their mothers, fostering a deep personal connection to environmental stewardship. It reflects our belief that small, meaningful actions can foster widespread commitment to environmental protection in the true spirit of Mission LiFE.

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The Report is testimony to the fact that India remains resolute in its commitment to a low-carbon development pathway, ensuring economic growth aligns with ecological sustainability. This Report stands as a testament to India's dedication to transparency and responsible climate action on the global stage.

**(Bhupender Yadav)**

एक कदम स्वच्छता की ओर

सत्यमेव जयते

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पर्यावरण, वन एवं जलवायु परिवर्तन
विदेश मंत्रालय
भारत सरकार
MINISTER OF STATE
ENVIRONMENT, FOREST AND CLIMATE CHANGE
EXTERNAL AFFAIRS
GOVERNMENT OF INDIA

कीर्तवर्धन सिंह
KIRTI VARDHAN SINGH

## Message

It is with great pride that we present India's Fourth Biennial Update Report (BUR - 4) to the UNFCCC. Under the visionary leadership of Hon'ble Prime Minister Shri Narendra Modi, India has made remarkable progress in climate action.

India's progress in decoupling economic growth from greenhouse gas emissions is a testament to our dedication to sustainable development. India's advocacy for LiFE (Lifestyle for the Environment) promotes sustainable living and calls for collective global action. India is at the forefront of transformative initiatives in the energy and transport sectors. Our efforts include expanding renewable energy capacity, advancing biofuel usage and launching the ambitious National Hydrogen Mission. Additionally, the Jal Jeevan Mission for water conservation and our extensive national afforestation programs are critical measures to enhance resilience and adaptation capacity.

46.3% of India's total installed electricity capacity comes from non-fossil fuel sources, including solar, wind, and hydropower. India remains the fourth largest producer of wind power and the fifth largest producer of solar power globally. With a goal of achieving 500 GW from non-fossil sources by 2030, This year our renewable energy capacity has crossed the 200 GW mark. We have reduced the emission intensity of our GDP by 33% between 2005 and 2019, ahead of our 2030 target. Our leadership in global initiatives like the International Solar Alliance (ISA) and the Coalition for Disaster Resilient Infrastructure (CDRI) further highlights our commitment to collective action. With these efforts India is well positioned to emerge as a global leader in renewable energy, contributing to environmental sustainability and energy security.

The BUR4 report is a testament to our commitment and readiness to lead by example in global climate governance. I commend the dedicated efforts of all those involved in preparing this comprehensive report and invite careful consideration of its contents.

**(Kirti Vardhan Singh)**

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लीना नन्दन
LEENA NANDAN

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MINISTRY OF ENVIRONMENT, FOREST
& CLIMATE CHANGE

## FOREWORD

India's Fourth Biennial Update Report (BUR-4) highlights some of the recent initiatives taken to fulfil our commitments towards global climate action. This report demonstrates our Nation's determination to achieve ambitious climate targets, emphasizing both economic growth and ecological integrity. Focus on avoiding Greenhouse Gas (GHG) emissions while fostering economic growth is an achievement that underscores our commitment to low-carbon, sustainable development.

With the active support of various Ministries and Departments, the Ministry of Environment, Forest and Climate Change (MoEFCC) has meticulously prepared this report, highlighting key achievements, ongoing mitigation actions and the nation's strategy to meet its climate targets under the UNFCCC and its Paris Agreement.

BUR-4 offers comprehensive data on India's GHG emissions for 2020 and is an update to the BUR-3 and the Third National Communication submitted to UNFCCC. The report highlights the consistent increase in carbon sequestration, as also advancements in renewable energy adoption and energy efficiency.

Overall, the document showcases India's advances in climate mitigation, sectoral innovations and institutional frameworks for monitoring, reporting, and verification (MRV), which are essential for transparent climate governance. We remain steadfast in our dedication to global collaboration for creating a cleaner and more equitable planet for all.

I commend the efforts of all those involved in the preparation of India's BUR-4.

(Leena Nandan)

New Delhi,
November 27, 2024.

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LiFE Lifestyle for Environment

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SPECIAL SECRETARY

सत्यमेव जयते

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GOVERNMENT OF INDIA
MINISTRY OF ENVIRONMENT, FOREST
& CLIMATE CHANGE

# PREFACE

India's Fourth Biennial Update Report (BUR-4) reaffirms our unwavering commitment to combating climate change within the framework of the United Nations Framework Convention on Climate Change (UNFCCC). This report provides a comprehensive account of India's climate policies and actions, demonstrating significant progress in mitigating vulnerabilities and aligning with global climate objectives. Despite contributing only a small fraction of cumulative global greenhouse gas (GHG) emissions, India stands as a leader in climate action, pioneering initiatives to decouple emissions from economic growth.

The BUR-4 highlights India's substantial advancements in emission reduction from business as usual scenario, renewable energy expansion and carbon sink enhancement. By 2020, India had reduced the emission intensity of its GDP by 36% from 2005 levels, reflecting improvements in energy efficiency and technology. This reduction keeps us on track to achieve a 45% reduction in emission intensity from 2005 levels by 2030. Our renewable energy capacity has also seen remarkable growth, with non-fossil fuel sources now accounting for 46.52% of installed power capacity, steadily progressing toward the 50% target by 2030. Additionally, India's forest and tree cover, and other land use sequestered around 522 million tonnes of $CO_2$ in 2020, contributing to our goal of creating an additional 2.5 to 3 billion tonnes of carbon sinks from forest and tree cover by 2030. These accomplishments underscore India's commitment to sustainable growth and sets an example of how economic development can align with climate action.

At the national level, we are embedding sustainability, amongst others, across key programs like Unnat Jyoti by Affordable LEDs for ALL (UJALA) program, Perform, Achieve and Trade (PAT) scheme and the National Electric Mobility Mission Plan (NEMMP). India led global mass movement - Mission LiFE launched by Hon'ble Prime Minister in Glasgow during COP 26 or *Ek Ped Maa Ke Naam/ एक पेड़ माँ के नाम* (Plant4Mother) launched by Hon'ble Prime Minister on the occasion of World Environment Day on 5th June, 2024 demonstrate how citizen centric actions can collectively make significant contributions in combating climate change. This report also underscores the importance of evidence-based policymaking and calls for enhanced global support to bolster climate resilience. India's BUR-4 is not just a report but a testament to our proactive stance on climate change and a call to the global community for partnership in building a sustainable and resilient future.

I commend the efforts of NATCOM team as well as all officials, scientists in institutions and allied Ministries for assisting and supporting this Ministry in timely completion of the BUR-4 report. I am sure this report would help all stakeholders in getting a better understanding of India's GHG profile and mitigation programmes as we move collectively towards attaining our updated Nationally Determined Contribution targets and the goal of Net Zero emissions by 2070.

(Tanmay Kumar)

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सत्यमेव जयते

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

**Message**

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.

Recognizing that climate change is a global collective action problem, India is committed to addressing the challenge with firm adherence to multilateralism based on equity and the principle of common but differentiated responsibilities and respective capabilities (CBDR-RC), as enshrined in the United Nations Framework Convention on Climate Change (UNFCCC).

India's climate actions are aligned with its Nationally Determined Contributions (NDCs), and the country remains steadfast in its efforts to contribute to the global climate goals under the Paris Agreement. Notable achievements include the reduction in the emission intensity of GDP by 36% between 2005 and 2020, achieving the initial NDC target well before the 2030 deadline. The country is firmly on track to achieve a 45% reduction in emission intensity from 2005 levels by 2030, demonstrating its proactive approach to climate mitigation. Additionally, India sequestered 522 million tonnes of $CO_2$ in 2020 through enhanced forest and tree cover, contributing significantly to global carbon sinks.

India presents its Fourth Biennial Update Report (BUR-4) to the United Nations Framework Convention on Climate Change (UNFCCC). The Report meets the prescribed guidelines and ensured that India's BUR-4 is comprehensive, consistent and transparent, meeting the highest standards of international climate reporting. The Report is testimony to the fact that India remains resolute in its commitment to a low- carbon development pathway, ensuring economic growth aligns with ecological sustainability. This Report stands as a testament to India's dedication to transparency and responsible climate action on the global stage.

This report is the culmination of collaborative efforts involving multiple stakeholders. I commend the dedicated contributions of all concerned Ministries, partner institutions, and our team at the Ministry of Environment, Forest and Climate Change (MoEFCC) for their tireless work in preparing India's BUR-4. Their efforts highlight the strength of India's institutional mechanisms in addressing the multifaceted challenges of climate change.

(Naresh Pal Gangwar)

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आज़ादी का अमृत महोत्सव

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*Meconopis Grandis* Flower

Photo Credit: GB Pant National Institute of Himalayan Environment

# Executive Summary

The Fourth Biennial Update Report (BUR-4) updates the Third National Communication (TNC), which was submitted to the UNFCCC in December 2023. This report (BUR-4) contains the National Greenhouse Gas (GHG) inventory for the year 2020.

## Key Highlights

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. Recognizing that climate change is a global collective action problem, India is committed to addressing the challenge with firm adherence to multilateralism based on equity and the principle of common but differentiated responsibilities and respective capabilities (CBDR-RC), as enshrined in the United Nations Framework Convention on Climate Change (UNFCCC).

In 2020, India's total GHG emissions, excluding Land Use Land-Use Change and Forestry (LULUCF), were 2,959 million tonnes of $CO_2e$ and 2,437 million tonnes of $CO_2e$ with the inclusion of LULUCF.

- Emissions by gas: Carbon dioxide - 80.53%; Methane - 13.32%; Nitrous oxide - 5.13%; and others 1.02%.
- Emissions by sector: Energy – 75.66%; Agriculture – 13.72%; Industrial Process and Product Use (IPPU) – 8.06%; and Waste – 2.56%.
- In 2020, India's forest and tree cover, along with other land use, sequestered approximately 522 million tonnes of $CO_2$, equivalent to reducing 22% of the country's total carbon dioxide emissions in 2020.

India has progressively continued decoupling economic growth from GHG emissions. Between 2005 and 2020, India's emission intensity of Gross Domestic Product (GDP) reduced by 36%.

By October 2024, the share of non-fossil sources in the installed electricity generation capacity was 46.52%. Total installed capacity of renewable power, including large hydropower, is 203.22 GW and cumulative renewable power installed capacity (excluding large hydro projects) has increased 4.5 times from 35 GW in March 2014 to 156.25 GW. The installed capacity of various renewable energy sources as of 31st October 2024 is as follows:

- Solar energy: 92.12 GW (35 times increase from 2.63 GW in March 2014);
- Wind energy: 47.72 GW (more than double the capacity of 21.04 GW in March 2014).

India's forest and tree cover has consistently increased and currently stands at 25.17% of the total geographical area of the country. During 2005 to 2021, additional carbon sink of 2.29 billion tonnes of $CO_2$ equivalent has been created.

# 1. Institutional Arrangement for the preparation of BUR-4

This report embodies information on national circumstances, the national GHG inventory for the year 2020, mitigation actions, an analysis of the constraints, gaps, related finance, technology, and capacity-building needs, information on domestic measurement, reporting, and verification (MRV), and additional information.

The Ministry of Environment, Forest and Climate Change (MoEFCC) is the nodal ministry under the Government of India for coordination and management of climate change-related programs, actions, and reporting information. MoEFCC, with its cross-ministerial and institutional network, is implementing and executing matters related to the National Communications and Biennial Update Reports (BURs). India has furnished its three National Communications (NCs) and three Biennial Update Reports (BURs). The third National Communication was submitted to UNFCCC in December 2023.

The institutional arrangements for preparing BUR include a National Steering Committee (NSC) and Technical Advisory Committee (TAC). The NSC, under the chairmanship of the Secretary, MoEFCC, oversees the preparation and implementation of the work programme of the BUR. Various Ministries and government Departments concerned with different information elements in this report have representation in the NSC. These Ministries and Departments provide inputs for the BUR. The TAC provides technical guidance for the preparation of the BUR. This committee has members from the government, academia, and civil society. Several studies were launched for the fourth Biennial Update Report (BUR-4), which were carried out through a network of scientific and research institutions with sector-specific expertise. The network of institutions has been expanded since the First Biennial Update Report (BUR-1). Academic and government experts reviewed the report, and there is thus a robust Quality Assurance/Quality Control (QA/QC) process in place.

# 2. National Circumstances

India has a diverse geography, with landscapes ranging from snow-capped mountain ranges to deserts in the west, plains, hills, plateaus, coastal regions, and islands. It also has climatic conditions ranging from continental to coastal, extremes of heat to extremes of cold, extreme aridity, and negligible rainfall to excessive humidity and torrential rain.

The southwest monsoon season is the principal rainy season of the country. June, July, August, and September constitute the core of the southwest monsoon season in most parts of the country. Still, the actual period of the monsoon in different regions of the country depends on the onset and withdrawal dates. The retreat phase of the southwest monsoon is followed by the northeast monsoon, which starts in October and continues until December. The northeast monsoon is a transition season associated with establishing the north-easterly wind regime over the Indian Peninsular Region.

On average, about 868.6 mm of rainfall is received nationwide between June and September during the monsoon season. The southwest monsoon season rainfall contributes 74.0% to the annual rainfall. The pre-monsoon (March-May) rainfall (130.6 mm) and post-monsoon season (October-December) rainfall (121.0 mm) contribute about 11% and 10% respectively, to the annual rainfall over India. The winter (January-February) rainfall (39.8 mm) contributes about 3.4% to the annual rainfall over India. The rainfall during the northeast monsoon varies from 209.6 to 480.7 mm in the States of the southern peninsula. For these States, the rainfall received during the northeast monsoon (post-monsoon season) contributes 30% of the annual rainfall.

Although inter-annual variability exists, total precipitation during the Indian summer monsoon has remained largely stable from 1901 to 2023. It has shown a weak decreasing trend during the recent few decades. The long-period (1971-2020) average (LPA) rainfall over the country during the monsoon season is 868.6 mm, and the annual average is 1160 mm. The annual rainfall during 2022 was 108% of LPA, while the SW monsoon season rainfall was 106% of LPA. The annual rainfall during 2023 was 95% of LPA. During the 2023 SW monsoon season, rainfall over the country was normal (94.4% of LPA).

The year 2023 was the second warmest year on record since 1901, with annual mean surface air temperature +0.65°C above the 1981-2010 period average. Past decades (2013-2022/ 2014-2023) were also the warmest decades on record, with anomalies of +0.41°C/ +0.46°C. The annual mean temperature during 1901-2023 showed a significant increasing trend of 0.66°C/100 years with a significant increasing trend in maximum temperature (1.01°C/100 years) and an increasing trend (0.31°C/100 years) in minimum temperature.

State-wise reports on observed rainfall trends and variability based on recent 30-year data (1989-2018) indicate 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. 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.

India's long coastline, with over 7,500 km of flat coastal terrain, a shallow continental shelf, high population density, particular geographical location, and specific physiographic features, makes it vulnerable to cyclones and their associated hazards. Thirteen coastal States and Union Territories (UTs) in the country, encompassing 84 coastal districts, are vulnerable to tropical cyclonic storms.

In 2022, three cyclonic storms formed over the north Indian Ocean: Severe Cyclonic Storm ASANI, Severe Cyclonic Storm MANDOUS, and Cyclonic Storm SITRANG. All three cyclones formed over the Bay of Bengal, while the Arabian Sea did not have any cyclonic storms. In 2023, six cyclonic storms formed over the North Indian Ocean. These include the Extremely Severe Cyclonic Storm MOCHA, Extremely Severe Cyclonic Storm BIPARJOY, Extremely Severe Cyclonic Storm TEJ, Very Severe Cyclonic Storm HAMOON and Severe Cyclonic Storm MICHAUNG & MIDHILI. Of these, four cyclones, MOCHA, HAMOON, MIDHILI, MICHAUNG formed over the Bay of Bengal & 2 cyclones, BIPARJOY, TEJ formed over the Arabian Sea.

Heatwaves typically occur between March and June and, in some cases, even extend until July in India. They are more frequent over the Indo-Gangetic plains of India. On average, 5-6 heatwave (HW) events occur every year over the northern parts of the country. Temperatures of more than 46°C have been recorded in many parts of the country in the past, especially over north and central India. The average Severe Heatwave (SHW) days of 1-3 days were mainly experienced over the country's northwest, north and eastern parts. Increasing trends in the HW were observed over most of the stations except a few stations in the plains along the foothills of the Himalayas, southern parts of central India, and east India, which showed decreasing trends during the period 1961-2023.

India is one of the few countries where forest and tree cover has continued to increase over the years, qualifying the country's forests as net sink owing to national policies aimed at conservation and sustainable management of forests. As per the India State of Forest Report (2023), India's total forest cover was 7,15,342.61 sq. km, which was 21.76 percent of the geographical area. The tree cover of the country is estimated as 1,12,014.34 sq km, which is 3.41 percent of the geographical area. Thus, the total forest and tree cover of the country was 8,27,356.95 sq km, which is 25.17 percent of the geographical area of the country.

Climate change impacts have direct consequences for water security. The initiatives undertaken in the water sector in the last decade reflect the importance of water management in reducing vulnerability and building climate resilience. Consequently, various government initiatives have focused on issues such as river rejuvenation, holistic river basin management, increasing storage, enhancing the efficiency of existing dams, water conservation and recharge, and security of water supply.

The Himalayan glacier systems are an important ecosystem within the Indian sub-continent. which supplies water to major Indian rivers, including the Ganga and the Brahmaputra. Several studies indicate that overall, the glacier snout recession has accelerated in the last few decades. In general, Himalayan glaciers are undergoing thinning and reduction in length and area in the present climate conditions.

Agriculture and allied activities (horticultural crops, livestock, fishing, forestry, and logging) play a significant role in India's economy and is the largest sector in terms to livelihood and employment. India's agriculture

sector has been witnessing robust growth, with an average annual growth rate of 4.6% over the last six years. At current prices, the share of agricultural and allied sector activities in the economy's total Gross Value Added (GVA) is 18.3, 20.4, 18.9, and 18.2 percent for 2019-20, 2020-21, 2021-22, and 2022-23, respectively.

Indian agriculture remains vulnerable to weather vagaries despite self-sufficiency in food grain production. Climate change and increased extreme weather events in recent decades, as well as uncertainty in the prediction of those events, further add to the challenges to farmers, causing widespread losses of agricultural output. Heatwaves and floods have mainly caused significant damage to crop production and crop harvesting activities in India.

Despite the above factors, there has been a consistent increase in the production of both food grains and horticultural products in India. This indicates the importance of developing climate-resilient crop varieties, appropriate farming systems, social security and welfare measures, and other interventions.

India's economy is 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. Poverty eradication and constant improvement of the ease of living is a priority on India's economic agenda.

Energy consumption needs to increase by a significant amount to meet India's developmental goals. In 2022-23 (Provisional), the Primary Energy Supply totalled 8,50,349 Kilo Tonnes of Oil equivalent (ktoe). Two major contributors to the total energy supply in the country were coal, which accounted for 57.82% of the total, and crude oil, which accounted for 31.48%. In 2022-23 (P), the final energy consumption (End Use) was 5,51,550 ktoe.

The industrial sector was the largest consumer of energy in the country with this sector itself using 48.95% of the total final energy consumption. Iron and steel were the sector's most energy-intensive industries, accounting for 15.15% of the industrial energy use, followed by chemicals and petrochemicals, 4.56 %, and construction, 1.80%. The consumption of the residential, agriculture, commercial, and public sectors and non-energy purposes represented 39.34% of the total final consumption in the country. In contrast, the transport sector accounted for 11.70% of the total final consumption.

The Indian Road network is the second largest in the World, with about 63.45 lakh km, of which 146 lakh km are national highways and 179 lakh km are state highways. The capacity of National Highways to handle traffic (passengers and goods) needs to keep pace with economic growth. Indian Railways has the fourth-largest network in the world and is one of the nation's major electricity consumers. The railroads run 9,146 freight trains and 13,523 passenger trains per day. Indian Railways ranks seventh globally and is the country's top employer, with 1.3 million employees. All this makes it clear that railways are an essential means of communication for transporting people and freight in India.

# 3. National GHG Inventory

India's emissions in 2020 were 29,58,589 Gg of $CO_2e$ greenhouse gases (GHGs) without Land Use, Land Use Change and Forestry (LULUCF). The LULUCF sector remained a net sink. Considering emissions and removals from the LULUCF sector, net national emissions were 24,36,656 $GgCO_2e$. A summary of sector-wise and gas-wise national emissions and removals is presented in Table ES 1.

***Table ES 1: Sector-wise National GHG emissions in Gg for 2020***

| GHG sources and removals | $CO_2$ emission | $CO_2$ removal | $CH_4$ | $N_2O$ | HFC 23 | $CF_4$ | $C_2F_6$ | $SF_6$ | $CO_2$ equivalent |
|---|---|---|---|---|---|---|---|---|---|
| Energy | 2181012 | NO | 1523 | 82 | NO | NO | NO | NO | 2238409 |
| IPPU | 201044 | NO | 232 | 8 | 2 | 1 | 0.27 | 0.004 | 238556 |
| Agriculture | NO | NO | 14290 | 342 | NO | NO | NO | NO | 405983 |
| LULUCF | 9369 | -532357 | 41 | 1 | NO | NO | NO | NO | -521933 |
| Waste | NO | NO | 2726 | 58 | NO | NO | NO | NO | 75641 |
| Memo Items | 802846 | NO | 0.09 | 0.11 | NO | NO | NO | NO | 802882 |
| Total Emission | 2382535 | — | 18771 | 489 | 2 | 1 | 0.27 | 0.004 | 2958589 |
| Net Emission | 2391904 | 532357 | 18811 | 490 | 2 | 1 | 0.27 | 0.004 | 2436656 |

*Abbreviation: NO - Not Occurring.*

The energy sector contributed the most to overall emissions, 75.66 percent, followed by the agriculture sector, 13.72 percent, IPPU, 8.06 percent, and Waste, 2.56 percent (Figure ES 1).

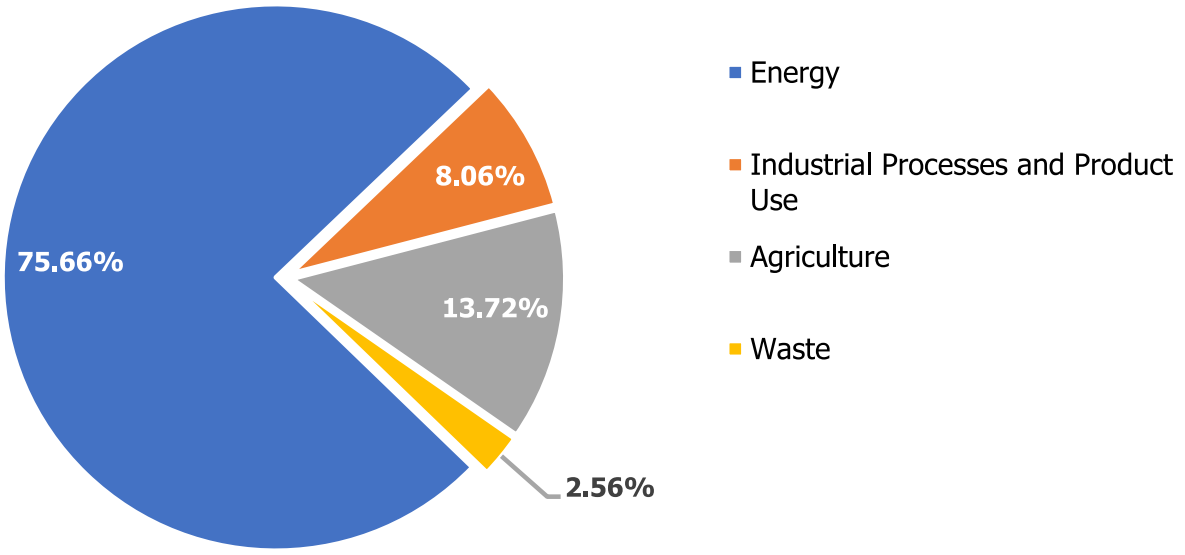



*Figure ES 1: Distribution of GHG emissions ($GgCO_2e$) by sector, 2020*

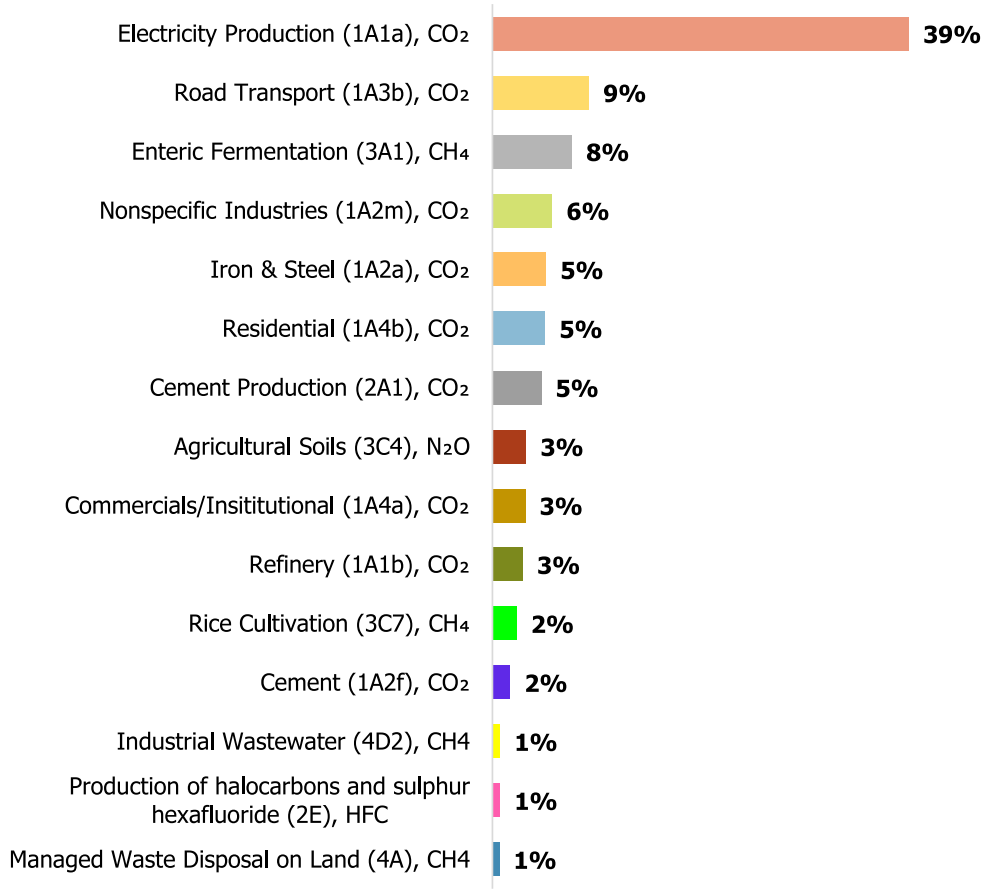



*Figure ES 2: Percentage share of greenhouse gas emissions by category, 2020*

Figure ES 2 shows the percentage share of the top 15 key emission categories for India for 2020 in terms of $CO_2e$.

Figure ES 3 shows national GHG emissions excluding LULUCF by type of gas for the year 2020. The $CO_2$ emissions accounted for 23,82,535 Gg (80.53 per cent); $CH_4$ emissions accounted for 3,94,185 $GgCO_2e$ (13.32 per cent) and $N_2O$ emissions accounted for 1,51,733 $GgCO_2e$ (5.13 per cent). In the case of fluorinated gases, emissions of HFC were 21,645 $GgCO_2e$ (0.73 per cent), $CF_4$ emissions 5,876 $GgCO_2e$ (0.20 per cent), $C_2F_6$ emissions 2,515 $GgCO_2e$ (0.09 per cent) and $SF_6$ emissions 100 $GgCO_2e$ (0.003 per cent).

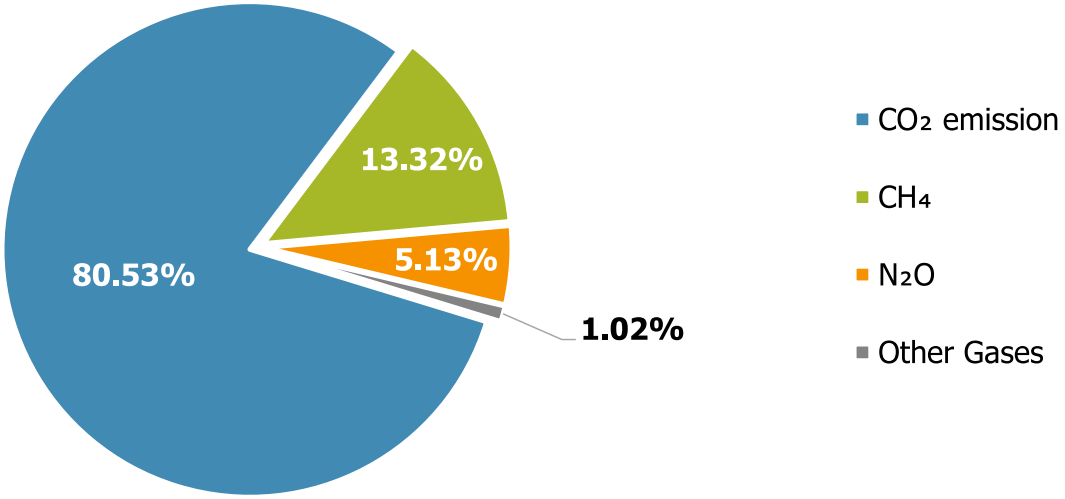



*Figure ES 3: Gas-wise emission for the year 2020*

Total national GHG emissions (including LULUCF) have decreased by 7.93 per cent with respect to 2019 and increased by 98.34 per cent since 1994 (Table ES 2 and Figure ES 4 and ES 5). The main contributors to the total GHG emission are $CO_2$ emissions generated from burning fossil fuels, methane emissions from livestock and increasing aluminium and cement production. The LULUCF sector remained net sink during the inventory period 2020.

***Table ES 2: Sector-wise National GHG emission in $MtCO_2e$ for 1994-2020***

| GHG Sources and Removals | 1994 | 2000 | 2007 | 2010 | 2014 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Mt $CO_2e$ | | | | | |
| Source | INC | SNC | SNC | BUR1 | BUR2 | BUR3 | TNC | TNC | TNC | BUR4 |
| Energy | 744 | 1027 | 1374 | 1510 | 1910 | 2129 | 2204 | 2344 | 2374 | 2238 |
| Industrial Processes and Product Use | 103 | 89 | 142 | 172 | 202 | 226 | 244 | 263 | 264 | 239 |
| Agriculture | 344 | 356 | 373 | 390 | 417 | 408 | 411 | 417 | 421 | 406 |
| LULUCF | 14 | -223 | -177 | -253 | -301 | -308 | -312 | -437 | -485 | -522 |
| Waste | 23 | 53 | 58 | 65 | 78 | 75 | 70 | 72 | 73 | 76 |
| Total (without LULUCF) | 1214 | 1524 | 1947 | 2137 | 2607 | 2839 | 2929 | 3096 | 3132 | 2959 |
| Total (with LULUCF) | 1229 | 1301 | 1772 | 1884 | 2306 | 2531 | 2617 | 2659 | 2647 | 2437 |

*Source: (MoEF, 2004); (MoEF, 2012); (MoEF, 2010); (MoEFCC, 2016); (MoEFCC, 2018); (MoEFCC, 2021); (MoEFCC, 2023).*

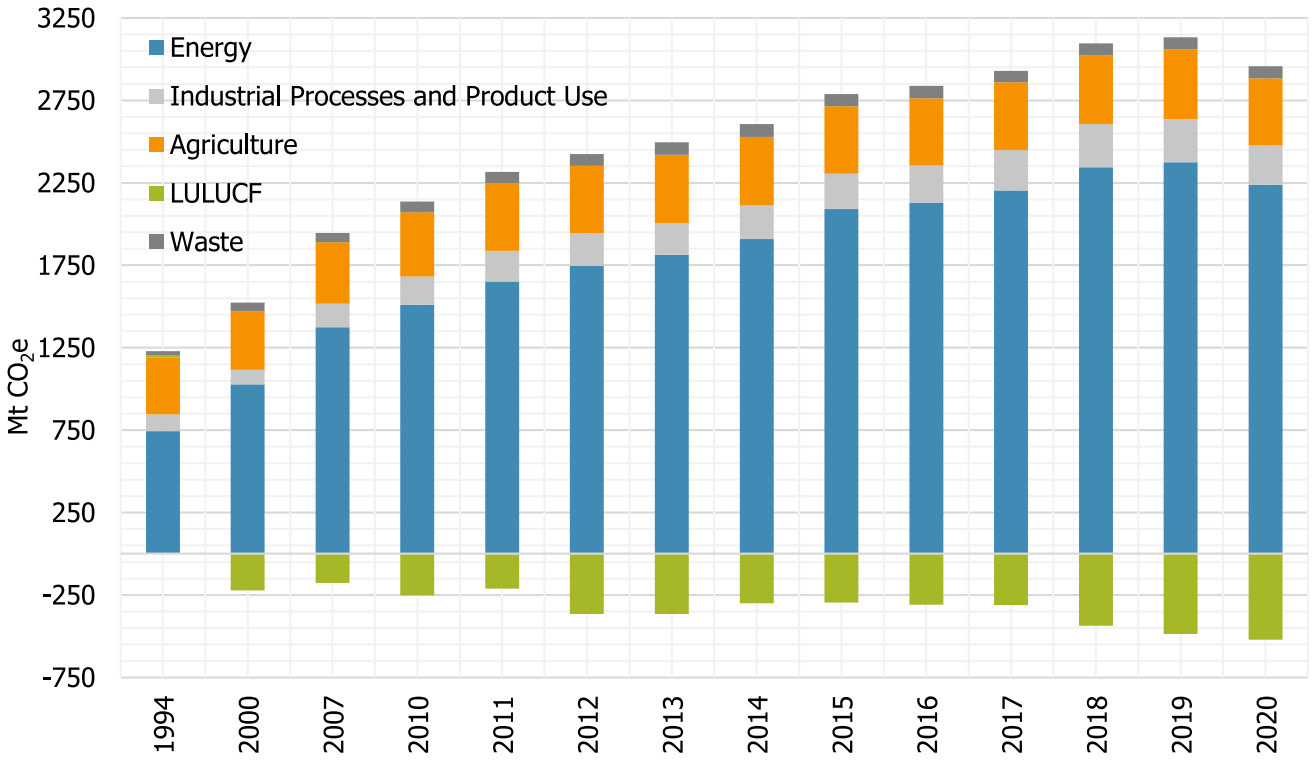



*Figure ES4: Sector-wise National GHG emission in Mt $CO_2e$ for 1994-2020.*

*Source: (MoEF, 2004); (MoEF, 2012); (MoEF, 2010); (MoEFCC, 2016); (MoEFCC, 2018); (MoEFCC, 2021); (MoEFCC, 2023).*

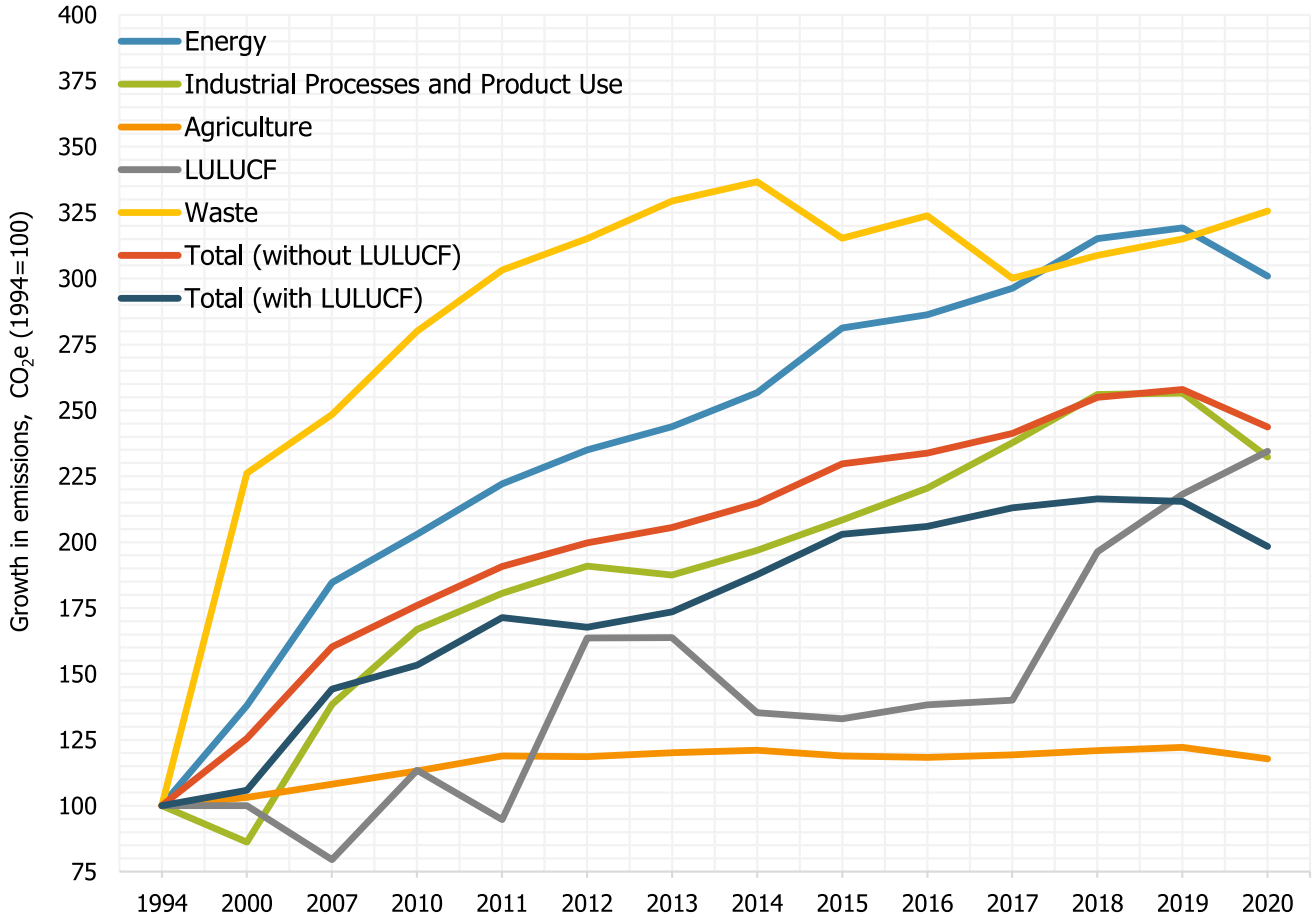



*Figure ES5: Growth in emissions of greenhouse gases, relative to 1994, illustrated by source categories, 1994-2020. Index 1994 = 100.*

*Source: (MoEF, 2004); (MoEF, 2012); (MoEF, 2010); (MoEFCC, 2016); (MoEFCC, 2018); (MoEFCC, 2021); (MoEFCC, 2023).*

Since 1994, India has undergone significant economic growth, resulting in an overall increase in greenhouse gas emissions. From 1994 to 2020, total $CO_2e$ emissions (excluding LULUCF) rose by 144 per cent. The waste sector experienced a growth of 226 per cent from 1994 to 2020, attributed to population growth and increased industrial activities. However, its contribution to overall emissions consistently hovers around 3 per cent, indicating a relatively low absolute contribution. The energy sector experienced a growth rate of 201 per cent from 1994 to 2020, primarily attributed to the ongoing rise in fossil fuel combustion. During the same period, the IPPU sector experienced a growth of 132 per cent, whereas the agriculture sector saw an increase of only 18 per cent (Figure ES 5). From 2000 to 2020, the LULUCF sector exhibited a 135 per cent increase in greenhouse gas removals.

# 4. Mitigation Actions

Despite India's contribution to historical emissions and to the current levels of global emissions being very low, India is committed to addressing climate change with firm adherence to multilateralism and based on the principles of equity and common but differentiated responsibilities and respective capabilities (CBDR-RC), as enshrined in the UNFCCC. India maintains that operationalizing the principle of equity and climate justice requires the global carbon budget to be equitably shared among all countries and used responsibly. Countries' historical and future responsibilities must be framed to limit their cumulative emissions within their fair share of this budget. Therefore, the fundamental principle that informs India's climate policy is to pursue its development goals according to national circumstances while keeping within its fair share of the global carbon budget.

Government of India has consistently undertaken several initiatives to promote non-fossil fuel based sources of energy. Owing to these, India stands 4th globally in renewable energy installed capacity, 4th in wind power capacity and 5th in solar power capacity. Over the past decade, the installed solar energy capacity has surged from approximately 2.63 GW in March 2014 to around 92.12 GW in October 2024, marking an extraordinary increase of nearly 35 times. These achievements align with the updated Nationally Determined Contributions (NDCs) of India which includes, inter-alia, achieving about 50 per cent cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030.

India has progressively continued decoupling economic growth from GHG emissions. Between 2005 and 2020, India's gross domestic product (GDP) emission intensity reduced by 36%. It also reaffirms India's commitment to make a fair and equitable contribution to the global effort to mitigate climate change.

India's forest and tree cover has consistently increased and currently stands at 25.17% of the total geographical area of the country. During 2005 to 2021, additional carbon sink of 2.29 billion tonnes of $CO_2$ equivalent has been created.

India's energy security policies are geared towards improving energy supply, improving people's living standards (in terms of energy consumption), and contributing to climate mitigation based on India's right to a fair share of the global carbon budget. Some of the key policies and measures to mitigate GHG emissions directly or indirectly across the different sectors are listed below.

## 4.1 Power

India's per capita electricity consumption remains significantly lower than the world average, at 1331 kWh per person in 2022-23. India's total electricity consumption reached around 1440.31 TWh in 2022-23, an increase of about 9.4% from 2021-22.

While coal remains the predominant source of electricity generation in India, RES (renewable energy sources) have grown by over 10.94 % (not including hydro) in generation and over 14.7 % (not including hydro) in Installed Capacity in the year 2023-24. As of October 2024, the share of non-fossil fuel-based power generation capacity in the country is already at 46.52%.

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 security, India's efforts for low-carbon development in the power sector have steadily contributed to the global effort for climate change mitigation.

Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY) 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.

Smart Meter National Program aims to enhance efficiencies for distribution utilities. Smart meters are crucial for smart grid initiatives to meet the challenges of the newly evolving energy mix for achieving an uninterrupted 24x7 power supply. Connected via a web-based monitoring system, smart meters reduce commercial losses, boost revenues and aid power sector reforms. Over 35.75 lakh smart meters have been installed in Uttar Pradesh, Delhi, Haryana, Bihar, Rajasthan, and Andaman under this program.

Demand-side management (DSM) programs assist distribution utilities in lowering power purchases from the wholesale market during peak-load times, thus reducing operational costs. For Phase 1 (2012-17) and Phase 2 (2021-26) of this program, the peak demand reduction potential is estimated at about 22.9 GW, and the energy requirement reduction potential is estimated to be 62.6 billion units across 28 distribution utilities.

The Street Lighting National Programme (SLNP) has brought a nationwide shift from conventional streetlights to smart, energy-efficient LEDs. Between 2015 and 2023, this scheme has led to annual energy savings of 8.75 billion kWh with avoided peak demand of 1,459 MW every year. Avoided emissions are estimated at 6.03 million tons of $CO_2$ per year in this period.

The Unnat Jyoti by Affordable LEDs for ALL (UJALA) program is estimated to have led to annual energy savings of 48.39 billion kWh and avoided peak demand of 9,788 MW annually between 2015 and 2024. During this period, avoided emissions are estimated at 39.30 million tons of $CO_2$ annually.

The Perform, Achieve, and Trade (PAT) scheme, which targets energy efficiency in selected 239 Thermal Power Stations, has led to energy savings of 7.72 million tonnes of oil equivalent and avoided emissions of about 28.74 million tonnes of $CO_2$ till FY 2021-22.

The Indian government has established minimum share of consumption of non-fossil sources by designated consumers as energy or feedstock and different share of consumption for various types of non-fossil sources for different designated consumers in respect of electricity distribution license and other designated consumers, to be in effect till March 2030 under the Energy Conservation Act, 2001. In 2024-25, 29.91% of total electricity is mandated to be purchased from renewable energy sources, increasing to 43.33% of total electricity from renewable energy sources till 2029-30.

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.

The total avoided emissions from renewable energy sources in 2023-24 (up to December) amount to 135.61 million tons of $CO_2$, with 57.47 $MtCO_2$ from wind, 69.40 $MtCO_2$ from solar, 2.09 $MtCO_2$ from biomass, and 6.66 $MtCO_2$ from small hydro.

In addition, National Green Hydrogen Mission, launched in 2023, aims to establish India as the global hub for production, usage and export of Green Hydrogen and its derivatives.

## 4.2 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 such as automotive, engineering, cement, textiles, steel, chemicals, pharmaceuticals, and consumer durables are pivotal in this growth trajectory.

In FY 2022-23, the total final energy consumption by the industrial sector in India was 2,70,000 ktoe (P), making it the largest energy consumer in the country, accounting for 48.95% of the total final energy consumption. The industry sector's most energy-intensive subsector 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%.

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. The scheme has evolved through seven cycles, currently encompassing 13 sectors comprising 1196 Designated Consumers (DC). Overall, the five PAT cycles (between 2012 – 2022), there has been cumulative energy savings of 3.35 Mtoe in the Cement industry, 6.14 Mtoe in the Iron and Steel industry, 2.13 Mtoe in the Aluminium industry, 0.33 Mtoe in the Textile industry, 0.63 Mtoe in the Paper and Pulp industry. In PAT-VII (latest cycle), 707 DCs from various sectors, 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. A new Advanced Industrial Technology Demonstration Centre (AITDC), UTPRERAK, was established at NPTI Badarpur in June, 2023. It will feature non-functional models of energy efficiency technologies in sectors such as Cement, Iron and steel, Pulp and paper, Textile, and Chlor-Alkali.

Bureau of Energy Efficiency (BEE) and United Nations Industrial Development Organization (UNIDO) project on Promoting Energy Efficiency and Renewable Energy in Selected MSME Clusters in India has been developed to promote market environment for introducing energy efficient technologies and enhancing the use of renewable energy technologies in process applications. It is operational in 23 MSME clusters including - Hand tools, Ceramics, Dairy, Foundry, Brass.

## 4.3 Transport

The transport sector 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 4.5% at constant prices. The electricity consumption in railways increased from 19.02 TWh in FY 2017-2018 to 31.81 TWh in FY 2023-24. 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 and adopting 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 electromobility for terrestrial transportation and 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 specific scenarios, is complemented by hydrogen and biofuel-based solutions (with medium confidence) is being explored and can become viable in the future.

Corporate Average Fuel Economy (CAFE) norms for passenger vehicles, introduced in FY 2017-18 and the second phase of the norms started in FY 2022-23, aims to reduce overall fuel consumption. These norms, coupled with standards for heavy-duty and light commercial vehicles, have led to (for FY 2019-20 to 2022-23) the collective energy savings amounting to 1.88 Mtoe, and the corresponding avoided emissions are estimated at 4.41 $MtCO_2$.

The Government has introduced various initiatives to encourage the adoption of electric vehicles (EVs) across the country. These efforts include offering tax benefits to EV owners and developing public charging infrastructure. The flagship program promoting electric mobility in India is FAME (Faster Adoption and Manufacturing of (Hybrid and) Electric Vehicles). Currently in its second phase, FAME-II implemented for three years starting from April 1, 2019, with a budget of 10,000 Cr, 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. Between 2018-19 and 2021-22, the collective energy savings amount to 0.142 Mtoe, and the corresponding avoided emissions are about 0.432 $MtCO_2$ due to the implementation of this scheme.

The Ethanol Blended Petrol program aims to boost biofuel usage in India by blending different types of biofuels with petrol. The "National Policy on Biofuels" of 2018 and 2022 amendment, 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.

Metro Rail development continues to expand, with 700 kilometres of operational track in 18 cities and 900 kilometres under construction across 27 cities.

As on July 25, 2024, 12 Greenfield Airports have been constructed/ operationalised since 2014. 48 airports/ airstrips have been constructed by Airport Authority of India since 2014. With the efforts of the Government of India, Airports like Delhi, Mumbai, Hyderabad, and Bengaluru have achieved Level 4+ as well as higher Airports International Council (ACI) Accreditation and have become Carbon neutral.

Indian Railways, one of the largest global rail networks covering over 69,000 route kilometers as on 31$^{st}$ March 2024, plays a vital role in India's transportation sector, ferrying nearly 19 million passengers daily. Electrification of railways has significantly reduced their dependence on non-renewable sources of energy and benefits both the environment and efficiency. Schemes such as Three-Phase locomotive technology, Auxiliary Power Units (APU), Computerized Fuel Management Systems and head-on Generation systems, LED Lighting, Dedicated Freight Corridors, Alternative fuels, and sustainable solutions have contributed to the energy conservation and mitigation actions within the Indian Railways.

## 4.4 Waste

The Waste sector is India's largest contributor to urban emissions after the energy sector. Municipal authorities mainly control waste management, which is a key focus for city-level efforts to reduce emissions.

To ensure effective waste management, specialized legislation has been enacted and periodically revised to adapt to evolving environmental conditions.

Atal Mission for Rejuvenation and Urban Transformation (AMRUT) 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. By 2023, AMRUT has facilitated the implementation of 13.9 million water tap connections, 14.5 million sewer connections, 6,347 MLD of sewage treatment capacity, 2322 park projects, and 692 stormwater drainage projects.

Swachh Bharat Mission (SBM)-Grameen and Swachh Bharat Mission (SBM)-Urban has catered to the three main objectives: (a) Attaining 100% Open Defecation Free (ODF) status, (b) Ensuring 100% scientific Solid Waste Management (SWM), and (c) Behaviour change.

As of October 2024, under the National Bioenergy Programme, the cumulative capacity of installed waste to biogas projects is 8,24,647 $m^3$/day and for waste to Bio-CNG/CBG is 4,92,135 kg/day spread across 89 plants. Additionally, waste-to-power generation projects (grid and off-grid) capacity is 401.79 MW, distributed among ten plants.

## 4.5 Buildings

Buildings contribute to emissions indirectly during their construction and operational phases. These emissions largely stem from the energy embedded in building materials, reflecting the energy used in their production processes. The main strategies for reducing emissions in the building sector concentrate on minimizing the use of energy and materials through design and new technologies.

National Mission for Sustainable Habitat (NMSH) aims is to mitigate and adapt to climate change within the built environment, encompassing sectors such as buildings, waste management, and transportation. 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.

The Energy Conservation Building Code (ECBC) 2017 encompassed both existing and forward-looking advancements in building technology and aims to reduce energy consumption while promoting low-carbon growth going beyond the provisions outlined in ECBC 2007. The overall energy conservation from 2018 to 2020 totals 59.3 MU, while for the year 2022-23, it is 19.89 MU. The avoided $CO_2$ emissions for the year 2022-23 is estimated to be 0.070 $MtCO_2$.

Building Energy Efficiency Programme (BEEP) aims to retrofit existing public, institutional, and industrial buildings with energy-efficient appliances and systems. Till 8$^{th}$ November 2024, the energy saved amounts to 1306 GWh. The corresponding avoided $CO_2$ emissions are estimated to be 1071 $MtCO_2$.

The Star Rating Scheme for commercial buildings in India aims to promote energy efficiency measures. The total energy saved across 4 categories of the Star Rating System from FY 2019-20 to 2022-23 amounts to 178.5 MU. The corresponding avoided $CO_2$ emissions are estimated to be 0.13 $MtCO_2$.

The Eco Niwas Samhita (ENS), an ECBC tailored for residential buildings, aims to enhance the energy efficiency of residential building design and construction, reducing electricity consumption over their lifecycle. For FY 2021-22 to 2022-23, the collective energy savings amount to 4.84 MU.

Unnat Jyoti by Affordable LEDS for All (UJALA) initiative aims to improve household energy efficiency by providing LED bulbs, tube lights, and energy-efficient fans at reduced prices. During FY 2019-20 to 2022-23, the total energy saved amounts to 2393.72 MU for LED lamps, 15.52 MU for LED tubelights and 19.21 MU for EE fans.

The Standards and Labelling (S&L) Programme is a key focus area for BEE which sets energy performance standards for appliances and rates their efficiency. Energy Savings in FY 22-23 from appliances manufactured during FY 2018-23 is 80.86 BU. The corresponding avoided $CO_2$ emissions in FY 2022-23 due to interventions in the period from 2018-23 is 57.46 $MtCO_2$.

## 4.6 Forestry

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 Programme (NAP), Green Highway Policy—2015, Policy for Enhancement of Urban Greens, National Agro-forestry Policy, and Sub-Mission on Agro-forestry (SMAF) are a few of the important policy interventions of the Government of India.

On World Environment Day in 2020, the Nagar Van Yojana scheme was launched to create 200 urban forests over the next five years until 2024-2025. These forests will range in area from a minimum of 10 Ha up to 50 Ha. 111 Nagar Vans approved against the target of 100 Nagar Vans in 100 days action plan, spread across 6 States and 1 UT of the country. More than 75 crore saplings have been planted so far till September 2024.

Mangrove Initiative for Shoreline Habitats and Tangible Income (MISHTI) was announced in the Union Budget 2023-24 to promote and conserve mangroves. Since the initiation of the Scheme, about 21500.36 ha area in 12 States/UTs has been brought under restoration through convergence. In addition, a total of 3836 ha has been taken up for restoration in the 6 States/UTs under the National CAMPA.

## 4.7 Water

The Government of India has prioritized water security by exploring various avenues such as increasing water sources, enhancing supply, managing demand, conserving water, managing wastewater, and reusing treated wastewater through initiatives like Jal Shakti Abhiyan, Atal Bhujal Yojana, Amrit Sarovar Mission, Master Plan for Artificial Recharge to Groundwater- 2020 etc.

The Government of India, in collaboration with the states, is executing the Jal Jeevan Mission (JJM), which aims to ensure tap water access to every rural household in the country by 2024. 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. As of November 2024, 78.9% of total rural households have been provided with functional household tap connections

## 4.8 Agriculture

India's voluntary declaration excludes mitigation in the agricultural sector. 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.

System of Rice Intensification is being implemented in 193 districts of 25 States during 2022-23. The emissions avoided due to SRI cultivation compared to conventional rice cultivation were 0.053 $MtCO_2$ during 2019-24.

Direct-seeded Rice (DSR) is one of the most efficient, sustainable, and economically viable rice production systems compared to conventional puddled transplanted rice (PTR). Using the DSR technique, a mitigation potential of 0.137 $MtCO_2$ was achieved during 2019-24.

Under the Crop Diversification Program (CDP), assistance is provided for four major interventions to replace paddy crops: alternate crop demonstrations, farm mechanization and value addition, site-specific activities, and contingency for awareness, training, monitoring, etc. The mitigation potential through CDP was 0.214 $MtCO_2$ during 2019-24.

A Central Sector Scheme on Crop Residue Management (CRM) was implemented from 2018-19. Emission reduction of 1.447 $MtCO_2$ was achieved during 2019-24 by avoiding crop residue burning using in-situ crop residue management machines.

Mission for Integrated Development of Horticulture (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. Under the MIDH, the cumulative carbon sequestered was estimated to be 1020.6 $MtCO_2$ from 2019 to 2024.

Sub-Mission on Agroforestry (SMAF) scheme also known as "Har Medh Par Ped" promotes the simultaneous cultivation of trees and crops. Under SMAF, the cumulative carbon sequestration potential of 2.378 $MtCO_2$ was achieved during 2019-24.

The restructured National Bamboo Mission 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 cumulative carbon sequestration potential achieved under the National Bamboo Mission during 2019-24 was 6.106 $MtCO_2$.

The Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) aims to improve on-farm water use efficiency, enhance the adoption of precision irrigation and other water-saving technologies (more crops per drop), and enhance aquifer recharge. The cumulative emission reduction amounted to 555.3 $MtCO_2$ from 2019-20 to 2023-24.

Solarization of Agriculture - Pradhan Mantri Kisan Urja Suraksha Evam Utthan Mahabhiyan (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 cumulative $CO_2$ emission reduction of 0.795 $MtCO_2$ was achieved during the period 2019-24 from standalone solar powered agriculture pumps installed under component B.

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. An emission reduction of 26.81 $MtCO_2$ was achieved during 2019-24 from Neem coated urea application.

The Agriculture Demand Side Management (AgDSM) initiative encompasses strategies and policies to alter power consumption behaviors among consumers, particularly farmers. Between 2019 and 2023, an emission reduction of 0.68 $MtCO_2$ was achieved.

# 5. Domestic Monitoring, Reporting and Verification Arrangements

Transparency mechanisms in the form of monitoring, reporting, and verification (MRV) frameworks serve as essential pillars to ensure the integrity of climate actions. Also, robust domestic MRV arrangements inform policymakers to make evidence-based decisions as it puts in place a learning process by identifying good practices and gaps in the existing system.

In India's climate action framework, institutional arrangements for MRV operate across national, state, and local levels. This tripartite structure involves collaboration among several ministries, departments, and governmental agencies, ensuring a cohesive approach to track the implementation of mitigation and adaptation strategies.

India is at the forefront of developing, utilising and exploring technology/technical advancements for conducting MRV, ensuring the highest levels of data accuracy, reliability, and transparency. The innovative tools and systems include remote sensing satellites, geographic information systems (GIS), and sophisticated monitoring devices that lead to vigilant and real-time observation of India's climate actions.

To improve MRV practices and reduce the chances of data silos, integrated platforms and geo-spatial technologies have been developed to provide a single window access for all datasets. India is complementing its existing technological tools for MRV practices by employing newer innovations such as Internet of Things (IoT), Artificial Intelligence (AI).

India's leveraging technological innovations for monitoring and reporting climate actions demonstrates the intention to strengthen environmental governance and foster sustainable development. Recognising the need for a holistic nature of the MRV process, India also actively engages with civil society organisations. This inclusive approach ensures broader participation in climate action initiatives, setting high standards in transparency and accountability and paving the way towards a more resilient and sustainable future.

India is preparing to transition into the ETF. The idea is to build an IT-enabled system – "National Institutional Coordination System (NICS)", which would bring relevant stakeholders together, supporting enhanced coordination and timely reporting. This would explore integrating information from different sources and platforms – GHG inventory inputs through the National Inventory Management System (NIMS); data providers from departments; policy and programme level outcomes; in-built MRVs of schemes; and also bind state and local level monitoring entities to one system.

The National Inventory Management System (NIMS), is being developed to support the preparation and management of a comprehensive national greenhouse gas. It would lead to a centralized digital system and facilitate electronic reporting requirements under the ETF [supporting inputs to common reporting tables (CRT)].

While India is transitioning to a more sophisticated climate reporting system, it acknowledges the imperative of a collective approach to address the climate crisis. Robust climate action transcends the efforts of any single ministry or department in a country; it necessitates seamless collaboration among various governmental and inter-governmental entities. This is vital because MRV processes not only play a vital role in informing and guiding sectoral initiatives but also build credibility and reliability of climate-related data. Under the ETF, through the implementation of systems like NIMS, India aims to strengthen its climate reporting mechanisms, striving for comprehensive, accurate, and transparent documentation of GHG emissions and its climate actions.

# 6. Finance, Technology, and Capacity Building Needs and Support Received

This section provides updated and detailed information on the financial resources, technology transfer and capacity-building needs and support received by India. It also highlights the context of international/ multilateral finance for climate action as relevant to India and the barriers to the flow and adequacy in meeting India's financial needs. It provides a non-prescriptive, voluntary technical guidance to aid in the preparation and reporting of information on financial, technical, and capacity-building needs and the support received for climate change-related activities.

The responsibilities, obligations, and commitments of the developed countries on providing Climate Finance to the developing countries under the UNFCCC and its Paris Agreement have consistently not been met. The decision text of COP 27, COP 28 and the first GST all have noted "with deep regret" that the goal of developed country Parties to mobilize jointly USD 100 billion per year by 2020 in climate finance has not been met up till 2021.

In relation to the size of India's economy and given its vulnerability to climate change and variability, the country's financing needs for climate action are pertinent. India's climate action is mainly financed by domestic resources as flows from developed countries have fallen far short of what is needed to combat climate change. India also recognizes that current climate finance falls short in scale, scope, and speed contrary to the letter and spirit of the Convention. It is heavily skewed towards loans rather than grants or sufficiently concessional loans, with a disproportionate focus on mitigation over adaptation.

India looks forward to climate specific grants and/or concessional loans, predominantly from public sources of funding, with appropriate balance between mitigation and adaptation and based on India's articulation of its needs and development aspirations.

An account of the development finance associated with projects approved by multilateral channels in the calendar years 2021 and 2022 across all sectors have been provided. It covers multilateral climate funds such as the Green Climate Fund (GCF) and the Global Environment Facility (GEF); and multilateral development banks (MDBs) such as Asian Development Bank (ADB) and the International Bank for Reconstruction and Development (IBRD).

India's climate strategy emphasises integrating advanced technologies across key sectors, such as solar, wind, bioenergy, electric vehicles, climate-resilient agriculture, and carbon capture, to foster low-carbon development and build resilience. Despite substantial national efforts and investments, barriers like slow international technology transfer and intellectual property rights (IPR) hinder the rapid adoption of these technologies.

A broad overview of the technological needs is provided in this chapter that are necessary for both mitigating climate change and adapting to its impacts across different sectors, aiming for a holistic approach to tackling global climate challenges. Additionally, several existing technologies across various sectors are also outlined that are crucial for combating climate change but require additional investments and scale-up to enhance their efficiency, affordability, and global adoption.

Technology transfer is a critical component of climate change mitigation and adaptation that faces both demand and supply-side challenges. On the demand side, access to relevant, affordable, and scalable technologies is often limited due to high costs, lack of infrastructure, and regulatory barriers. On the supply side, Intellectual Property Rights (IPR) regimes can act as a barrier to technology transfer, restricting access to technologies, especially for developing countries like India.

India's previous BURs have also outlined essential technologies required for mitigation and adaptation. However, despite detailed submissions through the first, second, and third BURs to the UNFCCC outlining India's technology needs, none of the required technologies have been effectively transferred, facilitated, or

made available under the current climate change regime. This lack of technology transfer has forced India to rely heavily on domestic resources and stretch national capacity, slowing its efforts to achieve critical climate objectives.

The background for capacity-building support in climate change in India is framed by the pressing need to address the increasing frequency and severity of climate-related impacts on its natural environments, economy, and society. As India navigates these challenges, the focus is on enhancing the country's capacity to understand, plan for, and respond to climate risks effectively.

To address the identified constraints and gaps in Greenhouse Gas (GHG) inventory reporting, sector-specific capacity-building needs have been outlined to enhance accuracy and efficiency. Further, to adequately respond to the impacts of climate change, India needs to focus on strengthening its knowledge systems to better understand climate risks and improve adaptation strategies across sectors. Institutional capacity building is fundamental for India to effectively tackle climate change. This involves inter-departmental synchronization, improved climate reporting, and the establishment of dedicated climate change units, while integrating traditional and indigenous knowledge systems into adaptation strategies to leverage local insights, thereby enhancing resilience and effectiveness in addressing climate challenges.

India also needs to build capacity in various sectors that includes climate science and impact research, advanced analytical skills, enhanced legal and regulatory expertise, public engagement and communication, technological adaptation and innovation, financial management and fundraising, multi-sectoral coordination, and leadership and strategic management.

Efficient, sustainable and iterative capacity building techniques can help create an enabling environment to effectively mitigate and adapt to climate extremes. India by means of the preceding three biennial update reports has extensively detailed out the constraints, gaps and needs such as the issues faced in estimating and reporting GHG inventories, estimating carbon stocks, non-availability, accessibility and consistency of relevant data. However, developed countries have been unsuccessful in providing ample and required capacity building support to the developing country parties such as India.

# 7. Additional Information

This chapter includes initiatives, including case studies, to promote clean and renewable energy, sustainable transport, energy efficiency, and allied efforts to achieve NDC targets and the net zero commitment.

The Government of India has taken several steps and initiatives to promote and accelerate renewable energy capacity and applications in different sectors in the country, inter-alia, including permitting Foreign Direct Investment (FDI) in renewable energy up to 100% under the automatic route; waiver of Inter-State Transmission System (ISTS) charges for inter-state sale of solar and wind power; the Viability Gap Funding (VGF) scheme for offshore wind energy projects; declaration of trajectory for Renewable Purchase Obligation (RPO); revised scheme for Flexibility in Generation and Scheduling of Thermal/ Hydro Power through bundling with RE & Storage Power; setting up of Ultra Mega Renewable Energy Parks for installation of RE projects at large scale; "Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan" (PM-KUSUM), Solar Rooftop Phase II, scheme; laying of new transmission lines under the Green Energy Corridor Scheme for evacuation of renewable power; VGF scheme for the development of 4,000 MWh of BESS projects; notification of standards for deployment of solar photovoltaic systems/devices; PM Electric Drive Revolution in Innovative Vehicle Enhancement (PM E-DRIVE) to promote the faster adoption of electric vehicles (EVs), the establishment of charging infrastructure, and the development of an EV manufacturing ecosystem in the country.

In February 2024, PM Surya Ghar: Muft Bijli Yojana was launched to transform the country's energy landscape by harnessing solar energy. As of 4$^{th}$ November 2024, the initiative has received 1.42 crore registrations and 23.79 lakh applications. A total of 5.56 lakh installations have been completed. The initiative also seeks to establish a model solar village per district throughout the country, which can aid and empower village communities to achieve energy self-reliance.

The initiative of "Galvanising Organic Bio-Agro Resources Dhan" (GOBARdhan) seeks to convert biodegradable/organic waste into biogas, compressed biogas (CBG), and organic manure. In June 2023, a one-stop repository to assess investments under this initiative was launched. During the financial year of 2023-24, 198 plants were set up across the country, including 12 compressed biogas plants and 186 biogas plants.

Sustainable transport initiatives such as the National E-Bus Programme, State EV Accelerator Programme, Shoonya—Zero Pollution Delivery Campaign, E-Amrit Portal, Production Linked Incentive (PLI) Scheme, E-Fast India, Decarbonisation of the Aviation Sector, and Energy Efficiency at Airports have been taken up.

The Government of India launched the National Green Hydrogen Mission in January 2023, recognizing the critical role of green hydrogen in low-carbon and self-reliant economic pathways. The Mission seeks to build capabilities to produce at least 5 million Metric Tonnes (MMT) of green hydrogen per annum by 2030.

Several new initiatives in weather and climate services have emerged, including the Atmospheric Research Testbed (ART) Facility in Central India, an extended-range drought monitoring system, and the National Framework of Climate Services.

India has taken several initiatives in international cooperation, such as the International Solar Alliance, One Sun, One World, One Grid; LeadIT 2.0 (in collaboration with Sweden); Coalition for Disaster Resilient Infrastructure; Global Biofuel Alliance; Mission LiFE—Lifestyle for Environment, International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE), Global Mangrove Alliance (GMA), Mission Innovation.

Further, India has taken several domestic initiatives, such as the Green Credits Programme, Ecomark Programme, PM Programme for Restoration, Awareness Generation, Nourishment and Amelioration of Mother Earth (PM—PRANAM), etc.

This BUR shows that India is not only going above and beyond its fair share of the mitigation burden but is also emerging as the front-runner in fair climate action.

# Background Information and Institutional Arrangements

## Background

Ministry of Environment, Forest and Climate Change (MoEFCC) is the Nodal Ministry in the Government of India dealing with collection and collation of information related to climate change-related programmes, actions and reporting information under Article 4.1 of the United Nations Framework Convention on Climate Change (UNFCCC). According to the Article, all Parties, considering their common but differentiated responsibilities and their specific national and regional development priorities, objectives and circumstances, shall develop, periodically update, publish and make available to the Conference of the Parties (COPs), the information following Article 12 of the Convention and decisions of the COPs and related guidelines. Accordingly, Parties communicate information on national inventories of greenhouse gases (GHGs) not controlled by the Montreal Protocol, steps taken or envisaged for implementing the decisions taken under the Convention and any other information that the Party considers relevant for the achievement of the objective of the Convention and suitable for inclusion in its communication. As per decision 2/CP.17 of the COPs to the United Nations Framework Convention on Climate Change (UNFCCC) titled "Outcome of the work of the Ad Hoc Working Group on Long-term Cooperative Action under the Convention", Non-Annex I Parties are required to submit a Biennial Update Report (BUR) every two years, either as a summary of parts of their national communication in the year or as a stand-alone update report. Accordingly, this is the fourth and last BUR submitted by India containing national GHG inventory of 2020 (i.e. pre Paris Agreement implementation phase) before the submission of the first Biennial Transparency Report (BTR-1).

BUR-4 provides updated insights into India's National Circumstances and the National GHG Inventory for 2020. It also covers Mitigation Actions, Financial, Technology, and Capacity Building requirements, as well as Domestic Monitoring, Review, and Verification (MRV) mechanisms. Additionally, BUR-4 addresses recommendations from the International Consultation and Analysis (ICA) process of BUR-1, BUR-2, and BUR-3, where applicable and feasible, to strengthen the transparency of mitigation actions and their impacts.

## Institutional Arrangements

The Ministry of Environment, Forests and Climate Change (MoEFCC), Government of India (GoI), is the executing and implementing agency for preparation of National Communications (NCs). 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 including BURs and BTRs. 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, and 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 IA1 and 1A2 depicts the implementation arrangement and responsibilities of various committees/institutes for BUR-4 preparation.

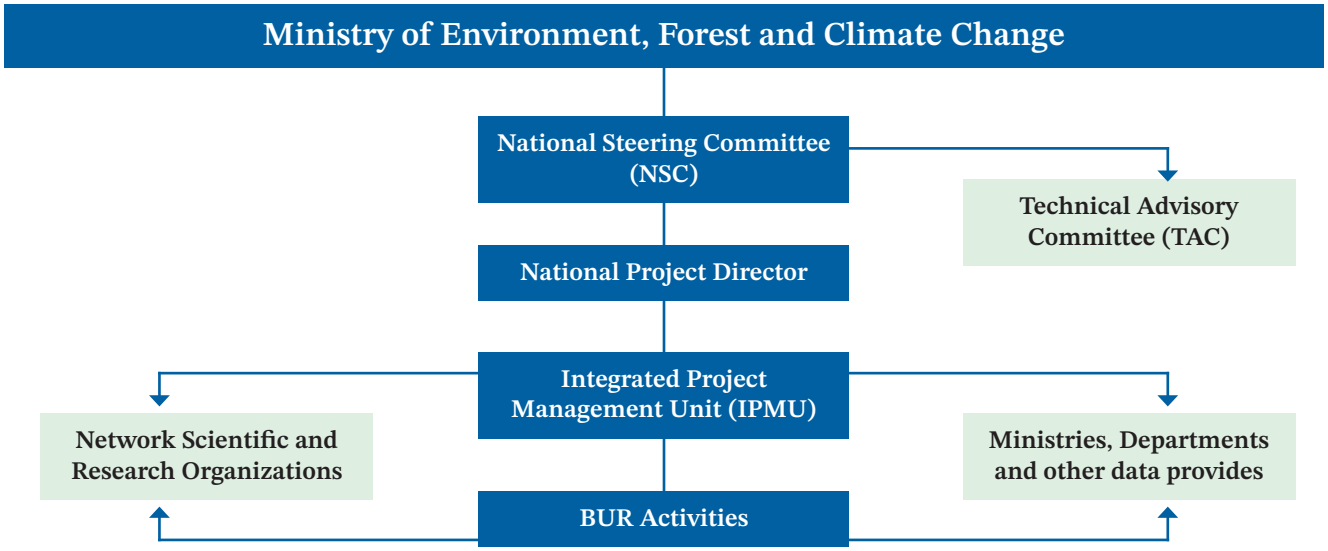



*Figure IA1: Implementation Arrangement for the Fourth Biennial Update Report*

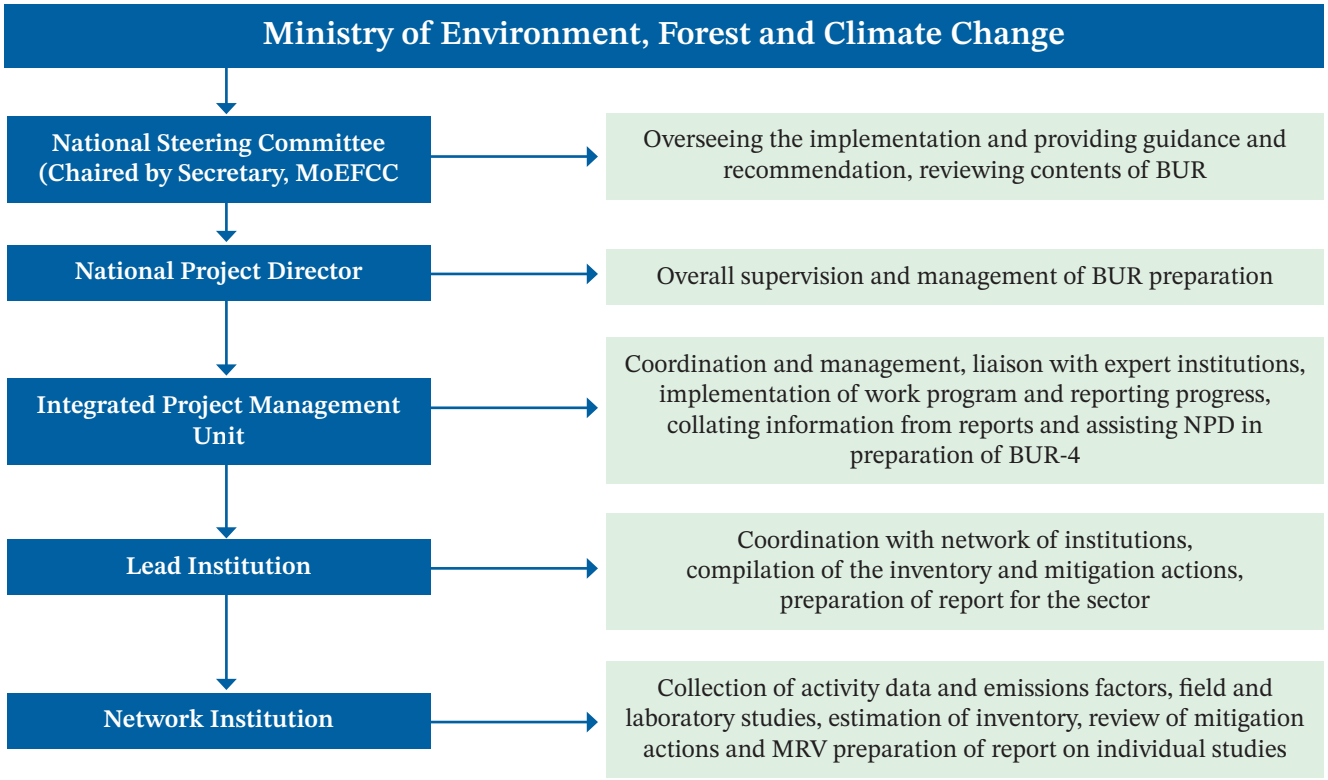



*Figure IA2: Key functions of various units pertaining to BUR-4 preparation*

For the preparation of the 4th Biennial Update Report, GoI has taken steps and made efforts towards creating a sustainable institutional structure. Preparation of the BUR-4 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. 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 BUR-4. 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 IA1).

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 found practical to have a Technical Advisory Committee (TAC) (refer to table IA1) to provide technical guidance to the preparation of BUR-4. This committee has members from the Government, Academia and Society.

***Table IA1: Composition of National Steering Committee and Technical Advisory Committee***

| Composition of National Steering Committee (NSC) | | Composition of Technical Advisory Committee (TAC) | |
|---|---|---|---|
| **SN** | **Designation** | **SN** | **Designation** |
| **Chairman** | | | |
| 1 | Secretary, Ministry of Environment, Forest and Climate Change (MoEFCC) | 1 | Special/Additional Secretary (In Charge: NATCOM matters), Ministry of Environment, Forest and Climate Change (MoEFCC) |
| **Members** | | | |
| 2 | Special Secretary, Ministry of Environment, Forest and Climate Change (MoEFCC) | 2 | Advisor, National Institution for Transforming India (NITI) Aayog |
| 3 | Chief Executive Officer (CEO), National Institution for Transforming India (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 Scientist G, Ministry of Earth Sciences (MoES) |
| 5 | Secretary, Department of Agriculture Co-operation and Farmers Welfare (DACFW), Ministry of Agriculture and Farmers Welfare or his representative (MoAFW) | 5 | Representative of Indian Council of Agricultural Research (ICAR) |
| 6 | Secretary, Department of Economic Affairs (DEA), Ministry of Finance (MoF) | 6 | Representative of Department of Science and Technology (DST) |
| 7 | Secretary, Ministry of New and Renewable Energy (MNRE) | 7 | Representative of Council of Scientific and Industrial Research (CSIR) |
| 8 | Secretary, Department of Science & Technology (DST) | 8 | Representative of Ministry of New and Renewable Energy (MNRE) |
| 9 | Secretary, Ministry of Coal (MoC) | 9 | Representative of Forest Survey of India (FSI) |
| 10 | Secretary, Ministry of Power (MoP) | 10 | Representative of Central Electricity Authority (CEA) |
| 11 | Chairman, Railway Board, Indian Railways | 11 | Representative of Directorate of Health Services |
| 12 | Secretary, Ministry of Road Transport & Highways (MoRTH) | 12 | Representative of Director General, The Energy and Resources Institute (TERI) |
| 13 | Secretary, Ministry of Ports, Shipping and Waterways (MOPSW) | 13 | Dr. Kirit Parikh, Chairman, Integrated Research and Action for Development (IRADe), New Delhi |

| Composition of National Steering Committee (NSC) | | Composition of Technical Advisory Committee (TAC) | |
|---|---|---|---|
| **SN** | **Designation** | **SN** | **Designation** |
| 14 | Secretary, Ministry of Petroleum & Natural Gas (MoPNG) | 14 | Dr. L. S. Rathore, Former Director General (DG), Indian Meteorological Department |
| 15 | Secretary, Department of Water Resources, River Development and Ganga Rejuvenation (DoWR, RD & GR) | 15 | Prof. K. S. Kavi Kumar, Madras School of Economics (MSE) |
| 16 | Secretary, Ministry of Health & Family Welfare (MoHFW) | 16 | Prof. A. K. Gosain, Indian Institute of Technology (IIT) Delhi |
| 17 | Secretary, Ministry of Earth Sciences (MoES) | 17 | Prof. N. H. Ravindranath, Indian Institute of Science (IISc) |
| 18 | Secretary, Department of Rural Development(DoRD) | 18 | Dr. R. Srikanth, National Institute of Advanced Studies (NIAS) |
| 19 | Secretary, Ministry of Housing and Urban Affairs (MoHUA) | 19 | Prof. Raman Sukumar, Indian Institute of Science (IISc) |
| 20 | Secretary, Department of Industrial Policy & Promotion (DIPP), Ministry of Commerce and Industry (MoCI) | 20 | Prof. Amit Garg, Indian Institute of Management (IIM) Ahmedabad |
| 21 | Secretary, Ministry of Steel (MoS) | 21 | Prof. Anamika Barua, Indian Institute of Technology(IIT) Guwahati |
| 22 | Secretary, Ministry of Civil Aviation (MoCA) | 22 | Prof. T. Jayaraman, M.S. Swaminathan Research Foundation (MSSRF) |
| 23 | Secretary, Ministry of Statistics and Programme Implementation (MoSPI) | 23 | Dr. Sumana Bhattacharya, National Institute of Advanced Studies (NIAS) |
| 24 | Director General, India Meteorological Department (IMD) | 24 | Dr. Tejal Kanitkar, National Institute of Advanced Studies (NIAS) |
| 25 | Joint Secretary, Ministry of External Affairs (MEA) | 25 | Joint Secretary, Ministry of Environment, Forest and Climate Change (MoEFCC) |
| 26 | Representative, United Nations Development Programme(UNDP), India-Office, New Delhi | 26 | Member Secretary, Scientist 'G'(NATCOM Cell), Ministry of Environment, Forest and Climate Change (MoEFCC) |
| 27 | Joint Secretary (Climate Change), Ministry of Environment, Forest & Climate Change (MoEFCC) | | |
| 28 | Scientist 'G' NATCOM Cell, Ministry of Environment, Forest & Climate Change (MOEFCC) | | |

This report encompasses information on India's National Circumstances, National GHG Inventory for 2020, Mitigation Actions, Financial, Technology and Capacity Building needs, Domestic Monitoring, Review and Verification (MRV), and some additional information. Several studies were launched to accommodate the requisites of the BUR-4. 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 BUR (Figure IA3).

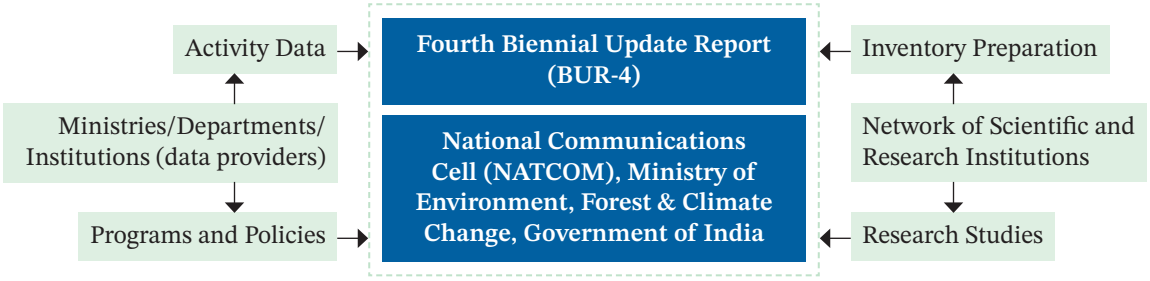



*Figure IA3: Institutional Arrangements for BUR-4*

***Table IA2: Data providers (ministries / departments / institutions / organisations) for the preparation of BUR-4***

| [1]Ministries/Departments of Government of India | Institutions/organisations |
|---|---|
| Ministry of Agriculture and Farmers Welfare (MoAFW) | All India Glass Manufacturers' Federation (AIGMF) |
| Ministry of Chemicals and Fertilizers (MoCF) | Bureau of Energy Efficiency (BEE), New Delhi |
| Ministry of Civil Aviation (MoCA) | Central Electricity Authority (CEA), New Delhi |
| Ministry of Coal (MoC) | Cement Corporation of India Limited (CCI), New Delhi |
| Ministry of Commerce and Industries (MoCI) | Cement Manufacturers Association (CMA), New Delhi |
| Ministry of Earth Sciences (MoES) | Central Public Health and Environmental Engineering Organisation (CPHEEO), New Delhi |
| Ministry of Fisheries, Animal Husbandry and Dairying (MoFAHD) | Coal Controller Organisation (CCO), Delhi |
| Ministry of Food Processing Industries (MoFPI) | Council of Scientific and Industrial Research (CSIR) |
| Ministry of Health and Family Welfare (MoHFW) | Central Pollution Control Board (CPCB), New Delhi |
| Ministry of Housing and Urban Affairs(MoHUA) | Directorate of Health Services (DHS) |
| Ministry of Jal Shakti (MoJS) | Directorate General Of Mines Safety (DGMS), Dhanbad |
| Ministry of Micro, Small & Medium Enterprises (MSME) | Fertiliser Association of India (FAI), Delhi |
| Ministry of Mines (MoM) | Indian Bureau of Mines (IBM), Nagpur |
| Ministry of New and Renewable Energy(MNRE) | Indian Council of Medical Research (ICMR), New Delhi |
| Ministry of Petroleum and Natural Gas (MOP&NG) | Indian Farmers Fertilizer Cooperative Limited (IFFCO), New Delhi |
| Ministry of Power(MoP) | Indian Institute of Forest Management (IIFM), Bhopal |
| Ministry of Railways(MoR) | India Meteorological Department (IMD) |
| Ministry of Road Transport and Highways (MoRTH) | Indian Space Research Organization (ISRO) |
| Ministry of Science and Technology (MoST) | Mahalanobis National Crop Forecast Centre (MNCFC), New Delhi |

| [1]Ministries/Departments of Government of India | Institutions/organisations |
|---|---|
| Ministry of Statistics and Programme Implementation(MoSPI) | National Institute of Solar Energy (NISE) |
| Ministry of Steel (MoS) | National Institution for Transforming India Aayog (NITI-Aayog) |
| Department for Promotion of Industry and Internal Trade (DPIIT) | Petroleum Planning and Analysis Cell(PPAC) |
| Department of Agricultural Research and Education (DARE), Ministry of Agriculture and Farmers Welfare (MoAFW) | Refrigeration and Airconditioning Manufacturers Association (RAMA) |
| Department of Agricultural Research and Education (DARE) | Society of Indian Automobile Manufacturers (SIAM) |
| Department of Economic Affairs (DEA) | Space Application Centre(SAC) |
| Department of Heavy Industry(DoHI) | |
| Department of Rural Development (DoRD) | |
| Department of Science and Technology (DST) | |
| Department of Space (DoS) | |
| Department of Water Resources, River Development and Ganga Rejuvenation (DoWR, RD & GR) | |

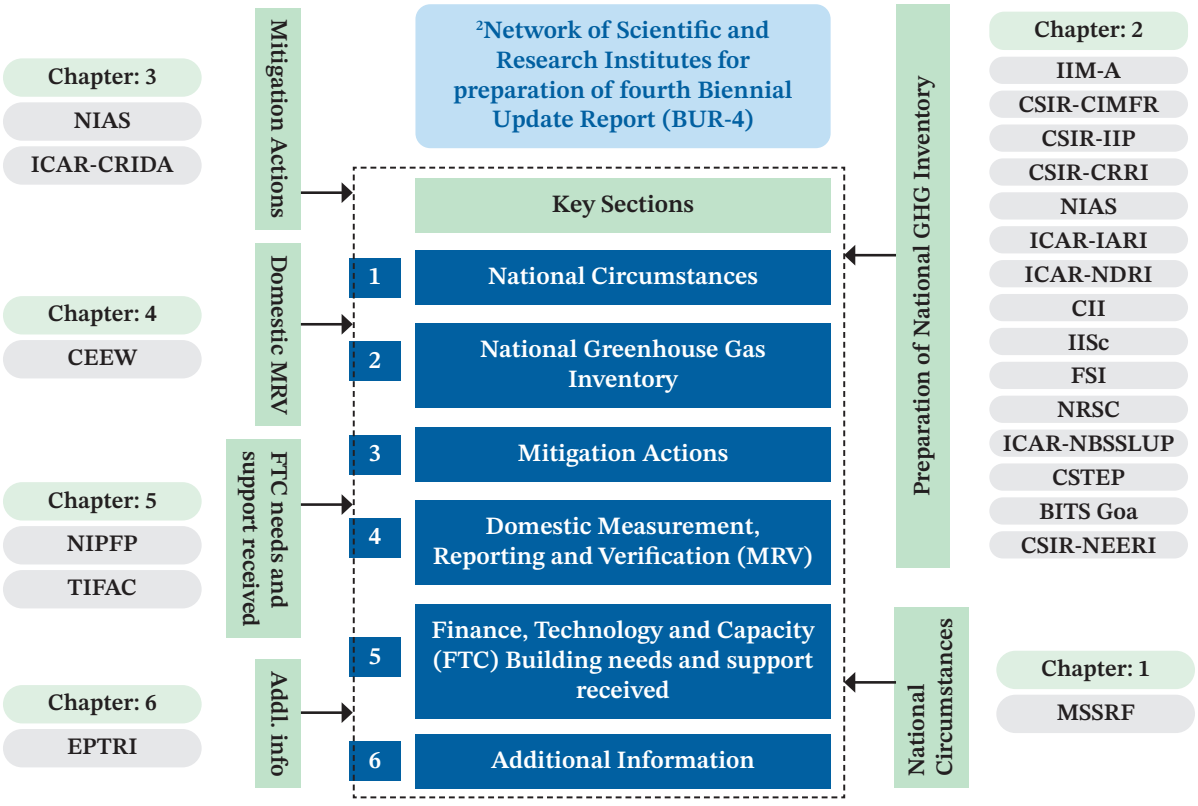



*Figure IA4: Network of scientific and research institutes for preparation of BUR-4*

***Table IA3: Network of scientific and research institutes for preparation of BUR-4***

| [2]Network of Scientific and Research Institutions | |
|---|---|
| IIM-A: Indian Institute of Management, Ahmedabad | ICAR-IARI: Indian Council of Agricultural Research -Indian Agricultural Research Institute, New Delhi |
| BITS Goa: Birla Institute of Technology and Science, Goa | CSIR-IIP: Council of Scientific and Industrial Research -Indian Institute of Petroleum, Dehradun |
| CSTEP: Center for Study of Science, Technology and Policy, Bengaluru | ICAR-NBSSLUP: Indian Council of Agricultural Research -National Bureau of Soil Survey & Land Use Planning, Nagpur |
| CII: Confederation of Indian Industry | ICAR-NDRI: Indian Council of Agricultural Research-National Dairy Research Institute, Karnal |
| CSIR-CIMFR: Council of Scientific and Industrial Research-Central Institute of Mining and Fuel Research, Dhanbad | IISc: Indian Institute of Science, Bengaluru |
| CSIR-CRRI: Council of Scientific and Industrial Research-Central Road Research Institute, New Delhi | MSSRF: MS Swaminathan Research Foundation, Chennai |
| CSIR-NEERI: Council of Scientific and Industrial Research- National Environmental Engineering Research Institute | NIAS: National Institute of Advanced Studies, Bengaluru |
| CEEW: Council on Energy, Environment and Water, New Delhi | NIPFP: National Institute of Public Finance and Policy, New Delhi |
| EPTRI: Environment Protection Training & Research Institute, Hyderabad | NRSC: National Remote Sensing Centre, Hyderabad |
| FSI: Forest Survey of India, Dehradun | TIFAC: Technology Information, Forecasting and Assessment Council, New Delhi |
| ICAR-CRIDA: Indian Council of Agricultural Research -Central Research Institute of Dryland Agriculture, Hyderabad | |

# Institutional Network

The Ministry of Environment, Forests 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 BUR-4. Many independent experts and think tanks also provided their inputs, comments and feedback for preparation of BUR-4.

Quality Assurance and Quality Control (QA/QC) and uncertainty analysis are performed at appropriate stages, including at the time of data collection and inventory preparation by the concerned institutions. The expert institutions, relevant Ministries and NGOs together have supported the preparation of BUR-4. These coordinating institutions and supporting network institutions are in the process of developing the required technical capacity, especially for the GHG inventory preparation, which India envisages as a continuous process. India is currently in the process of developing a National Inventory Management System (NIMS) that will coordinate consistently with the data providers and supporting institutions with adequate capacity for the preparation of National Communications and Biennial Transparency Reports (BTRs) on a continuous basis. Formalizing such an institutional arrangement requires financial, technological and capacity-building support from international institutions and Annex-I Parties on a continuous basis.

## Trans Himalayan Landscape

Photo Credit: GB Pant National Institute of Himalayan Environment

# Chapter-1:
# National Circumstances

## 1.1 Introduction

India is the world's most populous country and the fifth-largest economy, with one of the highest rates of economic growth. As India's Prime Minister, Shri Narendra Modi, noted in his address to the United Nations General Assembly on September 25, 2021: "Today, every sixth person in the world is an Indian. When Indians progress, the development of the world also gets a boost.When India grows, the world grows. When India reforms, the world transforms." While its contribution to global warming has been minimal relative to its demographic and geographical scale and ranks far below the global average, it is nevertheless committed to meeting this uniquely global challenge on the basis of its national efforts and international cooperation, founded on the multilateral framework of the United Nations Framework Convention on Climate Change (UNFCCC).

This first chapter of India's Fourth Biennial Update Report is on India's national circumstances. It is divided into eight sections, providing a broad overview of the country's current climate and socio-economic circumstances. It also includes a description of initiatives undertaken at various levels of government to address the challenge of global warming while furthering its own development agenda.

Section 2 of this chapter provides an overview of weather and climatic patterns, including special attention to the case of extreme events. Section 3 briefly outlines the key features of India's demographic and socio-economic circumstances. Section 4 underscores broader changes in land use and land use change patterns over the years. Section 5 looks at India's Energy Profile while Section 6 covers Sustainable development, Urbanization and broader Socio-economic transition. Section 7 describes the current policy measures undertaken to address questions of sustainability about transport and sustainability. Section 8 provides a brief overview of India's climate actions including; NAPCC, NDC, LT-LEDS.

## 1.2 Overview: Geographic and climatic parameters

The mainland of India extends between 66°E to 98°E and 8°N to 36°N. With a total land area of over 3.2 million square kilometers. The country also borders Pakistan, Bhutan, Bangladesh, Nepal, China and Myanmar. India is the seventh-largest country (approximately 2.3% of the world's land area). 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 extremes of heat to extremes of cold, 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 southern or peninsular India. Hence, the climate of coastal regions of India is equable or maritime. The Himalayan and adjoining mountain ranges extend from Kashmir in the Northwest to Arunachal Pradesh in the Northeast. These mountain ranges protect India from Central Asia's extremely cold and dry winds 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, with severe summer heat that alternates with extremely cold winters, while coastal climatic conditions are found in the Southeast and western regions. There is moderate precipitation and temperature across some parts of the country. The months of

June, July, August, and September constitute the core of the southwest monsoon season in most parts of the country, but the actual period of the monsoon in different regions of the country depends on the onset and withdrawal dates. The southwest monsoon season is the principal rainy season of the country. The monsoon approaches with moisture-laden winds, and this sudden approach is marked by violent thunderstorms and lightning. The heavy rainfall during the season brings floods to many parts of the country. 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. India's climate is significantly influenced by the presence of the Himalayas and the Thar Desert. The Himalayas act as a barrier to atmospheric circulation for both the summer monsoon and the winter westerlies.

## 1.2.1 Precipitation

Nearly 75% of the country's annual rainfall is received during the southwest monsoon season with a large spatial variability in its distribution. The Indian monsoon is one of the most prominent parts of the world's monsoon systems, which blows from the northeast during cooler months and reverses direction to blow from the southwest during the warmest months of the year. This process brings significant rainfall to the region from June to September, the principal rainy season. Overall, there is a huge inter-annual variability in its onset and withdrawal dates over different parts of the country. Rainfall distribution and intensity have a significant impact on various sectors, especially agriculture and water beside their impact on other ecosystems.

The all-India normal annual rainfall is 1160.1 mm, as per data from 1971-2020. The amount of rainfall 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. On the west of the line, joining Porbandar to Delhi and then to Ferozepur in Punjab, the rainfall reduces rapidly from 500 mm to less than 150 mm in the extreme west.

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 contributes 74.0% to the annual rainfall. June, July, August, and September receive 19.1%, 32.3%, 29.4%, and 19.3%, respectively, of the total southwest monsoon seasonal rainfall. The pre-monsoon (March-May) rainfall (130.6 mm) and post-monsoon season (October-December) rainfall (121.0 mm) contribute about 11% and 10% to the annual rainfall over India. The winter (January-February) rainfall (39.8 mm) contributes about 3.4% to the annual rainfall over India. The rainfall during northeast monsoon varies from 209.6 to 480.7 mm in the states of the southern peninsula, namely Tamil Nadu, Kerala, Karnataka, and parts of Andhra Pradesh. For these states, the rainfall received during northeast monsoon season (post-monsoon season) contributes 30% 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 1901-2023 and has shown a weak decreasing trend during the recent few decades (Fig 1.1).

However, the state-wise reports from the IMD on observed rainfall trends and variability based on recent 30 years of data (1989-2018) (Guhathakurta et al., 2020) indicate that Uttar Pradesh, Bihar, West Bengal, Meghalaya, and Nagaland have shown significant decreasing trends in southwest monsoon rainfall. Other states do not show any significant changes in monsoon rainfall. All these five states along with two more states viz. Arunachal Pradesh and Himachal Pradesh have also shown significant decreasing trends in annual rainfall. More variability is observed in district-wise rainfall trends for southwest monsoon rainfall and annual rainfall (Fig. 1.2) during the period 1901-2022.

The long-period (1971-2020) average (LPA) rainfall over the country during the monsoon season is 868.6 mm, and the annual average is 1160 mm. The annual rainfall during 2022 was 108% of LPA, while the SW monsoon season rainfall was 106% of LPA. The annual rainfall during 2023 was 95% of LPA. During the 2023 SW monsoon season, rainfall over the country was normal (94.4% of LPA).

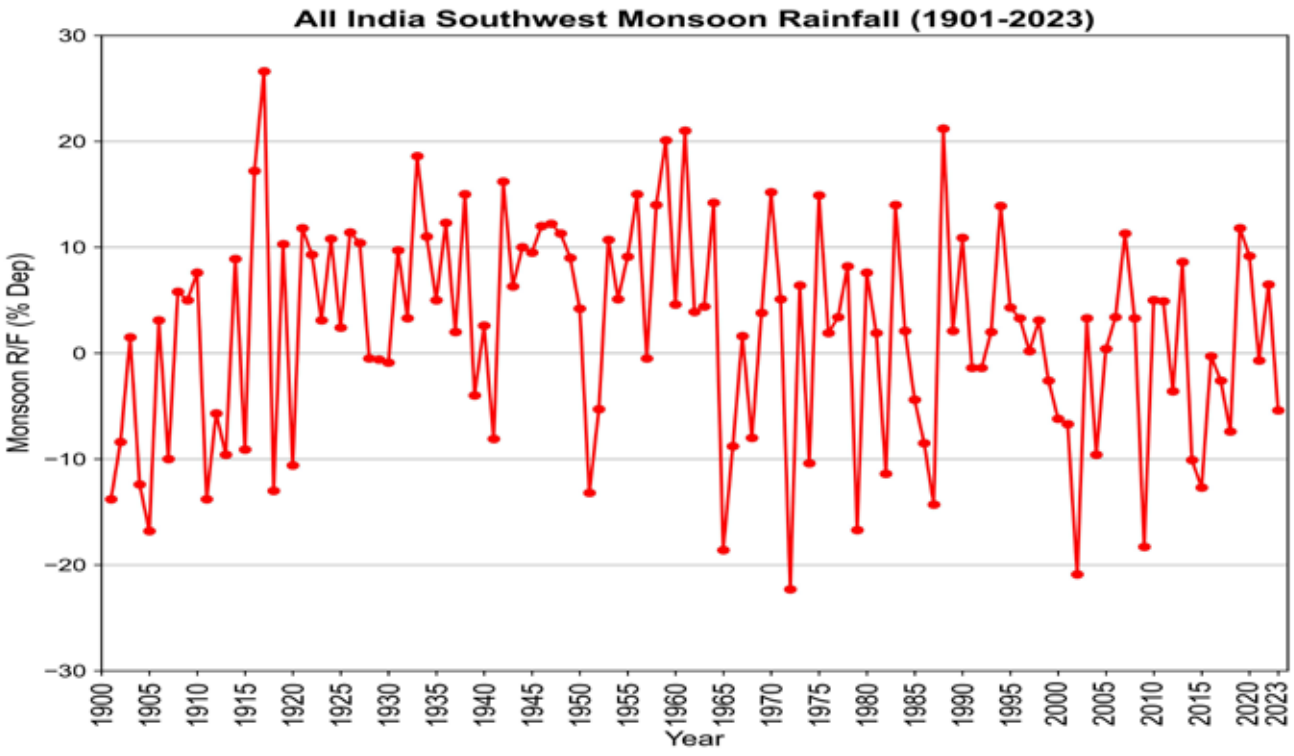



*Fig. 1.1: Percentage departure of area-weighted average monsoon season rainfall over India as a whole (1901-2023)*

*Source: IMD*

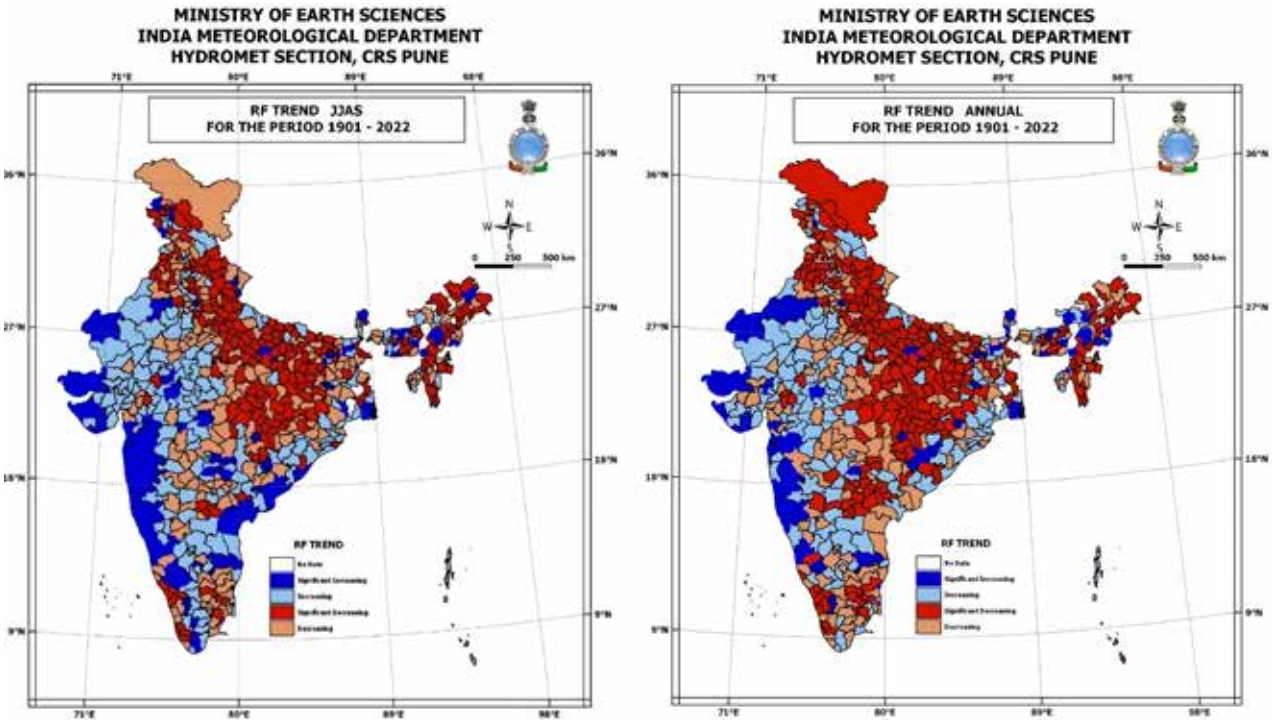



*Fig. 1.2: Trend in district rainfall during (a) monsoon season (JJAS) and (b) annual for the period 1901-2022.*

*Source: IMD*

During the monsoon season 2022, rainfall was 122% of LPA over the south peninsula, 119% of LPA over Central India, 101% of LPA over Northwest India, and 82% of LPA over east and northeast India. The 2022 northeast monsoon season (October-December) rainfall over the country was 119 % of its LPA. During 2022, northeast monsoon rainfall activity over the core region of South Peninsular India (comprising of 5 subdivisions viz. Coastal Andhra Pradesh, Rayalaseema, Tamil Nadu and Puducherry, South Interior Karnataka, and Kerala) during the season as a whole was 110% of Long Period Average (LPA).

During the monsoon season of 2023, rainfall was 101% LPA over Northwest India, 100% LPA over Central India, 92% LPA over the southern peninsula, and 82% LPA over east and northeast India. The 2023 northeast monsoon season rainfall over the country was 91% of LPA. The seasonal rainfall during the northeast monsoon 2023 over the core region of the south peninsula (comprising of 5 subdivisions viz. Coastal Andhra Pradesh, Rayalaseema, Tamil Nadu and Puducherry, South Interior Karnataka and Kerala), was 94% of LPA.

## 1.2.2 Temperature variation over India

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.

Temperature variations are even more pronounced in mountainous regions such as the Western Ghats in the south and the Himalayas in the north. March to May is usually a period of continuous and rapid rise of temperature. The highest temperature occurs in central and northern India, particularly in the desert regions of the north-west where the maximum may exceed 48°C for a considerable time duration often causing heat wave conditions. With onset and advancement of the southwest monsoon in June, there is a rapid fall in the maximum temperature in central India. The temperature stays uniform in the areas covering two-thirds of the country that receive a good amount of rainfall. The temperature falls in September when the monsoon retreats from northern India. Temperatures fall below freezing point during winter in the extreme northern parts of the country.

The year 2023 was second warmest year on record since 1901 with annual mean surface air temperature +0.65°C above the 1981-2010 period average. The five warmest years on record in descending order were 2016 (+0.71°C), 2023(+0.65°C), 2009 (+0.55°C), 2017 (+0.541°C) and2010 (+0.539°C). It may be mentioned that 12out of 15 warmest years were recorded during the recent past fifteen years (2009-2023). Past decades (2013-2022/ 2014-2023) were also the warmest decades on record with anomalies of +0.41°C/ +0.46°C. The annual mean temperature during 1901-2023 showed a significant increasing trend of 0.66°C/100 years (Figure-1.3) with significant increasing trend in maximum temperature (1.01°C/100 years) and an increasing trend (0.31°C/100 years) in minimum temperature.

The country averaged seasonal mean temperatures was also above average during the three seasons, with the winter (January to February), monsoon (June to September), and post-monsoon (October to December) seasons recording anomalies of +0.83°C, +0.74°C, +1.0°C respectively. However, the pre-monsoon (March to May) seasonal mean temperature was normal, with a recorded anomaly of +0.06°C. The country averaged mean monthly temperatures were warmer than normal during all the months of the year except two months (April and May). Among the 12 months, the highest country averaged monthly mean temperatures were recorded in August (0.90°C, warmest since 1901), September (0.91°C, warmest since 1901), November (1.05°C, warmest since 1901), December (1.11°C, warmest since 1901) and February (1.36°C, second warmest since 1901).

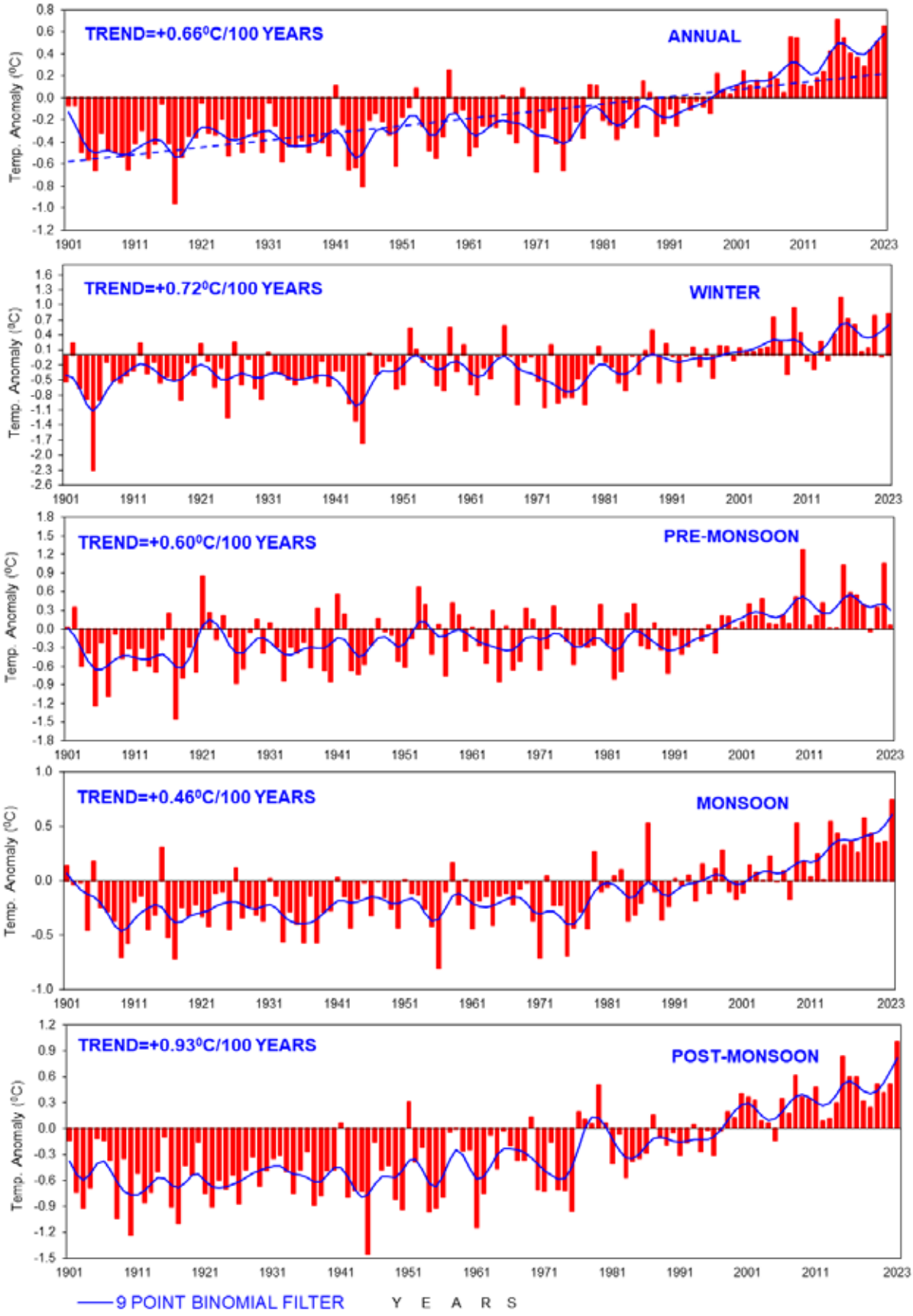



*Figure-1.3: All India mean temperature anomalies: (A) Annual (B) Winter (C) Pre-monsoon (D) Monsoon and (E) Post-monsoon for the period 1901-2023.*

*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 the 1981-2010 average).

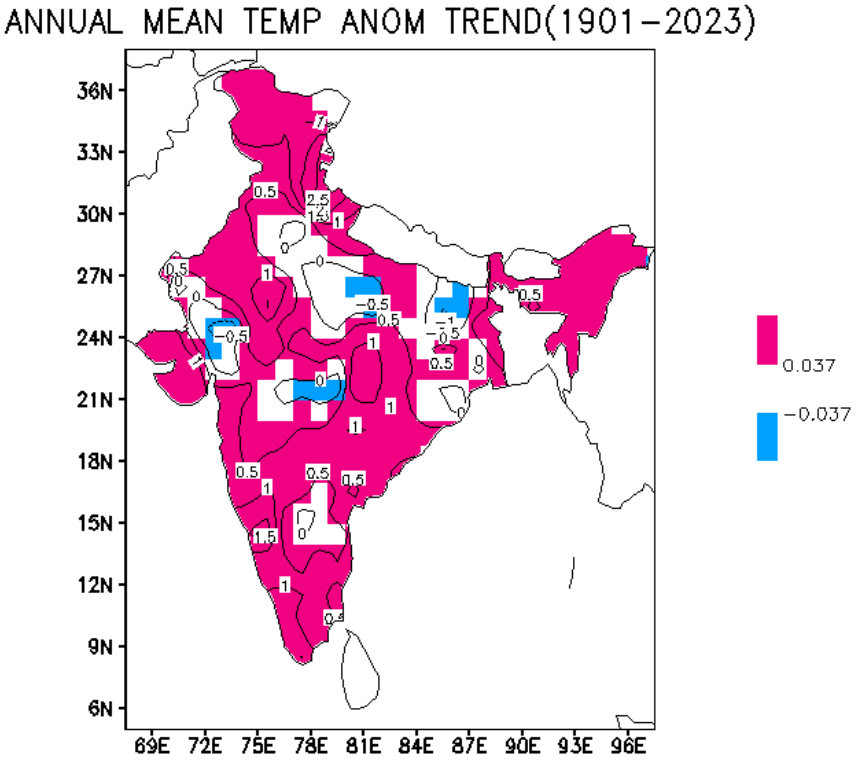



*Figure-1.4: Annual mean temperature anomaly trends (°C/100 years) 1901–2023. (Departure from 1981-2010 average)*

*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.**

On a seasonal scale, the highest increasing trend in the mean temperature was observed in the post-monsoon and winter seasons. Further, the trend of maximum temperature is higher than the minimum temperatures since 1901. Spatial warming trends (Figure-1.4) obtained from mean annual temperature anomalies based on the data for the period 1901-2023 suggest significant positive (increasing) trend over most parts of the country except in parts of some states that include Bihar, Uttar Pradesh, Maharashtra and Gujarat, where significant decreasing trend was observed.

## 1.2.3 Extreme weather events

Variations in rainfall, cyclones, heat waves, and cold waves are the main extreme weather events affecting different regions of India.

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 0.25ox0.25o gridded data, found that during the 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 on 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 $\leq$ 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. In contrast, significant decreasing trends are seen over Uttar Pradesh, Bihar, Jharkhand, Punjab and northeastern parts of the country during the southwest monsoon season.

Figure 1.5 gives the decadal variability of annual frequencies of rainfall events of different intensities. The decades 1981-90, 1991-2000 and 2001-2010 were having 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 are crucial for agriculture and other applications have been decreased in the recent few decades.


*Figure-1.5: Decadal variability of annual frequencies of different rainfall events over India.*

*Source: IMD*

The synoptic scale systems, including low-pressure areas and cyclonic disturbances (depressions and cyclones) that form over the northern Indian Ocean and particularly over the Bay of Bengal during the southwest monsoon season, contribute significantly to the southwest monsoon rainfall over India. As shown in Figure-1.6(a), the significant decreasing trend (at 99% confidence level) of the frequency of cyclonic disturbances during monsoon season is noticed during the last 72 years from 1951 to 2023 over the Indian region. During the post-monsoon season, from October to December, tropical cyclones are more frequent. Figure 1.6(b) shows the decreasing trend in the frequency of cyclonic storms over the north Indian Ocean during the post-monsoon season from October to December, which is significant at a 95% confidence level. Based on the statistics during 1891-2023, on average, 5 cyclones developed over the north Indian Ocean (NIO), [the Bay of Bengal and Arabian Sea together] in a year, with 4 developing over the Bay of Bengal (BoB) and 1 over the Arabian Sea (AS). A decreasing trend observed in the total number of Cyclonic Disturbances (CDs – Cyclonic Storms and depressions put together) during the period 1951 – 2023 as shown in Figure 1.6.

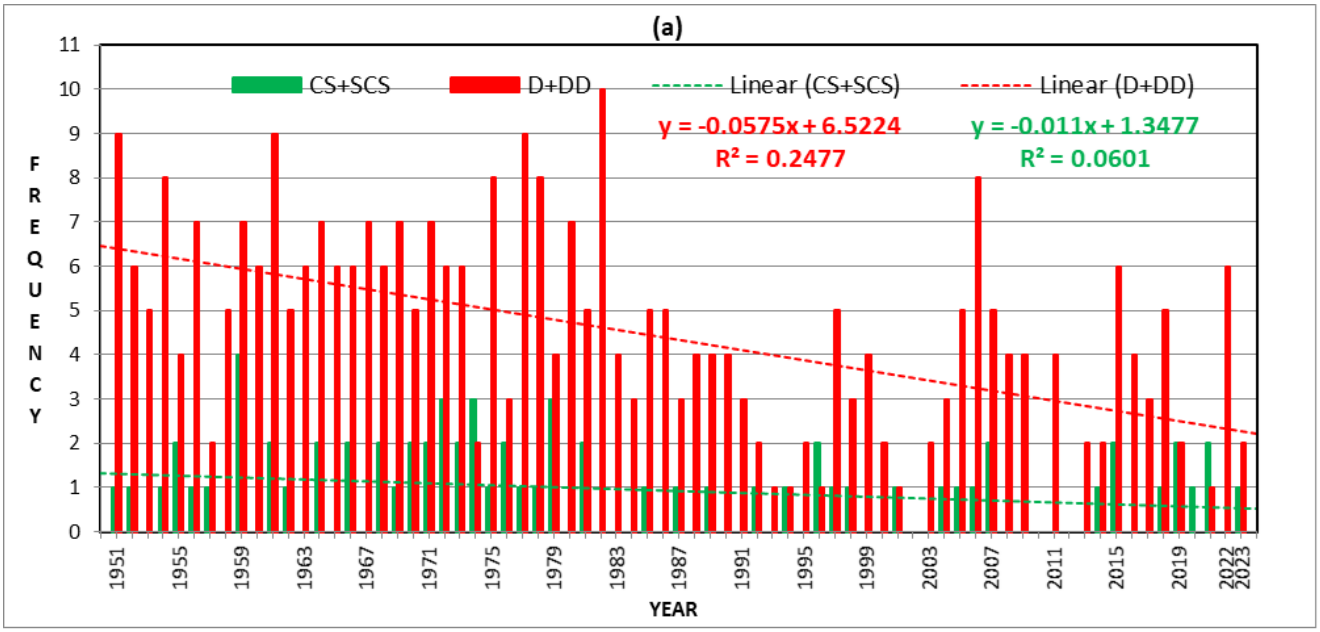



*Figure-1.6: Frequency of depressions and cyclonic storms formed over the northern Indian Ocean during (a) monsoon season and (b) post-monsoon season (1951-2023)*

*Source: IMD e-atlas.*

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

During 2022, three cyclonic storms formed over the north Indian Ocean. These include Severe Cyclonic Storm ASANI, Severe Cyclonic Storm MANDOUS, and Cyclonic Storm SITRANG. All three cyclones formed over the Bay of Bengal, while the Arabian Sea was devoid of any cyclonic storms. Of these, the Severe Cyclonic Storm MANDOUS (6 December to 10 December), formed in the post-monsoon season over the Bay of Bengal, crossed north Tamil Nadu, Puducherry and adjoining south Andhra Pradesh coasts between Puducherry and Sriharikota, close to Mamallapuram (Mahabalipuram) on 9$^{th}$ December as a cyclonic storm and claimed six lives from Andhra Pradesh, Tamil Nadu and Puducherry.

In 2023, six cyclonic storms formed over the North Indian Ocean. These include the Extremely Severe Cyclonic Storm MOCHA, Extremely Severe Cyclonic Storm BIPARJOY, Extremely Severe Cyclonic Storm TEJ, Very Severe Cyclonic Storm HAMOON, and Severe Cyclonic Storm MICHAUNG and MIDHILI. Of these, four cyclones, MOCHA, HAMOON, MIDHILI, and MICHAUNG, formed over the Bay of Bengal, and 2 cyclones, BIPARJOY and TEJ, formed over the Arabian Sea. Among these, the Extremely Severe Cyclonic Storm BIPARJOY, which formed over the Northeast Arabian Sea in the monsoon season from 6$^{th}$ to 19$^{th}$ June, claimed seven human lives from Rajasthan, while the Bhavnagar, Banaskantha, Devbhoomi Dwarka, Gandhinagar, Jamnagar, Junagadh, Kutch districts of Gujarat affected. However, there was zero mortality in Gujarat due to BIPARJOY.

The long coastline of more than 7500 km of flat coastal terrain, shallow continental shelf, high population density, geographical location, and physiological features of its coastal areas make India extremely vulnerable to cyclones and their associated hazards. Thirteen coastal states and Union Territories (UTs) in the country, encompassing 96 coastal districts, including 72 touching the coast and 24 not touching the coast, are affected by tropical cyclones. The performance of cyclone landfall, track, and intensity forecast has significantly improved in the recent decade (IMD, 2024).

## 1.2.4 Heatwaves and cold waves

Heatwaves typically occur between March and June and, in some cases, even extend till July in India. Heatwaves are more frequent over the Indo-Gangetic plains of India. On average, 5-6 heatwave (HW) events occur every year over the northern parts of the country. Temperatures over 46°C have been recorded in many parts of the country in the past, especially over north and central India. The IMD criteria for declaring heatwaves and cold waves are described in IMD Forecasting Circular No. 5/2015 (3.7).

The climatology of HW days over the country based on data from observational network of IMD point out that except over northeast India and large parts of Peninsula (South of ~21°N and west of 80°E), most areas of the country have experienced on an average ≥ 2 HW days. Many areas of West Rajasthan, Punjab, Haryana, northern parts of East Rajasthan, Madhya Pradesh, Chhattisgarh, Vidarbha, western Uttaranchal, East Uttar Pradesh, western parts of Jharkhand and Bihar, Gangetic West Bengal, northern parts of Odisha, Telangana, Coastal Andhra Pradesh, eastern parts of Rayalaseema and north Tamil Nadu on an average have experienced ≥8 HW Days. It is seen that average Severe Heatwave (SHW) days of 1-3 days were mainly experienced over northwest, north and eastern parts of the country. Increasing trends in the HW were observed over most of the stations except a few stations in the plains along foothills of Himalayas, southern parts of central India and east India, which showed decreasing trends during the period 1961-2023 (Figure-1.7a). Decreasing trends in Cold Wave days were observed at most of the stations (Figure 1.7b).

The frequency of occurrence of hot days (>90 percentile) during the pre-monsoon season shows a significant increase over the east and west coasts of India and interior peninsula. Likewise, an increasing trend in the frequency of warm nights is seen on the east coast, west coast, and north-west India. The frequency and duration of heat waves over north-west India and east coast of India have also increased. The duration of heat waves over central and north-west India has increased by about five days over the past 50 years. Based on data from observational network of IMD for the period 1961-2010, Pai et al. (2013) observed a slight increasing trend in all India Heat Wave and Severe Heat Wave days during summer season. No noticeable

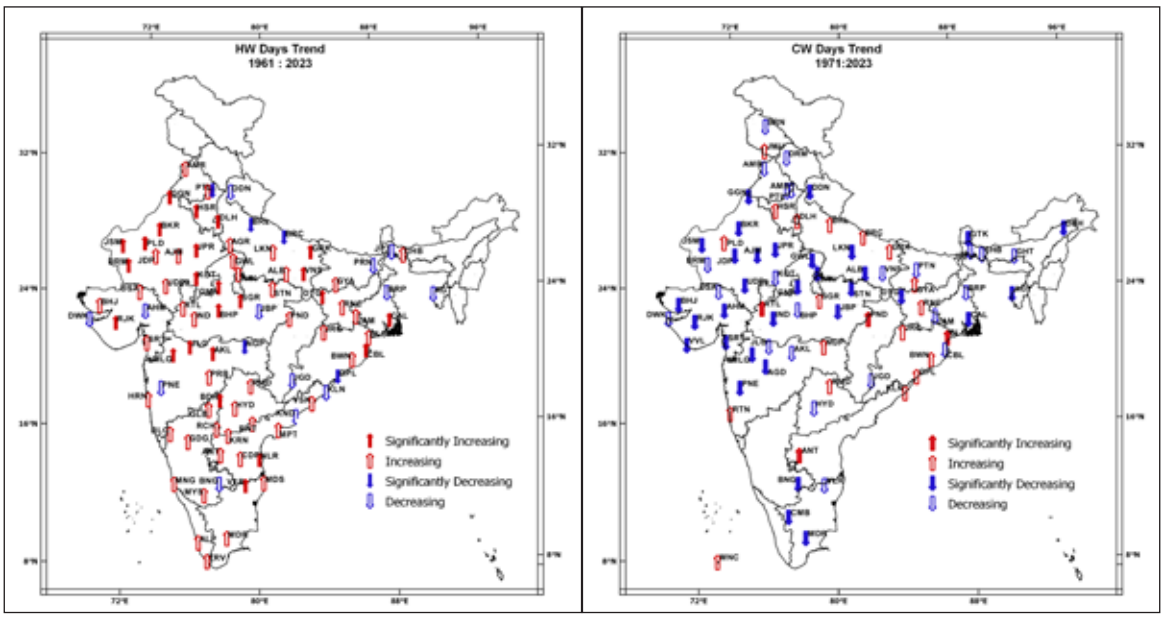



*Figure 1.7: (a) Trends in the Heat Wave (HW) days in April, May and June for the period 1961–2023 (b) Trends in the Cold Wave (CW) days during December, January and February for the period 1961–2023.*

*Source: IMD*

**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 the trends significant at 5% level, based on the nonparametric Mann–Kendall test.**

long-term trends were observed in the spatial coverage of the Heat Wave and Severe Heat Wave days over the country. For the period 1961-2013, the frequency, the total duration of heat waves per season, and maximum duration of heat waves have increased over India during the summer season (Rohini et al., 2016).

Drawing lessons from the ground-breaking Ahmedabad Heat Action Plan released in 2013, action have been taken up at the city, state, and national levels to implement extreme heat warning systems and preparedness plans. The National Disaster Management Authority (NDMA) identified 23 heat-prone states in 2019, up from 19 states in 2018 and convened annual workshops on preparedness, monitoring and management strategies with local officials and key experts.

At the national level, the NDMA provides the policy direction, through the National Guidelines for Preparation of Action Plan – Prevention and Management of Heat Wave, facilitates coordination to support state-level heat action plans. . State governments currently dealing with Heat Wave crisis have prepared Heat Action Plans; and Do's and Don'ts 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. The India Meteorological Department 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 warning for 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 NDMA, extensive awareness generation campaigns, preparedness workshops have significantly brought down the number of heat-related deaths and illnesses in the past few years.

According to the NDMA, the 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. During 2019 to 2021 there were no Loss of Life reported due to Heatwave, mainly due to continuous La Nina event. However, the heatwave related mortality reported for the year 2022 and 2023 are 30 and 169 respectively. Table 1.1 provides details of the extreme weather events and their impacts across different states in India during the years 2022 – 2023.

*Table 1.1: Weather extremes in India in the recent years (2022-2023)*

| Year | Month | Event | States Affected |
|---|---|---|---|
| 2022 | March. to June. | Severe heat wave | Central and east central parts of the country- Maharashtra, Odisha, West Bengal, Jharkhand, Chhattisgarh. |
| 2023 | April. to July. | Severe heat wave | Gangetic Plans and central Indian region- Uttar Pradesh, Odisha, Jharkhand, Maharashtra and Chhattisgarh. |
| 2022 | Jan. and Mar.-Nov. | Heavy rainfall resulting in floods, Landslide | Uttar Pradesh, Assam, Maharashtra, Himachal Pradesh, Manipur |
| | Jan.-Nov. | Lightning and Thunderstorm | Bihar, Uttar Pradesh, Odisha, Jharkhand, Madhya Pradesh, Maharashtra, Rajasthan, Chhattisgarh, Assam |
| 2023 | 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 |
| 2022 | Dec. | Severe Cyclonic Storm MANDOUS over the Bay of Bengal | Andhra Pradesh, Tamil Nadu and Puducherry. |
| | 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 | Jun. | Extremely Severe Cyclonic Storm BIPARJOY over Northeast Arabian Sea. | Rajasthan, Gujarat affected. |
| | Dec. | Severe Cyclonic Storm MICHAUNG over the southwest Bay of Bengal | Tamil Nadu, Andhra Pradesh, and Telangana. |
| | Nov. | Cyclonic Storm MIDHILI over the northwest Bay of Bengal. | Tripura and Mizoram. |
| | May | Extremely Severe Cyclonic Storm MOCHA over the northeast Bay of Bengal | Mizoram. |
| | Oct. | Extremely Severe Cyclonic Storm TEJ over the Arabian Sea. | No adverse weather over west coast of India was reported due to this system. |
| | Oct. | Very Severe Cyclonic Storm HAMOON over the Bay of Bengal | No adverse weather over coast of India was reported due to this system. |

## 1.2.5 Socio-economic and demographic characteristics

India is the -most populated country in the world (1441.7 million people or approximately 18% of the world's population), with a population density of approximately 473.2 persons per sq. km. India's urban population is projected to grow to 675 million in 2035 (~43% of its population) and to grow by an additional 2.2 billion by 2050 (~ 68% of its population) (United Nations Human Settlements Programme, 2022). Table 1.2 provides a snapshot view of the Indian economy.

***Table 1.2 Snapshot of the Indian economy***

| Indicator | Value (FY 2023-24) |
|---|---|
| Nominal GDP | 295.36 lakh crore [1] (USD 3,567.59 billion) |
| Nominal GDP Growth Rate | 9.6% [2] |
| GVA - Agriculture, forestry & fishing (nominal) | 47,25,223 crore (USD 570.75 billion) |
| GVA - Mining & Quarrying (nominal) | 5,25,881 crore (USD 63.52 billion) |
| GVA – Manufacturing (nominal) | 38,19,749 crore (USD 461.38 billion) |
| GVA - Electricity, gas, water supply & other utility services (nominal) | 6,63,458 crore (USD 80.14 billion) |
| GVA – Construction (nominal) | 23,83,877 crore (USD 287.94 billion) |
| GVA - Trade, hotels, transport, communications & services related to broadcasting (nominal) | 46,84,542 crore (USD 565.84 billion) |
| GVA - Financial, real estate & professional services (nominal) | 60,64,251 crore (USD 732.49 billion) |
| GVA - Public administration, defence & other services | 38,95,167 crore (USD 470.49 billion) |
| Forex Reserves | 53,91,256 crore (USD 646.419 billion) |
| Overall Exports | 36,19,292 crore (USD 437.113 billion) |
| Cumulative Gross FDI Equity Inflow (2002-03 to 2023-24) | 63,11,677 crore (USD 982.089 billion) |

**NOTES**

- GVA, forex reserves, exports and FDI inflow data are taken from the Reserve Bank of India's *Handbook of Statistics on Indian Economy 2023-24.*
    - GVA values are in Basic Prices (Base Year: 2011-12) Current Prices.
    - GVA Industry Total: INR 50,09,088 crore
    - GVA Services Total: INR 1,70,27,837 crore
    - GVA Agriculture, forestry & fishing total: INR 47,25,223 crore
    - Total GVA: INR 2,67,62,147 crores
- GVA numbers are converted from INR to USD considering the **average financial year exchange rate** of 1 USD = 82.7897 INR for 2023-24 as obtained from *Handbook of Statistics on Indian Economy 2023-24 (Table 139)*
- Cumulative FDI inflow is calculated using Table 149 on Foreign Investment Inflows from the *Handbook of Statistics on Indian Economy 2023-24.*

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.

Poverty eradication and constant improvement of the ease of living is a priority on India's economic agenda. On the human development aspect, according to the World Bank, India has halved the share of

1. https://pib.gov.in/PressReleseDetailm.aspx?PRID=2022323&reg=3&lang=1
2. https://pib.gov.in/PressReleseDetailm.aspx?PRID=2022323&reg=3&lang=1

the population living in extreme poverty between 2011 and 2019 (below $2.15 per person per day; 2017 PPP) (World Bank Poverty and Inequality Portal and Macro Poverty Outlook, 2023). Rural India has a significant weight in the Indian economy. Forty-five percent of the Indian workforce (of 565 million people) depends upon agriculture and allied activities.

Energy consumption needs to increase by a significant amount to meet India's developmental goals. In 2022-23 (provisional figures), Primary Energy Supply added up to 8,50,349 Kilo Tonne of Oil equivalent (ktoe); an increase of 14.33% from 2021-22. India represents 18% of the global population but its annual primary energy consumption per capita in 2022 was 25.4 gigajoules (GJ) (MoSPI, 2024). This is 1/3$^{rd}$ 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.

On electrification, the fifth round of data from the National Family Health Survey on conditions of well-being of households in India reported that in 2020, 97% of all households in India have access to electricity (95% of rural and 99% of urban households). However, India's per capita electricity consumption is also well below global averages and far below the electricity consumption of the high-income countries. India's per capita electricity consumption was 1331 Kwh/yr/person, in 2022-23.

The global COVID pandemic of 2019, severely impacted India's population, its link to global supply chains, and its economy. This included a contraction of the Indian economy by 7.7 percent in 2020- 21. Subsequently, the Government of India undertook various measures to combat the impact of the COVID-19 pandemic and to revive economic growth. This included the improvement and expansion of health infrastructure, revitalizing the fight against poverty, improving infrastructure development, as well as macroeconomic measures such as in-kind and cash transfer relief measures for households, employment provision measures, relief measures for MSMEs and NBFCs, funding schemes for social infrastructure, etc. Consequently, despite the general shocks suffered on account of the COVID-19 pandemic, by 2021-22 India achieved GDP level that is at par with the pre-pandemic levels (Ministry of Finance, Government of India, 2023).

India's commitment to sustainable development, contribution to climate mitigation, and achievement of a climate-resilient growth process require a future growth trajectory that is equitable, inclusive, and sustainable. India's present national circumstances as well as developmental challenges foreground its climate change adaptation and climate change mitigation policies. Different sectors of the Indian economy and the supply chains of various economic activity are affected by weather and climate extremes and variability. Further, a vast majority of India's population physically and economically is directly impacted by climatic and geographic parameters. The importance of understanding and monitoring India's geographical and climatic parameters is critical given its vast population, diverse geography, and varied climatic conditions.

## 1.3 Agriculture, climate variability, and climate change

Agriculture and allied activities (field crops, horticultural crops, livestock, fisheries and agro-forestry) play a central role in India's economy. It is the largest sector in terms of livelihood and employment. It contributes significantly to the Indian economy. India's agriculture sector has been witnessing robust growth with an average annual growth rate of 4.6 per cent over the last six years. In recent years the country has emerged as the net exporter of agricultural products, with exports in 2021-22 touching a record US $ 50.2 billion (according to the Economic Survey 2022-23 tabled in Parliament).

Agriculture retains 45.6 per cent of the total workforce (NITI Aayog, 2022). The share of agricultural and allied sector activities in the economy's total Gross Value Added (GVA) at current prices is **18.3, 20.4, 18.9** and **18.2** for the years 2019-20, 2020-21, 2021-22 and 2022-23, respectively (MoSPI, 2023). With a net sown area of approximately 140 million ha, which has remained the same in recent years, food grain production in 2021-22 rose to 315.72 million tonnes along with a significant increase in production of horticultural crops, milk, meat, fish, and eggs. 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 small and marginal farmers have traditionally always 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. 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.

## 1.3.1 Extreme events and their impact on agriculture

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 add to the challenges to farmers causing widespread losses of agricultural output. Heatwaves and floods have particularly caused major damage to crop production, and crop harvesting activities in India.

The months of March and April 2022 witnessed an unusual increase in maximum and minimum temperatures. Northwest and central India experienced their hottest April in 122 years with average and maximum temperatures reaching 35.9 and 37.8 degC, respectively. Anti-cyclones over western parts of Rajasthan in March and the absence of western disturbances had triggered the early and extreme heat waves. The districts of Punjab, Himachal Pradesh, Jammu and Kashmir, Haryana, Madhya Pradesh, Uttar Pradesh and Rajasthan were affected resulting in yield reduction of field crops like wheat (10-34%), maize (18%), chickpea (19%), cowpea (9-11%) and mustard (14-18%). Horticultural crops including fruit crops like mango, lemon, guava, papaya, kinnow and pomegranate; and vegetables including cole crops, cucumber, bitter gourd, okra, onion and tomato were also affected. Heat waves resulted in flower and fruit drop and reduced fruit size and resulted in yield reduction of tomato (40-50%), cucumber and bitter gourd (30-50%) and okra (40-50%). Livestock, poultry and fisheries production were severely affected by heat waves. It led to a reduction of milk yield by up to 11-15% in milch animals and egg production by 4-10% in layers. It increased the mortality up to 8% in broiler chicken and 3.5-4.0% in layers. It affected fish farming in plain areas due to water scarcity.

Heavy rains in Balrampur, Uttar Pradesh from 08$^{th}$ to 13$^{th}$ October 2022 led to waterlogging of 125691.79 ha crop area affecting crops such as paddy, maize, bajra, urad, and potato across the state (JRNA, 2021). In Assam, rice transplanting starts from mid-June to mid-July every year. However, in 2022, due to the early flooding and the subsequent flood waves in June and July, the sowing of rice has been delayed to August. Besides, the extreme events mentioned above, loss of life and crop damage were also observed due to lightning, thunderstorms, glacier bursts and landslides between 2019 and 2022. Glacier bursts triggering landslides and causing flash floods occurred in the state of Uttarakhand. Lightning events affected most of the west, east, and north India since mid-June due to the early stage of the Southwest Monsoon (ADRC, 2022).

## 1.3.2 Measures to address climate risks in agriculture

Despite the above factors, there has been a consistent increase in the production of both food grains and horticultural production in India. This indicates the importance of developing 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 pre-existing 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, National Mission for Sustainable Agriculture (NMSA), National Mission on Agricultural Extension and Technology, Prime Minister Fasal Bima Yojana, National Horticulture Mission, Pradhan Mantri Krishi Sinchayi Yojana (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), Atal Mission for Rejuvenation and Urban Transformation (AMRUT, and Jal Shakti Abhiyan).

- Sustainable integrated organic farming systems: To improve organic farming systems and to enhance the farmer's incomes, certain schemes have been implemented which include - 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, 59.1 lakh ha area has been brought under organic farming by 2021-22.
- Rainfed Area Development Scheme: The Rainfed Area Development (RAD) scheme focuses on integrating farming systems with activities such as agroforestry, horticulture, livestock, fishery, and apiculture. This 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): is a network project of the Indian Council of Agricultural Research (ICAR) launched in February 2011. The Project aims to enhance the resilience of Indian Agriculture to climate change and climate vulnerability through strategic research and technology demonstration. The research on adaptation and mitigation covers crops, livestock, fisheries, and natural resource management. Under the NICRA project, seed varieties/hybrids of rice, mungbean, maize, tomato and lentils tolerant to pests, 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 of 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 Government of India. 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 ₹25,186 crore and the money received as claims amounted to ₹1.2 lakh crore.

# 1.4 Important sectors: Forests, Biodiversity, and Water

This section provides a description of important ecosystems and sectors in India and the various response measures undertaken within these sectors to address the challenges of climate change. These sectors include Forests, Water, Wetland and Coastal systems, and the Himalayan cryosphere. Further, it also provides an assessment of the current state of vulnerability of these ecosystems, and policy measures undertaken regarding existing and future shocks and stresses faced within these regions.

## 1.4.1 Forests and Biodiversity

Forests are important ecosystems inIndia which provides various ecosystem goods and services. Forests are also regions of biodiversity hotspots. India is one of the few countries where forest and tree cover has continued to increase over the years, qualifying the country's forests as net sink owing to national policies aimed at conservation and sustainable management of forests.

Forests in India ranges from Tropical Evergreen Rain Forests in the Andaman & Nicobar Islands, the Western Ghats, and the Northeastern States, to Dry Alpine Scrub high of the Himalayas in the North. The country has Semi-Evergreen Rain Forests, Deciduous Monsoon Forests, Thorn Forests, and subtropical Pine Forests in the lower mountain zone and Temperate Mountain forests in the higher zones. On the other extreme, Tropical Dry Deciduous forests and Thorn forests are found in the desert and dry areas of Rajasthan and Gujarat. Diverse soil types, land forms, climatic conditions, altitude ranges and spatial vastness of the country have led to evolution of large number of forest types. Forest Survey of India (FSI), an organization under the Ministry of Environment, Forest and Climate Changes has mapped the forest of India into 6 Major Groups, 16 Type Groups and 200 Types in hierarchical manner and published in the form of an atlas in 2011 and again revised it in 2020.

## Forest cover and Recorded Forest Area (RFA)

The 'Forest Cover' refers to all tree patches that have canopy density of more than or equal to 10 % and area of one hectare or more in size, irrespective of land use, legal status and ownership. It may include orchards, bamboo, and palms etc. and is assessed through remote sensing. The 'Recorded Forest Area' or 'Forest Area' refers to all the geographical areas recorded as 'Forests' in government records irrespective of the actual

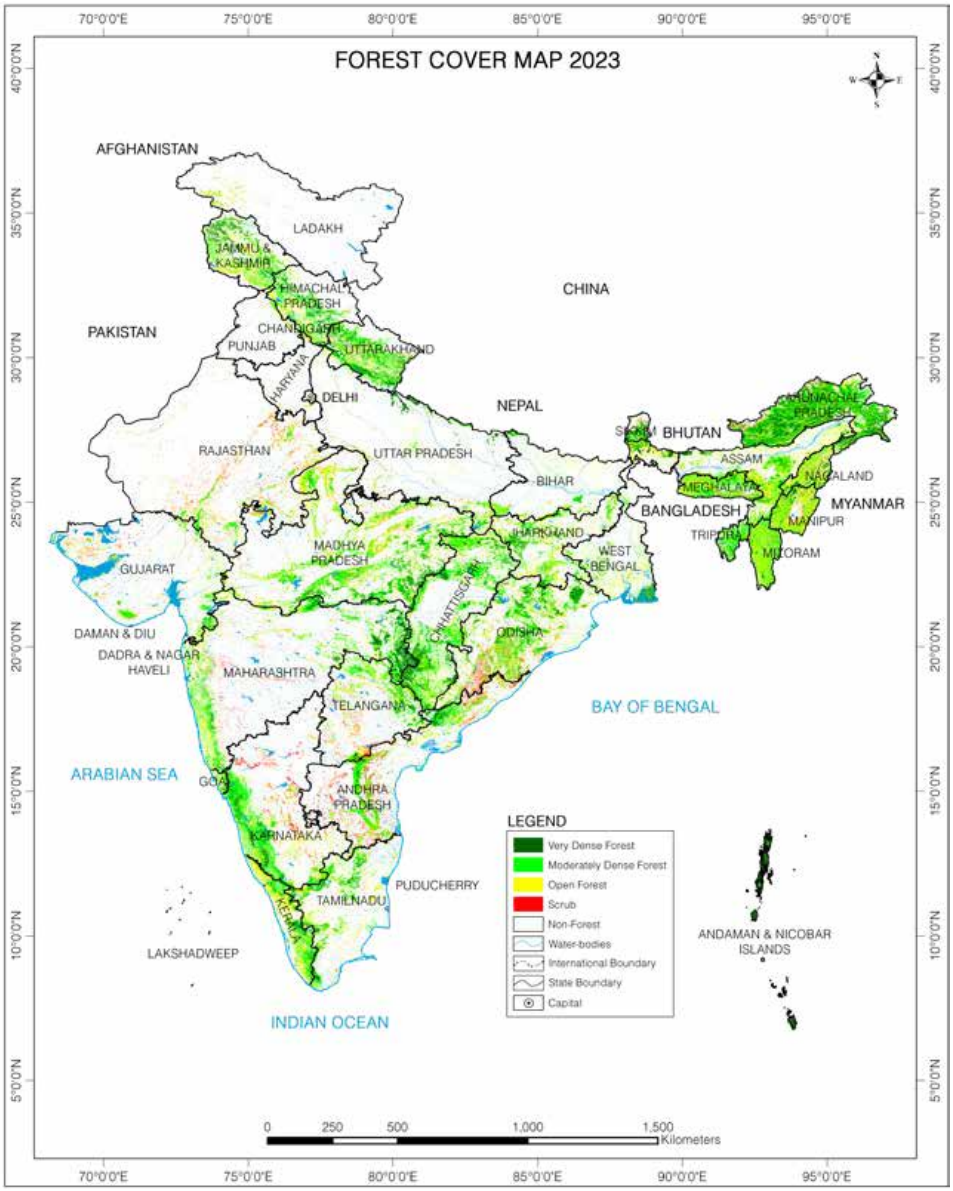



*Fig 1.8 Forest Cover Map of India 2023*

*Source: India State of Forest Report 2023*

trees growing on such lands. RFA mainly comprises of Reserved Forests (RF) and Protected Forests (PF) and Unclassed Forests notified under Indian Forest Act, 1927 or respective State Forest Acts. Additionally, RFA may also include all such areas, which have been recorded as 'Forest' in the revenue records or have been constituted so under any State Acts or local laws. Therefore, RFA may have blank areas with tree canopy density of less than 10% such as degraded lands, wetlands, rivers, creeks in mangroves, snow covered areas, glaciers and other snow-covered areas, alpine pastures, cold deserts and grasslands etc. As per the definition of 'Forest Cover' used in ISFR, such blank areas in RFA are excluded from the assessment of Forest Cover. On the other hand, there are areas outside the RFA comprising tree patches of more than one hectare in area, with canopy density of 10% and above. Such areas include plantations on the private and community lands, road, rail, and canal side plantations, rubber, shade trees in tea and coffee plantations etc. and are included in assessment of Forest Cover. Thus, RFA and Forest Cover overlap with each other but the two are not coterminous with each other.

The National Forest Policy of India 1988 envisages a goal of achieving 33 percent of the geographical area of the country under forest & tree cover. FSI, has been assessing forest cover since 1987 and tree cover since 2001. The remote sensing based nation-wide Forest Cover mapping at biennial interval, serves as a monitoring mechanism towards achievement of this goal. Periodic Forest Cover assessment at definite intervals helps in assessing the status of forests in the country and its broad trend. The results of the biennial Forest Cover assessment are published in the India State of Forest Report (ISFR) and is a widely used primary information source across the Central Government, State Governments and forestry professionals of the State Forest Departments, academia, international organizations and other stakeholders. These inputs about the forest resources of the country are used for broad evaluation and formulation of forest related policies, programmes, legislations and different activities in the country. The forest cover mapping carried out by FSI follows the following classification:

***Table 1.3: Forest Class Types***

| Class | Description |
|---|---|
| **Very Dense Forest** | **All lands with tree canopy density of 70 percent and above.** |
| **Moderately Dense Forest** | **All lands with tree canopy density of 40 percent and more but less than 70 percent.** |
| **Open Forest** | **All lands with tree canopy density of 10 percent and more but less than 40 percent.** |
| **Scrub** | **Forest lands with canopy density less than 10 percent.** |
| **Non-forest** | **Lands not included in any of the above classes. (includes water)** |

*Source: India State of Forest Report 2023*

As per the latest assessment of FSI, i.e. ISFR 2023, the total forest and tree cover of the country is 8,27,356.95 km² which is 25.17% of the geographical area of the country. The total Forest Cover has an area of 7,15,342.61 km² (21.76%) whereas the Tree Cover has an area of 1,12,014.34 km² (3.41%). The current assessment shows an increase of 156.41 km² in the Forest Cover at national level as compared to the previous assessment. The total forest and tree cover of the country has increased by 1445.81 km² as compared to the last assessment of ISFR 2021.

As a part of its updated Nationally Determined Contributions (NDC), India has committed to creating an additional carbon sink of 2.5 to 3 billion tonnes $CO_2$eq through additional forest and tree cover by 2030.

# Growing Stock

Growing Stock is the volume of all living trees in a forested area. Periodic estimation of the growing stock of wood is essential for developing national policies and strategies for sustainable use of the forest resources. The total growing stock of wood in the country is estimated at 6,429.64 M $m^3$, which comprises of 4,478.89 M $m^3$ inside forest areas and 1,950.75 M $m^3$ outside recorded forest areas (TOF). There is a total increase of 262.32 M $m^3$ (4.25%) in the growing stock of the country as compared to the estimates reported in ISFR 2021. Out of this, the increase in growing stock is 90.92 M $m^3$ (2.07%) inside the forests, and 171.40 M $m^3$ (9.63%) outside the forest areas. It is observed that the growing stock at the national level has been estimated as 86.10 $m^3$ per ha in forest areas.

Forests are also important sources of raw materials and income, providing employment opportunities to millions of forest-dependent communities specially tribals associated with forest products and services.

In India, the rural population is about 68% of the country's total population (Census 2011) and a significant part of it is dependent on the forests for meeting the needs of fuelwood, fodder, small timber and bamboo. The livestock population in the country is one of the largest in the world which significantly contributes to the socio-economic wellbeing of India's rural population (19th Livestock Census, 2012). As per the Census 2011, there are about 6,50,000 villages in the country, out of which nearly 1,70,000 villages are located in the proximity of forest areas, they are often termed Forest Fringe Villages (FFVs). Forests in these villages play an important role in socio-economic and cultural lives of the people inhabiting these villages. They have been dependent on the forests in their vicinity for fuel wood, fodder, timber and bamboo since ages but with the manifold increase in the population in the last 60 to 70 years, pressure on forests in the vicinity has also increased likewise. Most of these removals from forests, which take place in a gradual and continuous manner remain unrecorded. Thus, a possible major driver of impairment of forest productivity remains unassessed and does not get adequate attention of policy makers and forest managers. Also, the information on socio-economic and ecological aspects of dependence of people in FFVs and communities on forests is scant.

As per the study carried out by FSI in the Forest Fringe Villages and published in ISFR 2019, the estimates of quantities of fuelwood, fodder, small timber and bamboo collected annually by the people living in the FFVs from the nearby forests are 85 million tonnes, 1053 million tonnes, 5.8 million tonnes and 1.8 million tonnes respectively. Despite so much pressure on our forests, the forest cover and carbon stock of the country has shown an increasing trend over the last one decade. This was possible because of good policies of the government and commitment of India to reduce its emission intensity.

*Panel A- 2030 projection* *Panel B- 2050 projection* *Panel C- 2085 projection*

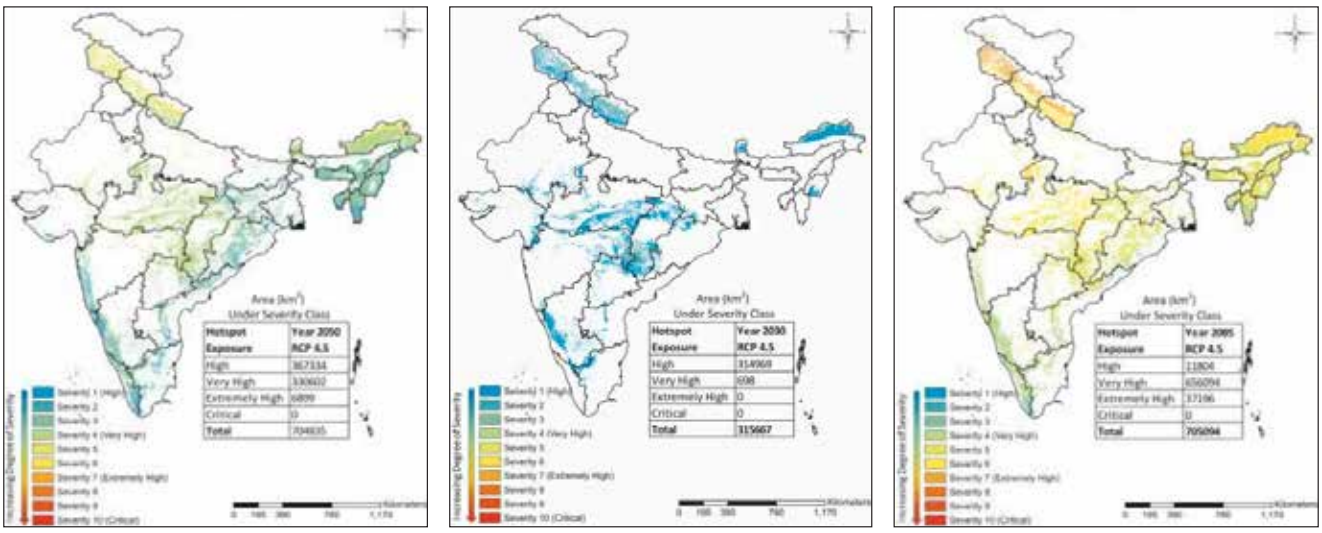


*Fig 1.9 Climate Change Exposure Hotspot Map of Forest Cover in India under RCP 4.5 scenario*

*Source: India State of Forest Report 2021*

Forest cover in India is also projected to be vulnerable to changes in temperature and precipitation. A study conducted by the Forest Survey of India (FSI) as part of its "The India State of Forest Report 2021" projects changes in climatic hotspots across India's forest cover. Figure 1.9 describes the Climate Change Exposure hotspot map for forest cover in India for the years 2030, 2050, and 2085 according to this study.

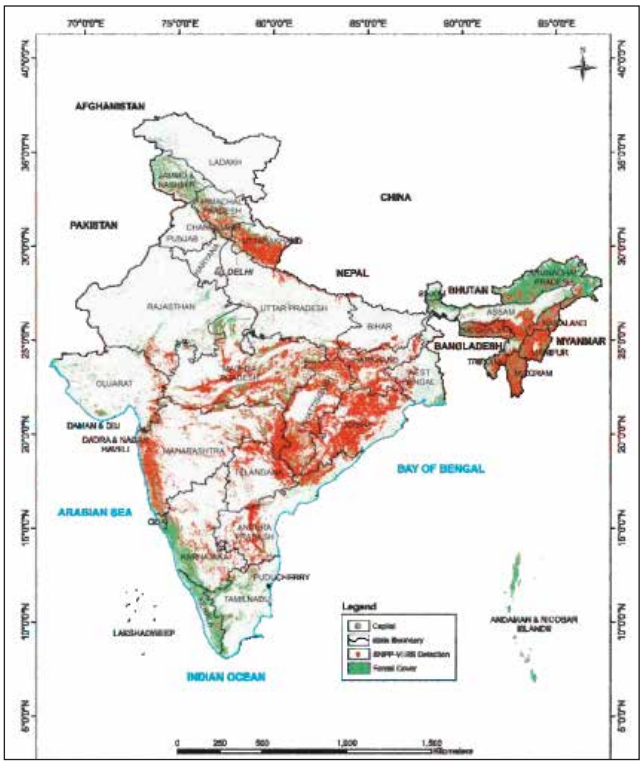
Climatic hotspots are areas that are identified to be sensitive to temperature and precipitation changes i.e. based on identifying temperature hotspots and precipitation hotspots within forest areas. A temperature hotspot is defined as any forested grid that is projected to experience a temperature rise of over 15 deg C compared to baseline period of 1860-1900. A precipitation hotspot refers to the change of rainfall greater or less than 20% with respect to the baseline period of 1960-1990.

The projections indicate a potential increase in the area under climatic hotspots within forest cover from 2030 to 2050 and 2085. By the year 2030 (under RCP 4.5 scenario) about 315667 sq.km. of forest cover will fall under climatic hotspots. This is projected to increase to 704835 sq km in 2050, and 795094 sq km. By 2050 these projections indicate that most forest cover area in India are projected to become temperature or precipitation hotspots.

Forest fires are a part of the broader forest environment and play a significant role in shaping the conservation and management of forest ecosystems. Although controlled forest fires have some benefits for regeneration of biodiversity, there are many harms associated with uncontrolled forest wires which are caused by extreme fire conditions driven by meteorological factors such as dry weather, high wind spends, low humidity, and high temperatures. Variability in weather and climatic conditions, as well as long term climate change can potentially increase extreme fire conditions leading to forest fires. This also has the potential risk of increasing GHG emissions from forests. Approximately 36% of the forest cover in India is estimated to be prone to frequent forest fires (IFSR 2019; 2021). In India severe fires in forest cover areas occur particularly in dry deciduous forests. This normally occurs in the period of November to June, with majority of fires having man-made causes.

The National Action Plan on Forest Fires (NAPFF) was constituted in 2018 with the objective of better management of forest fires towards minimizing their impacts on human lives and forest ecosystems. This

*Panel A- Forest fire hotspot- MODIS data*




*Panel B- Forest fire hotspot SNPP-VIIRS data*

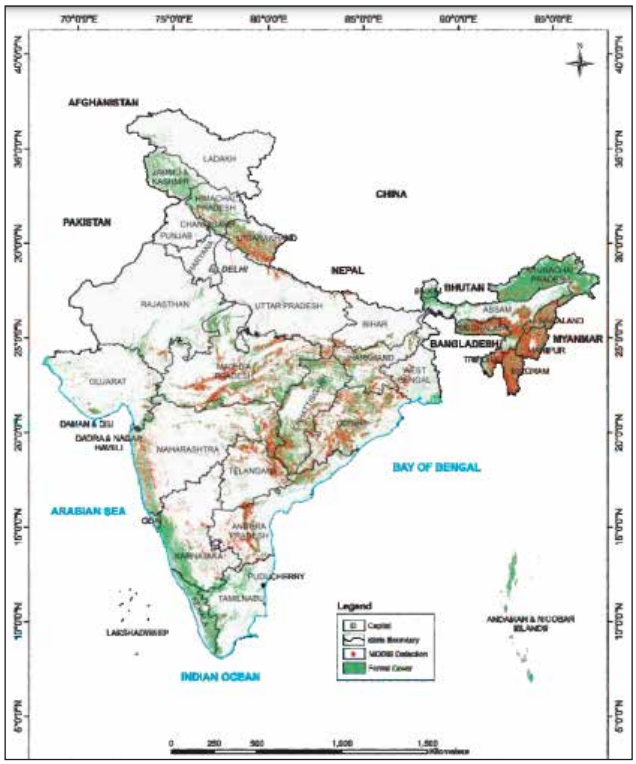



*Fig 1.10 Forest Fire Hotspot areas across India 2020-2021 season*

plan is structured around the generation and dissemination of forest fire alerts. At the first instance fire hotspots are recognized and alerted based on data from National Remote Sensing Centre (NRSC). This is based on analysing satellite data through Moderate Resolution Imaging Spectro-radiometer (MODIS) and Visible Infrared Imaging Radiometer Suite (SNPP-VIIRS) images. They are then mapped to various administrative attributes such as state, district, circle, division, range, and block boundaries. This information is combined with real-time forest fire data from the Forest Survey of India. The Forest Fire alert service of the FSI is currently provided to 131102 subscribers (2020-21). In the 2020-2021 forest fire season, 7955749 SMS alerts on forest fires were disseminated to the subscribers. In addition, early warning systems to categorize forest cover areas as vulnerable to forest fires are also being carried out. Further, the FSI Forest Fire Geo-portal provides user-friendly interactive data that maps and tracks real-time forest fire data.

For the 2020-2021 forest fire season, a total of 52785 fires were detected using MODIS data, and a total of 345989 instances were detected using SNPP-VIIRS data. From the SNPP-VIIRS data, it is observed that the maximum number of fire detections were found in the States of Odisha (51968), followed by Madhya Pradesh (47,795) and Chhattisgarh (38106). These numbers are used to represent forest fire hotspot data from these different satellite data sources and are presented in Figure 1.10

The Government of India, in its NDC, declared its long-term goal to increase India's geographical area under forest cover to eventually reach a target of 33% of its geographical area. Initiatives like the Green India Mission (GIM) aim to further increase the forest/tree cover to the extent of 5 million hectares (MHA) and improve the quality of forest/tree cover. This greening is intended to improve carbon sequestration and storage (in forests and other ecosystems), hydrological services, and biodiversity, and improve the provisioning of fuel, fodder, and non-timber forest products (NTFPs).

Other important policies around forests include National Afforestation Programme, Compensatory Afforestation Fund Management and Planning Authority, Nagar Van Yojana, National REDD+ (Reducing Emissions from Deforestation and forest Degradation) Strategy 2018, National Rural Livelihoods Mission, Forest Fire Prevention and Management Scheme and AMRUT (Atal Mission for Rejuvenation and Urban Transformation).

As indicated earlier, forests in India are also inclusive of various species of bio-diversity, including threatened and at-risk flora and fauna. With only 2.4% of world's land area, India accounts for 11% of recorded species of the world. In pursuance to Convention on Biological Diversity (CBD) adopted in the Rio Earth Summit of 1992, India enacted the Biological Diversity Act in 2002 and notified the Biological Diversity Rules in 2004 (amended in 2023). The Act provides for conservation of biological diversity, sustainable use of its components and fair and equitable sharing of the benefits arising out of the use of biological resources, knowledge and for matters connected therewith or incidental thereto. The Biological Diversity Act is implemented through a three-tier institutional mechanism: National Biodiversity Authority (NBA), State Biodiversity Boards (SBBs) and Biodiversity Management Committees (BMCs). NBA is a statutory body that performs facilitative, regulatory and advisory functions for the Government on biodiversity related issues. To achieve the country's national as well as international commitments of NDCs, carbon neutrality, eliminate the ambiguities and bring clarity about the applicability of the Act in various lands, promoting the plantation in non-forest land, enhancing the productivity of the forests, amendment in the existing Act has been made by promulgating the Forest (Conservation) Amendment Act, 2023. During last two years, the Forest Conservation Division has issued approximately 60 guidelines or clarifications to further streamline the process of approval under the Forest (Conservation) Act, 1980.

## 1.4.2 Water

Climate change impacts have direct consequences for water security. It is also recognized that climate change adaptation must build resilience, strengthened through healthy ecosystem services that rely on well-functioning river basins. The Government of India recognizes that climate change manifests itself in important ways through significant changes in the water cycle. The impact of climate change threatens to make floods and droughts more frequent and intense, and so there is a need for adequate adaptation measures to ensure e water security, power generation, drought mitigation, and flood control. The initiatives

undertaken in the water sector in the last decade reflect the importance of water management in reducing vulnerability and building climate resilience. Consequently, various government initiatives have focused on issues such as river rejuvenation, holistic river basin management, increasing storage, enhancing the efficiency of existing dams, water conservation and recharge, and security of water supply. In tandem with this, the hydrological monitoring network has been expanded significantly to mitigate the impact of floods and droughts.

Despite having approximately 18% of the world's population, India has only approximately 4 % of the world's freshwater resources. According to the Central Water Commission, the annual average per capita water availability in India between 2021 and 2031 is assessed to be between 1486 cubic meters and 1367 cubic meters per person, respectively. Annual per-capita water availability of less than 1700 cubic meter is considered as water stressed condition whereas annual per-capita water availability below 1000 cubic meters is considered as a water scarcity. This underlines the importance of water in India's climate policies and actions.

United Nations has recognized the significance of improving WUE for tackling global water scarcity in their Sustainable Development Goal (SDG) No. 6 (Clean Water & Sanitation). Under SDG 6.4, target has been set to substantially increase water-use efficiency across all sectors by 2030, and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity.

Increasing water use efficiency is an affirmation of India's commitment to the Environment by optimizing the use of limited water resources and minimizing wastage. In order to adapt to impacts of climate change on water resources, the National Water Mission (NWM) was established under National Action Plan for Climate Change (NAPCC) in 2011 in follow up of the decision of the Cabinet on 06-04-2011. One of the Goals of National Water Mission is to improve water use efficiency by 20%.

For fulfilling the requirement of one of the goals of NWM, Bureau of Water Use Efficiency (BWUE) has been established by Department of Water Resources, River Development and Ganga Rejuvenation on 20.10.2022 for promotion, regulation and control of efficient use of water in irrigation, industrial and domestic sectors. "Sahi-Fasal" is a campaign launched by NWM to nudge Indian agriculture to promote crops which 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 like paddy, sugar cane etc., to crops like corn, maize etc., which require less water. It also aims at effective pricing of inputs (water and electricity), the protection of the environment and assisting policymakers to improve procurement policies, and the creation of appropriate storage facilities and Catch the Rain Initiative has set annual targets for rainwater harvesting infrastructure expansion in identified districts experiencing critical water stress, contributing to groundwater recharge and climate resilience.

The initiative actively involves local communities and stakeholders, aiming to achieve water catchment in every available area, particularly rooftops, open grounds, and rural setups, with data collection at the district level.

The Government of India approved and set up the National Water Mission (NWM) as per the National Action Plan on Climate Change (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. National Water Mission's goal No. 4 is "to increase water use efficiency by 20%". Water use efficiency in agriculture has assumed critical importance because of the increasing areas under irrigation and higher water requirements for agriculture. "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 like paddy, sugar cane, etc., to crops like corn, maize, etc., which require less water. It also aims at effectively pricing inputs (water and electricity), protecting the environment, assisting policymakers in improving procurement policies, and creating appropriate storage facilities and markets.

India ranks third globally after China and the United States of America, with 5,334 large dams in operation. In addition, about 411 dams are currently under construction. There are also several thousand smaller dams. These dams are vital for ensuring the country's water security. Apart from structural measures to improve hydrologic safety, hydro-mechanical measures, seepage reduction, structural stability, etc., non-structural measures, such as dam break analyses, emergency action plans, and OM manuals, were put in place for the selected dams. In addition, DHARMA (Dam Health and Rehabilitation Monitoring), a system to monitor the health of dams, has been developed and is currently being used by 18 states.

The Dam Rehabilitation and Improvement Project (DRIP) 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. DRIP (Phase-I) World Bank-assisted Dam Rehabilitation and Improvement Project was initiated in April 2012. 223 dams located in seven States, i.e., Kerala, Madhya Pradesh, Odisha, Tamil Nadu, Karnataka, Jharkhand, and Uttarakhand, were taken up for rehabilitation measures to improve the safety and operational performances of these dams. Based on the success of DRIP Phase-I, the Ministry of Jal Shakti initiated another 10 externally funded schemes, DRIP Phase-II, and Phase-III. The scheme has provision for rehabilitation of 736 dams located in 19 States, including those under 3 Central agencies (Central Water Commission, Bhakra Beas Management Board, and Damodar Valley Corporation). It is a State Sector Scheme having a Central component, with a duration of 10 years, to be implemented in two Phases, i.e., Phase-II and Phase-III, each of six years duration with an overlap of two years.

Various irrigation and river water rejuvenation schemes in India have multiple objectives like expanding the cultivable area under assured irrigation, improving water use efficiency, Ground Water 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 optimising investments in storage projects by prioritising the completion of long pending major and medium irrigation projects and improving water use efficiency in agriculture through a variety of measures. The scheme combines the following programmes for development of water and irrigation resources- Accelerated Irrigation Benefits Programme (AIBP), Command Area Development and Water Management (CADWM) and Har Khet Ko Paani (HKKP) - Surface Minor Irrigation (SMI) and Repair, Renovation and Restoration (RRR) of water bodies. PMKSY-AIBP, including CADWM, has so far approved the completion of 60 ongoing AIBP projects and 85 CADWM projects, along with providing financial assistance to the implementation of new major and medium irrigation projects. Under PMKSY-AIBP, ninety-nine (99) long-pending Major/Medium Irrigation projects (and 7 phases) spread in 18 States were identified during 2016-17 for completion in mission mode. Out of these, 46 projects have been completed. An irrigation potential of 76.02 lakh ha is proposed to be created through these projects, out of which 64.14 lakh ha has been created up to March 2021. Under the SMI component of this scheme, 4.5 lakh hectares of minor irrigation using surface water is targeted through SMI and RRR of water bodies (2021-22 to 2025-26). Under the Repair, Renovation, and Restoration (RRR) of the Waterbodies scheme, 2,333 schemes are ongoing with an estimated cost of Rs. 1,981 crores. In the approval by the Government of India for the continuation of the scheme from 2021-22 to 2025-26, 4.5 lakh hectares of minor irrigation using surface water is targeted through SMI and RRR of water bodies. In the approval by the Government of India for the continuation of the scheme from 2021-22 to 2025-26, 4.5 lakh hectares of minor irrigation using surface water is targeted through SMI and RRR of water bodies.

The Ganga River basin represents a system of closely interconnected dynamism between the biotic (plants, animals, microorganisms) and abiotic (soil, water) components. Hence, adequate magnitude, timing, frequency, and duration of flows are essential to sustain river-dependent ecosystems. Following these recommendations, diverse interventions have been devised under the Namami Gange Programme to improve the river's health and ecosystem. 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 Mission mode, viz., Aviral Dhara, Nirmal Dhara, Ecological Restoration, Sustainable

Agriculture, Geological Safeguarding, Basin Protection Against Disasters, River Hazard Management and Environmental Knowledge Building and Sensitization. To address the threats to aquatic biodiversity and enable the restoration of viable populations of all endemic and endangered species in Ganga, NMCG, in partnership with Wildlife Institute of India (WII), Dehradun, Uttar Pradesh State Forest Department and Central Inland Fishery Institute (CIFRI), Barrackpore, is adopting a basin approach. The approach followed in the case of Ganga has been expanded to 13 more rivers by the Ministry of Environment, Forest and Climate Change.

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 in 256 water-stressed districts of the country. During Jal Shakti Abhiyan, officers, groundwater experts, and scientists from the Government of India worked with state and district officials, civil society, and communities to promote water conservation and resource management.

Climate change is expected to exacerbate current pressures on groundwater resources, particularly in a scenario where users increasingly turn to groundwater as surface water supplies become unreliable. Sustainable groundwater management initiatives offer significant drought resilience and climate adaptation opportunities. They also play an important 'stabilisation role' in coping with midseason dry spells, a 'buffering role' during monsoon failure, and a role as 'carry-over storage' during multiyear droughts. Improvement in groundwater conditions and consequent rise in water levels hold great promise for significantly reducing carbon emissions from diesel pumps used for irrigation.

Atal Bhujal Yojana (ATAL JAL) is a World Bank-aided Central Sector Scheme of the Government of India with an outlay of Rs 6,000 crore, focusing on community participation and demand-side interventions for sustainable groundwater management in identified water-stressed areas. The scheme (implemented since April, 2020) targets 8,220 water stressed Gram Panchayats of 229 administrative blocks/Talukas across 80 districts of seven States. These states include Gujarat, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan and Uttar Pradesh (accounting for about 37% of the total number of water-stressed (over-exploited, critical and semi-critical blocks in India).

The Jal Jeevan Mission (JJM) is a key initiative of the Government of India under the Ministry of Jal Shakti. The mission was launched in August 15, 2019, with the ambitious goal of providing tap water supply to every rural household by 2024. It focuses on sustainable water management, source sustainability, and community participation, emphasizing women's empowerment and the role of village-level committees. JJM promotes the integration of modern technology for monitoring and quality assurance, including IoT-based sensors and geo-tagging of infrastructure. It also addresses critical challenges like water scarcity, contamination, and climate-induced impacts. JJM has made remarkable progress in ensuring safe drinking water access for rural households As of September 2024, over 150 million tap connections have been installed, up from just three million in 2019 (PIB 2024).

There are several important institutions, regulatory bodies, and ongoing research and development that seek to regulate water resources, provide real time information, and aid in more efficient utilization of water resources. Some of these are mentioned below:

- The Central Water Commission (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 hydro-power development. The CWC also provides 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 resources 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 functions as an adviser and consultant 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 level, discharge, reservoir level, groundwater level, surface and groundwater quality etc. on the platform

- Water Resources Information System (India-WRIS) is a GIS-enabled public platform (accessible through URL: indiawris.gov.in) 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.

- The Central Ground Water Board (CGWB) is an institution under the Ministry of Jal Shakti, Government of India, responsible for the sustainable management and regulation of groundwater resources in the country. Established in 1970, the CGWB conducts extensive research, monitoring, and assessment of groundwater quality and quantity, facilitating the development of policies for effective groundwater management. It also engages in various initiatives, including aquifer mapping and the installation of monitoring networks, to address challenges related to groundwater depletion and contamination.

- Central Ground Water Authority (CGWA) has been constituted under section 3(3) of the "Environment (Protection) Act, 1986" for the purpose of regulation and control of ground water by industries, mining projects, infrastructure projects etc in the country. The guidelines in this regard, with pan-India applicability, were notified by the Ministry on 24 September 2020 with subsequent amendment on 29 March 2023. CGWA and States issue No Objection Certificate (NOC) for extraction of groundwater to various industries/project proponents as per their jurisdiction and as per the extant guidelines. The guidelines also include provisions for groundwater management in agriculture sector.

### 1.4.3 Himalayan Cryosphere

The Himalayan glacier systems are an important ecosystem within the Indian sub-continent. Water supply from snow and glacier melt affects the livelihood of large Himalayan Mountain communities. The Himalayan Mountain range supplies water to major Indian rivers, including the Ganga and the Brahmaputra. Climate change is most likely to enhance the retreat of glaciers. This may potentially increase the number of glacial lakes and expand the size of existing ones. The Indian Himalayan Region (IHR) is facing critical challenges while coping with the adverse effects of climate change. IHR also lies in Seismic Zones IV and V, making the region highly prone to earthquakes. Consequently, glacial lakes are vulnerable to breaches, unleashing sudden, potentially disastrous floods in the nearby communities.

In terms of precipitation (snow cover and snowfall) and glacial systems in the Himalayan cryosphere the following observations are to be made:

- Between 1991 and 2015, there has been a significant increase in total precipitation but a decrease in snowfall in the western Himalayan region (Negi et al., 2018).

- No significant trend in mean snow cover has been reported for the entire Himalayas, but significant inter and intra-annual variations in basins have been observed. Snow-covered areas (SCA) in Jhelum, Kosi, Gandaki and Manas River basins have decreased (2003-2012) (Gurung et al., 2017).

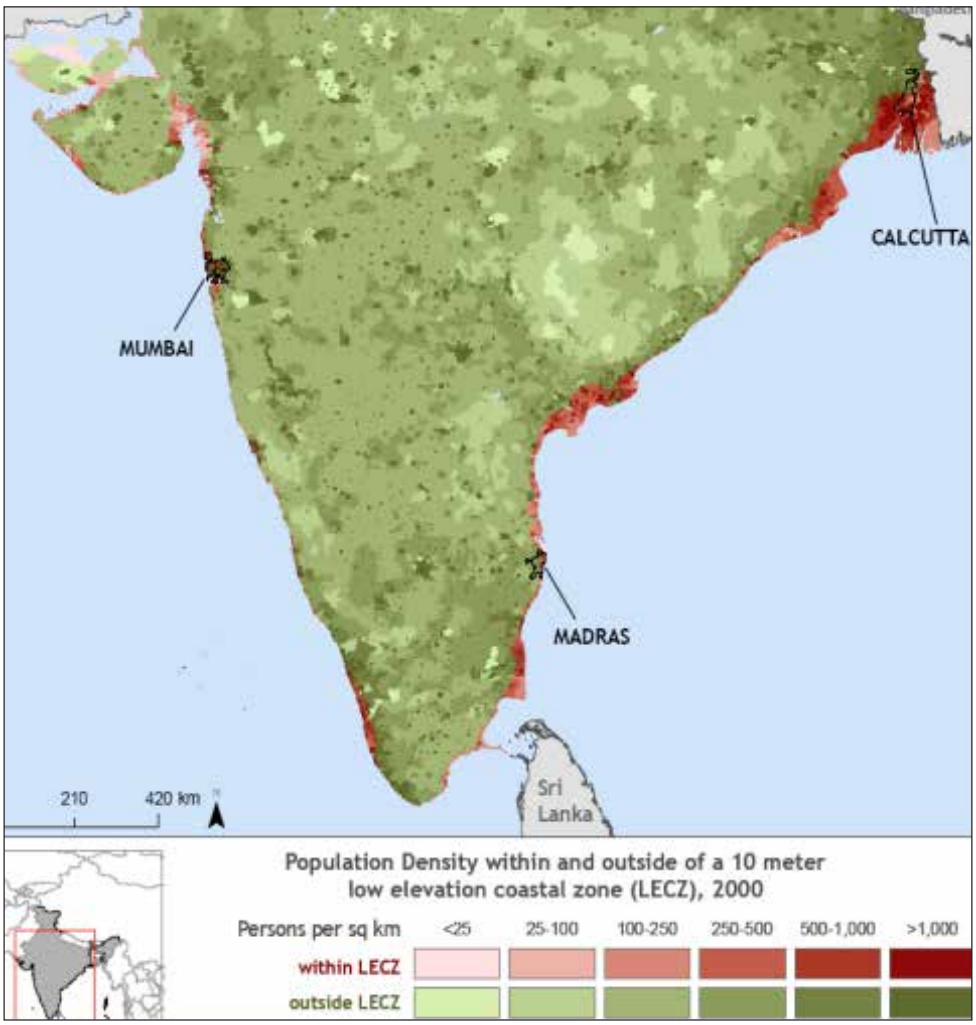



*Figure 1.11: Population density within and outside 10 m low elevation coastal zone (2000)*
*Source: INCOIS; available at https://incois.gov.in/documents/ITCOocean/Coastal_Vulnerability_Mapping.pdf*

- The mean rate of retreat of glaciers in the Himalayan region was estimated to be 14.2±12.9 ma-1 (Huss and Hock, 2018; Singh et al., 2020).
- A recent study published in the IMD journal MAUSAM, reported that between 1999-2019, several significant fluctuations in annual temperature anomaly over the Himalayan region has affected the Himalayan Cryosphere dynamics (Pandey et al, 2023). The study also states that other factors such as soil type, rock type, vegetation cover and soil moisture affect cryosphere shrinking and that there is no universal numerical cut-off point of cryosphere shrinking in the Himalayas (ibid).
- According to the 2021-22 annual report of the NCPOR, glaciers in the Chandra Basins of the Himalayan Cryosphere have experienced a glacier area loss rate of 0.2 $km^2a^{-1}$ and an increase in the number of glaciers on account of fragmentation. The report also states that based on an NCPOR of MODIS satellite data, there is no significant change in snow cover in the Chandra basin glaciers. However, it observes a slight decrease in snow cover in the area over the decades 2000 and 2019.

The research indicates that overall, the glacier tongues (snout) recession has accelerated in the last few decades. In general, Himalayan glaciers are undergoing thinning (mass loss) and reduction in length and area in the present climate conditions. However, the recession rate and the amount of mass loss of Himalayan glaciers vary from glacier to glacier depending on the geographical location and climatic regime. In addition, landslides and related phenomena are ubiquitous in the Himalayan region. Limited ice thickness and volume data is available in Himalaya due to challenges in applying radar and other field methods in rugged terrain. Large uncertainties of existing data estimates indicate the need for further improvement in the techniques.

## 1.4.4 Coastal regions, marine ecosystems, and wetlands

India's coastline spreads over nine states and five union territories and is recorded to be approximately 8000 km. It includes 1,208 island territories. Further it is important to note that 26% of the Indian population lives within 100km from the shoreline, with most of the coastal areas being low lying and vulnerable to disasters such as Tsunamis, Storm Surges, and Sea level rise. The figure 1.11 below shows the population density across the Indian shoreline and the presence of population in low elevated coastal zones of India.

Coastal regions are unique because of their position at the interface of the atmosphere, lithosphere, and hydrosphere. Across its coast, the important marine ecosystems found in India 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.

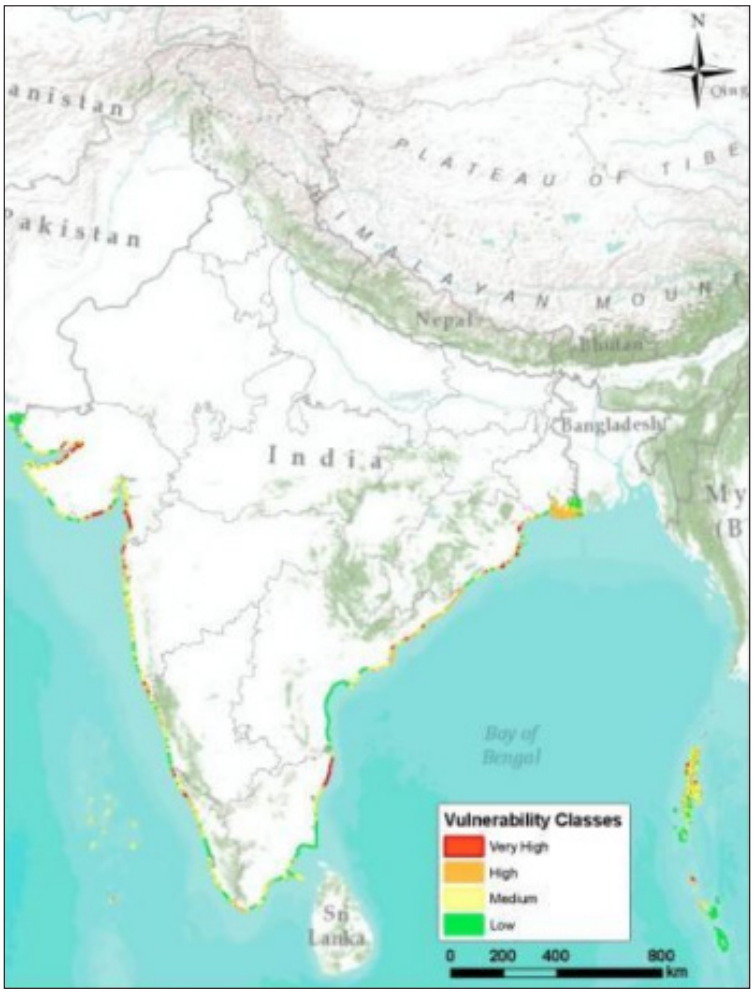



*Figure 1.12: Coastal Vulnerability Index Atlas of India (2012)*

*Source: INCOIS, (2012). Coastal Vulnerability Atlas of India. INCOIS-ASG-CGAM-CV-2012-01, Pages 212, Maps 156, INCOIS, Hyderabad, India. ISBN 978-81- 923474-0-0.*

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 (2019) examined the 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, with 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 analyzed 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 figure 1.12 below provides the existing vulnerability index map of India's coastline from 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 will affect populations, including fisherfolk, salt pan workers, farmers in coastal agriculture, urban populations, 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 (MoEFCC, 2020a).

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 thermal expansion of ocean water, as well as subsidence or uplift of land at various locations across 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, 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 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 with 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. The Wetland Conservation Project 'Conserving and Sustainably Managing Gangetic Floodplains of Uttar Pradesh' was sanctioned in June 2020 towards the comprehensive conservation and management of 282 Gangetic floodplain wetlands within a buffer of 10 km of the river Ganga in 27 Ganga riverbank districts of Uttar Pradesh. Similarly, a project called "Conserving and sustainably managing Gangetic floodplain wetlands of Bihar" was sanctioned to Bihar in December 2021 for wetland inventory, assessment and management planning within 10 km on either side of the main Ganga River channel in 12 districts in Bihar. The project will primarily focus on 387 natural wetlands > 2.25 ha. in area.

# 1.5 Energy Profile

This section provides a description of India's energy balance statistics (highlighting primary energy supply and primary energy demand) as well as India's policies for energy security and renewable energy. The information and statistics provided here are drawn from the report on India's Energy statistics 2024, prepared by the Ministry of Statistics and Planning in India for the financial year 2022-23.

India is home to 18% (approx.) of the global population but its annual primary energy consumption per capita in 2022-23 was 25.4 gigajoules (GJ) (MoSPI, 2024).

## 1.5.1 Primary energy supply and demand

In 2022-23 (provisional figures), the Primary Energy Supply increased to 8,50,349 Kilo Tonnes of Oil equivalent (toe), an increase of 14.33% from 2021-22. Two major contributors to the total energy supply in the country were coal, which accounted for 57.82% of the total, and crude oil, which accounted for 31.48%. Total Final Consumption (TFC) during 2022-23 was 5,51,550 ktoe.

The industrial sector was the largest consumer of energy in the country, consuming approximately half of the total final consumption i.e., 2,70,000 ktoe. Within the industrial sector, the most energy-intensive industries were iron and steel (15.15% of total final consumption), followed by chemicals and petrochemicals and construction (4.56% and 1.80%, respectively). Agriculture, residential consumption, commercial sector,

public sector, and other sectors combined to contribute a little less than 2/5th of the total final consumption. The transportation sector consumed approximately 1/10th of the total final consumption.

### 1.5.2 Energy security, post-COVID recovery, and future

India's energy security policies are geared towards improving energy supply, improving the standards of living of its people in terms of energy consumption, and contributing towards climate mitigation, based on India's right to a fair share of the global carbon budget. Currently, India's energy generation capacities are improving but are well below the consumption standards of most developed countries. To address climate change mitigation and to improve India's energy mix, there has been an increased effort to enhance the share of renewable energy sources. Most recently, India's updated NDC target submitted to the UNFCCC, intends to reduce emissions intensity of GDP by 45% in 2030 compared to 2005 levels. This updated target also includes achieving about 50 percent cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030. In recent years, the COVID-19 pandemic has presented challenges to the RE (Renewable Energy) sector. The pace of renewable energy project development and commissioning was impacted. Along with the broader policy goal of improving energy supply and increasing energy consumption standards, several measures have been undertaken to address risks to the energy sector caused by COVID-19.

Despite the challenges brought about by the Covid-19 pandemic, the Ministry of New and Renewable Energy's proactive measures have resulted in the installation of 211.39 GW (46.52%) of capacity from non-fossil fuel-based energy sources in India as of 31st October, 2024.

## 1.6 Sustainable development, Urbanisation, and broader socio-economic transitions

As seen in sections 1.2, 1.3, and 1.4, exposure to extreme events, the vulnerability of populations, and the negative consequences of such events remain an essential concern for India's economy and society. Climate change poses a considerable challenge to India's consistent and determined efforts to rapidly advance its development status with the declared aspirational goal of reaching the ranks of developed countries by 2047. In this journey, the need to overcome India's development deficits, is of the utmost priority.

The ability to improve climate adaptation strategies, vulnerability mapping, and disaster management are also intrinsically tied to the overall improvement of socio-economic parameters in the living conditions of India's population. The objective of achieving a sustainable transition to improve the living and working conditions of all citizens of India guides the policies of the Central Government of India. The following sections, therefore, highlight these broader concerns of sustainable development, long-term development strategies, and other socio-economic concerns.

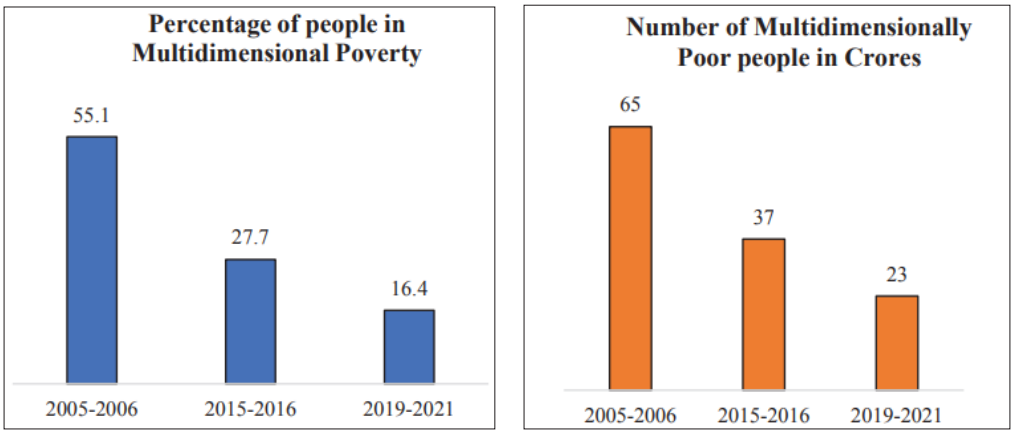



*Fig 1.13 Multidimensional Poverty and India over the years*
*Source: UNDP Report on Multidimensional Poverty, 2022*

## 1.6.1 Poverty eradication, Human Development, and Sustainable Development Goals

This sub-section highlights India's progress in eradicating poverty, achieving better human development, as well as achieving the Sustainable Development Goals (SDG). It also highlights broader policy frameworks for achieving broader sustainability transitions.

A significant portion of the Indian population has been uplifted from the conditions of destitute poverty prevalent at the time of Independence. This project continues in recent times with revisions in the national poverty line to reflect increasing decent standards of living. The 2024 report of the UNDP on Multidimensional Poverty Index (released in 2024) estimates that 16.4% of the population in India (234 million people in 2022) is multidimensionally poor while an additional 18.7 per cent is classified as vulnerable to multidimensional poverty (2666 million people in 2022). The average deprivation score among people living in multidimensional poverty is 42%. The share of the population that is multidimensionally poor adjusted by the intensity of the deprivations or the MPI score for India is 0.069. Further, the same UNDP report estimated that in India, 415 million people exited poverty between 2005-06 and 2019-21. This implies that India is on track to achieve the SDG target 1.2 of reducing at least by half the proportion of men, women, and children of all ages living in poverty in all its dimensions according to national definitions by 2030.

Improving India's 'Human Development' as measured and operationalized by the Human Development Index (HDI), is an important aspect of India's goal to achieve development for all. Over the recent years various challenges have affected the world including India, such as the Covid-19 pandemic in 2020 and 2021, and other global geo-political events such as the Russia-Ukraine conflict in 2022. According to the United Nations Development Programme (UNDP) report, between 2020 and 2021, approximately 90% of all countries registered a decline in their HDI score. India ranked 134 out of 193 countries in the 2023-24 UNDP HDI report. India is currently in the medium human development category with a HDI score of 0.633. However, India's HDI value has continued moving towards the global average HIS score over the past two decades.

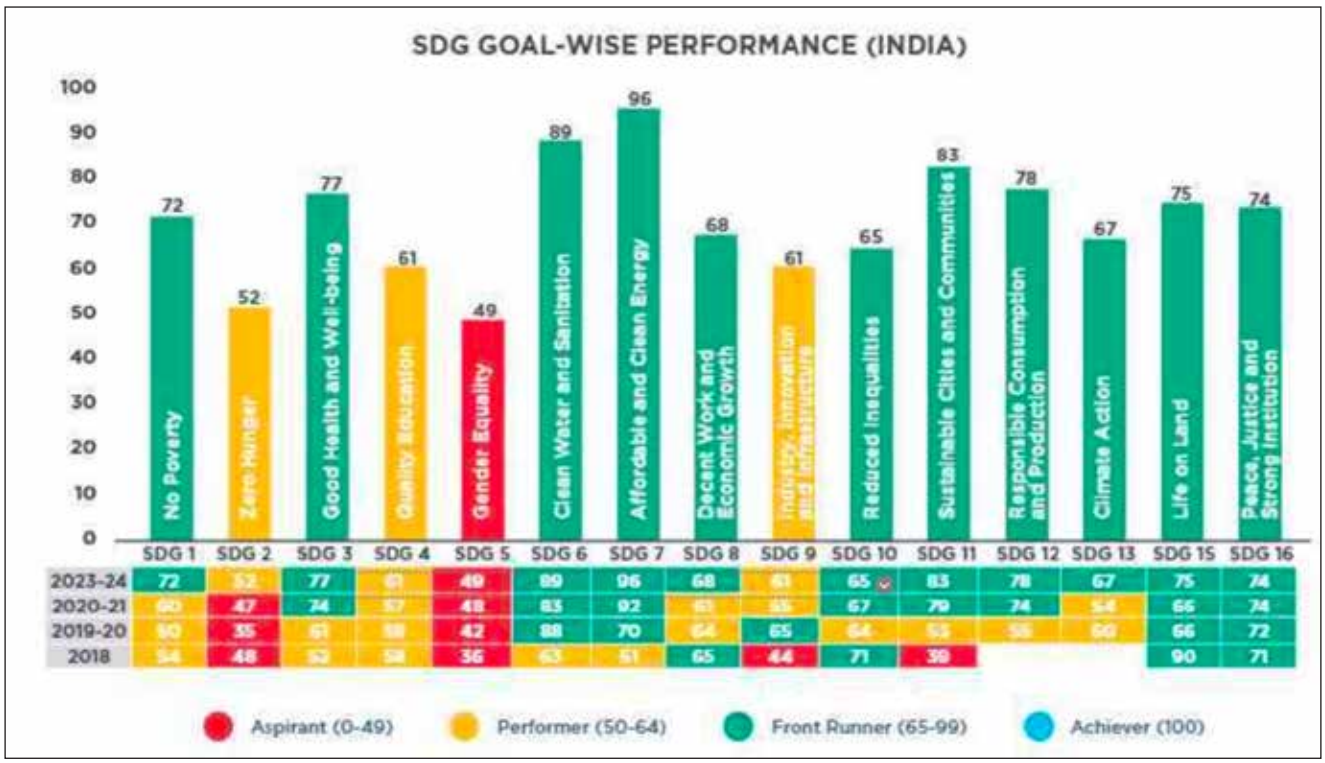



*Fig1.14 Overall performance of India across SDG India Index (2018 - 2024)*

*Source: NITI Aayog; Image source: Chapter 2; SDG India Index: Methodology and Results.*

Note: Yellow indicates Performer (Score 50-64), Green indicates Front Runner (Score 65-99)

An essential aspect of India's policy to achieve SDGs is that State government initiatives lead it. To monitor this transition, the NITI Aayog monitors and publishes the SDG India Index and Dashboard (derived from the National Indicator Framework (NIF), developed by the Ministry of Statistics and Programme Implementation (MoSPI) and the United Nations Resident Coordinator Office (UNRCO) in India). The NITI Aayog SDG Index and dashboard indicate that India's overall score improved to 71 in 2023-24 from 57 in 2018-19. The significant improvements in SDG indicators were related to SDG3 (good health and well-being;), SDG6 (clean water and sanitation), SDG 7 (affordable and clean energy; achieved by 15 states and 5 UTs), SDG 10 (reduced inequalities), SDG11 (sustainable cities and communities), SDG 12 (responsible consumption and production), SDG 15 (life on land) and SDG 16 (peace, justice, and strong institutions). The figure 1.17 below shows how India has performed across different SDG parameters over the past few years as per the SDG India Index.

## 1.6.2 Urbanisation

According to the 2011 Census of India, about 377.1 million out of the total population of 1210.2 million lived in urban areas. The decadal growth of India's urban population (between 2001- 2011) was approximately 31.08%. India has the second-largest urban system in the world, with about 11% of the global urban population living in Indian cities. According to the United Nations-Habitat's World Cities Report (2022), approximately 2/5$^{th}$ of the Indian population is projected to live in urban areas by 2035 (approx. 675 million). This figure is projected to increase to over 2/3$^{rd}$ 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 kilometre).

The major challenges related to rapid urbanisation include- housing, sustainable development infrastructure, water security, waste management, and sanitation. Although access to housing has improved over the last decade, accessible and affordable housing and drinking water for the poor is a major issue. According to the State of Housing in India 2013 (MoHUA, 2017), there are 98.32 million urban census households (or 32 per cent of total households in the country), with an average household size of 4.8 persons per household. The projected slum population India between 2011 to 2017 is estimated to have increased from 93 million people to 104 million people. More than 1/3$^{rd}$ of these houses is built using non-permanent roof material, 15% with temporary wall materials, and 12% with mud-based tile materials. Only 53.76 million urban houses were classified as good habitable conditions, 22.4 million houses were classified as 'livable habitable conditions', and 2.26 million houses were considered to be in 'dilapidated condition'. Nearly 96 per cent of the housing shortage in urban regions pertains to the economically weaker sections and lower-income groups. Access to clean and safe drinking water in urban areas is an immediate issue affecting the Indian population. Nearly 30 per cent of urban households relied directly on tubewells, water wells, springs, rivers, canals, tanks, ponds, and lakes for drinking water.

Some of the important policy schemes and resulting achievements in improving urban infrastructure in India in recent years are described below:

The Atal Mission for Rejuvenation and Urban Transformation (AMRUT) 2.0 was launched in 2021 towards improving urban water security and providing tap water connections for all households. Currently, under the AMRUT scheme, 4,830 projects worth ₹93,381 crore of Water Supply, Water Body Rejuvenation, Sewerage and Septage Management, Parks and Green Space Development were approved. More than 1.20 crore houses sanctioned so far and more than 64 lakhs completed under the Pradhan Mantri Awas Yojana- Urban. About 83 kms of metro rail lines commissioned in the cities of Pune, Mumbai, Kolkata, Kochi, Ahmedabad and Nagpur under Urban Transport Mission. To address concerns of housing. The Pradhan Mantri Awas Yojana-Urban (PMAY-U) was launched in 2015. By November 2022, more than 1.2 crore houses were sanctioned under the scheme (with 64 lakh completed houses). The houses built under the scheme include all basic amenities like kitchen, water supply, electricity and toilet. The Insurance Regulatory and Development Authority of India (IRDAI) issued IRDAI (Micro Insurance) Regulations, 2015, to improve insurance coverage for the urban poor of India. In the year 2020-21, approximately 10.7 lakh new micro-insurance policies were issued to individuals. The Smart Cities Mission was launched to promote cities with core infrastructure, decent quality of life, and sustainable environment. As a part of this scheme, currently 5,005 projects worth ₹92,766 crore

have been completed (until December 2022), with 2,737 projects worth 88,796 crore in the advanced stage of implementation. Further, Integrated Command and Control Centers (ICCC) developed in all 100 Smart Cities to incorporate technology in urban management; they became war rooms during COVID-19 pandemic.

Waste management and sanitation are an important concern affecting India's urban population. The 2011 Census of India indicates that 12% of the Urban population was still practising Open defecation (OD). Further, only 18% of the municipal solid waste (MSW) generated in Urban India was scientifically treated. The Swachh Bharat Mission (Clean India Mission) (SBM), launched in 2014, was aimed at addressing these challenges while also taking forward the country's committed mandate of meeting the Sustainable Development Goals (SDGs). The Mission has created a deep impact on people's health, livelihoods, quality of life and most importantly, in their thoughts and behaviour. In making urban India ODF, more than 70 lakh toilets have been built, delinked from socio-economic status or land rights, thus changing women's and children's lives and giving them greater dignity and safety.

Apart from the above, several important policies on waste management have improved the treatment and management of waste. Scientific processing of waste has gone up four times since 2014, from a mere 18% to 73%. Moreover, 98% of urban wards in the country are covered by a door-to-door collection of MSW. 89% of wards have started segregation of waste at source.

As an attempt to reduce pollution caused due to littered plastic waste in the country, the Ministry of Environment, Forest and Climate Change, Government of India, notified the Plastic Waste Management Amendment Rules, 2021, on August 12, 2021. The measures will promote a circular economy, reduce the plastic footprint of plastic packaging, promote the development of new alternatives to plastic packaging and provide the next steps for moving towards sustainable plastic packaging by businesses. Further, a variety of policy interventions have been introduced to encourage conversion of waste to value added products. The focus is on creating an eco-system so that waste to wealth projects and the circular economy approach become financially viable and sustainable. MoHUA has brought out the knowledge product 'Circular Economy in Municipal Solid and Liquid Waste Management 'in this context. The MoHUA is also allied with programmes like the LiFE (Lifestyle for Environment) Mission to promote sustainability. In line with the above existing policies, the LT-LEDS Climate-resilient urban development will be driven by smart city initiatives, integrated planning of cities for mainstreaming adaptation and enhancing energy and resource efficiency, effective green building codes and developments in innovative solid and liquid waste management.

### 1.6.3 Emission standards and regulations for urban air pollution

Improving the quality control of vehicular emissions and progressively improving the standards for vehicular emissions and pollution control have been the cornerstone of India's transport regulation policies. A separate project to address vehicle related air pollution is underway in the national capital city of Delhi and its adjoining areas. The Commission on Air Quality Management in Capital Region and Adjoining Areas (CAQM) has been set up for Air Quality Management in National Capital Region and Adjoining Areas for better co-ordination, research, identification and resolution of problems surrounding the air quality index and for matters connected therewith or incidental thereto.

## 1.7 Transportation

The transportation sector (consisting of road, rail, and air transport infrastructure) are significant to build capacities for improved economic growth, general human development, as well as play a key role in long-term climate mitigation and adaptation strategies. With the increase in income levels and urbanisation, the demand for transportation in India is likely to increase. The objective of achieving a sustainable transition to improve the living and working conditions of all citizens of India guides the policies of the Central Government of India. This section highlights the important policies undertaken to improve sustainability within road transport, rail transport, and air transport. It also details various policies and schemes undertaken to improve the production and adoption of electric vehicles to mitigate emissions from this sector.

## 1.7.1 Road transport initiatives

The Indian Road network is the second largest road network in the World with about 63.45 lakh km, of which 146 lakh km are national highways and 179 lakh km are state highways (MoRTH, 2024). The capacity of National Highways in term of handling traffic (passenger and goods) needs to keep pace with economic growth. Keeping India's climate commitments and goals in mind against the backdrop of highways as enablers of development, a rapid assessment of mitigation potential of sustainable road transportation on India's national highways is being carried out. This includes a study of 20 National Highways across India to quantify the potential emissions of $CO_2$ per km that can be avoided by the National Highway operations.

## 1.7.2 Rail transport initiatives

Indian Railways has the fourth-largest railway network in the world. It is one of the major consumers of electricity in the nation. The railroads run 9,146 freight trains and 13,523 passenger trains per day. The freight loaded onto Indian railways during the financial year (FY) 2021–22 increased by 15 per cent from the previous year to a value of around 1418.1 MT. With 1.3 million employees, Indian Railways ranks seventh globally and is India's top employer. (PIB 2022a). efficiency. According to Indian Railways, the increase in electrification since 2014 has been about ten times as of June 2021. The broad-gauge network scheduled for electrification is 64,689 route kilometres (RKM), out of which more than 42,600 RKM, or more than 66 per cent of railway lines, have already been completed. (PIB, 2021; IR, 2024).

Various sustainable mobility schemes and policies are already underway across the country. These include various capacity-building exercises and the creation of platforms to encourage citizen partnership in achieving sustainable mobility.

## 1.7.3 Policies for the promotion of electric vehicles

As part of India's commitment to a low-carbon development pathway, the Central government, over the past decade, has introduced various initiatives to encourage the adoption of electric vehicles (EVs) across the country. These efforts include offering tax benefits to EV owners and developing public charging infrastructure. The flagship program promoting electric mobility in India is FAME (Faster Adoption and Manufacturing of (Hybrid and) Electric Vehicles). Currently in its second phase, FAME-II has been implemented

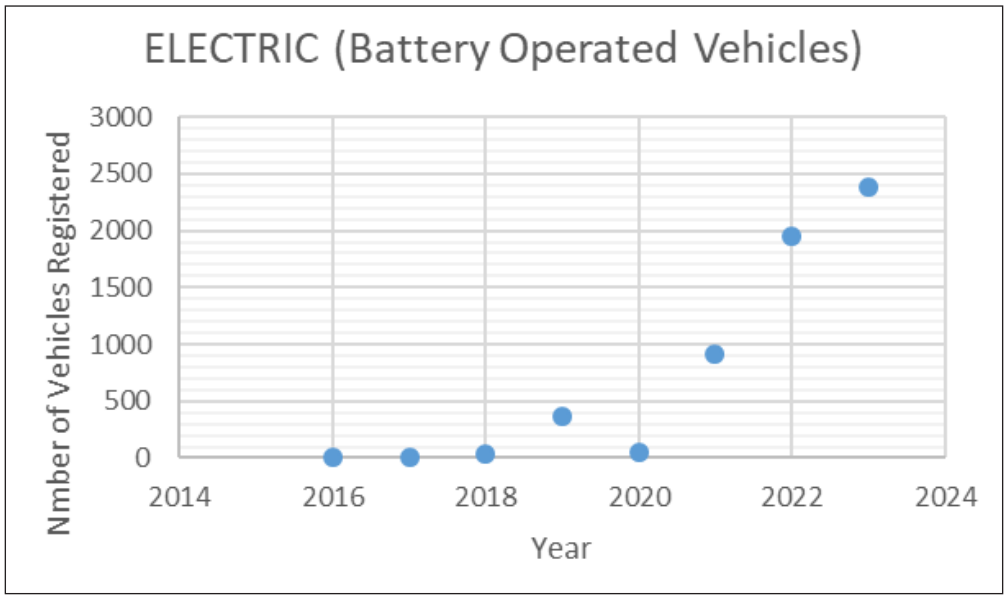



*Fig.1.15 Heavy Passenger Vehicles registered as EV operated*

*Source: Graph extracted from the VAHAN database https://vahan.parivahan.gov.in/vahan4dashboard/vahan/dashboardview.xhtml*

for three years starting from April 1, 2019, with a budget of 10,000 Cr. Fig.1.15 describes the number of electric vehicles registered under the category of heavy passenger vehicles (bus). For the number of electric vehicles registered under the category of heavy passenger vehicles, an increasing trend has been observed in India.

The PM E-DRIVE scheme with a budget outlay of Rs. 10,900 crores aims to accelerate EV adoption and establish essential charging infrastructure across the country, promoting cleaner and more sustainable transportation thereby reducing environmental pollution. The scheme provides subsidies (demand incentives for e-2W, e-3W, e-ambulances (Significant move for greener healthcare solutions), e-trucks and other new emerging EV categories) and Grants for creation of capital assets for e-buses, establishment of network of charging stations & upgradation of testing agencies. The scheme aims to support 24.79 lakh e-2Ws, 3.16 lakh e-3Ws, and 14,028 e-buses. (PIB 2024)

Also, almost all of the states except few have their State EV policy framework in place to accelerate EV adoption, circular economy and transition towards a greener future with no emissions.

# 1.8 Response to Climate Change

Climate Change is a global problem that requires collective actions and sharing of the global carbon budget or carbon space (for a particular temperature target) in a fair and equitable manner. Despite India's relatively low historical contribution to cumulative global GHG emissions and India's minimal per capita GHG emission, India is committed to addressing the global action problem of climate change based on equity and the principle of common but differentiated responsibilities and respective capabilities (CBDR-RC), as enshrined in the United Nations Framework Convention on Climate Change (UNFCCC).

India has been an active and leading voice in emphasizing the need for the world to take action to meet the intertwined challenges of sustainable development and poverty eradication as well as climate action. This role includes its active participation in the formation and signature/ratification of the UNFCCC itself, its adherence to the letter and spirit of the Kyoto Protocol and active participation in its implementation. Despite its minimal responsibility for global warming, India has pro-actively worked towards global solutions including joining the Copenhagen Declaration, the Cancun Agreements and eventually working actively for the finalization of the Paris Agreement.

## 1.8.1 National Action Plan on Climate Change (NAPCC)

The first set of domestic strategies enacted in India to address climate change were the National Missions under the National Action Plan on climate Change. The principles underlying the NAPCC include a) protection of the poor through an inclusive and sustainable development strategy, sensitive to climate change b) achievement of growth and poverty alleviation objectives while ensuring ecological sustainability c) efficient and cost-effective strategies for end-use demand-side management d)accelerated deployment of appropriate technologies for adaptation and mitigation e) market, regulatory, and voluntary mechanisms for sustainable development and f) effective implementation of the action plan through linkages with civil society, local governments, and public-private partnerships.

The National Action Plan on Climate Change (NAPCC) and includes nine national missions covering –

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

The NAPCC missions, therefore, recognize the important linkages between development goals and climate mitigation and adaptation levels. They are also cognizant of the trade-offs between them. India's developmental challenges relating to access to critical services, such as sanitation, housing, and transport, as managing urban growth and rural opportunities are crucial in achieving any climate-related policy. Thirty-four states and union territories have prepared their respective State Action Plans on Climate Change, in line with the NAPCC.

## 1.8.2 India's NDC submission to the UNFCCC

In line with the above principles, and the general emphasis of the NAPCC, India submitted an updated Nationally Determined Contribution in August 2022, in keeping with the provisions of the Paris Agreement. to the 26th Conference of Parties to the UNFCCC. India's updated Nationally Determined Contributions (NDCs) are currently as follows:

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 [UPDATED].
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 the Emissions Intensity of its GDP by 45 percent by 2030, from the 2005 level [UPDATED].
4. To achieve about 50 percent cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030, with the help of the transfer of technology and low-cost international finance, including from Green Climate Fund (GCF) [UPDATED].
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, Himalayan region, coastal regions, health and disaster management.
7. To mobilize domestic and new and 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.

Two of India's targets submitted in its NDCs are close to being achieved currently. As of 31st October 2024, 46.52% of the total cumulative power capacity in India (or 211.39 GW) was based on installed capacity from non-fossil fuel-based energy resources. Further, the emission intensity of its GDP has been reduced by 36 percent between 2005 and 2020. It is important to note that India's updated NDC does not set sector-specific mitigation targets, but India is committed to achieving and implementing various strategies to reduce emission intensity further, improve energy efficiency, and protect vulnerable sectors of the Indian economy (PIB, 2022).

An integrated approach to climate change and sustainability is also being adopted across several important economic policies and social welfare policies related to the building of social infrastructure.

Currently, India's mitigation and adaptation response measures have largely been funded domestically. However, it is also important to acknowledge the declaration made in India's NDC that multilateral and bilateral arrangements are a "critical enabler" in achieving goals for climate mitigation and adaptation. The NDC highlights the need "[to] mobilize domestic and new and additional funds from developed countries to implement the above mitigation and adaptation actions in view of the resource required and the resource gap".

## 1.8.3 Long-Term Low Carbon Development Strategies (LT-LEDS)

In line with the above targets and principles of India's NDC, India has also formulated its broader LT-LEDS as per Art 4.19 of the Paris Agreement to achieve net-zero carbon emissions by 2070 through low carbon development in accordance with the principles of equity, common but differentiated responsibilities and respective capabilities, in the light of different national circumstances. India's LT-LEDS was communicated to the UNFCCC on the occasion of COP27 at Sharm-el-Sheikh in 2022.

The LT-LEDS emphasizes that India has had a minimal historical contribution to the consumption of the global carbon budget, and its annual per capita emissions remain modest. Further, as a developing country with low per capita energy use, India has considerable energy needs for development. This growth and development are also essential to build climate resilience and mitigate the climate risk and vulnerability that India will face with increasing global warming.

As stated in the LT-LEDS India is "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 CBDR-RC and national assessments of its development futures."

Hence India's LT-LEDS is based on four important considerations:

1. 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
2. The importance of addressing the concerns of millions of people living in energy poverty and improving India's overall energy security (India represents 17% of the global population and yet its annual primary energy consumption per capita in 2019 was 28.7 gigajoules (GJ), far lower than many developed and developing countries)
3. India's commitment to shift to low-carbon development pathways and addressing issues of household energy, energy security, and energy for the development of all sectors of the economy.
4. Building adaptation capacities to potential climate impacts to sustain India's growth and development, including the general improvement of human development levels of all its population.

India's LT-LEDS includes seven broad strategies that seek to achieve all the targets submitted in its updated NDC as well as address important development concerns. These are:

(i) Low carbon development of electricity systems that can achieve developmental goals and aspirations

(ii) Creating and sustaining an integrated, efficient, inclusive, low-carbon transport system

(iii) Improving adaptation in urban design, energy and material-efficiency in buildings, and sustainable urbanisation

(iv) Moving towards an economy-wide decoupling of growth from emissions and development of an efficient, innovative low-emission industrial system

(v) Enhancing Forest and vegetation cover consistent with socio-economic and ecological considerations

(vi) Addressing economic and financial aspects of India's economy that can provide a low-carbon development and Long-Term Transition to Net-Zero by 2070

(vii) Making efforts to promote carbon dioxide removal and other related engineering solutions to climate mitigation

Important qualifications to these strategies and targets within the LT-LEDS include

1. Expanding renewables and strengthening the grid in the short to medium term while strengthening the electricity grid and enhancing its flexibility
2. Other technologies for low-emissions development such as a greater role for nuclear energy and enhance support for R&D into future technologies such as green hydrogen, fuel cells, and biofuels.
3. Appropriate demand-side measures to meet the growing demand for energy services using less energy, while energy supply to the bulk of the population
4. Rational utilization of fossil fuel resources to transition to a state where the share of coal in installed capacity and supply of power will decline, but also recognising that coal will be needed for power and energy, including grid stabilisation, supply to industry and to guarantee India's energy security
5. Careful monitoring and assessment of the economic, technical and political feasibility of Carbon Capture Utilisation and Storage (CCUS).
6. Assessing and addressing risks and vulnerabilities of economic and infrastructural development, improving governance capacities, improving access to adaptation finance, and ensuring that strategies are both "equitable and inclusive".
7. To channelise positive behavioural change leading to change in demand and consequent change in policies involving the Government and private sector as articulated by the 'Mission LiFE' programme launched by India in 2022.

## 1.8.4 Financial Instruments and strategies to deal with climate risks

Climate-related financial risks pose both micro and macro-prudential concerns. Globally, focus on sustainable forms of finance and climate risks has been engaging the attention of regulators, national authorities, and supra-national authorities. A few of the climate finance initiatives undertaken, under the aegis of the Reserve Bank of India (RBI), include:

**International cooperation:** RBI joined the Central Banks and Supervisors Network for Greening the Financial System (NGFS) as a Member in April 2021. As a member of NGFS, the Bank is building capacity in terms of international best practices, and risk management in the financial sector. It has also tried to mobilise mainstream finance to support the transition towards a sustainable economy.

**Sustainable Finance Group and Greening India's Financial System:** A dedicated Sustainable Finance Group (SFG) has been constituted by the RBI to lead the regulatory initiatives in the areas of sustainable finance and climate risk. It has also explored how climate scenario exercises can be used to identify vulnerabilities in RBI-supervised entities' balance sheets, business models and gaps in their capabilities for measuring and managing climate-related financial risks.

**Integrating climate-related risks into financial stability monitoring:** In 2022, a survey was undertaken to assess the approach, level of preparedness and progress made by the leading scheduled commercial banks in managing climate risk. It revealed that though banks have begun taking steps in the area of climate risk and sustainable finance, there was a need for more concerted efforts and further action in this regard. A Discussion Paper (DP) on Climate Risk and Sustainable Finance was issued in July 2022 soliciting views from the stakeholders. Based on the analysis of feedback received on the DP, the Reserve Bank announced in February 2023 to issue guidelines on (i) a broad framework for acceptance of Green Deposits, (ii) a disclosure framework on Climate-related Financial Risks, and (iii) guidance on Climate Scenario Analysis and Stress Testing.

**Framework for acceptance of Green Deposits:** This framework (announced on April 11, 2023) was made to encourage more regulated entities (REs) to offer green deposits to customers, protect depositors' interest, address greenwashing risks and help augment the flow of credit to green activities/projects. Eligible REs will have to allocate the funds raised from green deposits to (i) the renewable energy sector; (ii) energy efficiency;

(iii) clean transportation; (iv) climate change adaptation; (v) sustainable water and waste management; (vi) pollution prevention and control; (vii) green buildings; (viii) sustainable management of living natural resources and land use; or (ix) terrestrial and aquatic biodiversity conservation. The allocation of funds raised through green deposits will also be subject to annual independent third-party verification/assurance.

**Draft disclosure framework on Climate-related Financial Risks**: As per the framework, the REs should disclose information about their climate-related financial risks and opportunities for the users of financial statements on four broad pillars-governance, strategy, risk management and metrics and targets. It is aimed to foster an early assessment of climate-related financial risks and opportunities and facilitate market discipline.

**Sovereign Green Bonds:** During 2022-23, sovereign green bonds (SGrBs) spread over two tranches of ₹8,000 crore each were issued on January 25, 2023 and February 9, 2023. They comprised 5-year and 10-year bonds of ₹4,000 crore in each tranche. During 2023-24, 5-year and 10-year SGrBs of ₹5,000 crore in each tranche were issued on November 10, 2023 and December 8, 2023, respectively. Auctions of 30-year SGrBs (two tranches of ₹5,000 crore each) were held in January-February 2024. SGrBs issued during 2022-23 and 2023-24 were notified as 'specified securities' under the fully accessible route (FAR) on January 23, 2023, and November 08, 2023, respectively, and non-residents were allowed to invest in these securities without any restrictions.

**The Priority Sector Lending (PSL) policy:** The Priority Sector Lending (PSL) policy has evolved over the years to meet the credit requirements of the productive sectors which contribute significantly to economic growth. The identification of these sectors as priority sectors is based on emerging national priorities such as employment generation, alleviation of poverty and inclusive growth. In view of the increasing importance of non-conventional and renewable sources of energy and to give further impetus to this segment, 'renewable energy' was introduced as a separate category under priority sector in April 2015. Additionally, priority sector classification is available without any credit cap for bank loans to MSMEs engaged, inter alia, in water supply; sewerage, waste management and remediation activities; electric power generation using solar energy; electric power generation using other non- conventional sources, etc.

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Integrated Ammonia and Urea plant of Mangalore Chemical and Fertilisers Limited

Photo Credit: Fertiliser Association of India

# Chapter-2: National Greenhouse Gas Inventory

## 2.1 Introduction

This chapter presents information regarding India's greenhouse gas (GHG) inventory for the year 2020. It includes detailed descriptions of the methodologies employed, data sources utilized, uncertainties identified, quality analysis (QA) and quality control (QC) activities conducted, as well as an analysis of trends. The chapter incorporates data from the previous inventory submission, thereby enhancing the transparency, accuracy, consistency, comparability and completeness of the inventory.

As required by the UNFCCC guidelines to prepare BURs, the national inventory is prepared in accordance with the paragraphs 8-24 of the Annex to Decision 17/CP.8 (UNFCCC, 2002), meant for reporting National Communications (NC) from Non-Annex I Parties to the UNFCCC. The update is consistent with capacities, time constraints, data availability and the level of support received for reporting.

The year 2020 data presented in this Fourth Biennial Update Report marks a transition point in our national greenhouse gas reporting framework. Same year's data is also included in our first Biennial Transparency Report (BTR1), which covers the period 2020-2022. To ensure alignment with future reporting requirements and maintain consistency across both submissions, the 2020 inventory in BUR4 mostly follows the enhanced transparency framework methodology introduced for BTR reporting. This methodological update, combined with the exceptional circumstances of the COVID-19 pandemic in 2020, means that direct comparisons with 2020 data should be interpreted with caution. The change in methodology reflects our commitment to meeting evolved international reporting standards while maintaining the highest quality of greenhouse gas inventory data.

This chapter provides a thorough estimate of the greenhouse gas inventory for the year 2020, which includes information on the sources and sinks of carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride ($SF_6$) emissions. Energy, industrial processes and product use, agriculture, land use, land-use change and forestry (LULUCF), and waste are among the sectors covered. The 2006 IPCC guidelines have been followed as per the extant capacities.

India's submission of its BURs aligns with its perspective on the importance of the multilateral process under the UNFCCC in addressing the challenge of climate change. The consistent and prompt submission of BURs by developing countries cannot be equated with the submission of Biennial Reports (BRs) by developed countries, which are expected to take the lead in climate action. It is essential to highlight that these BRs, along with the Biennial Transparency Reports (BTRs) under the Paris Agreement (PA) do not replace the need for substantive climate action. The preparation of the inventory in a large country like India represents a substantial financial burden, necessitating the mobilization of considerable expertise for its execution. Further detailing of inventory requirements under the PA, especially in relation to the large-scale presence of the informal sector, is a new and additional burden. The incorporation of reporting requirements into the global climate regime and various environmental agreements should not result in a scenario where the execution of substantive actions is hindered by an excessive focus on reporting.

The COVID-19 pandemic had a significant, albeit transient, effect on global greenhouse gas emissions. The implementation of global lockdown measures in 2020 resulted in a substantial reduction in transportation and industrial operations, leading to a temporary decline in carbon dioxide emissions. India, along with numerous other countries, experienced a more pronounced decrease. India's net emissions fell by approximately 6 per cent in 2020 compared to 2019.

## 2.2 Institutional Arrangement for GHG Inventory

Scientific and research institutions from across India, in collaboration with various government agencies, contributed to the development of the national inventory. 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. The MoEFCC commissions studies to specialized institutions and collaborates with other governmental agencies tasked with the collection of official statistics and data. Following the establishment of these agreements, the technical team responsible for inventory engages in technical discussions with partners, oversees the updating and availability of information, and performs quality control.

In their respective fields of sectoral expertise, fifteen Indian institutions completed the inventory preparation exercise. Since India's Initial National Communication, many of these institutions and experts have contributed to the inventory preparation process. Various Ministries, Government agencies, and public sector organisations contributed to creation of the national inventory. The institutions involved in creating inventories across various industries are listed in Figure 2.1.

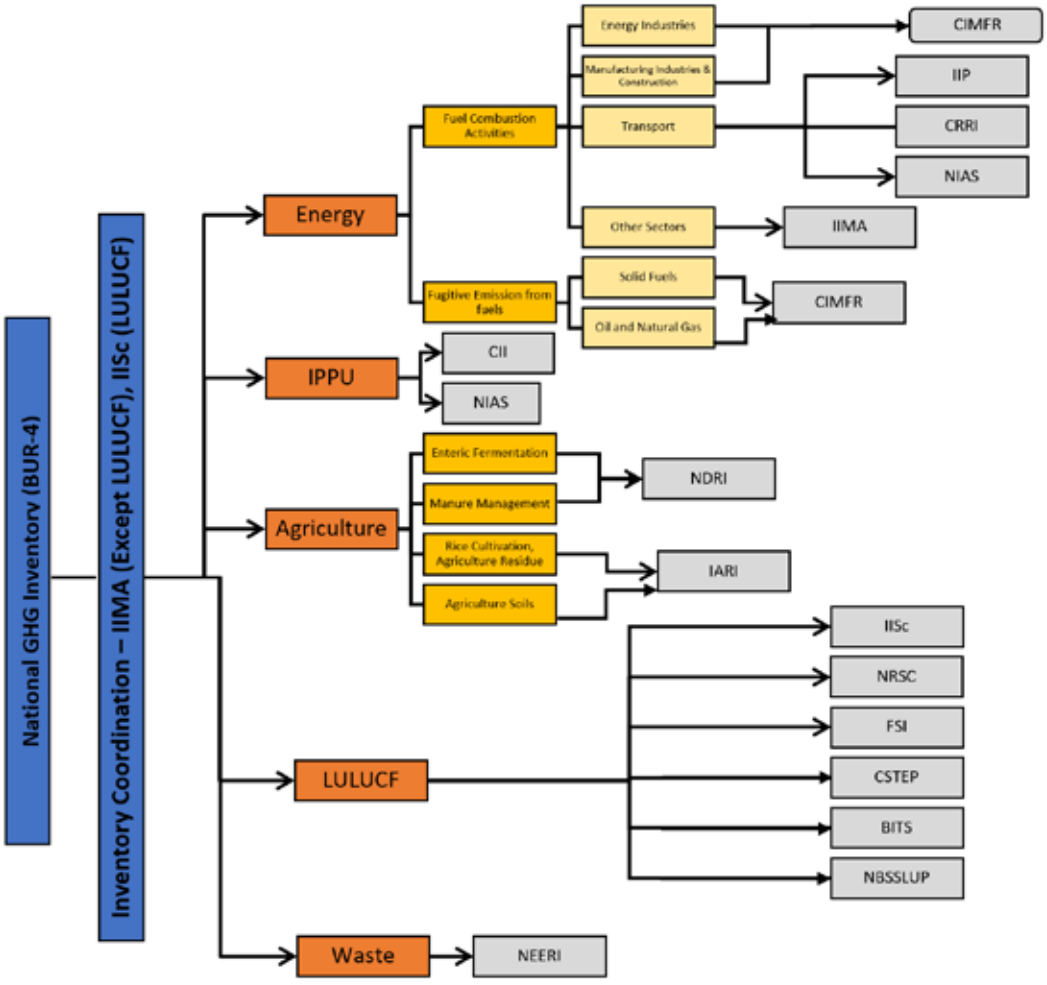


*Figure 2.1: Institutions involved in GHG inventory preparation*

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: Center 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

## 2.3 Methodology

The IPCC Guidelines (IPCC, 2006) provide a detailed estimation methodology for all the sectors and sub-sectors. The IPCC has created a system of methodological tiers to denote various degrees of methodological complexity. Tier 1 utilises an IPCC default value, Tier 2 uses country-specific emission factors based on measurements or IPCC Tier 2 emission factors, and Tier 3 is the most complex and data-intensive. Tier 3 may include models and inventory management systems tailored to address national circumstances, repeated over time, determined by high-resolution activity data and disaggregated at the sub-national level. Both default and country-specific emission factors have been employed and presented in Table 2.1 for all categories and gases. (IPCC, 1996).

***Table 2.1: Summary of emission factors and methodologies used in the fourth Biennial Update Report***

| Type of emission factor and level of methodological tier employed for GHG estimation | | | | | | |
|---|---|---|---|---|---|---|
| **Gas** | **$CO_2$** | | **$CH_4$** | | **$N_2O$** | |
| **Sector/ Category** | **Method used** | **Emission Factor** | **Method used** | **Emission Factor** | **Method used** | **Emission Factor** |
| **1. Energy** | | | | | | |
| A. Fuel combustion activities | | | | | | |
| 1. Energy industries | T1,T2,T3 | D, CS | T1 | D | T1 | D |
| 2. Manufacturing industries & construction | T1,T2,T3 | D, CS | T1,T2 | D | T1 | D |
| 3. Transport | T1,T2 | D, CS | T1, T2 | D | T1, T2 | D |
| 4. Other sectors | T1,T2 | D, CS | T1 | D | T1 | D |
| B. Fugitive emission from fuels | | | | | | |
| 1. Solid fuels | NO | | T2,T3 | CS | NO | |
| 2. Oil and natural gas | NO | | T1 | D | NO | |
| **2. Industrial Process** | | | | | | |
| A. Mineral industry | T1,T2 | D, CS | NO | | NO | |
| B. Chemical industry | T1,T2 | D, CS | T1 | D | T1, T2 | D, CS |
| C. Metal industry | T1,T2 | D, CS | T1 | D | NO | |
| D. Non-energy product use | T1 | D | NO | | NO | |
| E. Production of halocarbons | NO | | NO | | NO | |

| Type of emission factor and level of methodological tier employed for GHG estimation | | | | | | |
|---|---|---|---|---|---|---|
| **Gas** | **$CO_2$** | | **$CH_4$** | | **$N_2O$** | |
| **Sector/ Category** | **Method used** | **Emission Factor** | **Method used** | **Emission Factor** | **Method used** | **Emission Factor** |
| **3. Agriculture** | | | | | | |
| A. Enteric fermentation | NO | | T1,T2 | D, CS | NO | |
| B. Manure management | NO | | T1 | D | T1 | D |
| C. Rice cultivation | NO | | T2 | CS | | |
| D. Agricultural soils | NO | | NO | | T2 | CS |
| F. Field burning of agricultural residues | NO | | T1,T2 | D, CS | T1, T2 | D, CS |
| **4. Land Use, Land-Use Change and Forestry (LULUCF)** | | | | | | |
| A. Forest land | T2 | CS | T2 | D, CS | T2 | D, CS |
| B. Cropland | T2 | CS | NO | | NO | |
| C. Grassland | T2 | CS | NO | | NO | |
| D. Settlements | T2 | CS | NO | | NO | |
| E. Wetlands | NE | | NE | | NE | |
| F. Other Land | NA | | NA | | NA | |
| **5. Waste** | | | | | | |
| A. Solid waste disposal on land | NO | | T2 | D, CS | NO | |
| B. Wastewater handling | NO | | T1, T2 | D, CS | T1, T2 | D, CS |
| **Memo item (not accounted in total emissions)** | | | | | | |
| International bunkers | T1, T2 | D | T1, T2 | D | T1, T2 | D |
| $CO_2$ from biomass | T1 | D | NO | | NO | |
| T1- Tier 1; T2- Tier 2; T3- Tier 3; CS- Country Specific; D- IPCC Default, NO-Not Occurring, NA-Not Applicable, NE-Not Estimated | | | | | | |

A Global Warming Potential (GWP) quantifies the globally averaged relative radiative forcing of a specific greenhouse gas (refer to Table 2.2). It is characterized as the total radiative forcing over a designated timeframe resulting from the emission of 1 kilogram (kg) of the gas, in comparison to that of the reference gas $CO_2$. Direct radiative effects arise when the gas absorbs radiation directly. Indirect radiative forcing arises from chemical transformations of the original gas that yield greenhouse gases or when a gas affects other processes critical to radiative balance, such as the atmospheric lifetimes of different gases. All calculations in this report utilize the Global Warming Potential (GWP) of greenhouse gases (GHGs) over a 100-year period, as per IPCC AR2 (IPCC, 1995).

***Table 2.2: Global Warming Potentials Used***

| Gas | GWP (100 years) | Gas | GWP (100 years) |
|---|---|---|---|
| $CO_2$ | 1 | $CF_4$ | 6500 |
| $CH_4$ | 21 | $C_2F_6$ | 9200 |
| $N_2O$ | 310 | $C_4F_{10}$ | 7000 |
| HFC-23 | 11700 | $C_6F_{14}$ | 7400 |
| HFC-134a | 1300 | $SF_6$ | 23900 |

Furthermore, for the national GHG inventory, as set forth in paragraph 12 of Decision 17/CP.8, to the extent possible, the key categories are analyzed, pursuant to IPCC Good Practice Guidance (GPG), to identify the subsectors that should be prioritized in terms of methodological refinement, taking into consideration the national circumstances, as well as the contribution of the identified subsectors to the total emissions. (UNFCCC, 2002).

## 2.4 Quality Assurance (QA), Quality Control (QC)

Following the 2006 IPCC Guidelines, national inventories have to be transparent, well documented, consistent, complete, comparable, assessed for uncertainties and should be subjected to verification and QA/QC exercise. A few of the processes covered by the quality system are employee training, inventory planning and preparation, QA/QC procedures, peer-reviewed publications, data storage, follow-up, and improvements. The QA/QC plan also includes a timetable that details the various phases of the inventory, from its conception to its final reporting. The quality system ensures that the inventory is systematically planned, prepared, and followed up in accordance with specified quality requirements so that the inventory is continuously developed and improved. (IPCC, 2006a).

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 GPG section's list of Tier 1 general inventory level QA and QC procedures is used (IPCC, 2006a). Every category's emission is also examined and contrasted with previous years. Time-series data have undergone careful examination to look for outliers and confirm that the levels are appropriate.

### *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), 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 sources (IPCC, 2006a). In this inventory preparation exercise, general Tier 1 QC measures, according to the 2006 IPCC Guidelines, have been carried out as follows:

- 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.
- Checked for transcription errors in data input and references.
- Checked that emissions and removals were calculated correctly.
- Checked that parameters and units were correctly recorded and that appropriate conversion factors were used.
- Checked the integrity of database files.
- Checked for consistency in data between source categories.
- Checked that the movement of inventory data among processing steps is correct.
- Checked that uncertainties in emissions and removals are estimated and calculated correctly.
- Checked time series consistency.
- Checked completeness.
- Compared the reference and sectoral approach.
- Conducted trend checks.
- Review of internal documentation and archiving.

### *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.

- Information needs were complied with the methodological requirements stipulated by the 2006 IPCC Guidelines.
- Prepared and sent information queries to select data sources using official correspondence, telephone, and e-mail.
- Identified potential data sources, including organizations and independent experts.
- Collected data (activity data and emission factors) for all source/sink categories for Energy, IPPU, Agriculture, Waste, and LULUCF Sectors.
- Analyzed information to use for the calculation of emissions and reductions.
- 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.
- Processed and archived data.
- Assessed consistency of the methodologies applied and recalculated for inventory improvement.
- Checked reliability of results and elimination of errors.
- Developed and implemented QC procedures.
- Implemented Quality assurance conducted by MoEFCC and relevant experts.
- Key category analysis was done.
- An uncertainty assessment analysis was done.
- Final validation by the Technical Advisory Committee and the National Steering Committee through MoEFCC.
- Prepared the final version of the inventory report.

## 2.5 National Greenhouse Gas Emissions

In 2020, India's total GHG emissions excluding LULUCF amounted to 2,959 $MtCO_2e$ and including LULUCF amounted to 2,437 $MtCO_2e$. Total national emissions (including LULUCF) have decreased by 7.93 per cent with respect to 2019 and increased by 98.34 per cent since 1994 (Figure 2.2 and Table 2.3). The main contributors to the total GHG emission are $CO_2$ emissions generated from burning fossil fuels, methane emissions from livestock and increasing aluminium and cement production. The LULUCF sector remained net sink during the inventory period 2020.

***Table 2.3: Sector-wise National GHG emission in $MtCO_2e$ for 1994-2020***

| GHG Sources and Removals | 1994 | 2000 | 2007 | 2010 | 2014 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mt $CO_2e$ | | | | | | | | | |
| Source | INC | SNC | SNC | BUR1 | BUR2 | BUR3 | TNC | TNC | TNC | BUR4 |
| Energy | 744 | 1027 | 1374 | 1510 | 1910 | 2129 | 2204 | 2344 | 2374 | 2238 |
| Industrial Processes and Product Use | 103 | 89 | 142 | 172 | 202 | 226 | 244 | 263 | 264 | 239 |
| Agriculture | 344 | 356 | 373 | 390 | 417 | 408 | 411 | 417 | 421 | 406 |
| LULUCF | 14 | -223 | -177 | -253 | -301 | -308 | -312 | -437 | -485 | -522 |
| Waste | 23 | 53 | 58 | 65 | 78 | 75 | 70 | 72 | 73 | 76 |
| Total (without LULUCF) | 1214 | 1524 | 1947 | 2137 | 2607 | 2839 | 2929 | 3096 | 3132 | 2959 |
| Total (with LULUCF) | 1229 | 1301 | 1772 | 1884 | 2306 | 2531 | 2617 | 2659 | 2647 | 2437 |

*Source: (MoEF, 2004); (MoEF, 2012); (MoEF, 2010); (MoEFCC, 2016); (MoEFCC, 2018); (MoEFCC, 2021); (MoEFCC, 2023).*

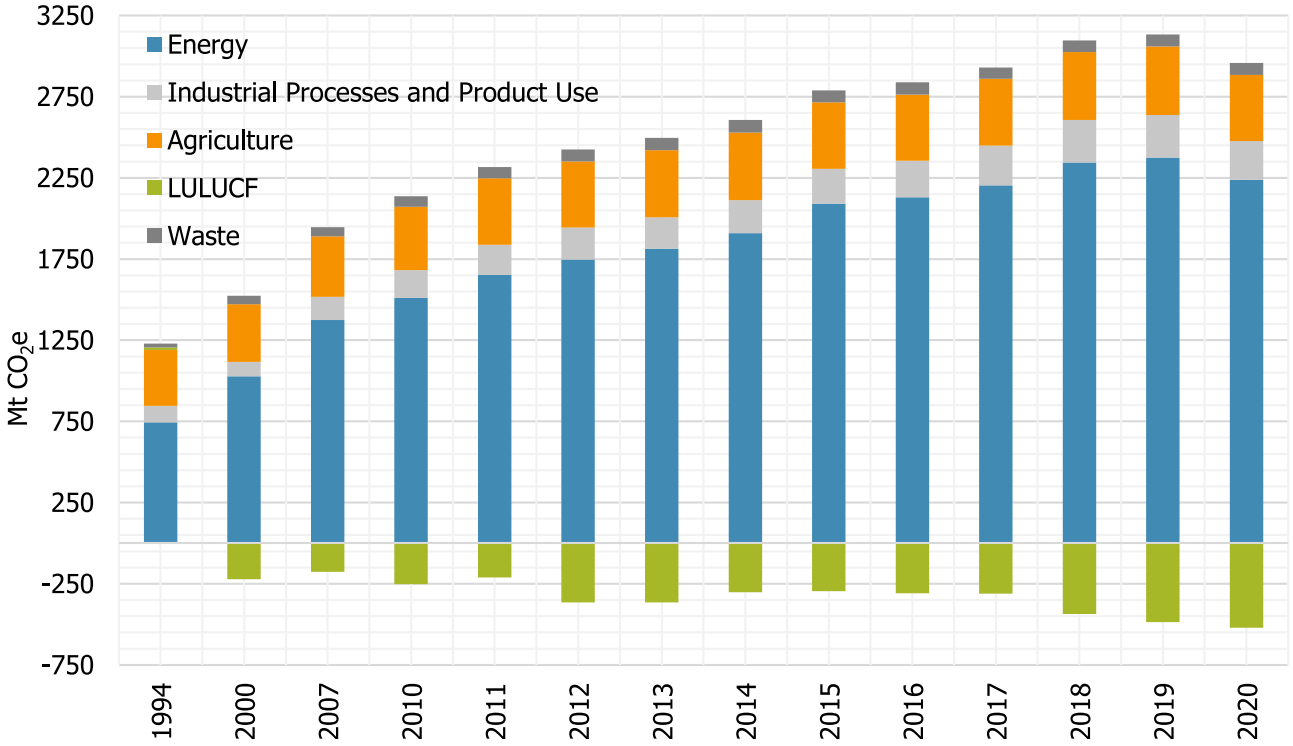


*Figure 2.2: Sector-wise National GHG emission in Mt $CO_2e$ for 1994-2020.*

*Source: (MoEF, 2004); (MoEF, 2012); (MoEF, 2010); (MoEFCC, 2016); (MoEFCC, 2018); (MoEFCC, 2021); (MoEFCC, 2023).*

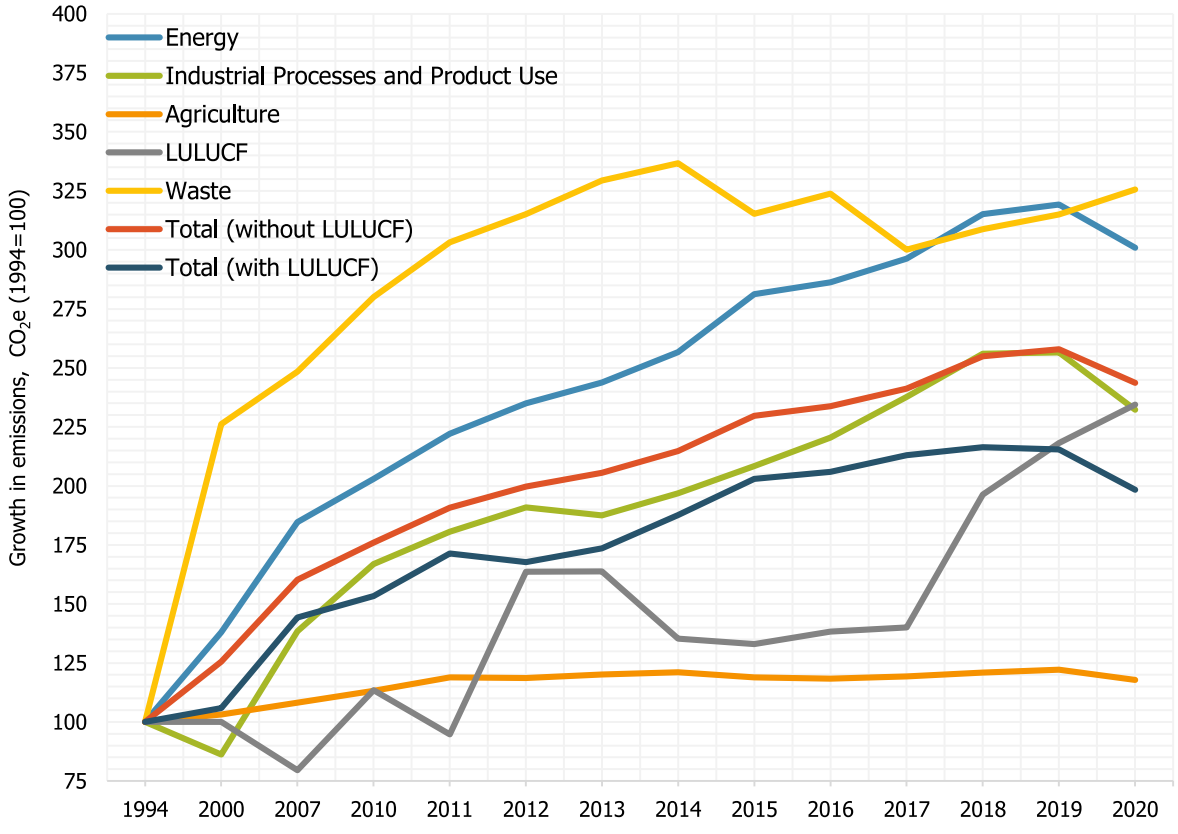


*Figure 2.3: Growth in emissions of greenhouse gases, relative to 1994, illustrated by source categories, 1994-2020. Index 1994 = 100.*

*Source: (MoEF, 2004); (MoEF, 2012); (MoEF, 2010); (MoEFCC, 2016); (MoEFCC, 2018); (MoEFCC, 2021); (MoEFCC, 2023).*

The section on sector-specific emissions presents a table listing the activity data and country-specific emission factors utilized in preparation of the inventory. In instances where emission factors were unspecified, India used the default emission factors outlined in the IPCC 2006 guidelines. Since 1994, India has undergone significant economic growth, resulting in an overall increase in greenhouse gas emissions. From 1994 to 2020, total $CO_2e$ emissions (excluding LULUCF) rose by 144 per cent. The waste sector experienced a growth of 226 per cent from 1994 to 2020, attributed to population growth and increased industrial activities. However, its contribution to overall emissions consistently hovers around 3 per cent, indicating a relatively low absolute contribution. The energy sector experienced a growth rate of 201 per cent from 1994 to 2020, primarily attributed to the ongoing rise in fossil fuel combustion. During the same period, the IPPU sector experienced a growth of 132 per cent, whereas the agriculture sector saw an increase of only 18 per cent (Figure 2.3). From 2000 to 2020, the LULUCF sector exhibited a 135 per cent increase in greenhouse gas removals.

## 2.5.1 Summary GHG Emissions in 2020

In 2020, India emitted 29,58,589 Gg of $CO_2e$ GHGs from Energy, IPPU, Agriculture and Waste sectors. LULUCF sector remained a net sink in 2020, accounting for the removal of 5,21,933 $GgCO_2e$ of emissions. Considering total emissions and removals, net national emissions in 2020 were 24,36,656 $GgCO_2e$. The energy sector contributed the most to the overall emissions with 75.66 per cent, followed by agriculture sector 13.72 per cent, IPPU by 8.06 per cent and Waste by 2.56 per cent (Figure 2.4). A summary of sector-wise national emissions and removals is presented in the Table 2.4.

***Table 2.4: Sector-wise National GHG emissions in Gg for 2020***

| GHG sources and removals | $CO_2$ emission | $CO_2$ removal | $CH_4$ | $N_2O$ | HFC 23 | $CF_4$ | $C_2F_6$ | $SF_6$ | $CO_2$ equivalent |
|---|---|---|---|---|---|---|---|---|---|
| Energy | 2181012 | NO | 1523 | 82 | NO | NO | NO | NO | 2238409 |
| IPPU | 201044 | NO | 232 | 8 | 2 | 1 | 0.27 | 0.004 | 238556 |
| Agriculture | NO | NO | 14290 | 342 | NO | NO | NO | NO | 405983 |
| LULUCF | 9369 | -532357 | 41 | 1 | NO | NO | NO | NO | -521933 |
| Waste | NO | NO | 2726 | 58 | NO | NO | NO | NO | 75641 |
| Memo Items | 802846 | NO | 0.09 | 0.11 | NO | NO | NO | NO | 802882 |
| **Total Emission** | **2382535** | **--** | **18771** | **489** | **2** | **1** | **0.27** | **0.004** | **2958589** |
| **Net Emission** | **2391904** | **-532357** | **18811** | **490** | **2** | **1** | **0.27** | **0.004** | **2436656** |

*Abbreviation: NO - Not Occurring. Note: The total may not match because of rounding.*

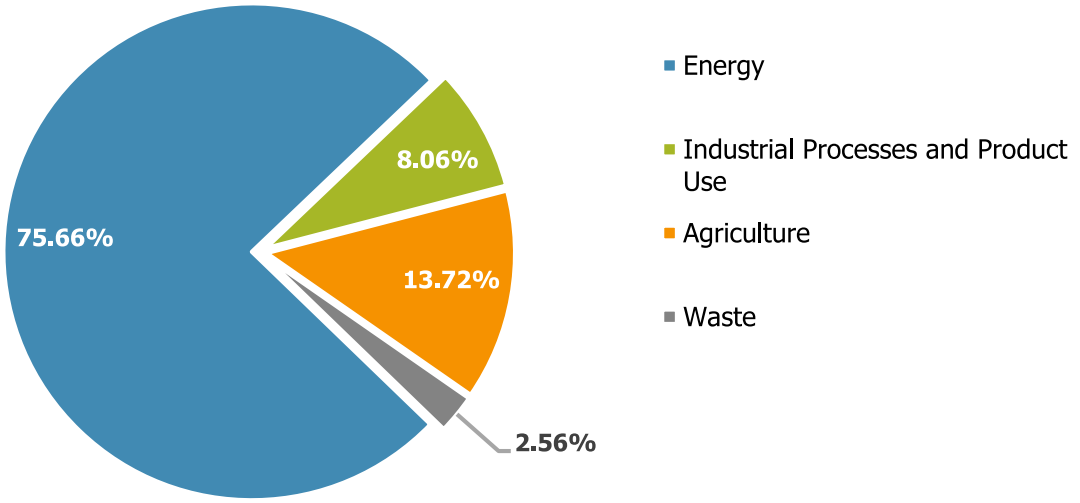


*Figure 2.4: Distribution of GHG emissions ($GgCO_2e$) by sector, 2020*

Figure 2.5 shows the percentage share of the top 15 key emission categories for India for 2020 in terms of $CO_2e$. The top category is from the energy sector, emissions from electricity production (1A1a-$CO_2$), contributing 39 per cent of the total emissions; followed by road transport (1A3b-$CO_2$), 9 per cent of the total emissions; 8 per cent of the total emissions from enteric fermentation (3A1-$CH_4$); 6 per cent of the total emissions from non-specific industries (1A2m-$CO_2$), 5 per cent of the total emission from each residential (1A4b-$CO_2$), iron and steel (1A2a-$CO_2$) and cement production (2A1-$CO_2$), 3 per cent of the total emissions from each commercial/institutional (1A4a-$CO_2$), refineries (1A1b-$CO_2$) and agricultural soils (3C4-$N_2O$). Emissions from rice cultivation (3C7-$CH_4$), cement (1A2f-$CO_2$), Industrial Wastewater (4D2-$CH_4$), production of halocarbons and sulphur hexafluoride (2E-SFC) and managed waste disposal on land (4A-$CH_4$) contribute 2, 2, 1, 1 and 1 per cent of total emissions respectively (Figure 2.5).

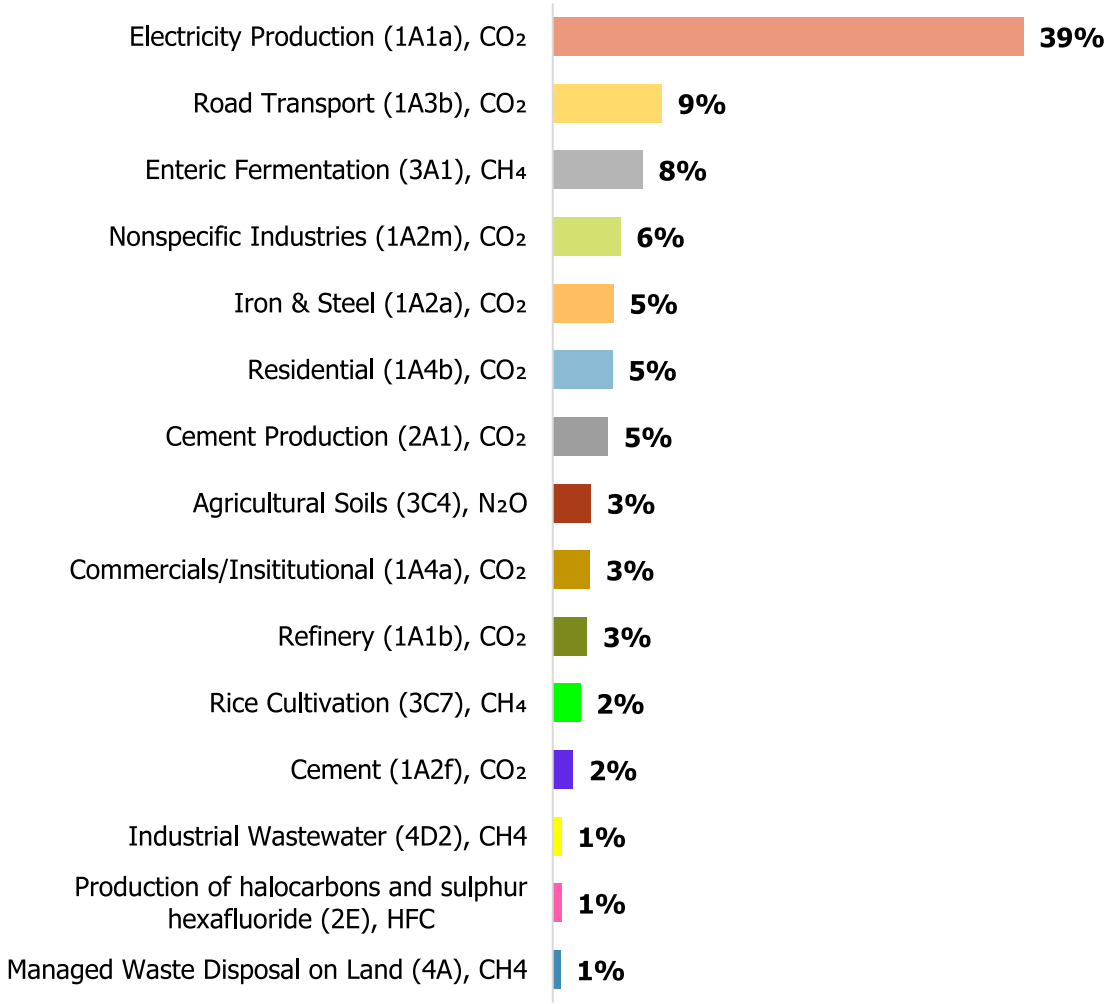


*Figure 2.5: Percentage share of greenhouse gas emissions by category, 2020*

## 2.6 Emission Trends by Gas

In 2020, GHG emissions excluding LULUCF at the national level by type of gas were as follows: emissions of $CO_2$ accounted for 23,82,535 Gg (80.53 per cent); $CH_4$ emissions accounted for 3,94,185 $GgCO_2e$ (13.32 per cent) and $N_2O$ emissions accounted for 1,51,733 $GgCO_2e$ (5.13 per cent). In the case of fluorinated gases, emissions of HFC were 21,645 $GgCO_2e$ (0.73 per cent), $CF_4$ emissions 5,876 $GgCO_2e$ (0.20 per cent), $C_2F_6$ emissions 2,515 $GgCO_2e$ (0.09 per cent) and $SF_6$ emissions 100 $GgCO_2e$ (0.003 per cent). Please see Figure 2.6.

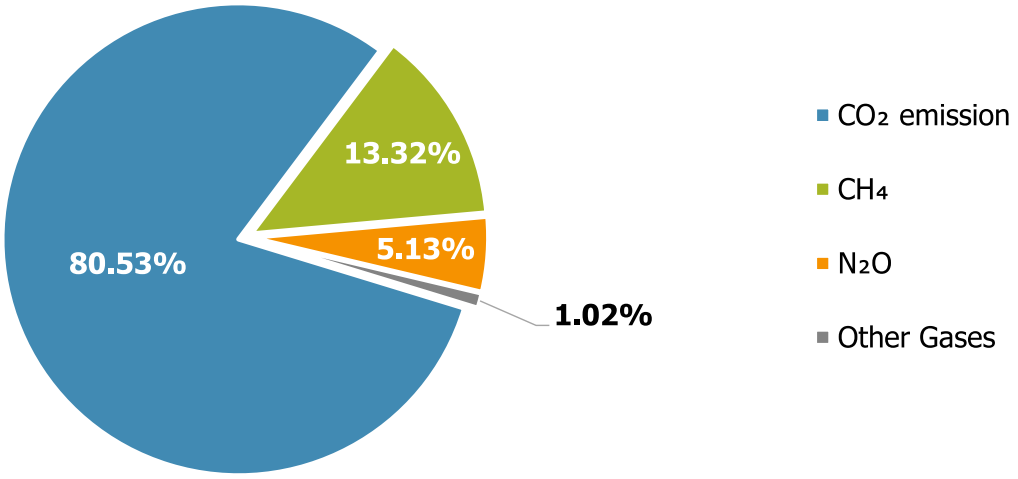


*Figure 2.6: Gas-wise emission for the year 2020*

# 2.7 Emission Trends by Sources

## 2.7.1 Energy Sector

The Energy sector, encompassing fossil fuel consumption and associated fugitive emissions, is the primary source of greenhouse gas emissions in the country, accounting for 75.66 per cent of total emissions in 2020, excluding LULUCF. In 2020, total emissions from the energy sector amounted to 22,38,409 Gg $CO_2e$, reflecting a decrease of 5.72 per cent compared to 2019, primarily attributed to the impact of the COVID-19 pandemic on economic activities nationwide. Figure 2.7 illustrates the distribution of greenhouse gas emissions within the energy sector.

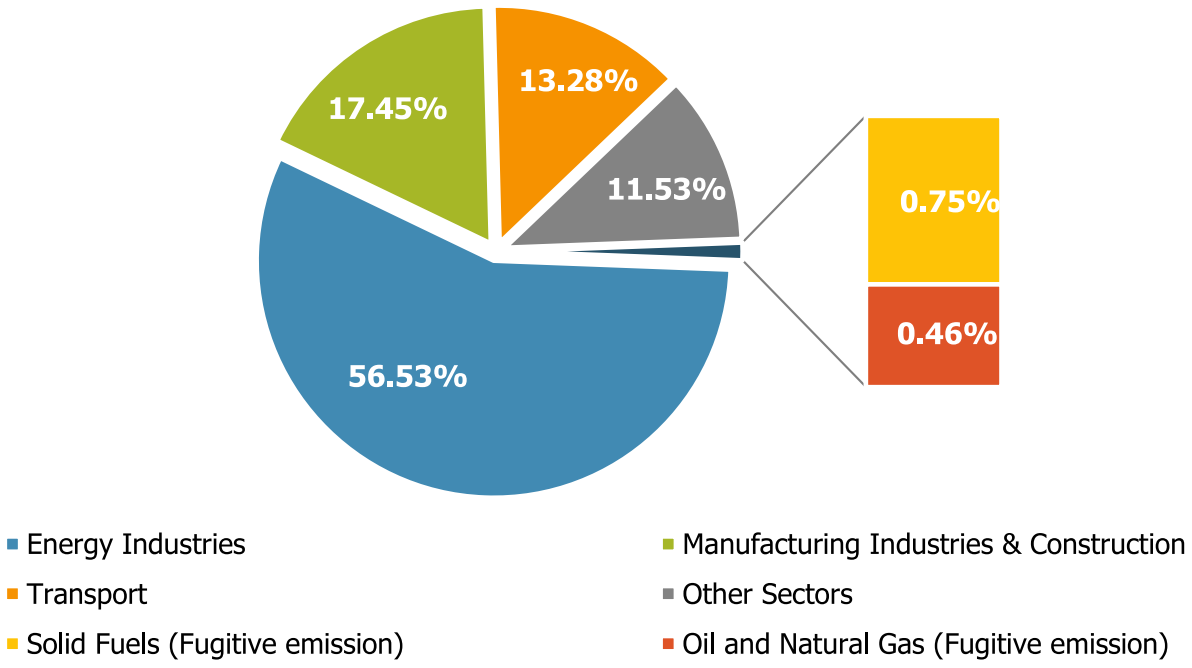


*Figure 2.7: Distribution of $CO_2e$ emissions across the Energy Sector Categories in 2020*

Energy sector emitted 92 per cent of the total national $CO_2$ emissions in 2020. This was primarily caused by fossil fuel combustion activities, which included the energy sector as well as manufacturing, transportation, and other industries. Energy-related fuel combustion activities account for 98.80 per cent of all emissions. 1.20 per cent of the total GHG emissions from the energy sector were caused by fugitive emissions.

## *Fuel combustion activities (1.A)*

The fuel combustion category includes emissions from fossil fuel burning inside or outside of a device designed to heat or provide heat to a process through heat or mechanical work. The total emissions from this category decreased by 1,26,920 (5.43 per cent) from 2019 levels to 22,11,513 $GgCO_2e$ emissions in 2020. Within the energy sector, energy industries are the largest contributor with a 56.53 per cent (12,65,328 $GgCO_2e$) of total emissions, followed by 17.45 per cent (3,90,667 $GgCO_2e$) from manufacturing industries and construction, 13.28 per cent (2,97,371 $GgCO_2e$) from transport and 11.53 per cent (2,58,147 $GgCO_2e$) from other sectors in 2020 (Figure 2.8).

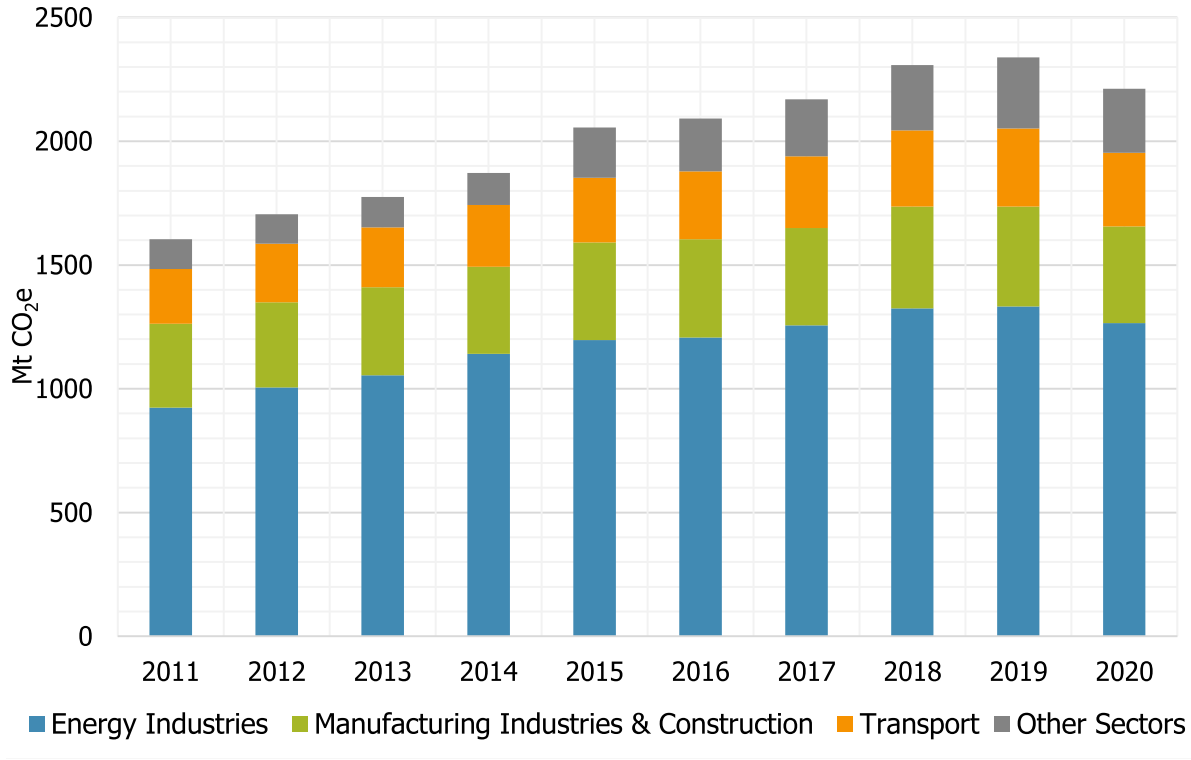


*Figure 2.8: Fuel combustion activities: GHG emissions (Mt $CO_2e$) per subcategory, 2011-2020*

## *Energy industries (1.A.1)*

This subcategory considers GHG emissions due to fossil fuel combustion for energy production industries and fuel extraction. Electricity production accounted for approximately 40 per cent of the total national emissions without LULUCF in 2020, which is the highest emitting category in India. In 2020, these emissions accounted for 11,71,624 $GgCO_2e$, decreasing 5.50 per cent (68,183 $GgCO_2e$) since 2019. Within this subcategory, electricity and heat production account for 92.59 per cent of the total, with petroleum refining accounting for 6.72 per cent and the manufacture of solid fuels and other energy industries accounting for 0.69 per cent. The consumption patterns of the fuels in energy industries have been shown in Table 2.5 and Figure 2.9. The overall country-specific emission factors used in energy industry emission estimation are shown in Table 2.6. It should be noted that sector-specific conversion factors and carbon emission factors have been estimated for specific categories, namely power generation, iron and steel industries, cement, and a few other industries (Table 2.8).

*Table 2.5: Category-wise fuel consumption in the energy industries (1A1) from 2017 to 2020.*

| Fuel consumption (TJ) | Year | Liquid Fuels | Gaseous Fuels | Solid Fuels |
|---|---|---|---|---|
| Electricity and Heat Production (1A1a) | 2017 | 1,04,131 | 5,56,095 | 12,042,123 |
| | 2018 | 1,13,869 | 5,64,840 | 12,716,478 |
| | 2019 | 1,11,090 | 5,21,435 | 12,777,830 |
| | 2020 | 45,279 | 4,96,303 | 12,079,717 |
| Petroleum Refining (1A1b) | 2017 | - | 13,04,753 | - |
| | 2018 | - | 13,56,150 | - |
| | 2019 | - | 14,53,757 | - |
| | 2020 | - | 14,84,350 | - |
| Manufacture of Solid Fuels and Other Energy Industries (1A1c) | 2017 | - | - | 5,97,591 |
| | 2018 | - | - | 6,23,029 |
| | 2019 | - | - | 6,37,818 |
| | 2020 | - | - | 6,31,859 |

*Sources: (CEA, 2017, 2018, 2019, 2020, 2021); (MoC, 2017, 2018, 2019, 2020, 2021); (CMIE, 2021); (MoC, 2017a, 2018a, 2019a, 2020a, 2021a); (MoPNG, 2016, 2017, 2018, 2019, 2020, 2021); (MoSPI, 2017, 2018, 2019, 2020, 2021); (MoPNG, 2019a, 2020a, 2021a); (CEA, 2017a, 2018a, 2019a, 2020a, 2021a).*

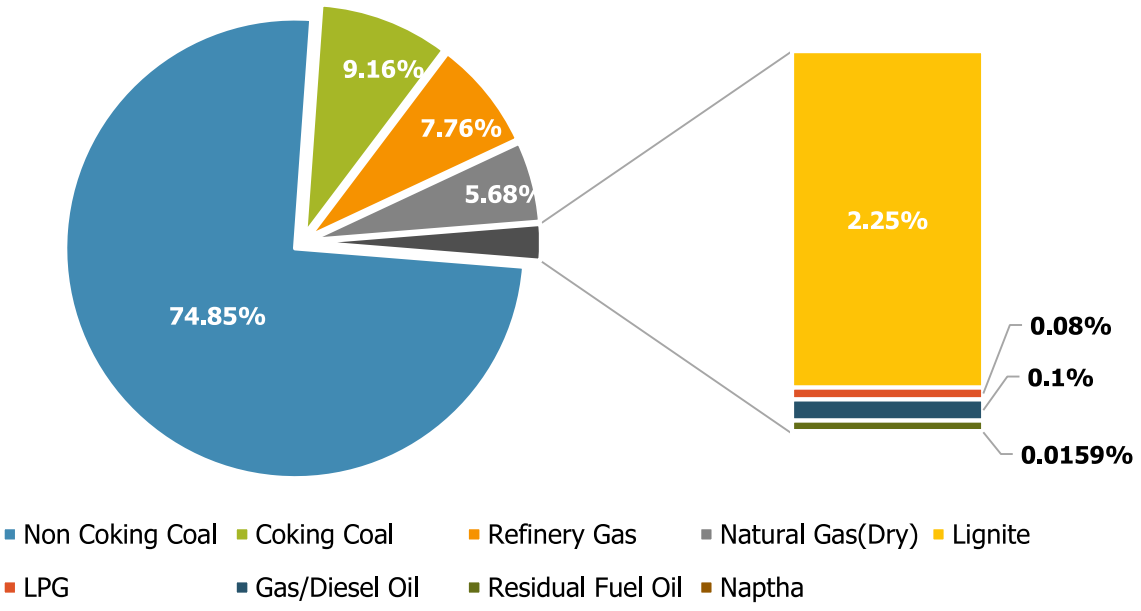


*Figure 2.9: Share of fuel consumption for energy industries for the year 2020*

*Table 2.6: Country Specific emission factors used in the energy industries (1A)*

| Fuel-wise emission factors | Electricity and heat production (1A1a) | | Manufacture of solid fuels and other energy industries (1A1c) | |
|---|---|---|---|---|
| | Net calorific value (TJ/ Kt) | Carbon emission factor (tC/TJ) | Net Calorific value (TJ/ Kt) | Carbon emission factor (tC/TJ) |
| Coking coal | 23.66 | 25.55 | 23.66 | 25.55 |
| Non coking coal | 17.09 | 26.39 | 18.26 | 26.28 |
| Lignite | 9.8 | 28.9 | 9.8 | 28.9 |

## *Manufacturing industries & construction (1.A.2)*

This subcategory includes GHG emissions generated by fossil fuels burning in industry, including burning for power and heat generation for in-house use. In 2020, GHG emissions accounted for 3,90,667 $GgCO_2e$, which was 17.45 per cent of total $CO_2e$ emissions from the energy sector. Category emission decreased by 3.46 per cent (14,010 $GgCO_2e$) since 2019. Emissions in the Cement, Iron & Steel, Non-ferrous metal, Textile/Leather, Fertiliser, Non-specific industries are behind the decrease. In contrast, emissions from mining & quarrying and engineering sector have increased. Within the subcategory, Non-specific industries contribute the most with 43.12 per cent, followed by 38.76 per cent by Iron and Steel industry, 12.75 per cent by Cement industry, 1.40 per cent by Mining and Quarrying, 1.10 per cent by Fertilizer industry and less than 1 per cent by Chemical, Non-ferrous metals, Pulp and Paper, Textile/Leather, Bricks and Engineering sectors individually (Figure 2.10 and Table 2.7).

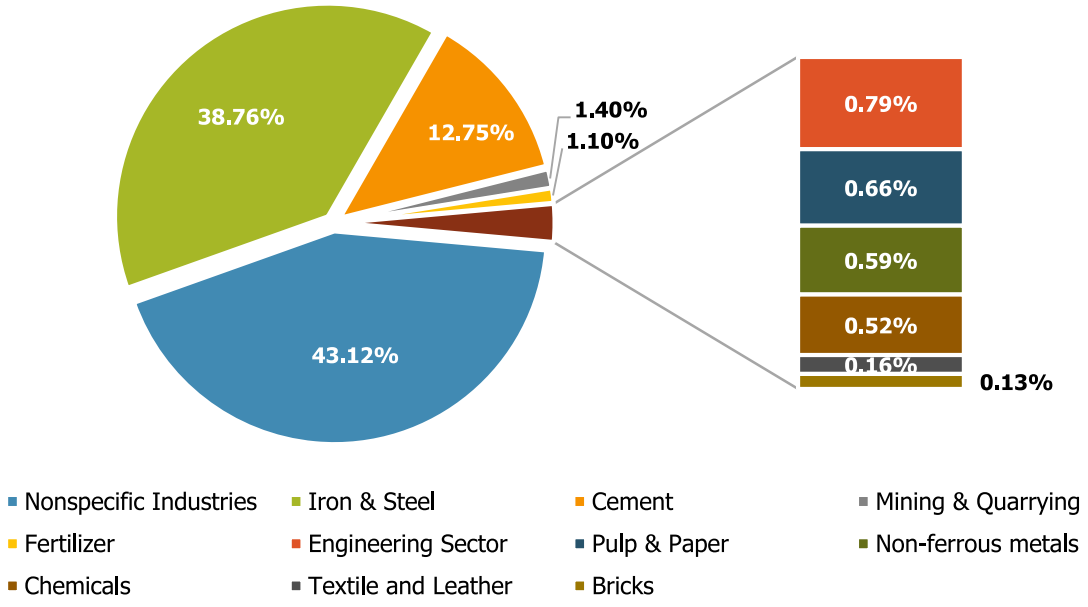


*Figure 2.10: Distribution of $CO_2e$ emissions across the manufacturing industries & construction categories in 2020*

***Table 2.7: Category-wise fuel consumption in the manufacturing industries & construction (1A2) from 2017 to 2020.***

| Fuel consumption (TJ) | Year | Liquid Fuels | Gaseous Fuels | Solid Fuels |
|---|---|---|---|---|
| Iron & Steel (1A2a) | 2017 | 54,648 | 50,965 | 14,73,010 |
| | 2018 | 54,712 | 50,220 | 16,60,554 |
| | 2019 | 50,886 | 30,510 | 16,37,955 |
| | 2020 | 47,879 | 27,086 | 15,60,926 |
| Cement (1A2f) | 2017 | 3,60,077 | - | 1,93,552 |
| | 2018 | 3,58,179 | - | 1,93,103 |
| | 2019 | 3,59,691 | - | 1,84,454 |
| | 2020 | 3,60,823 | - | 1,53,239 |
| Non-ferrous metals (1A2b) | 2017 | 11,687 | - | 33,864 |
| | 2018 | 16,065 | - | 18,365 |
| | 2019 | 15,233 | - | 13,119 |
| | 2020 | 14,854 | - | 12,047 |

| Fuel consumption (TJ) | Year | Liquid Fuels | Gaseous Fuels | Solid Fuels |
|---|---|---|---|---|
| Pulp & Paper (1A2d) | 2017 | - | - | 33,059 |
| | 2018 | - | - | 35,738 |
| | 2019 | - | - | 31,247 |
| | 2020 | - | - | 25,963 |
| Chemicals (1A2c) | 2017 | 15,911 | - | 7,949 |
| | 2018 | 18,658 | - | 8,210 |
| | 2019 | 17,775 | - | 7,472 |
| | 2020 | 17,794 | - | 6,896 |
| Mining & Quarrying (1A2i) | 2017 | 56,644 | - | - |
| | 2018 | 63,861 | - | - |
| | 2019 | 69,277 | - | - |
| | 2020 | 73,632 | - | - |
| Textile and Leather (1A2l) | 2017 | 3,725 | - | 26,105 |
| | 2018 | 3,371 | - | 29,568 |
| | 2019 | 2,956 | - | 10,181 |
| | 2020 | 2,611 | - | 4,268 |
| Bricks (1A2k) | 2017 | - | - | 6,074 |
| | 2018 | - | - | 7,600 |
| | 2019 | - | - | 5,819 |
| | 2020 | - | - | 4,800 |
| Fertilizer (1A2e) | 2017 | 21,695 | - | 41,667 |
| | 2018 | 20,214 | - | 38,682 |
| | 2019 | 17,101 | - | 38,423 |
| | 2020 | 13,287 | - | 35,291 |
| Engineering Sector (1A2h) | 2017 | 28,333 | - | - |
| | 2018 | 32,831 | - | - |
| | 2019 | 36,345 | - | - |
| | 2020 | 41,785 | - | - |
| Nonspecific Industries (1A2m) | 2017 | 2,09,841 | 1,46,956 | 15,17,321 |
| | 2018 | 1,87,379 | 1,44,774 | 15,48,310 |
| | 2019 | 1,96,208 | 1,73,016 | 15,23,755 |
| | 2020 | 2,08,639 | 1,93,493 | 14,73,806 |

*Sources: (MoPNG, 2017a, 2018a, 2019a, 2020a, 2021a); (CMIE, 2021); (MoC, 2017, 2018, 2019, 2020, 2021)*

The analysis of a large number of coal samples from various categories found in India yielded India-specific emission factors for coal. Table 2.8 provides a summary of sector-specific and country-specific values.

***Table 2.8: Country-specific emission factors used in the manufacturing industries & construction (1A2) and electricity power generation (1A1ai)***

| Fuel-wise Emission Factors | Electricity Power Generation (1A1ai), Iron & Steel (1A2a) | | Chemicals (1A2c), Textile and Leather (1A2l), Bricks (1A2k), Fertilizer (1A2e), Nonspecific Industries (1A2m) | | Pulp & Paper (1A2d) | | Non-ferrous metals (1A2b) | | Cement (1A2f) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Net Calorific Value (TJ/Kt) | Carbon Emission Factor (tC/TJ) | Net Calorific Value (TJ/Kt) | Carbon Emission Factor (tC/TJ) | Net Calorific Value (TJ/Kt) | Carbon Emission Factor (tC/TJ) | Net Calorific Value (TJ/Kt) | Carbon Emission Factor (tC/TJ) | Net Calorific Value (TJ/Kt) | Carbon Emission Factor (tC/TJ) |
| Coking coal | 23.66 | 25.55 | 23.66 | 25.55 | | | | | 23.66 | 25.55 |
| Non coking coal | 17.09 | 26.39 | 20.4 | 26.06 | 18.35 | 26.26 | 18.17 | 26.28 | 20.15 | 26.08 |
| Lignite | 9.8 | 28.9 | 9.8 | 28.9 | | | | | 9.8 | 28.9 |

## *Transport (1.A.3)*

This subcategory includes GHG emissions generated by burning fossil fuels in all activities of national transportation (aerial, terrestrial, railways and navigation), excluding military operations (maritime and aerial). Emissions from the transport sector total 2,97,371 $GgCO_2e$, accounting for about 13.28 per cent of total GHG emissions from the energy sector in the country for 2020. It is also the key emission category for India (without LULUCF). It has decreased by 5.54 per cent (17,445 $GgCO_2e$) from 2019 levels, mainly due to changes in methodology and allocation of consumption for the first BTR.

The road transport sector accounted for 94 per cent of the total GHG emissions from the transport sector, followed by civil aviation (4 per cent), railways (1 per cent) and water-borne navigation (1 per cent). Fuel consumption data for road, aviation and navigation sectors have been sourced from the statistics provided by Ministry of Petroleum and Natural Gas (MoPNG). For railways, data has been sourced from the statistics published by the Ministry of Railways (MoR).

***Table 2.9: Category-wise fuel consumption in the road transport (1A3b) in 2017 to 2020.***

| Fuel Consumption (TJ) | | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|
| Road Transport | Petrol | 10,91,067 | 11,65,319 | 12,60,128 | 11,16,171 |
| | Diesel | 20,60,532 | 21,44,637 | 21,69,776 | 24,09,405 |
| | Light Diesel Oil | 76 | 172 | 114 | 69 |
| | Fuel Oil | 968 | 3,552 | 4,668 | - |
| | Compressed Natural Gases | 1,23,362 | 1,42,385 | 1,53,812 | 2,48,319 |
| | Liquefied Petroleum Gases | 8,530 | 8,478 | 8,335 | 6,286 |

*Sources: (MoPNG, 2019a, 2020a, 2021a), (PPAC, 2021).*

The Railways sector consumes electricity, diesel, petrol, furnace oil and nominal amounts of coal. To avoid double counting, GHG emissions due to electricity consumption in railways is not included but is covered under 1A1a in electricity generation category (1A1), Table 2.10.

*Table 2.10: Category-wise fuel consumption in the railways (1A3c) from 2017 to 2020*

| Fuel Consumption (TJ) | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|
| Coal | 25.61 | 21.10 | 6.23 | 7.94 |
| Wood | 0.10 | - | 0.004 | 0.004 |
| High Speed Diesel | 1,01,189 | 97,878 | 87,944 | 50,387 |
| Light Diesel Oil | 0.73 | - | 0.18 | 0.04 |
| Petrol | 2.26 | - | 0.31 | 0.67 |
| Kerosene | 84.07 | 22.26 | 31.64 | 36.62 |

*Source: MoR, 2017; 2018; 2019; 2020; 2021.*

For the aviation sector, comprising of the domestic and international aviation, segregated Aviation Turbine Fuel (ATF) consumption data for both sectors was collected. The emission estimates made for the combustion of ATF in international aviation is reported separately as the memo item under international bunkers. In 2017, 2018, 2019 and 2020, India consumed 2,49,725; 2,69,936; 2,71,886; and 1,65,800 TJ of aviation turbine fuel, respectively.

The Navigation sector emission estimates are based on fuel consumption (HSDO, LDO and FO) segregated across the national and international maritime fleet. Emission estimates made for international fleets is reported as the memo item under marine bunkers separately.

*Table 2.11: Category-wise fuel consumption in the navigation (1A3d) from 2017 to 2020*

| Fuel Consumption (TJ) | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|
| Fuel Oil | 11,801 | 14,403 | 15,913 | 13,534 |
| High Speed Diesel Oil | 26,220 | 27,359 | 28,040 | 27,288 |
| Light Diesel Oil | 223 | 220 | 125 | 86 |

*Source: MoPNG, 2017a, 2018a, 2019a, 2020a, 2021a.*

## *Other sectors (1.A.4)*

This subcategory includes GHG emissions from fossil fuels burnt in commercial and institutional buildings, in homes and in activities related to agriculture, forestry, fisheries and the fishing industry. Cooking, lighting, space heating and cooling, refrigeration, and pumping characterize the residential, commercial, and agriculture sectors included in this category. In 2020, the other sectors together emitted 2,58,147 Gg of $CO_2e$, of which approximately 57 per cent was contributed by the residential sector, about 36 per cent by the commercial sector and rest 7 per cent by the biomass burnt for energy (non-$CO_2$ GHGs) and agriculture/ fisheries sectors put together.

*Table 2.12: Category-wise fuel consumption in the other sectors (1A4) in 2017, 2018, 2019 and 2020*

| Fuel consumption (TJ) | Year | Coking Coal | Non Coking Coal | Natural Gas | Liquefied Petroleum Gases | Other Kerosene | Gas/Diesel Oil | Residual Fuel Oil |
|---|---|---|---|---|---|---|---|---|
| Commercial/ institutional (1A4a) | 2017 | - | 8,77,200 | 76,260 | 98,658 | 4,249 | - | - |
| | 2018 | - | 9,99,600 | 82,173 | 1,11,836 | 4,262 | - | - |
| | 2019 | - | 10,40,400 | 97,296 | 1,23,661 | 3,789 | - | - |
| | 2020 | - | 8,73,924 | 82,659 | 89,208 | 3,005 | - | - |

| Fuel consumption (TJ) | Year | Coking Coal | Non Coking Coal | Natural Gas | Liquefied Petroleum Gases | Other Kerosene | Gas/Diesel Oil | Residual Fuel Oil |
|---|---|---|---|---|---|---|---|---|
| Residential (1A4b) | 2017 | 1,18,300 | 1,46,064 | 4,08,084 | 9,62,640 | 1,59,152 | - | - |
| | 2018 | 94,640 | 4,12,080 | 3,44,383 | 10,27,734 | 1,41,527 | - | - |
| | 2019 | 94,641 | 6,04,860 | 3,22,993 | 10,91,495 | 95,208 | - | - |
| | 2020 | 1,24,925 | 4,42,025 | 2,66,694 | 11,88,559 | 69,493 | - | - |
| Agriculture/ Forestry/ Fishing (1A4c) | 2017 | - | - | 8,104 | 358 | - | 26,778 | 2,065 |
| | 2018 | - | - | 8,262 | 869 | - | 27,854 | 3,133 |
| | 2019 | - | - | 8,554 | 1,172 | - | 27,306 | 3,215 |
| | 2020 | - | - | 7,895 | 1,301 | - | 25,665 | 3,411 |

*Source: (MoPNG, 2019a, 2020a, 2021a); (PPAC, 2021); (IEA, 2021); (MoC, 2017a, 2018a, 2019a, 2020a, 2021a)*

## *Comparison with reference and sectoral approach*

A comparison of $CO_2$ emissions results obtained with the reference approach and the sectoral approach allows for verifying the validity of the overall calculations performed. The reference approach uses the total values of national energy statistics, while the sectoral approach uses values related to each category that as a whole add up to the national energy sector.

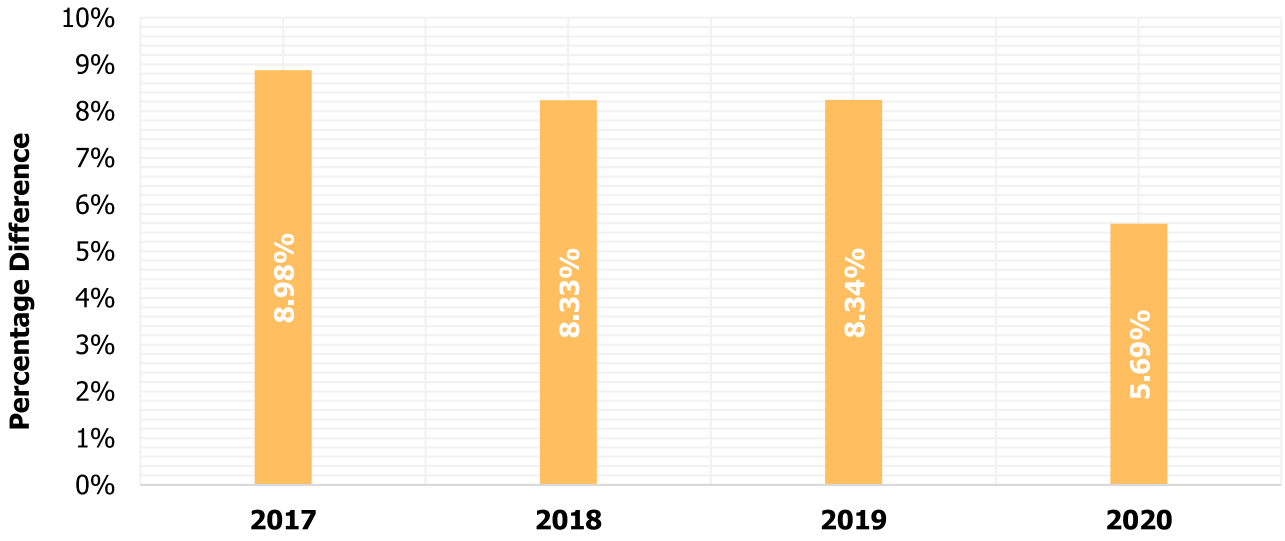


*Figure 2.11: Percentage difference between $CO_2$ emission with the Sectoral approach and the Reference approach, 2017-2020*

The reference approach was also used to estimate $CO_2e$ emissions from fuel combustion for the year 2020. The difference in estimates of $CO_2$ emissions in 2020 from fuel combustion using the sectoral and reference approaches was less than 6 per cent . It is proposed to work on refining the GHG estimates in future communications and reduce the gap. As per the reference approach, emissions were around 71 per cent from solid fuel combustion, around 26 per cent from liquid fuel and the remaining 3 per cent was from gaseous fuel combustion in 2020.

## *Fugitive emissions from fuels (1.B)*

All intentional or unintentional GHG emissions released during the extraction, processing, storage and distribution of fossil fuels are considered as fugitive emissions. The total fugitive emissions in the year 2020 were 26,896 $GgCO_2e$, of which 62 per cent were from coal mining and post-mining operations and 38 per cent were from oil and natural gas production and handling systems. Between 2019 and 2020, fugitive emissions to the atmosphere decreased by 25.08 per cent, owing primarily to lower levels of oil and gas production, gas processing and methodological improvements.

## *Solid fuels (1.B.1)*

Methane is the most significant GHG released during coal mining and handling. Data on coal production from surface and underground mines was collected to estimate methane emissions. Emissions from surface mining decreased by 1.20 per cent and from underground mining decreased by 4.38 per cent between the 2019 and 2020. Underground coal production data from underground mines is available under different categories (like Degree I, II and III). Due to a very few abandoned coal mines in India, abandonment done many years back, and very low production when the mines were active, the contribution of methane from these is considered insignificant and not estimated.

The amount of methane produced per tonne of coal produced is an emission factor for fugitive methane emissions (both underground and above-ground mining). Several measurements were taken in order to calculate the fugitive methane emission factors for coal mining and handling activities. Table 2.13 presents a list of country-specific emission factors for fugitive methane emissions from coal mining and handling activities. It may not be out of place to mention here that these emission factors (EFs) from coal mining and handling activities have been incorporated in the IPCC Emission Factor Database after due vetting of the Editorial Board with designated EF IDs 122973-122975 for underground mining and 124920-124921 for surface mining (IPCC, 2020).

***Table 2.13: Country-specific emission factors for coal mining activities***

| Operation (Mining / Post mining) | Methane emission factor (m3/tonne) | | | |
|---|---|---|---|---|
| | Surface mining | Underground mining | | |
| | | Degree - I | Degree - II | Degree - III |
| Mining | 1.18 | 2.91 | 13.08 | 23.64 |
| Post Mining (Handling) | 0.15 | 0.98 | 2.15 | 3.12 |

***Table 2.14: Coal production in coal mining activities in 2017, 2018, 2019 and 2020***

| Operation (Mining / Post mining) | Coal production (million tonne) | | | |
|---|---|---|---|---|
| | Surface mining | Underground mining | | |
| | | Degree - I | Degree - II | Degree - III |
| Mining and handling (2017) | 674.85 | 35.92 | 6.29 | 0.26 |
| Mining and handling (2018) | 717.93 | 35.81 | 6.27 | 0.25 |
| Mining and handling (2019) | 731.99 | 34.67 | 6.07 | 0.25 |
| Mining and handling (2020) | 724.45 | 26.76 | 7.05 | 0.47 |

*Sources: (MoC, 2017a, 2018a, 2019a, 2020a, 2021a).*

Efforts have also been made to provide an outlook towards future directions in inventory preparation in coal mining. It has been postulated that $CO_2$ emissions from coal mining might be significant and need investigation in line with 2019 IPCC Refinements (Singh, 2022).

### *Oil and natural gas (1.B.2)*

The sources of fugitive emissions from oil and gas systems include, but are not limited to, equipment leaks, evaporation and flashing losses, venting, flaring, incineration and accidental releases (e.g., pipeline dig-ins, well blow-outs and spills). While some of these emission sources are engineered or intentional (e.g., tank, seal and process vents and flare systems) and, therefore, relatively well characterized, the quantity and composition of the other emissions are generally subject to significant uncertainty. Emissions due to leakage/venting and flaring decreased by 16.66 per cent, while total emissions from oil and gas systems decreased by 46.04 per cent between 2019 and 2020. The data on flaring activities from the oil and gas sector to estimate $CO_2$ emissions needs further refinement in future reporting.

For fugitive emissions from oil and natural gas handling activities such as production, processing, distribution and venting/flaring, the IPCC default values of methane emission factor have been used and estimated methane emission from oil and natural gas systems in India is presented in Table 2.15.

***Table 2.15: Activity data for emissions from oil & gas systems in India (2020)***

| Oil | | | |
|---|---|---|---|
| Exploration | Onshore oil produced | 10^3m^3 | 17,652.08 |
| Production and upgrading | Oil produced | 10^3m^3 | 35,855.21 |
| Transport | Oil transported by pipelines | 10^3m^3 | 113917 |
| Refining/storage | Crude processed | 10^3m^3 | 2,75,580.75 |
| Distribution of oil products | Oil products consumed | 10^3m^3 | 2,68,852.68 |
| **Natural Gas** | | | |
| Exploration | Onshore Natural gas produced | 10^6m^3 | 10,208.00 |
| Production | Natural gas produced | 10^6m^3 | 28,493.00 |
| Processing | Net availability | 10^6m^3 | 28,402.25 |
| Transmission and storage | Sales | 10^6m^3 | 61,389.25 |
| Distribution | Natural gas consumed | 10^6m^3 | 61,389.25 |

## 2.7.2 Industrial Processes and Product Use Sector

The IPPU sector, which includes GHG emissions produced by a variety of industrial activities that transform raw materials by chemical or physical means, represented 8.06 per cent of GHG emissions (without LULUCF) in 2020. The same year, their emissions reached 2,38,556 $GgCO_2e$, decreasing by 9.48 per cent compared to 2019 mainly due to the decrease in the production of lime, aluminium, nitric acid and soda ash (Figure 2.12). A list of country-specific emission factors used in the IPPU sector is in the Table 2.20.

The category includes the emission estimates of $CO_2$, $CH_4$, $N_2O$, HFC-23, $CF_4$, $C_2F_6$, and $SF_6$ In 2020, the primary GHG emitted by the sector was $CO_2$, representing 84.28 per cent of the total GHG emissions in the sector, followed by HFC with 9.07 per cent, $CF_4$ with 2.46 per cent, $CH_4$ with 2.04 per cent, $C_2F_6$ with 1.05 per cent and $N_2O$ with 1.05 per cent and $SF_6$ to 0.04 per cent (Figure 2.13).

### *Mineral industries (2.A)*

$CO_2$ emissions from processes resulting from the use of carbonated raw materials in the production and use of a variety of industrial mineral products are included in this category. There are two major pathways for $CO_2$ release from carbonates: calcination and acid-induced $CO_2$ release. The process-related $CO_2$ equivalent emissions for the year 2020 from Cement, Lime, Glass, and Ceramics are 1,36,874 Gg (89.89 per cent), 15,008 Gg (9.86 per cent), 364 Gg (0.24 per cent) and 25 Gg (0.02 per cent) respectively.

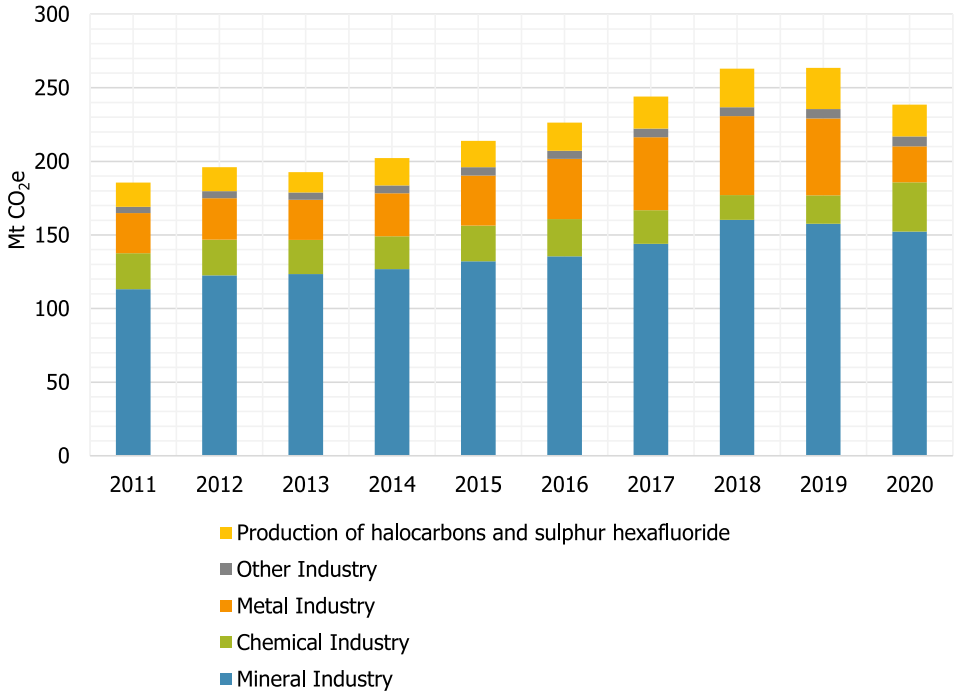


*Figure 2.12: Industrial Processes and Product Use: GHG emissions ($MtCO_2e$) as per subcategory, 2011-2020*

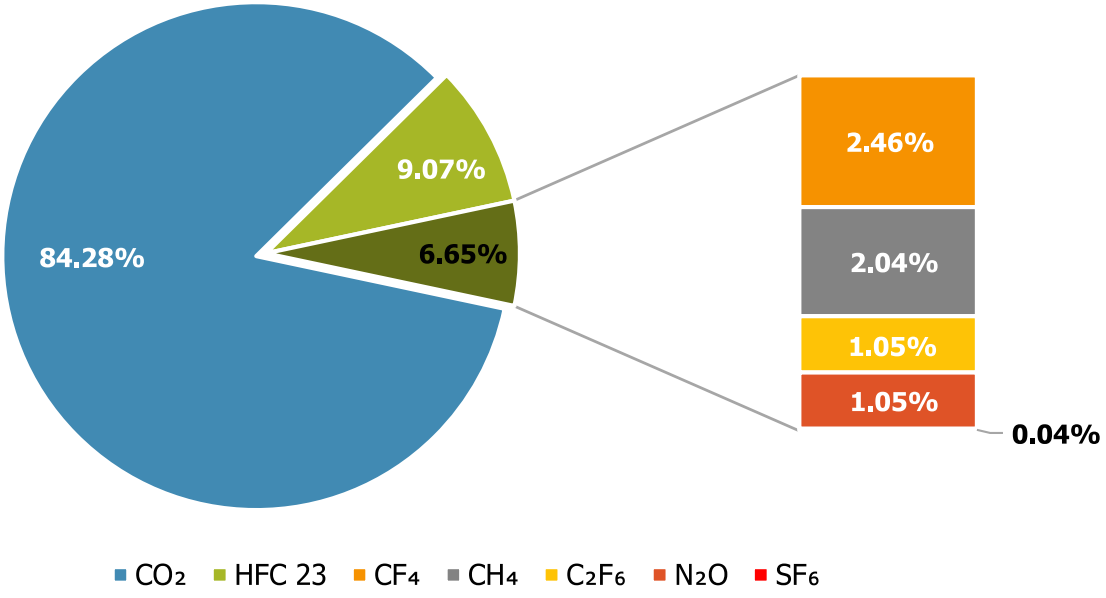


*Figure 2.13: Gas-wise distribution of emissions from the IPPU sector in 2020*

In India, about 97 per cent of the total production of limestone during 2018-19 was of cement grade and 3 per cent of other grades (IMYB, 2020). To avoid double counting, GHG emissions associated with the use of limestone in the cement manufacturing sector have been allocated accordingly.

*Table 2.16: Types of production in the mineral industries (2A) during 2017, 2018, 2019 and 2020*

| Production/consumption (million tonne) | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|
| Clinker production | 209.40 | 233.78 | 239.27 | 258.64 |
| Quick lime production | 190.05 | 211.21 | 208.28 | 200.97 |
| Dolomitic lime production | 2.20 | 2.65 | 2.23 | 2.31 |
| Glass (Float, Sheet, Bottles) production | 2.544 | 2.567 | 2.480 | 2.392 |
| Mass of calcium carbonate consumed | 0.0230 | 0.0241 | 0.0253 | 0.0264 |
| Mass of dolomite consumed | 0.0247 | 0.0258 | 0.0270 | 0.0282 |

*Sources: (CMA, 2017, 2018, 2019, 2020, 2021); (MoM, 2017, 2018, 2019, 2020, 2021); (AIGMF, 2017, 2018, 2019, 2020, 2021); (MoM, 2017, 2018, 2019, 2020, 2021).*

## *Chemical industries (2.B)*

This category includes GHG emissions from the production of several inorganic and organic chemicals, for which several countries' experience has confirmed that the sector contributes significantly to global or national GHG emissions.

In 2020, GHG emissions from this sector accounted for 33,496 $GgCO_2e$, an increase of 73.76 per cent since 2019. This is due to increased usage of natural gas as a feedstock for ammonia, ethylene and ferroalloys production. During the same period, soda ash and caprolactam emissions decreased. Within the category, ethylene production was the highest, with total emissions of 16,385 Gg $CO_2e$ in 2020, followed by emissions from ammonia production 11,049 $GgCO_2e$. Emissions from nitric acid production were 2,286 $GgCO_2e$, emissions from carbon black production were 1,781 $GgCO_2e$, emissions from soda ash production were 887 $GgCO_2e$, emissions from EDM & VCM production were 307 $GgCO_2e$, emissions from ethylene oxide production were 257 $GgCO_2e$, emissions from caprolactam production were 227 $GgCO_2e$, emissions from methanol production were 158 $GgCO_2e$, emissions from carbide production were 94 $GgCO_2e$ and from titanium dioxide production were 68 $GgCO_2e$ (Figure 2.14).

*Table 2.17: Types of production in the chemical industries (2B) during 2017, 2018, 2019 and 2020*

| Production (million tonne) | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|
| Ammonia | 14.94 | 14.72 | 14.40 | 14.99 |
| Nitric acid | 1.714 | 1.739 | 1.874 | 1.500 |
| Caprolactam | 0.0862 | 0.0909 | 0.0862 | 0.0813 |
| Calcium carbide | 0.0867 | 0.0842 | 0.0818 | 0.0854 |
| Titanium dioxide | 0.0580 | 0.0573 | 0.0514 | 0.0508 |
| Soda ash | 3.026 | 3.163 | 3.331 | 2.746 |
| Carbon black | 0.532 | 0.542 | 0.512 | 0.414 |
| Methanol | 0.240 | 0.269 | 0.200 | 0.220 |
| Ethylene | 4.172 | 3.930 | 5.808 | 6.390 |
| Ethylene dichloride | 0.282 | 0.325 | 0.344 | 0.331 |
| Vinyl chloride monomer | 0.781 | 0.792 | 0.857 | 0.818 |
| Ethylene oxide | 0.272 | 0.247 | 0.284 | 0.285 |

*Sources: (MoC&F, 2017, 2018, 2019, 2020, 2021); (FAI, 2021, 2022); (CMIE Prowess, 2021); (MoC&F, 2017a, 2018a, 2019a, 2020a, 2021a); (AMAI, 2017, 2018, 2019, 2020, 2021)*

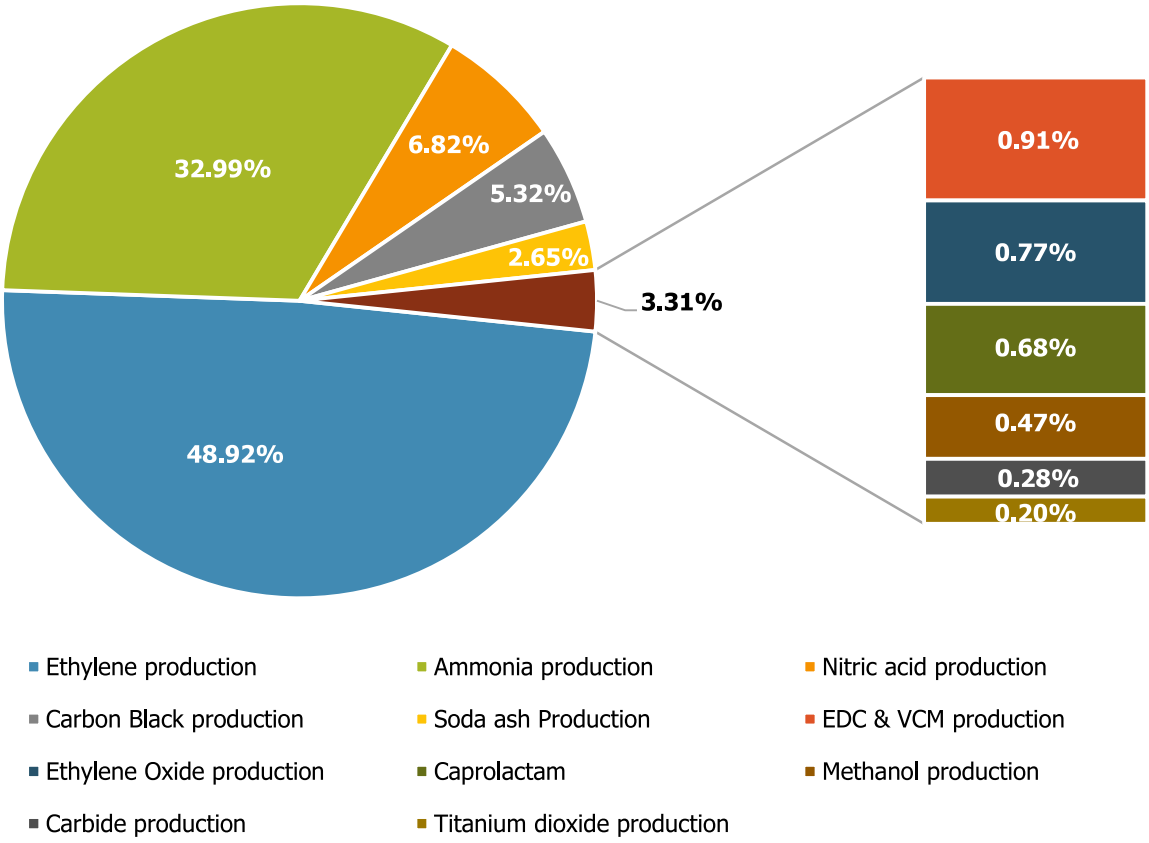


*Figure 2.14: Distribution of $CO_2e$ emissions across the Chemical Industries Category in 2020*

## *Metal Industries (2.C)*

GHG emissions from the production of metals such as ferroalloys, lead, zinc, aluminium, and magnesium are included in this category. The energy sector has reported metallurgical coke-related process emissions in iron and steel production. The total $CO_2$ equivalent emissions from metal industries for 2020 were 24,421 $GgCO_2e$, which was 53.29 per cent lower than 2019 levels. This mainly attributed to the decreased production of Aluminium. Aluminium industry emissions cover 58 per cent of the emissions of the metal industries in India. Magnesium production is the single estimated source of $SF_6$ , emitting 100.95 $GgCO_2eq$.

***Table 2.18: Types of production in the metal industries (2C) during 2017, 2018, 2019 and 2020.***

| Production (million tonne) | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|
| Ferro chromium | 0.944 | 0.944 | 0.927 | 1.456 |
| Ferro manganese | 0.518 | 0.518 | 0.518 | 0.666 |
| Ferro silicon | 0.090 | 0.090 | 0.090 | 0.135 |
| Silico manganese | 0.309 | 0.335 | 0.326 | 0.327 |
| Aluminium | 3.401 | 3.696 | 3.629 | 3.623 |
| Lead | 0.162 | 0.190 | 0.185 | 0.271 |
| Zinc | 0.791 | 0.696 | 0.688 | 0.708 |
| Magnesium | 0.0002 | 0.0002 | 0.0002 | 0.0002 |

*Source: (MoM, 2017, 2018, 2019, 2020, 2021); (Brown, et al., 2019); (MoC&F, 2017a, 2018a, 2019a, 2020a, 2021a).*

## *Non-energy product use (2.D)*

This category estimates emissions from the first use of fossil fuels as a product for primary purposes other than i) combustion for energy purpose, and ii) use as feedstock or reducing agent. The products covered here comprise lubricants and paraffin waxes.

In India, the lubricant market is dominated by the transportation sector. The total $CO_2$ emissions resulting from lubricant use in 2020 were 2,377 $GgCO_2e$, an increase of 6.29 per cent since 2019.

Emissions from the use of waxes occur primarily when waxes or paraffin derivatives are burned during use (for example, candles), incinerated with or without heat recovery, or in wastewater treatment (for surfactants). Total GHG emissions from paraffin wax for non-energy purposes were 169 $GgCO_2e$ in 2020, an increase of 2 per cent over 2019.

***Table 2.19: Types of production in the non-energy product use (2D) during 2017, 2018, 2019 and 2020.***

| Production (million tonne) | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|
| Lubricant production | 3.781 | 3.722 | 3.793 | 4.031 |
| Paraffin wax consumption | 0.215 | 0.264 | 0.280 | 0.286 |

*Source: MoPNG, 2017a, 2018a, 2019a, 2020a.*

## *Production of halocarbons (2.E)*

This category estimates emissions from the production of halocarbons which generated 21,645 $GgCO_2e$ (HFC23) in 2020, a decrease of 22.56 per cent compared to 2019. Production of Hydrochlorofluorocarbon was 0.0645, 0.0772, 0.0827 and 0.080 million tonne in 2017, 2018, 2019 and 2020 respectively.

## *Other industry (2.H)*

This category estimates emissions from Pulp & Paper industries, which generated 4,179 $GgCO_2e$ in 2020, an increase of 5.29 per cent compared to 2019 emissions. Production of paper was 18.40, 19.25, 20.29 and 21.43 million tonne in 2017, 2018, 2019 and 2020, respectively.

***Table 2.20: Country-specific emission factors used in the IPPU sector***

| Category | Type of gas | Emission factor | Source |
|---|---|---|---|
| 2.A.1 Cement | $CO_2$ | 0.5292 tonne $CO_2$/tonne clinker produced (With CKD correction factor) | Country-specific emission factors developed during the INC |
| 2.B.2 Nitric Acid | $N_2O$ | 4 – 11 kg $N_2O$/tonne HNO3 | Company-specific and based on the CDM database |
| 2.B.7 Soda Ash | $CO_2$ | 250 kg $CO_2$/tonne natural soda ash produced<br>70 kg $CO_2$/tonne of Soda Ash produced and<br>3 kg $CO_2$/tonne of soda ash produced | Technical EIA Guidance for soda ash industry - MoEF. Prepared by IL&FS, 2010. |
| 2.B.9.a | HFC-22 | 0.0289 tonne HFC-23/tonne HCFC-22 produced | Country-specific emission factor considered from the Monitoring Report of Gujarat Fluorochemical Ltd. (Major producer of HCFC-22), Ratio of HFC23 generation to HCFC22 production as 2.89 per cent. |
| 2.C.3 Aluminium | $C_2F_6$ | Prebaked: 0.44 kg $C_2F_6$ produced/ tonne of Aluminium produced<br>Soderberg: 0.07 kg $C_2F_6$/tonne of Aluminium produced | Data taken from the International Aluminium Institute report on the aluminium industry's global perfluorocarbon gas emissions reduction programme, which was the result of the 2004 anode effect survey. |

## 2.7.3 Agriculture Sector

The main GHG emissions from the agriculture sector are methane from livestock's enteric fermentation and rice cultivation and, methane and nitrous oxide from manure management and nitrous oxide from agricultural soils. The agriculture sector represented 13.72 per cent of the total GHG emissions (4,05,983 $GgCO_2e$) in 2020, a decrease of 4 per cent compared to 2019 (Figure 2.4). Agriculture's contribution to total emissions has been almost stable over the past decade (Figure 2.15).

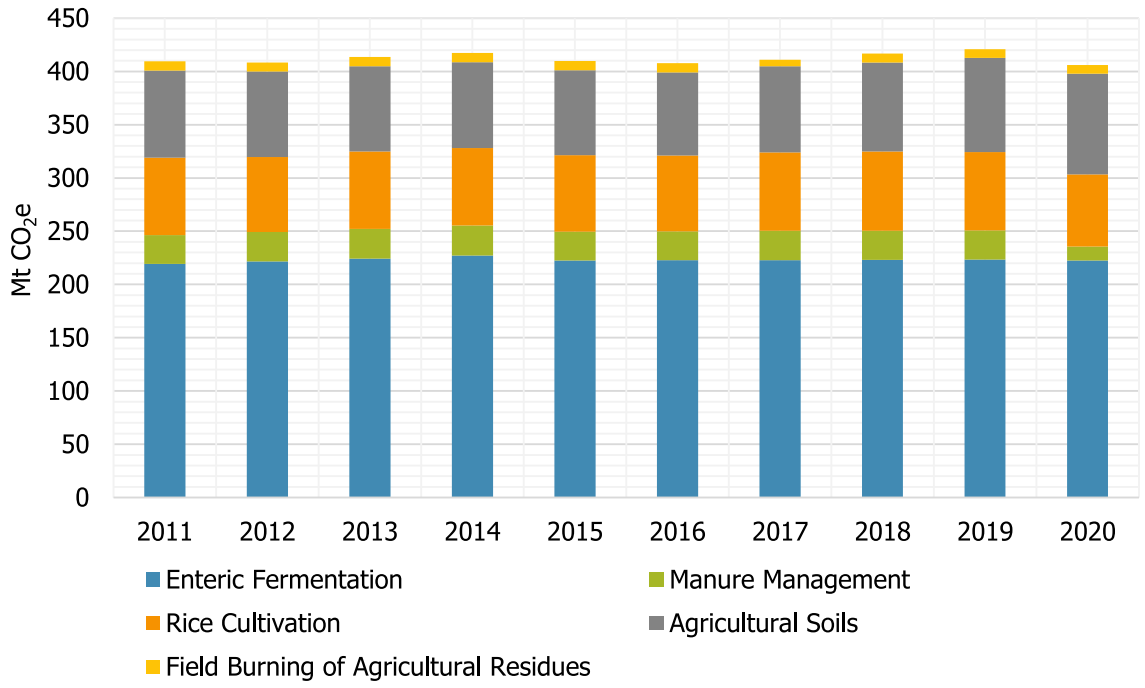


*Figure 2.15: Trend in GHG emissions ($MtCO_2e$) from the different subcategories of Agriculture sector, 2011-2020*

Agricultural activities contribute to emissions of GHGs ($CH_4$ and $N_2O$) through a variety of processes. The primary sources of $CH_4$ and $N_2O$ emissions in India are animal husbandry and crop production. Animal husbandry in India is dominated by cattle, buffalo, sheep, goat and pig. With regard to subcategories, 54.84 per cent of GHG emissions correspond to enteric fermentation, followed by 23.26 per cent from agricultural soils (18.41 per cent from direct $N_2O$ and 4.85 per cent from indirect $N_2O$), 16.68 per cent from rice cultivation, 3.22 per cent from manure management and 2 per cent corresponding to field burning of agricultural residues in 2020 (Figure 2.16).

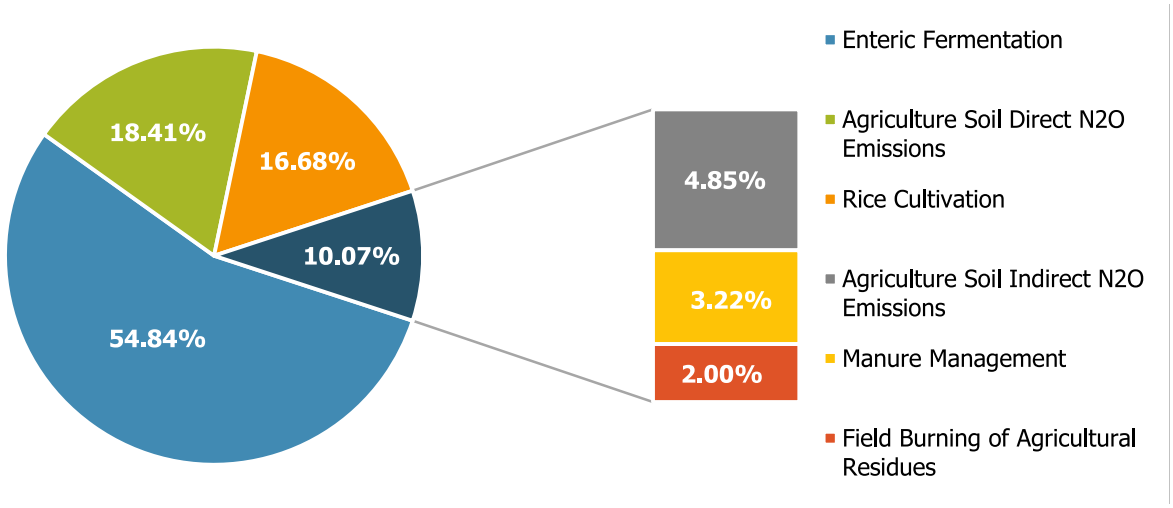


*Figure 2.16: Distribution of $CO_2e$ emissions (Gg) across the agriculture sector Categories in 2020*

## *Enteric fermentation (3.A)*

This category includes $CH_4$ emissions from herbivores as a by-product of the enteric fermentation. Ruminant livestock (e.g., cattle, buffalo, goat and sheep) are important sources while non-ruminants also produce moderate amounts.

In 2020, emissions from this category accounted for 2,22,632 $GgCO_2e$, a minor decrease of 0.28 per cent since 2019. (DoAHD&F, 2014), (DoAH&D, 2019).

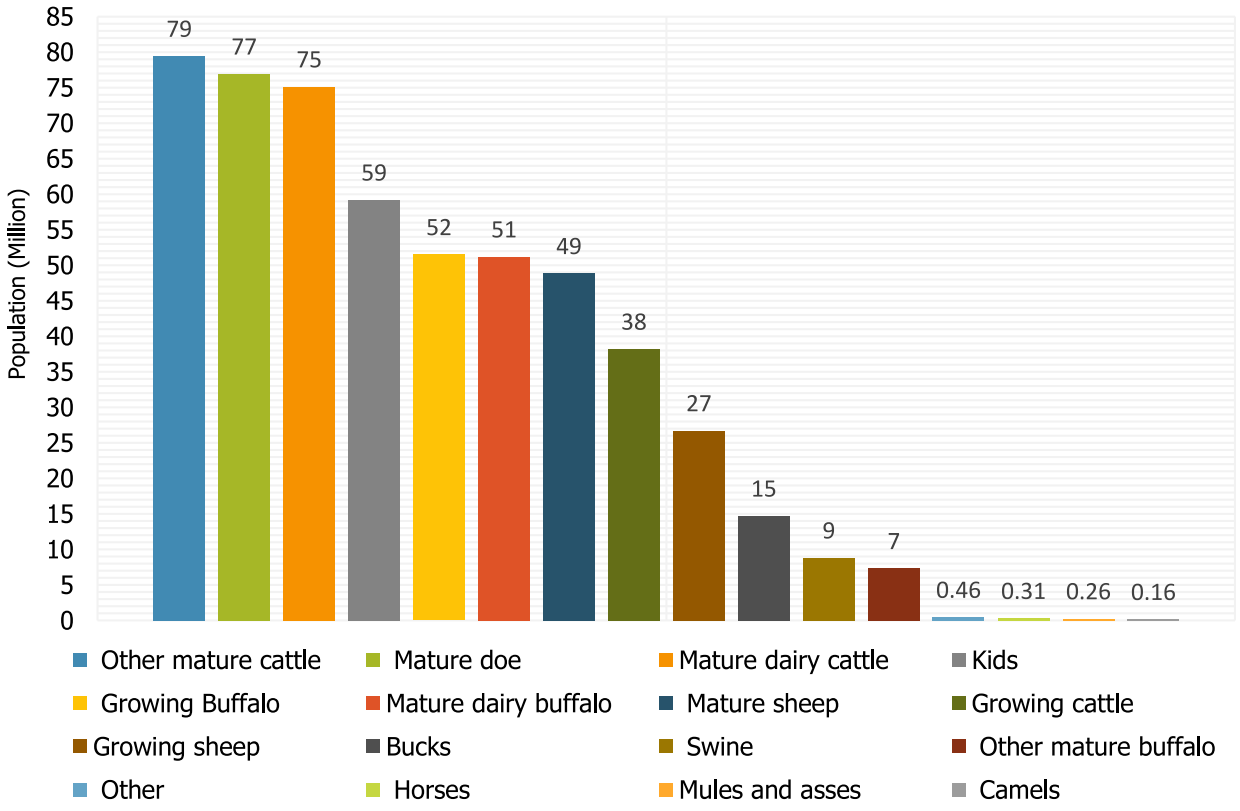


*Figure 2.17: Population in millions by livestock category, 2020*

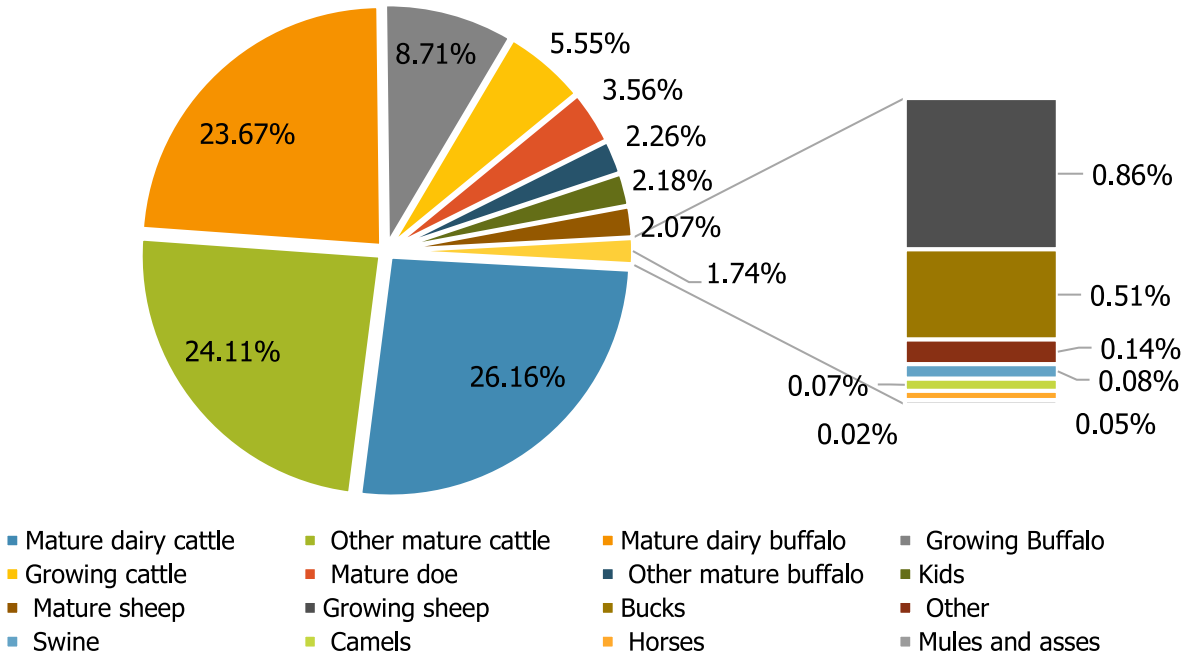


*Figure 2.18: Emission share by livestock categories, 2020*

## *Manure management (3.B)*

This category includes $CH_4$ and $N_2O$ emissions of manure decomposition under low oxygen or anaerobic conditions. In 2020, the GHG emissions from this category accounted for 13,072 $GgCO_2e$, a decrease by 52.49 per cent compared to 2019. Within the category for methane emissions, mature dairy cattle account for most of the emissions, representing 27.11 per cent of the subcategory, followed by mature dairy buffalo with 26.86 per cent, Other mature cattle with 21.56 per cent, while the rest contributed around 24.47 per cent of emissions (Figure 2.19).

***Table 2.21: Parameters and emission factors across various livestock categories in 2020***

| Livestock Category | Typical animal mass (average) | VS daily excretion (average) | $CH_4$ producing potential (Bo) (average) |
|---|---|---|---|
| | (kg/head) | (kg dm/head/day) | (m3 $CH_4$/kg VS) |
| Mature dairy cattle | 306.13 | 2.38 | 0.1 |
| Mature dairy buffalo | 410.75 | 3.46 | 0.1 |
| Other mature cattle | 265.59 | 1.79 | 0.1 |
| Growing Buffalo | 108.61 | 1.25 | 0.1 |
| Growing cattle | 110.9 | 1.02 | 0.1 |
| Other mature buffalo | 352.48 | 2.61 | 0.1 |
| Swine | 29.5 | 0.58 | 0.29 |
| Mature doe | 18.22 | 0.28 | 0.13 |
| Mature sheep | 30.69 | 0.34 | 0.13 |
| Kids | 10.79 | 0.22 | 0.13 |
| Growing sheep | 17.05 | 0.25 | 0.13 |
| Bucks | 18.39 | 0.21 | 0.13 |
| Other | 227.1 | 1.79 | 0.1 |
| Horses | 238 | NA | NA |
| Camels | 257.5 | NA | NA |
| Mules and asses | 153.37 | NA | NA |

Indirect emissions result from volatile nitrogen losses that occur primarily in the form of ammonia and NOx during storage as solid. Within the category, for nitrous oxide emissions, mature dairy cattle account for most of the emissions, representing 33 per cent of the subcategory, followed by other mature cattle with 22 per cent, mature dairy buffalo with 21 per cent, and remaining species with 24 per cent of the emissions during the year 2020 (Figure 2.20). However, from 2019 to 2020, there was not much change within this emission category.

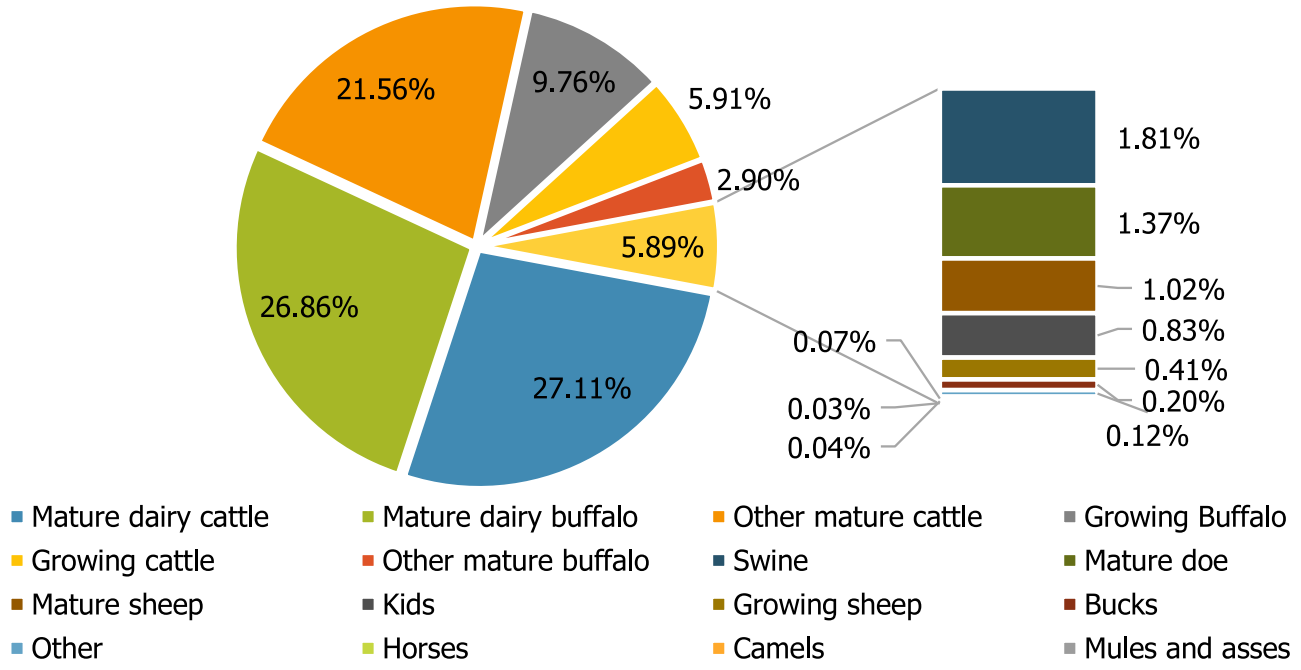


*Figure 2.19: Methane emissions from manure management by livestock category, 2020*

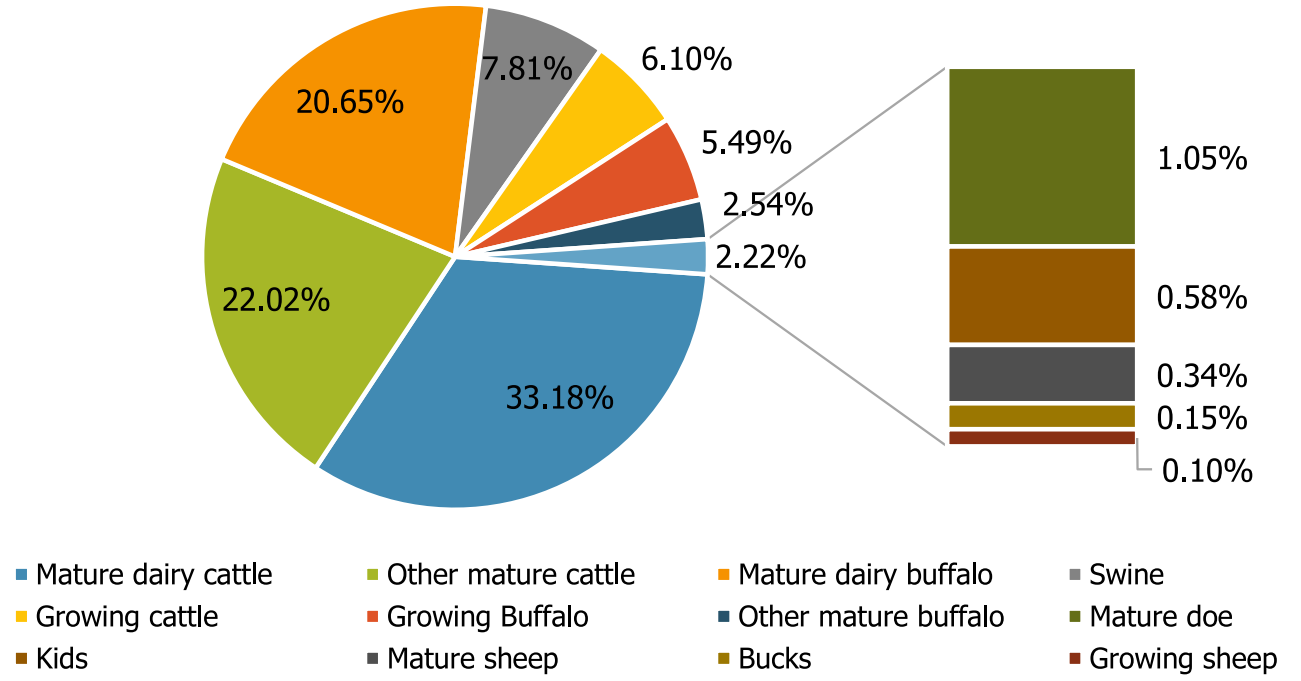


*Figure 2.20: Nitrous Oxide emissions from manure management by livestock category, 2020*

## *Rice cultivation (3.C)*

This category includes emissions of methane by the anaerobic decomposition of soil organic material in flooded rice paddies. In 2020, GHG emissions from this category accounted for 67,725 $GgCO_2e$, a decrease of 7.78 per cent from 2019. This change in trend of rice cultivation is directly related to decrease in area under rice.

In 2020, the total area under rice cultivation in the country was 45.24 million ha, and 3,225 Gg of methane was emitted. Figure 2.21 depicts the estimated emissions from different ecosystem types under different water regimes. Of the total land under rice cultivation, 39 per cent is under multiple aeration, 22.30 per cent is continuous flooding, 13.20 per cent is drought-prone, 10 per cent under single aeration, 7.50 per cent is flood prone, 5 per cent is upland and 3 per cent is deep water rice system.

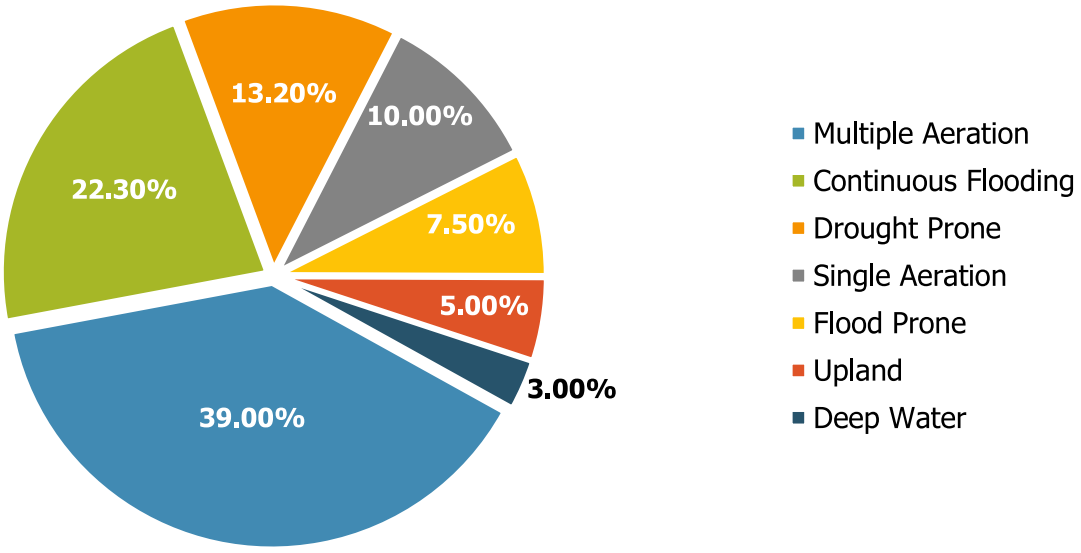


*Figure 2.21: Rice area (in per cent) under different types of water regimes, 2020*

## *Agriculture soils (3.D)*

In the national GHG inventory, the agriculture soils sub-sector is the largest single source of $N_2O$ emissions. Soil $N_2O$ emissions can be categorised into two types: direct and indirect. Net N additions to soils (synthetic or organic fertilisers, deposited manure, crop residues) and mineralization of N in soil due to cultivation/ land-use change on mineral soils were used to estimate direct $N_2O$ emissions. Indirect $N_2O$ emission was estimated from the volatilization of $NH_3$ and $NO_x$ from managed soils and the subsequent re-deposition of these gases and their products ($NH_4$ and $NO_3$) in soils after leaching and runoff of N, mainly as $NO_3$ from managed soils. Total emissions of $N_2O$ from managed soils have been estimated by adding direct and indirect $N_2O$ emissions.

In 2020, GHG emissions from this category accounted for 94,437 $GgCO_2e$, a 6.82 per cent increase from 2019. There has been an increase in emissions in this sub-sector due to synthetic fertiliser-based nitrogen consumption. Within the category, direct emissions of $N_2O$ from agricultural soils represent 79.15 per cent of the emissions, while indirect emissions of $N_2O$ from agricultural soils represent 20.85 per cent of total emissions.

***Table 2.22: Activity data used in agriculture soil (3D) during 2017, 2018, 2019 and 2020***

| Million tonne | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|
| Nitrogen consumption* | 16,959 | 17,629 | 19,101 | 20,078 |
| Nitrogen from compost | 1.1260 | 1.1260 | 1.1260 | 1.0843 |
| Nitrogen from crop residue | 2.581 | 2.624 | 2.623 | 2.496 |
| Manure nitrogen other than poultry | 1.049 | 1.057 | 1.051 | 1.321 |
| Nitrogen input from below-ground biomass | 2.341 | 2.384 | 2.376 | 2.278 |

**Source: (FAI, 2021, 2022).*

***Table 2.23: Country-specific emission factor used in agriculture soil (3D)***

| Parameter | Country specific coefficients |
|---|---|
| EF1 ($N_2O$ emission from applied fertilizer) | 0.55 % |
| EF4 ($N_2O$ emission from volatilized N from fertilizer and manure) | 0.50 % |
| EF5 ($N_2O$ emission from leached and run-off N from fertilizer and manure) | 0.50 % |
| FracGASF (Gas loss through volatilization from inorganic fertilizer) | 20 % |
| FracGASF-AM (Gas loss through volatilization from manure) | 20 % |
| Fracleach (Leaching loss of N from applied fertilizer and manure) | 10 % |

*Source: (Pathak et al., 2002; 2014); (Bhatia et al., 2004; 2005; 2013); (Cowan et al., 2021); (Jain et al., 2016); (Paul et al., 2024); (Chaterjee et al., 2023).*

## *Field burning of agriculture residues (3.F)*

The category includes $CH_4$ and $N_2O$ emissions generated due to on-farm burning of agricultural waste at croplands. Residues from eight crops (rice, wheat, cotton, maize, millet, sugarcane, jute, rapeseed and mustard) are generally burned in the field.

Emissions from field burning of agricultural residues were 279.55 Gg of $CH_4$ and 7.25 Gg of $N_2O$. In $CO_2$ equivalent terms, 8,117 Gg of emission occurred in 2020, showing a 2.88 per cent decrease from 2019 levels.

***Table 2.24: Country-specific emission factors used in field burning of agricultural residues (3F)***

| Crop | Residue-to-crop ratio | Dry matter fraction | Fraction burnt |
|---|---|---|---|
| Rice | 1.5 | 0.86 | 0.05 - 0.343 |
| Wheat | 1.7 | 0.88 | 0.1 - 0.25 |
| Maize | 1.5 | 0.88 | 0.1 |
| Jute | 2.15 | 0.80 | 0.1 |
| Cotton | 3 | 0.80 | 0.1 |
| Sugarcane | 0.4 | 0.88 | 0.25 |
| Rapeseed & mustard | 3 | 0.80 | 0.1 |
| Millets | 1.5 | 0.88 | 0.1 |

*Source: (Andreae, M. O. & Merlet, P., 2001); (Gadde, B. et al., 2009); (Jain et al., 2014, 2018 and 2021), (IARI, 2015-2020); (Bandyopadhyay et al., 2001).*

## 2.7.4 Land Use and Land-Use Change and Forestry Sector

The LULUCF sector, which includes GHG emissions and removals associated with forestry and land-use change, is the only sector in the country that consistently absorbs $CO_2$, making it one of the most important sectors from the mitigation perspective. This sector removed 22 per cent of the country's carbon dioxide emissions in 2020. In the same year, its emissions reached -5,21,933 $GgCO_2e$, increasing its status as a sink by 7.5 per cent since 2019, mainly due to adding a new sink category (Figure 2.22). While Forestland, Cropland, Settlements and Harvested Wood Products (HWP) are found to be a net sink, Grasslands are the only source land use category. With respect to total $CO_2$ removals in 2020, 66.91 per cent corresponds to Cropland, followed by 27.41 per cent of Forest land, 4.22 per cent of HWP and 1.35 per cent of Settlements (Table 2.25). Cropland is the dominant contributor to LULUCF total sink capacity in all the years since Cropland accounts for about 50 per cent of the total land area and farmers apply organic compost and fertilizer to crop fields.

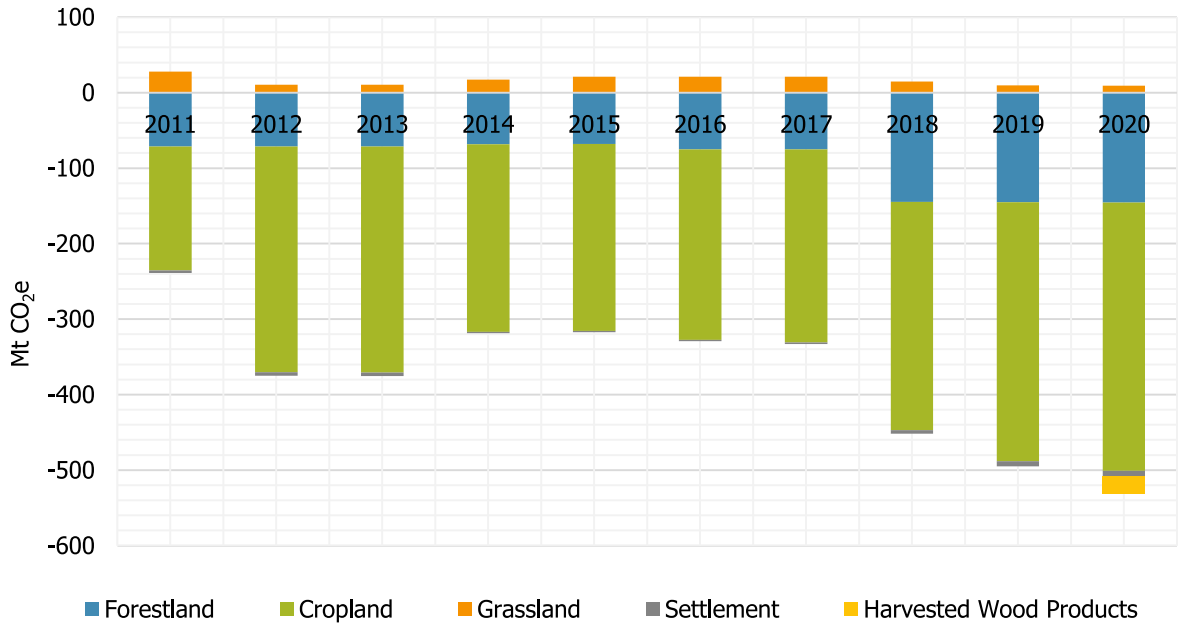


*Figure 2.22: LULUCF: GHG emissions/removals (Mt $CO_2e$) per subcategory, 2011-2020*

***Table 2.25: Total GHG balance for the 2020 in $GgCO_2e$***

| Land Category | Net $CO_2$ | $CH_4$ | $N_2O$ | Total |
|---|---|---|---|---|
| Forest Land | -1,46,667 | 851 | 203 | -1,45,612 |
| Cropland | -3,55,513 | - | - | -3,55,513 |
| Grassland | 9,369 | - | - | 9,369 |
| Settlements | -7,158 | - | - | -7,158 |
| Harvested Wood Products | -23,019 | - | - | -23,019 |
| Total | -5,32,357 | 851 | 203 | -5,21,933 |

India has been monitoring and estimating Land Use and Land Cover data using remote sensing technology coupled with ground-based observations. Land use and change trends for five land categories are given in Table 2.26. Land area is reported for the five IPCC land categories, except Wetlands due to activity data limitations. In India, area under different land use categories is estimated by the National Remote Sensing Centre and the area under the forest is monitored biennially by the Forest Survey of India. The definition for the different land categories is as follows (similar to the definitions used in BUR-3 and the Third National Communication):

- Forestland - all lands, more than 1 ha in area, with tree canopy density of more than 10%
- Cropland – includes all croplands, fruit gardens, and crop fallow area
- Grasslands (and Scrub) – the areas covered with grassy and herbaceous growth as well as degraded forests with less than 10 per cent tree canopy density
- Settlement – includes built-up areas and human habitations, both rural and urban
- Other Land – includes all non-vegetated areas such as snow, rocky outcrops, and surface water bodies.
- Harvested wood products – includes all solid wood, paper, and paperboard.

The area under Forestland has marginally increased during the period 2019-2020 by 770 km². The forest area for the year 2020 is estimated by extrapolating area estimates for 2019 (ISFR-2021) and 2017 (ISFR-2019). Area under Cropland is reported to be increasing marginally in recent years. Area under Grassland has marginally declined, while area under Settlements has increased by 0.32 Mha.

***Table 2.26: Land use change for India for the period 2005-2020 (in a million ha)***

| Year | Forest Land | Cropland | Grassland | Settlements | Other land | Total area |
|---|---|---|---|---|---|---|
| 2005 | 69.16 | 160.65 | 20.35 | 8.61 | 69.96 | 328.73 |
| 2006 | 69.24 | 160.94 | 20.42 | 8.72 | 69.41 | 328.73 |
| 2007 | 69.25 | 161.23 | 20.48 | 8.84 | 68.91 | 328.73 |
| 2008 | 69.27 | 161.53 | 20.55 | 8.96 | 68.42 | 328.73 |
| 2009 | 69.44 | 161.82 | 20.62 | 9.08 | 67.76 | 328.73 |
| 2010 | 69.50 | 162.12 | 20.69 | 9.20 | 67.23 | 328.73 |
| 2011 | 69.79 | 162.41 | 20.75 | 9.31 | 66.46 | 328.73 |
| 2012 | 69.98 | 162.71 | 20.82 | 9.43 | 65.79 | 328.73 |
| 2013 | 70.15 | 163.00 | 20.89 | 9.55 | 65.14 | 328.73 |
| 2014 | 70.49 | 163.29 | 20.89 | 9.55 | 64.51 | 328.73 |
| 2015 | 70.83 | 163.85 | 21.65 | 9.56 | 62.84 | 328.73 |
| 2016 | 71.03 | 164.40 | 22.42 | 9.57 | 61.31 | 328.73 |
| 2017 | 71.22 | 164.81 | 22.66 | 9.61 | 60.43 | 328.73 |
| 2018 | 71.30 | 165.22 | 22.91 | 9.64 | 59.66 | 328.73 |
| 2019 | 71.38 | 166.05 | 23.40 | 9.71 | 58.20 | 328.73 |
| 2020 | 71.45 | 168.93 | 22.26 | 10.03 | 56.06 | 328.73 |

*Source: FSI, 2005, 2007, 2009, 2011, 2013, 2015, 2017, 2019, 2021.*

## *Forest land (4.A)*

$CO_2$ and non-$CO_2$ inventory for Forestland is estimated using Tier-2 methods based on estimates from National Forest Area monitoring and Forest Inventory Methods. Refer to methods for estimating the area and carbon stock changes presented in ISFR (2021).

Activity Data: In India, Forestland is defined as "all lands, more than 1 ha in area, with a tree canopy density of more than 10%". The Forest Survey of India (FSI) periodically monitors the area under forest and publishes "State of Forest Reports" once in two years. The area is estimated using remote sensing data by the Forest Survey of India and the National Remote Sensing Centre. Detailed estimates of Forestland remaining Forestland and Land converted to Forestland and associated carbon stock changes for these two categories is not available.

Emission Factor: As per IPCC guidelines carbon stock in the forests includes five pools; aboveground biomass (AGB), belowground biomass (BGB), Litter, Deadwood and Soil Organic Carbon (SOC). Carbon stock change in Forestland category is based on Forest Inventory studies by the Forest Survey of India and the same is used for calculating $CO_2$ emissions and removals and reported under Forestland category.

The carbon stock in different pools for the year 2020 is given in Table 2.27. It can be observed that AGB pool is estimated to be 2,352 MtC and SOC pool is estimated to be 4,013 MtC during 2020. SOC dominates, by accounting for 55 per cent of the total carbon stock in Forestland.

***Table 2.27: Carbon stock in different pools in Forestland from 2015 to 2020 (in MtC)***

| Pools (Carbon stock in million tonnes) | C stock in 2015 (ISFR 2017) | C stock in 2017 (ISFR 2019) | C stock in 2019 (ISFR 2021) | C stock in 2020 (based on estimates of ISFR 2019 and ISFR 2021) |
|---|---|---|---|---|
| AGB | 2238 | 2256 | 2320 | 2352 |
| BGB | 699 | 700.8 | 719 | 728 |
| Deadwood | 30 | 35.8 | 48 | 54 |
| Litter | 136 | 127.9 | 107 | 97 |
| Soil | 3979 | 4003.6 | 4010 | 4013 |
| Total | 7,082 | 7,124 | 7,204 | 7,244 |

*Source: (IPCC, 2003); (IPCC, 2006); (FSI, 2005, 2007, 2009, 2011, 2013, 2015, 2017, 2019, 2021, 2023).*

Non-$CO_2$ ($CH_4$ and $N_2O$) GHG emissions are estimated for the Forestland subjected to biomass burning category. FSI collects information on occurrence of the fire on an area of 2 hectares around the plot centre during its regular inventory program. The forest fire emissions are estimated for three fire intensity classes, namely.

- Mild Fire Area
- Moderate Fire Area
- Heavy Fire Area

The area estimation under above three categories has been carried out using information collected for ISFR 2003, 2005, 2009, 2013, 2015, 2017, 2019 and 2021. The per hectare biomass loss for the three different categories is estimated on the basis of inventory data and the area estimates under three categories annualized. The methods adopted for estimation are described in Second National Communications - 2012 and BUR-1 (2016). Emission Factors used for $CH_4$ and $N_2O$ emission estimation is based on the default values given in IPCC 2006 Guidelines.

GHG emissions from forest fires: It can be observed that the $CH_4$ and $N_2O$ emissions has increased during the period 2005 - 2020. The $CH_4$ emission during 2020 is estimated to be 851.26 $GgCO_2e$ and $N_2O$ emission is estimated to be 203.28 $GgCO_2e$.

## *$CO_2$ emissions and removals in Forestland during 2020*

The carbon stock change and $CO_2$ emissions and removals for Forestland are given in Table 2.28. $CO_2$ removals for Forestland are estimated to be 146,667 $GgCO_2e$ during 2020. In other words, GHG emissions from Forestland (FL) are estimated to be -146,667.67 $GgCO_2e$.

*Table 2.28: Carbon stock change and $CO_2$ emissions and removals for the period 2000 to 2020*

| Year | Total Change in Carbon Stock (MtC) | Total net annual change in carbon stock MtC during the year | Total net annual change in $MtCO_2$ during the year | Total net change in Carbon stocks in $CO_2$ in Gg |
|---|---|---|---|---|
| 2000 | 6,836 | 19.8 | 72.60 | 72,600 |
| 2001 | 6,857 | 21.0 | 76.91 | 76,908 |
| 2002 | 6,878 | 21.0 | 76.91 | 76,908 |
| 2003 | 6,899 | 21.0 | 76.91 | 76,908 |
| 2004 | 6,920 | 21.0 | 76.91 | 76,908 |
| 2005 | 6,926 | 6.2 | 22.55 | 22,550 |
| 2006 | 6,933 | 6.1 | 22.55 | 22,550 |
| 2007 | 6,939 | 6.1 | 22.55 | 22,550 |
| 2008 | 6,945 | 6.2 | 22.55 | 22,550 |
| 2009 | 6,965 | 19.8 | 72.67 | 72,673 |
| 2010 | 6,985 | 19.8 | 72.67 | 72,673 |
| 2011 | 7,004 | 19.8 | 72.67 | 72,673 |
| 2012 | 7,024 | 19.8 | 72.67 | 72,673 |
| 2013 | 7,044 | 19.8 | 72.67 | 72,673 |
| 2014 | 7,063 | 19.0 | 69.67 | 69,667 |
| 2015 | 7,082 | 19.0 | 69.67 | 69,667 |
| 2016 | 7,103 | 21.0 | 77.00 | 77,000 |
| 2017 | 7,124 | 21.0 | 77.00 | 77,000 |
| 2018 | 7,164 | 40.0 | 146.67 | 1,46,667 |
| 2019 | 7,204 | 40.0 | 146.67 | 1,46,667 |
| 2020* | 7,244 | 40.0 | 146.67 | 1,46,667 |

**The estimates for 2020 are based on estimates for 2017 (ISFR-2019) and 2019 (ISFR-2021)*

## *Cropland (4.B)*

Cropland includes all annual and perennial crops (which do not qualify as forest) as well as temporary fallow land (i.e., land left uncultivated for one or several years before being cultivated again). Annual crops may include cereals, oils seeds, vegetables, root crops and forages. Perennial crops may include trees and shrubs, in combination with herbaceous crops (e.g. agroforestry) or as orchards, vineyards and fruit plantations, which do not qualify as forests. $CO_2$ emissions/removals are estimated only for the perennial tree biomass component in the croplands, along with SOC. Activity data and emissions/removal factors for Land converted to Cropland are not available. Therefore, GHG emissions/removals are estimated for the Cropland category.

Activity data is estimated by NRSC using remote sensing technology. Area under Cropland is estimated to be 168.93 Mha during 2020. The net sown area varies due to rainfall, market prices and other factors. The Cropland area has increased from 166.65 to 168.93 Mha during the period 2019 to 2020.

The two critical emission factors are annual rate of change in perennial biomass carbon stock and annual rate of change in soil carbon stock on per hectare basis. The methods for estimating the perennial tree biomass in croplands are similar to the methods adopted in BUR-3, for 2016 and Third National Communication for 2019, where biomass estimates from TOF forms the basis for estimating net carbon stock change. The Forest Survey of India periodically conducts inventories of Trees Outside Forests (TOF). Trees Outside Forests include tree cover comprising of small patches of trees (<1.0 ha) in plantations and woodlots, scattered trees

and farms, homesteads and urban areas as well as trees along linear features such as road, canals and cropland bunds. The State of Forest Reports provide the growing stock of TOF in cubic metres, for all land categories other than forest, including croplands.

## *Carbon stock change in biomass*

The biomass carbon stock for the perennial tree crops in Cropland during 2020 is extrapolated by taking the biomass carbon stock of TOF during two successive periods from 2017 to 2019. Biomass of TOF is available for the years 2009, 2011, 2013, 2015, 2017 and 2019. The biomass stock is extrapolated to other inventory years. The rate of change in biomass carbon stock is estimated using annual rate of change in growing stock of TOF biomass, converted to per hectare value. The root biomass is estimated by using the IPCC default value of 0.27. Biomass Conversion Expansion Factor (BCEF) of 0.9 that has been derived nationally is used. It can be observed that the growing stock of biomass in TOF has increased by 0.196 tC/ha/yr during 2019. During 2020, the biomass carbon stock change is estimated to be 0.097 tC/ha/yr, which is less than half of the previous year, which could be due to harvest of trees in different locations.

Soil Organic Carbon is estimated using the stock difference method. SOC values are estimated based on annual change in SOC stock obtained from different studies. NBSSLUP of ICAR have estimated rate of change in soil carbon stock in Croplands based on 348 multiperiod studies, which included 145 primary measurements made at two periods at the same point and reported by ICAR institutions, and 167 peer reviewed studies for the Indian region. The rate of change in SOC is estimated to be 0.38 tC/ha/yr. SOC rate of change values varied for different soil types from 0.27 tC/ha/yr for red soils to 0.49 tC/ha/yr for black soils. The rate of change used for estimation of net change in SOC stock in croplands is 0.38 tC/ha/yr during 2020. This value is slightly higher than the value used for the TNC (0.367 tC/ha/yr).

## *GHG emissions and removals from biomass and soil carbon stocks in Cropland*

Cropland in India is a net sink during 2005-2020 (Table 2.29). Net change in biomass and soil carbon stock in Cropland is estimated to be 356,160.75 $GgCO_2e$ during 2020 - a net sink.

***Table 2.29: Trends in changes in carbon stocks and $CO_2$ emissions and removals in cropland for the period 2005 to 2020 in $GgCO_2$***

| Year | Area under cropland (Mha) | Change in biomass carbon stock (MtC) | Change in SOC stock (MtC) | Total change in biomass and soil carbon in cropland (MtC) | Total change in biomass and soil carbon in cropland ($GgCO_2$) |
|---|---|---|---|---|---|
| 2005 | 160.65 | -3.89 | 59.44 | 55.55 | 2,03,668.30 |
| 2006 | 160.94 | -4.03 | 59.55 | 55.52 | 2,03,580.72 |
| 2007 | 161.23 | -4.03 | 59.66 | 55.62 | 2,03,953.03 |
| 2008 | 161.53 | -12.33 | 59.77 | 47.44 | 1,73,940.06 |
| 2009 | 161.82 | -12.35 | 59.87 | 47.52 | 1,74,257.01 |
| 2010 | 162.12 | -15.34 | 59.98 | 44.64 | 1,63,693.09 |
| 2011 | 162.41 | -15.37 | 60.09 | 44.72 | 1,63,990.28 |
| 2012 | 162.71 | 21.31 | 60.20 | 81.51 | 2,98,869.20 |
| 2013 | 163.00 | 21.35 | 60.31 | 81.66 | 2,99,409.84 |
| 2014 | 163.29 | 7.38 | 60.42 | 67.80 | 2,48,610.30 |
| 2015 | 163.85 | 7.29 | 60.13 | 67.42 | 2,47,218.33 |
| 2016 | 164.40 | 8.23 | 60.34 | 68.56 | 2,51,395.25 |
| 2017 | 164.81 | 10.88 | 60.49 | 71.36 | 2,61,187.59 |
| 2018 | 165.22 | 19.50 | 60.64 | 80.13 | 2,93,282.02 |

| Year | Area under cropland (Mha) | Change in biomass carbon stock (MtC) | Change in SOC stock (MtC) | Total change in biomass and soil carbon in cropland (MtC) | Total change in biomass and soil carbon in cropland ($GgCO_2$) |
|---|---|---|---|---|---|
| 2019 | 166.05 | 32.55 | 60.94 | 93.49 | 3,42,159.31 |
| 2020 | 168.93 | 32.94 | 64.19 | 97.13 | 3,56,160.75 |

*Rate of change in biomass carbon stock used = 0.097 tC/ha/yr during 2020*
*Rate of change in SOC stock used = 0.38 tC/ha/yr during 2020*

## *Grassland (4.C)*

Grassland includes areas covered with grassy and herbaceous growth as well as degraded forests with less than 10 per cent tree canopy density. In India, grassland includes many land categories other than forestland and cropland. These lands are used for livestock grazing or left barren and subjected to fire and erosion.

The area under Grassland is estimated to be 22.26 Mha for the year 2020. GHG emissions/removals are estimated for Grassland category, as Activity Data and Emission Factors are not available for land converted to grassland category.

Emission factor for Grassland include rates of change in perennial biomass stock per hectare per year and rate of change in SOC per hectare per year. Perennial biomass stock change in the grassland category is estimated using the method and source of data described for Croplands. An emission factor of -0.31 tC/ha/yr for SOC stock change for Grassland has been used in previous LULUCF sector GHG estimations and reporting. Since, no new additional data are available, the same value is used for 2020 also. The main source of data for biomass stock and stock change in Grasslands is from the study on Trees Outside Forests conducted by FSI for non-forestland categories including grassland, cropland, and settlements. The biomass and SOC stock rate of change (tC/ha/yr) used for $CO_2$ emission/removal estimation in grassland is given in Table 2.30.

The grasslands in India are a net source of $CO_2$ during the period 2005 to 2020 (Table 2.30). Grassland category was a source of 24,938 $GgCO_2e$ during 2005 and continues to be a source, but slightly lower at 9,386.30 $GgCO_2e$ for 2020.

***Table 2.30: Trends in changes in carbon stocks and $CO_2$ emissions and removals in Grassland for the period 2005-2020 in $GgCO_2e$***

| Year | Area in Mha | Rate of change in biomass carbon (tC/ha/yr) | Total biomass carbon stock change in MtC | Rate of change in SOC in tC/ha/yr | Total SOC stock change in MtC | Total change in biomass and soil carbon stock (MtC) | Total change in biomass and soil carbon in grassland ($GgCO_2e$) |
|---|---|---|---|---|---|---|---|
| 2005 | 20.35 | -0.024 | -0.49 | -0.31 | -6.31 | -6.80 | -24,938.80 |
| 2006 | 20.42 | -0.025 | -0.51 | -0.31 | -6.33 | -6.84 | -25,079.77 |
| 2007 | 20.48 | -0.025 | -0.51 | -0.31 | -6.35 | -6.86 | -25,162.47 |
| 2008 | 20.55 | -0.076 | -1.57 | -0.31 | -6.37 | -7.94 | -29,111.16 |
| 2009 | 20.62 | -0.076 | -1.57 | -0.31 | -6.39 | -7.97 | -29,206.53 |
| 2010 | 20.69 | -0.095 | -1.96 | -0.31 | -6.41 | -8.37 | -30,690.30 |
| 2011 | 20.75 | -0.095 | -1.96 | -0.31 | -6.43 | -8.40 | -30,790.19 |
| 2012 | 20.82 | 0.131 | 2.73 | -0.31 | -6.45 | -3.73 | -13,668.13 |
| 2013 | 20.89 | 0.131 | 2.74 | -0.31 | -6.48 | -3.74 | -13,712.33 |
| 2014 | 20.89 | 0.045 | 0.94 | -0.31 | -6.48 | -5.53 | -20,279.64 |
| 2015 | 21.65 | 0.044 | 0.96 | -0.31 | -6.71 | -5.75 | -21,079.17 |

| Year | Area in Mha | Rate of change in biomass carbon (tC/ha/yr) | Total biomass carbon stock change in MtC | Rate of change in SOC in tC/ ha/yr | Total SOC stock change in MtC | Total change in biomass and soil carbon stock (MtC) | Total change in biomass and soil carbon in grassland ($GgCO_2e$) |
|---|---|---|---|---|---|---|---|
| 2016 | 22.42 | 0.050 | 1.12 | -0.31 | -6.95 | -5.83 | -21,367.92 |
| 2017 | 22.66 | 0.056 | 1.26 | -0.31 | -7.02 | -5.77 | -21,104.41 |
| 2018 | 22.91 | 0.099 | 2.26 | -0.31 | -7.10 | -4.84 | -17,712.31 |
| 2019 | 23.40 | 0.196 | 4.59 | -0.31 | -7.25 | -2.66 | -9,750.721 |
| 2020 | 22.26 | 0.195 | 4.34 | -0.31 | -6.90 | -2.56 | -9,386.30 |

## *Settlements (4.E)*

Only Settlements remaining Settlements category is considered as Activity Data and Emission Factors are not available for Land converted to Settlements. The area under Settlements during 2020 is estimated to be 10.03 Mha. The area under Settlements has increased from 8.61 Mha in 2005 to 10.03 Mha in 2020.

The perennial biomass stock change for Settlements land category is estimated using the method and data described for Croplands. The main source of data for biomass stock change is from the study on Trees Outside Forests conducted by FSI for non-forestland categories including Settlements. In this assessment, only $CO_2$ emissions and removals from biomass carbon is considered for Settlements remaining Settlements. This is because, it is likely that bulk of the land converted to settlements will not come from forestland because of the Forest Conservation Act. Most expansion occurs in and around cities and villages which are dominated by marginal croplands and grasslands. Further, area under forests in India is increasing which indicates there may be no conversion of forestland to settlements.

The Settlements category is estimated to be a net source during the period 2005-2011 (Table 2.31) and a net sink from 2012 onwards, due to recorded changes in biomass of TOF. The Settlement land category is a net sink of 7171.45 $GgCO_2e$ during 2020.

***Table 2.31: Trends in carbon stock change in Settlements for the period 2005-2020 in $GgCO_2e$***

| Year | Area in Mha | Rate of change in biomass carbon (tC/ha/yr) | Total biomass carbon stock change in MtC | Total change in biomass carbon in Settlements ($GgCO_2e$) |
|---|---|---|---|---|
| 2005 | 8.61 | -0.024 | -0.21 | -764.73 |
| 2006 | 8.72 | -0.025 | -0.22 | -800.17 |
| 2007 | 8.84 | -0.025 | -0.22 | -810.98 |
| 2008 | 8.96 | -0.076 | -0.68 | -2,507.28 |
| 2009 | 9.08 | -0.076 | -0.69 | -2,540.25 |
| 2010 | 9.2 | -0.095 | -0.87 | -3,190.41 |
| 2011 | 9.31 | -0.095 | -0.88 | -3,231.29 |
| 2012 | 9.43 | 0.131 | 1.24 | 4,528.98 |
| 2013 | 9.55 | 0.131 | 1.25 | 4,585.56 |
| 2014 | 9.55 | 0.045 | 0.43 | 1,583.26 |
| 2015 | 9.56 | 0.044 | 0.43 | 1,560.07 |
| 2016 | 9.57 | 0.050 | 0.48 | 1,756.69 |
| 2017 | 9.61 | 0.056 | 0.54 | 1,969.67 |
| 2018 | 9.64 | 0.099 | 0.95 | 3,492.96 |
| 2019 | 9.71 | 0.196 | 1.90 | 6,965.57 |
| 2020 | 10.03 | 0.195 | 1.96 | 7,171.45 |

## *Wetlands (Flooded Land, 4.F)*

According to IPCC, 2006, Wetlands include any land that is covered or saturated by water for all or part of the year, and that does not fall into the Forestland, Cropland, or Grassland categories. Further, managed wetlands are restricted to wetlands where the water table is artificially changed (e.g., drained or raised) or those created through human activity (e.g., damming a river). and emissions from unmanaged wetlands are not estimated according to the IPCC 2006 Guidelines. $CO_2$ emissions/removals from Wetlands were not estimated due to the absence of Activity data and Emissions factors for Flooded land remaining Flooded land and Land converted to Flooded land.

## *Other Land (4.G)*

Other Land includes snow covered areas, rocky surface, water bodies, extremely degraded land, deserts, etc. The Other Land area may support no or insignificant vegetation. According to IPCC 2006 guidelines, carbon stock change or GHG emissions need not be estimated for "Other land remaining Other land". IPCC provides guidelines for estimating GHG emissions from "Land converted to Other land". In India, area under other land has continuously declined during the period 2005 to 2020. The area under Other Land has declined from 69.96 Mha in 2005 to 56.06 Mha in 2020.

GHG/$CO_2$ emissions are not estimated for Other Land category in India, since this land category has no vegetation, and therefore with no implications for $CO_2$ emissions or removals due to conversion of Other Land to another land category.

## *Harvested Wood Products (4.H)*

India has so far not reported GHG emissions/removals from HWP category due to the absence of Activity Data and Emission Factors. Harvested Wood Products (HWP) can play a significant role in the context of greenhouse gas emissions, both in terms of current levels and observed trends. The HWP categories included in the inventory process are as follows:

## *Solid Wood*

- Sawn Wood: Wood produced from both domestic and imported roundwood, sawn lengthways, or by profile-chipping processes.
- Wood Panel: An aggregate category comprising veneer sheets, plywood, particle board, and fiberboard.
- Paper and paperboard: The paper and paperboard category is an aggregate that includes a variety of products such as graphic papers, sanitary and household papers, packaging materials, and other types of paper and paperboard.
- For other solid wood products, the data is marked as "not estimated" (NE) due to insufficient data availability.

It is important to highlight that India is reporting carbon emissions/removals from the HWP pool for the first time, marking a significant step forward in enhancing the completeness of its emissions reporting within the LULUCF sector. These estimates provide a valuable understanding of the carbon dynamics associated with HWPs. As India continues to improve data collection and address gaps, particularly for missing product categories, the accuracy and comprehensiveness of future inventories will be greatly enhanced. This first-time reporting establishes a foundation for more detailed and refined GHG accounting in the coming years. This assessment was conducted through the Production Approach (Approach B), which utilizes production data for wood products, in line with the IPCC's prescribed methodology for calculating emissions.

The annual change in the stock of HWP in use produced from domestic harvest ($\Delta C_{HWP\ IU\ DH}$) followed an upward trajectory, increasing from 2919.45 Gg C in 2005 to 6278.06 Gg C in 2020. This suggests that

domestic production has grown substantially over this period, reflecting increased harvest activities and the domestic use of locally sourced wood products. In terms of international trade, annual imports of wood, paper products, and related materials have surged from 1715.34 Gg C in 2005 to 4083.01 Gg C in 2020, highlighting the country's growing reliance on foreign materials to meet its wood product demands. In contrast, annual exports of these products have remained relatively small, showing a slight decrease from 8.37 Gg C in 2005 to 3.71 Gg C in 2020. This indicates that India is a net importer of wood products, with most of its domestically harvested wood being utilized internally.

Regarding carbon emissions, the annual release of carbon to the atmosphere from HWP consumption ($\uparrow C_{HWP\ DC}$), which includes emissions from fuelwood, products in use, and products in solid waste disposal sites (SWDS), has shown a slight decrease from 77,495.69 Gg $CO_2$ in 2005 to 77,228.32 Gg $CO_2$ in 2020. Similarly, the release of carbon from HWP originating from domestic harvest (↑C HWP DH) has also declined from 75,315.31 Gg $CO_2$ in 2005 to 72,846.3 Gg $CO_2$ in 2020. This suggests that while wood products contribute to carbon emissions, the magnitude of these emissions has gradually reduced, potentially due to more efficient use or disposal practices.

The overall contribution of HWP to AFOLU $CO_2$ emissions/removals remains significant, indicating a net removal of $CO_2$ from the atmosphere. This contribution peaked at -23019.55 $GgCO_2$ in 2020, reflecting an especially strong net removal in that year. In summary, the total net change in carbon stock from HWP in use, particularly from domestic harvests, led to significant carbon removals, with sawn wood and wood panels contributing the largest share. Although the contribution of exported HWPs was relatively small, it still added to the overall carbon removals. The analysis highlights the important role of HWP in contributing to net carbon sequestration, aiding the country's efforts to mitigate climate change by enhancing carbon storage through harvested wood products.

## 2.7.5 Waste

In 2020, the waste sector, which includes GHG emissions from microbiological processes occurring in organic waste under anaerobic degradation and the anaerobic treatment of domestic and industrial wastewater, accounted for only 2.56 per cent of GHG emissions. In the same year, its emissions were 75,641 $GgCO_2e$, increasing by 3.35 per cent since 2019 (Figure 2.23). Around three-fourths (73.89 per cent) of the emissions from the waste sector come from wastewater treatment and discharge, followed by 25.31 per cent of the solid waste disposal and remaining from incineration and open burning of waste. In line with the enhanced transparency requirements, this inventory added emissions from the Biological Treatment of Solid Waste and Incineration and Open Burning of Waste as new categories under the Waste sector. This addition represents a significant improvement in the completeness of our national greenhouse gas inventory. The inclusion of this category aligns with the more comprehensive reporting approach required under the ETF and provides a more accurate representation of our national emissions profile. This methodological enhancement contributes to greater transparency and completeness in our national reporting.

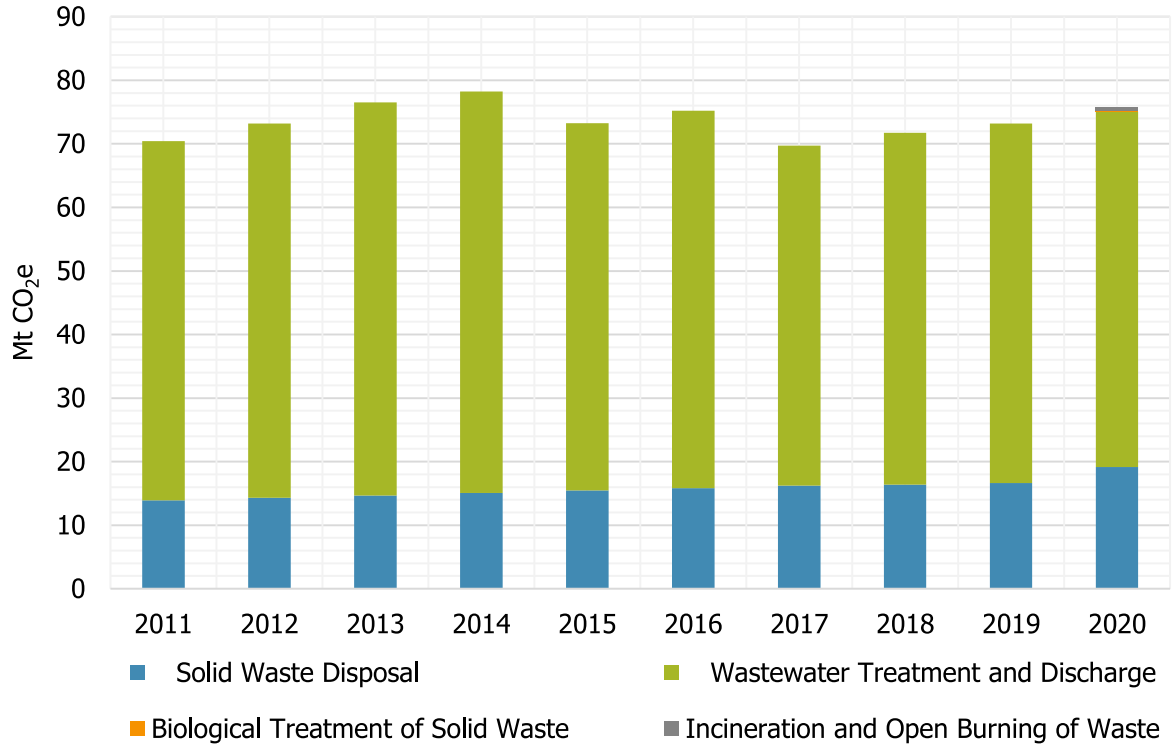


*Figure 2.23: Waste: GHG emissions (Mt $CO_2e$) per subcategory, 2011-2020*

## *Solid waste disposal (5.A)*

The category includes $CH_4$ emissions from the treatment and disposal of municipal, industrial, and other solid wastes at solid waste disposal facilities (SWDS). Solid waste disposal includes managed, unmanaged, and uncategorized waste disposed of in landfills. In 2020, GHG emissions accounted for 19,142 $GgCO_2e$, increasing by 15.26 per cent since 2019, because of methodological improvement and COVID19 pandemic. In 2020, a total of 51,527 Kt of MSW reached landfills in India, resulting in 912 Gg of Methane.

The IPCC's first order decay (FOD) method is used to estimate $CH_4$ emissions from MSW landfill sites. MSW is relatively dispersed, and shallow disposal depths do not induce anaerobic conditions. A portion of the methane is released and used for gas recovery. Because most disposal sites do not practise methane recovery, the default value of R is zero in estimation. Approximately 1,508 Kt of annual municipal solid waste is composted, resulting in the production of 6.03 Gg of methane.

## *Incineration and Open Burning of Waste (5.C)*

Incineration and Open Burning of Waste is a source of greenhouse gas emissions in the waste sector. This category encompasses both controlled incineration in designated facilities and uncontrolled burning of waste in open areas. Waste incineration refers to the controlled combustion of solid waste in dedicated facilities, often with energy recovery systems. This process, while managing waste volume, generates emissions through the oxidation of carbon content in both fossil-based materials (such as plastics) and biogenic materials present in the waste stream. Open burning of waste, on the other hand, refers to the uncontrolled combustion of waste materials in open dumps, backyards, or other unofficial disposal sites. This practice, though discouraged due to environmental and health concerns, remains prevalent in many areas. A total of 310.97 Kt waste incineration and burning generates 178 Gg of $CO_2$ in the year 2020.

## *Wastewater treatment and discharge (5.D)*

GHG emissions from the treatment or disposal of wastewater by anaerobic means, such as domestic wastewater, commercial and industrial wastewater, and which can be treated on site (not collected), transferred through the sewerage service to a central facility (collected), or eliminated without treatment in the vicinity or via drains, are included in this category. In 2020, GHG emissions from this category accounted for 55,893 $GgCO_2e$, decreasing only by 1.22 per cent since 2019 due to effective measures taken regarding domestic wastewater treatment. Within the category, domestic wastewater treatment and discharge contributes 61.06 per cent, while industrial wastewater treatment and discharge amounts to 38.94 per cent of emissions. Emissions from domestic wastewater treatment and discharge decreased by 11.58 per cent and industrial wastewater treatment and discharge emissions increased by 21.03 per cent since 2019.

Alcohol, coffee, dairy products, fruits and juices, poultry, organic chemicals, petroleum, plastic and resins, pulp and paper, sea food processing, soap and detergents, starch production, sugar refining, tannery, vegetable oils, and vegetables are examples of industrial wastewater. Production in all 16 sectors generates wastewater with significant organic load, which has the potential to emit methane depending on the type of wastewater treatment. According to the analysis, the vegetable and fruits processing followed by pulp & paper and alcohol have the highest GHG emissions per tonne of product or unit volume of treated wastewater.

The value of Biochemical Oxygen Demand (BOD) is taken to be 41 g per capita per day from ENVIS (Environmental Information System) Centre on Hygiene, Sanitation, Sewage Treatment Systems and Technology, whereas the range is 27-41 g per capita per day in IPCC guidelines. Organic waste removed as sludge is considered to be zero. In general, methane is generated in anaerobic processes in wastewater treatment facilities and inefficiently managed aerobic processes. $CH_4$ generated at anaerobic facilities can be recovered or combusted but in India recovery is considered to be zero due to the unavailability of appropriate technology.

***Table 2.32: Activity data and country-specific emission factors used in the wastewater treatment and discharge category (5D) in 2017, 2018, 2019 and 2020***

| | | 2020 | |
|---|---|---|---|
| Country population (billion) | | 1.347 | |
| Correction factor for additional industrial BOD discharged into sewers, I | | 1.25 | |
| Maximum $CH_4$ producing capacity, Bo, kg $CH_4$/kg BOD | | 0.6 | |
| Country-specific per capita BOD in inventory year, BOD, g/person/day | | 41 | |
| **Methane Emission Factor Value** | | | |
| Type of latrine | Septic tank (Urban High) | 0.18 | |
| | Latrine (Urban High) | 0.08 | |
| | Sewer (Urban High) | 0.67 | |
| | Other (Urban High) | 0.07 | |

| Industry production (million tonne) | 2017 | 2018 | 2019 | 2020 | Wastewater generation (M3 / Tonne) | COD Kg/ M3 | Methane correction factor |
|---|---|---|---|---|---|---|---|
| Alcohol | 3.11 | 3.36 | 3.36 | 3.82 | 24 | 77 | 0.8 |
| Coffee | 0.35 | 0.32 | 0.32 | 0.31 | 15 | 10 | 0.8 |
| Dairy products | 5.58 | 5.60 | 5.66 | 0.20 | 6 | 4 | 0.5 |
| Fruits and juices | 0.48 | 0.50 | 0.52 | 3.95 | 20 | 5 | 0.8 |
| Meat Industry | - | - | - | 8.63 | 13 | 4 | 0.8 |
| Organic chemicals | 1.64 | 1.80 | 1.88 | 2.35 | 31 | 3 | 0.3 |
| Petroleum | 36.01 | 35.68 | 34.20 | 0.26 | 0.44 | 0.5 | 0.3 |
| Plastic and resins | 0.01 | 0.01 | 0.01 | 3.86 | 0.6 | 3.7 | 0.3 |

| Industry production (million tonne) | 2017 | 2018 | 2019 | 2020 | Wastewater generation (M3 / Tonne) | COD Kg/ M3 | Methane correction factor |
|---|---|---|---|---|---|---|---|
| Pulp and paper | 16.41 | 17.66 | 18.82 | 21.43 | 143 | 7 | 0.1 |
| Sea food processing | 11.99 | 12.51 | 13.03 | 14.30 | 13 | 2.5 | 0.3 |
| Soap and detergents | 3.08 | 3.16 | 3.15 | 3.32 | 3 | 0.85 | 0.3 |
| Starch production | 0.49 | 0.48 | 0.50 | 0.64 | 5.5 | 10 | 0.8 |
| Sugar refining | 34.11 | 33.07 | 31.60 | 30.25 | 1 | 6.2 | 0.8 |
| Tannery | 0.06 | 0.06 | 0.07 | 0.07 | 53 | 3.3 | 0.8 |
| Vegetable oils | 1.78 | 1.81 | 1.86 | 9.45 | 2 | 0.85 | 0.2 |
| Vegetable | 3.56 | 3.69 | 3.66 | 3.75 | 20 | 5 | 0.6 |

*Source: (MoEF, 2010); (CSE, 2014); (FAO, 2016); (NEERI, 2010); (MoEFCC, 2018); (Census, 2011); (MoSPI, 2014); (CPCB, 2015).*

# 2.8 Key Categories

According to the IPCC Guidelines from 2006, identifying key categories is a good practise because it helps prioritise efforts and improves the overall quality of the national inventory. A "key category" is a source or sink category that is prioritised within the national inventory system because its estimate has a significant influence on a country's total inventory of direct GHGs in terms of absolute emissions, trend or uncertainty in emissions and removals (IPCC, 2006).

Table 2.33 presents the result of the level assessment using Approach 1 that identified 21 categories without LULUCF and 23 categories with LULUCF as key categories. As per IPCC Guidelines, 95 per cent cumulative contribution threshold has been used in this analysis to define an upper boundary for the key category identification.

In approach 1, key categories are identified using a pre-determined cumulative emissions threshold. Key categories are those that, when summed together in descending order of magnitude, add up to 95 per cent of the total level (IPCC 2006 GL volume 1, page 4.12).

***Table 2.33: Key category level assessment with and without LULUCF for 2020***

| Sr. No. | 2020 Without LULUCF | | | 2020 With LULUCF | | |
|---|---|---|---|---|---|---|
| | IPCC Code, Category, Gas | Gg $CO_2e$ | Level % | IPCC Code, Category, Gas | Gg $CO_2e$ | Level % |
| 1 | 1A1a Electricity production, $CO_2$ | 1165718 | 39.40% | 1A1a Electricity production, $CO_2$ | 1165718 | 33.29% |
| 2 | 1A3b Road transport, $CO_2$ | 270220 | 9.13% | 3B2 Cropland, $CO_2$ Removal | 355513 | 10.15% |
| 3 | 3A1 Enteric Fermentation, $CH_4$ | 222632 | 7.52% | 1A3b Road transport, $CO_2$ | 270220 | 7.72% |
| 4 | 1A2m Nonspecific Industries, $CO_2$ | 167401 | 5.66% | 3A1 Enteric Fermentation, $CH_4$ | 222632 | 6.36% |
| 5 | 1A2a Iron & steel, $CO_2$ | 150371 | 5.08% | 1A2m Nonspecific Industries, $CO_2$ | 167401 | 4.78% |
| 6 | 1A4b Residential, $CO_2$ | 147582 | 4.99% | 1A2a Iron & steel, $CO_2$ | 150371 | 4.29% |
| 7 | 2A1 Cement production, $CO_2$ | 136874 | 4.63% | 1A4b Residential, $CO_2$ | 147582 | 4.21% |
| 8 | 3C4 Agricultural soils, $N_2O$ | 94437 | 3.19% | 3B1 Forestland, $CO_2$ Removal | 146667 | 4.19% |
| 9 | 1A4a Commercials/Institutional, $CO_2$ | 92164 | 3.12% | 2A1 Cement production, $CO_2$ | 136874 | 3.91% |
| 10 | 1A1b Refinery, $CO_2$ | 84950 | 2.87% | 3C4 Agricultural soils, $N_2O$ | 94437 | 2.70% |
| 11 | 3C7 Rice Cultivation, $CH_4$ | 67725 | 2.29% | 1A4a Commercials/Institutional, $CO_2$ | 92164 | 2.63% |

| Sr. No. | 2020 Without LULUCF | | | 2020 With LULUCF | | |
|---|---|---|---|---|---|---|
| | IPCC Code, Category, Gas | Gg $CO_2e$ | Level % | IPCC Code, Category, Gas | Gg $CO_2e$ | Level % |
| 12 | 1A2f Cement, $CO_2$ | 49629 | 1.68% | 1A1b Refinery, $CO_2$ | 84950 | 2.43% |
| 13 | 4D2 Industrial Wastewater, $CH_4$ | 21763 | 0.74% | 3C7 Rice Cultivation, $CH_4$ | 67725 | 1.93% |
| 14 | 2E Production of halocarbons and sulphur hexafluoride, HFC | 21645 | 0.73% | 1A2f Cement, $CO_2$ | 49629 | 1.42% |
| 15 | 4A Managed Waste Disposal on Land, $CH_4$ | 19142 | 0.65% | 3B6 Harvested Wood Products, $CO_2$ Removal | 23019 | 0.66% |
| 16 | 4D1 Domestic and Commercial Wastewater, $N_2O$ | 17912 | 0.61% | 4D2 Industrial Wastewater, $CH_4$ | 21763 | 0.62% |
| 17 | 4D1 Domestic and Commercial Wastewater, $CH_4$ | 16218 | 0.55% | 2E Production of halocarbons and sulphur hexafluoride, HFC | 21645 | 0.62% |
| 18 | 2B8b Ethylene production, $CO_2$ | 15982 | 0.54% | 4A Managed Waste Disposal on Land, $CH_4$ | 19142 | 0.55% |
| 19 | 2A2 Lime production, $CO_2$ | 15008 | 0.51% | 4D1 Domestic and Commercial Wastewater, $N_2O$ | 17912 | 0.51% |
| 20 | 1B1aii Above ground mining, $CH_4$ | 13557 | 0.46% | 4D1 Domestic and Commercial Wastewater, $CH_4$ | 16218 | 0.46% |
| 21 | 1A3a Civil Aviation, $CO_2$ | 11855 | 0.40% | 2B8b Ethylene production, $CO_2$ | 15982 | 0.46% |
| 22 | | | | 2A2 Lime production, $CO_2$ | 15008 | 0.43% |
| 23 | | | | 1B1aii Above ground mining, $CH_4$ | 13557 | 0.39% |
| | **Total** | **2958589** | | **Total** | **3501370** | |

The trend of emission contributions from each category is examined to determine where the greatest absolute changes (either increases or decreases) have occurred over a given time period. Table 2.34 shows India's National GHG inventory from 2011 to 2020, with and without LULUCF, using the trend assessment Tier 1 methodological approach.

***Table 2.34: Key category trend assessment with and without LULUCF for 2011-2020***

| 2011-2020 without LULUCF | | | | 2011-2020 with LULUCF | | |
|---|---|---|---|---|---|---|
| Sr. No. | IPCC Code, Category, Gas | Trend Assessment (Txt) | % Contribution to Trend | IPCC Code, Category, Gas | Trend Assessment (Txt) | % Contribution to Trend |
| 1 | 1A4a Commercials/Institutional, $CO_2$ | 0.0849558 | 31.18% | 3B2 Cropland, $CO_2$ Removal | 0.08414578 | 25.66% |
| 2 | 1A4b Residential, $CO_2$ | 0.0279604 | 10.26% | 1A4a Commercials/Institutional, $CO_2$ | 0.07044977 | 21.49% |
| 3 | 1A1a Electricity production, $CO_2$ | 0.0266653 | 9.79% | 3B1 Forestland, $CO_2$ Removal | 0.02839979 | 8.66% |
| 4 | 3A1 Enteric Fermentation, $CH_4$ | 0.0196464 | 7.21% | 3A1 Enteric Fermentation, $CH_4$ | 0.02108024 | 6.43% |
| 5 | 1A1b Refinery, $CO_2$ | 0.0134906 | 4.95% | 1A4b Residential, $CO_2$ | 0.02088470 | 6.37% |
| 6 | 2A1 Cement production, $CO_2$ | 0.0122487 | 4.50% | 1A1b Refinery, $CO_2$ | 0.00980686 | 2.99% |
| 7 | 1A3b Road transport, $CO_2$ | 0.0107007 | 3.93% | 1A2m Nonspecific Industries, $CO_2$ | 0.00867068 | 2.64% |
| 8 | 3C7 Rice Cultivation, $CH_4$ | 0.0078881 | 2.90% | 3C7 Rice Cultivation, $CH_4$ | 0.00803862 | 2.45% |

| 2011-2020 without LULUCF | | | | 2011-2020 with LULUCF | | |
|---|---|---|---|---|---|---|
| Sr. No. | IPCC Code, Category, Gas | Trend Assessment (Txt) | % Contribution to Trend | IPCC Code, Category, Gas | Trend Assessment (Txt) | % Contribution to Trend |
| 9 | 2B8b Ethylene production, $CO_2$ | 0.0072531 | 2.66% | 2A1 Cement production, $CO_2$ | 0.00773136 | 2.36% |
| 10 | 1A2m Nonspecific Industries, $CO_2$ | 0.0063309 | 2.32% | 2B8b Ethylene production, $CO_2$ | 0.00585535 | 1.79% |
| 11 | 3C4 Agricultural Soils, $N_2O$ | 0.0038502 | 1.41% | 3C4 Agricultural Soils, $N_2O$ | 0.00512846 | 1.56% |
| 12 | 1A3c Railways, $N_2O$ | 0.0034347 | 1.26% | 1A2a Iron & Steel, $CO_2$ | 0.00389278 | 1.19% |
| 13 | 2A2 Lime production, $CO_2$ | 0.0033052 | 1.21% | 1A3b Road transport, $CO_2$ | 0.00379728 | 1.16% |
| 14 | 2C2 Ferroalloys production, $CO_2$ | 0.0029171 | 1.07% | 2A2 Lime production, $CO_2$ | 0.00310581 | 0.95% |
| 15 | 3A2 Manure Management, $N_2O$ | 0.0028072 | 1.03% | 1A3c Railways, $N_2O$ | 0.00291262 | 0.89% |
| 16 | 1A3b Road transport, $N_2O$ | 0.0027542 | 1.01% | 1A2f Cement, $CO_2$ | 0.00276596 | 0.84% |
| 17 | 4D1 Domestic and Commercial Wastewater, $CH_4$ | 0.0025779 | 0.95% | 3B3 Grassland, $CO_2$ | 0.00271312 | 0.83% |
| 18 | 2C3 Aluminium Production, CF | 0.0024279 | 0.89% | 3A2 Manure Management, $N_2O$ | 0.00256831 | 0.78% |
| 19 | 1A1c Manufacturing of Solid Fuel, $CO_2$ | 0.0022876 | 0.84% | 4D1 Domestic and Commercial Wastewater, $CH_4$ | 0.00251095 | 0.77% |
| 20 | 1B2b Natural gas, $CH_4$ | 0.0021252 | 0.78% | 2C2 Ferroalloys production, $CO_2$ | 0.00229113 | 0.70% |
| 21 | 1A2f Cement, $CO_2$ | 0.0021066 | 0.77% | 2C3 Aluminium Production, CF | 0.00222975 | 0.68% |
| 22 | 4D2 Industrial Wastewater, $CH_4$ | 0.0019720 | 0.72% | 1A3b Road transport, $N_2O$ | 0.00221307 | 0.67% |
| 23 | 2C3 Aluminium production, $CO_2$ | 0.0018353 | 0.67% | 4D2 Industrial Wastewater, $CH_4$ | 0.00210445 | 0.64% |
| 24 | 1A3a Civil Aviation, $CO_2$ | 0.0015975 | 0.59% | 1B2b Natural gas, $CH_4$ | 0.00192897 | 0.59% |
| 25 | 2B1 Ammonia Production, $CO_2$ | 0.0014822 | 0.54% | 3B5 Settlement, $CO_2$ Removal | 0.00179198 | 0.55% |
| 26 | 1A2m Fertilizer, $CO_2$ | 0.0012324 | 0.45% | 1A1c Manufacturing of Solid Fuel, $CO_2$ | 0.00178138 | 0.54% |
| 27 | 1A2m Engineering Sector, $CO_2$ | 0.0012226 | 0.45% | 1A3a Civil Aviation, $CO_2$ | 0.00159147 | 0.49% |
| 28 | 1A2a Iron & steel, $CH_4$ | 0.0011129 | 0.41% | | | |
| **Total** | | **0.27243** | | **Total** | **0.32790** | |

## 2.9 Uncertainty Assessment

Uncertainty estimates, according to the IPCC Guidelines (2006), are an essential component of a comprehensive inventory of GHG emissions and removals. The uncertainty analysis should be used to prioritise national efforts aimed at improving the accuracy and precision of future inventories, as well as to guide decisions on the methodology to be used. The Tier 1 methodological approach was used to estimate the overall inventory uncertainty. The overall inventory uncertainty was estimated using the Tier 1 methodological approach. An estimate of the overall quantitative uncertainty (±6.85 per cent level uncertainty and ±9.55 per cent trend uncertainty) in various categories is shown in Table 2.35. The uncertainty of estimates has been depicted by a range within which the estimated emissions lie. Uncertainties associated with the activity data were sourced from the data sources, or from the researchers who have done the collection of such data based on expert judgement of inventory estimation teams, and/or from IPCC 2006 Guidelines.

*Table 2.35: Overall Inventory Uncertainty in India for 2020*

| Sr. No. | IPCC Category | Category Number, Name | Gas | 2011 emissions or removals (Gg $CO_2$ equivalent) | 2020 emissions or removals (Gg $CO_2$ equivalent) | Activity Data Uncertainty (%) | Emission Factor Uncertainty (%) | Combined Uncertainty (%) | Contribution to Variance by Category in Year T | Type A sensitivity | Type B sensitivity | Uncertainty in Trend in National Emissions introduced by Emission Factor /Estimation parameter uncertainty (%) | Uncertainty in Trend in National Emissions introduced by Activity data Uncertainty (%) | Uncertainty introduced into the Trend in Total National Emissions (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Energy | 1A1a Electricity production | $CO_2$ | 867254 | 1165718 | 10.00% | 5.00% | 11.18% | 0.001386 | 0.003260 | 45.08% | 0.02305% | 6.37467% | 0.40637% |
| 2 | LULUCF | 3B2 Cropland | $CO_2$ R | 163990 | 355513 | 25.00% | 20.00% | 32.02% | 0.001057 | 0.051584 | 13.75% | 1.45900% | 4.86027% | 0.25751% |
| 3 | Energy | 1A3b Road transport | $CO_2$ | 193898 | 270220 | 5.00% | 3.00% | 5.83% | 0.000020 | 0.002976 | 10.45% | 0.01263% | 0.73884% | 0.00546% |
| 4 | Agriculture | 3A1 Enteric Fermentation | $CH_4$ | 219244 | 222632 | 5.00% | 50.00% | 50.25% | 0.001021 | 0.028668 | 8.61% | 2.02713% | 0.60873% | 0.04480% |
| 5 | Energy | 1A2m Nonspecific Industries | $CO_2$ | 143739 | 167401 | 20.00% | 5.00% | 20.62% | 0.000097 | 0.010515 | 6.47% | 0.07435% | 1.83084% | 0.03358% |
| 6 | Energy | 1A2a Iron & steel | $CO_2$ | 119844 | 150371 | 20.00% | 5.00% | 20.62% | 0.000078 | 0.004594 | 5.81% | 0.03248% | 1.64459% | 0.02706% |
| 7 | Energy | 1A4b Residential | $CO_2$ | 80343 | 147582 | 5.00% | 5.00% | 7.07% | 0.000009 | 0.015000 | 5.71% | 0.10607% | 0.40352% | 0.00174% |
| 8 | LULUCF | 3B1 Forestland | $CO_2$ R | 72673 | 146667 | 25.00% | 20.00% | 32.02% | 0.000180 | 0.018661 | 5.67% | 0.52782% | 2.00510% | 0.04299% |
| 9 | IPPU | 2A1 Cement production | $CO_2$ | 88810 | 136874 | 5.00% | 5.00% | 7.07% | 0.000008 | 0.006430 | 5.29% | 0.04546% | 0.37424% | 0.00142% |
| 10 | Agriculture | 3C4 Agricultural Soils | $N_2O$ | 81701 | 94437 | 20.00% | 5.00% | 20.62% | 0.000031 | 0.006254 | 3.65% | 0.04422% | 1.03285% | 0.01069% |
| 11 | Energy | 1A4a Commercials/ Institutional | $CO_2$ | 23023 | 92164 | 10.00% | 5.00% | 11.18% | 0.000009 | 0.023583 | 3.56% | 0.16675% | 0.50399% | 0.00282% |
| 12 | Energy | 1A1b Refinery | $CO_2$ | 48648 | 84950 | 25.00% | 100.00% | 103.08% | 0.000625 | 0.007379 | 3.28% | 1.04351% | 1.16136% | 0.02438% |
| 13 | Agriculture | 3C7 Rice Cultivation | $CH_4$ | 72670 | 67725 | 15.00% | 15.00% | 21.21% | 0.000017 | 0.011853 | 2.62% | 0.25144% | 0.55553% | 0.00372% |
| 14 | Energy | 1A2f Cement | $CO_2$ | 43121 | 49629 | 15.00% | 20.00% | 25.00% | 0.000013 | 0.003384 | 1.92% | 0.09571% | 0.40709% | 0.00175% |
| 15 | LULUCF | 3B6 Harvested Wood Products | $CO_2$ R | 0 | 23019 | 25.00% | 75.00% | 79.06% | 0.000027 | 0.008901 | 0.89% | 0.94409% | 0.31470% | 0.00990% |
| 16 | Waste | 4D2 Industrial Wastewater | $CH_4$ | 21580 | 21763 | 10.00% | 75.00% | 75.66% | 0.000022 | 0.002882 | 0.84% | 0.30572% | 0.11901% | 0.00108% |
| 17 | IPPU | 2E Production of halocarbons and sulphur hexafluoride | HFC | 16392 | 21645 | 15.00% | 50.00% | 52.20% | 0.000010 | 0.000212 | 0.84% | 0.01498% | 0.17754% | 0.00032% |

| Sr. No. | IPCC Category | Category Number, Name | Gas | 2011 emissions or removals (Gg $CO_2$ equivalent) | 2020 emissions or removals (Gg $CO_2$ equivalent) | Activity Data Uncertainty (%) | Emission Factor Uncertainty (%) | Combined Uncertainty (%) | Contribution to Variance by Category in Year T | Type A sensitivity | Type B sensitivity | Uncertainty in Trend in National Emissions introduced by Emission Factor /Estimation parameter uncertainty (%) | Uncertainty in Trend in National Emissions introduced by Activity data Uncertainty (%) | Uncertainty introduced into the Trend in Total National Emissions (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | Waste | 4A Managed Waste Disposal on Land | $CH_4$ | 13932 | 19142 | 15.00% | 50.00% | 52.20% | 0.000008 | 0.000108 | 0.74% | 0.00764% | 0.15702% | 0.00025% |
| 19 | Waste | 4D1 Domestic and Commercial Wastewater | $N_2O$ | 14815 | 17912 | 15.00% | 75.00% | 76.49% | 0.000015 | 0.000830 | 0.69% | 0.08801% | 0.14692% | 0.00029% |
| 20 | Waste | 4D1 Domestic and Commercial Wastewater | $CH_4$ | 20114 | 16218 | 10.00% | 20.00% | 22.36% | 0.000001 | 0.004259 | 0.63% | 0.12045% | 0.08869% | 0.00022% |
| 21 | IPPU | 2B8b Ethylene Production | $CO_2$ | 6103 | 15982 | 5.00% | 75.00% | 75.17% | 0.000012 | 0.002985 | 0.62% | 0.31661% | 0.04370% | 0.00102% |
| 22 | IPPU | 2A2 Lime Production | $CO_2$ | 24011 | 15008 | 5.00% | 75.00% | 75.17% | 0.000010 | 0.006767 | 0.58% | 0.71770% | 0.04103% | 0.00517% |
| 23 | Energy | 1B1aii Above ground Mining | $CH_4$ | 10089 | 13557 | 5.00% | 100.00% | 100.12% | 0.000015 | 0.000040 | 0.52% | 0.00565% | 0.03707% | 0.00001% |
| Total | | | | 2586132 | 3501366 | | | | 0.004694 | | | | | 0.009113 |
| **Total Uncertainties** | | | | | | **Uncertainty in Total Inventory** | | | **6.85%** | | **Trend Uncertainty** | | | **9.55%** |

# 2.10 Time Series Information

Consistent time series information on the GHG inventory, starting from the second national communication (inventory year 2000) to 2020 has been presented in the bar chart (see Figure 2.24). A summary table (Table 2.36) has been provided for national GHG inventory information contained in previous submissions. Inventory of 1994 was communicated in INC (MoEF, 2004). SNC contained a national inventory of 2000 (MoEF, 2012). Inventory of 2007 was given in SNC as a proactive approach. (MoEF, 2010). Inventory of 2010 was provided in BUR-1 (MoEFCC, 2016). In 2018, India had furnished its BUR-2 containing the national inventory of 2014 (MoEFCC, 2018) and in 2021, the BUR-3 with national inventory of 2016 was submitted (MoEFCC, 2021). In the last year, India submitted its Third National Communication (TNC) which contains the national inventory of 2019 (MoEFCC, 2023).

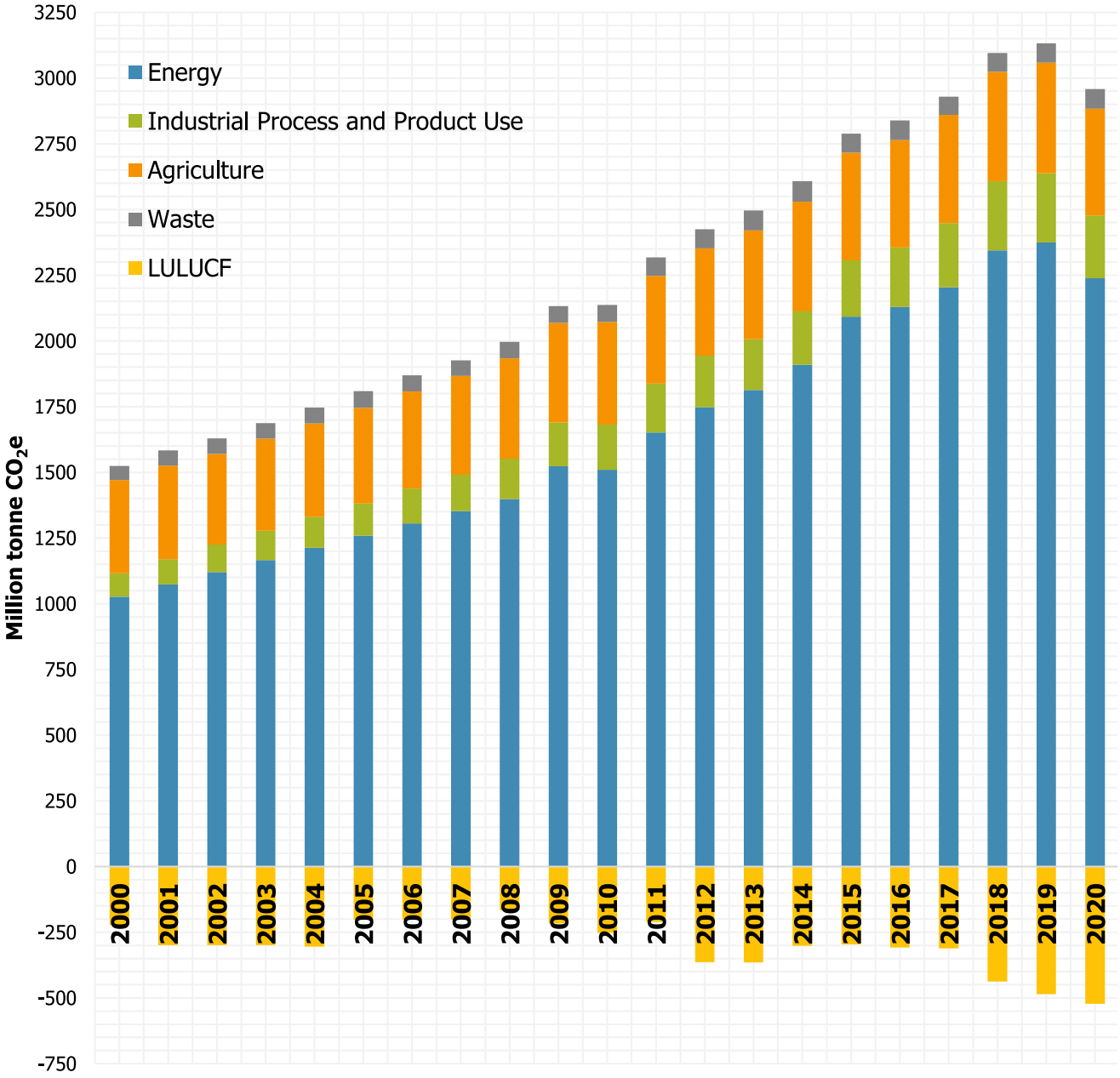


*Figure 2.24: Time series information of GHG emissions*

*Table 2.36: India's total emissions, 2011-2020*

| GHG Sources and Removals | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gg $CO_2$ Equivalent | | | | | | | | | |
| **1. Energy** | 1651928 | 1747686 | 1813559 | 1909766 | 2092102 | 2129428 | 2204263 | 2344325 | 2374330 | 2238409 |
| A. Fuel Combustion Activities | 1604503 | 1704639 | 1774788 | 1871709 | 2055017 | 2092250 | 2168704 | 2307753 | 2338432 | 2211513 |
| 1. Energy Industries | 924258 | 1005813 | 1053981 | 1140983 | 1197123 | 1206587 | 1255716 | 1324177 | 1331901 | 1265328 |
| 2. Manufacturing Industries & Construction | 338816 | 343603 | 356771 | 351910 | 394092 | 397739 | 393312 | 412086 | 404676 | 390667 |
| 3. Transport | 221202 | 236020 | 241253 | 250173 | 261517 | 274434 | 290732 | 307328 | 314817 | 297371 |
| 4. Other sectors | 120228 | 119202 | 122783 | 128643 | 202286 | 213490 | 228944 | 264162 | 287039 | 258147 |
| B. Fugitive Emission from fuels | 47426 | 43047 | 38771 | 38057 | 37084 | 37179 | 35559 | 36572 | 35898 | 26896 |
| 1. Solid fuels | 16388 | 16086 | 15568 | 16547 | 16614 | 17121 | 16065 | 16862 | 17017 | 16709 |
| 2. Oil and Natural gas | 31037 | 26961 | 23203 | 21511 | 20470 | 20058 | 19494 | 19710 | 18880 | 10187 |
| C. $CO_2$ Transport and Storage | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **2. Industrial Processes and Product Use** | 185543 | 196023 | 192616 | 202278 | 214020 | 226407 | 244143 | 262999 | 263540 | 238556 |
| A. Mineral Industry | 113193 | 122469 | 123369 | 126856 | 132075 | 135468 | 144048 | 160222 | 157665 | 152270 |
| B. Chemical Industry | 24387 | 24419 | 23190 | 22175 | 24269 | 25358 | 22696 | 16814 | 19277 | 33496 |
| C. Metal Industry | 27289 | 28033 | 27356 | 29242 | 34068 | 40814 | 49631 | 53735 | 52279 | 24421 |
| D. Other | 4283 | 4812 | 4955 | 5428 | 5581 | 5507 | 5955 | 6109 | 6370 | 6725 |
| E. Production of halocarbons and sulphur hexafluoride | 16392 | 16290 | 13745 | 18576 | 18027 | 19259 | 21812 | 26117 | 27949 | 21645 |
| **3. Agriculture** | 409374 | 408435 | 413683 | 417218 | 409703 | 407821 | 411091 | 416769 | 420968 | 405983 |
| A. Enteric Fermentation | 219244 | 221666 | 224280 | 227157 | 222396 | 222655 | 222784 | 223017 | 223251 | 222632 |
| B. Manure Management | 27221 | 27484 | 27766 | 28101 | 27220 | 27227 | 27503 | 27507 | 27511 | 13072 |
| C. Rice Cultivation | 72670 | 70600 | 72884 | 72843 | 71834 | 71322 | 73625 | 74268 | 73437 | 67725 |
| D. Agricultural Soils | 81701 | 80112 | 80047 | 80529 | 79715 | 77781 | 81064 | 83511 | 88412 | 94437 |
| E. Prescribed Burning of Savannas | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| F. Field Burning of Agricultural Residues | 8539 | 8573 | 8706 | 8589 | 8538 | 8836 | 6115 | 8465 | 8358 | 8117 |
| **4. LULUCF** | -210913 | -364221 | -364569 | -301193 | -296092 | -307820 | -311778 | -437000 | -485472 | -521933 |
| A. Forestland | -71438 | -71438 | -71222 | -68215 | -68033 | -75343 | -75320 | -144803 | -145025 | -145612 |
| B. Cropland | -163990 | -298869 | -299410 | -248610 | -247521 | -251975 | -255627 | -302455 | -343174 | -355513 |
| C. Grassland | 27746 | 10614 | 10649 | 17216 | 21039 | 21289 | 21131 | 14932 | 9726 | 9369 |
| D. Wetlands | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE |
| E. Settlement | -3231 | -4529 | -4586 | -1583 | -1578 | -1790 | -1963 | -4674 | -6998 | -7158 |
| F. Other Land | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE |
| G. Harvested Wood Products | NE | NE | NE | NE | NE | NE | NE | NE | NE | -23019 |
| H. Other | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **5. Waste** | 70442 | 73208 | 76539 | 78227 | 73247 | 75232 | 69716 | 71733 | 73189 | 75641 |
| A. Solid waste disposal on land | 13932 | 14307 | 14685 | 15065 | 15448 | 15832 | 16203 | 16392 | 16608 | 19142 |
| B. Waste-water handling | 56509 | 58900 | 61854 | 63162 | 57799 | 59401 | 53513 | 55341 | 56581 | 55893 |
| C. Biological Treatment of Solid Waste | NE | NE | NE | NE | NE | NE | NE | NE | NE | 127 |
| D. Incineration and Open Burning of Waste | NE | NE | NE | NE | NE | NE | NE | NE | NE | 479 |
| **Memo Items** | 768201 | 783702 | 797485 | 812068 | 755291 | 789359 | 793057 | 797502 | 801335 | 802860 |
| **International Bunkers** | 6399 | 6207 | 5083 | 4981 | 5281 | 6095 | 6157 | 6950 | 7114 | 4975 |
| Aviation | 3623 | 3791 | 3742 | 3714 | 3830 | 4396 | 4775 | 5442 | 5832 | 3223 |

| GHG Sources and Removals | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gg $CO_2$ Equivalent | | | | | | | | | |
| Marine | 2776 | 2416 | 1341 | 1267 | 1451 | 1699 | 1382 | 1508 | 1282 | 1751 |
| **$CO_2$ from Biomass** | 761802 | 777494 | 792401 | 807087 | 750010 | 783265 | 786900 | 790552 | 794221 | 797908 |
| **Total (without LULUCF)** | 2317287 | 2425352 | 2496397 | 2607488 | 2789072 | 2838889 | 2929214 | 3095826 | 3132028 | 2958589 |
| **Total (with LULUCF)** | 2106374 | 2061131 | 2131828 | 2306295 | 2492980 | 2531069 | 2617436 | 2658825 | 2646556 | 2436656 |

Abbreviations: IE – Included Elsewhere; NE – Not Estimated; NO – Not Occurring, NA – Not Applicable.

In accordance with Decision 2/CP.17, non-annex I parties should submit updates of their national GHG inventories in their BUR as contained in paragraphs 8-24 in the Annex to the Decision 17/CP.8, India's national GHG inventory for 2020 is presented in Tables 2.37 (Table 1 and Table 2).

*Table 2.37: India's National GHG Inventory for 2020 (Gg)*

| Table 1. National greenhouse gas inventory of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol and greenhouse gas precursors | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Greenhouse Gas Source and Sink Categories (Gigagram)** | **$CO_2$ emissions** | **$CO_2$ removals** | **$CH_4$** | **$N_2O$** | **CO** | **NOx** | **NMVOCs** | **SOx** |
| **Total national emissions and removals** | **2391904** | **532357** | **18811** | **490** | | | | |
| **1. Energy** | 2181012 | NA | 1523 | 82 | | | | |
| A. Fuel combustion (sectoral approach) | 2178612 | | 356 | 82 | | | | |
| 1. Energy industries | 1259038 | | 15 | 19 | | | | |
| 2. Manufacturing industries and construction | 388251 | | 35 | 5 | | | | |
| 3. Transport | 288888 | | 62 | 23 | | | | |
| 4. Other sectors | 242436 | | 244 | 34 | | | | |
| 5. Other (please specify) | | | | | | | | |
| B. Fugitive emissions from fuels | | | 1166 | | | | | |
| 1. Solid fuels | | | 796 | | | | | |
| 2. Oil and natural gas | | | 371 | | | | | |
| **2. Industrial processes** | 201044 | | 232 | 8 | | | | |
| A. Mineral products | 152270 | | | | | | | |
| B. Chemical industry | 30310 | | 32 | 8 | | | | |
| C. Metal production | 15918 | | 0.54 | | | | | |
| D. Other production | | | | | | | | |
| E. Production of halocarbons and sulphur hexafluoride | | | | | | | | |
| F. Consumption of halocarbons and sulphur hexafluoride | | | | | | | | |
| G. Other (Pulp and paper) | 2546 | | | | | | | |
| 1. Lubricant | 2377 | | | | | | | |
| 2. Paraffin wax | 169 | | | | | | | |
| 3. Pulp & paper | | | 199 | | | | | |
| **3. Solvent and other product use** | | | | | | | | |
| **4. Agriculture** | | | 14290 | 342 | | | | |
| A. Enteric fermentation | | | 10602 | | | | | |
| B. Manure management | | | 184 | 30 | | | | |
| C. Rice cultivation | | | 3225 | | | | | |
| D. Agricultural soils | | | | 305 | | | | |
| E. Prescribed burning of savannahs | | | | | | | | |

| Table 1. National greenhouse gas inventory of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol and greenhouse gas precursors | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Greenhouse Gas Source and Sink Categories (Gigagram)** | **$CO_2$ emissions** | **$CO_2$ removals** | **$CH_4$** | **$N_2O$** | **CO** | **NOx** | **NMVOCs** | **SOx** |
| **Total national emissions and removals** | **2391904** | **532357** | **18811** | **490** | | | | |
| F. Field burning of agricultural residues | | | 280 | 7 | | | | |
| G. Other (please specify) | | | | | | | | |
| **5. Land-use change and forestry** | 9369 | 532357 | 41 | 1 | | | | |
| A. Changes in forest and other woody biomass stocks | | | | | | | | |
| B. Forest and grassland conversion | 9369 | 146667 | 41 | 1 | | | | |
| C. Abandonment of managed lands | | 355513 | | | | | | |
| D. $CO_2$ emissions and removals from soil | | | | | | | | |
| E. Other (please specify) | | 7158 | | | | | | |
| **6. Waste** | | | 2726 | 58 | | | | |
| A. Solid waste disposal on land | | | 912 | | | | | |
| B. Waste-water handling | | | 1815 | 58 | | | | |
| C. Waste incineration | | | | | | | | |
| D. Other (please specify) | | | | | | | | |
| **7. Other (please specify)** | | | | | | | | |
| **Memo items** | | | | | | | | |
| **International bunkers** | 4938 | | 0.09 | 0.11 | | | | |
| Aviation | 3195 | | 0.02 | 0.09 | | | | |
| Marine | 1743 | | 0.07 | 0.02 | | | | |
| **$CO_2$ emissions from biomass** | 797908 | | | | | | | |

*Abbreviations: IE – Included Elsewhere; NE – Not Estimated; NO – Not Occurring, NA – Not Applicable.*

| Table 2. National greenhouse gas inventory of anthropogenic emissions of HFCs, PFCs and $SF_6$ | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Greenhouse Gas Source and Sink Categories (Gigagram)** | **HFCs** | | | **PFCs** | | | **$SF_6$** |
| | **HFC-23** | **HFC-134** | **Other (to be added)** | **$CF_4$** | **$C_2F_6$** | **Other (to be added)** | |
| **Total national emissions and removals** | 1.850 | | | 0.904 | 0.273 | | 0.004 |
| **1. Energy** | | | | | | | |
| A. Fuel combustion (sectoral approach) | | | | | | | |
| 1. Energy industries | | | | | | | |
| 2. Manufacturing industries and construction | | | | | | | |
| 3. Transport | | | | | | | |
| 4. Other sectors | | | | | | | |
| 5. Other (please specify) | | | | | | | |
| B. Fugitive emissions from fuels | | | | | | | |
| 1. Solid fuels | | | | | | | |
| 2. Oil and natural gas | | | | | | | |
| **2. Industrial processes** | 1.850 | | | 0.904 | 0.273 | | 0.004 |
| A. Mineral products | | | | | | | |
| B. Chemical industry | | | | | | | |
| C. Metal production | | | | 0.904 | 0.273 | | 0.004 |
| D. Other production | | | | | | | |

| Table 2. National greenhouse gas inventory of anthropogenic emissions of HFCs, PFCs and $SF_6$ | | | | | | | |
|---|---|---|---|---|---|---|---|
| Greenhouse Gas Source and Sink Categories (Gigagram) | HFCs | | | PFCs | | | $SF_6$ |
| | HFC-23 | HFC-134 | Other (to be added) | $CF_4$ | $C_2F_6$ | Other (to be added) | |
| **Total national emissions and removals** | 1.850 | | | 0.904 | 0.273 | | 0.004 |
| E. Production of halocarbons and sulphur hexafluoride | 1.850 | | | | | | |
| F. Consumption of halocarbons and sulphur hexafluoride | NA | NA | NA | NA | NA | NA | NA |
| G. Other (please specify) | | | | | | | |
| **3. Solvent and other product use** | | | | | | | |
| **4. Agriculture** | | | | | | | |
| A. Enteric fermentation | | | | | | | |
| B. Manure management | | | | | | | |
| C. Rice cultivation | | | | | | | |
| D. Agricultural soils | | | | | | | |
| E. Prescribed burning of savannahs | | | | | | | |
| F. Field burning of agricultural residues | | | | | | | |
| G. Other (please specify) | | | | | | | |
| **5. Land-use change and forestry** | | | | | | | |
| A. Changes in forest and other woody biomass stocks | | | | | | | |
| B. Forest and grassland conversion | | | | | | | |
| C. Abandonment of managed lands | | | | | | | |
| D. $CO_2$ emissions and removals from soil | | | | | | | |
| E. Other (please specify) | | | | | | | |
| **6. Waste** | | | | | | | |
| A. Solid waste disposal on land | | | | | | | |
| B. Waste-water handling | | | | | | | |
| C. Waste incineration | | | | | | | |
| D. Other (please specify) | | | | | | | |
| **7. Other (please specify)** | NA | NA | NA | NA | NA | NA | NA |
| **Memo items** | | | | | | | |
| **International bunkers** | | | | | | | |
| Aviation | | | | | | | |
| Marine | | | | | | | |
| **$CO_2$ emissions from biomass** | | | | | | | |

*Abbreviations: IE – Included Elsewhere; NE – Not Estimated; NO – Not Occurring, NA – Not Applicable.*

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# Appendix

**Detailed Greenhouse Gas Emissions from India, in 2020, by Sources and Removals by Sinks (Emissions are in Gigagrams).**

| | $CO_2$ emission | $CO_2$ removal | $CH_4$ | $N_2O$ | HFC 23 | $CF_4$ | $C_2F_6$ | $SF_6$ | $CO_2$ equivalent |
|---|---|---|---|---|---|---|---|---|---|
| **Total Emission** | **2382534.90** | | **18770.72** | **489.46** | **1.85** | **0.90** | **0.27** | **0.004** | **2958589.33** |
| **Net Emission** | **2391904.13** | **532357.26** | **18811.26** | **490.12** | **1.85** | **0.90** | **0.27** | **0.004** | **2436655.84** |
| **1. Energy** | 2181011.81 | | 1522.55 | 82.01 | | | | | **2238408.90** |
| A. Fuel Combustion Activities | 2178612.45 | | 356.32 | 81.99 | | | | | **2211512.71** |
| 1. Energy Industries | 1259037.79 | | 14.80 | 19.29 | | | | | **1265327.56** |
| a. Electricity production | 1165718.05 | | 12.69 | 18.19 | | | | | **1171623.55** |
| b. Refinery | 84949.83 | | 1.48 | 0.15 | | | | | **85027.02** |
| c. Manufacturing of Solid Fuel | 8369.91 | | 0.63 | 0.95 | | | | | **8676.99** |
| **2. Manufacturing Industries & Construction** | 388250.80 | | 35.31 | 5.40 | | | | | **390666.57** |
| a. Cement | 49629.25 | | 2.61 | 0.45 | | | | | **49822.53** |
| b. Iron & steel | 150371.19 | | 15.77 | 2.37 | | | | | **151437.24** |
| c. Nonferrous metals | 2307.16 | | 0.17 | 0.03 | | | | | **2318.99** |
| d. Chemicals | 2027.76 | | 0.12 | 0.02 | | | | | **2036.55** |
| e Pulp & paper | 2553.07 | | 0.26 | 0.04 | | | | | **2570.60** |
| f. Food & beverages | IE | | IE | IE | | | | | **IE** |
| g. Non-metallic minerals | IE | | IE | IE | | | | | **IE** |
| h. Mining & quarrying | 5464.86 | | 0.22 | 0.04 | | | | | **5483.18** |
| i. Textile/leather | 631.67 | | 0.05 | 0.01 | | | | | **635.18** |
| j. Bricks | 503.29 | | 0.048 | 0.01 | | | | | **506.53** |
| k. Fertilizer | 4267.72 | | 0.39 | 0.06 | | | | | **4294.85** |
| l. Engineering Sector | 3094.17 | | 0.13 | 0.02 | | | | | **3104.42** |
| m. Nonspecific Industries | 167400.66 | | 15.55 | 2.35 | | | | | **168456.49** |
| n. Glass Ceramic | IE | | IE | IE | | | | | **IE** |
| **3. Transport** | 288887.85 | | 61.96 | 23.17 | | | | | **297371.34** |
| a. Road transport | 270220.03 | | 61.52 | 21.28 | | | | | **278109.13** |
| b. Civil Aviation | 11854.73 | | 0.08 | 0.33 | | | | | **11959.26** |
| c. Railways | 3737.12 | | 0.21 | 1.44 | | | | | **4188.27** |

**Detailed Greenhouse Gas Emissions from India, in 2020, by Sources and Removals by Sinks (Emissions are in Gigagrams).**

| | $CO_2$ emission | $CO_2$ removal | $CH_4$ | $N_2O$ | HFC 23 | $CF_4$ | $C_2F_6$ | $SF_6$ | $CO_2$ equivalent |
|---|---|---|---|---|---|---|---|---|---|
| d. Navigation | 3075.97 | | 0.15 | 0.11 | | | | | **3114.68** |
| **4. Other sectors** | 242436.01 | | 244.25 | 34.14 | | | | | **258147.25** |
| a. Commercials/Institutional | 92164.07 | | 1.23 | 1.33 | | | | | **92602.23** |
| b. Residential | 147582.23 | | 4.61 | 1.04 | | | | | **148000.67** |
| c. Agricultural/fisheries | 2689.70 | | 0.34 | 0.02 | | | | | **2702.46** |
| d. Biomass burnt for energy | | | 238.07 | 31.75 | | | | | **14841.88** |
| **B. Fugitive Emission from fuels** | 2399.36 | | 1166.23 | 0.0194 | | | | | **26896.19** |
| **1 Solid fuels** | | | 795.66 | | | | | | **16708.76** |
| a. Above ground mining | | | 645.56 | | | | | | **13556.66** |
| b. Underground mining | | | 150.10 | | | | | | **3152.10** |
| **2 Oil and Natural gas** | 2399.36 | | 370.57 | 0.02 | | | | | **10187.43** |
| a. Oil | 725.52 | | 21.99 | 0.0002 | | | | | **1187.47** |
| b. Natural gas | 10.84 | | 294.38 | | | | | | **6192.87** |
| c. Venting and Flaring | 1663.00 | | 54.20 | 0.0191 | | | | | **2807.09** |
| **2. Industrial Processes and Product Use** | **201043.81** | | **231.60** | **8.11** | **1.850** | **0.904** | **0.273** | **0.004** | 238556.02 |
| **A. Minerals** | **152269.60** | | | | | | | | **152269.60** |
| 1. Cement production | 136873.80 | | | | | | | | **136873.80** |
| 2. Lime production | 15007.50 | | | | | | | | **15007.50** |
| 3. Limestone and Dolomite Use | | | | | | | | | |
| 5. Glass | 363.79 | | | | | | | | **363.79** |
| 6. Ceramics | 24.51 | | | | | | | | **24.51** |
| **B. Chemicals** | **30310.28** | | **32.06** | **8.11** | | | | | **33496.24** |
| 1 Ammonia production | 11049.12 | | | | | | | | **11049.12** |
| 2 Nitric acid production | | | | 7.37 | | | | | **2285.88** |
| 3. Carbide production | 93.96 | | | | | | | | **93.96** |
| 4. Titanium dioxide production | 68.06 | | | | | | | | **68.06** |
| 5. Soda ash Production | 886.94 | | | | | | | | **886.94** |
| 6. Methanol production | 147.09 | | 0.50 | | | | | | **157.69** |
| 7. Ethylene production | 15982.16 | | 19.17 | | | | | | **16384.76** |

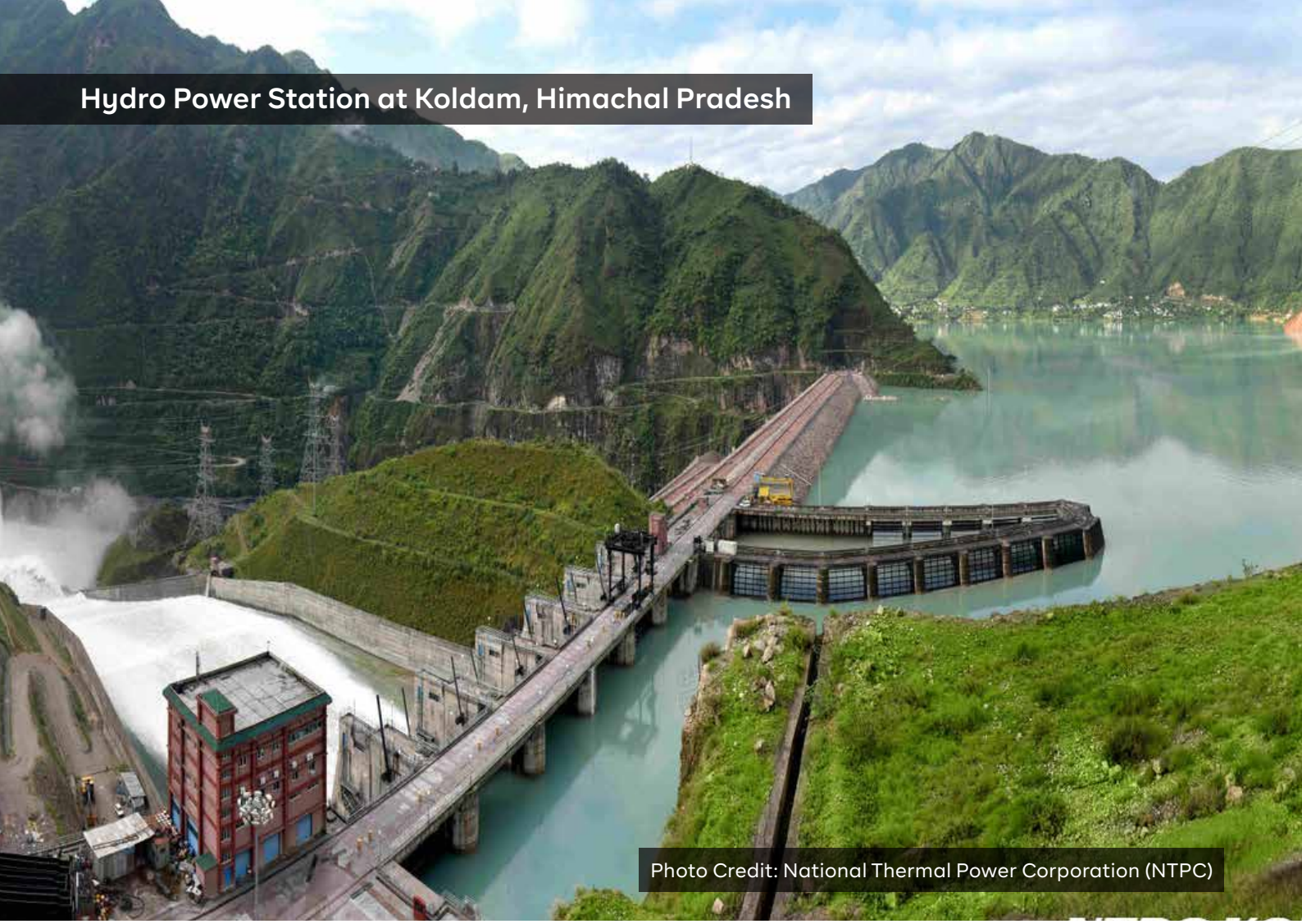
**Detailed Greenhouse Gas Emissions from India, in 2020, by Sources and Removals by Sinks (Emissions are in Gigagrams).**

| | $CO_2$ emission | $CO_2$ removal | $CH_4$ | $N_2O$ | HFC 23 | $CF_4$ | $C_2F_6$ | $SF_6$ | $CO_2$ equivalent |
|---|---|---|---|---|---|---|---|---|---|
| 8. EDC & VCM production | 305.38 | | | | | | | | **305.38** |
| 9. Ethylene Oxide production | 245.80 | | 0.51 | | | | | | **256.51** |
| 10. Acrylonitrile production | 0.0 | | 0.00 | | | | | | **0.00** |
| 11.Carbon Black production | 1531.78 | | 11.87 | | | | | | **1781.07** |
| 12. Caprolactam | | | | 0.73 | | | | | **226.88** |
| **C Metal Production** | **15918.32** | | **0.54** | | | **0.904** | **0.273** | **0.004** | **24421.00** |
| 1. Iron & Steel production | IE | | | | | | | | **IE** |
| 2. Ferroalloys production | 9678.94 | | 0.541321 | | | | | | **9690.31** |
| 3. Aluminium production | 5869.58 | | | | | 0.904 | 0.273 | | **14260.52** |
| 4. Lead production | 105.28 | | | | | | | | **105.28** |
| 5. Zinc production | 33.50 | | | | | | | | **33.50** |
| 6. Magnesium Production | 231.02 | | | | | | | 0.004 | **331.40** |
| **D. Non-energy product use** | **2545.60** | | | | | | | | **2545.60** |
| 1. Lubricant | 2376.68 | | | | | | | | **2376.68** |
| 2. Paraffin wax | 168.92 | | | | | | | | **168.92** |
| **E. Production of halocarbons and sulphur hexafluoride** | | | | | **1.850** | | | | **21644.58** |
| **F. Consumption of halocarbons and sulphur hexafluoride** | | | | | | | | | |
| **H. Other** | | | **199.00** | | | | | | **4179.00** |
| 1. Pulp & paper | | | 199.00 | | | | | | **4179.00** |
| **3. Agriculture** | | | **14290.38** | **341.57** | | | | | **405983.35** |
| A. Enteric Fermentation | | | 10601.54 | | | | | | **222632.27** |
| B. Manure Management | | | 184.29 | 29.68 | | | | | **13071.51** |
| C. Rice Cultivation | | | 3225.01 | | | | | | **67725.25** |
| D. Agricultural Soils | | | | 304.64 | | | | | **94437.14** |
| Direct $N_2O$ Emissions | | | | 241.11 | | | | | **74742.75** |
| Indirect $N_2O$ Emissions | | | | 63.53 | | | | | **19694.39** |
| F. Field Burning of Agricultural Residues | | | 279.55 | 7.25 | | | | | **8117.18** |

**Detailed Greenhouse Gas Emissions from India, in 2020, by Sources and Removals by Sinks (Emissions are in Gigagrams).**

| | $CO_2$ emission | $CO_2$ removal | $CH_4$ | $N_2O$ | HFC 23 | $CF_4$ | $C_2F_6$ | $SF_6$ | $CO_2$ equivalent |
|---|---|---|---|---|---|---|---|---|---|
| **4. LULUCF** | 9369.23 | 532357.26 | 40.54 | 0.66 | | | | | **-521933.50** |
| A. Forestland | | 146666.67 | 40.54 | 0.66 | | | | | **-145612.13** |
| B. Cropland | | 355513.19 | | | | | | | **-355513.19** |
| C. Grassland | 9369.23 | | | | | | | | **9369.23** |
| D. Settlement | | 7158.41 | | | | | | | **-7158.41** |
| E. Wetland | NE | NE | NE | NE | NE | NE | NE | NE | **NE** |
| F. Other land | NE | NE | NE | NE | NE | NE | NE | NE | **NE** |
| G. Harvested Wood Products | | 23019.00 | | | | | | | **-23019.00** |
| **5. Waste** | 479.28 | | 2726.19 | 57.78 | | | | | **75641.07** |
| **A. Solid waste disposal on land** | | | 911.53 | | | | | | **19142.13** |
| 1. Managed Waste Disposal on Land | | | 911.53 | | | | | | **19142.13** |
| **B. Waste-water handling** | | | **1808.63** | **57.78** | | | | | **55893.03** |
| 1. Industrial Wastewater | | | 1036.33 | | | | | | **21762.93** |
| 2. Domestic and Commercial wastewater | | | 772.30 | 57.78 | | | | | **34130.10** |
| **C. Biological Treatment of Solid Waste** | | | **6.030** | | | | | | **126.63** |
| **D. Incineration and Open Burning of Waste** | **479.28** | | | | | | | | **479.28** |
| **Memo Item (not accounted in total Emissions)** | **802845.91** | | **0.09** | **0.11** | | | | | **802882.42** |
| **International Bunkers** | 4938.20 | | 0.09 | 0.11 | | | | | **4974.71** |
| Aviation | 3195.17 | | 0.02 | 0.09 | | | | | **3223.34** |
| Marine | 1743.03 | | 0.07 | 0.02 | | | | | **1751.37** |
| **$CO_2$ from Biomass** | 797907.72 | | | | | | | | **797907.72** |

*Abbreviations: IE – Included Elsewhere; NE – Not Estimated; NO – Not Occurring, NA – Not Applicable.*



Hydro Power Station at Koldam, Himachal Pradesh

Photo Credit: National Thermal Power Corporation (NTPC)

Floating Solar Panels at Kayamkulam, Kerela

Photo Credit: National Thermal Power Corporation (NTPC)

# Chapter-3: Mitigation Actions

## 3.1. Introduction

Combating global warming is a challenge that requires global collective action. Robust international cooperation, especially multilateral efforts coordinated through the United Nations Framework Convention on Climate Change (UNFCCC) are therefore key to addressing this challenge. Climate science has established that global temperature rise is directly proportional to cumulative greenhouse gas (GHG) emissions, underscoring the need to keep emissions within a finite global carbon budget to limit warming. Developed countries have historically consumed a substantial portion of this budget, leaving limited room for emissions within safe thresholds. India's historical contribution to global GHG emissions is relatively small—approximately 4%—despite having around 17% 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. 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.

In its Nationally Determined Contributions (NDCs) under the Paris Agreement and in its Long-Term Low Carbon Development Strategy (LT-LEDS), as well as in other communications to the United Nations Framework Convention on Climate Change (UNFCCC), India has pledged to undertake ambitious climate change mitigation efforts based on its access to a fair and equitable share of the global carbon budget.

Government of India has consistently undertaken several initiatives to promote non-fossil fuel based sources of energy. Owing to these, India stands 4$^{th}$ globally in renewable energy installed capacity, 4$^{th}$ in wind power capacity and 5$^{th}$ in solar power capacity. Over the past decade, the installed solar energy capacity has surged from approximately 2.63 GW in March 2014 to around 92.12 GW in October 2024, marking an extraordinary increase of nearly 35 times. These achievements are in line with the updated Nationally Determined Contributions (NDCs) of India which includes, inter-alia, achieving about 50 per cent cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030. The sector-wise details of the installed capacity from non-fossil fuel-based energy sources are provided in Table 3.1.

India has progressively continued decoupling economic growth from GHG emissions. Between 2005 and 2020, India's gross domestic product (GDP) emission intensity reduced by 36%. It also reaffirms India's commitment to make a fair and equitable contribution to the global effort to mitigate climate change.

India's forest and tree cover has consistently increased and currently stands at 25.17% of the total geographical area of the country. During 2005 to 2021, additional carbon sink of 2.29 billion tonnes of $CO_2$ equivalent has been created.

***Table 3.1 Sector-wise details of the installed capacity from non-fossil fuel-based energy sources, as on 31.10.2024***

| Sector | Installed capacity (GW) | Under Implementation (GW) | Tendered (GW) | Total Installed/ Pipeline (GW) |
|---|---|---|---|---|
| Solar Power | 92.12 | 103.06 | 56.59 | 251.77 |
| Wind Power | 47.72 | 23.53 | 1.10 | 72.35 |
| Bio Energy (Including Biomass power/ Cogeneration and Waste to Energy) | 11.33 | — | — | 11.33 |
| Small Hydro | 5.08 | 0.46 | — | 5.54 |
| Hybrid/ Round the Clock (RTC)/ Peaking Power/ Thermal + RE Bundling | — | — | 32.00 | 32.00 |
| **Sub-Total** | **156.25** | **127.05** | **89.69** | **372.99** |
| Large Hydro | 46.97 | 20.05 | — | 67.02 |
| **Total** | **203.22** | **147.10** | **89.69** | **440.01** |
| Nuclear Power | 8.18 | 7.30 | 7.00 | 22.48 |
| **Total Non-Fossil Fuel** | **211.40** | **154.40** | **96.69** | **462.49** |

*Source: MNRE records, 2024*

In this chapter, as part of India's Fourth Biennial Update Report (BUR4), the range of initiatives for climate change mitigation across key sectors are listed and discussed. The discussion of laws, policies, plans, schemes, and interventions designed and implemented by various Government agencies is updated where relevant, compared to India's submissions to the UNFCCC in its Third National Communication. It is essential to underline that a large majority of these initiatives are undertaken by India through the efforts of the Central and State Governments and their agencies, and there are significant attendant costs associated with them. This chapter, therefore, also provides estimates of expenditure where possible. It must be noted, however, that these are underestimates of the actual cost of interventions for climate change mitigation as it is difficult to ascertain and measure the complete set of attendant and external costs for implementing every policy.

The following sections provide a detailed discussion of interventions in the power, industry, transport, agriculture, residential and buildings, waste, water, and forestry sectors. The policies, plans, and schemes listed in the tables in the subsequent sections are updated, where possible, from India's last submission to the UNFCCC, i.e. India's 3rd National Communication (TNC).

## 3.2. Power

India's per capita electricity consumption remains significantly lower than the world average, at 1331 kWh per person in 2022-23. India's total electricity consumption reached 1440.31 TWh in 2022-23 (provisional), an increase of about 9.4 % from 2021-22 (CEA, 2023a).

While coal remains the predominant source of electricity generation in India, RES (renewable energy sources) have grown by over 10.94 % (not including hydro) in generation and over 14.7 % (not including hydro) in Installed Capacity in the year 2023-24. 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).

As of October 2024, the share of non-fossil fuel-based power generation capacity in the country is already at 46.52% (CEA, 2024).

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. Table 3.3 lists the efforts for climate change mitigation in the power sector in India.

Additionally, the Government has taken several initiatives to incentivize higher penetration of non-fossil fuel sources in the total electricity mix in India. Listed below in Table 3.2 are a few of these initiatives.

***Table 3.2 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 of wind-solar based stations |
| **ix** | Green Term Ahead Market | Facilitates additional avenues to RE generators for 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 | Government of India has set up the Renewable Energy Management Centres (REMCs) at National, State and Regional level for real time monitoring of RE generation. |
| **xii** | Green Hydrogen technology | Ministry of New and Renewable Energy will establish a single portal for all statutory clearances and permissions required for manufacture, transportation, storage, and distribution of Green Hydrogen and Green Ammonia. |
| **xiii** | Green Energy Open Access | The 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 existing earlier. This new regulation has 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 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. |

## 3.3. 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 year 2022-23, the industrial sector experienced a growth of 6.7%, with manufacturing emerging as a key driver of economic expansion. Key sectors such as automotive, engineering, cement, textiles, steel, chemicals, pharmaceuticals, and consumer durables are pivotal in this growth trajectory (BEE, 2023a).

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.

A new Advanced Industrial Technology Demonstration Centre (AITDC), named UTPRERAK was established at NPTI Badarpur in June 2023. It features non-functional models of energy efficiency technologies in sectors like Cement, Iron & Steel, Pulp & Paper, Textile, and Chlor-Alkali. A list of initiatives in the industrial sectors, separated by sub-sector is given in Table 3.3.

## 3.4. 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, 2024). 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. The schemes and initiatives for climate change mitigation in the transport sector are given in Table 3.3.

## 3.5. 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 2019, the waste sector contributed 2.34 per cent to total greenhouse gas emissions, with 77.31 per cent coming from wastewater treatment and discharge, and 22.69 per cent from solid waste disposal. The waste sector contributed 73,189 Gg of $CO_2$, equivalent to total GHG emissions in 2019.

To ensure effective waste management, specialized legislation has been enacted and periodically revised to adapt to evolving environmental conditions. Some of the relevant laws, rules, and regulations are listed below.

(i) Ash Utilization Notification (2021) and as amended (2022 and 2024)
(ii) Battery Waste Management Rules (2022) and as amended (2023 and 2024)
(iii) Bio-medical Waste Management Rules (2016) and as amended (2018 and 2019)
(iv) Construction and Demolition Waste Management Rules (2016)
(v) E-Waste (Management) Rules (2022) and as amended (2023)

(vi) Green Credit Rules (2023) and Methodology for calculating Green credit (2024)

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

(viii) Manufacture, Storage and Import of Hazardous Chemicals (MSIHC) Rules (1989)

(ix) Plastic Waste Management Rules (2016) and as amended (2018, 2021, 2022, 2023, and 2024)

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

Further, Government of India has taken various initiatives to promote Circular Economy in various sectors. Metal industry is highly energy intensive industry and has a large production of waste e.g. from the iron and steel industry. Technologies for utilization of such waste to develop state of art steel slag roads have been developed in the country which could be effectively front-ended for more wider use

Details of other initiatives for mitigation in the waste sector are given in Table 3.3.

## 3.6. Buildings

Buildings contribute to emissions indirectly, during their construction and operational phases. These emissions largely stem from the energy embedded in building materials, reflecting the energy used in their production processes. Additionally, the total emissions produced by buildings over their lifespan are influenced by the emission profiles of the electricity utilised by them. After the process of construction, implementing improved design principles can further cut emissions by reducing the need for extensive heating and cooling. The main strategies for reducing emissions in the building sector concentrate on minimising the use of energy and materials through design and the application of new technologies and are discussed in Table 3.3.

## 3.7. 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 has increased from 6,92,027 sq.km to 7,15,342.61 sq.km, while the total tree cover has increased from 95,027 sq.km to 1,12,014.34 sq.km. This growth has led to a combined tree and forest cover expansion 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 $CO_2$eq through additional forest and tree cover by 2030. The total carbon stock in country's forest is estimated to be 7285.5 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 Programme (NAP), 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 (Economic Survey of India, 2022-23). Table 3.3 shows the details of some of these policies and initiatives.

## 3.8. Water

Groundwater use accounts for approximately 62% of irrigation, 85% of rural water supply, and 50% of urban water supply in India. In 2023, the total annual groundwater recharge was 449.08 BCM, marking an increase from the 437.6 BCM recorded in 2022. The annual extractable groundwater resources reached 407.21 BCM, and the annual groundwater extraction was reported to be 241.34 BCM in this year. Rainfall recharge is the primary source of replenishable groundwater resources, contributing to nearly 60% of the total annual groundwater recharge.

Compared to the 2022 assessment, the total number of assessment units have decreased from 7089 to 6553. Of the 6553 assessment units, 736 units in various States/ UTs (11.23%) have been categorized as 'Over-exploited', indicating that groundwater extraction exceeds the annually replenishable groundwater recharge. Additionally, 199 assessment units (3.04%) fall under the 'Critical' category, with groundwater extraction levels between 90-100%, 698 assessment units (10.65 %) are "Semi-critical", where the stage of groundwater extraction is between 70 % and 90 % and 4793 (73.14 %) are 'Safe 'units, where the stage of Groundwater extraction is less than 70 %. 127 assessment units, accounting for 1.94%, are designated as 'Saline' due to the prevalence of brackish or saline groundwater in their phreatic aquifers (CGWB, 2023).

In view of the above, the Government of India has prioritized water security by exploring various avenues such as increasing water sources, enhancing supply, managing demand, conserving water, managing wastewater, and reusing treated wastewater through initiatives like Jal Shakti Abhiyan, Atal Bhujal Yojana, Amrit Sarovar Mission, Master Plan for Artificial Recharge to Groundwater- 2020 etc. Some actions within the water sector aimed at achieving water-food-energy security are relevant to be discussed within the context of climate change mitigation and are discussed in Table 3.3. While the Pradhan Mantri Krishi Sinchayee Yojna (PMKSY) also contributes to interventions in the water sector, it is discussed in detail in the section on Agriculture in this chapter.

## 3.9. 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, 2024e). The sector contributes to 14.37 per cent of the total GHG emissions in India (MoEFCC, 2021). 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 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 small holder farming. The adaptation burden in this sector is currently, and also expected to be, very high and small holder 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. The details of these initiatives are discussed in Table 3.3.

*Table 3.3: Interventions for climate change mitigation in various sectors (Power, Industry, Transport, Waste, Buildings, Forestry, Water and Agriculture)*

| Sl. No. | Scheme/ Initiative | Description | Implementing agency | Description of Data, Targets, Results Achieved and Expenditure where updated and available | Data Sources |
|---|---|---|---|---|---|
| **POWER SECTOR** | | | | | |
| 1 | **Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY)** | The DDUGJY, launched in December 2014 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. | Ministry of Power, Government of India | By April 28, 2018, all inhabited un-electrified villages (as per Census of India, 2011) were electrified. 18,374 villages were electrified under the DDUGJY, including a total of 28.6 million households. The infrastructure created till date includes the installation of 693,181.52 ckm of 11 kV lines and 1,379,273 ckm of low tension lines. Additionally, 1,665,047 Distribution Transformers (DTR) have been constructed. | (MoP, n.d.); (PIB, 2023a) |
| 2 | **Integrated Power Development Scheme (IPDS)** | The Integrated Power Development Scheme (IPDS), launched in December 2014, 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 Sub-stations (GIS) and Real Time Data Acquisition System (RT-DAS). These are aimed at reducing Aggregate Technical & Commercial (AT&C) losses, with additional funding for underground (UG) cabling and 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. | Ministry of Power, Government of India | The Government of India provides a grant of 60% (85% for special category States) and an additional grant of 15% (5% for special category States), contingent upon meeting specified milestones. | (PIB, 2022a) |
| 3 | **Smart Meter National Program** | EESL, 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. | Energy Efficiency Services Limited (EESL), Ministry of Power, Government of India | As on date, EESL has installed over 35.75 lakh smart meters in Uttar Pradesh, Delhi, Haryana, Bihar, Rajasthan and Andaman under this programme. Apart from this, 3.03 Lac Smart Meters has been installed in the State of Assam. | (EESL, n.d.) |

| Sl. No. | Scheme/ Initiative | Description | Implementing agency | Description of Data, Targets, Results Achieved and Expenditure where updated and available | Data Sources |
|---|---|---|---|---|---|
| 4 | **Demand Side Management (DSM) for distribution utilities** | DSM programs assist utilities in lowering power purchases during peak-load times from the wholesale market, thus reducing operational costs. Providing distribution utilities with capacity building and other supports is crucial for effective DSM implementation. The program aims to enhance distribution utilities' ability to implement DSM measures. | Ministry of Power, Government of India | Ministry of Power (Government of India) had approved the Demand Side Management (DSM) scheme for the 2012-17 period and has further extended it for the 2021- 26 period.<br>For Phase-1 (2012-17) and Phase 2 (2021-26), Peak demand reduction potential is estimated at about 22.9 GW across 28 distribution utilities. Energy requirement reduction potential is estimated to be 62.6 billion units across 28 distribution utilities. In FY 2023-24, phase III of DSM scheme started with 33 distribution utilities participating from 4 zones: North, North-east, South, and West zone. | (BEE, 2023a) |
| 5 | **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. | Energy Efficiency Services Limited (EESL), Ministry of Power, Government of India | Till June 2024, EESL has installed over 13.1 million LED streetlights in urban local bodies (ULBs) and Gram Panchayats across India. Between 2015-2023, this scheme has led to annual energy savings of 8.75 billion kWh with avoided peak demand of 1,459 MW every year. Avoided emissions are estimated at 6.03 million tons of $CO_2$ per year in this period. | (PIB, 2024a) |
| 6 | **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. | Ministry of Power, Government of India | Till January 2024, over 368.6 million LED bulbs, 7.22 million LED tube lights and 2.36 million energy efficient fans (including over 55,000 brushless direct current (BLDC fans)) have been distributed by EESL across India. Between 2015 and 2024, this scheme is estimated to have led to annual energy savings of 48.39 billion kWh with avoided peak demand of 9,788 MW every year. Avoided emissions are estimated at 39.30 million ton $CO_2$ per year during this period. | (PIB, 2024a) |
| 7 | **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 TPPs 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. | Ministry of Power, Government of India | As of July 31, 2024, 94 units with a capacity of 65,290 MW (Supercritical/ Ultra-supercritical) and 6 units with a capacity of 4,240 MW (Ultra-supercritical) have been commissioned. Additionally, about 104 units with a capacity of 8,279.92 MW of inefficient and old thermal power generation units were retired between January 2018 and April 2024.<br>From 2011 to 2022, savings of 7.72 million tonnes of oil equivalent in energy and avoided emissions of about 28.744 million tonnes of $CO_2$ have been estimated due to these interventions. | (PIB, 2023b);<br>(BEE, 2023a) |

| Sl. No. | Scheme/ Initiative | Description | Implementing agency | Description of Data, Targets, Results Achieved and Expenditure where updated and available | Data Sources |
|---|---|---|---|---|---|
| 8 | **Hydro power** | 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. | Ministry of Power, Government of India | Due to multiple policies aiming to boost hydro power generation, it is estimated that India has a hydro power potential of about 133 GW, of which only 42 GW is currently utilized.<br><br>Based on the capacity utilisation of 42 GW, the avoided emission due to hydropower utilisation is 117.2 $MtCO_2$ in 2022. | (PIB, 2023c) |
| 9 | **Renewable Energy Sources (not including large hydro)** | 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.<br><br>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.<br><br>Under the National Bioenergy Programme, following bioenergy schemes are currently being implemented-<br><br>Programme on Energy from Urban, Industrial and Agricultural Wastes/ Residues (Waste to Energy Programme),<br><br>Scheme to Support Promotion of Manufacturing of Briquettes and Pellets and Biomass (Non-Bagasse) Based generation in Industries in the Country for the period from FY 2021-22 to 2025-26.<br><br>Biogas Programme for installing small (1-25 cubic meters) and medium size biogas plants (above 25 m3 -2500 m3) for clean cooking purposes and decentralised power generation (off-grid) and thermal application.<br><br>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. | Ministry of New and Renewable Energy, Government of India | The all-India level generation from renewable energy sources in 2023-24 includes 83,385.35 MUs from wind, 1,15,975.11MUs from solar, 3,417.19 MUs from biomass, and 9485.04 MUs from small hydro.<br><br>In 2024-25, 29.91% of total electricity is mandated to be purchased from renewable energy sources, increasing to 43.33% of total electricity from renewable energy sources till 2029-30. The target for wind energy is 3.48%, hydro is 1.33%, and distributed renewable energy is 4.5%.<br><br>Under the National Bioenergy Programme, the achieved capacity includes 10.72 GW from biomass power and cogeneration projects, 604.5 MW from Waste to Energy projects, and biogas plants with 50.95 lakh small units and 361 medium units generating 11.5 MW off-grid power.<br><br>The total avoided emissions from renewable energy sources in 2023-24 (up to December) amount to 135.61 million tons of $CO_2$, with 57.47 $MtCO_2$ from wind, 69.40 $MtCO_2$ from solar, 2.09 $MtCO_2$ from biomass, and 6.66 $MtCO_2$ from small hydro. This demonstrates a significant reduction in carbon emissions due to renewable energy generation. | (PIB, 2024b);<br><br>(CEA, 2023b);<br><br>(MNRE, 2024) |

| Sl. No. | Scheme/ Initiative | Description | Implementing agency | Description of Data, Targets, Results Achieved and Expenditure where updated and available | Data Sources |
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| 10 | **National Smart Grid Mission (NSGM)** | The National Smart Grid Mission, under the Ministry of Power and with technical support from USAID's South Asia Regional Energy Partnership (SAREP), leads assessments for Smart Distribution cities. NSGM and SAREP teams have conducted visits to five distribution utilities and held kick-off meetings to initiate data collection. | Ministry of Power, Government of India | 1. Two Smart Grid/Smart metering projects, funded by NSGM with Rs. 1160.1 million and Rs.348 million budgetary support by the Government of India, are nearing completion. As of November 2023, 1,69,330 smart meters have been deployed under these projects, with Rs. 313.2 million released to implementing utilities for milestone achievements.<br>2. Under this scheme 1,78,522 Smart Consumer Metering has been sanctioned and 1,69,557 has been installed. | (PIB, 2024a);<br>(National Smart Grid Mission, n.d.) |
| 11 | **National Green Hydrogen Mission** | 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.<br>To complement this, CSIR has launched Hydrogen Mission for technology innovation and development.<br>The overall goals of CSIR's Hydrogen Technology Mission is to demonstrate, integrate and showcase India's technology strengths across all three parts of $H_2$ value chain as technology showcases in multiple cities in India – connecting to industry & society. 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. | Ministry of New and Renewable Energy (MNRE), Government of India<br>Council of Scientific & Industrial Research, Ministry of Science and Technology, Government of India. | 1. GAIL Limited has initiated India's maiden project of blending Hydrogen into the City Gas Distribution grid. Two percent hydrogen by volume is blended into the CNG network, and 5% hydrogen by volume is blended into the PNG network at City Gas Station of Avantika Gas Limited (AGL), Indore, Madhya Pradesh.<br>2. NTPC Limited has initiated blending of Green Hydrogen up to 8% (vol/ vol) in PNG Network at NTPC Kawas Township, Surat, Gujarat from January 2023.<br>3. Other PSUs have undertaken various projects such as:<br>* Introduction of Hydrogen-based Fuel-Cell Electric Vehicle (FCEV) Buses in Leh and Greater Noida by NTPC.<br>* Development of a 60 kW capacity hydrogen fuel cell bus by Oil India Limited, which is a hybrid of electric drive and a fuel cell.<br>*Establishment of demonstration pilot plants for Green Hydrogen production through water electrolysis using solar power, biomass oxy steam gasification, and CBG reforming to refuel 15 Hydrogen Fuel Cell buses by Indian Oil.<br>4. By the year 2030, the mission aims to achieve a production capacity of at least 5 million metric tonnes (MMT) of green hydrogen annually with an associated renewable energy capacity of about 125 GW, 60-100 GW electrolyser capacity and about 1 lakh crore of Import saving. This initiative is expected to result in the avoidance of 50 million metric tonnes (MMT) of $CO_2$ emissions annually. | (PIB, 2023d) |

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| 12 | **Revamped Distribution Sector Scheme (RDSS)** | RDSS was introduced to aid distribution utilities in enhancing their operational efficiencies and financial sustainability. RDSS offers result-linked financial assistance to distribution utilities based on meeting predefined criteria and achieving minimum benchmarks. With a budget of approximately Rs. 3040 billion over five years (FY 2021-22 to FY 2025-26), including an estimated Government Budgetary Support (GBS) of around Rs.980 billion, RDSS aims to achieve the following objectives:<br><br>Reduce AT&C losses to pan-India levels of 12-15% by FY 2024-25.<br><br>Eliminate the gap between annual cost of supply and annual revenue realized by FY 2024-25.<br><br>Enhance the quality, reliability, and affordability of power supply to consumers through a financially sustainable and operationally efficient distribution sector. | Ministry of Power, Government of India | 1. 29,70,100 Smart Consumer Meters have been sanctioned and 21,83,606 have been installed.<br><br>2. 51,66,603 DT Meters have been sanctioned and 9,370 have been installed.<br><br>3. 1,82,807 DT Feeder Meters have been sanctioned and 12,337 has been installed | (PIB, 2021a);<br><br>(National Smart Grid Mission, n.d.) |
| 13 | **Sustainable Agrarian Mission on use of Agri-Residue in Thermal Power Plants (SAMARTH) Mission** | The revised Biomass Policy, issued on 16/06/2023 by the Government of India outlines price benchmarking and procurement procedures for biomass pellets for use in thermal power plants. An addendum to the policy, released on 03.05.2023, includes Bamboo and its by-products for pellet manufacturing. Additionally, a revised model contract for biomass procurement has been issued, and price benchmarking for biomass pellets in certain regions for co-firing in Thermal Power Plants has been notified. | Ministry of Power, Government of India | Biomass usage in 2023 surpassed 2.08 LMT, with cumulative usage exceeding 3 LMT. Orders for 31.50 LMT of Biomass pellets were placed in 2023 and tendering for ~ 38 LMT is ongoing. | (PIB, 2023e) |

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| **INDUSTRY SECTOR** | | | | | |
| **Cement Industry:** The Indian cement industry has one of the lowest specific energy consumptions globally. Between 1995 and 2015, specific electricity consumption in the cement industry decreased by 32%, from 110 kWh/ton of cement to 76 kWh/ton of cement (CII, 2019). Similarly, specific thermal energy consumption reduced by 11%, from 807 kcal/kg of clinker to 718 kcal/kg of clinker over the same period. From 2014-2015 to 2022-23 (P), the annual fossil fuel consumption within the industry (comprising coal and lignite) declined from 12.63 million tonnes (11.36 coal & 1.27 Lignite) to 8.96 million tonnes (8.12 coal & 0.84 Lignite). From 1996 to 2015, the proportion of Ordinary Portland Cement (OPC) in total cement production declined by 42%, while that of Portland Pozzolana Cement (PPC) increased by 46%. Meanwhile, the average for Portland PSC and other types remained at 9% during the same period. In 2021-22, the total installed cement capacity in India reached 537 million tonnes, marking a 51% increase from the levels recorded in 2014-15. Concurrently, the total cement production amounted to 360 million tonnes, reflecting a 30% increase from 2015. | | | | |
| 14 | **Perform, Achieve and Trade (PAT)** | Since its inception in 2012, the Cement industry has consistently been part of the PAT cycles, with new Designated Consumers (DCs) joining each rolling cycle. Currently, the industry's top-performing plant consumes 19% less energy than the global average, and approximately 40% of the total installed capacity is equipped with the latest technology and equipment, and is less than 10 years old. Key emission reduction measures implemented by the industry include:<br>• Increased utilisation of alternative fuels and raw materials<br>• Installation of Waste Heat Recovery Systems (WHRS) from pre-heater outlets<br>• Installation of Kiln shell radiation recovery systems<br>• Calcium looping technology for carbon capture<br>• Blending of fly ash/ slag residue | Ministry of Power and Bureau of Energy Efficiency, Government of India, | In all cycles except PAT Cycle IV (2018-19 to 2021-22), the industry exceeded its reduction targets. During PAT Cycle I (2012-15), it surpassed the target by 82%, while in PAT Cycles II (2016-17 to 2018-19) and III (2017-18 to 2019-20), it exceeded by 39% and 66%, respectively. In PAT Cycle V (2019-20 to 2021-22), it surpassed targets by 76%. However, in PAT Cycle IV (2018-19 to 2021-22), it fell short of the targeted energy savings by 50%.<br>Over all the five cycles, there has been a cumulative energy savings of 3.35 Mtoe. The avoided emissions in cycles I-V have been 4.34, 5.45, 0.339, 0.008, and 0.61 $MtCO_2$/year, respectively. | (MoM, 2019);<br>(MoM, 2022);<br>(BEE, 2023a);<br>(MoSPI, 2024b);<br>(BEE, 2024) |
| **Iron and Steel:** In year 2022-23, the iron and steel industry was the most energy-intensive sub-sector within the industry sector, accounting for 15.2% of the total industrial energy consumption. Iron ore production reached approximately 258 million tonnes, while crude steel and finished steel production were approximately 127 million tonnes and 123 million tonnes respectively during 2022-23. India ranks fourth globally in iron ore production and second in steel production, contributing approximately 7% and 6% to the global output, respectively. Coal, a primary energy source for both the steel and sponge iron industries, amounted to 78.9 million tonnes in consumption during FY 2022-23 (P) in contrast to 67 million tonnes in 2017-18. Within the industrial sector, Iron and Steel accounts for 7.1% of the coal used in the year 2022-23 (P). | | | | | |
| 15 | **Perform, Achieve and Trade (PAT)** | The PAT scheme has covered upto 204 Iron & steel plants as Designated Consumers (DCs) during the cycles I-VII so far. | Ministry of Power and Bureau of Energy Efficiency, Government of India | In all cycles, the industry exceeded its targets. During PAT Cycle I (2012-15), II (2016-17 to 2018-19), III (2017-18 to 2019-20), IV (2018-19 to 2021-22) and V (2019-20 to 2021-22), it surpassed targets by 41%, 25%, 25%, 85% and 56% respectively.<br>Over the five cycles, there has been a cumulative energy savings of 6.14 Mtoe. The avoided emissions in cycles I-V have been 6.51, 11.85, 1.69, 1.41 and 1.04 $MtCO_2$/year, respectively. | (PIB, 2018);<br>(PIB, 2022b);<br>(BEE, 2023a);<br>(MoM, 2023);<br>(MoSPI, 2024b) |
| **Aluminium Industry:** India's primary aluminium production stood at 3.5 million tonnes and bauxite production at 21.7 million tonnes for the year 2022-23. As per World Mineral Production, 2016-20, British Geological Survey, India's ranking in 2020 in world production in term of quantity was 3rd in aluminium (primary) and 6th in Bauxite | | | | | |

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| 16 | **Perform, Achieve and Trade (PAT)** | The PAT scheme has covered up to 14 aluminium plants as Designated Consumers (DCs) during cycles I-VII. | Ministry of Power and Bureau of Energy Efficiency, Government of India | In all cycles, the industry has exceeded its targets. During PAT Cycle I (2012-15), II (2016-17 to 2018-19), III (2017-18 to 2019-20) and V (2019-20 to 2021-22), it surpassed targets by 60%, 167%, 46% and 20% respectively.<br><br>Over the five cycles, there has been a cumulative energy savings of 2.13 Mtoe. The avoided emissions in these cycles have been 3.1, 4.2, 0.35 and 0.35 $MtCO_2$/ year, respectively. | (MoM, 2023) |
| 17 | **Measures taken by National Aluminium Company (NALCO)** | NALCO has introduced low-carbon technologies in the production process that contribute to reducing emissions.<br><br>1. Graphitization of cathode blocks used in smelters has led to reduction of specific electrical energy consumption.<br><br>2. In its captive power plant, NALCO has introduced chemical cleaning of condensers and revamping of preheaters in boilers, leading to a decrease in specific coal consumption.<br><br>3. Installation of anode slot cutting machine has led to the reduction of specific DC energy consumption. | National Aluminium Company (NALCO) | Graphitization of cathode blocks used in smelters has led to reduction of specific electrical energy consumption to 55 kWh/Mt.<br>Installation of anode slot cutting machine has led to the reduction of specific DC energy consumption to 140 kWh/Mt of hot metal. This is estimated to avoid up to 0.031 million tonnes of $CO_2$ per year. | (MoM, 2023) |
| **Fertilizer Industry:** The increased use of fertilizers has greatly boosted food grain production, leading to self-sufficiency in India. India ranks as the world's third largest producer and second largest consumer of finished fertilizers. India is a net importer of fertilizers, both finished as well as raw materials, while domestically producing approximately 75% of Urea, 40% of DAP, and 85% of NPKs. In year 2022-23 (up to Dec'22), total fertilizer production amounted to 362.73 LMT, comprising 210.98 LMT of Urea, 31.80 LMT of DAP, 76.5 LMT of NPKs, and 43.45 LMT of SSP. Total consumption during this period reached 471.88 LMT, including 281.39 LMT for Urea, 92.33 LMT for DAP, 12.83 LMT for MOP, and 85.33 LMT for NPKs. Imports during this period totaled 152.7 MT, with 62.44 LMT for Urea, 53.18 LMT for DAP, 16.22 LMT for MOP, and 20.86 LMT for NPKs. In FY 22-23 (P), the fertilizers industry was the primary consumer of natural gas, accounting for 32.4% of total consumption (a 32% increase in consumption from 2017-18). The share of the fertilizer and chemicals sector, in overall coal consumption, reduced to just 0.09% in FY 2022-23 (P), significantly less as compared to FY 2017-18 (a decrease in overall consumption by 56%). | | | | | |
| 18 | **Perform, Achieve and Trade (PAT)** | The PAT scheme has covered up to 37 fertilizer plants as Designated Consumers (DCs) during the cycles I-II so far. | Ministry of Power and Bureau of Energy Efficiency, Government of India | During PAT Cycle I (2012-15), the industry exceeded the targeted energy savings by 63%, resulting in avoided emissions of 0.93 $MtCO_2$/year. However, in PAT Cycle II (2016-17 to 2018-19), it fell short of the targeted energy savings by 13%, with avoided emissions of 1.18 $MtCO_2$/year. | (MoCF, 2023a);<br><br>(BEE, 2023a);<br><br>(MoPNG, 2023a);<br><br>(MoSPI, 2024b) |
| 19 | **Introduction of Target Energy Norms (TEN) (Nov 2015)** | The New Urea Policy (NUP), initiated in 2015, targets enhanced energy efficiency, increased urea production, and a rationalized subsidy burden. Categorizing urea units into three groups, the policy introduced group energy norms to boost energy efficiency in production plants. By setting target energy norms, the policy aimed to reduce energy consumption across all urea units. | Ministry of Chemicals & Fertilizers, Department of Fertilizer, Government of India | As of 2019-20, 18 out of 25 units demonstrated decreased energy usage compared to the pre-NUP period (2014-15), leading to substantial savings. | |

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| **Chemical & Petrochemical Industry:** The chemical industry is a vital component of India's growing industrial sector, encompassing over eighty thousand commercial products. It plays a crucial role in meeting basic needs and enhancing quality of life, contributing significantly to industrial and agricultural development. According to the National Accounts Statistics (NAS) 2024, the Chemicals and Chemical products sector constituted 1.6% of the Gross Value Added (GVA) for all economic activities in 2022-23 at constant 2011 prices. The Index of Industrial Production (IIP) for the Chemicals and Chemicals product remained stable between 116 and 127.4 during the period 2017-18 to 2023-24. In year 24-25 (up to Aug.'24), the production of major chemicals amounted to 6.5 million MT, marking a 41% decrease as compared to year 2017-18. Similarly, the total production of major petrochemicals declined by 45% during this period, reaching 26.6 million MT in 2022-23. As of year 22-23 this is the second most energy intensive sub-sector within the industry sector (following iron & steel industry), accounting for 4.6% of the annual energy consumption. In year 22-23 (P), naphtha consumption was 10.4 million tonnes (compared to 10.0 million tonnes in FY 2017-18). Natural gas consumption in the industry amounted to 1,959 MMSCM, representing 3.27% of total consumption, marking a decrease of 51% from FY 2017-18. | | | | | |
| 20 | **Perform, Achieve and Trade (PAT)** | Initiatives in this sector under the PAT scheme include:<br>- Zero-gap technology and the use of micro-turbine<br>- Feeding of 48 per cent hot Caustic Soda lye direct to flaker plants<br>- Change-over of fuel from Furnace Oil (FO) to Hydrogen in process heating/ steam requirement Utilizing Hydrogen in Captive Power Plants<br>- PEM Fuel Cell Technology using Hydrogen<br>- Hydrogen Compressed Natural Gas (HCNG) (Hydrogen blending with CNG)<br>- Hydrogen Co-firing in Industrial Gas Turbines | Designated consumer (DC), Ministry of Power and Bureau of Energy Efficiency, Government of India | During PAT Cycle I (2012-15), II (2016-17 to 2018-19), and V (2019-20 to 2021-22), the industry surpassed targets by 67%, 33%, and 50% respectively. However in PAT Cycle IV (2018-19 to 2021-22), it fell short of the target by 67%.<br>Over the four cycles (I, II, IV & V), there has been a cumulative energy savings of 0.23 Mtoe. The avoided emissions in cycles I, II, IV & V have been 0.62, 0.55, 0.003 & 0.01 $MtCO_2$/year, respectively. | (MoCF, 2023b);<br>(BEE, 2023a);<br>(MoSPI, 2024b) |
| **Micro, Small and Medium Enter-prises (MSME) Industries:** The Micro, Small, and Medium Enterprises (MSME) sector in India plays a crucial role in the nation's economic and social development, serving as a significant source of employment and fostering entrepreneurship. The Indian MSME sector makes up approximately 33% of the nation's total GDP and is projected to add value of US$ 1 trillion to India's overall exports by the year 2028. The energy demand in the MSME sector is estimated to be 1026 million MWh in 2023, which is about 20-25% of the total industrial energy consumption. The MSME sector in India comprises 633.9 lakh enterprises, with micro-enterprises dominating the market share at over 99%, followed by small enterprises at 0.5%, and medium enterprises at 0.01%. In 2022-23, 48.75% (309 lakhs) of all MSMEs were in urban areas, while are 51.25% (324.88 lakhs) of the total MSMEs were in rural areas. These figures encompassed 630.52 lakhs micro, 3.31 lakhs small, and 0.05 lakhs medium enterprises. As per BEE's UNNATEE (Unlocking National Energy Efficiency Potential) report (BEE, 2019a), energy consumption of the Indian MSME sector is estimated to increase to 500% in the next decade (by year 2031) and to realize the energy saving potential at MSMEs, an investment of ~12.3 Billion USD is required in next 14 years. | | | | | |
| 21 | **BEE-GEF-UNIDO Project 'Promoting Energy Efficiency and Renewable Energy in selected MSME clusters of India'** | The project "Promoting Energy Efficiency and Renewable Energy in Selected MSME Clusters in India" has an objective to develop and promote 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 31st March 2023. | The United Nations Industrial Development Organization (UNIDO) in collaboration with the Bureau of Energy Efficiency, and in partnership with the Global Environment Facility (GEF), Ministry of MSME and Ministry of New and Renewable Energy (MNRE), is executing this project. | Achieved a monetary investment of approximate INR 257.83 Crores. In the fiscal year 2022-23, the combined energy savings achieved through the Programme amounted to 0.024 MTOE, resulting in avoided emissions of 0.146 $MtCO_2$ emissions. | (BEE, 2023a);<br>(BEE, 2024) |

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| 22 | **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.<br>* The project aims to facilitate the validation of innovative low carbon technology thereby assist in scale up, deployment and scaling up of low-carbon technologies in India promoting innovation of low carbon technology solutions that address the existing technology gaps in 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 | 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) | During FY 2022, there was a total energy saving of 0.0007 MTOE and avoided GHG emissions of 0.002 $MtCO_2$. | (BEE, 2023a);<br>(BEE, 2024) |
| 23 | **Partial Risk Sharing Facility for Energy Efficiency" – WB-SIDBI-GEF project** | To transform the energy efficiency (EE) market in India by promoting increased level of EE investments, particularly through energy service performance contracting (ESPC) delivered through Energy Service Companies (ESCOs). "Partial Risk Sharing Facility for Energy Efficiency" project was initiated by Government of India partnering with World Bank to promote an increased level of investments in energy efficient projects, particularly through energy service performance contracting delivered through energy service companies ("ESCOs"). | Global Environment Facility(GEF) and the Clean Technology Fund (CTF), Government of India | In the fiscal year 2022-23, the combined energy savings achieved through the SIDBI-PRSF Programme amounted to 1939 TOE, resulting in avoided emissions of 17,104 $tCO_2$ emissions across 16 units. These savings were realized through a total investment of INR 1.41 billion. | (BEE, 2023a);<br>(BEE, 2024) |
| 24 | **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 big output. The MSME gets financial help 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. | Energy Auditors and consultants work in the SME Services Technology Limited (ISTSL), SIDBI. | A total of 1088 cases have been successfully processed under the 4E scheme, reflecting a robust engagement in facilitating economic empowerment.<br>During the fiscal year 2022-23, there were energy savings totaling 0.0246 MTOE, resulting in avoided emissions of 0.23 $MtCO_2$ emissions. | (BEE, 2023a);<br>(BEE, 2024) |

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| 25 | **EESL-UNIDO – GEF programme 'Promoting Market Transformation for Energy Efficiency in Micro, Small & Medium Enterprises'** | Energy Efficiency Services Limited (EESL), with aid from UNIDO and GEF, is implementing the project 'Promoting Market Transformation for Energy Efficiency in MSMEs' in 10 MSME clusters, and the project is in various stages of implementation. | Energy Efficiency Services Limited (EESL), United Nations Industrial Development Organization (UNIDO) | 1. In FY 2021-2022, the EESL-UNIDO-GEF 6 program achieved substantial energy savings nationwide. Across various sectors and states, significant reductions in energy consumption were observed.<br>2. In Gujarat's chemical sector, the Ankleshwar cluster saved 141 toe annually across 9 units, resulting in avoided emissions 913 $tCO_2$, with an investment of 96.62 lakhs INR.<br>3. In Punjab's forging sector, the BJL cluster saved 181 toe annually in 2 units, leading to avoided emissions of 335 $tCO_2$, with an investment of 64 lakhs INR.<br>4. In West Bengal's mixed sector, the Howrah cluster achieved savings of 597 toe annually across 5 units, resulting in and avoided emissions of 2604 $tCO_2$, with an investment of 96 lakhs INR.<br>5. In Assam's Tea sector, the Jorhat cluster saved 126 toe annually in 8 units, leading to avoided emissions of 486 $tCO_2$, with an investment of 117 lakhs INR.<br>6. The Gujarat textile sector in Surat saved 840 toe annually in 8 units, resulting in avoided emissions of 4093 $tCO_2$, with an investment of 126 lakhs INR.<br>7. In Tamil Nadu's rice sector, the Vellore cluster saved 33 toe annually in 2 units, leading to avoided emissions of 158 $tCO_2$, with an investment of 56 lakhs INR.<br>8. In Uttar Pradesh's textile sector in Varanasi, 1 unit saved 0.31 toe annually, resulting in avoided emissions of 3 $tCO_2$, with an investment of 3 lakhs INR.<br>9. Overall, across 35 units, the program achieved a total energy savings of 1918.31 toe, resulting in avoided emissions of 8592 $tCO_2$, with a total investment of 558.62 lakhs INR. | (BEE, 2023a);<br>(BEE, 2024) |

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| **Textile Industry:** The Indian textile industry is the third largest exporter of textiles and apparel worldwide. India's textiles and clothing sector play a vital role in the national economy, contributing 10.5% to the total merchandise exports in 2021-22, with a 4.6% share in global trade of textiles and apparel. During 2021-22, India's cotton production was around 312.0 lakh bales and consumption was 316.0 lakh bales. 36% of the global area under cotton cultivation is in India. During 2022-23 (up to Dec'22), the production of various jute goods in India (including Hessian, Sacking, Carpet Backing Cloth and others) was 0.92 million MT and the domestic demand was 0.84 million MT. India with the production of 34,903 MTs (During 2021-22) of silk is the second largest producer of silk in the world and also the largest consumer. India is the second largest producer of manmade fibres. India's export of MMF textiles and apparel was USD 9.56 bn for FY: 2021-22. For FY 2022-23(P), the coal consumption of textile industry stood at 0.09 million tonnes, while lignite consumption amounted to 2.62 million tonnes. | | | | | |
| 26 | **Perform, Achieve and Trade (PAT)** | PAT scheme for the textile industry includes the use of pulse dyeing technique, waste heat recovery systems, solar paint for textile industries, energy recovery from exhaust air by utilising special turbines | Ministry of Power and Bureau of Energy Efficiency, Government of India | In PAT Cycle I (2012-15), PAT Cycles II (2016-17 to 2018-19), and PAT Cycle III (2017-18 to 2019-20) the industry exceeded its reduction targets by 97%, 69% and 20% respectively. However, in PAT Cycle IV (2018-19 to 2021-22) and PAT Cycle V (2019-20 to 2021-22), it fell short of the targeted energy savings by 116% and 14% respectively. Over the five cycles, there has been a cumulative energy savings of 0.33 Mtoe. The avoided emissions in these cycles amount to 0.62, 0.66, 0.26, 0.01 and 0.05 $MtCO_2$/year, respectively. | (MoT, 2023); (BEE; 2023a); (MoSPI, 2024b); (BEE, 2024) |
| **Paper & Pulp Industry:** In year 2022-23(P), the coal consumption of paper industry was 1.20 million tonnes, while lignite consumption amounted to 0.92 million tonnes. | | | | | |
| 27 | **Perform, Achieve and Trade (PAT)** | Interventions under the PAT scheme for the Pulp and Paper Industry include Two Stage Oxygen Delignification – OxyTrac, BCTMP Process (bleached chemi-thermomechanical pulp), Super Batch Cooking, Ultra-Low Intensity Refining, Opti Batch Process, Biogas firing in rotary lime kiln (Replacement of Furnace Oil), Boiler Conversion (Fluidised bubbling to Spouted bed), Solar Energy Utilization for Process Heating at Low and Intermediate temperature (Replacement of LP Steam), Oxyfuel burning in lime kiln and black liquor boilers, Installation of Extended Delignification System for cooking of wood (to reduce steam consumption). | Ministry of Power and Bureau of Energy Efficiency, Government of India | In PAT Cycle I (2012-15), PAT Cycles II (2016-17 to 2018-19), PAT Cycle III (2017-18 to 2019-20) and PAT Cycle V (2019-20 to 2021-22) the industry exceeded its reduction targets by 144%, 163%, 45% and 35% respectively. However, in PAT Cycle IV (2018-19 to 2021-22), it fell short of the targeted energy savings by 90%. Over the five cycles, there has been a cumulative energy savings of 0.63 Mtoe. The avoided emissions in cycles I-V have been 1.24, 1.35, 0.02, 0.01 and 0.09 $MtCO_2$/year, respectively. | (BEE; 2023a); (MoSPI, 2024b); (BEE, 2024) |
| **TRANSPORT SECTOR** | | | | | |
| **Road Transport** | | | | | |
| 28 | **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%. | Ministry of Petroleum & Natural Gas, Ministry of Urban Development, Ministry of Road transport and highways | Replacing diesel with CNG vehicles has resulted in avoided emissions of about 84% for CO emissions, 58% for $NO_x$, and 97% for PM. | (MoPNG, 2014) |

| Sl. No. | Scheme/ Initiative | Description | Implementing agency | Description of Data, Targets, Results Achieved and Expenditure where updated and available | Data Sources |
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| 29 | **Corporate Average Fuel Economy (CAFE)** | Introduced in FY 2017-18 and the second phase of norms was 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 | Ministry of Road Transport and Highways, Government of India | For FY 2019-20 to 2022-23 the collective energy savings amount to 1.88 Mtoe and the corresponding avoided emissions are estimated at 4.41 $MtCO_2$ | (BEE, 2023a) |
| 30 | **Harit Path** | The Harit Path mobile application facilitated the geotagging of over 300,000 plants across more than 300 projects. | National Highways Authority of India (NHAI), Ministry of Road Transport and Highways, Government of India | NHAI planted over 2.5 million plants within 25 days in mid-2020, bringing the year's total to 3.52 million | (PIB, 2020) |
| 31 | **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. | National Highways Authority of India (NHAI), Ministry of Road Transport and Highways, Government of India | 781 kilometres of green Highways is proposed to be constructed and an MOU has been signed between GOI and World Bank.<br><br>INR 1000 crore per year will be available in the annual budget for plantation purpose. Rs. 7,662.47 crore is loan assistance from World Bank. | (MoRTH, n.d.) |
| 32 | **National Electric Mobility Mission Plan (NEMMP)** | Launched in 2013, the National Electric Mobility Mission Plan (NEMMP) 2020 aims to achieve national fuel security by promoting hybrid and electric vehicles in the country. Government aims to provide fiscal and monetary incentives to kick start this nascent technology. | Ministry of Heavy Industries, National Automotive Board, Government of India | The policy aims to deploy 400,000 passenger battery-powered electric vehicles (BEVs) by 2020 to reduce oil imports and $CO_2$ emissions. It sets an ambitious goal of achieving 6-7 million hybrid and electric vehicle sales annually from 2020 onward. The policy envisages to save a total of 9500 million litre of crude oil. | (Department of Heavy Industry, 2012);<br><br>(PIB, 2015);<br><br>(BEE, 2023a) |

| Sl. No. | Scheme/ Initiative | Description | Implementing agency | Description of Data, Targets, Results Achieved and Expenditure where updated and available | Data Sources |
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| 33 | **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 subsidising e-buses, e-three-wheelers, e-passenger cars, and e-two-wheelers, alongside developing charging infrastructure to alleviate range anxiety among electric vehicle users.<br><br>FAME-I encouraged electric and hybrid vehicle purchase by providing financial support. FAME-II focussed on electrification of public transport infrastructure and charging. EVs sold through 2030 could cumulatively save 474 MTOE worth INR 15 lakh crore and generate net $CO_2$ savings of 846 million tons over their operational lifetime. | Ministry of Heavy Industries, National Automotive Board, Government of India | Under the FAME-I scheme, 465 buses were sanctioned to various cities/ states. It promoted about 2,80,000 hybrid and EV sales. Phase-II aims to generate demand by way of supporting 7000 e-Buses, 5 lakh e-3 Wheelers, 55000 e-4 Wheeler Passenger Cars (including Strong Hybrid) and 10 lakh e-2 Wheelers.<br><br>The Department of Heavy Industry approved 6315 e-buses, with supply orders issued for 3738 as of December 9, 2022. Of these, 2435 e-buses have been deployed. In Phase II, the Ministry approved 2877 EV charging stations, with letters of award issued for 1822 as of December 9, 2022. Of these, 83 are commissioned and operational. Additionally, 1576 charging stations across 9 expressways and 16 highways were sanctioned under the FAME India Scheme Phase II.<br>In the time period between 2018-19 and 2021-22 the collective energy savings amount to 0.142 Mtoe and the corresponding avoided emissions are about 0.432 $MtCO_2$ due to the implementation of this scheme. | (BEE, 2023a) |
| 34 | **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. | Ministry of Housing and Urban Affairs, Government of India | For the period of 2002-2015, the collective avoided emissions due to this initiative are estimated at 0.86 $MtCO_2$ | (Economic Times, 2022);<br><br>(PIB, 2021b); (MoHUA, 2022) |

| Sl. No. | Scheme/ Initiative | Description | Implementing agency | Description of Data, Targets, Results Achieved and Expenditure where updated and available | Data Sources |
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| 35 | **Bus Rapid Transit System (BRTS)** | Implemented under the Jawaharlal Nehru Urban Renewal Mission and the National Urban Transport Policy of 2006, BRTS aims to enhance bus transport by funding buses, creating dedicated lanes, and expanding CNG bus fleets. Operational in 11 cities including Ahmedabad, Bhopal, Hubli-Dharwad, Surat, Visakhapatnam, and Indore, Ahmedabad's BRTS achieved a silver rating in 2013, while Hubli-Dharwad's system, a recent addition, notably improved local mobility, attracting a daily ridership of 90,000 passengers | Ministry of Housing and Urban Affairs, Government of India | For the period of 2006-2015, the collective avoided emissions are estimated at 0.039 $MtCO_2$. | (Gupta, 2020);<br>(ITDP, n.d.) |
| 36 | **Ethanol Blended Petrol Programme** | The Ethanol Blended Petrol program aims to boost biofuel usage in India by blending different types of biofuels with petrol. The "National Policy on Biofuels" of 2018 and 2022 amendment, 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. | Ministry of Petroleum and Natural Gas, GOI | The target of 10% ethanol blending set in the 'Roadmap for Ethanol Blending in India 2020-25' for ESY 2021-22 has already been achieved and Public Sector Oil Marketing Companies (OMCs) have started selling E20 (20% ethanol blended) petrol nationwide.<br>One Crore litre of ethanol blended petrol can save around 20,000 tons of carbon dioxide ($CO_2$) emission. Greenhouse gas emissions due to the EBP Programme were reduced by 318.2 lakh tons during 2014 to November 2022. | (MoPNG, 2023b) |
| **Civil Aviation** | | | | | |
| 37 | **Civil Aviation (carbon neutral growth)** | Airport Authority of India has successfully implemented the Airport Carbon Accreditation Programme at "Reduction" Level-1 at Kolkata, Bhubaneswar, Varanasi, and Trivandrum airports. By 2018, these efforts allowed the airports to reduce their carbon intensity per passenger to specific targets, resulting in their elevation to "Reduction" Level-2 (ACI, 2021).<br>MoCA is encouraging developers of new Greenfield airports, in collaboration with respective state governments, to prioritize carbon neutrality and net zero emissions in their development plans. | Airport Authority of India | As on July 25, 2024, 12 Greenfield Airports have been constructed/ operationalised since 2014. 48 airports/ airstrips have been constructed by AAI since 2014. With the efforts of the Government of India, Airports like Delhi, Mumbai, Hyderabad, and Bengaluru have achieved Level 4+ as well as higher Airports International Council (ACI) Accreditation and have become Carbon neutral. | (MoCA, 2021);<br>(Financial Express, 2023, April 25);<br>(PIB, 2024c) |

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| **COASTAL SHIPPING** | | | | | |
| 38 | **Sagarmala project** | Sagarmala Programme aims to boost trade efficiency and lower logistics costs through strategic infrastructure upgrades, including:<br>• Optimizing cargo transport modal mix to reduce domestic cargo costs.<br>• Siting future industrial developments near coasts to decrease bulk commodity logistics expenses.<br>• Building manufacturing clusters near ports to enhance export competitiveness.<br>• Streamlining EXIM container movements to cut down time and costs. | Ministry of Ports, Shipping and Waterways, GOI | There are 839 projects for implementation under the Sagarmala Programme. Out of which, 241 projects have been completed. These projects are being implemented by relevant central ministries, state governments, major ports, and includes projects supported under PPP, internal resources of Ports, and Equity Investments. | (MoPSW, n.d.);<br>(PIB, 2024i) |
| 39 | **Green Port project** | This project aims to enhance environmental sustainability across ports, with strict deadlines to ensure timely achievement of objectives. This include developing and executing monitoring plans, procuring necessary equipment for environmental pollution assessment, implementing dust suppression systems, and establishing sewage/wastewater treatment and garbage disposal facilities. | Ministry of Ports, Shipping and Waterways, GOI | Renewable power in major ports, 20.7 MW wind farm installed at DPT (Kandla); 500 kW solar plant, 150 kW solar rooftop, and 5 kW ground solar PV in 2020, at VO Chidambaranar port trust; 5.19 MW solar power plant at New Mangalore port trust. | (MoPSW, 2023) |
| **Railways:** Indian Railways, one of the largest global rail networks covering over 69,000 route kilometers as on 31st March 2024, plays a vital role in India's transportation sector, ferrying nearly 19 million passengers daily. Annually, Indian Railways consume over 20 billion kWh of electricity, around 2% of the country's total usage. Non-traction electricity consumption amounts to approximately 2.5 billion units per year. This underscores the significant potential for energy conservation within Indian Railways. Recognizing this, the Bureau of Energy Efficiency (BEE) has included various traction and production units of Indian Railways in the second phase of its Perform Achieve and Trade (PAT) scheme. | | | | | |
| 40 | **Three Phase locomotive technology, Auxiliary Power Units (APU), Computerized Fuel Management Systems and Head on Generation system** | Locomotives are equipped with a regenerative braking system that recaptures energy during braking and feeds it back into the grid. Head on Generation system leads to significant reductions in diesel consumption. | Ministry of Railways, Government of India | For FY 2022-23, the energy savings goal set for the PAT 2 scheme was 0.08 Mtoe. However, the actual energy savings achieved under the PAT 2 scheme amounted to 0.20 Mtoe, resulting in avoided emissions of about of 1 $MtCO_2$ | (BEE, 2023a);<br>(MoR, 2024) |
| 41 | **LED Lighting** | Indian Railways has implemented measures such as 100% LED lighting across all railway stations and the integration of LED lights in coaches. | | | |
| 42 | **Dedicated Freight Corridor** | Enhancing rail freight capacity along the Eastern and Western routes, marking significant progress in track linking and conducting successful trial runs to bolster the freight transport infrastructure | | | |
| 43 | **Alternative fuels and sustainable solutions** | Programmes for blending of biodiesel with high-speed diesel (HSD), the deployment of CNG/LNG-based dual fuel diesel engines for DEMU trains, and the provision of solar panels on specific trains such as the Swachata Express. | | | |

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| **WASTE SECTOR** | | | | | |
| 44 | **Atal Mission for Rejuvenation and Urban Transformation (AMRUT)** | AMRUT 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. | Ministry of Housing & Urban Affairs (MoHUA), Government of India | By 2023, AMRUT has facilitated the implementation of 13.9 million water tap connections, 14.5 million sewer connections, 6,347 MLD of sewage treatment capacity, 2322 park projects, and 692 stormwater drainage projects. The total expenditure for these initiatives amounted to INR 826 billion | (PIB, 2023f) |
| 45 | **Swachh Bharat Mission (SBM)-Grameen** | Launched in 2014, 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 - Grameen. | Department of Drinking Water & Sanitation, Ministry of Jal Shakti, Government of India | The achievements under this programme as of November 2024 are listed below:<br>1. 557525 ODF plus villages.<br>2. Different assets created includes 2,876 Faecal Sludge Management Plants, 3584 Plastic Waste Management Units, and 243240 Community Sanitary Complexes.<br>3. Solid and Liquid Waste Management (SLWM) Household Assets includes 7.3 million Soak/Leach/Magic Pits, 15.1 million Kitchen Gardens, 0.06 million Biogas Plants and 3 million Compost Pits.<br>4. Community Assets consist of 0.99 million Community Compost pits, 0.38 million Waste collection & Segregation sheds, 0.54 million vehicles for collection and transportation of waste, 1.82 million Community Soak pits, 1.33 million Drainage facility and 0.03 million WSP 3/5 Pond System | (MoJS, 2024a) |

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| 46 | **Swachh Bharat Mission (SBM)-Urban** | The Swachh Bharat Mission (Urban) (SBM-U) 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. | Ministry of Housing & Urban Affairs (MoHUA), Government of India | The achievements under this programme as of November 2024 are listed below:<br>1. Legacy Waste Management- The overall number of dumpsites is 2423. Of the 2455 lakh tonnes of legacy waste, 1255 lakh tonnes (51%) have been remediated, and out of 14813 Ha of area, 5516.7 Ha (37%) have been reclaimed. (Primarily dumpsites having legacy waste >= 1000 Tonne)<br>2. Solid Waste management - Among the 95,114 wards nationwide, 90,554 (95%) have achieved 100% Door-to-Door Collection, and 84,258 (89%) have attained 100% Source Segregation. Out of the total solid waste generated, which amounts to 1,45,352 TPD, the processing rate is 1,14,589 TPD.<br>3. Solid Waste Management (SWM) Plants- There are a total of 121 Biomethanation plants (4,271 TPD), 2627 Waste to Compost Plants (1,12,472.00 TPD), 46 waste to energy (19,154.00 TPD), 2640 MRF plants (98,722 TPD), 1215 C&D plants (59,281 TPD) and 323 SLRM (17,781.00 TPD). (Primarily plants having designed capacity >= 5TDP).<br>4. Liquid Waste Treatment (LWT) Plants- There are a total of 3181 Sewage Treatment Plants (STPs) with a combined design capacity of 82,714.10 MLD, along with 1398 Faecal Sludge Treatment Plants (FSTPs) with a collective design capacity of 1,17,316.14 KLD . (Primarily plants having designed capacity >= 5 MLD/ KLD).<br>5. Community & Public Toilets(CT/PT) - There are a total of 77,009 toilets, including 44,636 public toilets, 27,015 community toilets, and 5,358 urinals. | (MoHUA, 2024) |
| 47 | **Plastic Waste Management** | To eliminate single-use plastics, which have low utility and high littering potential, under the framework of "Extended Producer Responsibility" | Ministry of Environment Forest and Climate Change (MoEFCC), Government of India | As of March'21, the estimated Plastic waste (PW) generation for the year 2020-21 is around 4,126,997 TPA, with a per capita/year generation of 3,070 gms. The total waste processed amounted to 1,109,180 TPA | (CPCB, 2021) |

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| 48 | **Programme on Energy from Urban, Industrial and Agricultural Wastes/Residues** | The National Bioenergy Programme, launched on 2.11.2022, 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). ts goal is to enhance the production and availability of Compressed Bio-gas (CBG) as an alternative clean fuel for cooking and transportation. | Ministry of New and Renewable Energy, Government of India | As of October 2024, under the National Bioenergy Programme, the cumulative capacity of installed waste to biogas projects is 8,24,647 $m^3$/ day and for waste to Bio-CNG/CBG is 4,92,135 kg/day spread across 89 plants. Additionally, for waste to power generation projects (both grid and off-grid), the capacity is 401.79 MW distributed among 10 plants. | (MNRE, 2024) |
| 49 | **E-Waste Management** | The Central Pollution Control Board (CPCB) estimates e-waste generation nationwide using sales data from producers and the average lifespan of electronic equipment, as required by the E-Waste Management Rules, 2016. | State Pollution Control Boards (SPCBs)/ Pollution Control Committees (PCCs), Ministry of Environment Forest and Climate Change (MoEFCC), Government of India | For FY 2022, the overall e-waste generated amounted over 1.6 million tonnes, with a processing of 0.5 million tonnes. | (PIB, 2023g) |
| **BUILDING SECTOR** | | | | | |
| 50 | **National Mission for Sustainable Habitat (NMSH)** | 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. | Ministry of Housing and Urban Affairs, Government of India | Under AMRUT, over 6.2 million streetlights have been replaced to LEDs. | (MoHUA, 2021a) |

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| 51 | **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.<br><br>India is estimated to add 1 billion new commercial buildings with increased demand for air conditioning. If the future stock is built in compliance with ECBC, about 300 BU electricity will be saved by 2030 which translates to 250 $MtCO_2eq$ of carbon dioxide abatement. | State/Union Territory governments, Government of India | ECBC 2017 is estimated to lead to a 50% reduction in electricity use by 2030. The ECBC complaint buildings registered between FY 2018-20 and FY 2022-23 are 192, and 173, respectively.<br><br>Accordingly, the total energy savings for FY 2018-20 was 59.3 MU, and for FY 20222-23 was 19.89 MU, totalling to 79.19 MU. The avoided $CO_2$ emissions for the year 2022-23 is estimated to be 0.070 $MtCO_2$. | (BEE, 2023a) |
| 52 | **Building Energy Efficiency Programme (BEEP)** | Launched in 2017 by the Government of India, 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. | Energy Efficiency Services Limited (EESL), Ministry of Power, Government of India | Till 8th November 2024, the energy saved amounts to 1306 GWh. The corresponding avoided $CO_2$ emissions are estimated to be 1071 $MtCO_2$ | (EESL, n.d) |
| 53 | **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). | Bureau of Energy Efficiency (BEE), Ministry of Power, Government of India | The total energy saved across 4 categories of the Star Rating System from FY 2019-20 to 2022-23 amounts to 178.5 MU. The corresponding avoided $CO_2$ emissions are estimated to be 0.13 $MtCO_2$ | (BEE, 2023a) |
| 54 | **Eco Niwas Samhita (ENS) for Residential Buildings** | The ENS, an ECBC tailored for residential buildings was launched in 2018. 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. | Local Bodies & State government, Ministry of Power, Government of India. | As on 31st March 2023, over 1.55 million sqm of the residential built-up area has been compliant with ENS part 1.<br>As on 31st March 2023, around 148 training and capacity building programs have been conducted which trained around 10,000 stakeholders in the Government and private sector.<br>For FY 2021-22 to 2022-23 the collective energy savings amount to 4.84 MU | (BEE, 2023a) |

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| 55 | **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. | Local Bodies & State government, Bureau of Energy Efficiency, Ministry of Power, Government of India. | The estimated energy-saving potential through the proposed labeling program is around 388 BU by the year 2030 since its inception in 2018. | (BEE, 2023a) |
| 56 | **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. | Ministry of Housing & Urban Affairs, Government of India. Ministry of Rural Development, Government of India | As of June 20, 2024, over 118 lakh houses have been authorized through the Mission, with over 84 lakh already finished and the remainder in different stages of construction/grounding | (MoHUA, 2021b); (PIB, 2024h); (MoRD, n.d.) |
| 57 | **Standards and Labeling Programme (S&L)** | Initiated in 2006, the Standards and Labelling (S&L) Programme is a key focus area for BEE. It sets energy performance standards for appliances and rates their efficiency on a scale of 1 to 5 stars. | Ministry of Power, Government of India | Energy Savings in FY 22-23 from appliances manufactured during FY 2018-23 is 80.86 BU. The corresponding avoided $CO_2$ emissions in FY 2022-23 due to interventions in the period from 2018-23 is 57.46 $MtCO_2$. | (BEE, 2023a); (BEE, 2024) |
| 58 | **Unnat Jyoti by Affordable LEDS for All (UJALA)** | The UJALA initiative aims to improve household energy efficiency by providing LED bulbs, tube lights, and energy-efficient fans at reduced prices. It encourages the use of energy-saving lighting and addresses high initial investment costs, promoting wider adoption of LED lighting. | Energy Efficiency Services Limited (EESL), Ministry of Power, Government of India | During FY 2019-20 to 2022-23, the total energy saved amounts to 2393.72 MU for LED lamps, 15.52 MU for LED tubelights and 19.21 MU for EE fans. | (BEE, 2023a) |
| 59 | **Pradhan Mantri Ujjwala Yojana** | Launched in May 2016, 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.<br><br>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. | Ministry of Petroleum and Natural Gas (MoPNG), Government of India | As on March 4, 2024, there are about 10.31 crore PMUY beneficiaries. Government has taken several steps to encourage consumption of LPG, which include targeted subsidy of Rs. 200/- per 14.2 Kg refill upto 12 refills/year for PMUY beneficiaries for year 2022-23 and 2023-24, option of 5 Kg Double Bottle Connection (DBC), swap option from 14.2 kg to 5 Kg, upto 3 free refills to PMUY beneficiaries under Pradhan Mantri Garib Kalyan Package from April to December 2020 etc.<br><br>Per capita consumption of PMUY Beneficiaries has increased from 3.01 Refills per annum (in terms of 14.2 Kg refill) during FY 2019-20, to 3.71 refills during FY 202223 and further to 3.8 refills in 2023-24 (till October 2023). Active LPG consumers doubled from 14.52 crore in 2014 to 32.17 crore in February 2024. | (PIB, 2023i); (PIB, 2024d) |

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| **Non-Government Initiatives in Building Sector:** Alongside gov-ernment initia-tives, the private sector in India has taken a significant role in designing and developing energy-efficient green buildings. Notable exam-ples include Leadership in Energy and Environmental Design (LEED), Green Rating for Integrated Habitat Assessment (GRIHA), and ndian Green Building Council (IGBC). Various State Governments incentivize these initiatives by offering incentives such as additional floor area ratio, ranging from 3% to 15%, depending on the rating | | | | | |
| 60 | **Leadership in Energy and Environmental Design (LEED)** | LEED, created by the US Green Building Council, is a global rating system for environmentally-friendly buildings. It encompasses building design, construction, and operation, providing guidance to owners and operators on resource-efficient management. Relevant criteria include energy performance, demand response, energy metering, renewable energy production, green power, and carbon offsets. | Green Business Certification Inc (GBCI) | 73 LEED Zero projects have been certified. | (GCBI, n.d.) |
| 61 | **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. | Confederation of Indian Industry (CII) | As of March 1, 2024, 13155 projects of 11.51 billion sq.ft have been registered under IGBC | (IGBC, n.d.) |
| 62 | **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. | GRIHA Council | As of FY 2022-23, the total energy savings due to GRIHA is 0.0076 MTOE and the total GHG reduction amounts to 0.0714 Mt $CO_2$. | (BEE, 2023a) |

| Sl. No. | Scheme/ Initiative | Description | Implementing agency | Description of Data, Targets, Results Achieved and Expenditure where updated and available | Data Sources |
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| **FORESTRY SECTOR** | | | | | |
| 63 | **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. | Ministry of Environment, Forest and Climate Change (MoEFCC), Government of India | Prior to the The Forest (Conservation) Act, 1980, from 1951 to 1980, the annual rate of forest land diversion stood at 0.14 million hectares per annum. However, following the implementation of the legislation, from 1980 to 2020, the rate decreased significantly to 0.024 million hectares per annum. | (PIB, 2023j);<br>(MoEFCC, 2023a) |
| 64 | **Compensatory Afforestation Fund and Compensatory Afforestation Management and Planning Authority (CAMPA)** | Compensatory Afforestation Fund Management and Planning Authority (CAMPA) are meant to promote afforestation and regeneration activities as a way of compensating for forest land diverted to non-forest uses. | Ministry of Environment, Forest and Climate Change (MoEFCC), Government of India | Under CAMPA, significant plantation efforts have been conducted across both non-forest and degraded forest lands. In 2020-21, plantation activities were undertaken on 6,941 Ha of non-forest land. Concurrently, plantation work were conducted in 23,632 Ha of degraded forest land, indicating a 39% increase from the plantation works conducted in 2015-16. In the fiscal year 2020-21, afforestation efforts under CAMPA covered an area of 188,588 hectares, marking a significant increase of 156% compared to the figures recorded in 2017-18 | (MoEFCC, 2023b) |
| 65 | **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.<br>Mission Goals:<br>1. 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;<br>2. 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);<br>3. To increase forest based livelihood income of about 3 million households. | Ministry of Environment, Forest and Climate Change (MoEFCC), Government of India | Between fiscal years 2015-16 and 2020-21, the collective targeted area for advance work within the Green India Mission amounted to 167,151 Ha. Concurrently, the achievement in terms of the Creation of Plantation during this period reached 117,503 Ha.<br>The aggregate funds disbursed for the Green India Mission spanning from 2019-20 to 2022-23 totaled INR 512.43 crore, with a corresponding utilization of INR 475.6 crore during this timeframe.<br>In the fiscal year 2022-23, the fund released for the National Mission for a Green India amounted to INR 116.01 crore. The total cumulative fund disbursed from 2017-18 to 2022-23 stands at INR 616.86 crore. | (MoEFCC, 2023b) |

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| 66 | **National Afforestation Programme** | The objective of the National Afforestation Programme (NAP) scheme is ecological restoration of degraded forests and to develop the forest resources with peoples' participation, with focus on improvement in livelihoods of the forest-fringe communities, especially the poor.<br><br>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.<br><br>* NAP 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.<br><br>* 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. | Joint Forest Management Committees (JFMC) Ministry of Environment, Forest and Climate Change (MoEFCC), Government of India | From 2000-02 to 2020-21, the program has approved a total project area of 22,14,054 hectares, with funds released amounting to INR 3936 crores.<br><br>In FY 2021, the total approved project area amounts to 750 hectares, with a corresponding fund release of INR 39.54 crores.<br><br>In order to achieve the targeted objectives of national afforestation programmes, the Ministry has approved merger of NAP into Green India Mission (GIM) and accordingly financial allocation for both the schemes is provided under one budgetary head so that the overall greening efforts are augmented. The budget allocation for the merged scheme has increased from Rs. 160 crore in the year 2020-21 to Rs. 220 crore during the year 2021-22. | (PIB, 2022c);<br><br>(FSI, 2024) |
| 67 | **National Mission for Clean Ganga** | A crucial aspect of the National Mission for Clean Ganga (NMCG) under the Namami Gange Programme is implementing Forestry Interventions in the Ganga basin. The Forest Research Institute, Dehradun, has prepared an afforestation plan for 1.34 lakh hectares of land at an estimated cost of INR 2,294 Crores. | Ministry of Drinking Water and Sanitation (MoDWS) and Ministry of Jal Shakti, Departmentof Water Resources, River Development & Ganga Rejuvenation, Government of India | So far 33,024 hectare plantation has been carried out under Namami Gange, for which an expenditure of Rs. 398.5 crores has been incurred by the State Forest Departments of Uttarakhand, Uttar Pradesh, Bihar, Jharkhand, and West Bengal from the year 2016-17 onwards. | (National Mission for Clean Ganga, 2020) |
| 68 | **Green Highways Policy and National Green Highways Mission** | The Green Highways (Plantation, Transplantation, Beautification & Maintenance) Policy, 2015 covers all the National Highways of the country with the aim to promote greening of corridors. Under the policy, 244.68 lakh plants have been planted upto December, 2021 across 869 NH projects having length of 51,178 Km. | Ministry of Road Transport & Highways, Government of India | The Green Highway Policy has a total of 869 projects encompassing a combined length of 51,178.304 kilometres. National Highway Authority of India (NHAI) has successfully planted 402.28 lakhs plants till date along the National Highways as per the Green Highways Policy 2015. | (PIB, 2022d);<br><br>(PIB, 2024f) |

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| 69 | **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. | Ministry of Environment, Forest and Climate Change (MoEFCC), Government of India | In the scheme, 385 proposals have gained approval in diverse states and union territories. The allocation of funds for fiscal year 2020-21 amounted to INR 933.66 lakhs, for 2021-22 it stood at INR 11,580.73 lakhs, for 2022-23 it was INR 9,534.81 lakhs, and for 2023-24 it stands at INR 1,824.59 lakhs.<br><br>111 Nagar Vans approved against the target of 100 Nagar Vans in 100 days action plan, spread across 6 States and 1 UT of the country. More than 75 crore saplings have been planted so far till September 2024. | (MoEFCC, 2023c);<br><br>(PIB, 2023k);<br><br>(PIB, 2024g) |
| 70 | **Sustainable Forest Management** | India accounted for 2 per cent of the total global forest area as per the Global Forest Resources Assessment (FRA) 2020 published by Food and Agriculture Organization (FAO). The forest area of the India has shown a continuous increasing trend as against the decreasing trend of global forest area. The increasing trend of forest area coupled with increasing trend of the growing stock has resulted in increasing the total carbon sink in the county's forest and thus shown the commitment of India in global climate change. | Ministry of Environment, Forest and Climate Change (MoEFCC), Government of India | India is among the top 10 countries of the world in term of the total forest area and ranked 3rd in terms of average annual gain in the forest area. | (MoEFCC, 2023c);<br><br>(FSI, 2021);<br><br>(MoEFCC, 2024) |
| 71 | **Protected Areas** | The main intention underlying the declaration of the Protected Areas was to maintain the ecological viability of the wildlife rich forested areas. | Ministry of Environment, Forest and Climate Change (MoEFCC), Government of India | India currently has 106 National Parks and 573 Wildlife Sanctuaries, 220 Community Reserves and 123 Conservation Reserves, which are notified under the Wild Life (Protection) Act, 1972. This is an increase from 103 National Parks, 539 Wildlife Sanctuaries, 48 Community Reserves and 67 Conservation Reserves, a decade earlier in 2014. Together, these four categories of Protected Areas cover around 1,78,640.69 Sq Km of area, which is approximately 5.43% of India's total geographical area. The area under Protected Areas has increased by over 9,802 Sq. Km since 2014. | (ICFRE, 2015);<br><br>(FSI, 2021);<br><br>(MoEFCC, 2023c)<br><br>(MoEFCC, 2024) |

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| 72 | **REDD+** | In accordance with various COP decisions and requisites of the UNFCCC, India prepared and released its National REDD+ strategy in 2018. India has also submitted its national forest reference emission level or forest reference level (FREL/FRL) in 2018, which was revised as per the inputs from the Technical Assessment. The Ministry had entrusted ICFRE with the responsibility of developing the National REDD+ Strategy and Safeguard Information System for REDD+. | Ministry of Environment, Forest and Climate Change (MoEFCC), Government of India | India currently has 106 National Parks and 573 Wildlife Sanctuaries, 220 Community Reserves and 123 Conservation Reserves, which are notified under the Wild Life (Protection) Act, 1972. This is an increase from 103 National Parks, 539 Wildlife Sanctuaries, 48 Community Reserves and 67 Conservation Reserves, a decade earlier in 2014. Together, these four categories of Protected Areas cover around 1,78,640.69 Sq Km of area, which is approximately 5.43% of India's total geographical area. The area under Protected Areas has increased by over 9,802 Sq. Km since 2014. | (MoEFCC, 2023c); (MoEFCC, 2024) |
| 73 | **Forest Rights Act and Joint Forest Management** | India has made an effort to decentralize its forest management policy since the 1990s. | Ministry of Environment, Forest and Climate Change (MoEFCC), Government of India | 23,43,009 land titles totaling around 1,80,70,577.43 acres have been distributed (individual rights: 47,96,364 and community rights: 1,32,74,213) across States, upto 31.10.2023, under the Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006. | (PIB, 2023h); (MoEFCC, 2024) |
| 74 | **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). It will create around 22.8 million man-days with estimated carbon sink of 4.5 million tons of Carbon. | Ministry of Environment, Forest and Climate Change (MoEFCC), Government of India | Since the initiation of the Scheme in 2023-24, about 21500.36 ha area in 12 States/UTs has been brought under restoration through convergence. In addition, a total of 3836 ha has been taken up for restoration in the 6 States/ UTs under the National CAMPA with a total disbursement of ₹17.96 crores for taking up the first year interventions under the Scheme. | (MoEFCC, 2023c); (MoEFCC, 2024) |

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| **WATER SECTOR** | | | | | |
| 75 | **Jal Jeevan Mission (JJM)** | The 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. | Department of Drinking Water & Sanitation, Ministry of Jalshakti, Government of India | As of November 2024, 78.9% of total rural households have been provided with functional household tap connections | (MoJS, 2024b) |
| 76 | **Bureau of Water Use Efficiency (BWUE)- The Bureau of Water Use Efficiency (BWUE) is established to promote, regulate, and oversee efficient water usage in irrigation, industry, and households.** | BWUE (NWM) has completed 17 baseline studies to determine present status of Water Use Efficiency of various uses of Water in Irrigation Sector with WALMATARI, WALMI & CWRDM in Andhra Pradesh, Telangana, Maharashtra, and Kerala.<br><br>BWUE is taking forward the sahi fasal campaign in collaboration with Atal Bhujal Yojna. BWUE has conducted more than 9 workshops related to Sahi Fasal Campaign identified seven states (total 14 districts where ABY is being implemented).<br><br>BWUE (NWM) has taken up Benchmarking/ Demonstrative projects with TERI to prioritize interventions required to improve water use efficiency in Industries viz. Paper & Pulp, Thermal. | Ministry of Drinking Water and Sanitation (MoDWS) and Ministry of Jal Shakti, Department of Water Resources, River Development & Ganga Rejuvenation, Government of India | The Bureau of Water Use Efficiency (BWUE), established under the National Water Mission, promotes the efficient use of water across irrigation, domestic, municipal, and industrial sectors in India. Its key tasks include developing regulatory guidelines for water conservation, setting standards for water-efficient equipment, conducting water audits, and promoting research and development in water conservation. BWUE also works on creating resource centers, capacity building, and awareness programs to support water use efficiency across regions. | (MoJS, 2024c) |

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| **AGRICULTURE SECTOR** | | | | | |
| 77 | **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. | Ministry of Agriculture & Farmers Welfare | SRI is being implemented in 193 districts of 25 States during 2022-23. The area of rice cultivation achieved under SRI method was 25,186 ha during 2019-24. Studies have shown a significant increase in rice yield, with substantial savings of seeds (80-90%), water (25-50%), and cost (10-20%) and reduction in $CH_4$ emissions compared to conventional methods. The emissions avoided due to SRI cultivation compared to conventional rice cultivation were 0.053 $MtCO_2eq$ during 2019-24. | (MoEFCC, 2023c); (MoA&FW, 2024a); (Pathak and Aggarwal, 2012) |
| 78 | **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, conserve scarce resources like water and labor, reduces greenhouse gases 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. | Ministry of Agriculture & Farmers Welfare | As part of the NFSM and BGREI, DSR method of cultivation is being promoted in districts that have been selected for paddy interventions in NFSM and BGREI. The area of rice cultivation achieved under DSR system was 86,335 ha during 2019-24. Using DSR technique, mitigation potential of 0.137 $MtCO_2eq$ was achieved during 2019-24. | (MoEFCC, 2023c); (MoA&FW, 2024a); (Pathak and Aggarwal, 2012) |
| 79 | **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. | Ministry of Agriculture & Farmers Welfare | The Department of Agriculture & Farmers Welfare (DA&FW) is already implementing a Crop Diversification Programme, a sub-scheme of the Rashtriya Krishi Vikas Yojana (RKVY) in the traditional green revolution states, namely Punjab, Haryana, and Western Uttar Pradesh since 2013-14. The area diversified from paddy to alternate crops was 1,02,936 ha during 2019-24. The mitigation potential through CDP was 0.214 $MtCO_2eq$ during 2019-24. | (MoEFCC, 2023c); (MoA&FW, 2024a); (Pathak and Aggarwal, 2012) |

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| 80 | **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 due to 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. | Ministry of Agriculture & Farmers Welfare | During the period from 2018-19 to 2023-24, Rs. 3333.1 crores were released and distributed more than 2.47 lakh machines to the individual farmers and Custom Hiring Centres (CHCs) and more than 42000 CHCs were established in the 4 States, which also include more than 4500 balers & rakes. The number of burning events detected between 15 September to 29 October during 2021, 2022 and 2023 were 11461, 13964 and 6391, respectively i.e., 44.3% and 54.2% reduction in number of burning events were observed in the year 2023 as compared to 2021 and 2022, respectively. Emission reduction of 1.447 $MtCO_2eq$ was achieved during 2019-24 by avoiding crop residue burning using in-situ crop residue management machines | (MoEFCC, 2023c); (MoA&FW, 2023b); (MoA&FW, 2024a); (Bhatia et al., 2013). |
| 81 | **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. | Ministry of Agriculture & Farmers Welfare | Area covered under horticulture crops contributing to carbon sequestration is 28.63 million hectares till 2023-24 (Second Advance Estimates). The cumulative carbon sequestered was estimated to be 1020.6 $MtCO_2eq$ during the period 2019-24. | (Agricultural Statistics at a Glance, 2020, 2021, 2022); (MoA&FW, 2024b); (IPCC, 2019) |

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| 82 | **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. | Ministry of Agriculture & Farmers Welfare | The Sub-Mission on Agroforestry is introduced since 2016-17 as part of the recommendation of the National Agroforestry Policy, 2014 which is being implemented in 21 States and Union Territories, including Andhra Pradesh, Bihar, Gujarat, Maharashtra, Rajasthan, Tamil Nadu, and Uttar Pradesh. The scheme was discontinued from 01.04.2022. The area covered under SMAF in India was 4,45,588 ha as on 2023-24. The cumulative carbon sequestration potential of 2.378 $MtCO_2eq$ was achieved during 2019-24. | (MoEFCC, 2023c); (MoA&FW, 2023a); (MoA&FW, 2024a) |
| 83 | **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. | Ministry of Agriculture & Farmers Welfare | The area covered under NBM was 45,700 ha as on 2023-24. The quantum of cumulative carbon sequestration potential achieved during 2019-24 was 6.106 $MtCO_2eq$. | (MoEFCC, 2023c); (MoA&FW, 2024a); (Nath et al., 2015) |

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| 84 | **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. | Ministry of Agriculture & Farmers Welfare | The Department of Agriculture & Farmers Welfare is implementing centrally sponsored scheme of PDMC component of PMKSY in the country from 2015-16 to 2021-22. From the year 2022-23, the PDMC is being implemented under the Rashtriya Krishi Vikas Yojana (RKVY). So far, a total amount of Rs. 16815.66 crore has been released for the micro-irrigation scheme, covering an area of 70.04 lakh hectares. The assistance for installation of micro-irrigation systems is up to 5 hectares per beneficiary. The area covered under drip and sprinkler irrigation was 23.84 and 29.02 lakh ha, respectively during 2019-24. The cumulative emission reduction was amounted to 555.3 $MtCO_2eq$ from 2019-20 to 2023-24. | (MoA&FW, 2024a);<br>(Reddy et al., 2015) |
| 85 | **Solarization of Agriculture - Pradhan Mantri Kisan Urja Suraksha Evam Utthan Mahabhiyan (PM-KUSUM)** | PM-KUSUM scheme aims for de-dieselization of 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 of 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.<br>The scheme involves replacement of diesel pumps with solar pumps and panels that would result in day time reliable power for irrigation, enhancing farmers income by selling surplus solar power at pre-determined rates to DISCOMS and reducing electricity subsidy burden of the state/DISCOMs. | Ministry of New and Renewable Energy | The scheme has been launched in 2019 and was extended till 2026. The central financial assistance is now increased from installation of 7.5 HP capacity solar pumps to 15 HP capacity solar pumps to the individual farmers in the North-eastern States, Hilly States/UTs and Islands UTs, and for each farmer in the cluster/ community irrigation projects in high water table areas in all the States/ UTs.<br>Three solar integrated micro-irrigation projects at Precision Farming Development Centres (PFDCs) namely Ludhiana, Bhopal and Leh are being implemented by NCPAH under the PMKSY-PDMC. A project for the establishment of demonstration units on micro-irrigation systems across 190 Krishi Vigyan Kendras has been approved by the extension division of ICAR under PMKSY-PDMC.<br>Number of solar pumps installed under component B & C were 3,14,435 and 11,778, respectively during 2019-24. The cumulative $CO_2$ emission reduction of 0.79 $MtCO_2eq$ was achieved during the period 2019-24 from standalone solar powered agriculture pumps installed under component B. | (MNRE, 2020, 2021, 2022, 2023);<br>(MoEFCC, 2023c);<br>(PIB, 2023l);<br>(Gautam et al., 2020);<br>(MNRE, 2024) |
| 86 | **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. | Ministry of Chemicals & Fertilizers; Ministry of Agriculture & Farmers Welfare | A total of 134.05 million tonnes of neem coated urea was produced from 2019-24. An emission reduction of 26.81 $MtCO_2eq$ was achieved during 2019-24 from Neem coated urea application. | (Fertilizer Statistics 2021-22);<br>(MoA&FW, 2024a);<br>(IPCC, 2019b) |

| Sl. No. | Scheme/ Initiative | Description | Implementing agency | Description of Data, Targets, Results Achieved and Expenditure where updated and available | Data Sources |
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| 87 | **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. | Bureau of Energy Efficiency, Ministry of Power | As on 31st March 2023, 81,180 agricultural pumps have been installed. An emission reduction of 0.68 $MtCO_2eq$ was achieved between 2019-2023. | (BEE, 2019b, 2020, 2021, 2022, 2023b);<br><br>(EESL, 2023) |
| 88 | **Balanced Ration for Livestock** | 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 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 reduce 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. | Ministry of Fisheries, Animal Husbandry and Dairying | Number of animals covered under RBP between 2019-2024 are 1.63 lakhs. The emission reductions as a result of the RBP initiatives was 0.0205 $MtCO_2eq$ during 2019-24. | (Basic Animal Husbandry Statistics, 2017, 2019, 2020, 2021, 2022);<br><br>(MoFAH&D, 2024);<br><br>(Garg et al., 2012);<br><br>(Garg et al., 2013) |

| Sl. No. | Scheme/ Initiative | Description | Implementing agency | Description of Data, Targets, Results Achieved and Expenditure where updated and available | Data Sources |
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| 89 | **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. | Ministry of Fisheries, Animal Husbandry and Dairying | Number of cross bred/exotic cows and buffaloes fed with bypass protein supplement during 2019-24 are 7.51 lakhs. The emission reduction of 0.417 $MtCO_2eq$ was attained through supplementation of bypass protein during 2019-23. | (Basic Animal Husbandry Statistics, 2019, 2020, 2021, 2022);<br><br>(MoFAH&D, 2024);<br><br>(Hossain et al., 2017a) |
| 90 | **Green fodder Supplementation through National Livestock Mission (NLM)** | The Sub-mission on feed and fodder development is one of the sub-missions of NLM which aims towards strengthening of fodder seed chain to improve availability of certified fodder seed required for fodder production and encouraging entrepreneurs for establishment of fodder Block/Hay Bailing/Silage Making Units through incentivisation by providing 50% subsidy up to Rs. 50 lakhs. Also, the Central Government is providing assistance for the development of seed multiplication chain for production of quality fodder seed. Prior to 2021-22, there was only fodder seeds distribution programme, while fodder seeds production programme started only from 2021-22. | Ministry of Fisheries, Animal Husbandry and Dairying | Number of animals covered with green fodder feeding are 35.27 lakhs during 2019-24. The cumulative emission reduction due to inclusion of green fodder in the ration for the period 2019-24 was calculated to be 1.414 $MtCO_2eq$. | Document of The World Bank Report No. ICR00005044 (Implementation completion and Results report IDA-50740 i.e., National Dairy Support project) dated July 31, 2020;<br><br>(MoFAH&D, 2024);<br><br>(Hossain et al., 2017b);<br><br>(Sontakke et al., 2019) |
| 91 | **Silage feeding through National Livestock Mission (NLM)** | The Sub-mission on feed and fodder development is one of the sub-missions of NLM which aims towards strengthening of fodder seed chain to improve availability of certified fodder seed required for fodder production and encouraging entrepreneurs for establishment of fodder Block/Hay Bailing/Silage Making Units through incentivisation by providing 50% subsidy up to Rs. 50 lakhs. Also, the Central Government is providing assistance for the development of seed multiplication chain for production of quality fodder seed. Prior to 2021-22, there was only fodder seeds distribution programme, while fodder seeds production programme started only from 2021-22. | Ministry of Fisheries, Animal Husbandry and Dairying | Number of buffaloes fed with silage are 26361 during 2021-24. The cumulative emission reductions for the period 2019-24 was calculated to be 0.0019 $MtCO_2eq$. | |

| Sl. No. | Scheme/ Initiative | Description | Implementing agency | Description of Data, Targets, Results Achieved and Expenditure where updated and available | Data Sources |
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| 92 | **Rashtriya Gokul Mission** | The scheme is being implemented for development and conservation of indigenous bovine breeds since December 2014. The scheme is important in enhancing milk production and productivity of bovines to meet growing demand of milk and making dairying more remunerative to the rural farmers of the country. | Ministry of Fisheries, Animal Husbandry and Dairying | The scheme is also continued under umbrella scheme Rashtriya Pashudhan Vikas Yojna from 2021 to 2026 with a budget outlay of Rs. 2400 crore. Number of elite indigenous cows and buffaloes in milk as on 2023-24 are 487.2 and 243.6 lakhs, respectively. The reduction in emissions attained by producing female calves having high genetic merit germplasm for enhancing milk production and productivity for the period 2019-24 was computed to be 2.086 $MtCO_2eq$. | (MoFAH&D, 2024);<br><br>(Gerber et al., 2011) |

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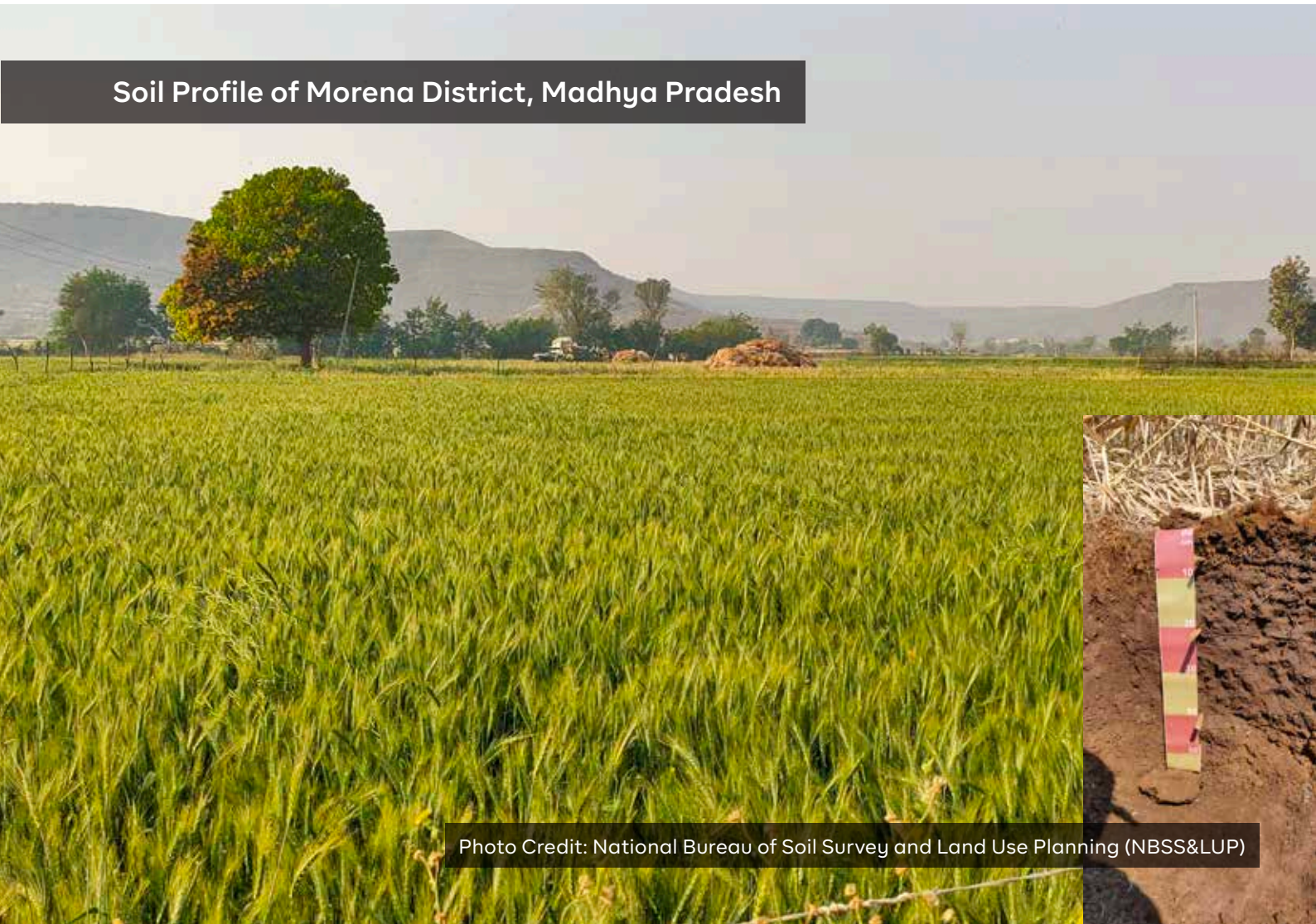
Measurement of Diameter at Breast Height (DBH) during forest inventory

Photo Credit: Forest Survey of India (FSI)



Soil Profile of Morena District, Madhya Pradesh

Photo Credit: National Bureau of Soil Survey and Land Use Planning (NBSS&LUP)

# Chapter-4: Domestic Measurement, Reporting and Verification (MRV)

## 4.1 Introduction

Transparency mechanisms in the form of monitoring, reporting, and verification (MRV) frameworks serve as essential pillars to ensure the integrity of climate actions. It builds trust among developed and developing countries as it offers reliable data and insights on countries' progress. Also, robust domestic MRV arrangements inform policymakers to make evidence-based decisions as it puts in place a learning process by identifying good practices and gaps in the existing system.

India has always endorsed transparency in its climate as well as sustainable development measures. India evaluates the effectiveness of mitigation measures and assesses adaptation efforts across several levels of governance in a decentralised manner. For its MRV framework, India leverages upon its existing robust institutional arrangement, which comprises various actors such as nodal ministries, public departments, private institutions, academia, and civil society organisations. This combination of the state as well as non-state actors in India's MRV framework leads to an inclusive and credibility process.

## 4.2 Overview of India's institutional monitoring and reporting processes

In India's climate action framework, institutional arrangements for MRV operate across national, state, and local levels. This tripartite structure involves collaboration among several ministries, departments, and governmental agencies, ensuring a cohesive approach to track the implementation of mitigation and adaptation strategies.

At the national level, the nodal ministry for climate change is the Ministry of Environment, Forest and Climate Change (MoEFCC). MoEFCC delegates the responsibility of monitoring and reporting on schemes and policies pertaining to the environment and forestry to its departments and entities. Forest and tree cover are monitored by the Forest Survey of India (FSI)[1] , and findings are biennially published in the India State of Forest Reports (ISFR, 2023). While the Indian Council of Forestry Research and Education (ICFRE)[2] has been designated to monitor and verify activities under the Green Credit Program (PIB, 2023). The Central Pollution Control Board (CPCB) monitors air and water pollution, along with hazardous waste from industries (CPCB, 2021).

The Ministry of Power (MoP) is another central ministry that oversees energy conservation and efficiency measures in the country. It has established a statutory body, the Bureau of Energy Efficiency (BEE), which employs energy performance standards through the Perform, Achieve and Trade (PAT) Scheme, Standards and Labelling (S&L) Program and Energy Conservation Building Code (ECBC) to monitor energy-intensive industries, energy efficiency of equipment/appliances and commercial buildings respectively (MoP, 2023). Central Electricity Authority (CEA), an attached office of the MoP, monitors state-wise generation of

1. Conducts survey and assessment of forest resources in the country.
2. Engages in forestry research, extension and education, catering to the Forest Department and the communities who benefit from forest resources.

renewable energy (RE) sources on a daily & monthly basis (CEA, n.d.) On the other hand, its co assisting body, the Central Electricity Regulatory Commission (CERC) monitors power plant efficiency (CERC, 2023).

## Box 1: In-built MRV for energy efficiency initiatives

**PAT Scheme**

Launched in 2012, the PAT scheme aims to reduce specific energy consumption (SEC), i.e., energy per unit of production, for designated consumers (DCs) in energy-intensive sectors. The scheme introduces a market mechanism to enhance cost-effectiveness through the certification of excess energy savings, which can be traded. The excess energy savings are converted into tradable instruments called Energy Saving Certificates (ESCerts), traded at the Power Exchanges. CERC serves as the market regulator, while the Grid controller of India (GCIL) manages the Registry. The India Energy Exchange (IEX) and Power Exchange India Limited (PXIL) and Hindustan Power Exchange (HPX) provide trading platforms where DCs bid for ESCerts in case of compliance shortfall. The PAT Scheme operates in cycles of three years each, with DCs assigned SEC reduction targets. After third-party verification of their performance, BEE issues or obligates the purchase of ESCerts, ensuring compliance scrutiny (PIB, 2022).

### Standard Labelling (S&L) Program

Standards and Labeling (S&L) program was initiated in 2006 with the key objective of providing consumers an informed choice regarding the energy savings and the cost saving potential of various energy consuming appliances. S&L program covers 38 appliances, out of which 16 appliances are under mandatory regime and remaining 22 appliances are under voluntary regime. S&L program has led to savings of 80.86 BU during 2022-23 due to interventions carried out during the FY 2018-23. Achieved a reduction of 57.46 Million tonne of carbon dioxide emissions. The S & L Program has been extended to Solar Photovoltaic Modules (Solar Panels) and Grid connected solar inverter during 2024.

### Energy Conservation Building Code (ECBC)

ECBC was launched in 2007 to provide minimum requirements for energy-efficient building design and construction. The ECBC is monitored by the ECBC Programme Committee (EPC). The Building Energy Passport (BEP) - Energy Monitoring Information System (EMIS) is an online platform for ECBC compliance, streamlining documentation and assessment processes. The building's energy efficiency is measured through check-metering and monitoring processes, enabling energy managers to collect, analyse, and manage energy consumption effectively. The Code mandates main metres to record energy, demand, and power factor, along with sub metres for specialised applications like façade lighting in shopping complexes and data centres in commercial buildings. These requirements, mandatory in the Code, facilitate efficient monitoring during operations for sustainable energy use (BEE, 2017).

One of India's flagship initiatives, Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles (FAME), which promotes the adoption of electric and hybrid vehicles, is monitored by the Ministry of Heavy Industries (MHI) with the help of the National Automotive Board (NAB) under the Department of Heavy Industry (DHI) (PIB, 2023). Similarly, the Department of Animal Husbandry and Dairying (DAHD) under the Ministry of Fisheries, Animal Husbandry and Dairying (MFAHD) provide livestock census data every five years (MFAHD, n.d.), and the Central Water Commission (CWC) under the Ministry of Jal Shakti (MoJS), monitor the water quality of rivers and water bodies periodically at regular intervals across India (MoJS, 2022). The Ministry

of Mines (MoM), through the Indian Bureau of Mines (IBM), monitors the performance of mines by tracking mining footprints using a Star Rating System (MoM, 2023).

Beyond these well-established institutional structures, the effectiveness of India's MRV initiatives is enriched by the active participation of prestigious scientific institutions. The Indian Space Research Organisation (ISRO), through its National Remote Sensing Centre (NRSC), employs cutting-edge technology to monitor extreme weather events via spatial flood early warning models (NRSC, 2023). The India Meteorological Department (IMD) is responsible for operating weather and climate monitoring services, providing detection and warning support across various economic sectors (IMD, 2022). Additionally, the National Disaster Management Authority (NDMA) oversees the preparedness for extreme weather events and the implementation of early warning systems nationwide (NDMA, n.d.).

At the state level, State Public Health Engineering Departments monitor drinking water supplied to rural households (PIB,2023). State Pollution Control Boards/Pollution Control Committees monitor the compliance of industrial emissions/effluent via the Online Continuous Effluent/Emission Monitoring Systems (OCEMS) (PIB, 2023). RE generation management is carried out by the State Load Despatch Centres (SLDCs) (HPSLDC, n.d.).

At a regional level, urban and rural local bodies, such as Municipal Corporations, monitor climate actions through dedicated departments/units. For instance, the Surat Municipal Corporation's Energy Efficiency Cell has an Energy Bill Monitoring System to keep checks on the energy consumed by all departments of the corporation. At a local body level, Biodiversity Management Committees (BMC) are formed to track and monitor biodiversity resources, including traditional knowledge, and the findings are recorded in People's Biodiversity Registers (PBR) (NBA, 2013).

***Table 4.1: Institutional processes for MRV across sectors***

| Name of Entity | Sector | Initiatives/Responsibilities | MRV Instrument |
|---|---|---|---|
| Central Electricity Authority, MoP | Energy | Monitoring 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, MoP | Energy | Monitors efficiency of power plants. | Adheres to Indian Electricity Grid Code for monitoring and reporting. |
| Bureau of Energy Efficiency, MoP | Energy | Monitors energy efficiency measures across the country, such as PAT, S&L Programme, and ECBC. | Inbuilt MRV mechanisms of initiatives and schemes. |
| Ministry of Statistics and Programme Implementation | Energy | Monitors installed capacity, production, consumption, import, export, and energy indicators. | Database for energy sources (annually). |
| Petroleum Planning and Analysis Cell, MoPNG | Energy | Monitors trends and analysis (consumption, production, import) for petroleum and natural gas. | Reports and studies (monthly). |
| Energy Efficiency Services Limited, MoP | Energy | Monitors energy efficiency of LED streetlights in the country. | Remotely monitoring through a central control system (annually). |
| Coal Controller's Organization, MoC | Industry | Monitoring baseline data for estimating emissions from industrial coal consumption. | Directory/statistic report (annually). |
| National Sample Survey Office, MoSPI | Industry | Monitors data on industrial energy use and forms important baseline data for estimating industrial emissions. | Findings reported in Annual Survey of Industries. |
| Indian Bureau of Mines, MoM | Industry | Monitors the performance of mines by tracking mining footprints. | Star Rating System; Reporting done through self-assessment followed by departmental verification. |
| Indian Railways, MoR | Transport | Monitors electrification of railway lines in the country. | Statistical Report prepared (annually). |

| Name of Entity | Sector | Initiatives/Responsibilities | MRV Instrument |
|---|---|---|---|
| Green Highways Division, MoRTH | Transport | Monitoring of survival and growth of plants along highways in the country. | Monitoring and reporting via geo-tagging. |
| National Automotive Board, MHI | Transport | Monitors the implementation of the Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles (FAME) scheme promoting electric and hybrid vehicles | Inbuilt management information systems for monitoring and reporting (periodically). |
| Department of Animal Husbandry and Dairying, MFAHD | Agriculture | Monitors livestock census data to calculate GHG emissions. | Reporting (every five years). |
| Department of Agriculture and Farmers Welfare, MoA&FW | Agriculture | Monitors indicators of crop production for major crops like rice, wheat, maise, pulses, and sugarcane. | All India database (annually). |
| Indian Council of Agricultural Research, MoA&FW | Agriculture | Tracks and monitors the status of crops, pests, and livestock to form baseline data for estimating emissions. | Data repository; GIS system (annually). |
| Forest Survey of India, MoEFCC | Forestry | Monitors 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). |
| Forest Survey of India, MoEFCC | Forestry | Monitors forest fires in the country. | Satellite data (annually). |
| Ministry of Statistics and Programme Implementation | Forestry | Monitors afforestation schemes across the country. | Performance reports (quarterly). |
| National Biodiversity Authority, MoeFCC | Forestry | Track and monitor biological resources and traditional knowledge (at the local level). | Biodiversity Management Committees report findings in People's Biodiversity Registers (periodically). |
| Indian Council of Forestry Research and Education, MoEFCC | Forestry and various other sectors | Monitors green credits from afforestation and other activities under the Green Credit Program (GCP). | Auditors/verifiers (periodically). |
| Central Pollution Control Board, MoEFCC | Waste | Tracks and monitors air and water quality and landfill/waste processing sites and management of hazardous waste. | Reporting is done annually. |
| Public Health Engineering Departments (state-wise) | Water | Monitors drinking water supplied to rural households. | Reporting is undertaken periodically. |
| Central Water Commission, MoJS | Water | Monitors water quality of rivers and water bodies across India and also has a reservoir monitoring system. | Reporting takes place monthly and annually; Reporting of reservoirs (weekly). |
| State Pollution Control Board/Pollution Control Committees | Waste | Monitors compliance with industrial emissions/effluents. | Reporting is done annually. |
| Indian Space Research Organisation - National Remote Sensing Centre, DoS | Climate resilience | Monitors extreme weather events via spatial flood early warning models using very high-resolution technology. | Real-time reporting (daily); annually. |
| India Meteorological Department MoES | Climate resilience | Operates weather and climate monitoring, detection and warning services for various sectors of the economy. | Real-time reporting (daily); annually. |
| National Disaster Management Authority, MHA | Climate resilience | Monitors preparedness for extreme weather events and early warning systems in the country. | Reports data hourly, daily, weekly, and monthly. |
| Source: Author's analysis | | | |

Table 4.1 provides a comprehensive overview of the extensive network of institutions and their respective departments committed to monitoring climate action across various sectors. These institutions employ state-of-the-art technology and innovative methodologies for data collection and analysis, which strengthens the MRV process.

## 4.3. Technologies for efficient monitoring and reporting of climate action

India is at the forefront of developing, utilising and exploring technology/technical advancements for conducting MRV, ensuring the highest levels of data accuracy, reliability, and transparency. The innovative tools and systems include remote sensing satellites, geographic information systems (GIS), and sophisticated monitoring devices that lead to vigilant and real-time observation of India's climate actions.

ISRO has developed a geo-spatial map of India to track renewable energy installations and potential sites, which provides a detailed visualisation of the country's energy resources. Its Visualisation of Earth Observation Data and Archival System (VEDAS) system uses earth observation data to monitor sectors such as agriculture, forestry, desertification, wetlands, marine ecosystems, polar science, hydrology, new & renewable energy and air quality monitoring (ISRO, n.d.) Geo-tagging of springs in the Indian Himalayan region through 'HIMAL' portal is conducted by the Botanical Survey of India (BSI) and the Zoological Survey of India (ZSI) to prepare a comprehensive dataset for land use and conservation planning (PIB, 2023). For monitoring forest plantations across the country, the MoEFCC and FSI leverage geo-spatial data, through 'e-Green Watch' portal. The FSI has also developed the 'Van Agni' Geo-portal, a single-point source of information for tracking large forest fires in near real-time.

To improve MRV practices and reduce the chances of data silos, integrated platforms and geo-spatial technologies prove beneficial. For instance, the India Climate Energy Dashboard (ICED) integrates 18 portals to provide a single window access for all datasets of India's energy sources. Similarly, for green energy access, the Grid Controller of India manages the Green Open Access Registry (GOAR) to integrate applications for green energy access, facilitating a unified platform to monitor the approval processes.

The MoA&FW uses the Weather Information Network Data Systems (WINDS) portal to collect hyper-local weather data from automatic weather stations and rain gauges for immediate risk assessment in crop insurance and disaster mitigation. It has also developed the Seed Authentication, Traceability & Holistic Inventory (SATHI) portal, through which it monitors seed traceability from production to distribution. Ministry of New and Renewable Energy (MNRE) monitors the implementation of the National Bioenergy Programme via the 'BioUrja' portal. The Bio-Urja Portal is specifically designed for Biomass based and Waste to Energy Projects. The portal tracks the Central Financial Assistance (CFA) applications in real-time such projects. It also tracks and monitors the performance of solar photo-voltaic systems and quantifies emission reductions from solar rooftop projects in India, through the Solar Plant Installation (SPIN) portal, also known as the National Portal for Rooftop Solar.

The Department of Science and Technology (DST) and Ministry of Electronics Information and Technology (MeITY) use a mobile application SoilSens to collect real-time data on soil moisture, temperature, and humidity. The MoJS uses the Bhuvan Ganga mobile app, to harvest data from the public, which collects and reports information on various pollution sources that affect the water quality of river Ganga. MoEFCC has also developed the SUP (Single-Use Plastics) mobile application for crowd-sourcing data to monitor the ban on single-use plastics and report the manufacturing, stocking, or distribution of single-use plastic usage and violations. Similarly, to monitor air quality, the CPCB has developed SAMEER, a mobile application that enables citizens to register complaints related to air pollution and serves as a grievance reporting system, which also serves as a validation tool for the data collected by official monitoring stations.

India is complementing its existing technological tools for MRV practices by employing newer innovations such as Internet of Things (IoT), Artificial Intelligence (AI). In the agriculture sector, precision farming, agricultural drones, livestock monitoring, smart greenhouses, and AI-powered imaging are being utilised to improve MRV practices. Institutes like IIT Ropar, IIT Bombay, and IIT Kharagpur are developing IoT-based solutions for crop prediction and AI technologies for precision agriculture (PIB, 2022). In the energy sector, Renewable Energy Management Centers (REMC) are equipped with AI-based renewable energy forecasting and scheduling tools that provide greater visualisation and enhanced situational awareness to grid operators (PIB, 2020). The PAT Scheme is being improved with the help of IoT-based monitoring and verification technology (BEE, 2021). Table 4.2 showcases platforms or technological advancements in the institutional MRV processes.

*Table 4.2: Technological and technical advancements in the MRV processes*

| Platform / Technology Name | Entity | Sector | Description |
|---|---|---|---|
| **MOBILES APPLICATIONS** | | | |
| UJALA | EESL | Energy | Real-time monitoring of the LED distribution across the country. |
| MERIT | MoP | Energy | Facilitation of renewable integration and promotion the trasnparent use of green and clean power. |
| GARV | RECL | Energy | Monitoring village and household electrification. |
| Vidyut Pravah | MoP | Energy | Real-time monitoring of power availability in the country (including shortages-peak hour and total energy shortage). |
| SoilSens | DST | Agriculture | Smart soil monitoring system embedded with sensors for measuring soil moisture, temperature, humidity. |
| Bhuvan Hailstorm | DA&FW | Agriculture | Monitor crop loss due to hailstorm, hailstorm occurrences, and their geographical locations. |
| Kisan Suvidha | MoA&FW | Agriculture | Monitors and provides updates on extreme weather, soil health cards, and market prices of commodities. |
| Meghdoot | IMD, ICAR | Agriculture | Provides high-resolution weather forecast based agro advisories to farmers. |
| mHariyali | MoHUA | Forestry | Monitoring of plantations and provides geo-tagging of plants. |
| Harit Path | NHAI | Forestry | Monitor plantation along national highways. |
| Bhuvan Ganga | MoJS | Waste | Uses crowd-sourced pollution data for monitoring and reporting on urban sewage, industrial wastewater, and solid waste disposal. |
| Swachhata | MoHUA | Waste | Monitoring civic issues relating to garbage (dumping and collection) and public toilets. |
| SUP | CPCB | Waste | Reporting of manufacturing, stocking, or distribution of single-use plastic to monitor the ban on single-use plastic effectively. |
| Mausam | IMD | Climate resilience | Provide information on observed weather, forecasts, radar images, and warning towards impending weather events. |
| SAMEER (National Air Quality Index) | CPCB | Cross-cutting | Collects data on air pollution via public complaints in the NCR region for monitoring and redressal purposes. |
| Ganga Shravan Abhiyaan | MoJS-CPCB | Cross-cutting | Recording data of water pollution for Clean Ganga Mission. |
| Meri LiFE | MoEFCC | Cross-cutting | Monitors real-time implementation of sustainability initiatives under Mission LiFE. |
| JALDOOT | MoRD | Cross-cutting | Monitors groundwater level. |
| **WEB-BASED PLATFORM** | | | |
| BioUrja | MNRE | Energy | Tracking online applications for grants of Central Financial Assistance (CFA) for Waste to Energy projects. |
| SPIN | MNRE-NIC | Energy | Tracking applications and installation of rooftop solar processes. |
| GOAR | MoP | Energy | Monitors the approval process for green energy access. |
| National Power Portal | CEA, MoP | Energy | Tracks category wise installed capacity (conventional/non-conventional energy installed). |
| RPO | MNRE | Energy | Monitors RPO compliance data. |
| National Building dashboard | EESL | Energy | Real-time monitoring of deemed energy savings, reduction in $CO_2$ emissions from retrofitted buildings by tracking energy demand and emissions. |
| SDG India Index | NITI Aayog | Energy and various other sectors | Monitors the progress of state and Union Territories across 100 indicators. Indicators related to climate change are renewable share installed generating capacity, $CO_2$ saved from LED bulbs, and loss of life due to extreme weather events. |
| India SDG Dashboard | MoSPI | Energy and various other sectors | A National Indicator Framework (NIF) for tracking SDG NIF indicators' progress presently consists of 302 indicators, which inter alia includes indicators related to clean energy, climate action and life below water and life on earth. |

| Platform / Technology Name | Entity | Sector | Description |
|---|---|---|---|
| FAME | DHI | Transport | Tracks and monitors total number of vehicles sold, fuel savings per day, and $CO_2$ reduction per day. |
| WINDS | DA&FW | Agriculture | Centralised platform hosting hyper-local weather data for risk assessment and decision-making in agriculture. |
| SATHI | DA&FW | Agriculture | Monitors seed traceability, authentication, and inventory to address challenges in seed production and certification. |
| Soil Health Card | DA&FW | Agriculture | Monitors 12 parameters (nitrogen, phosphorus and potassium, micro nutrient status, pH) in the soil across the States. |
| PMKSY | DA&FW | Agriculture | Year-wise area under micro-irrigation systems. |
| AgDSM | MoP | Agriculture | Monitors energy savings per year, $CO_2$ reduction per year, and cost savings per year. |
| National Transit Pass System | MoEFCC | Forestry | Monitors inter and intra state transit of timber, bamboo and other minor forest produce from private lands/ government/private depot. |
| Centralised EPR Portal for Plastic Packaging | MoEFCC | Waste | Monitors State and category-wise plastic waste procured and generated. |
| Swachh Bharat Urban/Gramin | MoHUA | Waste | Monitors total waste generated and processed, open defecation free village, community public and toilets construction. |
| **SATELLITE DATASETS** | | | |
| Geo-spatial Energy Map of India | NITI Ayog; ISRO | Energy | Provides geo-spatial data for energy planning and monitoring. |
| HIMAL | BSI and ZSI | Forestry | Digitising flora, fauna, and herbarium records while geo-tagging springs across the Indian Himalayan Region (IHR). |
| e-Green Watch | FSI | Forestry | Monitoring of processes related to plantations and other forestry works taken up under CAMPA funds. |
| Van-Agni | FSI | Forestry | Forest fire related data for continuous monitoring and tracking of large forest fires in a near real-time basis. |
| Wetlands of India Portal | MoEFCC | Forestry | Provides information and facilitates conservation efforts related to wetlands in India. |
| Bhuvan Geospatial Portal | NRSC-ISRO | Forestry | Monitors land use and land cover changes. |
| VEDAS | ISRO | Cross-cutting | Monitors sectors such as agriculture, forestry, desertification, wetlands, marine ecosystems, polar science, hydrology, new & renewable energy and air quality monitoring. |

Source: Author's analysis

India's leveraging technological innovations for monitoring and reporting climate actions demonstrates the intention to strengthen environmental governance and foster sustainable development. Recognising the need for a holistic nature of the MRV process, India also actively engages with civil society organisations. This inclusive approach ensures broader participation in climate action initiatives, setting high standards in transparency and accountability and paving the way towards a more resilient and sustainable future.

## 4.4. Complementary role of non-state actors in strengthening the MRV processes

Civil society initiatives are instrumental in advancing MRV mechanisms in India by collaborating closely with the government as well as operating autonomously. The Council on Energy, Environment and Water (CEEW)'s Centre for Energy Finance (CEEW-CEF) has collaborated with the CEA to develop the 'India Renewables Dashboard'. This dashboard provides operational insights into RE projects across India by capturing daily generation data at the state, regional, and national levels. The Energy and Resources Institute (TERI), backed by MNRE has developed the Green Rating for Integrated Habitat Assessment (GRIHA), India's national rating system for monitoring building systems' efficiency through digital metres. Alliance for an Energy-

Efficient Economy (AEEE) has collaborated with BEE to develop the State Energy Efficiency Index (SEEI) for tracking energy efficiency initiatives across states and UTs. Using 65 indicators across seven sectors identifies intervention areas, assesses policy performance, and fosters collaboration for transparency and accountability in India's energy sector. Vasudha Foundation along with NITI Aayog has developed the ICED for monitoring India's clean energy transition using 500 parameters, 2000 infographics, and interactive visualisations.

The Centre for Social and Economic Progress (CSEP) has launched the Electricity and Carbon Tracker, a pioneering platform for near real-time monitoring of electricity generation and associated carbon emissions in India. The Waste Tracker application, developed by Nirmal Vasundhara, in Gujarat monitors waste-management through the use of advanced analytics to assess the volume and cost of collected waste. The Living Heritage Foundation in Goa, has developed a user-friendly Tree Mapping App to monitor tree cover by geo-tagging trees across the state.

These initiatives have helped India build a robust framework of monitoring and reporting of its varied climate actions through a widespread network of public and private institutions. Leveraging technological innovations across governmental institutions and fostering partnerships with civil society has strengthened India's MRV process and demonstrated India's commitment to addressing climate change challenges comprehensively.

## 4.5. Transitioning to an Enhanced Transparency Framework

It is important to highlight that while India has established effective mechanisms for reporting climate actions, there remains a need for improved formal and institutionalised frameworks, particularly to foster interdepartmental collaboration and ensure the retention of expertise (Prasad & Gupta, 2019).

Limited formal arrangements lead to several challenges towards reporting the overall impact of GHG emission reduction and other benefits. For example, data provider agencies primarily collect information to track developmental targets, often overlooking climate mitigation impacts unless specified. Addressing this requires tracking policy-level mitigation and adaptation impacts and formal authorisation for national agencies to collect and report necessary information. And this becomes a particularly pertinent issue in light of the Enhanced Transparency Framework (ETF), which necessitates reporting in areas where India lacks previous experience.

India is preparing to transition into the ETF. In line with its stated objectives in the CBIT proposal, India is exploring tapping the full potential of existing institutions and creating an enabling environment across all levels of governance. The idea is to build an IT-enabled system – "National Institutional Coordination System (NICS)", which would bring relevant stakeholders together, supporting enhanced coordination and timely reporting. This would explore integrating information from different sources and platforms – GHG inventory inputs through the National Inventory Management System (NIMS); data providers from departments; policy and programme level outcomes; in-built MRVs of schemes; and also bind state and local level monitoring entities to one system.

### India's National Inventory Management System (NIMS)

The National Inventory Management System (NIMS), is being developed to support the preparation and management of a comprehensive national greenhouse gas. It would lead to a centralized digital system and facilitate electronic reporting requirements under the ETF (supporting inputs to Common Reporting Tables (CRT)).

The Indian Institute of Forest Management (IIFM) will host NIMS, and the Ministry of Environment, Forest and Climate Change (MoEF&CC) would serve as the nodal authority for NIMS and play a central role in

coordinating; providing strategic direction, and ensuring the overall effectiveness of NIMS in managing greenhouse gas inventories. Further, all relevant Ministries and Departments of Government of India and their scientific experts/institutes/organizations who provide data/undertake studies are part of the institutional structure of NIMS and would be responsible for providing sector-specific greenhouse gas emissions data.

***Table 4.3: Key features of NIMS***

| Category | Description |
|---|---|
| Principle | Transparency, Accuracy, Completeness, Consistency and Comparability |
| Objective | Create a GHG Data repository; transfer National GHG emissions Inventory data electronically; make GHG data available to users for analysis and policy interventions; support evidence-based decision-making, and guide domestic climate change policy initiatives. |
| Activities | Inventory planning; transparent and consistent data collection; quality control/quality assurance; key category analysis; and centralised archiving system. |
| Gases | $CO_2$, $CH_4$, $N_2O$, HFCs, PFCs, $SF_6$, $NF_3$ |
| Sectors | Energy, Industrial Processes and Product Use (IPPU), Agriculture, Land Use, Land-Use Change and Forestry (LULUCF), and Waste. |

Source: GoI, 2024

The NIMS will compile comprehensive GHG data across 200+ sub-categories for UNFCCC compliance reports. It is visualised to have an IT interface with various features such as user login, guidance and resources, navigation tree for sectors, completeness check, translation, as well as would allow users to import files as .xlsx and .json, and export all data entry grid as .Xlsx or as .json. With the help of NIMS, the data collection, processing, and analysis eases. This would improve data quality, enhance efficiency, increase transparency, ensure compliance with new standards and guidelines under UNFCCC, and inform policy development.

While India is transitioning to a more sophisticated climate reporting system, it acknowledges the imperative of a collective approach to address the climate crisis. Robust climate action transcends the efforts of any single ministry or department in a country; it necessitates seamless collaboration among various governmental and inter-governmental entities. This is vital because MRV processes not only play a vital role in informing and guiding sectoral initiatives but also build credibility and reliability of climate-related data. Under the ETF, through the implementation of systems like NIMS, India aims to strengthen its climate reporting mechanisms, striving for comprehensive, accurate, and transparent documentation of GHG emissions and its climate actions.

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Green Hydrogen Plant using plasma oxy gasification of municipal solid waste and agriculture waste technology

Photo Credit: Central Electricity Authority (CEA)

10 TPD Integrated Torrefaction and Pelletization Plant

Photo Credit: Central Electricity Authority (CEA)

10 TPD Methanol plant at Vindhyachal, Uttar Pradesh

Photo credit: Central Electricity Authority (CEA)

20 TPD Carbon capture plant at Vindhyachal, Uttar Pradesh

Photo credit: Central Electricity Authority (CEA)

# Chapter-5: Finance, Technology and Capacity Building Needs and Support Received

## 5.1 Introduction

In alignment with Paragraphs 14-16 of Annex III to Decision 2/CP-17, this chapter of India's Fourth Biennial Update Report (BUR-4) provides updated and detailed information on the financial resources, technology transfer, capacity-building, and technical support received by India. This support is sourced from the Global Environment Facility (GEF), Parties included in Annex II to the UNFCCC, the Green Climate Fund (GCF), multilateral institutions, and developed country Parties, specifically for activities related to climate change, including the preparation of the current BUR. The chapter also notes the context of international/multilateral finance for climate action as relevant to India and the barriers to the flow and adequacy in meeting India's financial needs. It is important to note that the coverage in this chapter is not a complete or final statement of India's finance and technology needs and requirements for low-carbon transition both in the short and long term.

The information provided is provisional, partial, and non-exhaustive. The chapter highlights the ongoing and critical need for financial, technical, and capacity-building support.

This chapter should be read in conjunction with the information furnished by the Government of India to the UNFCCC since 2004. The objective of this section is to provide non-prescriptive, voluntary technical guidance to aid in the preparation and reporting of information on financial, technical, and capacity-building needs and the support received for climate change-related activities.

### 5.1.1 International Context

Finance for climate action is an important enabling pillar for climate action under the United Nations Framework Convention on Climate Change (UNFCCC) and its Paris Agreement. However, there continue to be fundamental gaps between pledges of developed countries and the actual funding needs of developing countries. Reflecting these concerns, the first Global Stocktake under the Paris Agreement to assess the collective progress towards achieving its long-term goals (see Decision 1/CMA.5, in CMA, 2023), highlighted the growing gap between the needs of developing country Parties and the support mobilized and provided for their efforts to implement their NDCs. Such needs, as noted, are currently estimated at USD 5.8–5.9 trillion for the pre-2030 period. Moreover, it is highlighted that the adaptation finance needs of developing countries are estimated at USD 215–387 billion annually up until 2030.

In context of adaptation finance, the first GST also recognised that the provision of adaptation finance from developed country Parties to developing countries will have to be significantly scaled up, beyond the doubling from 2019 levels by 2025, to support the urgent and evolving need to accelerate adaptation and build resilience in developing countries. The GST further emphasised that scaling up new and additional grant-based, highly concessional finance and non-debt financial instruments is critical to supporting developing countries in their climate efforts (PIB, 2024a).

The responsibilities, obligations, and commitments of the developed countries on providing Climate Finance to the developing countries under the UNFCCC and its Paris Agreement have consistently not been met. The decision text of COP 27, COP 28 and the first GST all have noted "with deep regret" that the goal of developed country Parties to mobilize jointly USD 100 billion per year by 2020 in climate finance has not been met up till 2021 (UNFCCC, 2022, 2023). This goal was initially set to be reached by 2020 and extended to 2025. According to the recent OECD report, this goal has been met for the first time in 2022, when developed countries provided and mobilised a total of USD 115.9 billion in climate finance for developing countries (OECD, 2024). This includes public and private finance, where the public climate finance provided bilaterally and through multilateral channels mainly took the form of loans (69% or USD 63.6 billion) and, to a lesser extent, grants (28% or USD 25.6 billion).

However, ever since its first publication, the OECD report on climate finance has been widely challenged by researchers, civil society, and developing countries for its methodology and conclusions. It is widely argued that these amounts are overstated due to a lack of an agreed definition of what constitutes climate finance. The OECD report counts all financial instruments at cash face value rather than its grant-equivalence. Further, it does not provide the break-up between concessional and non-concessional loans. Its methodology also greatly overestimates the climate-specific nature of such finance. These figures are challenged by the Oxfam report on climate finance that discounts for the climate relevance of reported funds to estimate how much finance is actually targeting climate action and also discounts for grant equivalence (Oxfam, 2024). In contrast to the OECD report, the Oxfam report estimates that the climate-specific net assistance amounted to only USD 28-35 billion in 2022 as opposed to USD 115.9 billion reported by OECD.

India also recognizes that current climate finance falls short in scale, scope, and speed contrary to the letter and spirit of the Convention. It is heavily skewed towards loans rather than grants or sufficiently concessional loans, with a disproportionate focus on mitigation over adaptation. Numerous reports from multilateral institutions and academic studies have highlighted these issues as well (PIB, 2022).

Public funds for mobilising finance for climate action are essential to not exacerbate the debt burden of developing countries, but also to ensure predictability of finance flows. Instruments like grants and concessional loans are essential to achieve the scale, speed, and scope of finance flows for climate action.

The transition to low carbon development pathway will entail several costs pertaining to the development of new technologies, new infrastructure, and other costs. Given the already limited fiscal space in developing countries, and growing needs for stimulating recovery and protecting the most vulnerable, these countries face significant challenges in making such investments. Hence, more robust international cooperation in mobilising the resources is needed to secure a green development trajectory (PIB, 2024b).

Concessionality and affordability are important considerations, especially for nations facing debt issues. Accessibility is crucial, as current financing processes are often complex, requiring simplification and better coordination. Predictability in funding amounts and timelines will help countries plan their climate investments effectively. In view of this, India has been calling for a multilaterally agreed definition on climate finance to help gauge the levels of actual finance flows.

In addition, India has continued to lead key global initiatives such as the International Solar Alliance, One Sun One World One Grid, and the Coalition for Disaster Resilient Infrastructure, highlighting its dedication to global climate leadership and technological collaboration. India advocates for more significant control over the allocation and use of finance for climate action for adaptation, mitigation, and preventing future loss and damage.

It is in this overall context, India looks forward to climate specific grants and/or concessional loans, predominantly from public sources of funding, with appropriate balance between mitigation and adaptation and based on India's articulation of its needs and development aspirations.

## 5.2 Financial Needs and Support Received

In relation to the size of India's economy and given its vulnerability to climate change and variability, the country's financing needs for climate action are pertinent. India's climate action is mainly financed by domestic resources as flows from developed countries have fallen far short of what is needed to combat climate change.

Despite contributing minimally to the world's cumulative carbon dioxide emissions and low annual per capita emissions, India has taken major strides in committing to a low-carbon development pathway, contingent upon access to finance, technology, and capacity-building support. India has set ambitious short- and long-term climate goals, including achieving net zero by 2070. India's updated Nationally Determined Contribution (NDC) targets a cumulative 50 percent of electric power installed capacity from non-fossil fuel energy sources by 2030.

The Government of India has implemented a range of measures and initiatives aimed at promoting and accelerating renewable energy capacity across the nation, achieving this vision requires extensive investment in inter-state transmission systems (ISTS), with India planning to invest Rs. 2.8 lakh crore in ISTS for renewable energy evacuation by 2030 (RBI, 2023b). Other financial needs are associated with India's transport fuel and electric mobility targets, energy efficiency in industry, battery storage, and cooling demands for thermal comfort in buildings. While the government has taken several steps to promote EV adoption, challenges remain, including high initial EV costs compared to internal combustion engine (ICE) vehicles and limited charging infrastructure. Following a low-carbon pathway in the industrial sector will require substantial changes in production processes, costly retrofits, and the development and adoption of new technologies, as well as adjustments in business practices and policies. These challenges require significant international financial and technical support. However, India has successfully reduced emissions intensity in line with the NDC commitments, marked by a decline in the energy intensity of output (PIB, 2023).

The Union Budget 2020-21 outlined that the commitments under the Nationally Determined Contribution will be executed in various sectors by the concerned Departments/Ministries through the normal budgeting process. Subsequent Union Budgets have amplified efforts to mobilise resources for climate action through the sovereign green bonds and adoption of a climate finance taxonomy.

India, like other developing countries, is significantly affected by climate change and is significantly vulnerable to extreme weather events such as cyclones, floods, and droughts. These events result in loss of lives, damage to infrastructure, and hinder economic and social progress. The Reserve Bank of India (RBI) also highlights a substantial immediate cost, estimating that climate adaptation measures will require an expenditure of about Rupees 85.6 lakh crore by 2030 (RBI, 2023a; 2023b). Therefore, India requires significant financial and technological support and has significant needs to adapt to current and future climate risks in its most vulnerable sectors, including agriculture, water, natural ecosystems and biodiversity, and health. In addition, managing infrastructure is also a crucial aspect that requires consideration, given the likely increase in the frequency of extreme weather events in the country. The increasing frequency of cyclones in India has become a serious concern, causing extensive damage to infrastructure, life, and property, especially in coastal regions. Although improved disaster management, early warning systems, and resilient infrastructure like cyclone shelters have reduced cyclone-related fatalities over the years, economic losses remain substantial. To address this, it is crucial to scale up financing and technologies for climate-resilient infrastructure and disaster risk management.

### *5.2.1 Financial Support Received by India*

This section provides an account of the development finance associated with projects approved by multilateral channels in the calendar years 2021 and 2022 across all sectors. It covers multilateral climate funds such as the Green Climate Fund (GCF) and the Global Environment Facility (GEF); and multilateral development banks (MDBs) such as Asian Development Bank (ADB) and the International Bank for Reconstruction and Development (IBRD).

The strategic collaboration between such institutions and Indian financial entities has been crucial in facilitating access to finance for climate action. However, it has been seen that the fund size of the GCF has been highly inadequate. It has not been proportional to the requirements of developing countries. The current size of the portfolio is around USD 16 billion, which is a small fraction of the actual requirement of the developing nations. Although there has been an increase in the contribution pledge in GCF-2 compared to GCF-1, the size remains an issue for the effective implementation of climate actions. Financing by operating entities such as GCF requires high co-financing by the concerned developing country, which implies that this co-financing component has to be generated by the developing country concerned, often from public funding.

Article 13 of the Paris Agreement establishes a transparency framework to track progress on climate actions and commitments by all countries, ensuring accountability and building trust among parties. Its key purpose is to provide clarity, transparency, and understanding of climate actions and support under the Agreement, helping to assess the effectiveness of measures taken to achieve long-term climate goals. In line with this, GEF approved two projects in 2022 to support India: the "Preparation of India's First Biennial Transparency Report (BTR)" and the "Preparation of India's Fourth National Communication (4NC) and Fourth Biennial Update Report (BUR4) to the UNFCCC. These projects aim to effectively implement the Enhanced Transparency Framework (ETF) under the Paris Agreement, enabling India to meet its reporting commitments to the UNFCCC.

As noted in the previous BURs, there are significant issues with regards to tracking multilateral and bilateral funds, including lack of transparency, double counting, repackaging overseas development assistance, non-concessional loans and overstating climate specificity of projects. This unavailability of information is more profound at the level of bilateral reporting owing to which, an assessment of funds approved at bilateral level could not be made for the aegis of this report.

Table 5.1 here shows cumulative development finance of projects. The accuracy of climate specificity, a description of how this fund will be aligned to climate objectives and its impact are uncertain. It is to be noted that these figures are only the approved amounts for entire project periods and in no way should be read as finance received by India in the reporting period. Therefore, the figures presented in this section should be considered indicative, not exhaustive and likely to be a gross overestimate owing to the lack of proper reporting by different agencies and because they include the overall development finance and not climate specific finance.

Multilateral climate funds usually do not extend debt creating funds but are heavily co-financed often so by the recipient country, thus reducing the effectiveness of their assistance. In the case of MDBs, the majority of projects are financed through non-concessional market loans which are further vulnerable to exchange rate risks. Additionally, please note that the grant equivalence of these is uncertain in the absence of more granular information from the MDBs. An understanding of allocation, use of funds and disaggregated description of impact towards climate change remain uncertain. Thus, the figures in the following table should only be read as a sum of development finance associated with approved projects and not as finance exclusively approved for climate action.

***Table 5.1 Total Development finance (in million USD) from projects stated as approved in the years 2021 and 2022 ****

| | | | India | | | Multi-country incl. India | | |
|---|---|---|---|---|---|---|---|---|
| **Year** | **Channel** | **Institution** | **Grant** | **Equity** | **Loan** | **Grant** | **Equity** | **Loan** |
| **2021** | Multilateral Climate Funds | **GCF** | 4.5 | 132.5 | - | - | - | - |
| | | **GEF** | 9.83 | - | - | - | - | - |
| | Multilateral Development Banks | **ADB** | - | - | 4302 | - | - | |
| | | **IBRD** | - | - | 2754.5 | - | - | - |

| | | | India | | | Multi-country incl. India | | |
|---|---|---|---|---|---|---|---|---|
| Year | Channel | Institution | Grant | Equity | Loan | Grant | Equity | Loan |
| 2022 | Multilateral Climate Funds | GCF | - | 200 | - | 145 | 40.5 | - |
| | | GEF | 11.27 | - | - | - | - | - |
| | Multilateral Development Banks | ADB | - | - | 1808.3 | - | | - |
| | | IBRD | - | - | 4099 | - | - | - |

*Source: Department of Economic Affairs, Ministry of Finance, Government of India; GEF and GCF website*

**Notes:**

*Climate component, if any, of projects is not available. Government of India retains the right to modify the figures once granular data is available.

1. *All values should be read in USD millions.*
2. *The data for GCF and GEF has been compiled using project details from:*
   *2.1 https://data.greenclimate.fund/public/data/projects*
   *2.2 https://www.thegef.org/projects-operations/database*

*(Date of latest access: 10 October 2024)*

3. *The table includes projects with status "approved" in the calendar years 2021 and 2022.*

## *5.2.2 National Initiatives*

India's endeavours to address climate change through mitigation and adaptation are primarily financed by government budget allocations, along with a combination of market mechanisms, fiscal instruments, and policy interventions. The National Action Plan for Climate Change (NAPCC) comprises nine distinct missions, each with its own budgetary allocations and other financing sources. These missions include solar energy, enhanced energy efficiency, sustainable habitat, water, agriculture, Green India , sustaining Himalayan ecosystem human health, and strategic knowledge on climate change.

**National Adaptation Fund on Climate Change (NAFCC)** was established in 2015 with an initial outlay of INR 3,500 million to fund adaptation actions in State and Union Territories (UTs), that are not otherwise covered under the ongoing schemes/ programs. NAFCC is implemented under project mode and thirty projects worth INR8,474.80 million projects worth INR 8,474.80 million have been sanctioned in 27 States and UTs. These projects in agriculture, animal husbandry, water management, forestry and coastal resources management to enhance resilience and the adaptive capacity at the national and state level, in terms of availability of improved water and food security, livelihoods, and ecosystem services. A list of these projects is presented in Table 5.2.

***Table 5.2: List of approved projects under NAFCC (NABARD, 2023) (As in March 2023)***

| S. No | Name of project | State | Executing Entity | Project Outlay (INR in million) |
|---|---|---|---|---|
| 1. | Towards Climate Resilient Livestock Production System in Punjab | Punjab | Punjab State Council for Science and Technology, Government of Punjab | 174.0 |
| 2. | Conserve water through the management of run-off in the river basin to reduce vulnerability and enhance resilience for traditional livelihood in Nuapada | Odisha | Department of Water Resources, Government of Odisha | 200.0 |

| S. No | Name of project | State | Executing Entity | Project Outlay (INR in million) |
|---|---|---|---|---|
| 3. | Sustainable Livelihoods of Agriculture-Dependent Rural Communities in Drought Prone District of Himachal Pradesh through Climate Smart Solutions | Himachal Pradesh | Department of Environment, Science and Technology, Government of Himachal Pradesh | 200.0 |
| 4. | Model Carbon Positive Eco-Village in Phayeng of Manipur | Manipur | Directorate of Environment, Government of Manipur | 100.0 |
| 5. | Management and rehabilitation of coastal habitats and biodiversity for Climate Change Adaptation and Sustainable Livelihood in Gulf of Mannar, Tamil Nadu, India | Tamil Nadu | Department of Environment, Government of Tamil Nadu | 247.4 |
| 6. | Promotion of Integrated Farming System of Kaipad and Pokkali in coastal wetlands of Kerala | Kerala | Agency for Development of Aquaculture (ADAK), Department of Fisheries, Government of Kerala | 250.0 |
| 7. | Sustainable Agriculture Development through Expansion, Enhancement and Modelling | Mizoram | Department of Agriculture (Crop Husbandry), Government of Mizoram | 103.8 |
| 8. | Climate Adaptation Strategies in Wetlands along Mahanadi River Catchment areas in Chhattisgarh | Chhattisgarh | State Centre for Climate Change, Dept. of Forest, Govt. of Chhattisgarh | 214.7 |
| 9. | Climate Resilient Sustainable Agriculture in Rain-Fed Farming (Kandi) Areas of Jammu and Kashmir | Jammu and Kashmir | Agriculture Production Department, Government of Jammu and Kashmir | 225.2 |
| 10. | Spring-shed development works for rejuvenation of springs for climate resilient development in the water stressed areas of Meghalaya | Meghalaya | Directorate of Soil and Water conservation, Government of Meghalaya | 229.2 |
| 11. | Resilient Agricultural Households through Adaptation to Climate Change in Mahbubnagar District, Telangana | Telangana | Environment Protection Training and Research Institute (EPTRI), Government of Telangana | 240.0 |
| 12. | Integrated surface Water Management through Rejuvenation of 20 tanks and 32 village ponds for Climate Change Adaptation in Puducherry | Puducherry | Department of Science and Technology, Govt. of Puducherry | 167.6 |
| 13. | Climate Resilient Interventions in Dairy Sector in Coastal and Arid Areas in Andhra Pradesh | Andhra Pradesh | Department of Animal Husbandry, Government of Andhra Pradesh | 127.1 |
| 14. | Conservation and Management of Indigenous Varieties of Live Stocks (Cattle and Sheep) in the wake of Climate Change in Karnataka | Karnataka | Department of Animal Husbandry and Veterinary Services, Government of Karnataka | 242.2 |
| 15. | Increasing Adaptive Capacity to Climate Change through Development of Climate-Smart Villages in Select Vulnerable Districts of Madhya Pradesh | Madhya Pradesh | State Knowledge Management Centre on Climate Change (SKMCC), EPCO and Urban Development and Environment Department, Government of Madhya Pradesh | 248.8 |

| S. No | Name of project | State | Executing Entity | Project Outlay (INR in million) |
|---|---|---|---|---|
| 16. | Scaling-up Climate Resilient Agriculture Practices towards Climate Smart Villages (CSVs) in Haryana | Haryana | Department of Agriculture, Government of Haryana | 221.0 |
| 17. | Rain Water Harvesting and Sustainable Water Supply to the Hilly Areas in Darjeeling as an Adaptive Measure to Potential Climate Change Impacts | West Bengal | Municipal Engineering Directorate, Department of Municipal Affairs, Government of West Bengal | 231.2 |
| 18. | Management of Ecosystem of Kaziranga National Park by Creating Climate Resilient Livelihood for Vulnerable Communities through Organic farming and Pond Based Pisciculture | Assam | Kaziranga National Park (KNP) under Department of Environment & Forests (DoEF), Government of Assam | 245.7 |
| 19. | Efficient Water Management and agriculture technology adoption for climate adaptive and resilient farming systems in 51 villages of Nandurbar and Buldhana districts of Maharashtra State | Maharashtra | Department of Water Conservation, Government of Maharashtra through Vasundhara Watershed Development Agency (VWDA) | 229.5 |
| 20. | Climate Change Adaptation for Natural Resource Dependent Communities in Kachchh, Gujarat | Gujarat | Gujarat Ecological Education and Research (GEER) Foundation | 213.6 |
| 21. | Addressing Climate Change Vulnerability of Water Sector at Gram Panchayat level in Drought prone areas of Sikkim | Sikkim | Rural Management and Development Department, Government of Sikkim | 246.7 |
| 22. | MukhyaMantri Jal Swavlamban Abhiyaan for Climate Change Adaptation and Water Harvesting In Arthuna, Anandpuri and Sajjangarh blocks of District Banswara | Rajasthan | Department of Watershed Development & Soil Conservation, Government of Rajasthan | 249.7 |
| 23. | Scaling Climate Smart Agriculture through Mainstreaming Climate Smart Villages in Bihar | Bihar | Department of Agriculture, Government of Bihar | 230.6 |
| 24. | Ecosystem Services based Adaptation to Climate Change in Bundelkhand Region of Uttar Pradesh | Uttar Pradesh | Forest and Wildlife Department, Government of Uttar Pradesh | 198.0 |
| 25. | Enhancing Climate Resilience of Forests and its Dependent Communities in Two Landscapes of Jharkhand | Jharkhand | Department of Forest, Government of Jharkhand | 247.3 |
| 26. | Gene Pool Conservation of Indigenous Rice Varieties under Traditional Integrated Rotational Farming System (Jhum Optimization) for Promoting Livelihood and Food Security as Climate Change Adaptation Strategy in Nagaland | Nagaland | Department of Agriculture, Government of Nagaland | 246.7 |
| 27. | Climate Resilience Building in Rural Areas through Crop Residue Management | Regional Project: Punjab, Haryana, Uttar Pradesh and Rajasthan | Department of Agriculture of the Respective State Government | 1206.6 |

| S. No | Name of project | State | Executing Entity | Project Outlay (INR in million) |
|---|---|---|---|---|
| 28. | Climate proofing of rainfed watersheds in Salem and Virudhunagar districts of Tamil Nadu | Tamil Nadu | Tamil Nadu Watershed Development Agency, Government of Tamil Nadu | 238.0 |
| 29. | Restoration of degraded landscapes to natural state of ecosystem for climate resilience and livelihood improvement of vulnerable communities | Regional Project: Telangana, Rajasthan, Maharashtra | Department of Forest of the Respective State Government | 1261.0 |
| 30. | Addressing Climate Change Vulnerability of Papum-Poma River for conservation and recharging of its springs | Arunachal Pradesh | Environment and climate change centre, State Climate change cell | 239.2 |
| | **Total** | | | **8474.8** |

## *5.2.3 Aligning the Financial System with Sustainability*

The financial system of the country is aligning itself in the direction of sustainability, including low-carbon development and towards a development-led energy transition. Climate-related financial risks pose both micro and macro-prudential concerns. Globally, focus on sustainable forms of finance and climate risks has been engaging the attention of regulators, national authorities and supra-national authorities. The Reserve Bank of RBI has been playing a key role in nudging banks towards mobilising green resources for green activities and projects (RBI, 2024b). Accordingly, the following are the notable developments:

### A. Sovereign Green Bonds

With the aim of mobilising resources for green public infrastructure projects, the Government of India announced the issuing of Sovereign Green Bonds as a part of the government's overall market borrowings for 2022-23. 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 (DEA, 2022). The proceeds raised from these Sovereign Green Bonds shall be used for the financing and/or refinancing of expenditures for green projects.

India's sovereign green bonds highlight its commitment to expanding renewable energy production and reducing carbon intensity by financing projects in renewable energy and the electrification of transportation. Proceeds from these green bonds directed toward renewable energy will facilitate the deployment of established technologies—primarily solar power, wind and small hydropower—while also supporting research and development into emerging technologies like tidal energy. Additional project categories eligible for funding from these sovereign green bonds include sustainable water and waste management, energy efficiency, green buildings, climate change adaptation, sustainable management of natural resources and land use, as well as the conservation of terrestrial and aquatic biodiversity.

The following are the categories and typologies of the projects for which the sovereign green bonds shall be applicable (DEA, 2022).

***Table 5.3 Categories of projects for sovereign green bonds***

| S.No. | Green Project Category | Eligibility Criteria |
|---|---|---|
| 1. | Renewable Energy | a. Investments in solar/ wind/biomass/hydropower energy projects to integrate energy generation and storage.<br>b. Incentivising adoption of renewable energy. |

| S.No. | Green Project Category | Eligibility Criteria |
|---|---|---|
| 2. | Energy Efficiency | a. Design and construct energy efficient and energy saving systems and installations in government buildings and properties.<br>b. Supporting public lighting improvements.<br>c. Supporting construction of new low-carbon buildings as well as energy-efficient retrofits to existing buildings.<br>d. Projects to reduce electricity grid losses. |
| 3. | Clean Transportation | a. Promote public transportation including its electrification and transport safety.<br>b. Subsidies to adopt clean fuels like electric vehicles – including building charging infrastructure. |
| 4. | Climate Change Adaptation | a. Projects aimed at making infrastructure more resilient to 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 | a. Promoting water efficient irrigation systems.<br>b. Installation/upgradation of wastewater infrastructure including transport, treatment and disposal systems.<br>c. Water resource conservation.<br>d. Flood defence systems. |
| 6. | Pollution Prevention and Control | a. 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. |
| 7. | Green Buildings | a. 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 | a. Environmentally sustainable management of agriculture, animal husbandry, fishery and aquaculture.<br>b. Sustainable forestry management including afforestation/reforestation.<br>c. Support to certify organic farming.<br>d. Research on living resources and biodiversity protection. |
| 9. | Terrestrial and Aquatic Biodiversity Conservation | a. Projects relating to coastal and marine environments.<br>b. Projects related to biodiversity preservation, including conservation of endangered species, habitats and ecosystems. |

During 2022-23, sovereign green bonds (SGrBs) spread over two tranches of INR8,000 crore each were issued on January 25, 2023 and February 9, 2023. They comprised 5-year and 10-year bonds of INR4,000 crore in each tranche. During 2023-24, 5-year and 10-year SGrBs of INR5,000 crore in each tranche were issued on November 10, 2023 and December 8, 2023, respectively. Auctions of 30-year SGrBs (two tranches of INR5,000 crore each) were held on 19$^{th}$ January and 2$^{nd}$ February 2024. SGrBs issued during 2022-23 and 2023-24 were notified as 'specified securities' under the fully accessible route (FAR) on January 23, 2023, and November 08, 2023, respectively. Non-residents were allowed to invest in these securities without any restrictions. On the whole, SGrBs worth INR16000 crore were issued in 2022-23 and in 2023-24, the amount mobilized was INR20000 crore, making the total to be INR36000 crores (US$ 4 billion).

In addition, Government of India (GoI) raised 10-year SGrBs worth INR 1,697.40 crores during H1: 2024-25. Further, GoI plans to raise INR 10,000 crore each under 10-year and 30-year securities respectively, i.e., INR 20,000 crore of SGrBs in H2:2024-25. It may also be noted that SGrBs of 10-year tenor issued by the Government in H2:2024-25 is designated as 'specified securities' under the FAR by RBI on November 07, 2024. During H2:2024-25, GoI has raised INR 5,000 crore in 10 year- SGrBs till December 05, 2024.

**B. Acceptance of Green Deposits**

In April 2023, RBI issued a Framework for acceptance of Green Deposits to encourage the regulated entities (REs) to offer green deposit products to customers and augment the flow of credit to green activities/ projects while protecting the depositors' interest and addressing greenwashing concerns.

Regulated entities (REs) will have to allocate the funds raised from green deposits to (i) renewable energy sector; (ii) energy efficiency; (iii) clean transportation; (iv) climate change adaptation; (v) sustainable water and waste management; (vi) pollution prevention and control; (vii) green buildings; (viii) sustainable management of living natural resources and land use; or (ix) terrestrial and aquatic biodiversity conservation. REs can engage with any appropriate and reputed domestic/ international agency for external review of the Financing Framework, Third-party Verification/ Assurance and Impact Assessment of the green activities/ projects.

**C. The Priority Sector Lending (PSL) policy**

The Priority Sector Lending (PSL) policy has evolved over the years to meet the credit requirements of the productive sectors which contribute significantly to economic growth. The identification of these sectors as priority sectors is on the basis of the emerging national priorities such as employment generation, alleviation of poverty and inclusive growth.

The overarching philosophy behind prescribing the PSL target for banks is to enable sections of society, which though creditworthy, are unable to access the formal banking system, for adequate and timely credit. Further, the extant guidelines aim to encourage and support environment friendly lending policies to help achieve Sustainable Development Goals (SDGs). The following have been categorized under priority sector:

1. Agriculture
2. Micro, Small and Medium Enterprises
3. Export Credit
4. Education
5. Housing
6. Social Infrastructure
7. Renewable Energy
8. Others
9. Weaker Sections

In view of the increasing importance of non-conventional and renewable sources of energy and in order to give further impetus to this segment, 'renewable energy' was introduced as a separate category under priority sector in April 2015. Accordingly, bank loans up to a limit of INR15 crore to borrowers for purposes like solar based power generators, biomass-based power generators, windmills, micro-hydel plants and for non-conventional energy based public utilities *viz.*, street lighting systems, and remote village electrification, were classified under priority sector. For individual households, the loan limit was INR10 lakh per borrower.

In September 2020, the credit limit under 'renewable energy' was increased from INR15 crore to INR 30 crore in order to provide further stimulus to the sector. The credit cap for the individual household category continued to remain at INR10 lakh.

Further, loans to farmers for installation of stand-alone Solar Agriculture Pumps, solarisation of grid connected Agriculture Pumps, and installation of solar power plants on barren/fallow land or in stilt fashion on agriculture land owned by farmer, without any cap, were also made eligible under 'Farm Credit' for PSL classification.

Additionally, priority sector classification is available without any credit cap for bank loans to MSMEs engaged in the manufacture or production of goods, in any manner, pertaining to any industry specified in the First Schedule to the Industries (Development and Regulation) Act, 1951 or engaged in providing or

rendering of any service or services. This includes bank loans to MSMEs engaged in water supply; sewerage, waste management and remediation activities; electric power generation using solar energy; electric power generation using other non- conventional sources, etc. (RBI, 2024)

**D. Green Debt Securities**

In 2017 SEBI introduced the regulatory framework for listed issuances of green debt securities as a mode of sustainable finance. Green debt securities are created to fund projects that have positive environmental and/or climate benefits. Proceeds from these bonds are earmarked for green projects. The SEBI (Issue and Listing of Non-Convertible Securities) Regulations, defines green debt security as a debt security issued for raising funds that are to be utilised for project(s) and/ or asset(s) falling under any of nine categories including Renewable and sustainable energy including wind, solar, bioenergy, other sources of energy which use clean technology, Clean transportation including mass/public transportation, Sustainable water management including clean and/or drinking water, water recycling, Climate change adaptation etc subject to the conditions as may be specified by the Board from time to time. The regulatory framework for green debt securities is aligned with Green Bond Principles (GBP) of International Capital Market Association (ICMA). In February 2023, SEBI enhanced the scope of the regulatory framework for green debt securities by including new sub categories of debt securities including blue bonds (related to water management and marine sector), yellow bonds (related to solar energy), transition bonds and sustainable finance securities in relation to pollution prevention and control, eco-efficient products, etc.

**E. Climate-related Data Disclosures**

SEBI adopted sustainability reporting norms for listed entities mandating ESG-related disclosures by the top 100 listed entities (by market capitalisation) early in 2012. Over the years, reporting requirements were expanded to cover the top 500 and then the top 1000 entities. SEBI introduced the new sustainability reporting requirements under the Business Responsibility and Sustainability Report (BRSR), which are more granular with quantifiable metrics. The BRSR was mandatory for the top 1000 listed entities (by market capitalisation) from 2022–23. In July 2023, the SEBI also introduced the BRSR core for ESG disclosures for value chains that were applied to the top 250 listed companies from 2024-25 and will be extended to the 1000 top-listed entities in a phased manner by 2026-27. The value chain shall encompass a listed entity's top upstream and downstream partners, cumulatively comprising 75 per cent of its purchases/sales (by value), respectively. The BRSR Core is a sub-set of the BRSR, consisting of a set of Key Performance Indicators (KPIs)/metrics under specific ESG attributes.

To conclude, currently, India majorly relies on domestic sources to secure the substantial funds necessary for its climate mitigation and adaptation efforts, especially the latter. However, these sources, especially state finances (main drivers for supporting adaptation initiatives) are currently under severe stress, underscoring the urgent need for increased international funding. Though there has been some growth in international finance for adaptation and mitigation, the financial requirements for achieving India's Nationally Determined Contributions (NDCs) remain largely unmet. Increase in international support is essential for India to effectively tackle climate challenges and accelerate its climate objectives.

## *5.2.4 Financial Instruments and Strategies to Deal with Climate Risks*

Climate-related financial risks pose both micro and macro-prudential concerns. Globally, focus on sustainable forms of finance and climate risks has been engaging the attention of regulators, national authorities, and supra-national authorities. A few of the finance for climate action initiatives undertaken (under the aegis of the Reserve Bank of India) include:

**International Best Practices:** RBI joined the Central Banks and Supervisors Network for Greening the Financial System (NGFS) as a Member in April 2021. As a member of NGFS, the Bank is building capacity in terms of international best practices, and risk management in the financial sector. It has also tried to mobilise mainstream finance to support the transition towards a sustainable economy. RBI has actively engaged in capacity building through workshops and discussions to promote sustainable finance and

achieve the Sustainable Development Goals (SDGs). Events included side events conducted as part of the G20 Sustainable Finance Working Group (SFWG), a seminar on 'Financing for SDGs: Role of Microfinance'', a panel discussion on 'Bridging the SDGs Financing Gap', and a symposium on 'Climate Risk and Sustainable Finance'.

**Sustainable Finance Group and Greening India's Financial System:** A dedicated Sustainable Finance Group (SFG) has been constituted by the RBI to lead the regulatory initiatives in the areas of sustainable finance and climate risk. It has also explored how climate scenario exercises can be used to identify vulnerabilities in RBI-supervised entities' balance sheets, business models and gaps in their capabilities for measuring and managing climate-related financial risks.

**Integrating Climate-Related Risks into Financial Stability Monitoring:** In 2022, a survey was undertaken to assess the approach, level of preparedness and progress made by the leading scheduled commercial banks in managing climate risk. It revealed that though banks have begun taking steps in the area of climate risk and sustainable finance, there was a need for more concerted efforts and further action in this regard. A Discussion Paper (DP) on Climate Risk and Sustainable Finance was issued in July 2022 soliciting views from the stakeholders. Based on the analysis of feedback received on the DP, the Reserve Bank announced in February 2023 to issue guidelines on (i) Broad framework for acceptance of Green Deposits, (ii) Disclosure framework on Climate-related Financial Risks (RBI, 2024a), and (iii) Guidance on Climate Scenario Analysis and Stress Testing.

## 5.3 Technology Needs and Support Received

India's climate action plans rely on enhanced financial commitments, strategically directed towards technological innovation and capacity-building. The strategy aims to make new technologies accessible and affordable, aligning with India's socio-economic objectives. A key focus is on developing a technology ecosystem that addresses immediate challenges of climate mitigation and adaptation while fostering long-term sustainable development (PIB, 2024c).

Technological innovation is central to India's climate strategy, focusing on carbon capture, utilisation and storage (CCUS), advanced biofuels, and waste-to-energy solutions. Mission Innovation 2.0 facilitates funding for clean energy innovations through Public-Private Partnerships, accelerating the pace of innovation. Initiatives like Mission Innovation (MI) and the International Solar Alliance (ISA) highlight India's global leadership in clean energy. India achieved about 40 percent cumulative electric power installed capacity from non-fossil fuel-based energy resources in November 2021 and is well on target to achieve its NDC commitment of about 50 percent cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030. The National Green Hydrogen Mission aims to make India a leader in green hydrogen production (MNRE, 2023). Additionally, India is enhancing climate resilience through sustainable agriculture, water management, and urban planning.

India's bioeconomy has grown from $10 billion in 2014 to over $130 billion in 2024, with projections to reach $300 billion by 2030. This growth reflects India's focus on sustainable development and innovation. The BioE3 (Biotechnology for Economy, Environment, and Employment) Policy, launched recently, promotes high-performance regenerative bio-manufacturing to address climate change and resource depletion. The policy encourages the transition from chemical-based industries to sustainable bio-based models, fostering a circular bioeconomy and achieving net-zero carbon emissions through innovative waste utilization. It aims to create significant employment opportunities, particularly in tier-II and tier-III cities, through bio-manufacturing hubs that drive regional economic development. Five Bioenergy Centres have been established to facilitate the production of low-carbon bio-based products, reducing greenhouse gas emissions from the transport sector. India invests in R&D for advanced biofuels and waste-to-energy technologies, supported by international collaborations. Indigenous innovations are central to India's climate change strategy, integrating science, technology, and societal outcomes to promote green energy and sustainable practices. The BioE3 Policy strengthens India's position as a global leader in bio-manufacturing while addressing challenges such as resource overuse, waste generation, and climate change impacts like biodiversity loss and glacier melt (PIB, 2024d).

India is also improving energy efficiency across various sectors by implementing the Energy Conservation Building Code and setting standards for electrical appliances. The agricultural sector is adopting climate-resilient crops and better irrigation methods to ensure food security.

Cleaner fossil energy initiatives focus on developing clean coal technologies and $CO_2$ utilisation projects to mitigate emissions from coal-fired power plants. Clean energy centres are established, and research priorities are set for off-grid systems to support renewable energy integration in remote areas. Energy storage efforts focus on developing advanced materials for hydrogen storage and other storage solutions, crucial for balancing energy supply and demand and supporting the transition to a low-carbon economy. Sustainable practices in fisheries, marine research, coastal tourism, and renewable energy generation focus on harnessing the Blue Economy's potential. The National Research Foundation (NRF) Bill, 2023, promotes research and innovation across India's educational and research institutions, with significant funding from non-governmental sources. India plans to enhance precision irrigation and clean water technologies to mitigate climate impacts. However, these efforts often necessitate deploying India's own resources, which are diverted from other essential needs due to the lack of committed assistance from developed countries.

India is strengthening infrastructure to better cope with climate change impacts, boosting urban and rural resilience, refining water management systems, and promoting sustainable farming practices. The Clean Energy Ministerial (CEM) setup provides a platform for demonstrating commitment to clean energy development through significant initiatives that include the Global Lighting Challenge (GLC) campaign, Street Lighting National Programme, Unnat Jyoti by Affordable LEDs for All (UJALA) programme, and the 'One Sun-One World-One Grid' Initiative.

India's climate strategy extends beyond its borders, engaging in global partnerships and seeking international cooperation and financing. However, current institutional arrangements are insufficient to deliver immediate technology development, deployment, diffusion and transfer, necessitating further improvements. Scaling up infrastructure and securing investments pose significant challenges, requiring a comprehensive approach involving technical, financial, and policy solutions. India's focus on indigenous and cutting-edge technologies underlines its commitment to addressing climate change through innovative, sustainable solutions with global benefits.

### *5.3.1 Technology Needs & Requirements*

India's climate strategy emphasises integrating advanced technologies across key sectors, such as solar, wind, bioenergy, electric vehicles, climate-resilient agriculture, and carbon capture, to foster low-carbon development and build resilience. Despite substantial national efforts and investments, barriers like slow international technology transfer and intellectual property rights (IPR) hinder the rapid adoption of these technologies. India must access global innovations to complement domestic efforts and avoid duplicating work. However, in the absence of promised technology and financial support, India is forced to divert resources from other essential needs to develop these solutions independently.

India's previous BURs have outlined essential technologies required for mitigation and adaptation. However, despite detailed submissions through the first, second, and third BURs to the UNFCCC outlining India's technology needs, none of the required technologies have been effectively transferred, facilitated, or made available under the current climate change regime. This lack of technology transfer has forced India to rely heavily on domestic resources and stretch national capacity, slowing its efforts to achieve critical climate objectives. Some of India's key technology needs identified are presented in Table 5.4.

*Table 5.4 Sector wise Key Technology Needs*

| Sr. No | Sector | Subsector | Description | Type of Technology | Expected Use, Impact and Estimated Results | Additional Information |
|---|---|---|---|---|---|---|
| 1. | Energy | Solar Energy | Development and demonstration of ultra-efficient photovoltaic cells.<br>• Development and demonstration of Hybrid Solar PV-Thermal technologies with thermal storage.<br>• Demonstration of space-saving PV applications, e.g., agri-PV, buildings PV. | Advanced Photovoltaics | Enhanced efficiency, lower costs, and higher adoption rates. | Critical for areas with high solar potential and for applications requiring flexible high-efficiency cells.<br>Meeting both electricity and heating/cooling needs.<br>Utilizing solar in a land-efficient and less space-intensive manner. |
| 2. | Energy | Wind Energy | Use of floating wind turbines for offshore energy production. | Offshore Wind Turbines | Expands potential for wind energy generation | Utilized in European and other developed countries |
| 3. | Energy | Geothermal Energy | More efficient resource assessment, exploration, and development of geothermal energy sources for electricity generation and geothermal ground source heat pumps (GSHP) direct-use applications; harnessing geothermal from abandoned oil and gas fields. | Geothermal Drilling Technology, tools and technologies for geothermal resource investigations, data analysis, demonstration of cost effective and efficient geotherm electricity production, heating, cooling, agriculture, tourism applications | Stable, low-emission energy source, significant for heating/cooling and electricity. | Prominent in Iceland and New Zealand. |
| 4. | Industrial | Cement and Steel | Implementation of energy-efficient production processes and alternative materials. | Low-carbon Technologies | Significant reduction in industrial carbon emissions. | Technological innovations from Japan and Germany. |
| 5. | Industrial | Cement, Iron & Steel | CCUS | Technologies linked to Carbon Capture, Utilisation and Storage | Significant reduction in industrial carbon emissions. | Critical for Hard to Abate Sectors. |
| 6. | Transport | Electric Vehicles | Accelerating the adoption of electric vehicles across the country. | Electrification Technology | Decrease in emissions from the transport sector, promotion of cleaner air. | Major advances in battery technology from South Korea and Japan. |
| 7. | Building and Construction | Green Building | Integration of green roofs and building-integrated photovoltaics. | Energy Efficient Materials and Practices | Improved building energy efficiency, reduction in urban heat islands. | Widely used in Germany and Singapore. |

| Sr. No | Sector | Subsector | Description | Type of Technology | Expected Use, Impact and Estimated Results | Additional Information |
|---|---|---|---|---|---|---|
| 8. | Agriculture | Precision Agriculture | Use of IoT and AI for optimizing resource use and crop health monitoring. | Climate Resilient Agriculture Technologies | Increased crop yields, reduced use of water, fertilizer, and pesticides. | Growing use in the US, Netherlands, and Israel. |
| 9. | Water | Desalination | Use of renewable energy for desalination processes. | Solar and Wind Powered Desalination | Provides fresh water in arid regions without contributing to carbon emissions. | Prominent in the Middle East and North Africa. |
| 10. | Water | Carbon sequestration in deep saline aquifers | This process involves injecting $CO_2$, typically captured from large stationary sources like power plants, into deep geological formations that contain saline water. | Carbon Capture, transport, injection & storage and monitoring & verification. | Enhance the capacity and safety of $CO_2$ storage in saline aquifers, making them a vital option for large-scale carbon mitigation | Germany, USA, Norway. |
| 11. | Forestry | Forest Management | Advanced forest management and monitoring systems. | Remote Sensing and GIS | Helps in the preservation and sustainable management of forest resources. | Satellite technology and GIS mapping solutions from Canada. |
| 12. | LULUCF | Grassland monitoring and management | Grassland mapping | Remote Sensing and GIS | Helps in assessment of carbon sequestration potential, sustainable land management and biodiversity conservation | Remote sensing technology used in the USA and Australia |
| 13. | Public Health | Disease Surveillance Systems | Enhancing disease surveillance to predict outbreaks linked to climate change. | Health Informatics | Early warning systems to prevent and control disease spread. | Software and data analytics technology from the USA. |
| 14. | Forestry | Forest Fire Management | Advanced monitoring and automated systems to prevent and manage wildfires. | Fire Detection and Management Systems | Early detection and more efficient management of forest fires. | Critical for fire-prone areas like Australia and California. |
| 15. | Infrastructure | Flood Management | Enhanced flood barriers and water-sensitive urban design. | Advanced Hydrological Modelling Software | Protects vulnerable communities from flooding, reduces economic losses. | Key for coastal and flood-prone regions worldwide. |

This integrated table offers a broad overview of the technological strategies necessary for both mitigating climate change and adapting to its impacts across different sectors, aiming for a holistic approach to tackling global climate challenges.

### *5.3.1.1 Additional Technologies for Climate Change Mitigation and Adaptation*

Table 5.5 outlines several existing technologies across various sectors that are crucial for combating climate change but require additional investments and scale-up to enhance their efficiency, affordability, and global adoption. Investments in these technologies will be crucial for achieving long-term sustainability goals and effectively addressing both mitigation of greenhouse gas emissions and adaptation to climate impacts.

***Table 5.5 List of Additional Technologies for Climate Change Mitigation and Adaptation***

| Sr. No | Sector | Technology | Description | Potential Impact and Benefits | Status and Needs |
|---|---|---|---|---|---|
| 1. | Energy | Nuclear Energy | Advanced Small Modular Reactors for stable, low-carbon power generation. | Significant baseload power with minimal emissions. | Requires investment in safety, waste management, and newer technologies. |
| 2. | Energy | Advanced Bioenergy | Conversion of biomass to liquid fuels and energy. | Renewable sources that can replace fossil fuels reduce waste. | Needs advancements in conversion efficiency and sustainability. |
| 3. | Energy | Hydrogen production | Green Hydrogen Production Technologies | Advancement in clean Fuel Technology, and Utilization of Green Hydrogen in all the hard to abate Sectors | Research & Development to improve effectiveness and reduce costs. |
| 4. | Energy | Energy Storage Systems | Technologies related to Advanced Battery Chemistries, Solar-thermal energy storage, Hydrogen Storage, and Flywheel Energy Storage | Essential for integrating renewable energy into the grid. | Scaling up to meet national grid demands, reducing costs. Critical to all hard to abate sectors |
| 5. | Energy | Clean Coal Technology | Advanced Supercritical & Ultra Supercritical Coal Technology | Reduction in GHG Emissions Intensity | Supports transition |
| 6. | Energy | Wave and Tidal Power, salinity gradient power, osmotic energy | Harnessing ocean energy for electricity generation, desalination, environmental monitoring | Sustainable energy source with high potential in coastal areas. | Technical and financial investment for commercial deployment. |
| 7. | Industry | Advanced Materials | Development of materials with lower environmental impacts. | Reduces energy consumption and emissions in industries. | Research and development, market acceptance needed. |
| 8. | Industry | Energy Efficient Technology Integration | Integration of Technologies like Inert Anode Technology in the Non-Ferrous Sector, Anode Stem Material Technology in Aluminium, Advanced Pot Controller, Solar Powered Mechanical Vapour Recompression (MVR), and Production of Limestone Calcined Clay Cement (LC3) | Efficient solutions to reduce emissions and enhance performance in various industrial processes. | Critical to all hard to abate sectors |
| 9. | Industry | Bio-Refinery Plant for Multi-Functional Product | Biomass to produce a variety of bio-based value products | Renewable and sustainable alternative to fossil-based refineries. | Critical for Refinery Sector |
| 10. | Agriculture | Genetically Modified Organisms (GMOs) | Crops engineered for higher yields and resilience to climate impacts. | Increases agricultural efficiency and resilience. | Public acceptance, regulatory approvals required. |
| 11. | Building and Construction | Passive Solar Design | Techniques that take advantage of the climate for temperature control. | Reduces heating and cooling needs, lowering energy use. | Wider adoption and integration into building codes needed. |
| 12. | Transport | Hydrogen Fuel Cells | Hydrogen as a clean alternative fuel, particularly for public transport. | High-energy, zero-emission fuel option. | Developments in production, storage, and fuel cell technology. |

| Sr. No | Sector | Technology | Description | Potential Impact and Benefits | Status and Needs |
|---|---|---|---|---|---|
| 13. | Public Health | Climate-Informed Health Surveillance | Systems that use climate data to predict health risks and disease outbreaks. | Improves responses to climate-related health threats. | Investment in data analytics and global monitoring systems. |
| 14. | Urban Planning | Smart Cities Technologies | IoT devices for better resource management in urban areas. | Enhances urban resilience, efficiency, and sustainability. | Integration into existing infrastructures, policy support. |
| 15. | Forestry | Advanced Reforestation Techniques | Use of drone technology for tree planting and monitoring. | Speeds up reforestation efforts and enhances monitoring. | Further development to improve effectiveness and reduce costs. |
| 16. | Infrastructure | Resilient Infrastructure Design | Designing infrastructure to withstand climatic stresses. | Ensures durability and functionality in changing climates. | Innovative engineering solutions, standards development, significant funding. |
| 17. | Waste | Waste Minimization and Prevention | Strategies and technologies aimed at reducing the generation of waste at the source. | This includes process optimization, material substitution, and design for the environment. | Technologies like Lime-Free Conversion of Green Liquor is crucial in pulp and paper sector |
| 18. | Waste | Sustainable Waste Management Technologies | Strategies and technologies related to Waste Collection and Transportation, Treatment and Processing, Waste Monitoring and Analytics, and Advanced Recycling. | This includes controlling waste generation, proper storage, systematic collection, efficient transfer and transport, effective processing, responsible disposal, recycling and resource recovery. | Transition from Linear to Circular Economy |

The table identifies critical areas where technological advancements and investments are necessary to address the ongoing challenges posed by climate change effectively. Through collaborative efforts among governments, industries, and communities, these technologies can be developed and deployed at scales necessary to make a significant impact.

## *5.3.2 Technology Development & Technology Transfer*

Technology transfer is a critical component of climate change mitigation and adaptation that faces both demand and supply-side challenges. These challenges must be addressed within the framework of the Common but Differentiated Responsibilities and Respective Capabilities (CBDR-RC) principles outlined by the UNFCCC. The Convention, along with subsequent agreements such as the Kyoto Protocol and the Paris Agreement (Article 10), emphasises the central role of transferring financial resources and technology from developed to developing nations for climate action. 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, India has not received significant technology transfer under the UNFCCC-guided regime.

On the demand side, access to relevant, affordable, and scalable technologies is often limited due to high costs, lack of infrastructure, and regulatory barriers. Also, predicting future technology requirements in the rapidly evolving realm of technology development is challenging and the adoption and effective use of these technologies gets compounded due to the required technical skills, which are often lacking, especially in developing countries. Financial support is also crucial as the adoption of new technologies often requires significant investment. On the supply side, Intellectual Property Rights (IPR) regimes can act as a barrier to technology transfer, restricting access to technologies, especially for developing countries like India. Also, there has been a noteworthy decline in public spending on R&D and patenting outputs in these areas by developed countries which is contrary to their responsibility to provide and develop technologies for reducing GHG emissions. Developed countries have not been meeting these obligations. Addressing both demand

and supply side issues is crucial for effective technology transfer, requiring a comprehensive approach that includes policy interventions, capacity building, financial support, and international cooperation (PIB, 2024e).

### *5.3.3 Demand Side Issues in Technology Implementation*

India's sizable and growing energy needs comes from the prospect of spiralling greenhouse gas emissions (GHGs). Environment-friendly technology comes at a cost. The challenge is both the lack of innovation at a sufficient pace as well as lack of affordability of physical and asset-heavy solutions, especially those developed for new market segments by early-stage startups. The landscape of technology is constantly changing, and this makes it difficult to accurately predict what technologies will be needed in the future. Innovations that reduce costs and make technologies available at affordable prices will find the markets. For instance, next-generation solar technology of perovskite tandem solar cells. could help solar power get even more efficient, and cheaper.

Accurately expressing technological commercialization demands and achieving supply-demand matching is a significant challenge that involves understanding the application scenarios, university-industry collaboration, and other relevant factors. Moreover, the adoption and effective use of these emerging technologies often require specialised technical skills. However, there is often a gap between the skills that are needed and the skills that are available in the workforce. This skills gap can hinder the adoption of new technologies and limit their effectiveness.

### *5.3.4 Supply Side Issues in Technology Implementation*

The transfer of advanced technologies is crucial for developing nations like India to address climate change, but several supply-side issues hinder this process. These challenges need to be addressed within the principles of equity and common but differentiated responsibilities and respective capabilities (CBDR-RC) of the UNFCCC. Deploying advanced technologies requires significant upfront investments, including costs for acquiring technology licences, building infrastructure, and training personnel. These high capital requirements can deter both public and private sector investments. Additionally, there is often a gap in the technical expertise needed to handle and operate these technologies. Without adequate training, optimising their use and ensuring efficient operation is challenging.

One major supply-side issue is the complexity of transferring advanced technologies due to high licensing fees and stringent intellectual property rights (IPR). While some argue that strong IPR enforcement fosters innovation, it can also limit technology diffusion even in advanced economies as well as access to critical technologies and their rapid diffusion in developing nations. Negotiating favourable terms for technology transfer agreements is essential to balance respecting intellectual property rights with making technologies accessible. The rapid advancement of climate technologies necessitates a skilled workforce, yet there is a shortage of trained professionals capable of designing, installing, operating, and maintaining complex systems. Comprehensive education and training programs are needed to equip the workforce with these skills. Collaborations with academic institutions, industry, and international experts are essential for developing specialised curricula and training modules.

International collaborations are essential for the exchange of technology and the innovation of clean tech. For these partnerships to succeed, strengthened structures are necessary. The growth of infrastructure for emerging technologies, such as manufacturing capabilities, the incorporation of renewable energy, and biofuel production facilities, presents significant challenges. The lack of sophisticated infrastructure can lead to delays in implementation and increased costs. The intricate regulatory system in India, which necessitates numerous approvals, can also postpone projects and inflate expenses. Regular alterations in policies introduce unpredictability, obstructing long-term investments.

The UNFCCC emphasises the central role of transferring financial resources and technology from developed to developing nations for climate action. Developed countries have a responsibility to develop technologies that accelerate innovation towards the elimination of GHG emissions. Despite provisions for IPR protection,

investments in low-carbon technology R&D have been inadequate. Public R&D budgets in renewable energy technologies have declined significantly, affecting the availability and cost of these technologies. India's practice of releasing data on patents being worked provides a valuable guide for focusing on viable technologies. However, developed countries lack similar provisions, highlighting a gap that needs to be addressed. A database tracking patents related to low-carbon technologies and their commercialization status would aid in climate change mitigation and adaptation efforts.

# 5.4 Constraints & Gaps

While India's climate initiatives are beyond its responsibility in terms of equity and CBDR-RC, there are nevertheless substantial challenges, as highlighted by the latest NCs and BURs (UNFCCC, 2024). Limited data infrastructure, varying methodologies, and accessibility barriers are some of the hurdles that India faces. Financial constraints further impede progress towards building up an efficient data-infrastructure framework and the adoption of advanced technologies. In sectors like agriculture, energy, transportation, and heavy industry, there are notable inadequacies and gaps. For instance, sustainable practices in agriculture still need enhancement, and the integration of renewable energy into the national grid faces obstacles (GoI, 2022). Addressing these constraints requires substantial improvements, including strengthening data collection infrastructure, increasing financial allocations for environmental monitoring, and standardising reporting practices across sectors and regions.

## 5.4.1 GHG Inventory Reporting: Constraints, Gaps and Improvements.

India is committed to accurately report its Greenhouse Gas (GHG) inventory across major sectors like energy, industry, LULUCF, and waste as per the Convention, its Paris Agreement and the extant decisions of the COP and CMA. By employing advanced as well as befitting methodologies and estimated country-specific emission factors (EFs) for sectors, India is continually refining its GHG estimates. The country is working to enhance its emission inventory system to maintain quality and transparency. However, the progress in this direction requires more financial, technical, and capacity support as the needs identified in India's Third Biennial Update Report (BUR-3) have not been yet addressed. Despite leading many developing nations in inventory preparation, India is facing challenges due to non-availability of granular information and particularly fuel consumption statistics in industrial sectors, and data where the sources are large in number, but dispersed spatially with low emission levels per emitting entity. The absence of robust mechanisms for timely data updates adds to these challenges. Nevertheless, efforts to enhance the GHG inventory system continue, aiming to meet both national and international reporting requirements effectively. India is continually improving the accuracy of its GHG inventory by developing a comprehensive system.

### *Energy Sector*

Energy Sector inventory reporting involves methodological upgradation, data refinement, and expanding sectoral coverage during fuel consumption data collection. Capturing fugitive emissions from oil and gas sectors requires technological advancements, which face financial challenges. Incorporating new categories and gases also requires significant capacity-building and financing.

Emissions estimates mainly utilise activity data from government sources. However, industry reports are also utilised if the required data are not available through Government publications/ reports. A more effective data collection system is needed for comprehensive fuel consumption details and sectoral GHG emissions. It's crucial to obtain specific quality metrics for all coal categories including imported coal, detailed records of coal grade deliveries, and develop India-specific sectoral values for NCV and CEF for fuels used in energy and manufacturing sectors. The entire exercise starting from sample collection to analysis, particularly for coal is highly cost intensive.

Uncertainty are there in several sectors, viz. residential, commercial/ Institutional, Fertiliser, non-metallic minerals, non-ferrous metals, chemicals, Textiles, agricultural (stationery fuel combustion), Pulp & paper,

Cement, Iron & steel, manufacture of solid fuel, Engineering Sectors (civil, electrical, electronics, mechanical etc.), where full coverage/ complete information are lacking. Enhancing data accuracy is essential, requiring significant technical and financial support. For liquid fuels, estimation of country specific emission factors is important for transport and various industrial sectors.

Technical constraints and sectoral policy limitations, along with resource constraints, impede corporate GHG accounting and emissions reporting. Data gaps, often overlooking smaller industries, need to be addressed for better accuracy.

## *IPPU*

India employs country-specific emission factors for sectors like cement, soda ash, and nitric acid, while for other sectors default emission factors are utilized. However, the country-specific emission factors in use were established during India's initial national communication and are now comparatively very old, necessitating revisions. According to the 2006 IPCC guidelines, it is advisable to utilise the most detailed, technology-specific, and country-specific emission factors available, particularly those based on direct measurements from various stationary combustion sources. Insights from discussions with both national and international experts indicate that India would greatly benefit from developing its own tailored emission factors. Given this understanding, there is a compelling need for India to create emission factors that specifically reflect its unique circumstances. In the initial phase, India can focus on developing these emission factors for key industries such as cement, ammonia, and iron and steel, thereby enhancing accuracy and relevance of emissions data significantly. This effort is a vital step towards improving India's ability to monitor and mitigate greenhouse gas emissions, aligning with the country's broader climate objectives and commitments.

Further, capacity building of both inventory compilers and data providers is essential. This strengthening of skills and knowledge can lead to more accurate data collection and reporting, ultimately improving the overall quality of national emissions inventories. By enhancing these capabilities, better alignment and effective collaboration with international standards, which is crucial for informed decision-making in climate action can be achieved.

## *Agriculture*

In the agricultural sector, the main constraints in GHG inventory reporting are linked to various data availability issues. Notably, there is a deficiency in updated crop production data, and detailed information on crop-wise nitrogenous fertiliser usage at sub-national level is not publicly accessible. Also, the state-wise rice area under different IPCC classified water regimes is not available. This lack of data leads to increased uncertainty in emission of $CH_4$ and $N_2O$, which are derived from diverse activities including manure management, rice cultivation under various water regimes, use of organic amendments, crop residue burning, and the application of nitrogenous fertilisers (McKinsey and Company, 2020). The data related to crop specific area burned is not available, leading to large uncertainty in emission estimates. Moving to higher tier requires accurate modelling, which needs detailed data on land use, soil characteristics, crop and location specific fertiliser application rates and climate conditions, and these data sets are not available at regular interval. Emissions are therefore estimated by the use of generalised emission factors, with focus on macro-level analyses that may overlook the detailed variability of micro-level agricultural practices.

The development of precise, country-specific emission factors and sequestration rates is challenging, particularly in specialized systems like fruit tree plantations where comprehensive data on carbon dynamics is scarce. Technological limitations, especially in rural areas, affect the precision of GHG monitoring, compounded by a shortage of skilled personnel and financial limitations which hinder comprehensive Measurement, Reporting, and Verification (MRV) systems.

The Department of Agriculture, Co-operation, and Farmers Welfare (DAC&FW) has initiatives aimed at enhancing productivity and resource efficiency. However, the specific mitigation benefits of these initiatives, such as organic farming, conservation agriculture and micro irrigation, have not been quantified yet. Policy frameworks lack robust enforcement mechanisms, stalling effective implementation of GHG mitigation

strategies. Additionally, cultural preferences and traditional farming methods often resist adoption of modern practices. There is a need for more awareness and training among farmers and agricultural officials to enhance the adoption rate of mitigation practices.

Compounding these challenges is the state of sustainable agriculture in India, as detailed in the report 'Sustainable Agriculture in India 2021.' It highlights a range of sustainable agriculture practices and systems (SAPSs) that are not yet widely adopted, with many practices being implemented by less than four percent of farmers. The diversity and fragmentation in the adoption of these practices contribute to difficulties in gathering consistent and comprehensive data across different regions and farming systems. The report underscores the need for enhanced data collection and reporting mechanisms, as well as broader policy support and technological deployment to scale up sustainable practices across India's diverse agricultural landscape, thereby improving the accuracy of emission estimates and facilitating more effective climate action strategies. The detailed data collection at granular level is highly constrained due to financial limitations.

## *LULUCF*

India's Land Use, Land-Use Change, and Forestry (LULUCF) sector faces a number of challenges including consistent time series data and limited data availability on the rate of change of biomass and soil organic carbon (SOC) in different land use categories except for forestland. Standardised reporting needs to consider more transparent harmonisation of various reports/communications/dashboards built across different institutions focusing on dynamics of land cover, that can be revisited for facilitating verification in the long term. There is also a need to revisit components considered under dominant land cover categories, in view of sectors gaining significance after revised policies or conditions of land use practices. Capacity building is required to capture the data requirements for estimating carbon stock using the gain and loss approach. Furthermore, a significant lack of comprehensive wetland data hinders the estimation of carbon emissions. Finance is a major constraint and additional financial support is required to build capacity to adopt suitable land transition models, carbon measurement models, and generate Emission Factors (such as above-ground biomass, below-ground biomass, dead wood, litter, and soil organic carbon fluxes) in different land categories.

In terms of technology and methodologies, substantial advancements are required. Advanced process-based modelling techniques are crucial for moving towards higher tier methodology and facilitating the regular generation of inventory data. A rapid (annual or biennial) cover and change estimation protocol in sync with LULUCF requirements to address cover dynamics as well as tier 3 approach, using mapping supported by model-based indicators, can be a robust alternative in the long term.

A move towards greater transparency and methodological clarity through standardised reporting on adequacy and a unified approach to LULUCF accounting will assist in aligning national commitments (NDCs). Unified approach has potential to account for interdisciplinary parameters spread across sectors of land and vegetation management/cultivation, especially with respect to carbon positive alternative land use aspects being witnessed in various biophysical settings of the country.

## *Waste*

Numerous challenges and deficiencies in estimating GHG emissions within the waste management sector highlights the urgent need for integrated strategies to improve waste management practices and the accuracy of emission calculations.

One of the primary concerns is the significant gap in the comprehensive collection and reporting of waste data, especially concerning the volumes processed and the methods of waste treatment. This issue directly impacts the precision of GHG emissions estimates. Additionally, inconsistencies in waste collection, management, and reporting methodologies across different regions lead to disparities that affect national estimates. Priorities and mandates are different for each reporting agencies, standardizing these methodologies at the national level is crucial to unify reporting and enhance data reliability.

Specific challenges in the sector include the complex nature of municipal solid waste (MSW) management, where the varied composition of MSW, differing levels of recycling, and the proportion of waste undergoing composting or reaching landfills influence methane emissions from anaerobic decomposition. Moreover, the diverse industrial processes and hazardous wastes generated pose challenges in uniform reporting and treatment, impacting GHG emission assessments. Similarly, construction and demolition waste often go unreported in detail, creating significant gaps in understanding its management and associated emissions. In the case of industrial wastewater, despite using expert judgement, few industries are considered for GHG emissions, as most of them operate in the unorganised sector and operate as small and medium scale units example food and beverage industries, this leads to lower estimates. Additionally, few of the industries, such as pulp and paper industry, organic chemicals have upgraded their effluent management with advanced treatment systems and the information could not be captured for estimation. Hence, there is a wide variation in technology acceptance in these industries leading to larger uncertainties in the estimate. Periodical dissemination of data of these industries for effluent management systems w.r.t the requirement of GHG estimates would certainly improve the uncertainties.

Similar situation exists for wastewaters generated from domestic and industrial wastewater as multiple agencies have to collaborate for activity data and emission factors when using Tier 1 and 2 levels. Climbing the top Tier would reduce uncertainty from using default values for AD and EF.

Technological and methodological limitations further complicate emissions estimates. Current methodologies may not fully capture the nuances of organic waste degradation in landfills, affecting methane generation estimates. The sector also suffers from limited access to advanced waste processing and GHG measurement technologies, which can lead to either underestimation or overestimation of emissions. Introducing more sophisticated technologies could significantly improve accuracy.

Additionally, the significant role of the informal sector in waste management, including collection and preliminary processing, is often inadequately captured in official statistics, leading to underreported emissions. Addressing these issues is vital for enhancing waste management strategies, which will not only improve handling and reporting but also enhance the accuracy and reliability of GHG emission estimations for future communications.

**Additional Constraints**

India continues to encounter systemic challenges beyond GHG inventory management, which impact both its mitigation and adaptation efforts. One critical issue is the decentralised Measurement, Reporting, and Verification (MRV) system, which introduces variability in data collection and reporting across states and sectors. Many states lack mandates for the integration of State Action Plans on Climate Change (SAPCCs). On the financial front, India's access to international finance for climate action remains constrained, as a substantial portion of financial assistance is offered as loans rather than grants. This loan-heavy financing increases the fiscal burden, particularly in socially-oriented adaptation projects. In alignment with UNFCCC guidance, India emphasises the need for a more predictable and balanced flow of financial resources to support long-term planning for mitigation and adaptation measures. Additionally, barriers to technology transfer, such as intellectual property restrictions and high costs, have delayed the deployment of advanced renewable energy solutions and adaptation technologies like climate-resilient agriculture and disaster management systems.

Socio-economic challenges, such as poverty, unemployment, and inequality, limit the capacity of vulnerable communities to adopt mitigation and adaptation measures. A substantial portion of the population depends on climate-sensitive sectors like agriculture, fisheries, and forestry for their livelihoods. Climate actions that alter traditional practices or restrict resource use can adversely affect these communities unless alternative livelihoods or support mechanisms are provided. Balancing economic development with environmental sustainability remains a critical challenge. Behavioural changes at individual and community levels are essential for energy conservation, waste management, and sustainable consumption patterns. Without widespread education and awareness campaigns, achieving these behavioural shifts remains challenging.

The transition to the Enhanced Transparency Framework (ETF) under the Paris Agreement intensifies pressure on India's reporting frameworks. There are persistent challenges in ensuring transparency regarding allocating and categorising finance for climate action across various projects. This lack of clarity complicates evaluating how effectively these funds contribute to technology transfer and capacity-building initiatives, limiting the ability to measure their impact accurately. Capacity building remains essential for aligning national GHG inventory practices with these international standards, ensuring transparency, accuracy, and consistency in reporting under UNFCCC guidelines.

***Table 5.6 Constraints Gaps and Requirements***

| Sector | Constraint | Details |
|---|---|---|
| Energy Sector Constraints | Resource limitations | Capturing emissions from MSMEs and fugitive emissions from oil and gas is complex and resource-heavy. |
| | High data collection costs | Significant expenses are incurred for coal quality assessments and fuel combustion measurements. |
| | NCV & CEF values | Country-specific NCV & CEF values need to be developed for gaseous and liquid fuels |
| IPPU Sector Constraints | Old emission factors | Emission factors require updates to reflect current technologies and processes. |
| | Data Granularity | Increased activity data resolution, strengthening fuel testing capacities |
| | Emission Estimation Limitations | Additional finance and capacity building is needed for emission estimation from gasification and pyrolysis |
| | Training gaps among data providers | Limited capacity-building programs hinder accurate data compilation and reporting. Support required for harmonization of the corporate reporting and national inventory reporting |
| Agriculture Sector Constraints | Data gaps in crop and fertiliser usage | Insufficient data on crop production and crop-wise nitrogenous fertiliser usage at sub national level. |
| | Quantification of Mitigation Actions | Additional finance and capacity building is needed to quantify mitigation actions |
| | Measurement across different agro-ecological zones | Intensive measurements across the different agro-ecological zones, |
| | Technological challenges in rural areas | Lack of advanced monitoring technologies reduces efficiency in GHG reporting. |
| LULUCF Sector Constraints | Inconsistent biomass and SOC data | Data gaps on biomass changes and Soil Organic Carbon (SOC) hinder accurate estimations. |
| | Reporting challenges across institutions | Lack of harmonized reporting complicates land-use change tracking. |
| Waste Sector Constraints | Disparities in data collection and reporting | Varied regional methodologies result in inconsistent national waste estimates. |
| | Insufficient hazardous waste data | Limited reporting on industrial hazardous waste and wastewater treatment. |
| | Inadequate capture of informal waste sector data. | The informal sector's contribution to waste management is often underreported, affecting accuracy. |

| Sector | Constraint | Details |
|---|---|---|
| **Other Constraints** | | |
| Decentralised MRV System | Variability in MRV systems | Data collection and reporting differ across states and sectors, affecting consistency. |
| Financial Constraints | Loan-heavy international finance | Climate finance is often offered as loans, increasing the fiscal burden. |
| | Unpredictable financial flows | Uncertain resource availability limits long-term mitigation and adaptation efforts. |
| Technology Transfer Barriers | IPR and high-cost technologies | Intellectual Property Rights (IPR) and high costs hinder access to advanced renewable technologies. |
| | Adoption challenges for adaptation technologies | Limited adoption of climate-resilient technologies like drought-resistant crops or disaster systems. |
| Socio-Economic Challenges | Dependence on vulnerable livelihoods | Many communities rely on climate-sensitive sectors like agriculture and fisheries. |
| | Disruption to traditional practices | Climate actions can disrupt traditional practices without offering sustainable alternatives. |
| | Balancing development with sustainability | Aligning economic growth with sustainability remains complex. |
| Behavioural Constraints | Behavioural shifts | Promoting energy conservation and sustainable consumption requires widespread behavioural shifts. |
| | Insufficient awareness campaigns | Targeted education and awareness programs towards adoption of sustainable practices. |
| | Community engagement | Training programs that incorporate socio-economic aspects of climate adaptation. |
| ETF Challenges | Increased reporting pressure under ETF | The Enhanced Transparency Framework (ETF) under the Paris Agreement raises the demand for reporting. |
| | Lack of financial transparency | Difficulty in categorising and tracking climate finance usage complicates accountability. |

### *5.4.2 Gaps in Research and Innovation*

The identified research gaps across sectors highlight the urgent need for targeted financial support to build capacity and strengthen India's efforts toward sustainable development. In the energy sector, challenges include gaps in grid management research and limited innovation in battery storage, while sector-specific benchmarks for energy-saving technologies remain underdeveloped. Adaptation efforts, such as improving the climate resilience of infrastructure and rural electrification, are constrained by a lack of research.

The industrial sector faces barriers such as high costs and limited access to advanced low-carbon technologies, with insufficient R&D in Carbon Capture and Storage (CCS) and cleaner production processes. Additionally, adaptation is limited by a lack of research into supply chain resilience and vulnerability assessments, crucial for future-proofing industries. In transportation, low R&D investment in electric vehicle (EV) technology, sustainable charging infrastructure, and limited studies on low-emission public transport systems present significant challenges. Adaptation gaps include insufficient research on the resilience of transport infrastructure and behavioural studies on non-motorized transport.

Building and construction sectors are hindered by the low adoption of energy-efficient materials and gaps in urban planning research, while guidelines for climate-resilient architecture remain inadequate. Water resources management requires a better understanding of hydropower emissions and improved regional climate prediction models. Research on sustainable bioresources, such as carbon sequestration through marine resources and scalable algal biofuels, remains limited, as does the resilience of marine ecosystems to climate change.

Low public awareness and engagement further weaken climate action efforts. Addressing these gaps through targeted financial support will enable the necessary research, development, and training across sectors, bolstering India's capacity to meet national goals and contribute to global climate efforts in a just and equitable manner.

## 5.5 Capacity-Building Needs and Support Received

The background for capacity-building support in climate change in India is framed by the pressing need to address the increasing frequency and severity of climate-related impacts on its natural environments, economy, and society. As India navigates these challenges, the focus is on enhancing the country's capacity to understand, plan for, and respond to climate risks effectively.

The agricultural sector, which supports a significant portion of India's population, faces unpredictability due to changing weather patterns. This uncertainty undermines food security and increases the vulnerability of rural populations. Building capacity in climate-resilient agricultural practices, improved water management, and sustainable farming techniques is essential to adapt to these changes and to secure livelihoods. As the frequency of climate-induced health risks rises, there is an urgent need to strengthen the healthcare infrastructure and community health programs to manage new and escalating health threats effectively.

Additionally, the socio-economic impacts of climate change in India necessitates the enhancement of critical infrastructure to withstand extreme weather events, requiring capacity building in resilient construction practices and urban planning. This includes not only technical and infrastructural enhancements but also socio-economic interventions to support affected communities. Strengthening institutional frameworks and policy formulations is equally important for effective climate action as it involves training policymakers, enhancing inter-agency coordination, and developing policies that integrate climate resilience into all aspects of governance and development planning. Furthermore, there is a need for the development of capacity-building programs that address socio-economic barriers, including community engagement, livelihood diversification, and support mechanisms for vulnerable populations.

### 5.5.1 Sectoral Capacity Building Needs: Addressing Constraints & Gaps in GHG Inventory Reporting

To address the identified constraints and gaps in Greenhouse Gas (GHG) inventory reporting, sector-specific capacity-building needs have been outlined to enhance accuracy and efficiency.

**Energy Sector:** Capacity-building efforts in the Energy sector should focus on improving methodologies for estimating emissions, particularly from the Oil and Natural Gas (O&NG) sectors where capturing fugitive emissions is challenging. This includes training in advanced measurement and reporting techniques, enhancing technical expertise in data collection methodologies, and developing cost-effective strategies for fuel analysis. Emphasis should also be placed on the integration and management of renewable energy sources into the grid, enhancing grid stability to handle variable inputs from renewables. Training programs targeting industry personnel, regulatory agencies, and data providers can strengthen Measurement, Reporting, and Verification (MRV) systems. Policy interventions can promote standardized data sharing and transparency across the sector. Additionally, financial support is needed to adopt advanced technologies for monitoring fugitive emissions and to expand sectoral coverage in GHG inventories. Emission estimation is a major challenge from transport modes due to lack of data on vehicle types and usage patterns & limited

adoption of low-emission technologies. Therefore, Capacity building is crucial to model emission for various transport modes, development of sector-specific emission factors, transitioning to electric and low-emission vehicles, and enhancing data collection on transportation activities.

**Industrial Processes and Product Use (IPPU) Sector:** In the IPPU sector, capacity-building initiatives should aim to enhance the technical skills of professionals involved in emissions inventory compilation. This includes training in advanced measurement techniques, data analysis, and alignment with international reporting guidelines. Training programs on advancements in Carbon Capture and Utilization (CCU) technologies are required, specifically for hard-to-abate sectors such as Cement and Steel. Additionally, training that focuses on process optimization and energy efficiency can help industries improve operational efficiencies and reduce emissions. Enhancing skills in environmental compliance and accurate emissions reporting is also necessary. Training programs that are tailored for informal sector participants is required. Efforts are needed towards development of simplified reporting tools & mobilizing financial incentives to formalize data collection, and capacity building for integrating informal practices into formal reporting systems. Establishing collaborations between government agencies, industry stakeholders, and research institutions can facilitate the sharing of best practices and development of updated emission factors. Financial support is essential to support extensive data collection and to develop infrastructure for regular monitoring and reporting.

**Agriculture Sector:** Capacity-building efforts in the agriculture sector should focus on improving data collection infrastructure and training farmers and extension workers in data recording and Sustainable Agriculture Practices (SAPs). This includes enhancing mechanisms to gather accurate data on crop production and fertilizer usage, which is critical for developing sustainable practices resilient to climate change. Implementing training programs on precision agriculture technologies can aid in better resource management and reduce the sector's vulnerability to climate anomalies. Increasing awareness and training on climate impact mitigation—focusing on manure management, organic amendments, and water-efficient practices—is also essential. Educational programs can promote the benefits of SAPs, while investments in technology can facilitate more accurate and efficient data gathering and reporting.

**Land Use, Land-Use Change, and Forestry (LULUCF) Sector:** Capacity-building needs in the LULUCF sector include training in geospatial analysis, remote sensing, and modelling techniques for land-use and land-cover change. Training forestry management personnel in enhanced techniques for forest conservation, reforestation, and afforestation can increase carbon sequestration potential. Capacity building in policy development and community engagement is necessary to ensure sustainable land use and forest management practices are effectively implemented. Strengthening inter-institutional coordination can facilitate data sharing and standardization. Financial investments are necessary to acquire advanced technological tools and support long-term monitoring initiatives. Developing country-specific emission factors and enhancing MRV systems in the LULUCF sector are essential for improving transparency and accuracy in reporting.

**Waste Sector:** Capacity-building efforts in the Waste sector should aim to standardize data collection and reporting practices across regions, integrating the informal sector into formal waste management systems through training and support. Focus should be on training in new waste processing and recycling technologies, including waste-to-energy processes, to reduce emissions from landfills. Enhancing understanding of waste management regulations and best practices can improve compliance and reporting in this sector. Investing in technological upgrades for waste treatment facilities and enhancing the skills of waste management professionals can improve emission estimates and promote the adoption of cleaner technologies. Public education campaigns can develop skills in community outreach to promote waste reduction, segregation, and recycling at the consumer level, further aiding in the sector's overall efficiency and environmental performance. Effective implementation of these recommendations requires substantial financial investments to develop and disseminate tailored emission factors, support the training and capacity building of inventory compilers and data providers, invest in advanced waste processing and GHG measurement technologies, and establish standardized practices, all of which will enhance data accuracy, improve reporting quality, and align waste management strategies with broader climate objectives and commitments.

### *5.5.2 Needs to Strengthen Knowledge Systems on Climate Change Risk & Adaptation*

To adequately respond to the impacts of climate change, India needs to focus on strengthening its knowledge systems to better understand climate risks and improve adaptation strategies across sectors. High-resolution climate modeling tailored to India's diverse climatic zones is essential for accurate predictions and effective adaptation planning. Enhanced climate data collection, especially in remote regions, is critical and should involve modern monitoring technologies and integrate indigenous knowledge systems.

Comprehensive vulnerability assessments are needed to address region-specific risks, factoring in both physical and socio-economic vulnerabilities. Additionally, building capacity for data management and analysis within local and national institutions is vital for informed decision-making. Developing targeted capacity building programs to integrate informal sectors across all relevant areas, ensuring comprehensive data capture and emission reporting is needed. Collaborative research between government, academia, and international bodies will help develop new methodologies for climate risk assessment and adaptation, fostering resilient infrastructure and more effective climate resilience strategies nationwide

### *5.5.3 Needs to Enhance Resilience and Adaptive Capacity*

To reduce climate risk exposure, India must adopt key strategies to mitigate adverse weather impacts and build community resilience. Enhancing weather and climate services is crucial, with a focus on upgrading early warning systems using advanced technology and data analytics to provide accurate, timely alerts, particularly for vulnerable communities. Improved flood management, including better dam capacity, river basin management, and sustainable urban drainage, alongside community-based flood programs, can significantly reduce the toll of flood events. Ecosystem-based approaches, such as restoring wetlands, forests, and mangroves, play a vital role in mitigating climate impacts by reducing storm surges and managing urban heat and flooding. In some cases, the long-term relocation of communities from high-risk areas may be necessary, requiring careful planning to ensure social integration and access to livelihoods. Building local capacity through training programs for officials and community leaders, along with active community engagement in planning processes, ensures that climate adaptation strategies are effective, sustainable, and aligned with local needs.

**Needs to Enhance Resilience and Adaptive Capacity**

India's strategy to enhance resilience and adaptive capacity against climate change focuses on advancing research and innovation, improving financial mechanisms for rural communities, and promoting diversified livelihoods. Significant investment in research is crucial for developing climate-resilient crops, water-efficient irrigation systems, and sustainable housing designed to withstand extreme weather events. Innovation hubs and partnerships among academia, government agencies, and the private sector can translate research findings into scalable solutions.

Strengthening financial resilience through robust rural credit mechanisms is vital. Offering low-interest loans and tailored insurance products to farmers and rural entrepreneurs can provide the necessary financial support for adopting adaptive technologies and practices. Expanding financial literacy programs will further help communities manage climate-related financial risks effectively. Promoting livelihood diversification, such as agroforestry, aquaculture, and eco-tourism, can reduce dependence on traditional agriculture, making communities more resilient to climate shocks. Capacity-building initiatives are essential to equip communities with the skills needed to manage new livelihood opportunities effectively.

Integrating traditional knowledge with modern scientific approaches can create adaptive solutions that are culturally relevant and environmentally sustainable, enhancing local resilience. Effective implementation of these strategies requires supportive policy frameworks and strong institutional capacities. This includes policies for sustainable land use, water management, and energy efficiency, alongside enforcing building codes and environmental regulations. Empowering institutions at all levels will ensure the effective delivery of resilience initiatives. This integrated approach aims to strengthen India's resilience to climate change,

reducing the vulnerability of its ecosystems and communities. Achieving these goals will require sustained collaboration across multiple sectors and disciplines to ensure that adaptation strategies are inclusive, sustainable, and impactful.

### *5.5.4. Institutional Capacity Building Needs*

Institutional capacity building is fundamental for India to effectively tackle climate change. This involves inter-departmental synchronization, improved climate reporting, and the establishment of dedicated climate change units, while integrating traditional and indigenous knowledge systems into adaptation strategies to leverage local insights, thereby enhancing resilience and effectiveness in addressing climate challenges. A focused approach to developing climate change policies and training personnel is essential for robust climate governance. Developing an integrated response framework that promotes collaboration across different government departments and agencies will ensure policy alignment across various sectors such as energy, agriculture, and urban development to ensure that climate change considerations are integrated into all aspects of planning and implementation. Establishing standardized climate reporting protocols to improve the accuracy and consistency of climate data collection will aid in monitoring and evaluating the effectiveness of climate strategies.

Financial support in advanced data management systems that can handle large volumes of climate data, providing real-time insights and forecasts that can guide policy and decision-making. Setting up dedicated climate change units within key government departments for developing and implementing climate-related strategies will ensure that climate considerations are mainstreamed in all departmental activities. Implementing targeted training and capacity building programs focussed on developing specific skills related to climate change adaptation and mitigation, such as climate risk assessment, environmental economics, and sustainable development practices. Furthermore, developing a centralized Climate Change Information Pool that aggregates research, best practices, case studies, and learnings from climate accessible to all stakeholders, including government agencies, researchers, businesses, and the public.

### *5.5.5 Additional Capacity-Building Needs*

India also needs to build capacity in various sectors that includes climate science and impact research, advanced analytical skills, enhanced legal and regulatory expertise, public engagement and communication, technological adaptation and innovation, financial management and fundraising, multi-sectoral coordination, and leadership and strategic management. Climate science research should focus on local and regional impacts of climate change, such as precipitation patterns, temperature fluctuations, biodiversity, agriculture, and water resources. Advanced analytical skills are crucial for interpreting complex climate data and translating it into actionable insights. Legal and regulatory expertise is essential for crafting effective legislation and regulations that support climate goals. Public engagement and communication strategies should be enhanced to better inform and involve communities in climate initiatives. Technological adaptation and innovation should focus on developing new technologies that can mitigate climate impacts or adapt to changing conditions. Financial management and fundraising skills should be strengthened to ensure sustainable and well-funded projects. Finally, leadership and strategic management skills should be enhanced to guide complex projects and drive innovation in climate change mitigation and adaptation strategies. The following table outlines other capacity building needs.

*Table 5.7 Other Capacity Building Needs*

| Category | Capacity Building Needs |
|---|---|
| Strengthen Knowledge Systems | • Development and deployment of high-resolution climate models.<br>• Improvement in climate data collection methods.<br>• Comprehensive vulnerability assessments and risk profiling. |
| Reduce Exposure to Climate Risks | • Enhancement of weather and climate services, including early warning systems.<br>• Strategies and infrastructure improvements to address floods.<br>• Implementation of ecosystem-based approaches for risk reduction.<br>• Planning for long-term relocation of vulnerable communities. |
| Enhance Resilience and Adaptive Capacity | • Encouraging research and innovation in climate adaptation technologies.<br>• Establishment of rural credit mechanisms to support adaptation investments.<br>• Programs that promote community involvement in climate initiatives and training in livelihood diversification strategies to enhance resilience among vulnerable populations. |
| Financial Requirements for Mitigation & Adaptation | • Identification and mobilization of financial resources needed for implementing mitigation and adaptation strategies.<br>• Development of financial instruments and mechanisms to support climate projects. |
| Institutional Capacity Building | • Strengthening of institutional frameworks for effective climate governance.<br>• Development of policies and programs that integrate climate considerations into national and local planning.<br>• Training and capacity building of government officials and stakeholders involved in climate action. |
| Additional Capacity Building Needs | • Training in the adoption and development of climate-resilient technologies<br>• Community engagement and education to keep pace with evolving climate science and technologies.<br>• Training in developing and implementing climate-related legislation and regulations.<br>• Training in designing and implementing monitoring and evaluation systems. |

Efficient, sustainable and iterative capacity building techniques can help create an enabling environment to effectively mitigate and adapt to climate extremes. This dynamic and evolving process should essentially be carried out on an individual, organisational and national level. India by means of the preceding three biennial update reports has extensively detailed out the constraints, gaps and needs such as the issues faced in estimating and reporting GHG inventories, estimating carbon stocks, non-availability, accessibility and consistency of relevant data. However, in a global failure of coordination, developed countries have been unsuccessful in providing ample and required capacity building support to the developing country parties such as India.

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Sapling plantation under Ek Ped Maa Ke Naam Abhiyan

Photo Credit: Ministry of Environment, Forest & Climate Change (MOEFCC)

# Chapter-6: Additional Information

## 6.1 Introduction

As per the Decision 2/CP.17, Annex 3, Para 2 (g), the scope of BURs also includes providing additional information that the non-annex I Party considers relevant to the achievement of the objective of the Convention and deems suitable for inclusion in its Biennial Update Report (BUR). This chapter on additional information encapsulates the significant initiatives of the Government of India focusing on promoting clean and renewable energy, sustainable transportation, energy efficiency, and international collaborations, which aim at achieving its NDC targets and the net zero pledge.

## 6.2 Promotion of Clean and Renewable Energy

### 6.2.1 Renewable Energy

#### *6.2.1.1 Production of energy from renewable energy sources*

The Government of India has undertaken several steps and initiatives to promote and accelerate renewable energy capacity in the country, aiming to achieve 500 GW of installed electric capacity from non-fossil sources by 2030. These include, inter-alia, the following:

- Allowing 100% Foreign Direct Investment (FDI) in Renewable energy under the automatic route;
- Exemption of Inter-State Transmission System (ISTS) charges for inter-state sale of solar and wind power for projects to be commissioned by 30$^{th}$ June 2025;
- Approving the Viability Gap Funding (VGF) scheme offshore wind energy projects, with a total outlay of Rs.7,453 crore. This includes an outlay of Rs.6,853 crore for the installation and commissioning of 1 GW of offshore wind energy projects (500 MW each off the coast of Gujarat and Tamil Nadu) and a grant of Rs.600 crore for upgradation of two ports to meet logistics requirements for offshore wind energy projects.
- Setting a trajectory for Renewable Purchase Obligation (RPO) up to the year 2029-30;
- The Ministry of Power, Government of India, issued a revised "Scheme for Flexibility in Generation and Scheduling of Thermal/ Hydro Power through Bundling with RE & Storage Power" on 12 April 2022 (Amended on 21 June 2023) to increase RE generation capacity and optimize its uptake.
- Establishing Renewable Energy Parks to provide land and transmission access to RE developers for installation of RE projects at large scale ;
- Launching of schemes such as "Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan" (PM-KUSUM), Solar Rooftop Phase II, 12000 MW Central Public Sector Undertaking (CPSU) Scheme Phase II;

- Laying of new transmission lines and creating new sub-station capacity under the Green Energy Corridor Scheme for evacuation of renewable power;
- Approving the Viability Gap Funding (VGF) scheme to support the 4,000 MWh Battery Energy Storage Systems projects by 2030-31, with up to 40% of the capital cost as budgetary support;
- Notification of standards for deployment of solar photovoltaic systems/devices;
- Notification of Quality Control order for Solar Thermal Systems, Devices and Components (Quality Control) Order, 2024
- Star labeling program for Solar PV modules has been launched under voluntary regime by Bureau of Energy Efficiency
- Standard and labeling program for Grid Connected Solar Inverters up to to capacity of 100 kW has also been launched under voluntary regime by Bureau of Energy Efficiency
- Establishing a Project Development Cell for attracting and facilitating investments;
- Issuing of Standard Bidding Guidelines for tariff-based competitive bidding process for procurement of Power from Grid Connected Solar PV and Wind Projects;
- Issuing orders that require distribution licensees to secure power dispatch through a Letter of Credit (LC) or advance payment to ensure timely payment to RE generators;
- Notification of prescribed trajectory of RE power bids issued by Renewable Energy Implementation Agencies from FY 2023-24 to FY 2027-28. CEA-PL-12-67/1/2023-CEET I/43642/202418. Further, the Ministry of Heavy Industries (MHI) formulated PM Electric Drive Revolution in Innovative Vehicle Enhancement (PM E-DRIVE) with an outlay of 10,900 ₹ crore, being implemented from 1st October 2024 to 31st March 2026, for faster adoption of electric vehicles (EVs) paving the way for setting up of charging infrastructure and development of EV manufacturing eco-system in the country (PIB, 2024).

### *6.2.1.2 India's Largest Floating Solar Power Project*

India's largest floating solar power project, the Ramagundam Floating Solar PV Project at Ramagundam, Telangana, became fully operational in July 2022. This 100 MW floating solar project is spread over 500 acres of a reservoir comprising 40 blocks, each with a capacity of 2.5MW. Each of the 40 blocks consists of a floating platform and an array of 11,200 solar modules. The project is estimated to avoid the emission of 1,65,00 tons of $CO_2$ and the water evaporation of 32.5 lakh cubic meters per year (PIB, 2023).

### *6.2.1.3 PM – Surya Ghar: Muft Bijli Yojana*

In February 2024, PM Surya Ghar: Muft Bijli Yojana was launched to transform the country's energy landscape through the harnessing of solar energy. Through a substantial of the cost of installing solar panels on rooftops, the initiative is projected to generate significant savings for the Government annually in electricity costs while meeting the country's renewable energy commitments. As of 4th November 2024, the initiative has received 1.42 crore registrations and 23.79 lakh applications. A total of 5.56 lakh installations have been completed. The initiative also seeks to establish a *model* solar village per district throughout the country, which can aid and empower village communities to achieve energy self-reliance (PIB, 2024).

### *6.2.1.4 GOBARdhan*

The initiative of "Galvanising Organic Bio-Agro Resources Dhan" (GOBARdhan) seeks to convert biodegradable/organic waste into biogas, compressed biogas (CBG), and organic manure. Under this initiative, during the financial year of 2023-24, 198 plants were set up across the country, including 12

compressed biogas plants and 186 biogas plants (PIB, 2024). In June 2023, to facilitate the expansion of this scheme, a one-stop repository (https://gobardhan.co.in) was launched by the Ministry of Jal Shakti to assess investments and participation in the biogas/Compressed Biogas sector (PIB, 2023).

### *6.2.1.5 National Bio-Energy Programme*

In November 2022, the Ministry of New and Renewable Energy launched the National Bioenergy Programme to be implemented in two phases from 2021-22 to 2025-26. The programme seeks to investigate viable solutions for energy recovery from the vast surplus of biomass and other waste available in the country (MNRE, 2022). The program comprises the following sub-themes:

a. **Waste to Energy Programme:** The Waste to Energy Programme seeks to support the establishment of waste-to-energy projects for the generation of biogas/bioCNG/power/producer or syngas from urban, industrial, and agricultural wastes/residues (PIB, 2022). Financial assistance has been made available for successfully commissioning waste-to-energy plants (MNRE, 2022).

b. **Biomass Programme:** The Biomass Programme seeks to support the establishment of biomass briquette/pellet manufacturing plants while supporting biomass (non-bagasse) based cogeneration projects in industries nationwide. Similarly, this programme also provides financial assistance for the setting up of the said manufacturing and co-generation plants (MNRE, 2022).

c. **Biogas Programme:** The biogas programme seeks to support the establishment of biogas plants for clean cooking fuel, lighting, and meeting the thermal and small power needs of users with the aim of reducing GHG emissions, improving sanitation while generating employment, and enabling women empowerment. Another objective of the programme is the promotion of biogas based decentralised renewable energy sources of power generation (3 kW to 250 KW capacity) from the biogas generated through the biogas plants established (MNRE, 2023).

### *6.2.1.6 National Biofuels Policy*

The policy has been amended to advance the blending target of 20% bioethanol in petrol from 2030 to 2025-26 and to include additional feedstocks for biofuel production. This aims to enhance the production and use of biofuels like ethanol and biodiesel, supporting R&D and establishing bioenergy centres for bio-manufacturing low-carbon bio-based products, thereby reducing dependency on fossil fuels and supporting rural economies.

## 6.2.2 Sustainable Transportation

In the transport sector, the activities identified are in three areas namely, efficiency improvement in the conventional fuel vehicles, adoption of electric mobility and modal shift to Railways. The fuel efficiency norms for passenger cars; Heavy Duty Vehicles; and Light & Medium Commercial Vehicles have been notified to reduce carbon footprints. The targeted emission reduction against transport sector is 187 $MtCO_2$.

### *6.2.2.1 National E-Bus Programme*

India's current fleet of 1.5 million buses primarily runs on diesel fuel. As an initiative to promote and transition to electric buses, the Government has launched the National E-Bus Programme. This initiative is expected to popularise e-buses by encouraging private sector participation in procuring and operating these vehicles, fostering their adoption throughout the country. Through this initiative, the prices of e-buses without subsidy have decreased by 29% compared to the cost of petrol/diesel vehicles. After successful pilots, the government rolled out a large unified tender for 5,450 e-buses worth more than USD 1 billion across five States. (PIB, 2023).

### *6.2.2.2 State EV Accelerator Programme*

In line with the need for a robust policy framework that enable transition to Electric Vehicles (EVs) and encourage investment, NITI Aayog has taken a leading role in guiding States and Union Territories to develop and adopt EV policies within the scope of this programme. As of July 2023, NITI Aayog has inspired 33 States/UTs to adopt EV policies, while seven States/UTs are currently drafting their policies (NITI Aayog, 2023).

It is envisaged that the new sales of 2 and 3-wheeler segment will completely shift to electric and 4-wheeler is assumed to be 40% of total new vehicle sale by 2030. Government of India has taken several initiatives to promote electric mobility across the country including accelerated deployment of public Electric Vehicle (EV) charging infrastructure in the country.

### *6.2.2.3 Shoonya- Zero Pollution Delivery Campaign*

In light of the increasing demand for urban freight, the NITI Aayog and Rocky Mountain Institute (RMI) launched "Shoonya-Zero Pollution Delivery Campaign," an initiative promoting zero-pollution delivery vehicles in the year 2021. The initiative seeks to raise awareness of EVs among consumers and recognizes industry efforts through an integrated combination of corporate branding, impact assessment, and consumer awareness. The aims of the campaign include (i) Build awareness and demand for zero pollution delivery among consumers; (ii) Recognise and promote industry efforts towards fleet electrification and (iii) Set the final-mile delivery sector on a pathway to 100% electrification. The major components of the campaign are detailed below:

a. Corporate Branding Programme: Accreditation of all vehicles, delivery partners, and parcels with unique brand logos to certify and encourage the initiatives of e-commerce companies, vehicle manufacturers, and fleet aggregates under this initiative.

b. Consumer Awareness Drive: Campaigns to build public awareness and demand for zero-pollution rides and deliveries among consumers while highlighting the health and environmental benefits of adopting EVs.

c. Resource Toolkits: Providing EV users with online tools to assess the costs and impact of adopting electric vehicles.

### *6.2.2.4 E-Amrit Portal*

At the COP26 summit in Glasgow, UK, in 2021, India launched 'E-Amrit,' a web portal on EVs that serves as a one-stop destination for all information on EVs, including their purchase, investment, opportunities, policies, subsidies, etc. This portal is sought to complement the initiatives of the Government of India on raising awareness of EVs while sensitizing consumers on the benefits of switching to EVs (NITI Aayog, 2022).

### *6.2.2.5 Production Linked Incentive (PLI) Scheme*

In 2021, a PLI scheme for Automobiles and Auto Components was launched by India's Department of Heavy Industries, which proposes financial incentives of up to 18 percent to boost domestic manufacturing of advanced technology products while attracting investment in the automotive manufacturing value chain. Battery electric vehicles (all vehicle segments that meet the performance criteria of the FAME-II scheme) and hydrogen fuel cell vehicles (all vehicle segments) are also eligible under this scheme, thereby creating an enabling environment for transitioning to EVs (PIB, 2022).

PLI scheme on Advanced Chemistry Cell (ACC) Battery storage has been approved by the Union Cabinet with budgetary outlay of Rs. 18,100 crores. The scheme will strengthen the ecosystem for Electric Mobility and Battery Storage in the country. The scheme envisages to enhance India's manufacturing capabilities

of Advanced Chemistry Cell (ACC) by setting up of Giga scale ACC and battery manufacturing facilities in India with emphasis on maximum domestic value addition.

### *6.2.2.6 E-Fast India*

Spearheaded by NITI Aayog, e-Fast (Electric Freight Accelerator for Sustainable Transport-India) is India's first electric freight platform launched in September 2022 through the collaborative efforts of 12 knowledge partners. The platform aims to galvanize the transition towards cleaner and greener freight transportation while facilitating active collaborations at the national and international levels and exploring technological integration and associated research (PIB, 2022).

### *6.2.2.7 BS VI Fuel Economy Standards*

Indian Emission standards based on global standards such as European regulation instituted by the government to regulate the output of air pollutants from compression ignition engines and Spark-ignition engines equipment, including motor vehicles. India has leapfrogged one stage of emission norms, moving directly from Bharat Stage (BS)-IV emission norms to the introduction of BS-VI norms in 2020.The transition to BS IV Fuel Economy Standards is estimated to reduce almost 70% in nitrous oxides and hydrocarbons, and 50% reduction in matter emissions, compared to BS-IV norms.

### *6.2.2.8 National Motor Replacement Program (NMRP)*

Enables easier and faster adoption of efficient motors by addressing the barrier of paying a higher upfront cost by the industry.

### *6.2.2.9 Decarbonisation of the Aviation Sector*

The government has undertaken the following initiatives to fast-track decarbonisation of the aviation sector in the country:

1. India joined the International Civil Aviation Organization (ICAO) Assistance Capacity Building and Training for Sustainable Aviation Fuels Programme.

    - CORSIA – Carbon Offsetting and Reduction Scheme in International Aviation: In order to achieve ICAO's aspirational goal of Carbon Neutral Growth from 2020 onwards, ICAO has adopted market-based measure Carbon Offsetting Reduction Scheme for International Aviation (CORSIA) in its 2016 assembly, under which an aeroplane operator will be required to purchase and cancel "emissions units" to offset any increase in $CO_2$ emissions covered by the scheme. With the exception of a few types of international operations, CORSIA aims to address any annual increase in total $CO_2$ emissions from international civil aviation above the baseline value, which will be set to 2019 annual emissions levels during the pilot phase 2021 to 2023.

    - Phased Implementation:
        - In order to take into account the special circumstances and respective capabilities of States, CORSIA will be implemented in phases: From 2021 until 2026, only flights between States that "volunteer" to participate in the pilot and/or first phase will be subject to offsetting requirements. From 2027, all international flights will be subject to offsetting requirements, except flights to and from Least Developed Countries (LDCs), Small Island Developing States (SIDs), Landlocked Developing Countries (LLDCs), and States, which represent less than 0.5% of international RTK, unless they volunteer to participate.

    - India monitors & collects the verified emissions generated by airlines (International Flights) as per DGCA Civil Aviation Requirements (CAR) Section 10 Series C Part 1 and reports annually to ICAO.

    - India will participate in CORSIA mandatory phase from year 2027 onwards.

2. Sustainable Aviation Fuel

   - Sustainable aviation fuels (SAF) are a viable alternative to traditional aviation fuels to reduce carbon emissions. Non-biofuel methods as effective air traffic management and new aircraft designs with improved fuel efficiency cannot deliver a complete decrease in carbon emissions. Sustainable aviation fuel (SAF), however, has tremendous potential to help in achieving zero emissions goals as SAF is considered to be up to 100% less carbon-intensive over their entire lifecycle compared to fossil jet fuel, for example by using biomass feedstocks that absorb $CO_2$ while they grow up. SAF can be synthesized from a wide range of sustainable, renewable feedstocks, such as municipal waste, waste biomass, sugar and used cooking oils. SAF is proven, safe and even seven production pathways are ASTM-approved today, and more than a quarter million commercial flights have already been operated on SAF since 2011. SAF will support India to meet the Sustainable Development Goals defined by the United Nations, including climate action, good health and well-being, and no poverty, amongst others. The primary benefits of moving to SAF is the reduction of carbon footprint which in turn enhances environmental and health benefits, in addition to economic benefits.

   - India's Initiatives:
     - National Biofuels Coordination Committee formed under MoPNG has recommended to blend Sustainable Aviation Fuel with ATF in near future with the following initial indicative blending percentages (initially for international flights):
     - 1% in 2027,
     - 2% in 2028,
     - 5% by 2030

   - India has joined ICAO's Assistance, Capacity-building and Training for Sustainable Aviation Fuels (ACT-SAF) programme- India has agreed to ICAO's proposal on carrying out SAF feasibility Study in India.

   - DGCA has granted approval for Airbus ferry flights to use 5% blended fuel from Toulouse to India.

   - M/s Vistara conducted its ferry flight of B-787 from USA to India using 28% of SAF blended fuel on 29$^{th}$ March 2023.

   - DGCA has granted approval to M/s Air Asia and it carried out its first commercial domestic flight (Pune to Delhi) with 0.75% SAF blended fuel on 19$^{th}$ May 2023.

   - M/s Praj Industries has started Sustainable Aviation Fuel demonstration facility at its R&D centre in Pune.

3. Mangalore Refinery and Petrochemicals Ltd. would build a bio-ATF pilot plant at Mangalore using CSIR-Indian Institute of Petroleum's technology using non-edible oils and used cooking oil as feedstock.

4. Indian Oil Corporation Ltd. (IOCL) has planned an 86.8 TMTPA plant at Panipat using LanzaJet ATJ (alcohol to Jet) Technology. The Corporation has also signed an MoU with Praj Industries to establish a plant for developing ATJ fuels (PIB, 2023).

5. India's first commercial passenger flight using an indigenously produced Sustainable Aviation Fuel (SAF) blend was flown on 19 May 2023 from Pune to Delhi (PIB, 2023).

Further, in order to reduce Greenhouse Gas emissions in the airspace, the Ministry of Civil Aviation (MoCA) has undertaken the following initiatives (PIB, 2023):

1. Flexible Use of Airspace (FUA): Since its implementation in August 2020, approximately 90,000 $tCO_2$ of carbon emissions have been reduced cumulatively, and 128 Conditional Routes (CDRs) have been promulgated.

2. Implementation of Central Air Traffic Flow Management (C-ATFM): The C_ATFM was operationalised in January 2017, making India the seventh country in the world to implement it. The system's implementation resulted in the saving of approximately 2,141 tonnes of ATF in 2022-23, reducing carbon emissions by approximately 6,767 $tCO_2$.
3. Implementation of Performance-Based Navigation (PBN) has improved the operational efficiency of aircraft operations and reduced fuel consumption and GHG emissions.
4. Continuous Descent Operations (CDOs) have been implemented to permit aircraft to maintain a fuel-efficient arrival flight path, reducing fuel consumption and noise on the ground.

*Fig. 6.1 Solar panels installed at the airport*

## *6.2.2.10 Energy Efficiency at Airports*

India is committed to encouraging airports to use 100% green energy by 2024 and achieve a net zero by 2030. It must be noted that as of April 2023, 25 AAI airports are using 100% green energy. The Ministry of Civil Aviation has also mandated the use of renewable energy as part of the bid document for upcoming airports in the country while working towards encouraging sustainable aviation fuel (PIB, 2023). As a part of these efforts, airports across the country are also undertaking initiatives such as energy efficient Heating, Ventilation, and Air Conditioning (HVAC) and lighting systems, use of renewable energy through offsite mechanisms such as open access and long-term Power Purchase Agreements (PPA). The following are a few achievements of airports that further the cause of decarbonization.

The country's top two major airports, Delhi and Mumbai, have achieved the highest-level 4+ carbon accreditation of Airports Council International (ACI), making them two of the only three airports in the Asia-Pacific region that have achieved this feat (as of May 2023).

The Airport Authority of India (AAI) has installed solar power plants across various airports with a cumulative capacity of more than 54 MWp. It is in the process of procuring 53 million units of solar energy through open access and green power tariffs to increase the share of renewable energy in the energy mix to 35%.

Cochin Airport is the first green airport in the world to be fully powered by solar energy.

A pilot project to provide taxi bots for green taxiing is being undertaken in Chennai and Kolkata airports. These bots can tow aircraft without running their engines, saving the burning of ATF and reducing GHG emissions (PIB, 2023).

## *6.2.2.11 India's First Hydrogen Bus*

To create a carbon-neutral Ladakh, the NTPC Limited, a Public Sector Undertaking (PSU), launched India's first hydrogen buses on public roads. Considered the first green hydrogen mobility project, these fuel cell buses are also designed to operate in sub-zero temperatures in rarefied atmospheres, a characteristic

feature of Ladakh (NTPC, 2023). In addition to this, NTPC is also set to have Hydrogen-Based Fuel Cell Electric Vehicle (FCEV) buses in Greater Noida. Oil India Limited, another PSU that is engaged in conducting oil exploration activities within India and overseas, has developed a 60-kW capacity hydrogen fuel cell bus, a hybrid of an electric drive and a fuel cell (PIB, 2023).

#### *6.2.2.12 National Mission for Enhanced Energy Efficiency (NMEEE)*

The NMEEE was primarily aimed to strengthen the market for energy efficiency by creating conducive policy regime and by leveraging innovative and sustainable business models for improving the energy efficiency. NMEEE unrolled four initiatives - Perform Achieve and Trade Scheme (PAT), Market Transformation for Energy Efficiency (MTEE), Energy Efficiency Financing Platform (EEFP), Framework for Energy Efficient Economic Development (FEEED).

To align objectives of the erstwhile NMEEE with the revised goals under the NDCs, it has been revised with the title Roadmap of Sustainable and Holistic Approach to National Energy Efficiency (ROSHANEE). The mission clearly outlines the strategies for achieving India's Nationally Determined Contribution commitments made under the Paris Agreement.

### 6.2.3 Carbon Neutrality

#### *6.2.3.1 National Green Hydrogen Mission*

On account of the vital role that green hydrogen plays in low carbon and self-reliant economic pathways, the National Green Hydrogen Mission of ₹19,744 crore was launched by the Government of India in January 2023. With an overarching objective of making India a global hub for the production, usage, and export of green hydrogen and its derivatives, the mission will lead to significant decarbonization of the economy and reduce dependence on fossil fuel imports. The Union Budget for 2024-25 has allocated INR 600 crore for the National Green Hydrogen Mission, a 102% increase from the previous year. The tender for the selection of Green Hydrogen Producers under the Strategic Interventions for Green Hydrogen Transition (SIGHT) Scheme (Mode-1-Tranche-I) was awarded on January 9, 2024, to 10 companies for a total capacity of 4,12,000 tons per annum. This significant initiative is aimed at positioning India as a leader in green hydrogen production.

For the achievement of the same, the Mission seeks to build capabilities to produce at least 5 million metric tonnes (MMT) of green hydrogen per annum by 2030 (PIB, 2023). Its other outcomes include 50MT of carbon abatement cumulatively, 60-100 GW of electrolyzer installations, 125 GW of renewable energy for green hydrogen production, and creating 6,00,000 new jobs (MRE< 2023). The following initiatives are supplementing the implementation of the Mission:

1. Strategic Interventions for Green Hydrogen Transition (SIGHT): The Strategic Interventions for Green Hydrogen Transition Programme is a financial measure under the mission that supports domestic manufacturing of electrolyzers and the production of green hydrogen (PIB, 2023).

2. Green Hydrogen Standard: In August 2023, the Ministry of New and Renewable Energy issued the Green Hydrogen Standard for India, becoming one of the first few countries in the world to announce a definition of Green Hydrogen (PIB, 2023). According to the definition, green hydrogen is to have well-to-gate emission of not more than 2kg $Co_2$ equivalent/kg $H_2$ as a twelve-month average and shall include that which is produced by both but not limited to electrolysis or conversion of biomass (MNRE, 2023).

3. Research and Development Roadmap for Green Hydrogen Ecosystem in India: To propel the creation of a green hydrogen ecosystem in India, the Ministry of New and Renewable Energy developed a Research and Development Roadmap for a Green Hydrogen Ecosystem in India. Building on the understanding that research and innovation are essential preconditions for enabling a green hydrogen ecosystem, the report was developed with various stakeholders in the Government, industry, and

academia. The Roadmap identifies thematic areas such as hydrogen production, storage, transport, end-use applications, safety, and an enabling hydrogen framework (MNRE, 2023).

4. Initiatives by Public Sector Undertakings: As of December 2023, Public Sector Undertakings (PSUs) have initiated the following:

   i. Gas Authority of India Limited (GAIL), a Public Sector Undertaking (PSU), has initiated India's maiden project of blending Hydrogen in the City Gas Distribution Grid. For this, two percent by volume of hydrogen is being blended in the CNF network, and five percent by volume of hydrogen is being blended into the PNG network at the City Gas Station of Avantika Gas Limited (AGL) located in Indore, Madhya Pradesh (PIB, 2023).

   ii. NTPC Limited has also initiated the blending of Green Hydrogen up to 8% (vol/vol) in the PNG network at NTPC Kawas Township, Surat, Gujarat, since January 2023 (PIB, 2023).

5. Scheme for Pilot Projects for the use of Hydrogen in the Transport Sector: In line with the vision to establish a green hydrogen ecosystem in the transport sector, the Government of India launched 'Scheme Guidelines for the Implementation of Pilot Projects for the Use of Green Hydrogen in the Transport Sector' and identified Scheme Implementing Agencies (SIAs). This scheme, which shall be implemented through the Ministry of Road Transport and Highways and identified Scheme Implementing Agencies (SIAs) seeks to support the development of necessary technologies for the use of green hydrogen as an alternative fuel in buses, trucks, and four-wheelers through the adoption of fuel cell-based propulsion technology/internal combustion engine-based propulsion technology. In addition to this, the scheme shall also support other forms of innovative uses of hydrogen that will reduce emissions in the transport sector (PIB, 2024). Its objectives are as follows (MNRE, 2024):

   i. To support the deployment of Green Hydrogen as fuel in buses, trucks, and four-wheeler vehicles in a phased manner on a pilot basis

   ii. To validate the technical feasibility and performance of Green Hydrogen operated vehicles under real-world operational conditions

   iii. To evaluate the economic viability of hydrogen-based vehicles

   iv. To assess the effectiveness of hydrogen refueling station

   v. To evaluate the performance of hydrogen-based vehicles and identify the areas for improvement

   vi. To demonstrate safe and secure operations of hydrogen-based vehicles and hydrogen refueling stations.

6. Scheme for Pilot Projects for the use of Hydrogen in the Shipping Sector: In February 2024, as an extension of its initiatives under the National Green Hydrogen Mission, the Ministry of New and Renewable Energy launched 'Scheme Guidelines for Implementation of Pilot Projects for the use of Green Hydrogen in the Shipping Sector.' The scheme will be implemented through the Ministry of Ports, Shipping and Waterways (MoPSW), and identify implementing agencies. The thrust areas for the identified pilot projects include retrofitting of existing ships to enable them to run on green hydrogen and the development of bunkering and refueling facilities in ports on international shipping lanes for fuels based on green hydrogen (PIB, 2024). The objectives of the scheme are as follows (MNRE, 2024):

   i. To support the deployment of green hydrogen and its derivatives as fuel for ship propulsion, including bunkering and refueling on a pilot basis

   ii. To validate technical feasibility and performance of green hydrogen and its derivatives-based ship propulsion in real-world operational conditions.

   iii. To evaluate the economic viability of the use of green hydrogen and its derivatives in the shipping sector

   iv. To assess the effectiveness of green hydrogen and its derivatives in ship propulsion and bunkering and refueling systems on ports

v. To evaluate the performance of green hydrogen and its derivatives-based propulsion system, bunkering, and refueling systems and identify the areas of improvement.

vi. To demonstrate safe and secure operations of green hydrogen and its derivatives-based population system, bunkering, and refueling systems.

7. Scheme for Pilot Projects for Use of Hydrogen in the Steel Sector: The Ministry of New and Renewable Energy in February 2024 launched 'Scheme Guidelines for the Implementation of Pilot Projects for the Use of Green Hydrogen in the Steel Sector under the National Green Hydrogen Mission' to be implemented by the Ministry of Steel. The thrust areas of the scheme is to assess the potential use of Green Hydrogen in the steel industry and supports setting up of pilot projects in the steel sector. MECON, a CPSE under Ministry of Steel has been nominated as Scheme Implementing Agency for implementation of pilot projects in iron & steel sector. Currently, pilot projects are being implemented in three key production routes: Project to produce DRI using 100% Hydrogen using vertical Shaft, use of hydrogen in existing Blast Furnace to reduce coal/ coke consumption and injection of Green Hydrogen in existing vertical shaft based DRI making unit to partially substitute the natural gas.

   i. To advance technologies and expertise for the utilisation of green hydrogen in steel making processes, while addressing any existing gaps.

   ii. To support the deployment of green hydrogen and its derivation in the steel industry, on a pilot basis

   iii. To evaluate the technical feasibility and performance of green hydrogen and its derivatives in the iron and steel manufacturing in real-world operational conditions.

   iv. To evaluate the economic viability of the use of green hydrogen and its derivatives in the iron and steel sector

   v. To evaluate the performance of green hydrogen and its derivatives based low-carbon iron and steel and identify the areas for improvement

   vi. To demonstrate safe and secure operations of green hydrogen and its derivatives-based production of low-carbon iron and steel.

8. Green Hydrogen Hubs: The National Green Hydrogen Mission also seeks to identify and develop regions capable of supporting larger-scale production and/or utilisation of hydrogen in the form of Green Hydrogen Hubs. For the same, three major ports in the country (Deendayal, Paradip, and V.O Chidambaranar) have been identified for development as Green Hydrogen Hubs (PIB, 2024).

9. National Green Hydrogen Portal: In May 2024, the government launched a dedicated portal that would act as a one-stop location for all information relevant to the National Green Hydrogen Mission, its progress, and the development of a green hydrogen ecosystem in India.

10. Other decarbonization initiatives:

    The cooling demand is set to rise in the future. This will result in increased use of refrigerants and energy use for cooling. The Kigali Amendment to the Montreal Protocol for phase down of Hydrofluorocarbons (HFC) has for the first time recognized the linkages between refrigerant transition and energy efficiency of air-conditioning equipment.

    The India Cooling Action Plan (ICAP) seeks to provide an integrated vision towards cooling across sectors encompassing inter alia reduction of cooling demand, refrigerant transition, enhancing energy efficiency and better technology options with a 20-year time horizon.

    BEE and SIDBI are jointly implementing several initiatives for decarbonization of Indian industrial sectors. We believe that this cooperation will further be strengthened with the launch of decarbonization facilities today. Which includes decarbonization challenge fund and industrial decarbonization financing facility.

11. Financial Initiatives

    (a) **Energy Efficiency Financing Platform (EEFP):** The main objective of EEFP is to upscale energy efficiency financing in India by providing a platform where Financial Institutions (FIs) can interact with industries for financing and implementation of energy efficiency projects, technologies and appliances. Under Financing Energy Efficiency Programme (FEEP) BEE has been working upon various financing initiatives from capacity building of FIs to designing incentives for FIs and industries.

    (b) **Framework for Energy Efficiency Economic Development (FEEED):** BEE has created financial instruments including an Energy Efficiency Financing Platform which aims to interact with Financial Institutions (FIs), project developers and other stakeholders for the implementation of energy efficiency projects and accelerating energy efficiency financing.

# 6.3 Weather and Climate Services

## 6.3.1 Initiatives by the Ministry of Earth Sciences

### *6.3.1.1 Atmospheric Research Testbed (ART) Facility in Central India*

The ART program is an observational and analysis research effort launched by the Ministry to understand and help compare observations with modeling forecasts and simulations for accelerating improvements in observational methodology and monsoon prediction models. A 72 m tall tower has been installed with three levels of instruments for GHG measurements, photosynthetically Active Radiation (PAR) sensors and Line PAR sensors, eight levels of multicomponent weather censors, and soil moisture measurements at ten levels below growth. These multilevel measurements will facilitate the generation of information about the variation and mixing of GHGs within the surface layers and above (MoES, 2023).

### *6.3.1.2 NCMRWF Extended Range Drought Monitoring System*

The Ministry of Earth Science developed a new drought monitoring system using a standardised precipitation index (SPI) computed from a multi-week extended range prediction system (NERP) based on the Unified global coupled modeling system that has been implemented for characterising the droughts on sub-seasonal timescales (MoES, 2023).

## 6.3.2 National Framework of Climate Services (NFCS)

The Indian Meteorological Department (IMD), In January 2024 (Nandi, 2023), launched the National Framework of Climate Services (NFCS). Created under the aegis of the Global Framework for Climate Services (GFCS), the framework is set to strengthen the production, availability, delivery and application of science-based climate monitoring and prediction services. Its major objectives are as follows (IMD, 2022):

1. Set up a formal mechanism that will facilitate mutually agreed responsibilities and commitments covering the five pillars of the GFCS and its priority areas to enable timely and targeted exchange of relevant information.
2. Promote improved coordination between services providers and user sectors.
3. Create sustainable platforms to enable timely and targeted exchange of climate information leading to improvement in the delivery of climate services.
4. Facilitate improved understanding of the roles and responsibilities of different agencies in climate-sensitive decision contexts to further allow customisation of services as required.

# 6.4 Disaster Management

## 6.4.1 Heat Action Plans

The Heat Action Plans are a comprehensive early warning system and preparedness plan for extreme heat events, that presents immediate as well as long-term actions to increase preparedness, information-sharing, and response coordination to reduce the health impacts of extreme heat on vulnerable populations. The National Disaster Management Authority (NDMA) and IMD are working with 23 States in the country that are prone to high temperatures in the preparation and implementation of these plans. The main aims of the Heat Actions Plans are as follows:

1. Establishment of Early Warning Systems and Inter-Agency Coordination to alert residents on predicted high and extreme temperatures.
2. Capacity-building and training programmes for health care professionals at local level to recognise and respond to heat-related illnesses, particularly during extreme heat events.
3. Dissemination of public awareness messages on protection against extreme heat waves.
4. Collaborations with non-government and civil society organisations to improve and build temporary shelters, water delivery mechanisms in public areas.
5. Identification of vulnerable populations and the health risks specific to each group.
6. Development of effective strategies, agency coordination and response planning to address heat health risks.
7. Creation of a Heat Health Information Surveillance System (HHISS) to monitor and assess the impact of heat waves on human health.
8. Reduction of heat exposure and promotion of adaptive measures by launching new efforts including the mapping of high-risk areas, access to potable drinking water and cooling spaces during extreme heat days (MoES, 2023).

## 6.4.2 Climate Hazard and Vulnerability Atlas of India

IMD launched a web-based online 'Climate Hazard and Vulnerability Atlas of India' that has been comprehensively created for the thirteen most hazardous meteorological events that potentially cause extensive damages, economic, human and animal losses. This atlas currently assists State government authorities and Disaster Management Agencies in the planning and taking of appropriate action to tackle various extreme weather events that can assist in the building of climate change resilient infrastructure (PIB, 2023).

# 6.5 Gender and Climate Change

## 6.5.1 Women in Disaster Risk Reduction

India has ensured that women remain pivotal to the disaster risk management and planning. Prominence was given to women empowerment and their leadership role in the revision of the National Disaster Management Plan (NDMP). Some of the major initiatives for the involvement of women in disaster risk management and planning are:

1. To increase the participation of women in disaster risk management, an increased number of women are being trained as Aapda Mitra volunteers, in the maintenance and management of Cyclone

Shelter Management and Maintenance Committees (CSMMC). As of December 2023, out of the 94,197 trained Aapda Mitra Volunteers, 16,822 are women.

2. Key roles have been allotted to women in various Task Force Groups that are related to disaster preparedness and rescue operations, training and mick drills.

3. The Mahila Contingent from the Central Armed Police Forces (CAPFs) are being trained and deployed for National Disaster Response Force (NDRF) for disaster management (PIB, 2023).

## 6.5.2 Clean Cooking Fuel

### *6.5.2.1 Pradhan Mantri Ujjwala Yojana*

The Ministry of Petroleum & Natural Gas launched the Pradhan Mantri Ujjwala Yojana (PMUY) in May 2016, with the dual objectives of empowering women and enabling social change. The scheme provides LPG (Liquefied Petroleum Gas) connections to women from Below Poverty Line (BPL) households, thereby eliminating exposure to serious health hazards associated with cooking based on fossil fuels. This shift has led to a revolution in clean fuel cooking in the country since burning residential solid fuels comprises 58% of black carbon emissions, whilst also being a significant contributor to household air pollution. To expand this initiative, in September 2023, it was sought to release 75 lakh LPG connections over the financial years of 2023-24 to 2025-26, taking the number of beneficiaries under the scheme to 10.35 crore (PIB, 2023).

### *6.5.2.2 Pratyaksh Hastantarit Labh*

The initiative Pratyaksh Hastantarit Labh (PAHAL), monitors the sale of subsidized LPG cylinders in the black market by transferring electronically the applicable subsidy to the individual's bank account. This ensures that the distribution of LPG cylinders to the beneficiaries was effectively implemented.

### *6.5.2.3 GIVE IT UP*

Designed as a voluntary initiative, GIVE IT UP encouraged people to voluntarily surrender their subsidies, resulting in millions of Indians giving up their subsidies, which ensured that these funds could be redirected to those who were in genuine need of the subsidy for access to clean cooking fuel.

# 6.6 India's Global Initiatives

## 6.6.1 Global Biofuel Alliance (GBA)

On the sidelines of G20 meeting in 2023, the Global Biofuel Alliance (GBA), was launched along with Singapore, Bangladesh, Italy, USA, Brazil, Argentina, Mauritius and UAE. The alliance seeks to serve as a catalytic platform that can foster collaboration for the advancement and widespread adoption of biofuels (MEA, 2023). In addition to seeking cooperation and to intensify use of sustainable biofuels, it shall build on strengthening markets, facilitating global biofuels trade, and the development of concrete policies for enabling the use of biofuels across the world (PIB, 2023).

## 6.6.2 International Solar Alliance

The International Solar Alliance (ISA), conceived as a joint effort of India and France at the sidelines of CoP21 (Conference of Parties) at the UNFCCC (United National Framework on the Convention of Climate Change), seeks to mobilise the efforts against climate change through the deployment of solar energy solutions. With 116 countries as the signatories to the ISA Framework Agreement, 94 countries have submitted the necessary instruments to become full members of the ISA.

ISA seeks to assist nations and policymakers through support in analytics and advocacy, capacity building, programmatic support, risk mitigation, innovative financing instruments and investment mobilisation. It attempts to address various existing gaps in the policy and regulatory ecosystems, techno-commercial viability, equipment quality, implementation of global standards, technical competence, data availability, and information sharing through the following initiatives:

A. Programmatic Support: The ISA has nine comprehensive programmes namely, Scaling Solar Applications for Agriculture Use (SSAAU), Affordable Finance of Scale, Scaling Solar Mini-Grids, Scaling Solar Rooftop, Scaling Solar E-mobility and Storage, Solar Park, Solarising Heating and Cooling System, Solar PV Battery and Waste Management and Solar for Green Hydrogen. These programmes are at various levels of development and implementation across different countries. For example, 'Programme 3: Scaling Solar Mini-Grids', launched in 2017 in Gujarat, India saw the development of a E-Handbook for Solar Mini-Grids on the technical aspects of solar mini-grids, benefits and best practices, and the training of 479 technicians across 40 member countries.

B. Grant Support: ISA also provides technical and financial support to Least Developed Countries (LDCs) and Small Island Developing States (SIDS) for the establishment of solar pilot projects. As of 2023, 27 countries have availed a grant of up to 50,000 USD for the implementation of projects in the areas of solarisation of health care centre's, solar pumps, solar cold storage and others.

C. STAR-C: A STAR Centre is a training, knowledge, and expertise hub on solar energy and a go-to place for the member countries at regional and country levels to meet Countries' capacity-building needs by building capable solar workforces, sensitizing policymakers and financial institutions, incubating enterprises, standardizing products and services, and creating knowledge repository on information/ data related to solar energy. A STAR Centre has all the necessary equipment, instruments, and pedagogy for multi-stakeholder training. As of October 2024, seven STAR centers are operational in Ethiopia, Somalia, Ghana, Cuba, Bangladesh, Cote d'Ivoire, and Kiribati.

Eleven demonstrations projects funded by ISA and commissioned in ISA Member Countries are a solar cold storage projects in Bhutan, Djibouti and Senegal, solarization of primary healthcare centres in Burkina Faso and a hospital in Mauritius, solarisation of schools in Cambodia, solar-powered water pumps in Cuba, Ethiopia, the Gambia and Tonga, solar streetlights in Samoa.

### *6.6.2.1 One Sun One World One Grid*

The initiative of One Sun One World One Grid (OSOWOG), was first envisaged in the First Assembly of the ISA in 2018, which aims to connect different regional grids through a common grid for the transfer of renewable energy power, unleashing the ultimate potential of renewable energy sources. The Initiative was then launched by the Prime Minister of India and the Prime Minister of the United Kingdom during the 'Accelerating Innovation and Clean Technology Deployment' event at the World Leaders Summit at the CoP 26 in 2021.

The following are the three objectives of the initiative through its three key pillars of engagement:

a) Political Engagement: Attaining political engagement for trust building among member countries through an intergovernmental steering group that has representation from every region.

b) Institutional Engagement: Enabling institutional engagement between international financial and technical institutions through a joint coordination committee that includes ISA and other partners such as the World Bank.

c) Research and Knowledge Sharing: It seeks to promote research and knowledge sharing through the Green powered Future Mission, a newly launched international innovation program that encourages peer to peer learning networks of regulators and grid operators.

Overall, through this initiative, OWOSOG seeks to bring more technical, financial and research co-operation to facilitate cross-border renewable energy transfer projects, enable a faster leap towards a global ecosystem

of interconnected renewables and provide a pool of investment for low-carbon and innovative solar projects while creating millions of new green jobs (ISA, 2022).

## 6.6.3 LeadIT 2.0

The Leadership Group for Industry Transition (LeadIT), launched by the Governments of Sweden and India at the UN Climate Action Summit in September 2019 and supported by the World Economic Forum gathers 18 countries and 21 companies that are committed to action to achieve the Paris agreement. The Group's second phase was launched at COP28 in December 2023, marking a joint commitment by the member countries and companies for an inclusive industry transition. This second phase builds on three pillars of activities namely; creation of a just and equitable industry transition including the monitoring of the pace of transition, promotion of technology transfer and co-development and support industry transition partnerships for coordinated multilateral assistance.

During the World Climate Action Summit at the COP28, the heads of Government of India and Sweden launched a new North-South partnership that jointly spearheaded an ambitious and accelerated industry transition. While agreeing to take immediate action together for a just and equitable transition and net-zero emissions from industry by 2050 in line with the goals of the Paris Agreement, by launching the India -Sweden 'Industry Transition Partnership' (MEA,2023).

The Group hosts multiple components in order to track and assist various groups for the decarbonisation of the respective sectors and their companies such as the transition tracker, green steel tracker and the green cement technology tracker. The Group also provides assistance through the 'Roadmap Planner' which provides decision-makers with detailed guidelines and recommendations to identify the main steps, key actors, essential actions and measures to achieve decarbonisation targets as well as the industry transition vision. The Planner also serves as a neutral platform for linking diverse narratives and disconnected strategies at various governance levels for the creation of coherent industry transition pathways.

## 6.6.4 Coalition for Disaster Resilient Infrastructure

An India-led initiative launched in September 2019 at the New York Climate Action Summit, the Coalition for Disaster Resilient Infrastructure (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 2 private sector organizations. The following are the initiatives being undertaken by CDRI for building resilience:

### *6.6.4.1. 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 Small Island Developing States (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.

### *6.6.4.2. 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 conceptualised 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) (ICWA, 2023).

### *6.6.4.3. Disaster Resilient Infrastructure (DRI) Connect*

It is a digital stakeholder learning, engagement, 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 (ICWA, 2023).

### *6.6.4.4. 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.

### *6.6.4.5. Infrastructure Resilience Accelerator Fund*

Launched at the India Pavilion at CoP27 in 2022, the Infrastructure Resilience Accelerator Fund (IRAF) is a CDRI Multi-Partner Trust Fund, established with the support of UNDP and the United Nations Office for Disaster Risk Reduction (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 such as the Government of India, the United Kingdom, Australia, and the European Union.

#### *6.6.4.6. 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.

#### *6.6.4.7. Finance for Resilient Infrastructure Programme*

The Finance for Resilient Infrastructure Programme (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 conceptualised in collaboration with the Department of Economic Affairs (DEA), other key infrastructure ministries of the Government of India and NITI Aayog (CDRI, 2022).

### 6.6.5. National Infrastructure Pipeline

The G20 New Delhi Leaders' Declaration includes a commitment to triple renewable energy capacity globally by 2030 aligning with India's efforts to attract significant investments to meet renewable energy targets and strengthen infrastructure resilience against climate change impacts. National Infrastructure Pipeline focuses on strengthening infrastructure to cope with climate change impacts, boosting urban and rural resilience, refining water management systems, and promoting sustainable farming practices.

### 6.6.6 International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE)

India hosted the 41st Steering Committee Meeting of the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE) in March 2024 that witnessed participation from delegates of Austria, Chile, France, European Commission, Japan, Germany, Netherlands, UAE, US, Singapore and South Korea. The Committee saw discussions centering around initiatives undertaken for green hydrogen at the international level while investigating opportunities to collaborate with such international initiatives. The Working Groups (WGs) constituted by the Committee deliberated on "Regulations, Codes, Standards and Safety" and "Education and Outreach", while the Task Forces ideated and provided suggestions on "Hydrogen Skills", "Hydrogen Production Analysis", "Hydrogen Certification Mechanisms" and "Hydrogen Trade Rules" (PIB, 2024).

### 6.6.7 Mission Innovation

Mission Innovation (MI) is a global initiative of 23 Countries and the European Commission (on behalf of the European Union) catalysing a decade of action and investment in research, development and demonstration to make Clean Energy affordable, attractive and accessible for all (http://mission-innovation.net). It was announced at COP21 on November 30, 2015, as world leaders came together in Paris to commit the ambitious efforts to combat climate change.

India took initiative in sowing the seed of 'Mission Innovation', a term coined by our Hon'ble Prime Minister Shri Narendra Modi. The initiative focuses on maximizing the impact of research, development, and demonstration (RD&D) investments through collaborative efforts and partnerships with stakeholders worldwide.

The Department of Science and Technology (DST) is the designated country focal point and coordinates MI activities in India. Since inception of MI, DST is actively participating in MI workstreams and scaled up its R&D programmes as per the goals and targets of MI.

India is participating in six MI missions namely Clean Hydrogen, Green Powered Future, Carbon Dioxide Removal, Urban Transition, Integrated Biorefineries, Zero Emission Shipping and exploring opportunities in Net-Zero Industries. India is also an active member and contributing to MI Discovery zone with prime focus on Innovation Community on Affordable Heating and Cooling of Buildings (IC-7), Materials for Energy, Sustainable Aviation Fuel and Insight module. India is also the member of MI Steering Committee and the Technical Advisory Group.

India hosted the joint Ministerial Event of the 8th Mission Innovation (MI-8) and 14th Clean Energy Ministerial (CEM-14) alongside the G20 Energy Transition Ministerial Meeting (ETMM) from July 19-22, 2023, in Goa, witnessing 3,000 participants to address global clean energy challenges. A delegation from India also took part in the 9th Mission Innovation Ministerial (MI-9) held in Foz do Iguaçu, Brazil from 30th Sept to 4th Oct 2024. Mission innovation workstreams have the potential to unlock affordable decarbonisation for sectors responsible for more than half of global emissions.

### 6.6.8 Clean Energy Ministerial (CEM) Initiatives

The Clean Energy Ministerial (CEM) is a high-level global forum that promotes policies and programs advancing clean energy technology. The CEM serves as an international leadership platform, a convening platform, an action platform, and an acceleration platform. It helps shape the global clean energy agenda, facilitates knowledge exchange, and supports members in achieving domestic clean energy objectives. The initiatives under CEM, such as the Global Lighting Challenge and One Sun-One World-One Grid, continue to support clean energy development.

## 6.7 Other Environmental Initiatives

Other relevant actions and environmentally sustainable initiatives (e.g., circular economy, LiFE, knowledge management etc.,) undertaken by the Government of India and other State Governments.

### 6.7.1 Lifestyle for Environment (LiFe) Movement: Mission LiFE

LiFE or Lifestyle for Environment is an India-led mass movement that was introduced by the Prime Minister of India at COP26 in Glasgow in November, 2021, calling upon the global community at individuals and institutions to drive LiFE as an international mass movement towards 'mindful and deliberate utilisation, instead of mindless and destructive consumption' to protect and preserve the environment. Thereafter, Mission LiFE was launched by Hon'ble Prime Minister in October, 2022 in the presence of the UN Secretary General Antonio Guterres at Kevadia, Gujarat as an advocacy and awareness movement to protect and preserve the environment.

Mission LiFE is a behavioural change framework that works through simple behavioural nudges to transform the way individuals and communities' function, and to make them more synchronous with nature. It aims to create a network of **Pro Planet People** who are dedicated to adopting and promoting environmentally conscious and sustainable lifestyles. It comprises of comprehensive and non-exhaustive list of seventy-five individual LiFE actions spread across seven themes, namely, save water, save energy, reduce waste, reduce e-waste, reduce single-use plastics, adopt sustainable food systems, and adopt healthy lifestyles. To fulfil this target mission LiFE envisions three core shifts in our collective approach towards sustainability which are as follows:

- **Change in Demand (Phase 1):** Nudging individuals across the world to practice simple yet effective environment-friendly actions in their daily lives.

- **Change in Supply (Phase 2):** Changes in large-scale individual demands are expected to gradually nudge industries and markets to respond and tailor supply and procurement as per revised demands.
- **Change in Policy (Phase 3):** By influencing the demand and supply dynamics of India and the world, the long-term vision of LiFE is to trigger shifts in large-scale industrial and government policies that can support both sustainable consumption and production.

To catalyse pan-India advocacy and awareness about LiFE, a mass mobilization drive was undertaken by various Ministries, State/UT Governments, and their Field Offices and institutions and so far, more than 3.93 crores people have participated in 19.45 Lakh LiFE events. Hon'ble Prime Minister launched the campaign 'Ek Ped Maa Ke Naam'(Plant4Mother) by planting a sapling of Peepal Tree at Buddha Jayanti Park, New Delhi on 5th June, 2024 on the occasion of World Environment Day. Under the campaign, people are encouraged to plant a tree as mark of love, respect and honor for their mother and also to take a pledge for protecting trees and Mother Earth. The campaign aims for halting land degradation and eco-restoration of degraded land parcels. The campaign was attributed as India's quest towards sustainable development. Under this campaign, MoEFCC has assigned a plantation target of 80 crore trees by September 2024 and 140 crore trees by March 2025. By the end of November 2024, the plantations undertaken have crossed one billion trees, thereby achieving the target set for Sept. 2024. This has been made possible through collective efforts of Government Agencies, village-level institutions, the local people, and other stakeholders (MoEFCC, 2024).

The Ministry has also developed two dedicated portals for LiFE, in order to create a structured reporting format that can track the progress being made under Mission LiFE. The Mission LiFE Portal is a repository of Creatives and Videos on Mission LiFE. The Meri LiFE Portal has been developed to capture the progress of the mass mobilisation drives/events under Mission LiFE.

Aligned with Mission LiFE's objectives, 'Ideas4LiFE' has been launched to invite innovative ideas on seven themes of LiFE to promote environmentally friendly lifestyles and combat climate change. The initiative seeks practical and impactful citizen centric solutions from students, faculty, and research scholars for promoting sustainable lifestyles. The last date for submission of the ideas on the web portal https://ideas4life.in/ is 15th October, 2024. More than 3916 students have so far registered on the portal and 1057 students have submitted their ideas on the portal. The winning ideas under each theme under this initiative will be recognized and awarded with attractive prizes for individuals as well as for institutions.

The United Nations Environment Assembly (UNEA), at its Sixth Session held in Nairobi, Kenya, on 1st March, 2024, unanimously adopted the resolution on promoting sustainable lifestyles (UNEP/EA.6/l11) submitted by India and co-sponsored by Sri Lanka and Bolivia which is a significant move forward on globalisation of the concept of Lifestyle for Environment (LiFE).

Mission LiFE and its principles have also been incorporated in the non-quantitative targets of India's Nationally Determined Contributions (NDCs). It has been appreciated across the Globe according to references in IPCC Working Group III, Sharm–El–Sheikh implementation plan, G7 Communique, in joint statement of official visit of Hon'ble PM of India to USA, G20 New Delhi Leaders' Declaration, Green Rising initiative in CoP 28.

India securing a position as Board Member on the Board of 10-Year Framework of Programmes for sustainable consumption and production patterns is a global acknowledgement of India's leadership and efforts towards promoting sustainable lifestyles.

Prime Minister addressed the 'Summit of the Future' on September 23, 2024 held at the United Nations in New York. In his address, Prime Minister highlighted India's vision for shaping a sustainable world for future generations. Calling for the primacy of a human-centric approach in our collective quest for a bright global future, the Prime Minister highlighted India's success at scaling sustainable development initiatives and, in this regard, noted that the country had lifted 250 million people out of poverty in the last decade. He also underlined India's commitment to "One Earth, One Family, One Future" as a guiding principle. Besides, a delegation led by Secretary, MoEFCC visited the United Nations Headquarters, New York to participate in the Summit of the Future, Side Event: "Empowering Youth for Sustainable Futures: Inter-generational Responsibility and Skills for a Just Transition" co-organised by the UNEP, CYMG and the Government of

Cyprus, Portugal, in collaboration with ILO and UNICEF in New York. At this event held on 20.09.2024, MoEFCC focused on youth engagement for a just transition towards sustainability, highlighting India's Mission LiFE initiative and the Green Skill Development Programme. The Secretary's speech emphasized the need to equip youth with green skills, aligning with the principles of inter-generational equity.

## 6.7.2 International Big Cat Alliance (IBCA)

The Union Cabinet chaired by Prime Minister Shri Narendra Modi approved the proposal of India to become a member country of the International Big Cat Alliance (IBCA) by signing and ratification of the Framework Agreement on the establishment of the International Big Cat Alliance (IBCA).

- On the occasion of Commemorating 50 years of India's Project Tiger on April 9, 2023 the Prime Minister launched an International Big Cat Alliance aiming at securing the future of big cats and landscapes they thrive. Seven big cats include Tiger, Lion, Leopard, Snow Leopard, Puma, Jaguar and the Cheetah. Out of these five big cats viz. Tiger, Lion, Leopard, Snow Leopard and Cheetah are found in India.
- The Union Cabinet in its meeting held on 29.02.2024 approved the establishment of International Big Cat Alliance with Headquarters in India with a one-time budgetary support of Rs. 150 crores for a period of five years from 2023-24 to 2027-28.
- The International Big Cat Alliance aims to be multi-country, multi-agency coalition of 95 big cat range countries, non-range countries interested in big cat conservation, conservation partners and scientific organizations working in the field of big cat conservation besides business groups and corporates willing to contribute to the cause of big cats, to establish networks and develop synergies in a focused manner so as to bring to a common platform a centralized repository of successful practices and personnel, backed by financial support which can be leveraged to strengthen the conservation agenda in the field to arrest decline in big cat population and reverse the trend. This is a demonstrative step in leadership position on big cat agenda, to bring range countries and others on a common platform.
- IBCA envisages synergy through a collaborative platform for increased dissemination of gold standard big cat conservation practices, provides access to a central common repository of technical know-how and corpus of funds, strengthens the existing species-specific intergovernmental platforms, networks and transnational initiatives on conservation and protection and assists securing our ecological future and mitigate adverse effects of climate change.
- All UN member countries are eligible for becoming the member of IBCA. Twenty-four (24) countries (including India) have consented to be a member of IBCA. Nine International Organizations have also consented to be a partner organization of IBCA. So far four countries have become member of International Big Cat Alliance including India, Nicaragua, Eswatini and Somalia.
- The Framework Agreement is intent to establish IBCA to collectively address common challenges for the protection and conservation of seven Big Cats in the world. The parties to this agreement shall be guided by the principles of coordinated action for protection and conservation of seven big cats, seeking the benefits of collective action under the IBCA.
- The Alliance focuses on the sustainable use of natural resources and mitigates challenges emanating from climate change. By safeguarding big cats and their habitats, the IBCA contributes to natural climate adaptation, water and food security and well-being of thousands of communities reliant on these ecosystems. IBCA would instill cooperation among countries for mutual benefit and immensely contribute in furthering long term conservation agenda (PIB, 2023).
- India becoming a founder member of International Big Cat Alliance is a great moment that demonstrates country's leadership in conservation and sustenance of Big Cats. It will definitely help in mutual benefit and understanding in the areas of Big Cats conservation across the globe.

## 6.7.3 Global Mangrove Alliance (GMA)

The Global Mangrove Alliance (GMA) is an unprecedented collaboration that seeks to bring together NGOs, governments, scientists, industry, local communities and funders towards a common goal of conserving and restoring mangrove ecosystems.

Since the launch of GMA at the World Ocean Summit in 2018, collaborative approach has increased with ability to leverage funding; promote scientific research; strengthen coastal management and governance, education, disaster risk reduction, climate mitigation and adaptation related plans and policies; and accelerate the conservation and restoration of mangroves at scale.

In 2022, the GMA revised its Goal containing three critical strands to be achieved by 2030: Halt loss, Restore half, Double protection.

- **Halt Loss (Reduce net mangrove losses driven by direct human actions to zero).** Human-driven loss represents 62% of total losses. Halting this human driven loss would save approximately 168km² by the end of 2030.
- Restore Half **(Put back mangroves to cover at least half of all recent loss).** Of the 11,700km² of mangroves lost since 1996, approximately 8,183km² are considered restorable. This goal seeks to restore half of this area by 2030. The goal is deeply ambitious but has enormous potential.
- **Double Protection (Ensure long-term secure protection is increased from 40% to 80% of remaining mangroves).** 42% of mangroves are currently in protected areas. However, the urgency to secure a further 61,000km² under conservation measures, including traditional protected areas and Other Effective Area-based Conservation Measures (OECMs) is fundamental (MoEFCC, 2024).

## 6.7.4. Green Credit Program (GCP)

Within the LiFE movement, the Green Credit Rules, 2023 were notified by the Government of India under the Environmental Protection Act of 1986. These rules put in place a mechanism to encourage voluntary environmental positive actions that result in the issuance of green credits. These rules are an innovative market-based mechanism that incentivise environment positive actions that will promote the LiFE movement aiming at encouraging sustainable lifestyles by driving consumer and community towards behavioural changes that promote environmentally friendly actions. The Program endeavours to encourage voluntary tree plantation across the country while promoting inclusivity, ensuring transparency and meeting compliance requirements.

The first phase of the GCP focuses on the following initiatives:

a. Land Inventory: A flat land inventory with registered plantation blocks is being made available to entities to encourage voluntary plantation, plantation under Corporate Social Responsibility (CSR) and Environmental Social Governance (ESG) compliance. This initiative seeks to ensure that the identified land is optimally utilised for plantation and allied environmental activities.

b. Tree Plantation Activities: The tree plantation activities seek to increase the green cover across the country. In order to obtain the green credits under the initiative, the individuals/entities are required to register their activities through the dedicated built portal of https://moefcc-gcpregistry.in/registry/tree-plantation-projects, where post-verification, tradable Green Credit certificates are awarded by the administrator.

## 6.7.5 Ecomark Programme

Launched in 2023, the Ecomark Scheme provides accreditation and labelling for household and consumer products that meet specific environmental criteria while maintaining quality standards as per Indian norms. Thereby, the products accredited under the Ecomark scheme will adhere to specific environmental criteria,

ensuring minimal environmental impact while building consumer awareness of environmental issues and encouraging eco-conscious choices. It also seeks to build consumer awareness of environmental issues and encourage eco-conscious choices (PIB, 2023).

## 6.7.6 Circular Economy

### *6.7.6.1. Institutional Initiatives*

In line with India's vision of transitioning from a linear economy to a circular economy, the Government of India has been actively formulating policies that enable this transition effectively. In addition to its various regulations, such as the Plastic Waste Management Rules, e-Waste Management Rules, Construction and Demolition Waste Management Rules, and Metals Recycling Policy, in 2021, 11 committees have been formed to prepare comprehensive action plans for enabling a transition in their respective focus areas. These committees comprising officials from the Ministry of Environment, Forests and Climate Change (MoEF&CC), NITI Aayog, domain experts, academics, and industry representatives are to carry out the necessary modalities to ensure effective implementation. The areas of focus include 11 end-of-life products/recyclable materials/waste that continue to pose considerable challenges or are emerging as new challenge areas (PIB, 2021).

In 2022, a Circular Economy Cell (CE Cell) was constituted in NITI Aayog to work in the area of circular economy efficiently. Following which, 10 of such sectoral Circular Economy plans have been finalised to be implemented by the respective Ministries and Departments. The Cell is also actively working in coordination with the Ministry of Road Transport and Highways (MoRTH) to operationalise the Vehicle Scrapping programme and develop a strategy for scrapping the fleet of unfit and old Central and State Government Vehicles (NITI Aayog, 2022).

In this regard, The Ministry of Road Transport and Highways has launched the Voluntary Vehicle Modernization Program or Vehicle Scrapping Policy to create an ecosystem for phasing out unfit polluting vehicles across the country through a network of Registered Vehicle Scrapping Facilities (RVSFs) and Automated Testing Stations (ATSs) recognizing the importance of fleet modernization and circular economy.

### *6.7.6.2. National Circular Economy Roadmap for Reduction of Plastic Waste in India*

In December 2023, the flagship document on 'National Circular Economy Roadmap for Reduction of Plastic Waste in India' was released as the result of a collaborative effort between leading research institutions from India and Australia. The document aims to foster research and industry partnerships between the two countries of India and Australia and co-develop a roadmap for India's transition to a circular economy in the Plastics sector (PIB, 2023). The roadmap could potentially reduce landfill in the country by 30%, recycling rates could increase to 67% and 80% of waste streams could be digitally tracked and managed by 2035 (PIB, 2023).

## 6.7.7 PM – PRANAM

The PM Programme for Restoration, Awareness Generation, Nourishment and Amelioration of Mother-Earth (PM – PRANAM), approved in June 2023, supports States and Union territories to save the health of the planet through the promotion of sustainable and balanced use of fertilisers, the adoption of alternate fertilisers, organic farming and the implementation of resource conservation technologies (CSRIO, 2023).

# 6.8 Use of Plastic in Road Construction

In 2023, the Ministry of Road Transport and Highways, issued guidelines for the utilisation of plastic waste in the hot mix bituminous wearing coat/periodic renewal. These guidelines are mandatory for the wearing coat of service roads along National Highways (NHs) and slip roads throughout NHs that are within 50 kms

periphery of urban areas with a population of more than 5 lakhs (MoRTH, 2023) as an extension of similar guidelines notified by the Ministry in 2015 and 2021. These notifications build on the Guidelines for the Use of Waste Plastic in Hot Bituminous Mixes (Dry Process) in Wearing Courses of 2013 developed by the Indian Roads Congress. Further, as of July 2021, 703 km of NHs have been constructed in India that have utilised waste plastic in the wearing coat of flexible pavement (PIB, 2021). The Ministry of Housing and Urban Affairs has also recommended to States and Union Territories to utilise plastic waste up to 8% of the weight of bitumen in roads within cities, including roads of housing colonies and office complexes (Indian Express, 2024)

## 6.9 Swachh Bharat Mission (SBM)

India started the innovative solutions such as waste-to-energy initiatives and climate-resilient sanitation infrastructure. The effect of SBM produce many good impact throughout the country. A 2018 World Health Organization (WHO) report estimated that over 3 lakh diarrhoeal deaths were prevented in 2019 compared to 2014. Nature magazine recently reported that it helped avert 60,000-70,000 child deaths annually.

There are almost 1.57 lakh Safai Mitra Suraksha Shivirs have been conducted in which over 36.34 lakh Safai Mitras have benefited across the country. There are top 5 State performers in the transformation of Cleanliness Target Units such as Uttar Pradesh, Bihar, Gujrat, Tamil Nadu and Rajasthan. The top States performed well in the Campaign 'Swachhata Mein Jan Bhagidari' are Bihar, Uttar Pradesh, Telangana, Maharashtra, and Andhra Pradesh. There are the projects of sanitation and cleanliness run by the Indian Government such as GOBARdhan, AMRUT and National Mission for Clean Ganga. (PIB, 2024)

## 6.10 CDM projects in India and transition to the Paris Agreement mechanism

In December 2003, the Government of India (GoI) established the National CDM Authority (NCDMA), which granted Host Country Approval to a total of 3,400 projects as of December 31, 2020. Out of this, the CDM Executive Board has recorded a total of 1,719 projects. A total of 331 million CERs have been issued during the commitment period of the CDM. Since January 1, 2021, the Government of India has not granted approval for any project under the Clean Development Mechanism (CDM), since the process of transition to the mechanism embodied in Article 6.4 of the Paris Agreement was underway. Out of a total of 998 eligible projects in India, 549 projects have submitted applications for transitioning from the Clean Development Mechanism (CDM) to the Article 6.4 mechanism. According to the decision made by the National Designated Authority for the Implementation of the Paris Agreement (NDAIAPA), only projects that meet the criteria specified in Article 6.4 will be permitted to transition, on a case-by-case basis. The following figure (Figure 6.2) shows the various categories and the number of CDM projects approved in those categories until December 31, 2020.

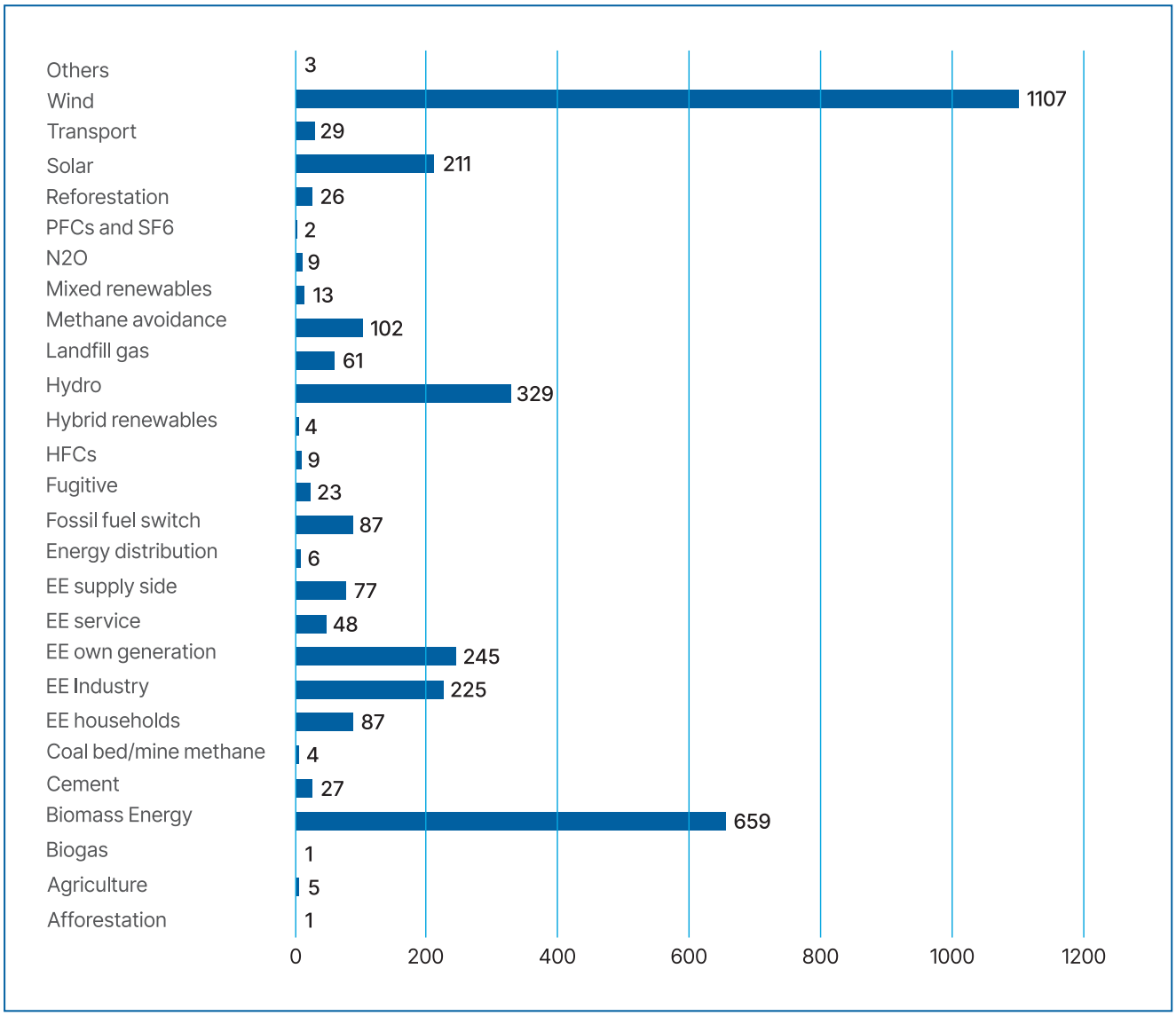


*Fig. 6.2 CDM projects approved by NCDMA for operation in India.*

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*Meconopsismerakensis* Flower

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