India

Third Biennial Update Report to The United Nations Framework Convention on Climate Change

India

Third Biennial Update Report to the United Nations Framework Convention on Climate Change

Ministry of Environment, Forest and Climate Change
Government of India

India

Third Biennial Update Report to the United Nations Framework Convention on Climate Change

CITATION: MoEFCC. (2021). India: Third Biennial Update Report to the United Nations Framework Convention on Climate Change. Ministry of Environment, Forest and Climate Change, Government of India.

Secretary
Ministry of Environment, Forest and Climate Change, Government of India
Indira Paryavaran Bhawan, Jor Bagh Road, New Delhi-110003
Phone: +91 11 -24695262 / 24695265
Fax: +91 11 - 24695270

National Project Director
India's Third National Communication and other New Information to the UNFCCC,
Scientist-G, Ministry of Environment, Forest and Climate Change, Government of India,
Indira Paryavaran Bhawan, Jor Bagh Road, New Delhi - 110003
Telefax: +91 11 - 24695293
E-mail: jrbhatt@nic.in

Contents

List of Figures

List of Tables



मंत्री
पर्यावरण, वन एवं जलवायु परिवर्तन,
सूचना एवं प्रसारण और
भारी उद्योग एवं लोक उद्यम
भारत सरकार

स्वच्छ भारत
एक कदम स्वच्छता की ओर

सत्यमेव जयते

MINISTER
ENVIRONMENT, FOREST & CLIMATE CHANGE,
INFORMATION & BROADCASTING AND
HEAVY INDUSTRIES & PUBLIC ENTERPRISES
GOVERNMENT OF INDIA

प्रकाश जावडेकर
Prakash Javadekar

MESSAGE

With this Third Biennial Update Report (BUR), India once again marks its commitment to its responsibilities and obligations under the United Nations Framework Convention on Climate Change (UNFCCC). Despite the challenges posed by the COVID-19 pandemic, the task of preparing the report proceeded on schedule and has been completed mainly due to the considerable efforts of our scientists, scholars and officials. This is testimony to the degree of commitment that India attaches to its responsibilities under the Convention and its Agreements and Protocols.

As we have always maintained, India will strive its utmost to meet the challenge of global warming. India recognizes that climate change is a global collective action problem that can only be met by global cooperation based on the multilateral framework of the UNFCCC. The basic principles of this framework and the Paris Agreement are Equity and Common-but-Differentiated Responsibilities and Respective Capabilities.

This BUR spells out how we are sparing no effort for the up-scaling of renewable energy that can power the growth of the household and service sectors in a very significant manner. The BUR also demonstrates how the use of fossil fuel is being technologically improved.

Further, apart from championing and safeguarding the tenets of multilateralism, India is hosting, supporting and nurturing the International Solar Alliance (ISA) and the Coalition for Disaster Resilient Infrastructure (CDRI) to help others. With Sweden, India is leading the world on the industry track to reduce emissions from energy-intensive and hard-to-abate sectors, by promoting international collaboration between countries and industry groups.

As the BUR elaborates, India's effort at green technologies for development is spread across all sectors including industry, agriculture, business and commerce. India has a robust framework for the protection and conservation of its biosphere resources. As home to some of the distinctive biodiversity hot-spots of the world, it is also committed to preserving and enhancing biodiversity.

India's efforts, achieved largely through its own financial and human resources, can be expanded further if financial assistance, technology transfer and capacity building needs are met as per commitments of developed countries.

।। प्लास्टिक नहीं, कपड़ा सही ।।

पर्यावरण भवन, जोर बाग रोड़, नई दिल्ली-110 003 फोन : 011-24695136, 24695132, फैक्स : 011-24695329
Paryavaran Bhawan, Jor Bagh Road, New Delhi-110 003, Tel.: 011-24695136, 24695132, Fax : 011-24695329
ई-मेल/E-mail : minister-efcc@gov.in

The problem of climate change has largely been caused by the developed countries. They must reduce their excessive consumption patterns and adopt climate-friendly lifestyles. They should take the lead in combating the problem that they have caused, and partner with developing countries by providing them new and additional financial resources and environmentally benign technologies as committed under the UNFCCC.

Our Hon'ble Prime Minister believes in convenient action to combat climate change. India is optimistic and committed to use technology and innovation to ensure that our future generations inherit a better world.

I am sure this document will be received well and serve as a useful communication of our inventory and suite of initiatives.

With best wishes.

Date: 16.02.2021

(Prakash Javadekar)

Babul Supriyo
Union Minister of State
Ministry of Environment, Forest & Climate Change
Government of India

बाबुल सुप्रियो
केन्द्रीय राज्य मंत्री
पर्यावरण, वन एवं जलवायु परिवर्तन मंत्रालय
भारत सरकार

सत्यमेव जयते

स्वच्छ भारत
एक कदम स्वच्छता की ओर

Message

It gives me immense pleasure to write message for India's third Biennial Update Report to the United Nations Framework Convention on Climate Change. I commend the efforts of the scientific community, officials, scholars and consultants for this achievement.

The year 2020 is one of transition for global efforts in tackling climate change as we move towards the implementation of the Paris Agreement. India, as a responsible international player and a firm believer in multilateralism as the means to address global challenges, has always worked towards the implementation in letter and spirit of the Convention and the subsequent Kyoto Protocol. The Paris Agreement will be no exception. India, as a front-runner in climate action, is one of the few countries on track to overachieve its "2^{0} C compatible" Nationally Determined Contribution (NDC) targets submitted as part of the Paris Agreement.

India is progressively decoupling its economic growth from greenhouse gas emissions. India's emission intensity of GDP reduced by 12 per cent between 2005 and 2010 while a reduction of 24 per cent was achieved between 2005 and 2016.

The problem of climate change has been precipitated primarily because of the excessive consumption patterns and profligate lifestyles of the developed nations of the world. Recognizing the importance of lifestyle issues in climate change, India's first NDC Goal is to promote a healthy and sustainable way of living based on our traditions and values of conservation and moderation. International agencies rate India's efforts to address climate change highly and acknowledge that India is on track to meet both its voluntary declaration of mitigation action for the pre-2020 period and its post-2020 NDC goals.

India is making progress on a daily basis in the deployment of renewable energy. With the announcement by the Hon'ble Prime Minister of a target of 450 GW of renewable energy, India has shown itself to be a global leader in climate ambition reflecting its strong commitment to limiting the rise in global temperatures.

Office: 5th Floor, Aakash Wing, Indira Paryavaran Bhawan, Jor Bagh Road, New Delhi-110 003
☎ (+91) 11- 24621921/22 • Fax : (+91) 11- 24695313
Cell : (+91) 9811777143 • 9810711980
E-mail : mos4ef.cc@gmail.com

India's efforts at climate change are wide-ranging. We have made plans to make our transport sector green through ramping up e-mobility. India has leapfrogged from BS-IV emission norms and directly shifted to BS-VI emission norms in the entire country from 1st April, 2020. The country is also working to considerably increase the proportion of the biofuel blend in petrol and diesel. India has stabilized, protected and enhanced its forest and tree cover over the years and the carbon stock in India's forests has increased. India's commitment to rapidly increasing her renewable energy capacity reflects its strong commitment to limiting the rise in global temperatures.

I congratulate the network of scientists, experts and officials involved in the work of preparing India's BUR-3, even under the trying conditions of the COVID-19 pandemic. And now we are providing indigenous COVID vaccine to the world.

(Babul Supriyo)

प्रकृतिः रक्षति रक्षिता
Nature Protects if She is Protected

सचिव
भारत सरकार
पर्यावरण, वन एवं जलवायु परिवर्तन मंत्रालय
SECRETARY
GOVERNMENT OF INDIA
MINISTRY OF ENVIRONMENT, FOREST AND CLIMATE CHANGE

सत्यमेव जयते

आर पी गुप्ता
R P Gupta

FOREWORD

I am proud to present India's third Biennial Update Report (BUR-3) to the United Nations Framework Convention on Climate Change (UNFCCC) towards the fulfillment of India's commitments under the Convention.

The problem of climate change poses an existential challenge for humanity. For India, this challenge is compounded by the immediate concerns of eradicating poverty and accelerating development though it has had a relatively very limited role in causing the problem. However, India is committed to addressing the challenge of climate change by adhering to the paramountcy of UNFCCC processes. India has proactively contributed to multilateral efforts to combat climate change and continues to do so while undertaking her own independent, enhanced initiatives in climate mitigation and adaptation besides meeting all its commitments under the UNFCCC, Kyoto Protocol and the Paris Agreement.

Under the leadership of Hon'ble Prime Minister Shri Narendra Modi, India has taken very significant steps for combating climate change and will continue its enhanced efforts in the future as well.

India has progressively continued decoupling of economic growth from greenhouse gas emissions. The emission intensity of GDP (excluding emissions from the agriculture sector) has reduced by 24 per cent between 2005 and 2016, thereby achieving our goal to reduce the emissions intensity of GDP by 20-25 per cent from 2005 levels earlier than the target year of 2020. It is well on its way to meet its commitment under NDCs to reduce its emissions intensity of GDP by 33-35 per cent below 2005 levels well before 2030. India's share of non-fossil sources in installed capacity of electricity generation increased from 32 per cent in March 2014 to 38 per cent by November 2020. Generation from renewable energy sources has doubled between 2014-15 and 2018-19 and our Prime Minister has further announced the aspirational target of increasing our renewable energy capacity to 450 GW.

India has an age-old tradition of living in harmony with nature. India's total forest and tree cover has increased to 8,07,276 km^2 which is 24.56 per cent of the total geographical area of the country.

We launched one of the largest campaigns for cleanliness and are discouraging the usage of single-use plastic.

इंदिरा पर्यावरण भवन, जोर बाग रोड, नई दिल्ली-110 003 फोन: (011) 24695262, 24695265, फैक्स: (011) 24695270
INDIRA PARYAVARAN BHAWAN, JOR BAGH ROAD, NEW DELHI-110 003 Ph.: (011) 24695262, 24695265, Fax: 011-24695270
E-mail: secy-moef@nic.in, Website: moef.gov.in

To further strengthen the transition to clean fuels locally, the Government has provided LPG connections to a total of 80.33 million households in rural areas, thus giving them clean cooking fuel and a healthy domestic and external environment. More than 366 million LED bulbs have been distributed under the UJALA scheme. In India's efforts towards the use of cleaner automobile fuel, a substantial leap has been made from Bharat Stage-IV (BS-IV) to Bharat Stage-VI (BS-VI) emission norms by April 1, 2020, which was earlier scheduled to be adopted only by 2024.

This year in particular is important for India and other member countries of UNFCCC, as we collectively work towards saving lives, overcoming social and economic consequences of the pandemic while also preparing to move into the implementation phase of the Paris Agreement in post-2020 period.

The world must think of adopting more sustainable consumption patterns in line with available natural resources ensuring equitable access, as per the clarion call of 'Sustainable Lifestyle' by the Hon'ble Prime Minister of India, during the Paris COP in 2015.

India is home to one-sixth of humanity. We are aware that if India succeeds in achieving its development objectives, it will go a long way in the achievement of global goals. We have, therefore, taken the "inclusive or whole of the society" approach - by engaging our States, our local governments, our civil society, communities, and our people. Our motto is *'Sabka Saath, Sabka Vikaas, Sabka Vishwas'* - meaning 'Together, for everyone's growth, with everyone's trust' in line with the global resolve under the Sustainable Development Goals to leave no one behind.

I congratulate all those involved in the preparation of India's third BUR.

(R P Gupta)

New Delhi
18th February, 2021

रवि एस. प्रसाद, आई.ए.एस.
Ravi S. Prasad, I.A.S.

सत्यमेव जयते

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

PREFACE

India believes in multilateralism and is committed to the cause of Climate Change. The regular submission of our National Communication and Biennial Update Reports (BUR) signifies the same.

The 3rd BUR contains the inventory of Green House Gases (GHG) for the year 2016 and also brings out the various initiatives of the Government of India for mitigation and adaptation. It is a combined effort of several reputed institutions, scientists, Ministries, civil society organizations and the private sector — exemplifying our transparent and all inclusive approach to Climate Change.

It is evident that India is over-achieving its pre-2020 commitment of reducing emission intensity of GDP by 20% to 25% by 2020 over 2005 levels. The current report till 2016 shows a reduction of 24% already. It must be underlined that this achievement has become possible only due to proactive and innovative efforts by the Government and other stakeholders.

We are also confident that the Paris Agreement NDC Goals for the period 2021-2030 will be achieved in time. It must be highlighted that the ambitious policies and programmes launched by the Government in order to achieve these goals require a lot of investment and resources. At times, it calls for balancing or rationing allocation for other essential needs. It is in this context that India emphasises the need for finance and technology transfer to ensure timely climate action. Private Sector, NGOs and citizens in India have also put in their efforts and resources to contribute to this important task.

I congratulate the NATCOM team as well as all officials, scientists, institutions and Ministries for assisting the Ministry (EF&CC) in completing the task in a timely manner and I am sure that this report would help all the stakeholders in understanding India's GHG inventory and programmes in a better way.

Date: 16.02.2021

(Ravi S. Prasad)

पाँचवा तल, पृथ्वी विंग, इंदिरा पर्यावरण भवन, जोर बाग रोड़, नई दिल्ली–110 003, फोनः (011) 24695242, फैक्सः (011) 24695260
5th Floor, Prithvi Wing, Indira Paryavaran Bhawan, Jor Bagh Road, New Delhi-110 003, Tel.: (011) 24695242, Fax: (011) 24695260
E-mail: ravis.prasad@nic.in, Website: moef.gov.in



Executive Summary

Key highlights

- In 2016 India's total GHG emissions, excluding Land Use Land-Use Change and Forestry (LULUCF) were 2,838.89 million tonne CO_2e and 2,531.07 million tonne CO_2e with the inclusion of LULUCF. Carbon dioxide emissions accounted for 2,231 million tonne (78.59 per cent), methane emissions for 409 million tonne CO_2e (14.43 per cent) and nitrous oxide emissions for 145 million tonne CO_2e (5.12 per cent).

- India has progressively continued decoupling of economic growth from greenhouse gas emissions. India's emission intensity of gross domestic product (GDP) has reduced by 24 per cent between 2005 and 2016.

- India is therefore on track to meet its voluntary declaration to reduce the emission intensity of GDP by 20-25 per cent from 2005 levels by 2020.

- India is implementing one of the largest renewable energy expansion programmes with a target of achieving 175 GW of renewable energy capacity by 2022 and later up to 450 GW.

- Installed capacity of solar energy in India has increased by more than 14 times from 2.63 GW in March 2014 to 36.91 GW in November 2020.

- As on 30 November 2020, installed capacity of wind energy was 38.43 GW.

- The cumulative renewable power installed capacity (excluding hydro above 25 MW) has increased by 2.6 times from 35 GW in March 2014 to 90.39 GW in November 2020 and constitutes over 24 per cent of the country's installed power capacity. With the inclusion of large hydro, the total installed capacity would be 136 GW and the share of renewable energy in installed capacity would be over 36 per cent.

- By November 2020, the share of non-fossil sources in installed capacity of electricity generation was 38.18 per cent.

- Generation from renewable energy sources has doubled between 2014-15 and 2018-19 while the generation from non-renewable sources has increased by 19 per cent during the same period. This has been actively promoted by the "must-run" status of renewable energy generation.

- India's commitment to the expansion of renewable energy has not been affected by the economic contraction due to the COVID-19 pandemic. The priority status of renewable energy generation has been maintained during this period, representing a considerable and highly significant effort at climate mitigation.

- Coal will however continue to be an integral part of India's energy requirements, both for electricity generation and non-electricity uses and remains essential for India's developmental needs and energy security. This is in keeping with India's claim to a fair share of the global carbon budget and India's significant underutilization of this share thus far.

- Forest and tree cover has increased by 1.3 million ha between the 2015 and 2019 assessments of the Forest Survey of India. This is an increase of 1.65 per cent in forest and tree cover area. In the India State of Forest Report (ISFR) 2019, the total carbon stock in forest was estimated as 7,124.6 million tonne C or 26,124 $MtCO_2$ showing an increase of 42.6 million tonne C or 156.2 $MtCO_2$ as compared to the last assessment in 2017. The annual increase in the carbon stock is 21.3 million tonne C, which is 78.1 $MtCO_2$.

- Forest and tree cover sequestered 331 $MtCO_2$ in 2016 which is around 15 per cent of total carbon dioxide emissions occurring in the country. India's LULUCF sink (CO_2 removal) is on the rise by 3.4 per cent between 2014 and 2016 and by approximately 40 per cent between 2000 and 2016.

- Perform Achieve and Trade (PAT) scheme for energy efficiency in industries and other energy-intensive sectors launched in 2012, covering 478 designated consumers (DCs), avoided emissions of 31 $MtCO_2$ in cycle I (2012-13 to 2014-15). PAT Cycle II (2016-17 to 2018-19), resulted in total savings of approximately 13.28 Mtoe, translating into 61.34 $MtCO_2$ of avoided emissions.

- As on November 2020, more than 366.85 million LED bulbs, 7.207 million LED tube lights, and 2.340 million energy efficient fans were distributed by EESL across India under the UJALA scheme, which has led to cumulative emission reduction of 180.08 $MtCO_2$ from 2014-15 to November 2020.

- Under the Street Lighting National Programme (SLNP), more than 11.25 million LED street lights have been installed until September 2020. The programme has led to a cumulative energy savings of 18.071 billion units and emission reduction of 14.82 $MtCO_2$ from 2015-16 to 2019-20.

- Energy efficiency initiatives in the Micro, Small and Medium Enterprises (MSME) sector have led to total energy savings of 0.022 Mtoe and avoided emissions of 0.124 $MtCO_2$ in 2018-19.

- The Department of Heavy Industry is administrating Faster Adoption and Manufacturing of (Hybrid) and Electric Vehicles (FAME) India Scheme for promotion of electric/hybrid vehicles in India since 1 April 2015. In the First Phase of the Scheme about 0.28 million hybrid and electric vehicles are supported by way of demand incentive amounting to about INR 3,590 million.

- Taken together, India's mitigation actions speak of the enormous effort that the country is undertaking, through its own resources, without any significant support from developed countries in terms of climate finance, technology transfer or capacity building.

- India's climate actions are even more significant in the background of its huge development needs and expenditure. Among the outstanding examples of such needs and expenditure are the programmes to improve sanitation and water supply to millions of households, and permanently improve the health of tens of millions of Indian women by the provision of clean cooking fuel to substitute traditional biomass burning.

- India's climate action is widely acknowledged by independent, international assessments to be among the few that are compatible with the well below 2ºC warming target of the Paris Agreement.

- India's contribution to global emissions, both cumulative and on annual basis are well below its equitable share of the global carbon budget by any criterion of equity.

- Notwithstanding its level of responsibility, India is a leader in high ambition, especially with the indication of increasing its target for installed capacity in renewable energy from 175 GW to 450 GW.

- India’s commitment to multilateral efforts and global cooperation in climate action is amply demonstrated by its initiation of, and the provision of resources to, the International Solar Alliance (ISA) in partnership with France. Further, in response to the global concern over losses and damages, especially due to infrastructure losses from disasters and extreme events, it has initiated the Coalition for Disaster Resilient Infrastructure (CDRI), announced at the UN Climate Action Summit in 2019. India also co-leads with Sweden the leadership group for Industry Transition in hard-to-abate sectors initiated in the preparation for the United Nations Climate Action Summit in 2019.

- Reductions in agricultural sector emissions have been achieved in 2017-18 and 2018-19 as a result of various initiatives such as expansion of area under horticulture, system of rice intensification, neem coated urea, direct seeded rice cultivation, solar pumps, micro-irrigation, balanced feedstock and bypass protein.

- India undertakes numerous programmes focused on adaptation in agriculture, led by the flagship programme, National Initiative on Climate Resilient Agriculture (NICRA).

- The National Adaptation Fund for Climate Change (NAFCC) supports adaptation action, in, *inter alia*, agriculture, water, forestry, livestock and ecosystems. Till date, 30 adaptation projects have been approved at a total cost of INR 8,470 million.

- India is a vulnerable nation with respect to extreme weather events such as cyclones and intense rainfall as well as ongoing climate change with increased impacts in the future. Its long coastline and the number of islands that lie within its national boundaries, render it particularly vulnerable to the impact of sea-level rise which needs to be recognized by the international community.

- India will continue to remain focused on its key development imperatives, strengthening its current efforts, including poverty eradication, provision of basic amenities, especially water and sanitation, and livelihoods and employment generation for its entire population. India’s climate actions will be centered on integration with the achievement of these key development goals, especially following the severe impact of the COVID-19 pandemic and the urgent requirements of post-COVID recovery.

Background information and institutional arrangements

This report embodies information on national circumstances, national GHG inventory, mitigation actions, and an analysis of the constraints, gaps, and related finance, technology and capacity building needs, including information on domestic measurement, reporting and verification (MRV). The Ministry of Environment, Forest and Climate Change (MoEFCC) is the nodal ministry under the Government of India (GoI) for coordination and management of climate change-related programmes, actions and reporting information under Article 4.1 of the Convention. MoEFCC, with its cross-ministerial and institutional network, is implementing and executing matters related to the National Communications and Biennial Update Reports (BURs). India furnished its Initial National Communication (INC) in 2004, the Second National Communication (SNC) in 2012, the First Biennial Update Report (BUR-1) in 2016 and the Second Biennial Update Report (BUR-2) in 2018 to the United Nations Framework Convention on Climate Change (UNFCCC). International Consultation and Analysis (ICA) of BUR-1 and BUR-2 were completed in 2017 and 2019 respectively.

The third BUR presents updated information on the National GHG Inventory, Mitigation Actions and Financial, Technology and Capacity Building needs. It also addresses the suggestions made during the ICA process for BUR-1 and BUR-2 wherever relevant and within the scope of present capacity in order to enhance the transparency of mitigation actions and their effects.

The preparation of the BUR required a comprehensive study, and technical as well as administrative arrangements, in addition to stakeholders' participation in various tasks and activities. A National Steering Committee (NSC) under the chairmanship of the Secretary, EF&CC steers the preparation and implementation of the work programme of the BUR. Various line ministries and government departments that are most concerned with various elements of information in this report have representation in the NSC. A Technical Advisory Committee (TAC) provides technical guidance to the preparation of the BUR, with members from government, academia and civil society.

Several studies were launched to meet the requirements of preparing the third BUR. These studies were carried out by institutions having sector-specific expertise. Besides, various ministries, government departments, and Public Sector Undertakings (PSUs) provided inputs for preparation of this BUR.

Global warming is a global collective action problem that can be solved only by international cooperation on the basis of multilateral processes, especially and primarily those under the aegis of UNFCCC. Every country's climate action therefore has to be based on the principle of equity and common but differentiated responsibilities in accordance with respective capabilities, as has been ratified in Article 3.1 of the Convention.

This third BUR, recognizing the importance of this perspective, also presents therefore the global context of all the data and information provided herein on India's National Greenhouse Gas (GHG) inventory and on mitigation, finance, technology and support for capacity building. This context will enhance the facilitative sharing of views process that will consider this third BUR from India.

The data, information and analysis presented in this third BUR show that India's efforts and the current scale and scope of its domestic climate action, judged in the light of global equity, its historical responsibility and current capability, exceed, by any scientific measure, its fair share of the global burden of climate action.

National Circumstances

India has a diverse geography with landscapes varying from snow-capped mountain ranges to deserts, plains, hills, plateaus, coastal regions and islands. The diverse geography of India manifests varied climate regimes 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. India's climate is significantly influenced by the presence of the Himalaya and the Thar Desert, as the former acts as an orographic barrier to atmospheric circulation for both the summer monsoon and the winter westerlies and keeps them confined within the subcontinent, thus playing a major role in causing precipitation.

The Indian monsoon is one of the most prominent climate systems of the world providing nearly 75 per cent of the annual rainfall of the country. During June to September, an average 880.6 mm of rainfall is received. Rainfall distribution and intensity have a significant impact over different socio-economic sectors, especially agriculture and hydrology, besides impact on other aspects of various ecosystems.

The rainfall trends for the period 1989-2018 showed a decreasing trend for the annual and monsoon season in the districts of eastern and central India, while the districts in the western part experienced an increase. Overall, the decreasing trend is visibly dominant over large part of India.

The annual mean temperature during 1901-2019 showed a significant increasing trend (0.61°C/100 years), with a higher increasing trend in maximum temperature (1.00°C/100 years) and relatively lower increasing trend (0.22°C/100 years) in minimum temperature.

The year 2019 was the seventh warmest year on record since 1901 with annual mean surface air temperature +0.36°C above the 1981-2010 average. The five warmest years on record in order are: 2016 (+0.71°C), 2009 (+0.54°C), 2017 (+0.54°C), 2010 (+0.54°C) and 2015 (+0.42°C). The 11 out of 15 warmest years were recorded during the recent past fifteen years (2005-2019).

The long coastline of over 8,000 km with flat coastal terrain, shallow continental shelf, high population density, particular geographical location and specific physiographic features, makes India vulnerable to cyclones and its associated hazards. Thirteen coastal States and Union Territories (UTs) in the country, encompassing 84 coastal districts, are affected by tropical cyclones.

During 2019, eight cyclonic storms formed over the north Indian Ocean. Out of these 8 systems, one system each formed during the winter (Cyclonic Storm “Pabuk”) and pre-monsoon season (Extremely Severe Cyclonic Storm (ESCS), “Fani”) over the Bay of Bengal. In the case of Arabian Sea, the five cyclones formed during 2019 equal the previous record of 1902 for the highest frequency of cyclones in the region.

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. Increasing trends in the heatwaves were observed over most of the stations across India. The frequency of occurrence of hot days during the pre-monsoon season shows a significant increase over the east and west coasts of India and interior peninsula.

The Himalayan mountain range is one of the major water towers of Asia and a large concentration of snow and glaciers make it possible to support water supply of major Indian rivers such as Indus, Ganga and Brahmaputra. The snow cover area in the Indus, Ganga and Brahmaputra basins ranges from 85 per cent in the winter to approximately 10 per cent in the summer.

The total glacial extent in the Indian Himalaya varies from 20,785 km^2 to 27,915 km^2. Most of the Himalayan glaciers are retreating and the rates of retreat have probably accelerated in the past few decades. The mean rate of retreat is 14.2±12.9 ma^{-1}. In the Himalaya, investigations of 39,500 km^2 of glacier area indicate a rate of loss of 4.3±2.4 per cent/decade. In the Indus basin, the area loss rate is observed to be 2.5±2.5 per cent/decade.

At present the sea level along the Indian coast is estimated to be rising at about 1.7 mm/year and at different rates along various parts of the coast. It has the potential to exacerbate the inundation of low lying areas during extreme events such as storm surges while leading to increased coastal erosion.

Water has been recognized as being vital to India's economic growth, the well-being of its people, and the sustainability of ecosystems. The Ministry of Jal Shakti (MoJS) has been created by the Government in May 2019 to deal with water issues in an integrated manner under a single umbrella.

Among the various types of marine ecosystems in India, tidal mudflats, mangroves, estuaries, lagoons, beaches, marshes, vegetated wetlands and coral reefs have the major share. There are 25 Marine Protected Areas (MPAs) with an area of 6,200 km^2 in peninsular India, along with 97 major estuaries, 34 major lagoons and 5,790 km^2 of coral reefs. Mangroves are spread over an area of 4,975 km^2, which is 0.15 per cent of the country's total geographical area. These areas have been mapped and identified in India for conservation and sustainable management.

India is among the few countries in the world where, despite ongoing developmental efforts, forest and tree cover is increasing. The total forest cover of the country, as per the latest assessment of the India State of Forest Report (ISFR 2019) is 7,12,249 km^2 which is 21.67 per cent of the total geographic area of the country. There has been an increase of 3,976 km^2 (0.56 per cent) of forest cover, 1,212 km^2 (1.29 per cent) of tree cover and 5,188 km^2 (0.65 per cent) of forest and tree cover put together, at the national level compared to the previous assessment 2017. The carbon stock in India's forests has been estimated to be 7,124.6 million tonne in 2019, showing an increase of 42.6 million tonne compared to the previous assessment of 2017.

Agriculture plays a vital role in India's economy. In 2011, of the total workforce 54.6 per cent was engaged in agriculture. The share of agricultural and allied sector activities in the economy's total gross value added (GVA) at current prices is 18 per cent and 17.1 per cent, for the years 2017-18 and 2018-19 respectively. Agriculture constitutes a particular source of social and economic vulnerability under climate change for India as share of small and marginal operational holdings (less than <2 hectares) became 86.08 per cent of the total holdings in 2015-16, against 85.01 per cent in 2010-11. Their share in the operated area stood at 46.94 per cent in the current census as against 44.58 per cent in 2010-11. The number of operational holdings had risen from 138.35 million in 2010-11 to 146.45 million in 2015-16, an increase of 5.86 per cent.

The National Innovations in Climate Resilient Agriculture (NICRA) programme is in place to enhance the resilience of Indian agriculture, covering crops, livestock and fisheries to climatic variability and climate change through development and application of improved production and risk management technologies and by demonstration of site specific technology packages on farmers' fields for adapting to current climate risks. The project has been implemented in 151 districts involving over one hundred thousand farm families across the country.

As per the 2019 census, the total livestock population is 535.780 million in the country showing an increase of 4.6 per cent over Livestock Census-2012, and the total poultry in the country is 851.810 million in 2019, with a registered increase of 16.8 per cent in the total poultry. The dairy sector in the country witnessed a growth of 36.6 per cent in milk production between 2013-14 and 2018-19. Livestock ownership is a vital element of the livelihoods of a major proportion of farmers in rural areas.

The share of regular wage/salaried employees in the workforce has increased by 5 percentage points from 18 per cent in 2011-12 to 23 per cent in 2017- 18 as per usual status. In absolute terms, there was a significant jump of around 26.2 million new jobs in this category. Various steps are being taken for generating employment in the country like encouraging the private sector, fast-tracking various projects involving substantial investment and increasing public expenditure.

In terms of energy consumption, India uses only 6 per cent of the world's primary energy, but sustained economic growth is placing increasing demands on its energy resources. India's per capita energy consumption grew from 19,669 MJ (mega joules) in 2011-12 to 24,453 MJ in 2018-19(P).

Both power and industry sectors are large consumers of energy in the country. The estimated consumption of raw coal by industry has increased from 587.81 million tonne during 2009-10 to 968.25 million tonne during 2018-19 with a CAGR of 5.12 per cent. The maximum use of natural gas is in the fertilizer industry (27.84 per cent) followed by power generation (22.30 per cent), while 17.10 per cent of natural gas is used in the transport/distribution network. India's energy intensity (at 2011-12 prices) decreased from 0.2747 MJ per rupee (MJ/INR) in 2011-12 to 0.2321 MJ/INR in 2018-19(P).

The transport sector is one of the fastest growing sectors in India. Indian Railways (IR) with over 68,000 route kms is the third largest network in the world under single management. During the year 2018-19, Indian Railways carried 1,200 million tonne of freight and 8,400 million passengers making it the world's largest passenger carrier and 4th largest freight carrier.

India has strived to ensure that it follows a growth path that delivers sustainable development and protects the environment by investing in various schemes aligned with its Nationally Determined Contribution (NDC), like the Swachh Bharat Mission, the National Smart Grid Mission, and the Atal Mission for Rejuvenation and Urban Transformation (AMRUT). Notwithstanding its economic realities, India's mitigation strategies emphasize clean and efficient energy systems, enhanced energy efficiency, resilient urban infrastructure, safe, smart and sustainable green transportation networks, and planned afforestation, as well as the holistic participation of all sectors.

Currently 93 per cent of the population has access to basic water with another approximately 90 million to be covered. Further, under Swachh Bharat Mission (Urban) to make the country open defecation free (ODF), more than 6.2 million individual toilets and 0.59 million community and public toilets have been constructed. As on December 2020, under the mission, 4,340 cities have been declared ODF, while 100 per cent door-to-door waste collection has been achieved in over 83,434 wards. Similarly, under the Swachh Bharat Mission (Grameen), about 107.29 million household toilets have been constructed in rural areas and all States/UTs have declared themselves open defecation free.

The COVID-19 pandemic has had a serious impact on India. The need to protect the population and take appropriate public health measures has had a serious impact on the economy, with a GDP contraction of 23.9 per cent in the first quarter of the fiscal year 2020-21. The full extent of this economic impact is yet to be known as the pandemic and relevant control measures are still continuing and the shape of the recovery has many uncertainties. Despite these, India continues to adhere to its commitments under the UNFCCC and the Kyoto Protocol and Paris Agreement and continues to make pro-active efforts in climate action. In particular, renewable energy generation has continued with its “must-run” status, despite the consequent pressure on thermal power generation and its capacity to provide cheaper power. This cost differential represents a significant economic effort at climate mitigation by India, over and beyond its responsibilities and commitments as a developing country party under the UNFCCC and the Paris Agreement.

National Greenhouse Gas Inventory

This BUR presents the detailed GHG inventory of the year 2016. In 2016, India's total greenhouse gas emissions excluding LULUCF amounted to 2,839 $MtCO_2e$ and including LULUCF amounted to 2,531 $MtCO_2e$.

Table ES1: Sector-wise National GHG emission in Gg for 2016

GHG Sources and Removals (Gigagram)	CO_2 emission	CO_2 removal	CH_4	N_2O	HFC 23	CF_4	C_2F_6	SF_6	CO_2 equivalent
Energy	2,064,840	NO	2072	68	NO	NO	NO	NO	2,129,428
Industrial Processes and Product Use	166,227	NO	187	11	2	4	1	0.004	226,407
Agriculture	NO	NO	14,423	339	NO	NO	NO	NO	407,821
Land Use, Land Use Change and Forestry	21,289	330,765	55	2	NO	NO	NO	NO	-307,820
Waste	NO	NO	2820	52	NO	NO	NO	NO	75,232
Total without LULUCF	2,231,068	----	19,502	469	2	4	1	0.004	2,838,889
Total with LULUCF	2,252,356	330,765	19,557	471	2	4	1	0.004	2,531,069
Memo Items	789,305	NO	1	0.13	NO	NO	NO	NO	789,359

Abbreviation: NO – Not Occurring.

In 2016, GHG emissions excluding LULUCF at the national level by type of gas were as follows: Emissions of CO_2 accounted for 2,231 Mt (78.59 per cent); CH_4 emissions accounted for 409 $MtCO_2e$ (14.43 per cent) and N_2O emissions accounted for 145 $MtCO_2e$ (5.12 per cent).

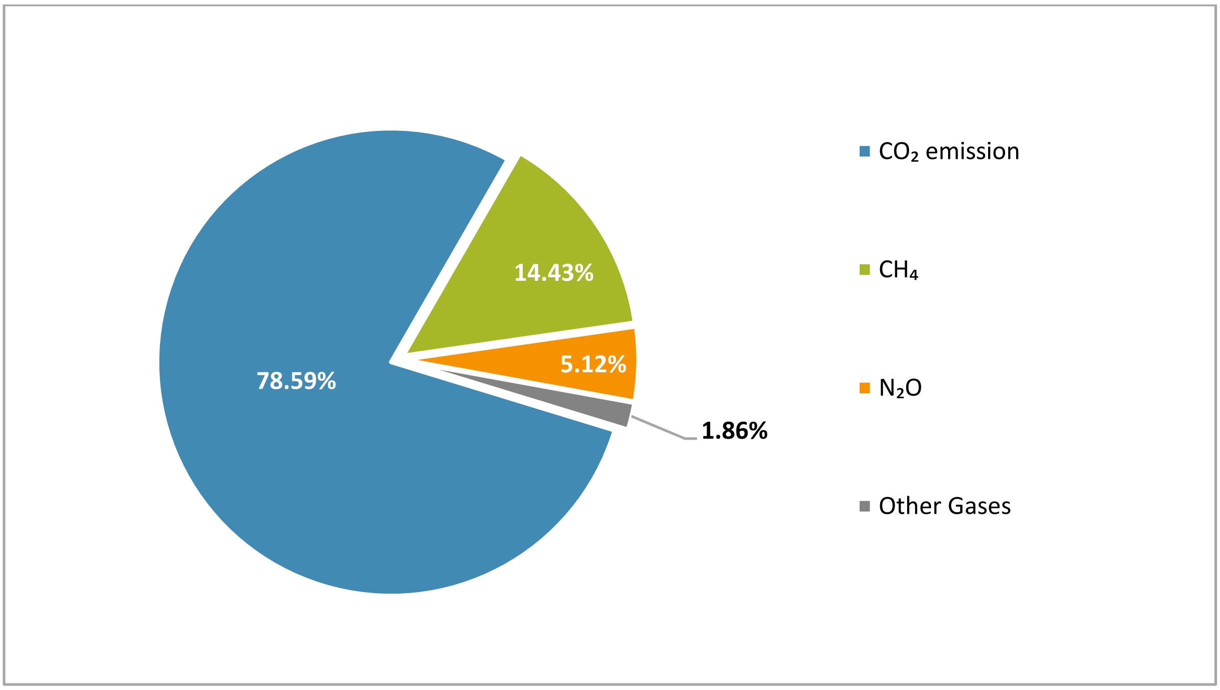


Figure ES1: Gas-wise emission for the year 2016

In 2016, top 15 emission categories in terms of CO_2 equivalent represented in below figure.

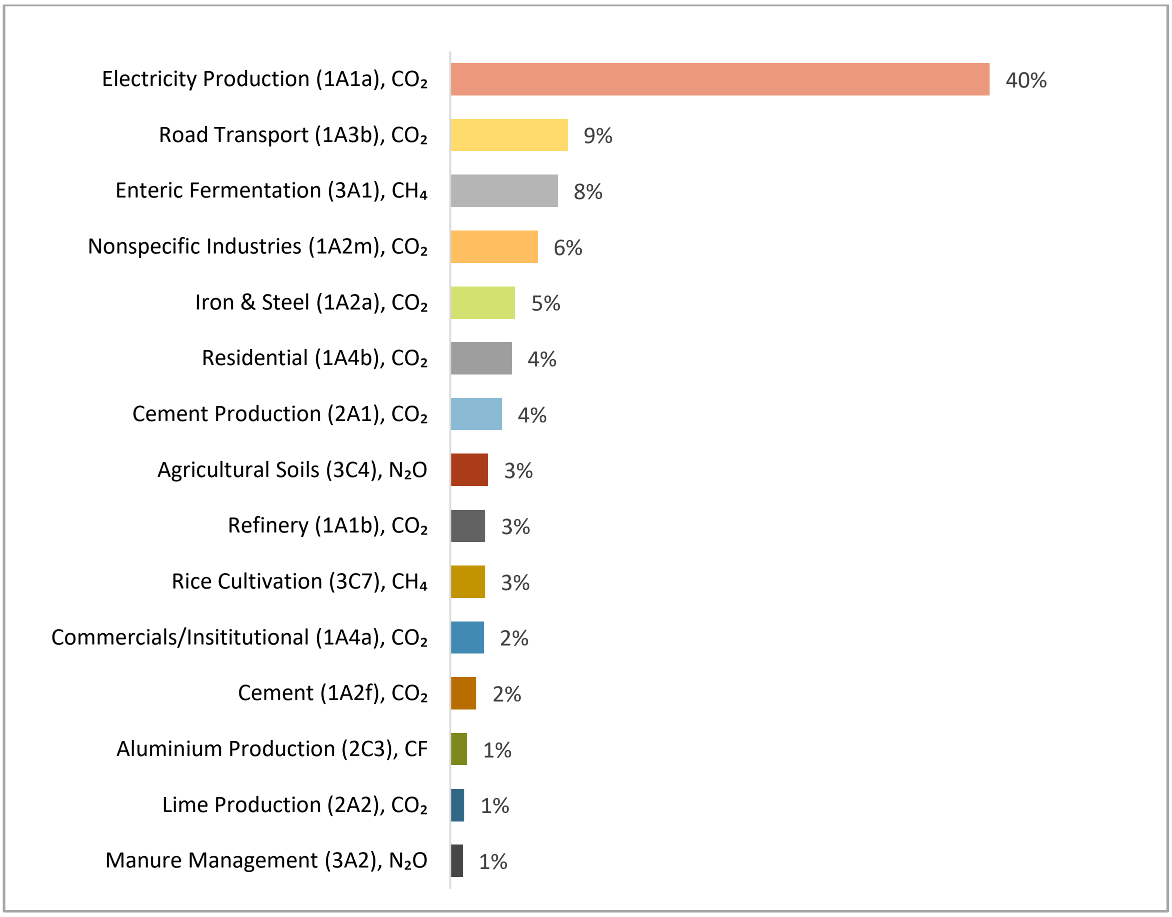


Figure ES2: Greenhouse gas emissions by category, $GgCO_2e$, 2016.

The energy sector accounted for about 75 per cent of the total GHG emissions for the year 2016. Electricity production was the single largest source in this category, accounting for about 40 per cent of the national total GHG emissions in 2016. The manufacturing industries and construction together emitted 18.68 per cent of total emissions from the energy sector.

Transport contributed to 13 per cent of emissions from the energy sector with predominant share of 90 per cent arising from road transport followed by civil aviation (6 per cent), railways (3 per cent) and domestic water-borne navigation (1 per cent). In 2016, the 'other sectors' together contributed about 10 per cent to energy sector emissions with approximately 60 per cent share coming from the residential sector, about 32 per cent from the commercial sector and the remaining 8 per cent from biomass burnt for energy (non-CO_2 GHGs) and agriculture/fisheries sectors put together. A comparison of fossil fuel combustion emissions using both the reference approach and the sectoral approach was conducted, and the difference was found to be 6 per cent in 2016.

The total fugitive emissions in the year 2016 were 37,179 Gg CO_2e, of which 46 per cent was from coal mining and post mining operations, and 54 per cent from oil and natural gas production and handling systems. Fugitive methane emissions have registered a decrease of 2 per cent between 2014 and 2016, mainly due to a relative reduction in underground mining activities. Fugitive emissions contributed to 1.8 per cent of emissions from the energy sector.

The Industrial Processes and Product Use (IPPU) category accounted for 8 per cent of the total GHG emissions. In 2016, the main GHG emitted by the sector was carbon dioxide (CO_2), representing 73.4 per cent of the total GHG emissions in the sector, followed by carbon tetrafluoride (CF_4) with 10.67 per cent, hydrofluorocarbon (HFC) with 8.51 per cent, hexafluoroethane (C_2F_6) with 4.11 per cent, methane (CH_4) with 1.73 per cent, nitrous oxide (N_2O) with 1.52 per cent and SF_6 with 0.04 per cent.

The agriculture sector is the main source of CH_4 and N_2O emissions. CH_4 emissions occur from this sector mainly due to livestock rearing (enteric fermentation and manure management) and rice cultivation. N_2O is principally emitted due to the application of fertilizers to agricultural soils. In the year 2016, the agriculture sector emitted 407,821 Gg of CO_2e, which amounted to around 14 per cent of the emissions of India for that year. It is a decrease of 2.25 per cent since 2014, the first time a decrease in India's inventory was registered for a sector between two consecutive inventory years. Within agriculture, in 2016, 54.6 per cent of GHG emissions were due to enteric fermentation, followed by 17.5 per cent from rice cultivation, 19.1 per cent from fertilizer applied to agricultural soils, 6.7 per cent from manure management, and 2.2 per cent due to field burning of agricultural residues.

The LULUCF sector was a net sink of 307,820 Gg CO_2e in 2016, registering an increase in the net sink activity by 39 per cent since 2000. Forest land, cropland and settlements categories were net sinks while grassland was a net source of CO_2. About 15 per cent of India's carbon dioxide emissions in 2016 were removed from the atmosphere by the LULUCF sector.

The waste sector contributed 2.7 per cent to total GHG emissions in 2016. It was dominated by emissions from wastewater treatment and discharge. More than three fourth (78.9 per cent) of the emissions from the waste sector come from wastewater treatment and discharge, followed by 21.04 per cent from solid waste disposal.

The key categories are identified for India's National GHG inventory 2016 based on the level assessment using Approach 1, where a 95 per cent cumulative contribution threshold has been used in this analysis to define an upper boundary for the key category identification. The level assessment without LULUCF reveals that CO_2 emissions from electricity production were the largest category with 39.5 per cent of total emissions occurring in the country, followed by CO_2 emissions from road transport with 8.6 per cent, and by CH_4 emissions from enteric fermentation that accounts for about 7.8 per cent.

According to the Inter-governmental Panel on Climate Change (IPCC) Guidelines (2006), uncertainty estimates are an essential part of a comprehensive inventory of GHG emissions and removals. The overall inventory uncertainty was estimated using the Tier 1 methodological approach. An estimate of the overall quantitative uncertainty is ±6.96 per cent level uncertainty and ±7.90 per cent trend uncertainty.

Mitigation actions

As per the provisions of Article 12, paragraphs 1(b) and 4, and Article 10, paragraph 2(a), of the Convention, India made a voluntary declaration to reduce the emission intensity of its GDP by 20-25 per cent from 2005 levels by 2020 (excluding emissions from agriculture) in 2010. In 2015, India further enhanced ambition in its NDCs to reduce the emission intensity of its GDP by 33-35 per cent below 2005 levels by 2030. Based on the National GHG Inventory, it is confirmed that India has successfully continued decoupling its economic growth from GHG emissions, resulting in reduction of the emission intensity of its GDP by 24 per cent between 2005 and 2016.

This result is the outcome of the pro-active efforts of the GoI in the implementation of the provisions of the Convention, contextualizing it to its national circumstances and widening the mitigative efforts across sectors. The planned and implemented policies and measures mitigate emissions of GHGs across sectors either directly or indirectly. In addition to effective policymaking, appropriate measures to increase the share of cleaner and renewable energy in the total energy mix by replacing fossil fuels are also being carried out across sectors. Electricity generation from renewable energy sources such as solar, wind, hydro and nuclear, and modern sources such as waste to energy and biofuels has contributed significantly to the mitigation of emissions. Through proactive measures and conscious action, the economy has been increasingly making efforts to improve energy efficiency and enhance CO_2 removal through increasing tree and forest cover, without compromising on the developmental priorities of the country.

Power sector

Ensuring energy security, improving access and affordability of modern energy resources for all Indians, diversifying energy resources, enhancement of resource use efficiency, reducing technical and commercial losses in power transmission, and enhancing renewable energy are the pillars of India’s energy policies.

The power sector in India is fuelled by conventional sources such as coal, lignite, natural gas, oil and nuclear power and renewables such as wind, hydro, solar, waste, and biofuels. The power sector in India has witnessed a transformation over the past few years, with an increasing focus on clean and sustainable power generation sources. In 2015-16, the Indian government set a target of achieving 175 GW of renewable energy capacity by 2022 which was later indicated to be enhanced to 450 GW. In recent years, policies and programmes have been developed and implemented in the energy sector with a focus on addressing climate change concerns. India's NDC includes a target to achieve 40 per cent electric power installed capacity from non-fossil fuel-based sources by 2030.

The share of non-fossil-fuel-based electricity generation in total installed capacity reached approximately 38.18 per cent in November 2020. There has been an increasing focus on the use of renewables in power generation which is further aided by enabling government policies, together with regulatory support, at both the Centre and the States. The power generation capacity share of renewables grew from 4.98 per cent as on March 2006 to 23.92 per cent by September 2020. Other sources of power generation like gas, diesel, and nuclear witnessed a diminishing trend between 2005 and 2020.

As of 30 November 2020, installed renewable power capacity (excluding hydro above 25 MW) has reached 90.39 GW, contributing approximately 24 per cent of the country's installed capacity of electricity generation.

The Energy Conservation Act came into existence in 2001, with the objective of conservation and the efficient use of energy. The adoption of energy efficiency schemes/ programmes has led to the overall energy savings of 23.728 Mtoe for the year 2018-19. After the success of the first Perform, Achieve and Trade (PAT I) cycle (2012-13 to 2014-15), which resulted in total energy savings of 8.67 Mtoe, and emission reduction of 31 $MtCO_2$, PAT II was rolled out. PAT II cycle (2016-17 to 2018-19) resulted in total savings of approximately 13.28 Mtoe savings, translating into 61.34 $MtCO_2$.

The MSME sector in India recorded a total 63.38 million units, employing about 110.98 million persons. To promote technology upgradation and modernization, GoI has been employing several measures aimed at fostering a regime that could remove barriers for accelerated technology upgrades focusing on energy efficiency and innovation in the MSME sector. The objective is mainly to improve the energy efficiency of MSME sector in India through accelerating adoption of energy efficient technologies, knowledge sharing, capacity building and development of innovative financial mechanisms. The initiatives led to a total emission reduction of 0.124 $MtCO_2$ in 2018-19.

Under Unnat Jyoti by Affordable LEDs for All (UJALA) scheme, as on November 2020, over 366.85 million LED bulbs, 7.207 million LED tube lights, and 2.340 million energy efficient fans have been distributed across India. This has led to a GHG emission reduction of 180.08 $MtCO_2$ from 2014-15 to November 2020.

Under SLNP, up to September 2020, EESL has installed over 11.25 million Light Emitting Diode (LED). This has resulted in cumulative energy savings of 18.071 billion units and emission reduction of 14.82 $MtCO_2$ from 2015-16 to 2019-20.

Building sector

India currently has about 7.61 billion sq. ft. of green building footprint, 6,055 registered projects, and 780 certified projects as on 15 October 2020.

So far, 17 states and UTs have notified the Energy Conservation Building Code (ECBC) and around 335 demonstration buildings are ECBC compliant. Fifty buildings have been constructed, with a cumulative built-up area of 0.16 billion sq. m ensuring an approximate energy saving of 0.17 billion kWh.

EESL is implementing the Buildings Energy Efficiency Programme (BEEP) to retrofit commercial buildings in India into energy efficient complexes. Till date, EESL has completed building energy efficiency projects in 10,344 buildings including railway stations and airports. Energy audits shows energy saving potential to the tune of up to 30-50 per cent in these buildings.

To recognize energy-efficient buildings, as well as to stimulate their large scale replication, India has developed its building-energy rating system GRIHA (Green Rating for Integrated Habitat Assessment), based on 34 criteria such as site planning, conservation and efficient utilization of resources. As on October 2020, India has 1,825 GRIHA registered projects with approximately 52.5 million sq. m of 'green' built-up area.

Under the Smart City Mission, 100 Smart Cities have been selected through a two-stage competition. A total of 5,151 projects worth INR 20,50,180 million have been included by selected 100 cities in their Smart City proposals.

Transport sector

The transport sector is rapidly growing in India, contributing significantly to the GDP of the country. However, the sector is largely oil-dependent and accounts for 9.7 per cent of the country's total GHG emissions (without LULUCF).

While India is operating in the same global context as other countries who have adopted an Electric Vehicle (EV) policy, its unique mobility pattern necessitates an EV policy that is tailor-made to India's particular needs. India is one of 16 member countries of the Electric Vehicles Initiative (EVI), a multi-government policy forum dedicated to accelerating the introduction and adoption of electric vehicles worldwide.

One of the major regulatory announcements was the skipping of Bharat Stage (BS)-V emission norms and the advance introduction of BS-VI from 1 April 2020.

An increase in the share of alternative fuels in the overall fuel mix is yet another strategy to reduce emissions from the sector. GoI has notified the National Policy on Biofuels-2018, which *inter-alia* aims to develop alternate fuels and to reduce import dependency as one of the objectives. The policy envisages an indicative target of 20 per cent blending of ethanol in petrol and 5 per cent blending of bio-diesel in diesel by the year 2030.

The Green National Highways Corridor project will help in building safer, greener and more resilient national highway corridors in the Indian states of Rajasthan, Himachal Pradesh and Andhra Pradesh.

The National Electric Mobility Mission Plan (NEMMP) aimed to deploy 400,000 passenger battery electric vehicles (BEVs) by 2020. The sales of electric two-wheelers in India rose from 54,800 units in 2018 to 1,26,000 units in 2019. The Department of Heavy Industry is administering the Faster Adoption and Manufacturing of (Hybrid) and Electric Vehicles (FAME) India Scheme for promotion of electric/hybrid vehicles in India since 1 April 2015. In the first phase of the scheme 0.28 million hybrid and electric vehicles are supported by way of demand incentive amounting to about INR 3,590 million. Phase-II of FAME India Scheme for a period of three years began in April 2019 with a total budgetary support of INR 100,000 million. From April 2019, the second phase of the FAME II scheme encompasses strict speed, range and energy efficiency requirements. The States of Karnataka, Telangana, Maharashtra, Uttar Pradesh, Kerala, Uttarakhand, Andhra Pradesh, Delhi and a few more have rolled out their EV/Draft EV policies. These states are proposing several fiscal incentives to car and battery manufacturers, charging infrastructure companies and consumers.

Urban Rail, popularly referred to as Metro Rail, has seen substantial growth in India in the recent years. More cities are becoming reliant on the metro rail to meet their day-to-day mobility requirements. India has currently eleven operational metro systems in 18 cities, while 900 km Metro/RRTS is under construction in 27 cities.

Agriculture sector

The National Mission on Sustainable Agriculture (NMSA) under the National Action Plan on Climate Change (NAPCC), aims to transform agriculture into an ecologically sustainable, climate-resilient production system by devising appropriate adaptation and mitigation strategies for ensuring food security, equitable access to food resources, enhancing livelihood opportunities and contributing to economic stability at the national level.

Pradhan Mantri Krishi Sinchayee Yojana (PMKSY), another scheme to achieve convergence of investments in irrigation at the field level, expand cultivable area under assured irrigation, and improve on-farm water use efficiency to reduce wastage of water, has resulted in an emissions reduction of 11.979 $MtCO_2$ during 2017-18 and 2018-19.

Crop diversification programme has been implemented since 2013-14 to promote alternatives to water-intensive paddy cultivation including crops like pulses, oilseeds, maize, cotton, and agroforestry to tackle the problem of depleting water table in select states.

Forestry sector

Approximately 80 per cent of the country's terrestrial biodiversity exists in forests, and more than 300 million people have a high dependency on the forest for their livelihood. Forests as a carbon sink have a prominent role in mitigating climate change. Various legislations and acts have been formulated by the Indian government for the conservation of forests and their resources. LULUCF sequestered 330.76 Mt of CO_2, which is about 15 per cent of India's total CO_2 emissions from all sectors in 2016. The forest and tree cover has increased from 8,02,088 km^2 in 2017 to 8,07,276 km^2 in 2019. The net change in the carbon stocks of forests was +42.6 Mt or 156.2 $MtCO_2$ equivalent between the assessments of 2017 and 2019.

The Forest (Conservation) Act, 1980 laid the foundation for protection and conservation of the country's natural forests. The Compensatory Afforestation Fund Act 2016 has made compensatory afforestation mandatory, in case of diversion of forest land to non-forestry uses. Similarly, the Compensatory Afforestation Fund Management and Planning Authorities (CAMPAs) at both the Centre and States ensure expeditious and transparent utilization of amounts realized from forest land diverted for non-forestry purposes.

Progress on various fronts has been made under plantation programmes such as the Twenty Point Programme, National Afforestation Programme, National Green Highways Mission, and the National Mission for Green India. It is expected that the afforestation drive under National Green Highways Mission, launched in July 2016, will help in sequestering approximately 0.156 million tonne CO_2 annually.

A total of 29 State Forest Department Agency projects are currently operating in the country with a total expenditure of INR 38.20 billion to treat an area of 2.19 million ha till 2018-19 under the National Afforestation Programme. In 2018-19, INR 1.59 billion have been earmarked for the Green India Mission which marks an increase of 48.8 per cent over the previous allocation. Green India Mission (GIM) has also taken up the World Bank Funded Ecosystems Service Improvement Project (ESIP) which is being implemented in two States namely, Chhattisgarh and Madhya Pradesh.

The GoI made the Bonn Challenge pledge in 2015 to bring under restoration 13 million hectares (Mha) of degraded land by 2020 and an additional 8 Mha by 2030. In total, 9.81 Mha were brought under restoration across India (from 2011 till 2016-17). Out of the total restoration efforts carried out across the country, 94.4 per cent were by government agencies, 3.6 per cent by NGOs and 2 per cent by private companies.

Waste sector

The current focus of the GoI is on the rapid expansion and modernization of waste management infrastructure as well as sanitation infrastructure and facilities. This is considered indispensable for mitigation action from the waste sector.

As on September 2020, a total of 216 Waste-to-Energy plants with aggregate capacity of 370.45 MWeq have been set up in the country to generate power or biogas or Bio CNG from agricultural, urban, industrial and municipal solid wastes. The estimated potential to generate power from Municipal Solid Waste (MSW) is about 500 MW which would be increased to 1,075 MW by 2031. Apart from this, the Ministry of New and Renewable Energy (MNRE) is implementing a programme on energy recovery from urban and industrial wastes including wastewater. MNRE has also undertaken various other programmes on energy from urban, industrial and agricultural wastes/residues.

Under Swachh Bharat Mission, IR had earlier set a target to fit bio-toilets in the entire fleet of railway coaches by the year 2021-22. This target was achieved earlier than targeted. All passenger carrying BG coaches, from April 2020 onwards, are fitted with bio-toilets and direct discharge of human waste from trains has thus been eliminated.

Mitigation Action: Global Context

Independent scientific studies of global climate action in comparative terms agree that India’s climate actions are 2^{o} C warming compliant and that India is on track to fulfilling its pre-2020 voluntary pledge as well as being on track to meeting its commitment under the Paris Agreement.

In contrast, Annex-I Parties have failed to meet their pre-2020 commitments, as noted by the Subsidiary Body on Implementation report on “Compilation and synthesis of Fourth Biennial reports of Parties included in Annex I to the Convention” has noted. Non-EIT (Economies in Transition) Annex-I Parties reduced their annual total emissions from 1990 to 2018 by only 1.5 per cent without LULUCF (and 3.1 per cent with LULUCF). Annex-I Parties as a whole have reduced emissions from 1990 to 2016 only by 12.5 per cent without LULUCF (and 16.6 per cent with LULUCF) in contrast to the benchmark of 25-40 per cent established in the Fourth Assessment Report (AR4) of the IPCC.

Contextualizing India's efforts, it is to be noted that the 28 most developed nations (non-EIT Annex-I Parties) with only 13.5 per cent of the global population and 58 per cent of global GDP have contributed 57 per cent of global cumulative emissions between 1850 and 1990, and 37 per cent between 1990 and 2017. This implies a permanent overdrawing from the global carbon budget by any measure or consideration of equity, thus having a permanent impact on the development path of all developing nations.

This overdrawing from the global carbon budget cannot be redressed by commitments to carbon neutrality by 2050, especially as in the next 10 years the most that developed countries are set to reduce their annual emissions is only 2.2 per cent to 5.8 per cent, based on their Fourth Biennial Reports to the UNFCCC. Without carbon neutrality being achieved by these countries substantially before 2050, and without further substantial removal of carbon by them through sinks, the Paris Agreement goal of global balance between emissions by sources and removals by sinks by 2050 cannot be achieved in keeping with equity and climate justice. India, for its part, is mindful of the challenge of neutrality, and where ecological considerations dictate is taking pro-active steps for carbon neutral development as in the Union Territory of Ladakh.

Domestic Measurement, Reporting and Verification Arrangements

The operational design of MRV in India is implemented in a decentralised manner, with efforts distributed at multiple levels of governance. The governance framework in the country mainly adopts a 3-tier system for administering and monitoring policy schemes and actions as the flow of information involves a bottom-up approach with several tiers (local, sub-national and national) of standard reporting.

Enhancing transparency and accountability by making information accessible through online web-portals/ digital dashboards has led to effective tracking of schemes' performances across all States, on a single platform. GoI has developed numerous dashboards in related sectors such as power, transport, agriculture and forestry.

Building a robust national data repository system is essential for the development of baselines and estimating accurate GHG emission inventories (identifying emission sources, baseline projections and forecasting trends). In India, there are a number of data repositories at various levels (sub-national and national) maintained by respective departments/ministries. For example, the National Power Portal developed by Central Electricity Authority (CEA) provides information on installed renewable capacity and its generation. The Open Government Data (OGD) India platform supports the open data initiative of the GoI.

It is important to develop a robust MRV system to assess the performance of schemes and actions and outline the responsibilities of key actors (nodal agencies and implementing bodies). A robust Monitoring & Verification system has been developed by BEE for the PAT scheme in order to assess the savings achieved by industries. The assessment is done only for the final year of the three-year cycle to establish whether the Designated Consumers (DCs) have achieved their targets or not. Similarly, the Standards & Labelling programme, the national standards for emission and discharge of environmental pollutants for the Central Pollution Control Board (CPCB), and the Climate Smart Cities Assessment Framework developed by the Ministry of Housing and Urban Affairs (MoHUA) under the Smart Cities Mission are key examples of some of the scheme specific MRVs. For such monitoring and evaluation mechanisms on a widespread scale, finance and additional support (technology, infrastructure, capacity building) is required.

MRV alone, however, is of insubstantial value if not accompanied by adequate climate action. Further reporting under the Enhanced Transparency Framework of the Paris Agreement will result in enhanced burdens on developing country Parties in terms of diversion of expenditure and highly skilled human resources from the needs of both development and real climate action.

Finance, technology and capacity building needs and support received

India has been reporting on constraints and gaps and related financial, technical and capacity-building needs, consistently and periodically since 2004 with the submission of INC to UNFCCC and thereafter, the second national communication in 2012, the first BUR in 2016 and the second BUR in 2018.

India's financial needs to fulfil its obligations under the Convention and its Paris Agreement are enormous and multiplying rapidly in the present-day context. The transition to low carbon economy while continuously weathering climate-induced events and disasters is a costly affair, requiring new, additional and climate-specific financial resources.

As regards financial needs in Indian NDCs, preliminary estimates indicate that India would need around USD 206 billion (at 2014-15 prices) between 2015 and 2030 for implementing adaptation actions in key areas like agriculture, forestry, fisheries, infrastructure, water resources and ecosystems. The GCF finance to India as per the latest available information amounts to only USD 177 million (since inception), out of which only USD 77.8 million is grant-based finance. These funds would be insufficient if the current trend prevails, falling short of meeting our requirements.

The funds for GEF-7 replenishment (2018-2022) is lower than GEF-6 and the funds under climate change focal area have also reduced. India's STAR allocation for climate change declined by almost 50 per cent from GEF-6 (USD 87.88 million) to GEF-7 (USD 47.24 million). India has about 8.45 per cent of total GEF-7 STAR indicative allocation under climate change.

India's climate actions are largely financed from domestic sources both budgetary as well as a mix of market mechanisms together with fiscal instruments and policy interventions. The national initiatives include Climate Change Action Programme (CCAP) and NAFCC.

Connecting science, technology and innovation with societal outcomes drive sustainable economic and social progress for India. It is the guiding principle of the Government of India's perspective on science and technology.

The upgradation of the emission inventory system is a dynamic process, and sustained efforts are being made to ensure that India's GHG emission inventory is of high quality, transparent and consistent with the requirements of the IPCC inventory guidelines. The GoI plans to ride the tier ladder using key category analysis and uncertainty assessment which requires new and additional financial, technical and capacity support.

As expressed through the national reporting process to the Convention since 2004, support for enhancing capacity building is of vital importance to India. All Government programs have a component on capacity building/ training/ awareness creation and most of these programs have started accounting for climate variabilities in their respective sectors to ensure economic growth and sustainable development. Weather and climate forecasting and other services, and establishment of robust energy management systems are some of the key areas where capacity building support is needed.

There are persistent inadequacies in the fulfilment of commitments by the Annex-I Parties with respect to finance. These include postponement of the target date for USD 100 billion per year from 2020 to 2025, lack of transparency in reporting, lack of clarity on finance from public sources that is new and additional, the preponderance of loans over grants, and the skewed emphasis on mitigation in contrast to adaptation.

In technology transfer, despite arguing for the sanctity of the international property rights regime, technology development in all the Annex-I countries has registered a significant slow-down across all sectors of the UNFCCC recognized categories of "climate change mitigation technologies." Following a peak in 2009 to 2011, patenting activity in these technologies has fallen over a range from 30 to 80 per cent, indicating that in the absence of legally binding commitments, Annex-I parties have significantly slowed down their technology development.

Additional Information

The Additional Information chapter contains, among others, information and success stories from renewable energy sector, sustainable transportation, and international cooperation and initiatives,

One of the world's largest solar rooftop systems was installed on Brabourne stadium in Mumbai in August 2018 with a total roof area of 1.621 million sq. ft. of roof sheds, with 2,280 installed solar panels and the potential of offsetting 840 tonne of CO_2 annually. Similarly, the world's largest solar park is located in Bhadla, Rajasthan with a total area of 10,000 acres (40 km^2) with a total capacity of 2,245 MW.

Setting up of Asia's largest solar power project at Rewa, Madhya Pradesh, and enabling Cochin International Airport to be the first airport in the world to be fully powered by solar energy are examples of India's growing efforts in expanding the renewable energy sector.

Indian Railways, the third largest rail network in the world is striving towards green mode of transport. The National Electric Mobility Mission Plan 2020, hydrogen fuel bus and car projects in Leh and Delhi, India's first solar-powered ferry "Aditya" in Kerala and flying transport aircraft with blended bio-jet fuel vouch for India's plans to turn from fossil fuel to green sources in the transport sector.

There are several new initiatives in weather and climate services including the upgrade of forecast models, adoption of high performance computing and improved agrometeorological services.

In international cooperation, apart from championing and safeguarding the tenets of multilateralism, India leads two key initiatives, by hosting, supporting and nurturing the ISA and CDRI. Furthermore, following the United Nations Climate Action Summit, 2019, India, with Sweden, is co-leading the Leadership Group for Industry Transition to drive transformation in hard-to-decarbonize and energy-intensive sectors. This BUR shows that it is not only that India is going above and beyond its fair share of the burden of mitigation, but that it is in reality emerging as the front-runner in fair climate action.

*****

Background Information and Institutional Arrangements

MoEFCC is the nodal Ministry in the GoI for coordination and management of climate change-related programmes, actions and reporting information under Article 4.1 of the Convention. According to the Article, all Parties, taking into account 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 (UNFCCC, 1992). Accordingly, Parties communicate information on national inventories of greenhouse gases not controlled by the Montreal Protocol, steps taken or envisaged to implement the Convention and any other information that the Party considers relevant to the achievement of the objective of the Convention and suitable for inclusion in its communication. Later, through its decision 1/CP.16, paragraph 60, the COPs decided to enhance reporting from Parties not included in Annex I to the Convention stating that "Developing countries, consistent with their capabilities and the level of support provided for reporting, should submit biennial update reports containing updates of national greenhouse gas inventories, including a national inventory report and information on mitigation actions, needs and support received". The decision also states the need to consider national capabilities and financial support required to facilitate the timely preparation of biennial update reports. Decision 2/CP.17, Paragraph 41(f) and (g) mandated Non-annex I Parties to submit BURs every two years with the national GHG inventories being not more than four years older than the submission year. In fulfillment of these requirements, MoEFCC with its cross-ministerial and institutional network is implementing and executing the matters related to the NCs and BURs.

Previous submissions

Towards the fulfillment of reporting obligations under the UNFCCC, India has so far furnished two full national communications and two BURs (Figure IA1) to the UNFCCC:

(i) Initial National Communication (INC) in June 2004, containing national GHG inventory of 1994.
(ii) Second National Communication (SNC) in May 2012, containing national GHG inventory for the year 2000.
(iii) First Biennial Update Report (BUR-1) in January 2016, containing national GHG inventory for the year 2010.
(iv) Second Biennial Update Report (BUR-2) in December 2018, containing national GHG inventory for the year 2014.

As a proactive measure, the national GHG inventory for the year 2007 was published domestically in 2010 (MoEF, 2010). Summary of the 2007 inventory was provided in Second National Communication (MoEF, 2012). As a fulfilment of the requirement of enhanced reporting and updating of information, India's Third BUR is being presented to the UNFCCC.

Figure IA1: India's National Communications and BURs

The second BUR (MoEFCC, 2018) gave an account of the National Inventory for the year 2014 and time series for 2000-2014 covering the five IPCC Categories: Energy, IPPU, Agriculture, LULUCF, and Waste. Total emissions in 2014 excluding LULUCF were 2,607,488 GgCO_2e. Distribution of emissions by gases and sectors is as shown in Figure IA2.

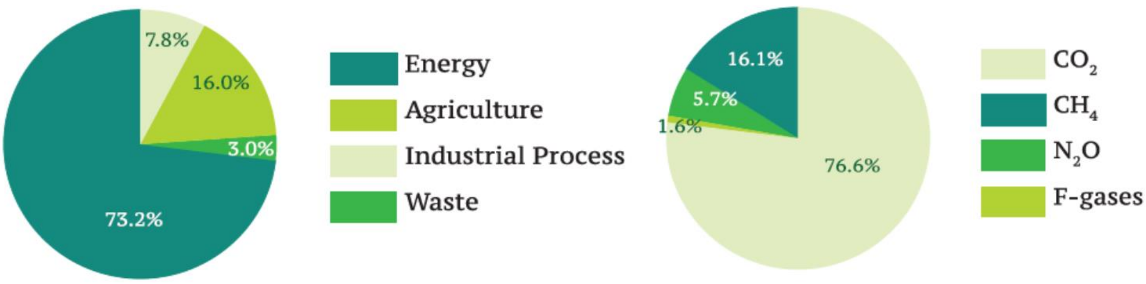


Figure IA2: Distribution of GHG emissions, by gases and sectors in 2014

In 2014, about 12 per cent of national emissions (without LULUCF) were sequestered by the LULUCF sector. With LULUCF sequestration included, total GHG emissions were 23,06,295 Gg CO_2e for 2014.

The second BUR presented government schemes relating to low carbon economic development such as those relating to renewable energy, energy efficiency, transport, power and status of implementation of the mitigation actions in the country.

Government of India and various State governments under the federal constitutional structure of India have undertaken many proactive policies and measures across sectors and regions as general steps taken or envisaged to implement the Convention, its Protocol, and Agreement keeping in mind the national circumstances. Most of these policies and measures mitigate GHGs directly or indirectly.

The third BUR presents updated information on the National GHG Inventory, Mitigation Actions and Financial, Technology and Capacity Building needs. It also addresses the suggestions made during the International Consultation and Analysis

(ICA) process for BUR-1 and BUR-2 wherever relevant and within the scope of present capacity in order to enhance the transparency of mitigation actions and their effects. This would be without engaging in discussion on the appropriateness of India's mitigation actions and their effects, and enhancing the consistency of the methods used for preparing GHG inventories with the appropriate methods as per IPCC 1996 Revised guidelines and 2006 guidelines as referred to in the UNFCCC reporting guidelines on BURs. These are appropriately reported in various chapters of BUR-3.

Institutional Arrangements

For the preparation of National Communications including the BURs, MoEFCC established National Communication (NATCOM) Project Management Unit, which comprises Programme Officers who assist the National Project Director in the compilation of the communications. The current implementation arrangement is depicted in Figure IA 3. After the submission of the BUR-1, activities for the preparation of India's BUR-2 and BUR-3 were launched under the GEF-UNDP-GOI project "Preparation of Third National Communication (TNC) and Other New Information to the UNFCCC".

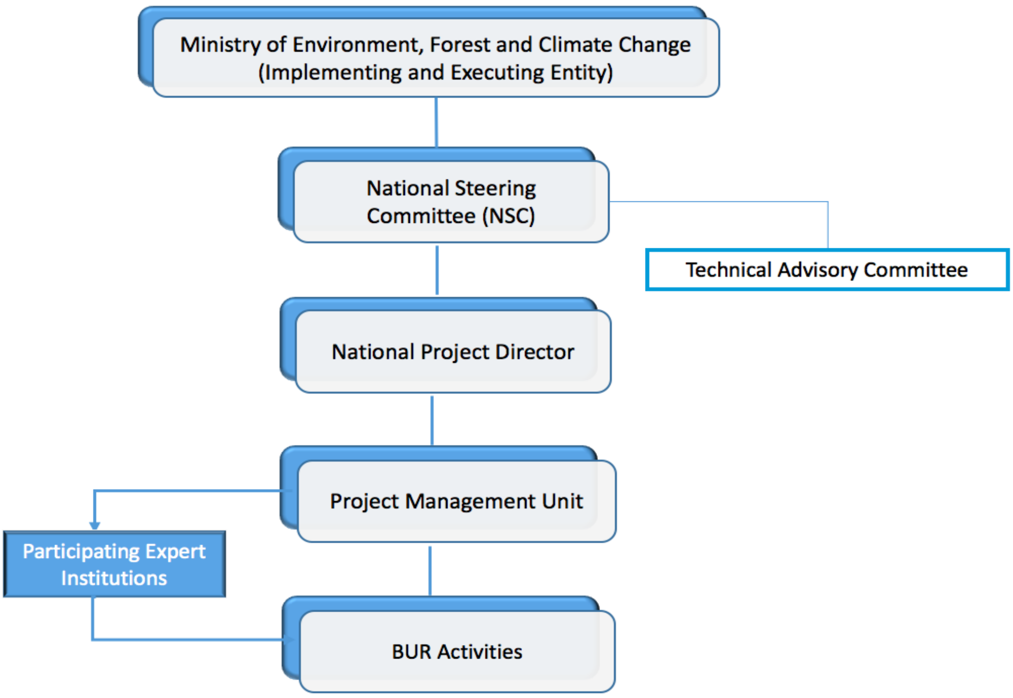


Figure IA3: Implementation Arrangement for the third BUR

For the preparation of National Communication on a continuous basis, GoI has taken steps and made efforts towards creating a sustainable institutional structure. Preparation of the BUR 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. National Steering Committee

(NSC) under the chairmanship of the Secretary, MoEFCC is in place that oversees the preparation and implementation of the work programme of the BUR. Various line Ministries and Government departments that are most concerned with various elements of information in this report have representation in the National Steering Committee. Composition of NSC is provided in Annexure II.

Technical consultations on multiple and multidisciplinary aspects of information relating to 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) to provide technical guidance to the preparation of BUR. This committee has members from the government, academia and society. Composition of TAC is provided in Annexure II.

This report encompasses information on National Circumstances, National GHG Inventory, Mitigation Actions, and an analysis of the Constraints, Gaps, and related Financial, Technical and Capacity Needs including information on domestic MRV. Several studies were launched to accommodate the requisites of the third BUR. These studies were carried out by institutions having sector-specific expertise. Besides, various ministries, government departments, and PSUs provided inputs for preparation of this BUR (Figure IA 4).

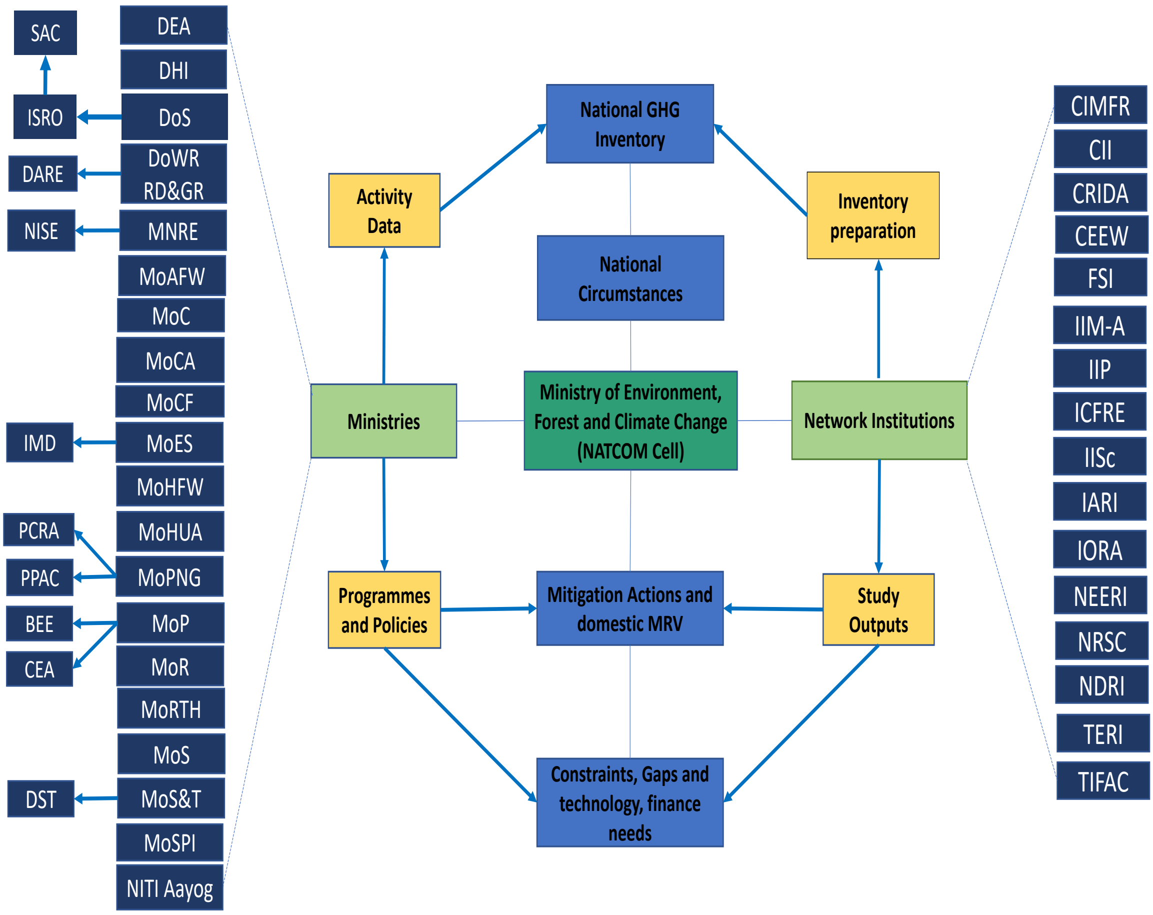


Figure IA4: Institutional Arrangements for the Third BUR

Acronyms:

Network Institutions

CEEW:	Council on Energy, Environment and Water, New Delhi
CII:	Confederation of Indian Industry, New Delhi
CIMFR:	Central Institute of Mining and Fuel Research, Dhanbad
CRIDA:	Central Research Institute of Dryland Agriculture, Hyderabad
FSI:	Forest Survey of India, Dehradun
IARI:	Indian Agricultural Research Institute, New Delhi
ICFRE:	Indian Council of Forestry Research and Education, Dehradun
IIM-A:	Indian Institute of Management, Ahmedabad
IIP:	Indian Institute of Petroleum, Dehradun
IISc:	Indian Institute of Science, Bengaluru
IORA:	IORA Ecological Solutions, New Delhi
NDRI:	National Dairy Research Institute, Karnal
NEERI:	National Environmental Engineering Research Institute, Nagpur
NRSC:	National Remote Sensing Centre, Hyderabad
TERI:	The Energy and Resources Institute, New Delhi
TIFAC:	Technology Information, Forecasting and Assessment Council, New Delhi

Ministries / Departments

BEE:	Bureau of Energy Efficiency
CEA:	Central Electricity Authority
DARE:	Department of Agricultural Research and Education
DEA:	Department of Economic Affairs
DHI:	Department of Heavy Industry
DOS:	Department of Space
DST:	Department of Science and Technology
IMD:	India Meteorological Department
ISRO:	Indian Space Research Organization
MoAFW:	Ministry of Agriculture and Farmers Welfare
MoC:	Ministry of Coal
MoCF:	Ministry of Chemicals and Fertilizers
MoCA:	Ministry of Civil Aviation
MoES:	Ministry of Earth Sciences
MoHFW:	Ministry of Health and Family Welfare
MoHUA:	Ministry of Housing and Urban Affairs
MoP:	Ministry of Power
MoPNG:	Ministry of Petroleum and Natural Gas
MoR:	Ministry of Railways
MoRTH:	Ministry of Road Transport and Highways
MoS:	Ministry of Steel
MoSPI:	Ministry of Statistics and Programme Implementation
MoS&T:	Ministry of Science and Technology
DoWR RD&GR:	Department of Water Resources, River Development & Ganga Rejuvenation
MNRE:	Ministry of New and Renewable Energy
NISE:	National Institute of Solar Energy
NITI Aayog:	National Institution for Transforming India
PCRA:	Petroleum Conservation Research Association
PPAC:	Petroleum Planning and Analysis Cell
SAC:	Space Application Centre

Institutional Network

MoEFCC, being the implementing and executing entity assigns several studies and conducts activities including workshops and national consultations for the preparation of BUR. The institutional network of second BUR was also employed for the third BUR. This BUR also includes some elements from the studies carried out under the Impacts, Vulnerability and Adaptation component. A large number of experts not engaged in preparation of BUR also provided their inputs, comments and feedback. For details on the institutions and the experts involved in preparation of BUR-3, please refer to Annexure II.

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. 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 supporting institutions with adequate capacity for the preparation of National Communications and BURs 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.

References

MoEF. (2010). India: Greenhouse Gas Emissions 2007 (INCCA Indian Network for Climate Change Assessment, p. 64). Ministry of Environment and Forests, Government of India.

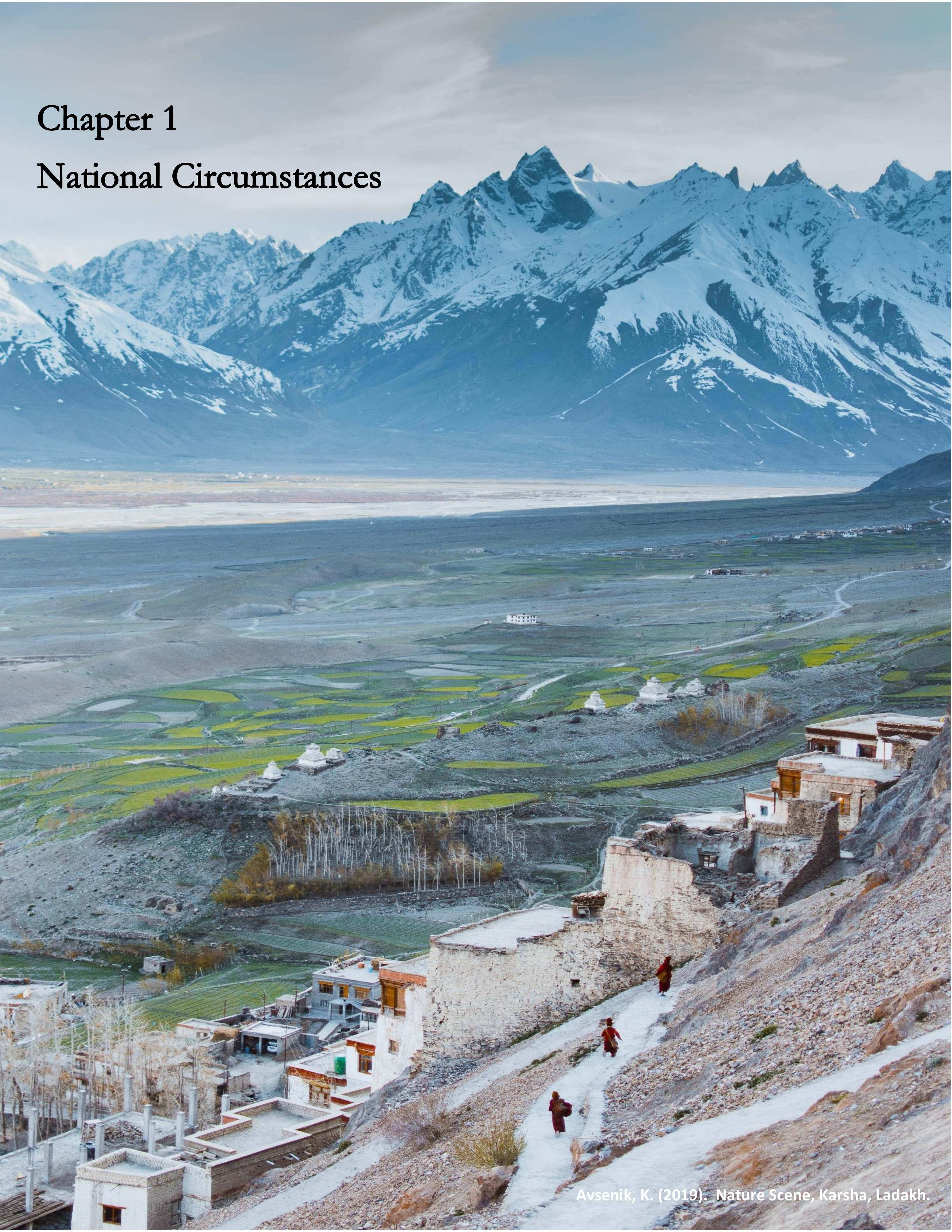
MoEF. (2012). India Second National Communication to the United Nations Framework Convention on Climate Change (p. 310). Ministry of Environment and Forests, Government of India.

MoEFCC. (2018). India Second Biennial Update Report to the UNFCCC (p. 228). Ministry of Environment, Forest and Climate Change.

UNFCCC. (1992). United Nations Framework Convention on Climate Change. https://unfccc.int/files/essential_background/background_publications_htmlpdf/application/pdf/conveng.pdf

Chapter 1

National Circumstances



Avsenik, K. (2019). Nature Scene, Karsha, Ladakh.

Key Points

Chapter 1 National Circumstances

- India's annual average temperature is increasing at a statistically significant rate of 0.61ºC per 100 years over the period 1901-2019. There is a significant increasing trend in the maximum temperature of 1ºC/100 years and a relatively lower increase, also significant, in minimum temperatures of 0.22ºC/100 years.
- The year 2019 was the seventh warmest year on record since 1901 with annual mean surface air temperature +0.36ºC above the 1981-2010 period average.
- Between 1989 and 2018 there have been significant changes in the frequency of dry days, rainy days (rainfall of amount 2.5 mm or more but less than 6.5 cm), and heavy rainfall (rainfall of amount 6.5 cm or more).
- A significant decreasing trend (at 99 per cent level of confidence) of the frequency of intense cyclonic disturbances during monsoon season is noticed during the last 59 years from 1961 to 2019 over the Indian region.
- Based on the observed cyclonic activities during 1891-2019, on an average 5 cyclones developed over the north Indian Ocean region in a year, with an average of 4 cyclone activities developing over the Bay of Bengal and 1 cyclone activity developing over the Arabian Sea.
- During 2019, eight cyclonic storms formed over the north Indian Ocean. Out of these eight systems, one system each formed during the winter and pre-monsoon season, over the Bay of Bengal.
- The frequency and duration of heat waves over north-west India and the east coast of India have increased. The duration of heat waves over central and north-west India has increased by about five days over the past 50 years.
- Monitoring of winter precipitation and temperature in the Western Himalaya suggests a significant increase in total precipitation but a decrease in snowfall from 1991 to 2015.
- Although no significant trend in mean snow cover for the entire Himalaya has been reported, some inter-annual and intra-annual variations in basins have been observed.
- Most of the Himalayan glaciers are retreating and the rates of retreat have probably accelerated in the past few decades, but the observed tendencies are not regionally uniform. The mean rate of retreat is 14.2±12.9 ma^{-1}, but with high levels of uncertainty in the estimates.
- India launched the Coalition for Disaster Resilient Infrastructure (CDRI) on the sidelines of the UN Secretary General's Climate Action Summit in September 2019. This international partnership of national governments, UN agencies, multilateral development banks, private sector, and knowledge institutions will

promote the resilience of new and existing infrastructure systems to climate and disaster risks, thereby ensuring sustainable development.

- Approximately 30 per cent of India's population is dependent on the rich, exploitable coastal and marine resources, and a number of urban and economic centers of strategic importance, including two of the megacities of India, Mumbai and Chennai, are located along the coast.
- Currently, sea levels along the Indian coast are rising. The long term average of sea level rise is about 1.7 mm/year. However, these are changing at different rates along the Indian coast.
- India is the second largest aquaculture producing country in the world accounting for about 6.3 per cent of the global fish production. The government has taken several initiatives to enhance productivity and sustainable fish production. India is among the few countries in the world where, alongside ongoing developmental efforts, forest and tree cover are increasing considerably. Comparison with some other emerging and advanced economies shows that India's growth in forest cover has been positive.
- In contrast to the huge emissions from forest fires globally, the emissions from forest fires in India contribute a mere 1.0-1.5 per cent of all global emissions from wildfires, even though India accounted for 2 per cent of the total global forest area in 2015, according to the Global Forest Resource Assessment (FRA) by the Food and Agriculture Organization (FAO).
- At the national level, 18-28 per cent of forests grids are expected to be affected by projected climate change under different emission scenarios in the short (2030s) and long (2080s) term. The impacts are anticipated to be high on Himalayan and North-eastern forest ecosystems, particularly in the long term, while the Western Ghats are likely to be less impacted, particularly in the short-term scenario.
- Agriculture plays a vital role in India's economy. Of the total workforce 54.6 per cent was engaged in agricultural and allied sector activities (Census 2011). The share of agricultural and allied sector activities in the economy's total Gross Value Added (GVA) at current prices is 18.0 per cent and 17.1 per cent, respectively, for years 2017-18 and 2018-19.
- The net sown area is approximately 140 million ha, which has remained the same in recent years. Food grain production in 2019-20 rose to 295.67 million tonne along with significant increase in production of horticultural crops, milk, meat, fish and eggs.
- Net irrigated area in the country is 68.385 million ha. The total micro-irrigation area covered under Centrally Sponsored Schemes on micro-irrigation from 2005-06 to 2019-20 (as on November 2019) is 8.747 million ha.

- Soil health and quality remain a matter of great concern for GoI. By August 2019, 27.232 million soil samples have been collected and analysed and 107.952 million soil health cards have been distributed to farmers.
- Livestock is an important additional source of income for millions of rural families, apart from those directly dependent on it, and has an important role in achieving the goal of doubling farmers' incomes. The livestock sector has grown at a compound annual growth rate of 7.9 per cent during the last five years.
- Agriculture in India is dominated by marginal, small and medium farmers and not by "industrial agriculture" as in developed countries. These vulnerable sections will suffer the brunt of climate change impact while having no hand in the making of the problem of global warming. The National Initiative on Climate Resilient Agriculture (NICRA) is the flagship project dedicated to the building of climate resilience of the agricultural sector in the country.
- India's per capita energy consumption grew from 19,669 MJ (mega joules) in 2011-12 to 24,453 MJ in 2018-19(P). In 2018-19(P), primary energy supply added up to 906.09 million tonne of oil equivalent (Mtoe).
- As per present estimates, India has a renewable energy potential of about 1,097,465 MW for commercially exploitable sources *viz*. wind – 3,02,251 MW (at 100 m mast height), small hydro - 21,134 MW; bio-energy - 22,536 MW, solar power – 7,48,990 MW and industrial waste - 2,554 MW.
- In the year 2018-19(P), India's per capita energy consumption was 24,453 MJ which is just one-third of the world average. Per capita energy consumption of India grew by 24.32 per cent from 2011-12 to 2018-19.
- In India, CNG is being widely used in transport across the country. City Gas Distribution (CGD) networks have been declared as a "public utility". At present (October 2019), 1838 CNG stations are making available CNG to meet the requirement of 3.454 million CNG vehicles in the country.
- The share of the construction sector in the economy's total GVA (at constant prices) is 7.7 per cent and 7.8 per cent, respectively, for years 2017-18 and 2018-19 and the share of construction sector in the country's GDP at current prices is 7.0 per cent and 7.1 per cent, for the years 2017-18 and 2018-19 respectively.
- India's achievement in the composite SDG index score has improved from 57 in 2018 to 60 in 2019.
- In India, all States/UTs have declared themselves open defecation free, recording a jump from the 2014 figure of 38 per cent villages with sanitation. In 2019-20, 95.97 per cent of wards had 100 per cent door to door waste collection system as compared to 40.91 per cent in 2015-16.
- The response to the COVID-19 pandemic in 2020 has had a serious contractionary impact on the economy. In the short-term, India has made every

effort to maintain its climate action on track successfully through this period. However, notions that India can go completely “green” immediately or that it can take dramatic steps such as ceasing all new coal commitments with immediate effect, are beyond even the realm of speculation. The foremost priorities will lie in restoring the economy to its normal condition, restore normalcy in business, commercial and social life, before climate action can take dramatic new steps forward. The scale of GDP loss and reduction in GVA speak to this issue clearly and unambiguously.

Chapter 1
National Circumstances

1.1 Climate

India has a diverse geography with landscapes varying from snow-capped mountain ranges to deserts, plains, hills, plateaus, coastal regions and islands. India manifests varied climate regimes ranging from continental to coastal, from extremes of heat or cold, with aridity and negligible rainfall to excessive humidity and torrential rainfall. India's climate is significantly influenced by the presence of the Himalaya and the Thar Desert as the former acts as an orographic barrier to atmospheric circulation for both the summer monsoon and the winter westerlies and keeps them confined within the subcontinent, thus playing a major role in rainfall. The northern parts of the country have a continental climate with severe summer conditions that alternate with cold winters when temperatures drop below the freezing point. In contrast, there are the coastal regions of the country, where the warmth is unvarying with moderate temperatures and the rains are frequent throughout the year. India's climate variability is due to several characteristic features, including the southwest and northeast monsoon seasons, a hot weather season characterized by severe thunderstorms and heat waves, and cold weather seasons characterized by cold waves. The temperatures over India show large spatial and seasonal variation, while the South-west monsoon is the principal weather system which contributes to the major part of precipitation in the country, between June and September. Agriculture and water resources are the two sectors which are largely dependent on the monsoon thus affecting the livelihoods of a large part of India's population.

1.1.1 Precipitation

Nearly 75 per cent of the annual rainfall of the country 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 southwest during the warmest months of the year and reverses direction to blow from northeast during cooler months. This process brings large amount of rainfall to the region during June to September and is regarded as the principal rainy season during which an average of about 880.6 mm of rainfall is received over the country (IMD, 2019). Overall, there is a large inter-annual variability in its onset and withdrawal dates over different parts of the country.

Rainfall distribution and intensity have a significant impact over different socio-economic sectors, besides their impact on landscapes and ecosystems. The rainfall amount exceeds 1000 mm annually in areas in Eastern India and extends to over 2500 mm along almost the entire West Coast and the 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. The pre-monsoon and post-monsoon seasons contribute about 11 per cent and 10 per cent of annual rainfall (on all India basis, respectively).

Although there is inter-annual variability, the total precipitation during the Indian summer monsoon has remained largely stable over the period 1901-2019 and has shown a weak decreasing trend during the recent few decades (Figure 1.1). Based on the rainfall data from the India Meteorological Department (IMD) Observational Network, it is found that five states *viz.* Bihar, Meghalaya, Nagaland, West Bengal and Uttar Pradesh have shown significant decreasing trends in Southwest monsoon rainfall during 1989-2018. Other states do not show any significant changes in monsoon rainfall in the recent 30 years period (1989-2018). However, there are many districts which show significant changes in southwest monsoon and annual rainfall during the recent 30 years period (1989-2018). The annual and monsoon season district wise rainfall trends are presented in Figure 1.2.

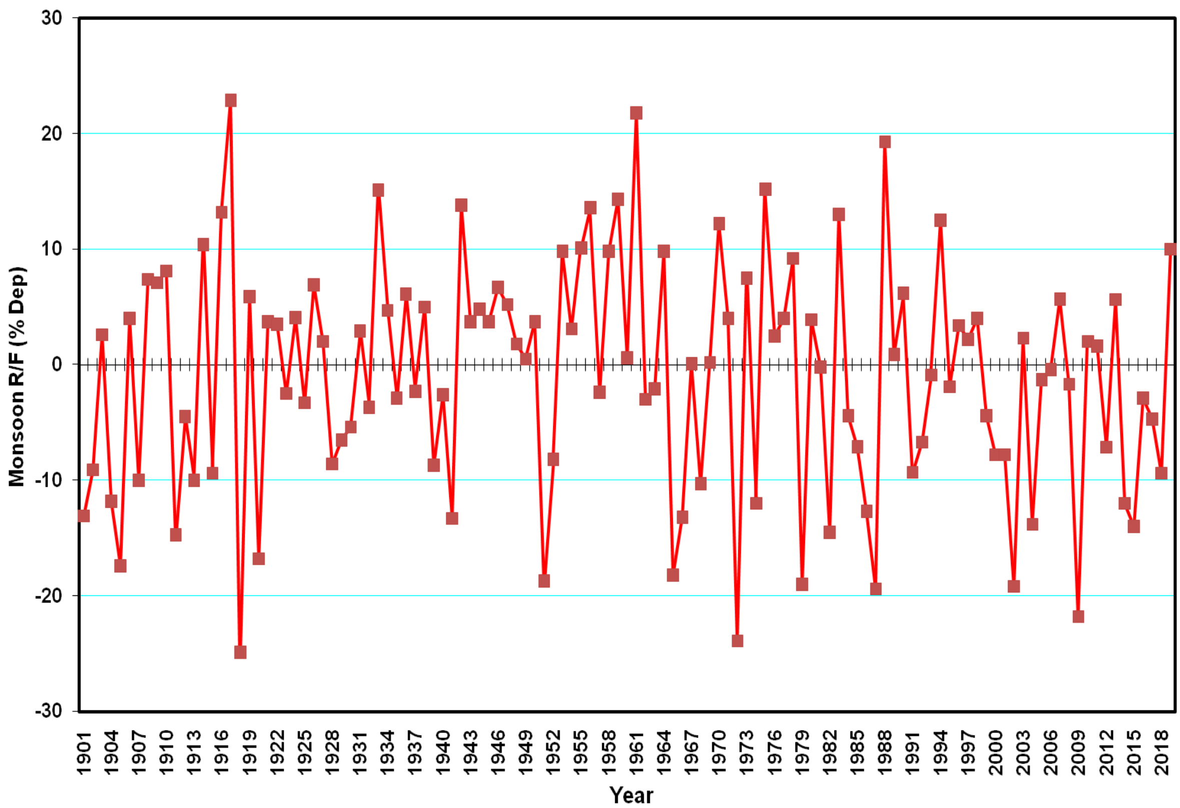


Figure 1.1: Percentage departure of area weighted monsoon season rainfall over India as a whole (1901-2019). Source: IMD, 2020.

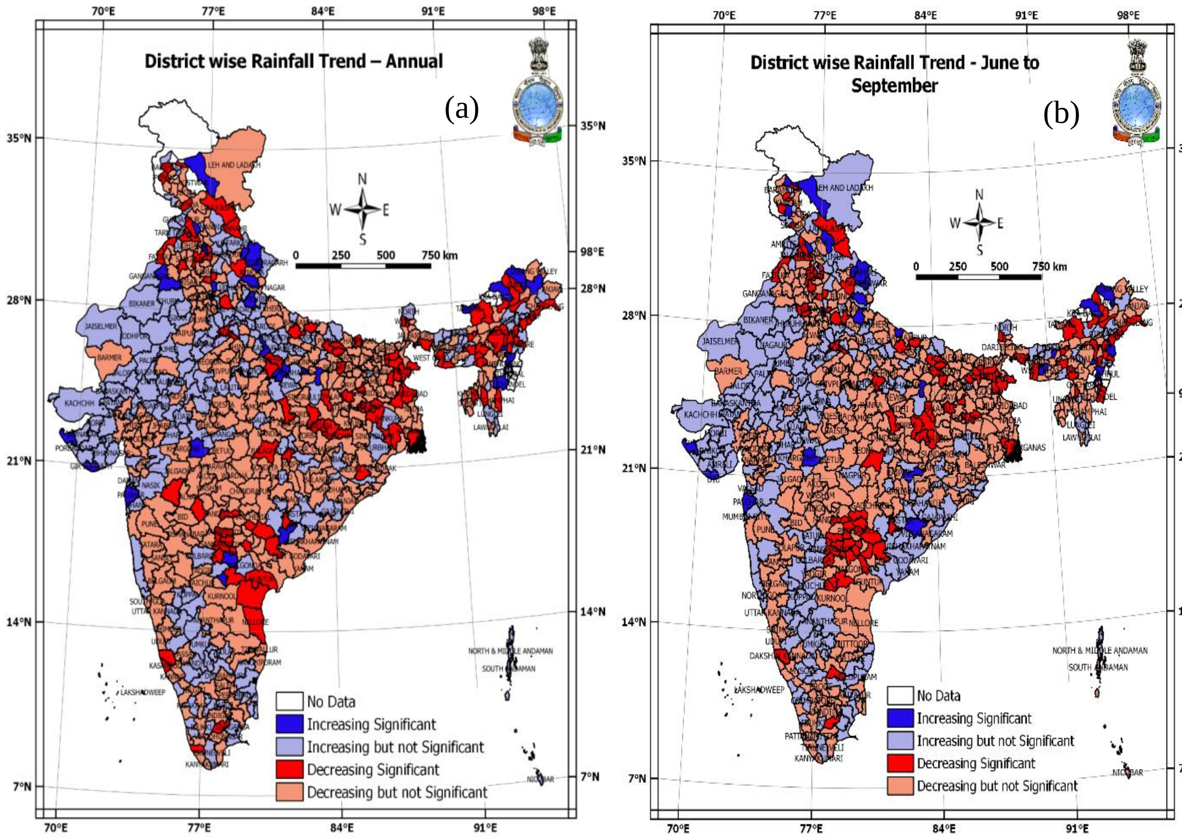


Figure 1.2: (a) District-wise annual rainfall trend; and (b) monsoon season rainfall trends for the period 1989-2018. Source: IMD, 2020.

1.1.2 Rainfall situation in recent years

The long period average (LPA) rainfall for the period 1961-2010 over the country as a whole for summer monsoon season is 880.6 mm and annual average is 1176.9 mm. The annual rainfall during 2019 over the country was 110 per cent of LPA and rainfall during the SW monsoon season was 110 per cent of LPA. During the monsoon season in 2019, among the four large geographical regions of the country, Central India and South Peninsular India received 129 per cent and 116 per cent of its LPA rainfall respectively, while Northwest India received 99 per cent and East and Northeast India received 88 per cent of its LPA rainfall. The 2019 northeast monsoon season (October-December) rainfall over the country as a whole was above normal (130 per cent of LPA). The seasonal rainfall during the northeast monsoon season over the core region of the southern peninsula (comprising of 5 subdivisions *viz.* Coastal Andhra Pradesh and Yanam, Rayalaseema, Tamil Nadu, Puducherry and Karaikal, South Interior Karnataka and Kerala and Mahe), was normal (109 per cent of LPA). The 2018 northeast monsoon season rainfall over the country as a whole was substantially below normal (56 per cent of LPA), the 6th lowest since 1901 (IMD, 2020).

1.1.3 Climate variation over India

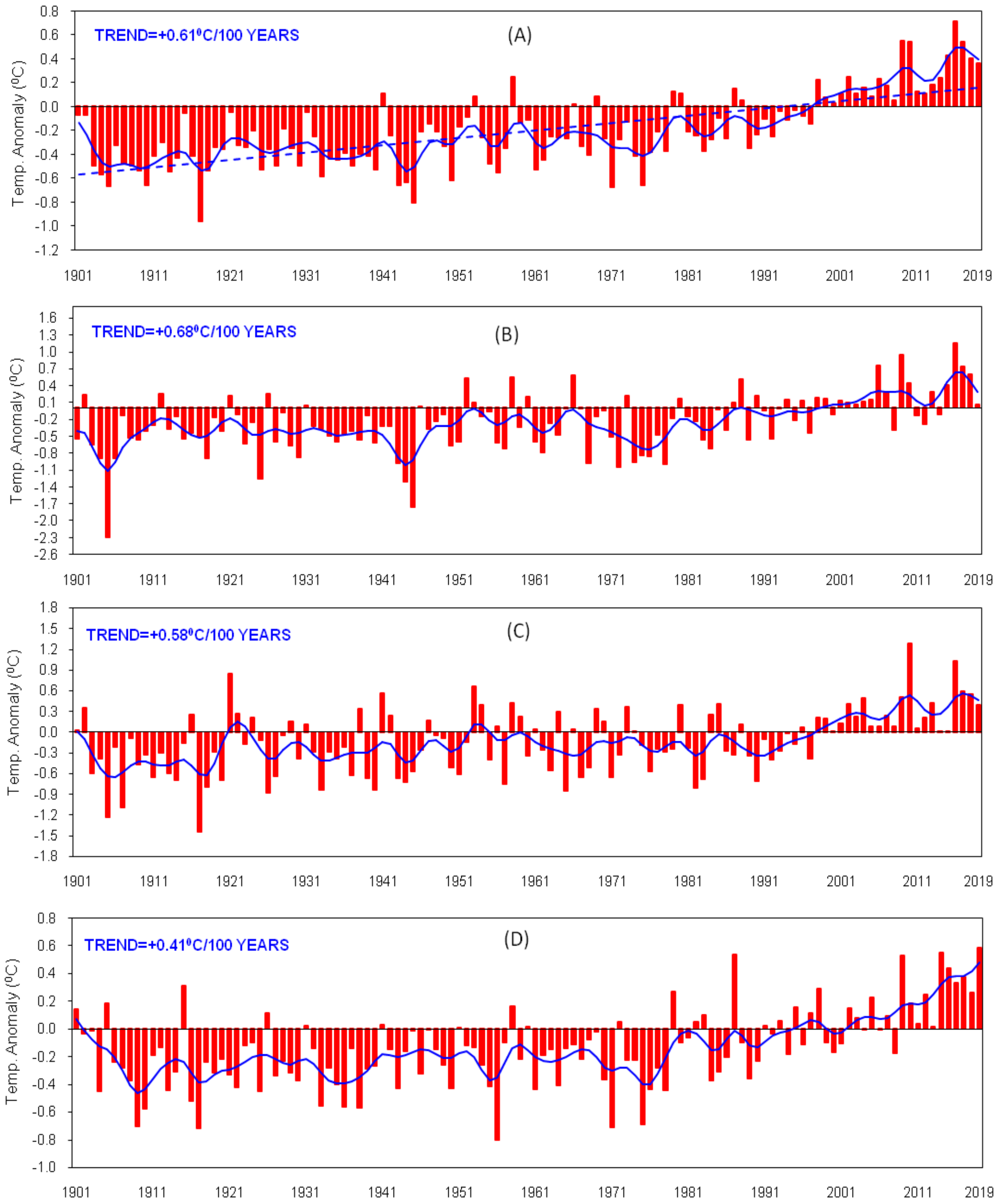
The surface air temperature shows wide spatial and seasonal variation over India. Due to the influence of continental winds over most of the country, the winter is severe in the north, but the temperature becomes moderate as one moves towards the south. During the coldest months of December and January, the mean maximum temperature varies from 33°C in southern parts of the country to about 12°C in the plains of 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 Himalaya in the north. March to May is usually a period of the continuous and rapid rise of temperature. The highest temperatures occur 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 the onset and advent of 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 gets a good amount of rainfall. The temperature again 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 annual mean temperature during 1901-2019 showed a significant increasing trend of 0.61°C/100 years (Figure 1.3) with a higher increasing trend in maximum temperature (1.0^{o}C/100 years) as compared to a lower increasing trend (0.22^{o}C/100 years) in the minimum temperature. The trend is highest during the post-monsoon season (0.88°C/100 years) followed by winter season (0.68°C/100 years). The rise of maximum and minimum temperatures, during the past 30 years, is mostly confined to the northern, central and eastern/ north-eastern parts of the country. Spatial warming trends (Figure 1.4) obtained from mean annual temperature anomalies based on the data for the period 1901-2019 suggest significant positive (increasing) trend over most parts of the country except in parts of some States that include Rajasthan, Gujarat, Uttar Pradesh and Bihar, where significant decreasing trend was observed.

1.1.3.1 Temperature in recent years

The 2018 annual mean land surface air temperature for the country was +0.41^{o}C above the 1981-2010 average, thus making the year 2018 as the sixth warmest year on record since 1901. The year 2019 was the seventh warmest year on record since 1901 with annual mean surface air temperature +0.36^{o}C above the 1981-2010 period average. The five warmest years on record in order were: 2016 (+0.71^{o}C), 2009 (+0.54^{o}C), 2017 (+0.54^{o}C), 2010 (+0.54^{o}C) and 2015 (+0.42^{o}C). It may be mentioned that 11 out of 15 warmest years were recorded during the recent past fifteen years (2005-2019). Past decades (2001-2010/2010-2019) were also the warmest decades on record with anomalies of +0.23ºC/+0.36ºC. The country averaged seasonal mean temperatures were also above the average during all the four seasons with the monsoon season (anomaly +0.58ºC) being the warmest since 1901. The country averaged mean monthly temperatures during 9 months of the year, 2019 (except January, March and December) were warmer than the normal with mean temperatures exceeding the normal by about 1.02ºC during June (fourth warmest since 1901) and by 0.77ºC during the months of April (seventh warmest), July (0.68ºC, warmest) and November (0.72ºC, third warmest).



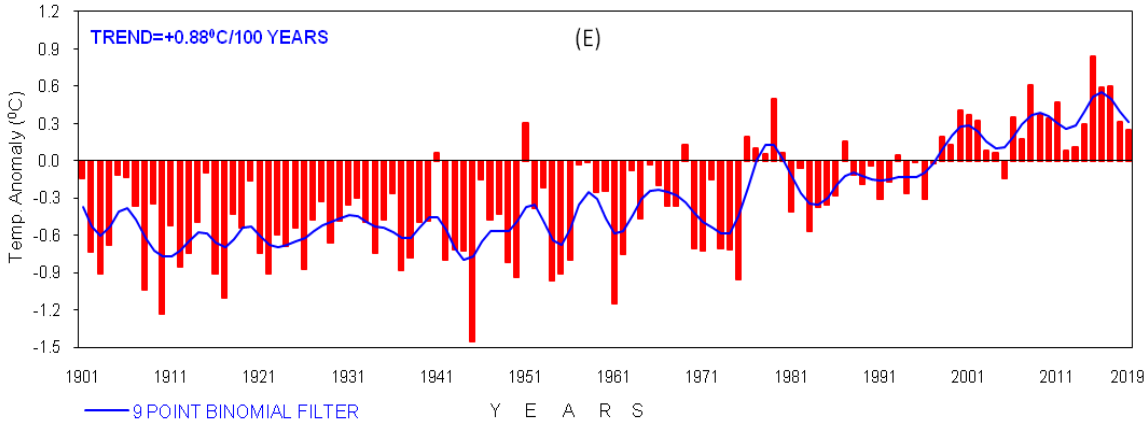


Figure 1.3: All India mean temperature anomalies (A) Annual, (B) Winter, (C) Pre Monsoon, (D) Monsoon and (E) Post monsoon for the period 1901-2019 shown as vertical bars. The solid blue curve had sub-decadal time scale variations smoothed with a binomial filter (departures from the 1981 - 2010 average). Source: IMD, 2019.

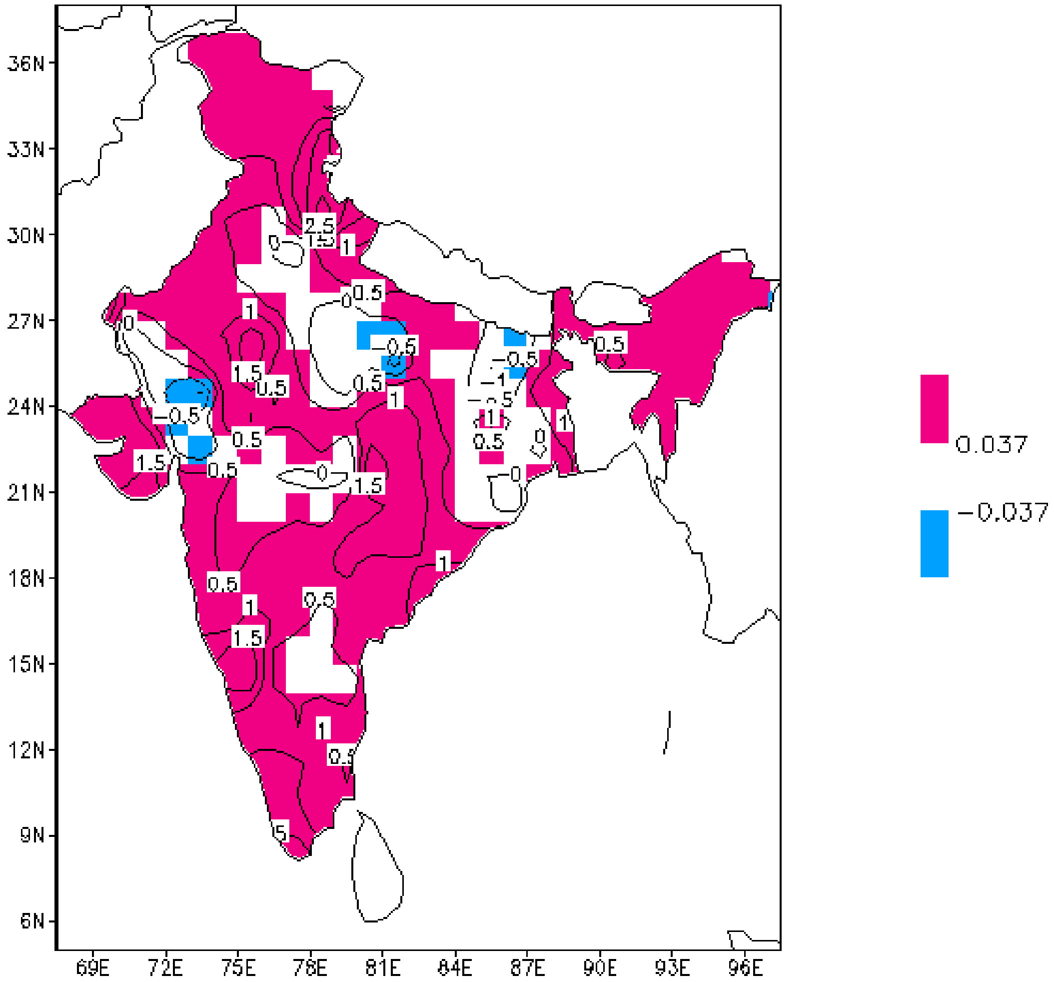


Figure 1.4: Annual mean temperature anomaly trends (°C /100 years) are shown as contour lines. The trends significant at the 95% level are shaded. Positive trends are shown in red while the negative trends are shown in blue. Period of analysis: 1901–2019. (Departure from 1981-2010 average). Source: IMD, 2020.

1.2 High impact weather events

1.2.1 Dry and rainy days, rainstorms

The recent 30 years data (1989-2018) shows significant changes in the frequency of dry days, rainy days (rainfall of amount 2.5 mm or more but less than 6.5 cm) and heavy rainfall (rainfall of amount 6.5 cm or more) (Figure 1.5). IMD state wise rainfall reports on observed rainfall variability and trends (IMD, 2020) show a significant increasing trend in the frequency of dry days during the period 1989-2018 over Guntur and Prakasam districts of Andhra Pradesh, Bihar, northern parts of Chhattisgarh, Jharkhand, Madhya Pradesh, Odisha, Tamil Nadu, Uttar Pradesh and West Bengal during the south west monsoon rainfall and all these states along with Telangana have also shown significant increasing trends in dry days in annual scale while significant decreasing trends in dry days over Gujarat, Karnataka, Maharashtra and Punjab states. Significant increasing trends in the frequency of rainy days over Rajasthan, Gujarat, Maharashtra, Andhra Pradesh, northern parts of Madhya Pradesh and parts of Odisha and Chhattisgarh while significant decreasing trends in Uttar Pradesh, Bihar, Jharkhand, Punjab and northeastern parts of the country.

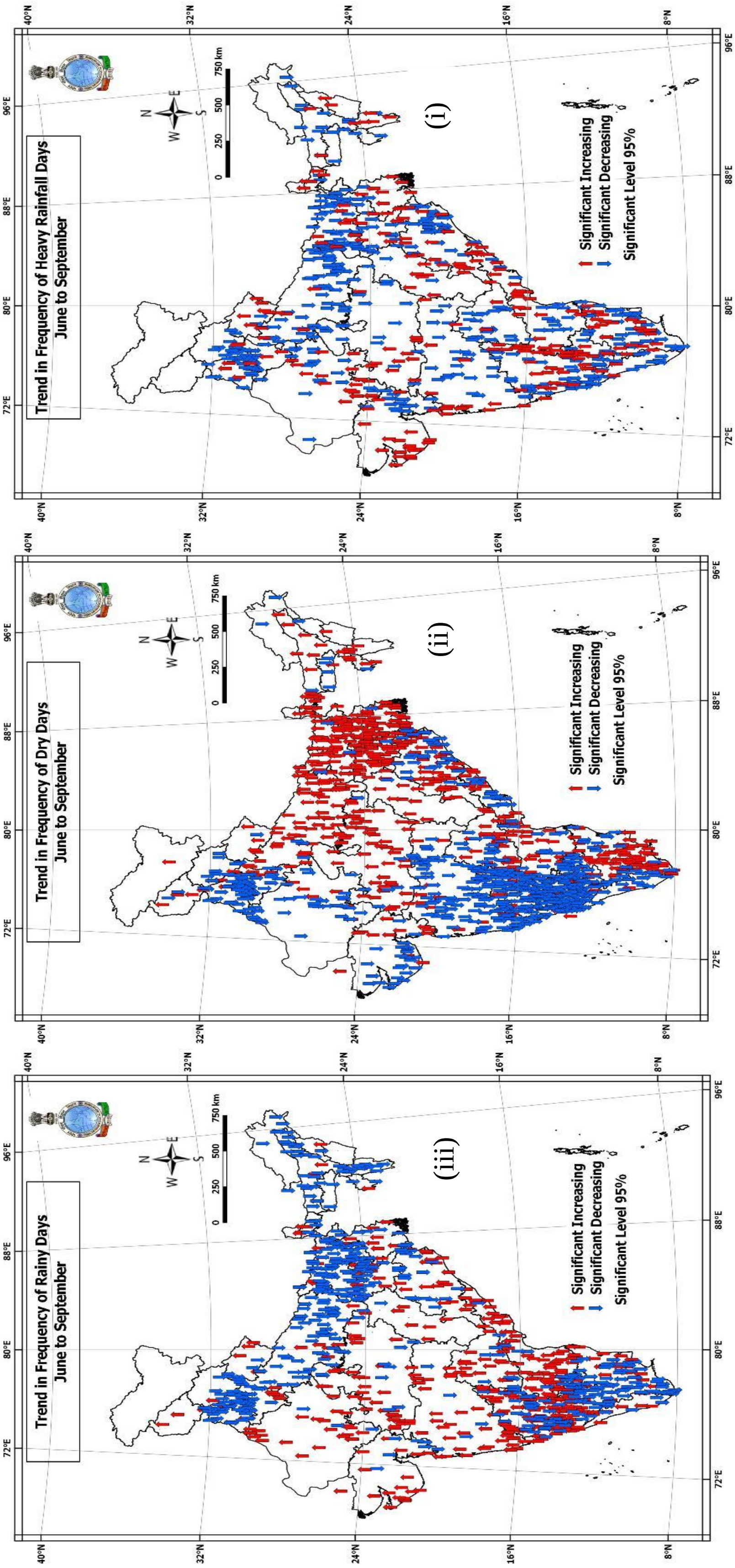
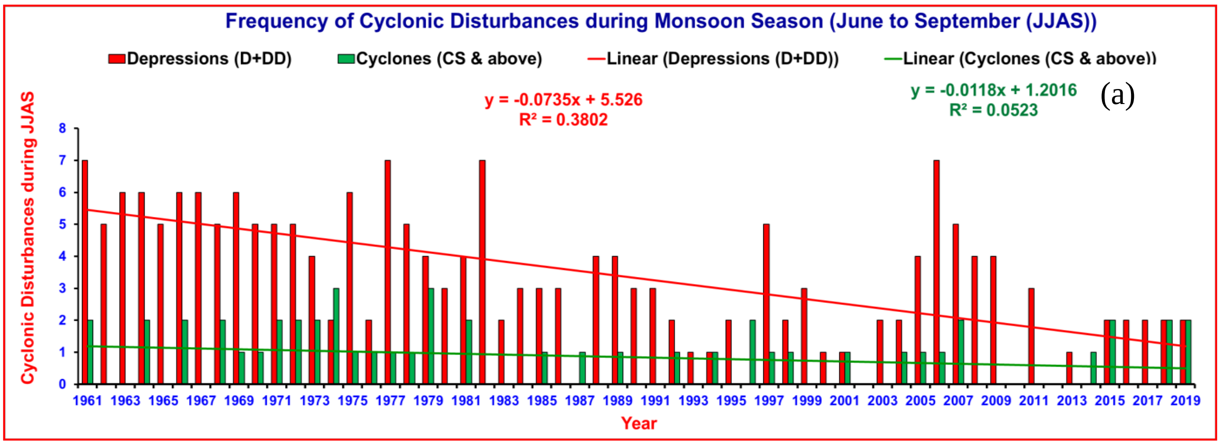


Figure 1.5: Spatial distribution of trend in frequency of (i) Dry Days (ii) rainy days (daily rainfall of 2.5 mm or more but less than 6.5 cm) (iii) heavy rainfall events (rainfall greater than equal to 6.5 cm) during southwest monsoon season over India based on 30 years of data (1989-2018). Source: IMD, 2020.

1.2.2 Cyclonic disturbances

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 (BoB) during the southwest monsoon season, contribute significantly to the southwest monsoon rainfall over India. The long coastline of over 8,000 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 its associated hazards. Thirteen coastal States and Union Territories (UTs) in the country, encompassing 84 coastal districts, are affected by tropical cyclones.

As shown in Figure 1.6 (a), the significant decreasing trend (at 99 per cent level of confidence) of the frequency of intense cyclonic disturbances during monsoon season is noticed during the last 59 years from 1961 to 2019 over the Indian region. Figure 1.6 (b) shows the decreasing trend of the frequency of cyclonic storms over the North Indian Ocean (NIO) (BoB and the Arabian Sea together) during the post-monsoon season from October to December which is significant at 95 per cent confidence level.



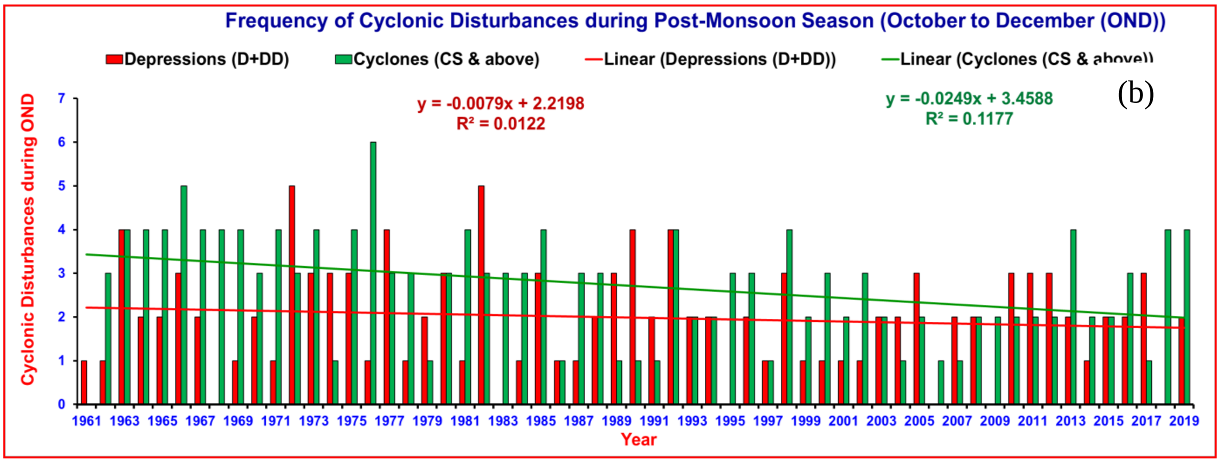


Figure 1.6: Frequency of depressions and cyclonic storms formed over the northern Indian Ocean. Legends: D - depression (maximum sustained wind speed 17-27 kt), DD - deep depression (maximum sustained wind speed 28-33 kt), CS & above - cyclonic storm and above (maximum sustained wind speed ≥ 34 kt). Source: IMD, 2020.

Based on the observed cyclonic activities between 1891-2019, on average, while at least 5 cyclones developed over NIO in a year, with an average of 4 cyclone activities developing over BoB and 1 cyclone activity developing 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 1961 – 2019 is shown in Figure 1.6. 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). However, during last two years, enhanced activity was observed. During 2018, seven cyclonic storms were formed over NIO. One cyclonic storm formed over BoB in monsoon season (September) and crossed north Andhra Pradesh-Odisha coast near Gopalpur on 20th September. Three systems, which formed over BoB during the post monsoon season, crossed the Indian coast. The first system "Titli" formed over the east central BoB on 8th October and crossed the Odisha coast on 11th. This storm claimed over 78 lives from coastal districts of Odisha. The second one "Gaja" which formed over the east central Bay on the 10th November, crossed Tamil Nadu coast on 15th and after moving across the south peninsula, it re-emerged into the Arabian Sea as a deep depression. This storm claimed over 40 lives from coastal districts of Tamil Nadu. The last cyclonic storm of the year 2018 "Phethai", which formed over the southeast BoB on the 13th December, crossed the Andhra Pradesh coast on 17th December. It did not cause any loss of life.

During 2019, eight cyclonic storms formed over the North Indian Ocean. Out of these 8 systems, one system each formed during the winter (Cyclonic Storm "Pabuk") and pre-monsoon season ESCS, "Fani") over the Bay of Bengal. The ESCS "Fani" crossed the Odisha coast near Puri on 3 May 2019 and claimed 64 lives from different districts of the state. The monsoon season too witnessed 2 very severe cyclonic storms (VSCS) "Vayu" and "Hikka" over Arabian Sea in the month of June and September respectively. During the post-monsoon season, 3 systems formed over the AS and 1 system over BoB. The VSCS "Bulbul" which formed over the BoB crossed West Bengal and Bangladesh coasts across Sundarbans forest on 9th November. Considering the past data (1891-2018), the highest number of cyclones formed in both the Indian seas together was 10 during four years (1893, 1926, 1930 and 1976). In case of AS, the 5 cyclones formed during 2019 equals the previous record of 1902 for the highest frequency of cyclones. The year 2019 also witnessed development of more intense cyclones over the Arabian Sea. Out of 5 cyclones formed in the AS, there have been two very severe cyclonic storms, one extremely severe cyclonic storm and one super cyclonic storm. However, the cyclone activity over BoB during 2019 has been subdued as only 3 cyclones formed against the normal of 4 per year.

The performance of cyclone landfall, track and intensity forecast has shown significant improvement. The annual average track forecast errors in 2019 have been 69 km, 104 km and 149 km, respectively for 24, 48 and 72 hours against the past five years average error of 86, 132 and 178 km based on data of 2014-2018. Accurate forecast of the recent cyclones has saved thousands of human lives.

1.2.3 Heatwave and coldwave trends

The heatwaves typically occur between March to June, and in some cases even extend till July in India. Heatwaves (HWs) are more frequent over the Indo-Gangetic plains of India. On an average, 5-6 HW events occur every year over the northern parts of the country. The temperatures in excess of 46°C have been recorded in many parts of the country in the past, especially over north and central India. Higher daily peak temperatures and longer, more intense HWs are becoming increasingly frequent globally due to climate change. The climatology of HW days over the country based on data from the observational network of IMD point out that except over northeast India and large parts of Peninsula (South of ~21°N & 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 Uttarakhand, 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 has been observed 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 Himalaya, southern parts of central India and east India, which showed decreasing trends during the period 1961-2019 (Figure 1.7a). Decreasing trends in coldwave (CW) 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 HW over central and north-west India has increased by about five days over the past 50 years.

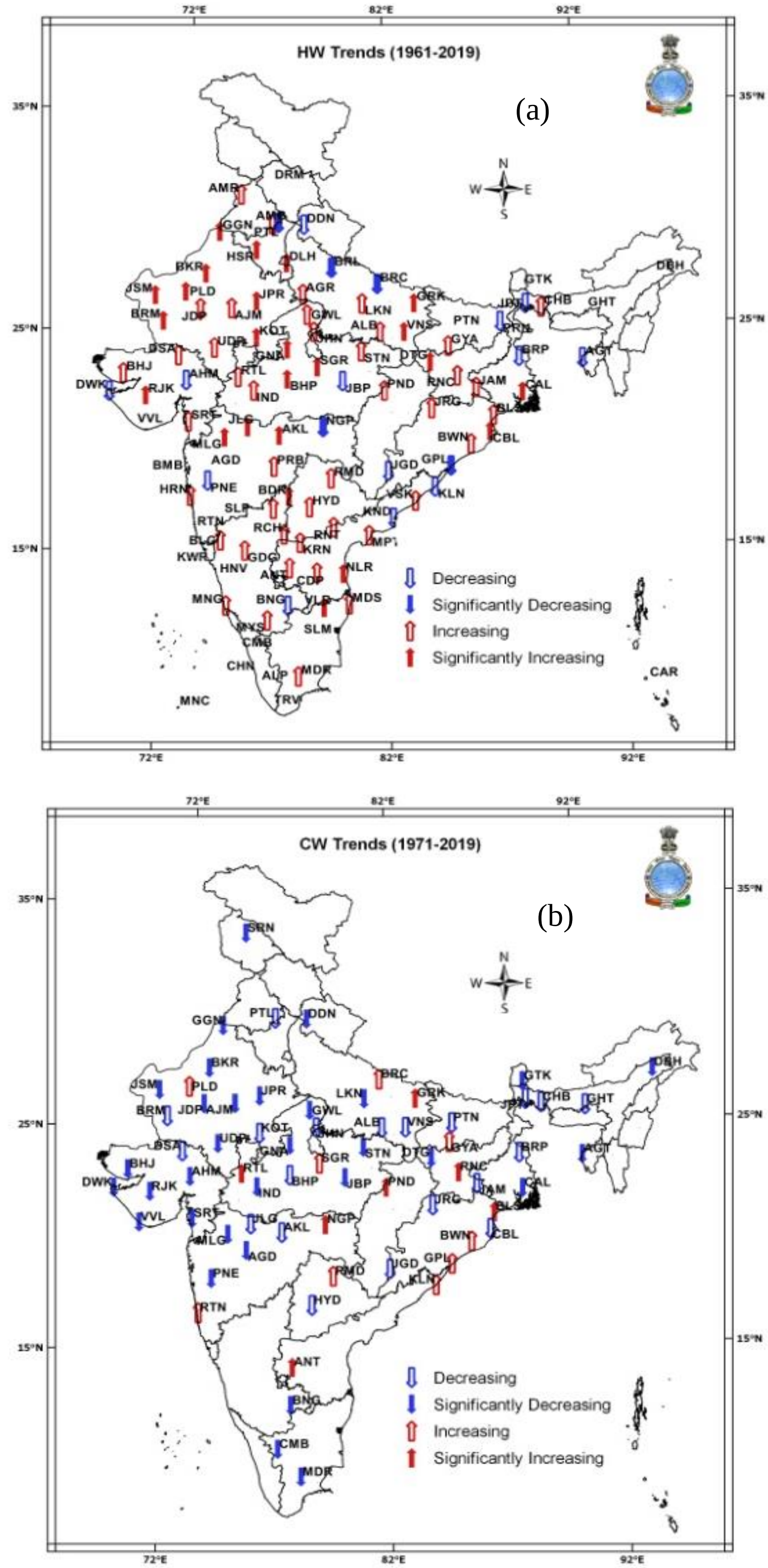


Figure 1.7: (a) Trends in the Heat Wave (HW) days of 103 stations during April, May and June for the period 1961–2019. (b) Trends in the Cold Wave (CW) days of 86 stations during the December, January and February for the period 1971–2019. Nonparametric Mann–Kendall test was used to test the significance of the trends. Source: IMD, 2020.

1.2.4 Heatwave and coldwave during recent years

Severe Heatwave/Heatwave (SHW/HW) conditions were observed from 26 March to 4 April 2018 over Rajasthan and Gujarat State and on one or two days in Uttarakhand, Himachal Pradesh and north Konkan. Its spatial extent and severity started to diminish gradually from 5 April 2018. The heat wave conditions re-emerged on 28 April, and till 18 May, it was mainly confined to some parts of Rajasthan and Vidarbha. From 19-30 May, heatwave was observed over Madhya Pradesh on many days and over Haryana, Chandigarh & Delhi, Uttar Pradesh, Saurashtra & Kutch on a few days. During 31 May to 5 June, heatwave conditions were confined to west Rajasthan and then from 16 to 20 June, it was observed over Jharkhand, Bihar, Odisha and Gangetic West Bengal and coastal Andhra Pradesh. It was observed over parts of north and central region during 22-25 June. The heat wave conditions fade away from the entire country by 26 June 2018. During 2019, HW/SHW conditions were observed in all the months of the summer season. HWs were observed during 26-31 March, 1-16 April 26-30 April 2019 at a few places in parts of central & northwest India. Heat wave conditions again re-emerged in the last week of the month of April over some parts of central India and Maharashtra. During the month of May, its spatial extent increased as it was observed on few days in isolated parts of the entire country except over northeast, extreme north & west coast of India. Vidarbha experienced heatwave to severe heat wave conditions throughout the month of May 2019.

Severe Coldwave (SCW) conditions prevailed over most parts of the country on most of the days during January 2018. Severe cold day/cold day conditions also prevailed at a few places over Bihar and Uttar Pradesh on most of the days during the month. During 17–31 December 2018, SCW conditions prevailed mainly over north, north western and central parts of the country and on isolated days over some parts of Bihar, Jharkhand, Central Maharashtra, Marathwada, north Interior Karnataka and north coastal Andhra Pradesh.

The plains of north India and adjoining Central India experienced unusual cold day conditions during the second half of December, 2019 following an active Western Disturbance, which affected the region during 11-14 December 2019. Widespread cold day conditions were observed over Punjab, Haryana, Chandigarh, Delhi and Uttar Pradesh on the 16 December which intensified further to severe cold day conditions during 17-19 December. Severe cold day conditions prevailed in most places over northern parts of the country till 30 December 2019. The 30 December, 2019 was the coldest day. On this day maximum temperature departures of up to -15^{o}C were observed over the north Indian region. Table 1.1 shows some of the weather extremes during the years 2018, 2019 and 2020 that caused disasters in many areas.

Table 1.1: Weather extremes in India in the recent years (2018-2020)

Temperatures			
Year	Month	Event	Details
2018	January and December	Severe Coldwave	Intense cold wave related incidents in northern parts of the country including Uttar Pradesh, Bihar and Jharkhand.
2019	December	Severe Coldwave / cold day	Intense cold wave related incidents in northern and central parts of the country including Uttar Pradesh, Bihar, Jharkhand and Madhya Pradesh.
2019	April-June	Severe heat wave (SHW)	Intense heat wave conditions prevailed over eastern and central parts of the country including Bihar and Maharashtra.
2020	January	Severe Coldwave	Intense cold wave related incidents in northern parts of the country.

Precipitation			
Year	Month	Event	Details
2018	June-September	Heavy rainfall resulting in floods	Heavy rainfall resulting in floods caused loss of life in Kerala, Karnataka and Uttar Pradesh.
	March-November	Lightning and thunderstorm	Lightning and thunderstorm events caused loss of life in various parts of Uttar Pradesh from April to September, in Jharkhand from 2nd May to 14th September, in West Bengal from 30th March to 14th November, in Bihar from 30th March to 8th June.
2019	July-September	Heavy rainfall resulting in floods	Heavy rainfall resulting floods caused loss of life in Bihar, Maharashtra, Uttar Pradesh and northern parts of Kerala.
	March-October	Lightning and thunderstorm	Lightning and thunderstorm events caused loss of life in various parts of Jharkhand from March to October, in Bihar from May to October and Maharashtra from April to October.
	January-March-November-December	Snowfall	Snow avalanche caused loss of life in Jammu & Kashmir and Leh.
2020	January	Snowfall	Snow avalanche caused loss of life in Jammu & Kashmir.
	March to July	Thunderstorm and lightning	Thunderstorm & lightning caused loss of life in various parts of country including Bihar, Jharkhand and Madhya Pradesh
	June-August	Heavy rainfall resulting in floods, Landslide	Heavy rainfall resulting floods caused loss of life and properties in Assam, Bihar, Rajasthan, Kerala, Karnataka, Maharashtra, Odisha, South Chhattisgarh and Telangana.

Dust storm			
Year	Month	Event	Details
2018	May and June	Dust storm	Dust storm caused loss of life in various parts of Uttar Pradesh, Rajasthan and Haryana.

Cyclones			
Year	Month	Event	Details
2018	May	Cyclonic storm ‘SAGAR’ over Arabian Sea	No adverse weather over west coast of India was reported due to this system.
	May	Extremely severe cyclonic storm ‘MEKUNI’ over Arabian Sea	No adverse weather over west coast of India was reported due to this system.
	September	Cyclonic storm ‘DAYE’ over east central Bay of Bengal and adjoining Myanmar	The storm caused extremely heavy rainfall at isolated places over Odisha, north Andhra Pradesh, Chhattisgarh, Vidarbha and heavy to very heavy rainfall at a few places over Telangana.
	October	Very severe cyclonic storm ‘LUBAN’ over east central Arabian Sea	No adverse weather over west coast of India was reported due to this system.
	October	Very severe cyclonic storm ‘TITLI’ over east central Bay of Bengal	Loss of life due to Very Severe Cyclonic storm ‘TITLI’ in Odisha and Andhra Pradesh.
	November	Very severe cyclonic storm ‘GAJA’ over east central Bay of Bengal (10-19 November)	Loss of life due to Very Severe Cyclonic storm ‘GAJA’ in Tamil Nadu.
	December	Severe cyclonic storm ‘PHETHAI’ over southeast Bay of Bengal (13-18 December 2018)	The storm caused heavy to very heavy rainfall over coastal Andhra Pradesh and adjoining Odisha.
2019	January	Cyclonic storm ‘PABUK’ over Andaman Sea	No adverse weather over west coast of India was reported due to this system.
	April-May	Extremely severe cyclonic storm (ESCS) ‘FANI’ over east central equatorial Indian Ocean and adjoining southeast Bay of Bengal	Loss of life due to ESCS ‘FANI’ in Odisha.
	June	Very severe cyclonic storm ‘VAYU’ over southeast and adjoining east central Arabian Sea	No adverse weather over west coast of India was reported due to this system
	September	Very severe cyclonic storm ‘HIKAA’ over Arabian Sea	No adverse weather over west coast of India was reported due to this system
	November	Super cyclonic storm ‘KYARR’ over Arabian Sea	No adverse weather over west coast of India was reported due to this system.
	November	Extremely severe cyclonic storm ‘MAHA’	No adverse weather over west coast of India was reported due to this system.

		over Arabian Sea	
	November	Very severe cyclonic storm ‘BULBUL’ over Bay of Bengal	Claimed 13 lives in West Bengal.
	December	Cyclonic Storm ‘PAWAN’ over Arabian Sea	No adverse weather over west coast of India was reported due to this system.
2020	May	Super cyclone ‘AMPHAN’ over the Bay of Bengal	Claimed 86 lives in West Bengal.
	June	Severe cyclonic storm ‘NISARGA’ over the Arabian Sea	Claimed 4 lives in Maharashtra.

Source: IMD, 2020.

1.2.5 Floods

Floods are a natural calamity that India faces every year, in some part or the other of its territory, of varying degrees of magnitude, leading to loss of human lives and livestock, loss of flora and fauna, and extensive damage to crops, houses and public utilities. The occurrence of floods can be attributed to various factors, including wide variability in rainfall both in time and space, inadequate carrying capacity of rivers, river bank erosion and silting of river beds, landslides and poor natural drainage in flood prone areas. In the Himalayan regions snowmelt and glacial lake out-bursts are additional potential causal factors. Flood management schemes are formulated and implemented by the concerned State Governments as per their priority. The Union Government supplements the efforts of the States by providing technical guidance and promotional financial assistance for the management of floods in critical areas. The GoI launched the Flood Management Programme (FMP) during the XI Plan (2007-12) for providing Central assistance to the State Governments for taking up works related to river management, flood control, anti-erosion works, drainage development, flood proofing works, restoration of damaged flood management works and anti-sea erosion works which were continued during the XII (2012-17) Plan. It was extended beyond as a component of the "Flood Management and Border Areas Programme" (FMBAP) for the three-year period from 2017-18 to 2019-20. In order to formulate the strategy for flood management works in the entire country and river management activities and works in the border areas for the period 2020-2023, a Committee has been constituted by NITI Aayog. (MoJS, 2020a). MoES have installed flood warning systems in Chennai and Mumbai, and are also steering the South Asia Flash Flood Guidance (SAsiaFFG) System. The damage due to floods / heavy rains during 2010 to 2018 is given in Table 1.2 and Figure 1.8.

Table 1.2: Damage due to Floods / Heavy rains during 2010 to 2018

S. No.	Year	Area affected in million ha	Population affected in million	Damage to Crops (Area in million ha)		Damage to Houses		Cattle Lost (Nos.)	Human live Lost (Nos.)	Damage to Public Utilities in	Total damages Crops, Houses & Public utilities
				Area (mha)	Value (INR million)	Nos.	Value (INR million)			INR million	INR million (6+8+11)
1	2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
i.	**2010**	2.62	18.30	4.994	58,874	2,93,830	8760	39,706	1582	1,27,573	1,95,206
ii.	**2011**	1.90	15.97	2.718	13,938	11,52,518	4105	35,982	1761	60,536	78,579
iii.	**2012**	2.14	14.69	1.95	15,341	1,74,526	2406	31,558	933	91,700	1,09,446
iv.	**2013**	7.55	25.93	7.484	63,781	6,99,525	20,328	1,63,958	2180	3,89,378	4,73,488
v.	**2014**	12.78	26.51	8.007	72,552	3,11,325	5820	60,196	1968	77,109	1,55,481
vi.	**2015**	4.48	33.20	3.374	1,70,439	39,59,191	80,470	45,597	1420	3,22,002	5,72,911
vii.	**2016**	7.07	26.56	6.658	40,527	2,78,240	1147	22,367	1420	15,079	56,753
viii.	**2017**	6.08	47.34	4.972	89,520	12,52,914	93840	26,673	2063	1,23,298	3,06,658
ix.	**2018**	7.72	37.40	2.515	37,082	9,13,414	25,087	60,279	1839	1,21,329	1,83,498

Source: CWC, 2020a.

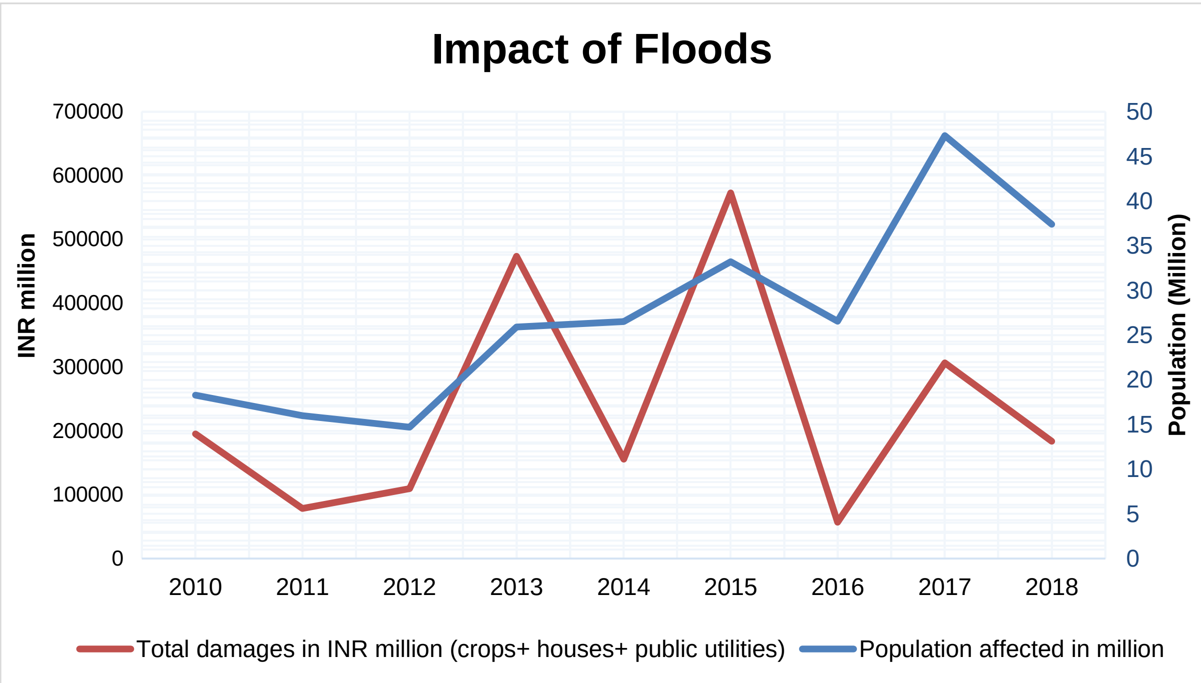


Figure 1.8: Population affected and total damage caused including crops, housing and public utilities (at current prices). Source: CWC, 2020a.

1.2.6 Extreme heat warning systems and preparedness

Drawing lessons from the ground-breaking Ahmedabad Heat Action Plan released in 2013, actions 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 is leading efforts by supporting state-level heat action plans and facilitating coordination at the national level through updated National Guidelines for Preparation of Action Plan – Prevention and Management of Heat Wave. State governments who are currently dealing with Heat Wave crisis have prepared Heat Action Plans; and Do's & Don'ts to alleviate the impact of heat wave. 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 IMD continues to provide the vital seasonal outlook for the hot weather season; and daily temperature forecasts for over 447 cities. The IMD forecasts are a critical trigger for prompting early warning for extreme heat by city officials. Sustained efforts, including timely release, update 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 all assisted to significantly bring down the number of heat-related deaths and illnesses in the past few years. According to NDMA, heatwave related mortality has reduced from 2,040 deaths in 2015 to 1,111 deaths in 2016 and further reduced to 384 deaths in 2017 and 25 deaths in 2018. Though it increased marginally in 2019 to 226, this has dipped to 4 in 2020.

1.2.7 Early warning systems for thunderstorms and lightning in India

A dedicated end-to-end forecast system for predicting thunderstorms and lightning has been developed and 48 real-time lightning sensors have been installed across the country. A mobile application called 'DAMINI' has also been developed to give alerts on impending lightning activity over the given area. These tools help to disseminate forecasts and warnings on time and help in preparing appropriate strategies to disseminate early warning to the concerned stakeholders.

1.2.8 Decreasing trend in Aerosol Black Carbon over India

Black Carbon (BC) is one of the most important light-absorbing aerosol species in the atmosphere, which has the potential to affect regional climate due to its absorption and consequent atmospheric warming. The long-term measurements of BC over the Indian region from the regional network of aerosol observatories (ARFINET) over the Indian mainland and adjoining islands under the Aerosol Radiative Forcing over India (ARFI) project of ISRO-GBP clearly showed a decreasing trend in BC over India. The emission control measures imposed by the government in various sectors have played a significant role in keeping the particulate emission, including that of BC under check. Studies in this regard indicate that improvement in combustion technology and fuel quality has resulted in an increase in efficiency and a consequent decline in BC emission intensities from industries, the residential sector and transportation in India.

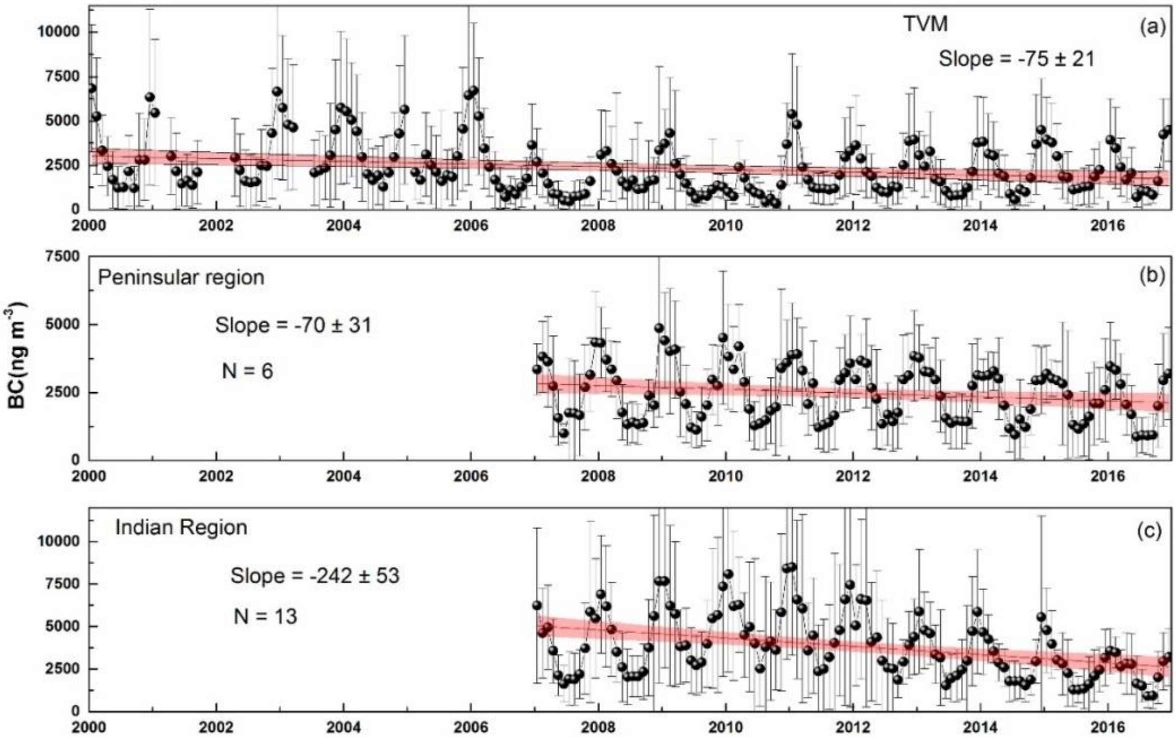


Figure 1.9: Long term trend in (a) BC over Trivandrum (TVM) during the period 2000-2016 (b) mean BC over the peninsular region during the period 2007-2016 and (c) mean BC over the Indian region during the period 2007-2016. The points represent the monthly mean data and the vertical bars represent the standard deviation. A linear fit (red line) with 95% confidence band (shaded portion) is shown. N represents the number of stations from which data has been used. Source: Manoj et. al., 2019.

1.3 Development of climate resilience and disaster risk reduction

India plays an active role in global initiatives on disaster management. India is a signatory to the Sendai Framework for Disaster Risk Reduction and is committed to achieve the priorities and the objectives through systematic and institutional efforts. With multi-dimensional initiatives and expertise, India is taking a leading role in strengthening regional cooperation among South Asian countries for reducing disasters. India is one of the participating countries and works closely with the United Nations International Strategy for Disaster Reduction 2015-2030 (MoHA, 2018).

1.3.1 Weather forecasting mechanism

The weather forecasting and early warning systems in the country are comparable to most of the developed countries in the world in terms of accuracy, lead time and associated impact. The IMD is dedicated for monitoring, detection and forecasting of weather and climate including early warning for severe weather events such as cyclones and heavy rainfall. The IMD continuously expands its infrastructure for meteorological observations, data exchange, monitoring and analysis, forecasting and warning services using contemporary technology. IMD uses a suite of quality observations from satellites, radars and conventional and automatic weather stations for monitoring of cyclones and prediction of weather. It includes INSAT 3D, 3DR and SCATSAT-1 satellites, Doppler Weather Radars (DWRs) along the coast and coastal automated weather stations (AWS), automatic rain gauges (ARGs), meteorological buoys and ships. The High Performance Computing (HPC) system has been upgraded by 6.8 peta flops so as to support the ongoing efforts on modelling (MoES, 2020).

Heavy rainfall events lead to floods over different river basins of the country. River basin floods are dealt by the Central Water Commission (CWC), MoJS. In order to meet specific requirements of flood forecasting, which is provided by CWC, MoJS, IMD operates Flood Meteorological Offices (FMOs) at thirteen locations *viz.,* Agra, Ahmedabad, Asansol, Bhubaneshwar, Guwahati, Hyderabad, Jalpaiguri, Lucknow, New Delhi, Patna, Srinagar, Bengaluru and Chennai. Apart from this, the IMD also supports Damodar Valley Corporation (DVC) by providing Quantitative Precipitation Forecast (QPF) for Damodar river basin areas for their flood forecasting activities. CWC is working in close association with IMD and State governments for timely flood forecast whenever the river water level rises above warning level. The FMOs operated by the IMD provide meteorological support to the CWC for issuing flood warnings well in advance in respect of the 43 rivers of India covering 146 river basins. The CWC issues flood forecasts 6 hours to 30 hours in advance for 176 stations using QPF received from FMOs and *in-situ* hydrometeorological data.

1.3.2 Ocean state forecast, warning and advisory services (OSF) from INCOIS

The Indian National Centre for Ocean Information Services (INCOIS) provides operational ocean information, forecast and advisory services. At present, under the ocean state forecast services, INCOIS provides forecasts of wave height, direction and period (of both wind waves and swell waves), sea surface currents, sea surface temperature, mixed layer depth (the well mixed upper layer of the sea), depth of the 20^{o} isotherm (a measure of the depth of the thermocline), astronomical tides, wind speed and direction and oil-spill trajectory. This prior information on the state of the seas surrounding the Indian subcontinent is vital for the smooth operational activities of not only for those who are venturing out into the sea but also for those at the sea shore. The users can take appropriate informed decisions based on the forecast of sea conditions for saving life and property. The forecast is available separately for various oceanic basins in the Indian Ocean. These services are being utilized by a wide spectrum of stakeholders ranging from fishermen to commercial operational agencies. These forecasts are generated operationally on HPCs and disseminated in local languages by different modes, including the latest information and computational technology tools. It is estimated that about one million users are using these services through direct or indirect channels.

Warning services such as high wave alerts, rough sea alerts, swell surge alerts, perigean spring tide alerts and INCOIS-IMD joint bulletins are also in place. User-friendly customized products like 'Ocean state forecast along ship routes', ‘Search and Rescue Aid Tool (SARAT)’, ‘Oil spill trajectory prediction system’, 'Sea state forecast for port and harbors’, 'OSF-Web map services' and many other services have been developed and made operational. Water quality nowcasts and forecasts, impact-based forecast system and climate service - advisories on future sea level, wave surge, and productivity, are being developed and would be operational in near future.

During extreme weather conditions, the INCOIS-IMD joint bulletins consisting of meteorological and oceanic information, forecasts and advisories, along with high sea state warnings are issued. Storm surge and related inundation warnings are also included in these bulletins. The storm surge and wave surge conditions or rough sea conditions due to the combined/isolated effects of swells (long period ocean surface waves) and/or tides in the form of warnings and advisories are also included in these bulletins.

High wave alerts or warnings are issued whenever there is a chance to have high impending waves during the coming days in the coastal waters of India. These are found to be helpful to the users for their operational planning and safety.

Warnings on swell surges or related rough sea conditions are issued when there is a chance of high period swells (“Kallakkadal” phenomena) to hit Indian coastline and the bulletins are disseminated to the coastal population through various modes. If the swell surge is associated with a spring tide (or perigean spring tide), the devastation will be much more. This is also warned well in advance.

1.3.3 Tsunami early warning service 24 X 7 operations

The Indian Tsunami Early Warning Centre (ITEWC) was established in 2007 at INCOIS, Hyderabad, as an autonomous body under Ministry of Earth Sciences. It came into being after the deadly Tsunami that hit India on 26 December 2004. The centre functions 24X7 to provide timely tsunami advisories to Indian coastal regions and countries in Indian Ocean. As a Tsunami Service Provider for Indian Ocean under IOC-UNESCO Indian Ocean Tsunami Warning and Mitigation System (IOTWMS), India is providing tsunami bulletins to 25 Indian Ocean Rim countries, *i.e.,* Australia, Bangladesh, Comoros, France (La Réunion), India, Indonesia, Iran, Kenya, Madagascar, Malaysia, Maldives, Mauritius, Mozambique, Myanmar, Oman, Pakistan, Seychelles, Singapore, South Africa, Sri Lanka, Tanzania, Thailand, Timor Leste, UAE and Yemen.

1.3.4 Storm surge early warning service

The INCOIS developed the Storm Surge Early Warning System in 2014 and providing services to IMD for further dissemination to the stakeholders and public. Decision Support System (DSS) based on a Standard Operating Procedure (SOP) was developed to provide timely information on the storm surge heights and associated coastal inundation along the Indian coast due to cyclones in the NIO. Since 2014, INCOIS monitored about 40 cyclones and provided the storm surge early warning services to IMD. It is planned to extend the service to WMO-ESCAP countries.

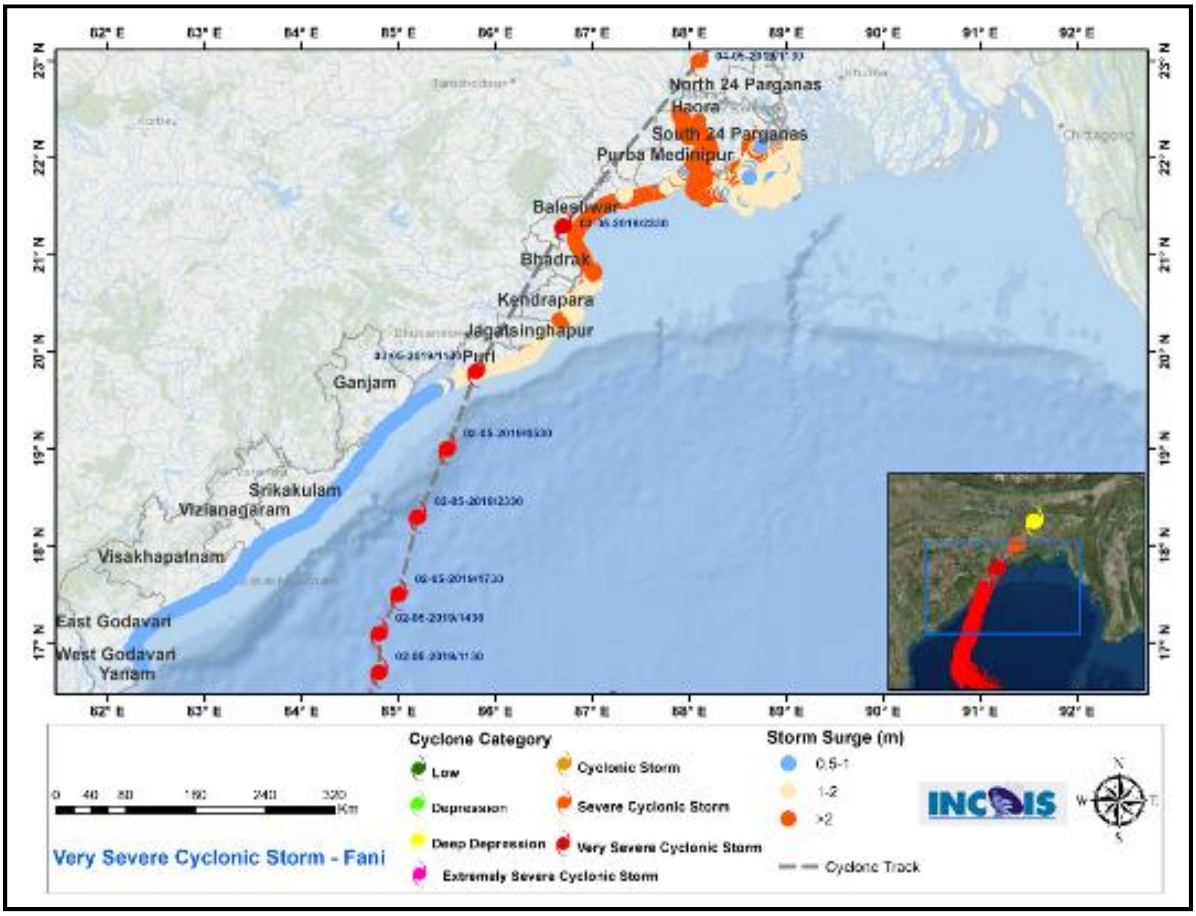
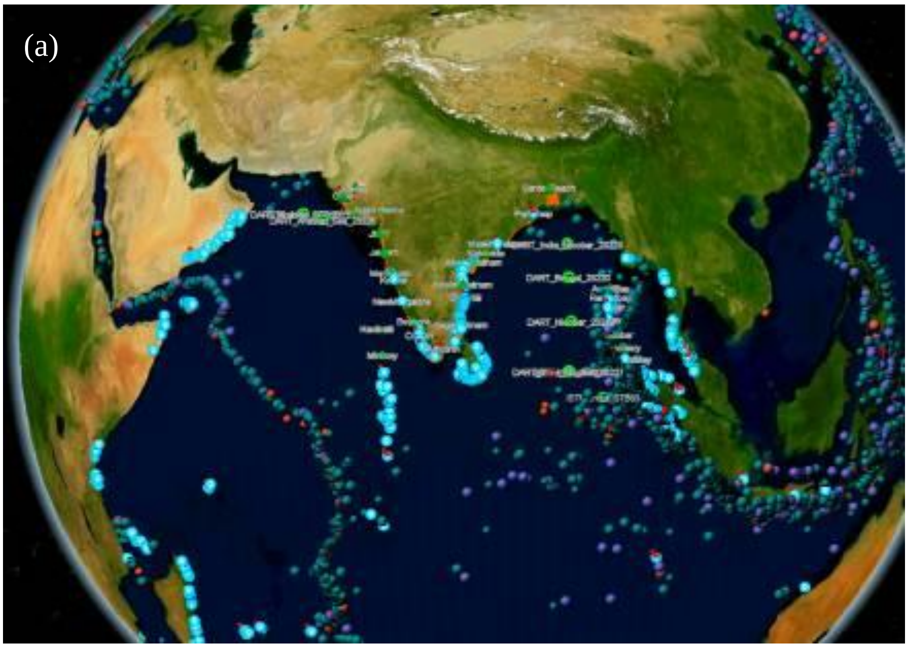


Figure 1.10: Storm surge forecast of very severe cyclonic storm – 'Fani'

INCOIS has also monitored the cyclonic storm 'Hikka' that crossed Oman coast and provided the necessary information to IMD to disseminate for the international stakeholders.

1.3.5 Multi hazard vulnerability mapping

Coastal multi hazard vulnerability assessment was done considering the implication of future sea level rise. INCOIS has generated multi hazard vulnerability maps on 1:25000 scale using the following parameters like rate of sea level change, shoreline changes, extreme water level and their return periods and higher resolution topography of entire mainland. These maps are used to assess risk from coastal inundation and various hazards, *viz.,* storm surges and tsunami. The 3D visualization and analysis system (3DVAS) application was integrated with updated data and maps. The application includes the following data - 3D Data: Realistic buildings associated with socio-economic data and high resolution coastal topography; 2D data: aerial photos; imageries; administrative boundaries; land use; transport; landmarks and multi-hazard vulnerability maps; geophysical data (tsunami), historical earthquakes; observation networks; coastal forecast points; coastal forecast zones and unit sources.



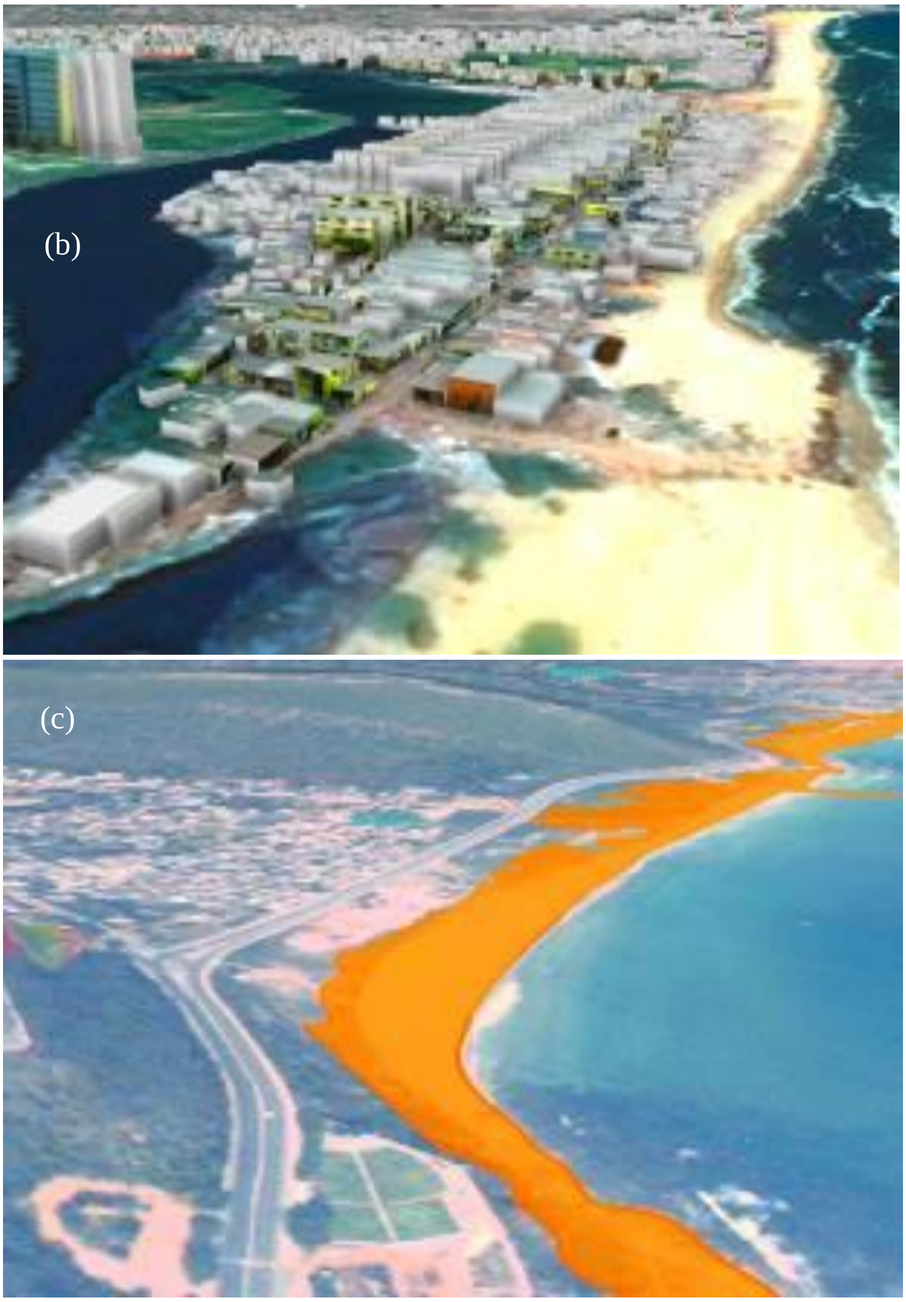


Figure 1.11: 3DVAS integrated with 3D and 2D spatial data (a) MHVM, (b) 3D Buildings and (c) Overlaid on 3D terrain

1.3.6 Disaster management and response

India's effective handling of extreme weather events in the recent past is an outcome of a series of policy initiatives and enhancement of early warning capabilities, advanced preparation, training and capacity development. The improved forecasting models, public awareness campaigns and well-drilled evacuation plans helped minimise the loss of life from various extreme events including cyclones.

The primary responsibility for disaster management rests with the State governments. The concerned State governments undertake relief measures in the wake of natural disasters including floods from the State Disaster Response Fund (SDRF) in accordance with GoI's approved norms. Additional assistance is extended from the National Disaster Response Fund (NDRF) as per established procedure. State-wise details of releases from SDRF and NDRF during the year 2018-19 to 2019-20 (as on 29 January 2020) are presented in Table 1.3. There are institutional mechanisms at the national, state and district level in the country to develop appropriate preparedness and prompt response mechanism for effective management of natural disasters. Accurate advance forecasts of tropical cyclone 'Amphan' in India underpinned a successful disaster mobilization campaign, including the evacuation of more than 3 million people, which has been praised for limiting casualties and serve as a textbook example for multi-hazard early warning systems (WMO, 2020).

Table 1.3: Statement showing state-wise details of releases of funds during the year 2018-19 and 2019-20 (As on 29 January 2020)

S. No.	State	Sanctioned (from 2009-10 to 2014-15)@		No of projects completed **	Central share released (from 2009-10 to 2019-20#) (in million) INR
		Total no. of Projects	Area of the projects (million ha)		
1.	Andhra Pradesh*	432	1.810	158	10,606.8
2.	Arunachal Pradesh	156	0.467	13	2,443.3
3.	Assam	372	1.577	143	4,927.5
4.	Bihar	123	0.612	-	1,513.1
5.	Chhattisgarh	263	1.195	112	3,078.8
6.	Gujarat	610	3.103	292	12,886.4
7.	Haryana	88	0.362	-	987.0
8.	Himachal Pradesh	163	0.840	-	2,835.8
9.	Jammu & Kashmir^	159	0.652	-	2,308.2
10.	Jharkhand	171	0.911	20	1,915.2
11.	Karnataka	571	2.569	304	18,947.0
12.	Kerala	83	0.423	26	1,093.0
13.	Madhya Pradesh	517	2.937	204	14,974.9
14.	Maharashtra	1186	5.128	598	24,139.5
15.	Manipur	102	0.491	5	1,491.0
16.	Meghalaya	96	0.236	47	1,730.3
17.	Mizoram	89	0.373	23	2,598.9
18.	Nagaland	111	0.476	61	5,391.5
19.	Odisha	310	1.700	127	10,043.1
20.	Punjab	67	0.314	-	604.2
21.	Rajasthan	1025	5.764	361	24,152.7
22.	Sikkim	15	0.066	-	220.8
23.	Tamil Nadu	270	1.368	112	9,249.4
24.	Telangana*	330	1.399	121	5,903.0
25.	Tripura	65	0.213	20	2,109.6
26.	Uttarakhand	65	0.346	-	1,310.8

27.	Uttar Pradesh	612	3.045	86	8,084.9
28.	West Bengal	163	0.693	-	1,970.8
	Total	8,214	39.07	2,833	1,77,517.5

Source: MoA&FW, 2019a.

@Sanctioned under the erstwhile Integrated Watershed Management Programme (IWMP), which has been amalgamated as the Watershed Development Component (WDC) of the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) with effect from 2015-16.

*As per final audited details received from Andhra Pradesh and Telangana after bifurcation of erstwhile Andhra Pradesh ^^erstwhile Jammu & Kashmir

**As on 31.10.2019 reported by States

#As on 31.10.2019 including releases under the erstwhile IWMP.

Note: There is no sanctioned project in Goa.

India launched the Coalition for Disaster Resilient Infrastructure (CDRI) on the side-lines of UN Secretary General's Climate Action Summit in September, 2019. This international partnership of national governments, UN agencies, multilateral development banks, private sector, and knowledge institutions will promote the resilience of new and existing infrastructure systems to climate and disaster risks, thereby ensuring sustainable development. Developed through consultations with more than 35 countries, CDRI envisions enabling measurable reduction in infrastructure losses from disasters, including extreme climate events. Currently, 19 countries and 4 multilateral organizations are members of the Coalition.

A few notable initiatives taken by the government to make its forecasting systems more accurate in the wake of increasing climate disasters with various research institutes and other leading agencies include the following: i) Bilateral agreement with National Oceanic and Atmospheric Administration (NOAA), United States of America (USA) and United Kingdom Met. Office for improvement in numerical weather prediction (NWP) modelling w.r.t. global forecast system and Unified Model (UM) respectively. ii) With the support of World Meteorological Organisation (WMO) and Japan Meteorological Agency (JMA), an ensemble prediction system has been installed in IMD in 2011 for cyclone track prediction and prediction of location specific cyclone strike probability iii) A bilateral collaboration between India and United States involving National Centre for Environment Prediction (NCEP), USA, IMD, INCOIS and Indian Institute of Technology (IIT), Bhubaneswar has resulted in experimental implementation of high resolution Ocean Atmosphere Coupled Model *viz.* Hurricane Weather Research & Forecast (HWRF) Model for north Indian Ocean with resolution of 2, 6 and 18 km (MoES, 2020).

1.4 Himalayan cryosphere

The Himalayan mountain range is one of the major water towers of Asia, and a large concentration of snow and glaciers make it possible to support water supply of major Indian Rivers as the Indus, the Ganga and the Brahmaputra. The Indus River is considered more vulnerable under future climate change scenarios due to large population, high water stress, snow/glacier melt and geopolitical conditions

(Immerzeel et al., 2019). In addition, the livelihood of large Himalayan mountain communities also depends on the availability of water from snow and glacier melt.

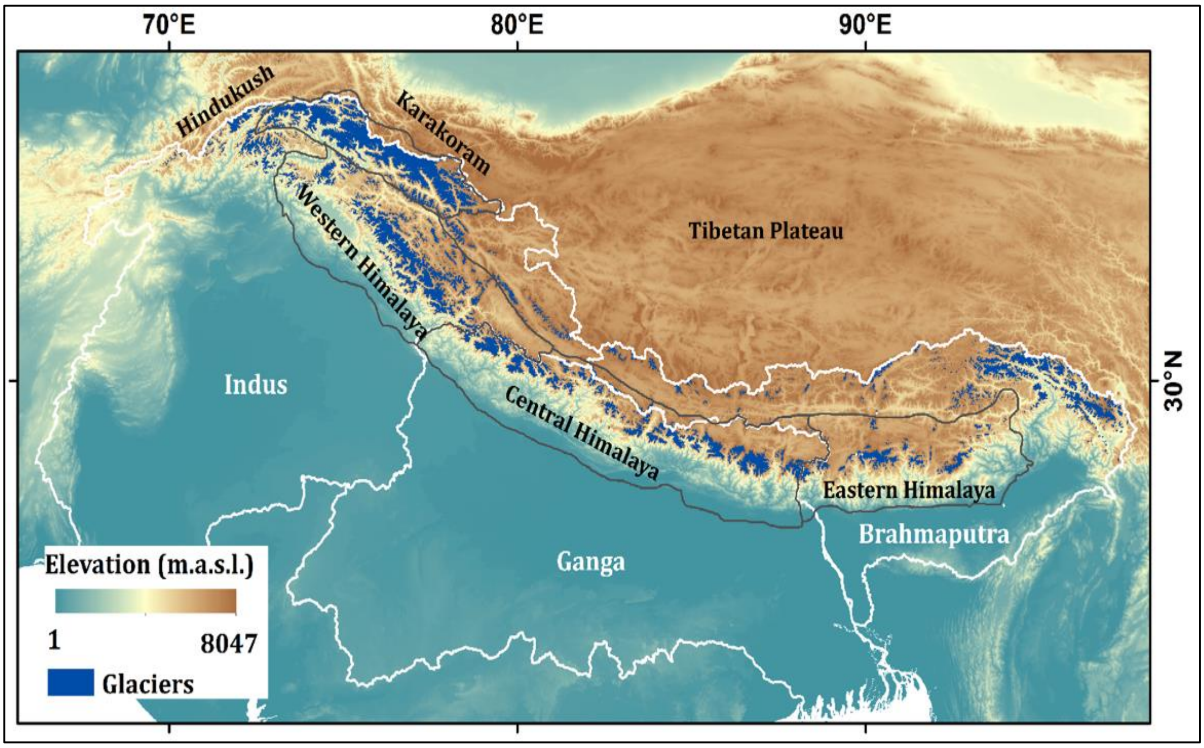


Figure 1.12. Glacier area in Indus, Ganga and Brahmaputra basins based on Randolph Glacier Inventory (RGI) 5.0. The divisions of Karakoram-Himalayan region from Bolch et al., 2012.

1.4.1 Snow cover

Snow during winter covers a large area (1.59±0.15 million km^2) in the Hindu Kush Himalayan region (Gurung et al., 2011a). The snow cover area (SCA) in Indus, Ganga and Brahmaputra basins ranges from 85 per cent in the winter to approximately 10 per cent in the summer (Figure 1.13). Monitoring of winter precipitation and temperature in Western Himalaya suggest a significant increase in total precipitation but a decrease in snowfall from 1991 to 2015 (Negi et al., 2018).

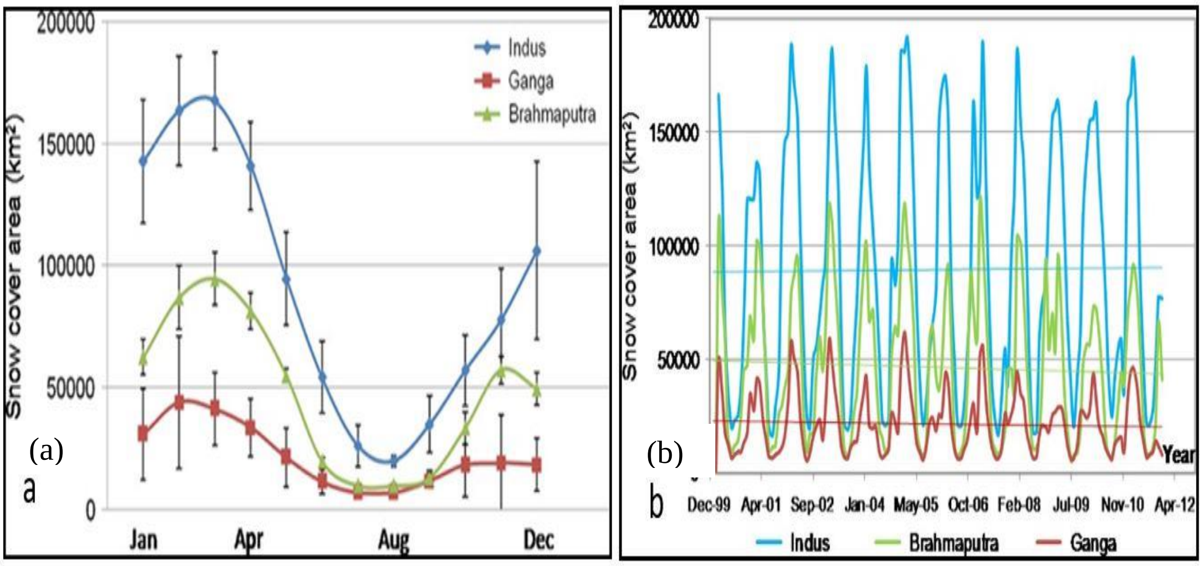


Figure 1.13: (a) Seasonal snow cover variability in three major Himalayan basins (2000 to 2011) (b) Inter-annual SCA variability shows no significant trend. Source: Singh et al., 2014.

Although no significant trend in mean snow cover for the entire Himalaya has been reported, however, some significant inter-annual and intra-annual variations in basins have been observed. SCA in Jhelum, Kosi, Gandaki and Manas river basins have shown a decreasing trend (2003-2012), with a statistically significant negative correlation with temperature (Gurung et al., 2017).

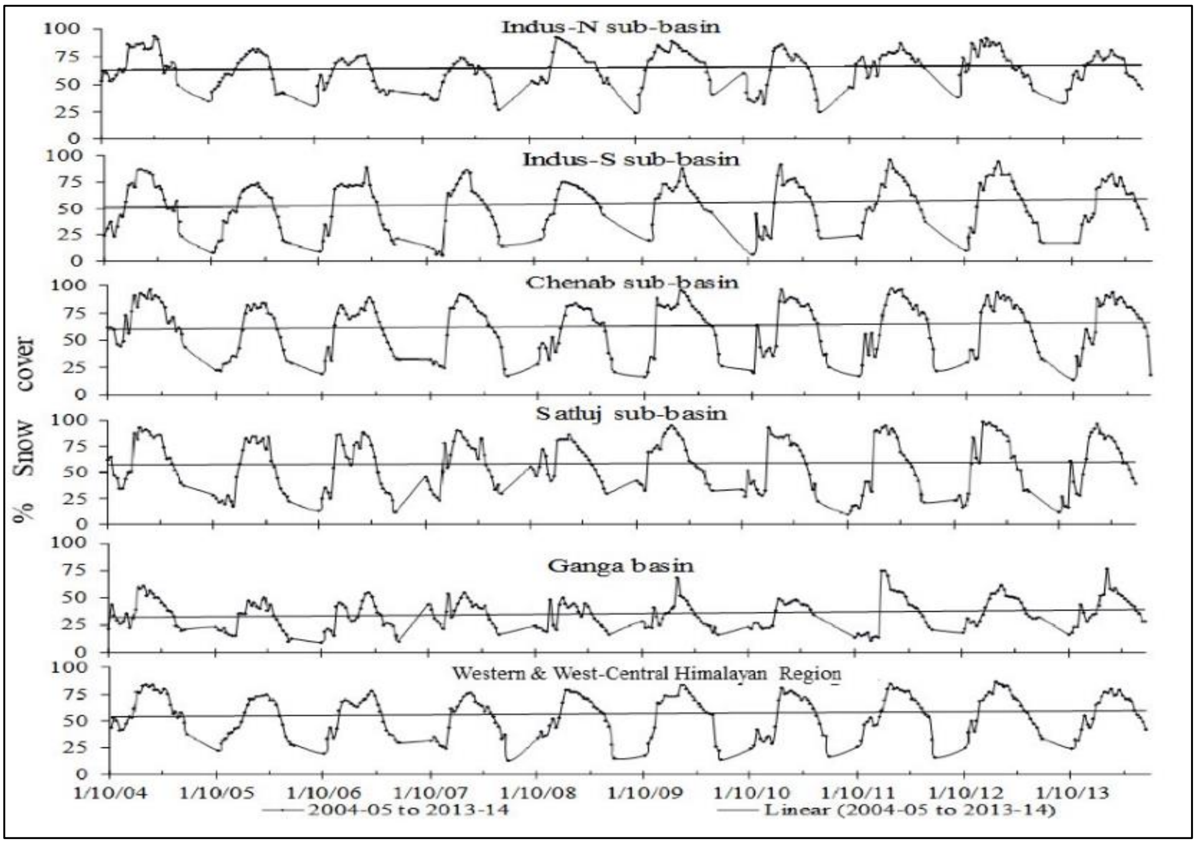


Figure 1.14: Variation in snow cover area for basins in western and west central Himalaya from 2004 to 2014. Source: Rathore et al., 2018.

1.4.2 Glacier area

The total glacial extent in the Indian Himalaya (excluding Nepal, Bhutan and Karakoram) varies from 20,785 to 27,915 km^2.The best estimate for the total glacier area in the Indian Himalaya is 25,041±1,726 km^2 (Kulkarni & Karyakarte, 2014). A few glacier inventories in the Himalaya suggest that the Indus basin has the maximum number of glaciers and the largest glaciated area, whereas the Ganga basin has the least (Figure 1.15). The average glaciated area in the Indus basin is 26,150±3,744 km^2, whereas the average glaciated areas in Ganga and Brahmaputra basins are 11,621±3,773 km^2 and 15,606±3,584 km^2, respectively.

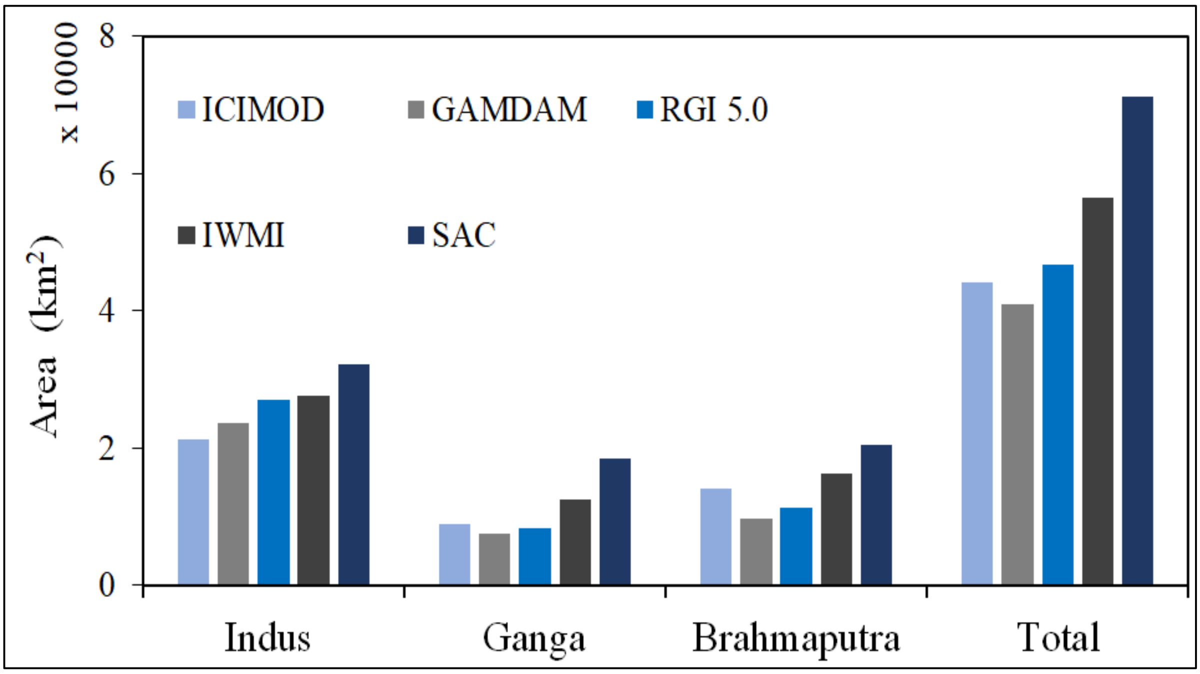


Figure 1.15: Comparison of the glaciated area in the Indus, Ganga and Brahmaputra basins estimated by Space Applications Centre (SAC), International Centre for Integrated Mountain Development (ICIMOD), Randolph Glacier Inventory (RGI), International Water Management Institute (IWMI)and GAMDAM glacier inventory. Source: Sharma et al., 2013.

1.4.2.1 Glacier retreat and area loss

Most of the Himalayan glaciers are retreating and the rates of retreat have probably accelerated in the past few decades, but the observed tendencies are not regionally uniform (Bolch et al., 2012; Bahuguna et al., 2014). In the Himalayan region, the retreat of glaciers will have an enormous impact, as glaciers play an important role in river runoff (Huss & Hock, 2018; Singh et al., 2020). The mean rate of retreat is 14.2±12.9 ma^{-1}. In Himalaya, investigation of 39,500 km^2 glacier area indicate rate of loss as 4.3±2.4%/decade (Dobhal & Mehta, 2008; Sharma et al., 2016). In the Indus basin, the area loss rate is observed to be 2.5±2.5%/decade whereas Ganga and Brahmaputra basins were observed to lose glacier area at the rate of 2.7±2.4%/decade and 7.7±9.4%/decade, respectively. In another study carried out by SAC - Indian Space Research Organization (ISRO), 2018 Glaciers representing climatically diverse terrains in the Himalaya were mapped and monitored between 2001 and 2010/2011 (Bahuguna et al., 2014). The net loss in 10,250.68 km^2 area of the 2018 glaciers put together was found to be 20.94 km^2 or 0.2 per cent.

1.4.2.2 Glacier mass

Limited data on ice thickness and volume is available in Himalaya due to challenges involved in the application of radar and other field methods in rugged terrain. Recent estimates of glacier mass were made using Randolph glacier Inventory (RGI 5.0) and various scaling methods. This suggests a mass of glacier stored water in Himalaya to be 4190±2662 Gt (Kulkarni et al., 2020), large uncertainties indicate the need for further improvement in the techniques.

1.4.2.3 Glacier mass balance

Glacier mass balance is estimated using field, remote sensing and modelling techniques. Mass balance estimates using the glaciological method are available for 30 glaciers in the Indus, Ganga and Brahmaputra basins (Kulkarni & Shirsat, 2019). The cumulative mass balance of these glaciers is calculated using the available field data (Figure 1.16). This analysis suggests an overall negative mass balance trend for all the glaciers, indicating a substantial mass loss. Out of the 211 measurements, only 16 positive mass balance records are observed since 1975. To summarize, the decadal trend in field mass balance indicates a negative trend, varying from -0.42 m.w.e.a^{-1} in the 1970s to -0.78 m.w.e.a^{-1} in 2000s (Bolch et al., 2012; Pratap et al., 2016; Azam et al., 2018).

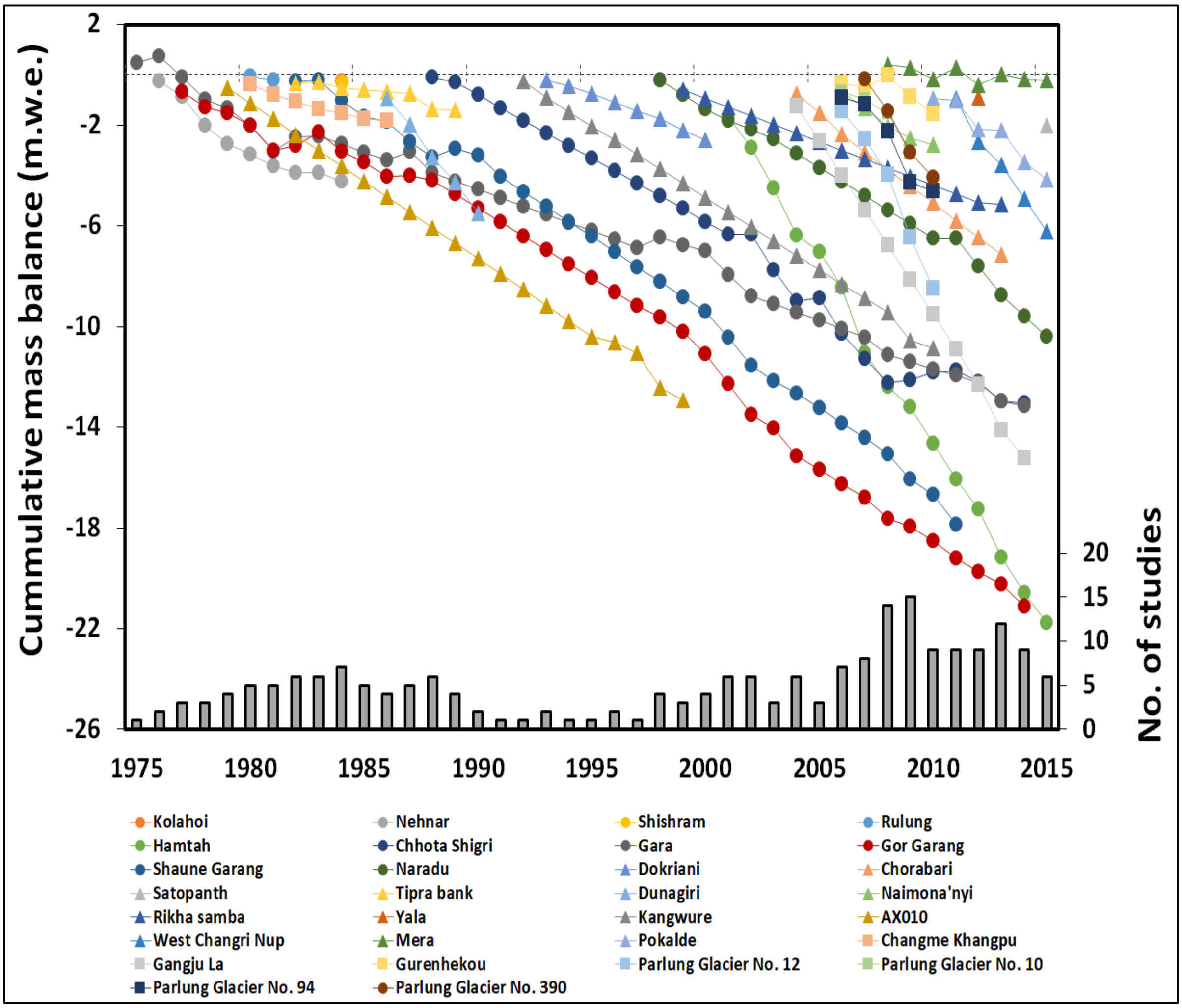


Figure 1.16: Cumulative mass balance of 30 glaciers based on the glaciological mass balance data from 1975 to 2015. Glaciers in the Indus, Ganga and Brahmaputra basins are shown by circles, triangles and squares, respectively. Source: Kulkarni & Shirsat, 2019.

1.4.2.4 Contribution of snow and glacier melt in stream runoff

Seasonal snow and glacier melt contribute significantly to the stream runoff of rivers originating in the Himalaya. The Indus basin has the most considerable dependence on snow and glacier melt, followed by the Brahmaputra and the Ganga basins (Kulkarni & Shirsat, 2019). It contributes to about 62 per cent of the total annual discharge in Indus, 20 per cent in Ganga and 25 per cent in Brahmaputra basins (Lutz et al., 2014).

1.4.2.5 Glacial lake outburst flood (GLOF)

Many glaciers form glacial lakes in the Himalayan region. Due to an increased ice and snowmelt the accumulation of water in these lakes is increasing. Sudden discharge of large volumes of water with debris from these lakes potentially causes glacial lake outburst floods (GLOFs) in valleys downstream.

NDMA released “Guidelines for the Management of Glacial Lake Outburst Floods (GLOFs)” in October 2020. The guidelines aim to mitigate GLOF disaster risks that are increasing, including plausibly due to climate change. These guidelines will enable concerned ministries or departments of State/UT, central governments and other stakeholders to take concerted action for preparedness, prevention, mitigation, and response to GLOFs. These Guidelines also emphasize on awareness and capacity building of the relevant stakeholders including communities and tourists in hilly mountain regions.

1.5 Coastal and marine ecosystems

Coastal regions are unique because of their position at the interface of atmosphere, lithosphere and hydrosphere. India’s coastline over 8,000 km spans nine maritime states and five UTs, including two island territories. It has 1,208 island territories and an Exclusive Economic Zone (EEZ) of 2.02 million km^2.

Among various types of marine ecosystems in India, tidal mudflats, mangroves, estuaries, lagoons, beaches, marshes, vegetated wetlands and coral reefs have a major share. There are 25 Marine Protected Areas (MPAs) with an area of 6,200 km^2 in peninsular India, along with 97 major estuaries, 34 major lagoons and 5,790 km^2 of coral reefs. The mangroves are spread over an area of 4,975 km^2, which is 0.15 per cent of the country’s total geographical area (MoEFCC, 2019d; FSI, 2019). These areas have been mapped and identified in India for conservation and sustainable management. The conservation of the marine ecosystems is largely linked to coastal zone management activities. However, like most coastal regions of the world, coastal areas of India are densely populated and approximately 30 per cent of its human population is dependent on the rich exploitable coastal and marine resources. A number of urban and economic centres of strategic importance, including two of the four megacities (Mumbai and Chennai) of India are located along the coast (EnviStats India Vol II, 2020).

Seaweeds are an essential component of our coastal communities, and seaweed aquaculture has the potential to locally reduce the negative impacts of climate change through carbon uptake, reduction of agricultural GHG emissions, and protection of shores from coastal erosion. These positive effects will depend on local environments and the local use of the seaweeds being farmed (e.g., sea vegetable, commercial compounds, livestock supplement).

1.5.1 Protection and management of coastal areas

The Survey of India and National Centre for Sustainable Coastal Management (NCSCM) have mapped the hazard line for the entire coast of India, which includes vulnerability mapping of flood, erosion and sea level rise. The outputs will be used by all the coastal States and UTs in managing coastal vulnerability in the coming years and as a tool for preparation of disaster management plans.

The Coastal Regulation Zone Notification, 2011 mandated the preparation of Coastal Zone Management Plan (CZMP) within two years from the date of publication of notification. The government issued a new Coastal Regulation Zone Notification in January 2019. The coastal States/UTs are required to revise/update their CZMPs prepared as per CRZ Notification, 2011 to align it with CRZ Notification, 2019, as per guidelines issued by this Ministry on 26 June 2019 (MoEFCC, 2019a).

With the objective of assessing the impact of climate change on the coastal areas of the country, the National Centre for Coastal Research (NCCR), Ministry of Earth Sciences (MoES) is carrying out work on developing a decision support system for climate change impact assessment on geographical areas and socio economic impact in the coastal areas. NCCR has also prepared shoreline change maps for the period 1990-2018. In the past three decades, the overall long-term shoreline change result along entire Indian mainland coast shows that about 32 per cent of the coastline is under varying degree of erosion, 27 per cent is of accreting nature and the remaining 41 per cent is in a stable state (MoES, 2020b).

A national strategy for coastal protection, along with guidelines for coastal protection measures, has been framed for all coastal States and UTs by MoEFCC. Under the Integrated Coastal Zone Management Project (ICZMP), MoEFCC has undertaken delineating and demarcating the hazard line along the entire coastal belt of the country, including the inter-tidal areas. The hazard line is indicative of the shoreline changes, including the sea level rise due to climate change and is a projection of impact due to sea level rise, and shoreline changes over a long period of time *viz.* over 100 years. This line is required to be used by the coastal state agencies concerned, as a tool for disaster management for the coastal environment, including planning of adaptive and mitigation measures. The hazard line for the entire coast of the country has been mapped and is featured in the new CZMPs of the coastal states/UTs approved by the government.

The ICZMP also envisages large-scale assessment of the risks associated with shoreline changes and preparation of a framework for development of management solutions to combat these risks. Under the Phase-I of the project, shoreline management plans are prepared for five identified coastal stretches in Gujarat, Odisha and West Bengal, on a pilot basis (MoEFCC, 2019b).

In the arena of adaptation to climate change, in the context of coastal protection management, a Technical Assistance (TA) agreement was signed by the Government of India with the Asian Development Bank (ADB) for the project “Climate Resilient Coastal Protection and Management Project (CRCPMP)”, to support mainstreaming of climate change considerations into coastal protection and management. As a part of this project, a reference manual on "Climate Change Adaptation Guidelines for Coastal Protection and Management in India" was prepared and released in March 2019 by CWC, DoWR, RD & GR and MoJS, New Delhi.

The Coastal Management Information System (CMIS) has been initiated by the DoWR, RD & GR, MoJS, during the XIIth Plan (2012-17) for the collection of 9 coastal parameters *viz.* Tide, Wave, Current, Wind, Riverine Data, Bathymetry, Shoreline change, Beach Profile and Coastal Sediment at 8 nos. of CMIS sites, covering 5 States and 1 UT (*viz.* Tamil Nadu, Kerala, Maharashtra, Gujarat, Goa and UT of Puducherry) to create an integrated data bank on coastal processes. This will further help in determining causes of erosion/ sediment transportation/ defining sediment cell and sediment budget for evolving long term plans for coastal protection measures which can also facilitate climate change adaptations.

1.5.2 Fisheries

India is the second largest aquaculture producing country in the world and its total fish production accounts for about 6.3 per cent of the global fish production. The sector provides livelihood to about 16 million fishers and fish farmers at the primary level and almost twice the number along the value chain.

The government has taken several initiatives in a sustainable and responsible manner to enhance fish production and productivity. India has about 0.26 million marine fishing crafts of different categories to harness the estimated potential of marine fishery resources (5.31 million metric tonne) available in our jurisdictional waters (MoFAH&D, 2019a). The total fish production in the country stood at 13.42 million metric tonne (provisional) during 2018-19. Of this, the marine fisheries contributed 3.71 million metric tonne and the inland fisheries contributed 9.71 million metric tonne (DEA, 2020). During 2018-19, export of marine products stood at 13, 92,559 metric tonne and valued at INR 4,65,890 million.

The fish production in the country is growing at an annual average rate of 7 per cent from 2017-19. The details of total fish production and GVA in the fisheries sector in the country during the last four years are given in the Table 1.4.

Table 1.4: Fish production (in million tonne) and its GVA in India

Year	Marine	Inland	Total	Growth rate (%)	Gross Value Added (GVA) (in INR million) at current prices
2015-16	3.600	7.162	107.62	4.89	13,27,200
2016-17	3.625	7.806	114.31	6.22	15,46,430
2017-18	3.688	8.902	125.90	10.14	18,65,610
2018-19 (p)	3.710	9.710	134.20	6.60 (p)	21,29,150

Source: MoFAH&D, 2020 (p-provisional), GVA Figures are as per First Revised Estimates of National Income 2018-19.

1.5.2.1 Programmes to promote fisheries

Realizing the immense scope for development of fisheries and aquaculture, the GoI has restructured the Central Plan Schemes under an umbrella of Blue Revolution. The restructured Centrally Sponsored Scheme (CSS) on Blue Revolution: Integrated

Development and Management of Fisheries was approved in December, 2015 by the CCEA with a total central budgetary outlay of INR 30,000 million for five years (i.e., till end of 2019-20). Under the CSS, central financial assistance of INR 3120.9 million has been released to various coastal state governments/UTs during last two years i.e. 2017-18 to 2018-19 and current year (2019-20) for introduction of a total 918 deep sea fishing vessels and 313 traditional fishermen have been trained (MoFAH&D, 2019b).

Government of India has created a new Ministry of Fisheries, Animal Husbandry and Dairying (MoFAH&D) with two separate Departments i.e., (i) the Department of Fisheries and (ii) the Department of Animal Husbandry and Dairying vide Cabinet Secretariat's Gazette Notification No. 1763 dated 17 June 2019, with a view to providing sustained and focussed attention towards the development of fisheries sector including welfare of fishermen and other fisher-folk and strengthening of their livelihoods (MoFAH&D, 2019c).

Fisheries resources

The National Policy on Marine Fisheries, 2017 proposes to keep sustainability of the resources at the core of all actions. The State/UT Governments are implementing their respective 'Marine Fishing Regulation Act(s)' (MFRAs) to ensure sustainable fishing practices. Workshops, meetings and awareness programs are organized from time to time by the Central and State/UT Governments, Coast Guards, Fisheries Research Institutions, Inter-governmental Organization (IGO), Fisheries Universities and Colleges, other agencies as well as Fishermen Associations/Federations to sensitize the stakeholders including fishermen to spread awareness and to follow sustainable practices in the fisheries to ensure quality (MoFAH&D, 2019d).

Table 1.5: Marine and inland resources

Marine resources and dependency on livelihoods	
Length of coastline (km)	8,118**
Exclusive economic Zone (million sq.km)	2.02*
Number of fish landing centres	1,547**
Number of fishing villages	3,477**
Number of fisherman families	8,93,258**
Fisher-folk population	3,774,577**
Inland Resources	
Rivers and canals (million km)	0.195*
Reservoir (million ha)	3.15*
Tanks and ponds (million ha)	2.41*
Flood plain lakes (million ha)	0.812*
Brackish water (million ha)	1.24*
Saline/alkaline affected areas (million ha)	1.2*

Source: *DEA, 2020; **EnviStats India Vol I, 2020.

1.5.2.2 Fishery advisory services

INCOIS provides Potential Fishing Zone (PFZ) and Tuna Fishery Advisory services every day on operational basis. The advisory provides real-time information to the fishermen on the most probable areas of fish aggregation so that the fishermen can directly navigate to such areas without having to search for the fish shoals. This results in reduction of time and effort spent and the search time for finding the fish shoals. In addition to these direct benefits to the fishermen, indirect benefits are in terms of reduction in emission of CO_2 to the atmosphere. Several researchers and institutes have made independent studies towards estimation of these environmental benefits.

1.5.2.3 Coral bleaching alert system

Satellite based Coral Bleaching Alerts were provided as advisories on the hotspots, degree of heating weeks and the variation of SST anomalies on bi-weekly basis. There have been no events of coral bleaching recorded since 2016.

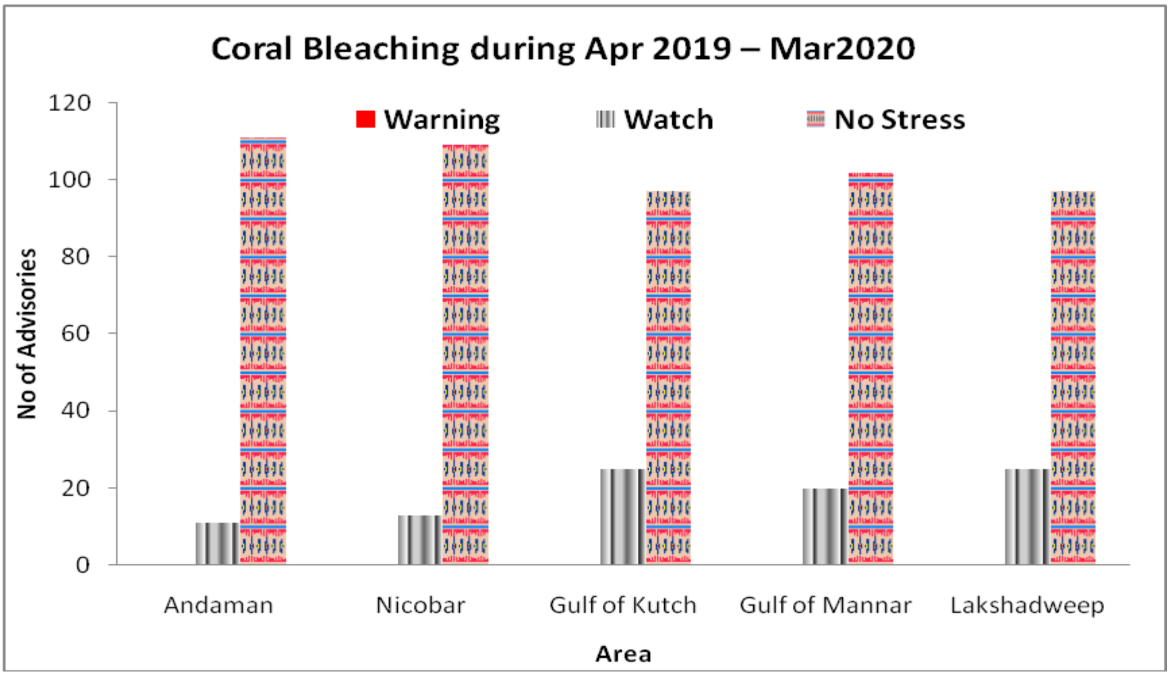


Figure 1.17: Numbers of Coral bleaching advisories issued during 2019-20

These products are disseminated from INCOIS through the web and made available on user interactive interface.

Box 1: Implementation of Pradhan Mantri Matsya Sampada Yojana (Source: Transforming India, 2020).

- Total estimated investment of INR 2,00,500 million to be implemented during FY 2020-21 to FY 2024-25

- To augment fish productivity at a sustained average annual growth rate of 9 per cent to achieve target of 22 MMT
- To generate direct employment to about 1.5 million fishers, fish farmers and fish vendors.
- Doubling of fishers, fish farmers and fish worker's income by 2024.

1.6 Sea level rise

With a coastline over 8,000 km in length and numerous islands as part of the national territory, India is also vulnerable to sea-level rise and will be in the frontline of its impacts as well as suffering from increased exposure to coastal hazards including storm surges during cyclones, increased impact of cyclones and related hazards. The total population of the coastal districts of India is 171 million, accounting for 14.1 per cent of India's population, based on the 2011 Census (IOMENVIS, 2017). This includes sections of the population with heightened vulnerability such as fisherfolk using low-powered or traditional craft, salt pan workers, farmers in coastal agriculture, and fisherfolk whose livelihoods depend on aquaculture in the coastal regions. The urban population of major cities and urban settlements along the coast have also vulnerable sections liable to be affected by alluvial flooding, with a clear link between urban slum populations and vulnerability to alluvial flooding. These urban areas are also the location of considerable wealth in the form of assets and infrastructure, including the megacities of Mumbai and Chennai. Thus, coastal vulnerability is a key aspect of vulnerability to climate change and India is one of the leading affected countries in this regard. India's vulnerability to sea-level rise and its exposure to coastal hazards are thus very comparable to that of the Small Island Developing States.

Table 1.6: Rate of change of sea-level at 10 major ports in India

S. No.	Location	Rate of change of sea-level (mm/year)	Duration of data used (years)
1.	Chennai	0.33	1916-2005
2.	Diamond Harbour	5.16	1948-2005
3.	Haldia	2.89	1972-2005
4.	Kandla	3.18	1950-2005
5.	Kochi	1.30	1939-2005
6.	Mumbai	0.74	1878-2005
7.	Paradeep	1.03	1966-2005
8.	Port Blair	2.20	1916-1964
9.	Vizag	0.97	1937-2005
10.	Okha	1.5	1964-1991

Source: MoEFCC, 2020a.

Sea level rise is a slow phenomenon and varies globally depending on local site factors. Based on the study by INCOIS as well as the studies published in scientific literature, on an average, at present, the sea level along the Indian coast is estimated to be rising at about 1.7 mm/year (MoEFCC, 2020a). It was observed that, the sea levels are changing at different rates along the Indian coast. Rising sea levels alone may not impact much, but it can exacerbate the coastal inundation along low lying areas during the extreme events such as tsunami, storm surge, coastal flooding and coastal erosion. It will have cumulative impact on inundation during extreme events causing increased coastal inundation. INCOIS has estimated rate of change in the sea levels from the long term data (monthly mean sea levels) obtained from the sea level gauges installed at 10 major ports given in Table 1.6.

These rates may also include the manifestations in sea level change due to the subsidence or uplift of land at those locations. Since no long term data on land subsidence or upliftment is available for these locations, the rate of increase of sea level due to the changes in climate could not be separated. For example, the higher rate of sea level increase at Diamond Harbour is also due to the larger land subsidence happening there. The same may apply to Kandla, Haldia and Port Blair as well.

The INCOIS has prepared a Coastal Vulnerability Index (CVI) for the entire coastline as part of the Tsunami Early Warning System. CVI mapped at 1:100000 scale was prepared based on the assessment of probable implications of sea-level rise to the coast (climatic and momentary due to tsunami/storm surge), coastal slope, shoreline change rate, coastal elevation, coastal geomorphology, tidal range and significant wave height. These maps are available through website of INCOIS (https://www.incois.gov.in/portal/cvi/index.html). In addition, INCOIS has also prepared the Multi-Hazard Vulnerability Maps (MHVM) for mainland of India at 1:25000 scale. The MHVMs indicate the probable coastal flooding due to oceanogenic disasters like tsunami and storm surges. Both have used the sea level change rate as one of the parameters (MoEFCC, 2020a).

INCOIS has also initiated ocean climate change advisory services under the Deep Ocean Mission with an aim to assess and provide future projections of the impact of climate change on various coastal oceanographic parameters. This initiative will provide quantitative indicators for the possible changes in sea-level, coastal erosion, increasing intensity of cyclone, wind waves and storm surges and change in the marine water quality parameters at seasonal to decadal timescale for helping the planning for future marine system driven economy and offshore/coastal installations/constructions. These advisory services will be based on a suite of state-of-the-art numerical ocean models and an improved network of ocean observation. The proposed mission will be implemented during the financial period 2020-2025 (MoES, 2020).

With a view to conserve and protect the unique environment of the marine areas of the country, and to promote development in a sustainable manner, the Central

Government issued the Coastal Regulation Zone (CRZ) and Island Protection Zone notification which lay down strong emphasis on adaptation to impact of sea level rise. To enforce the provisions of the notification, the GoI has constituted National Coastal Zone Management Authority (NCZMA) and Coastal Zone Management Authorities (CZMA) for coastal states/UTs under Environment (Protection) Act, 1986 (EPA). Adequate powers under EPA have been provided to these authorities to ensure implementation of the provisions of the notification. The notification also provides for constituting district level committees in each coastal district.

The preparation of Shoreline Change Atlas of Indian Coast was initiated by Space Application Centre (SAC), Ahmedabad in collaboration with Central Water Commission. The Atlas comprises shoreline change maps prepared using satellite data of 1989-91 and 2004-06 time-frame on 1:25000 scale for the entire country. The maps show eroding, stable and accreting coast along with the status of coastal protection measures taken up by maritime States/UTs (CWC, 2020b).

1.6.1 Ocean Observational programmes

MoES has scaled up efforts to establish and sustain various in-situ ocean observational systems in the Indian Ocean to support operational ocean state forecast and services. Such platforms include tsunami gauges, tide gauges, Wave Rider Buoy (WRB), coastal Acoustic Doppler Current Profilers (ADCPs), Argo floats, drifters, AWS, and moorings networks. These systems provide information on tsunamis and trends on sea-level, wave characteristics, ocean currents, and other ocean physical and biogeochemical variables. Information obtained through these platforms is essential to improve weather and disaster warning and the development of coastal economies, which in turn helps the policymakers, social and environmental conservationists for better preparedness and disaster risk management capacity. These observational programmes are implemented by INCOIS, National Institute of Ocean Technology (NIOT) and National Institute of Oceanography (NIO).

1.7 Water resources

Water has been recognized as being vital to India's economic growth, well-being of its people, and the sustainability of ecosystems. Over the last few years, GoI as well as state governments have been implementing a range of projects focused on groundwater recharge; responsible use of water for agriculture; and use of technologies such as micro-irrigation.

To deal with water issues in an integrated manner under a single umbrella, MoJS has been created by the government in May 2019. The Ministry includes two Departments namely, the Department of Water Resources, River Development & Ganga Rejuvenation (DoWR, RD & GR) and the Department of Drinking Water and

Sanitation (DW&S). The mandate of DoWR, RD & GR includes development, conservation and management of water as a national resource; overall national perspective of water planning and coordination in relation to diverse uses of water and interlinking of rivers; formulation of general policy, guidelines and programmes for development and regulation of the country's water resources; conservation, development, management and pollution abatement of rivers; regulation and development of inter-state rivers and river valleys; water laws and legislations; assessment of water quality; and matters relating to rivers common to India and neighbouring countries.

The government has launched Jal Jeevan Mission (JJM) to enable every rural household in all the States and UTs to have functional household tap connection for providing potable water at service level of 55 litre per capita per day by the year 2024 (MoJS, 2020). Currently, there are 28.95 per cent households with functional household tap connections (FHTC) for water supply. Percentage of the rural population getting safe and adequate drinking water within premises through pipe water supply has increased to 42.49 in 2019-20 compared to 35.76 in 2015-16 (MoSPI, 2020b).

Jal Shakti Abhiyan (JSA) is also launched by the government to spread awareness among all stakeholders in 256 water stressed districts about water conservation in two phases. Currently, 93 per cent of the population has access to basic water with another approximately 90 million to be covered, while the prevalence of open defecation in rural India has dropped from 90 per cent in 2000 to 36 per cent in 2017, compared to 4.75 per cent in urban India (WHO/UNICEF JMP, 2019). Further, a number of states have done notable work in the field of water management/conservation. Of these, mention can be made of '*Mukhyamantri Jal Swavlamban Abhiyan'* in Rajasthan, '*Jalyukt Shibar'* in Maharashtra, '*Sujalam Sufalam Abhiyan'* in Gujarat, Mission 'Kakatiya' in Telangana, 'Neeru Chettu' in Andhra Pradesh, '*Jal Jeevan Hariyali'* in Bihar among others. To supplement the efforts of the Ministry of Jal Shakti, NITI Aayog has prepared the second Round of Composite Water Management Index (CWMI 2.0). NITI Aayog first launched and conceptualized the Composite Water Management Index in 2018 as a tool to instill a sense of cooperative and competitive federalism among the states. The CWMI is an important tool to assess and improve the performance of states/ UTs in efficient management of water resources.

CPCB, in collaboration with the State Pollution Control Boards, monitors the water quality of aquatic resources across the country through a network of 4022 monitoring stations under the National Water Quality Monitoring Programme (MoEFCC, 2019c). To prevent pollution in water bodies, 60 action plans out of 61 Priority I and Priority II polluted river stretches pertaining to 18 States and 1 UT have been approved. These action plans cover aspects such as source control (municipal sewage management, industrial pollution control, waste management), river catchment/basin management (adoption of good irrigation practices, rainwater harvesting, utilization of treated sewage, groundwater recharge aspects), flood plain zone protection and its management (setting up of biodiversity parks, removal of encroachments, plantation on both sides of the river), Ecological/Environmental Flow (E-Flow), *in-situ* remediation of drains, septage management, water conservation in industries through Zero Liquid Discharge (ZLD), bio-mining of existing legacy dumpsites and watershed management.

The dynamic groundwater resources of the country are being periodically assessed jointly by Central Ground Water Board (CGWB) and state governments. As per the 2017 assessment of CGWB, out of the total 6,881 assessment units (Block/ Taluks/ Mandals/ watersheds/ Firkas) in the country, 1,186 units in various States/UTs (17 per cent) have been categorized as ‘Over-exploited’ where the annual groundwater extraction is more than annual extractable groundwater resource. There are 313 units categorized as ‘Critical’ while 972 units are categorized as ‘Semi-critical’. The aforementioned assessment also reports 4,310 units as ‘Safe’ and 100 units as ‘Saline’.

Further, CGWB periodically monitors the groundwater levels throughout the Country on a regional scale, through a network of monitoring wells. In order to assess the decline in water level on a long-term basis, pre-monsoon water level data collected by CGWB during pre-monsoon 2019 has been compared with the decadal average (2009-2018). Analysis of water level data indicates that about 61 per cent of the wells monitored have registered decline in groundwater levels, mostly in the range of 0-2 m. During the pre-monsoon period of 2019, the depth to water level in the country ranged from less than 2 metre to more than 40 metre below ground level (mbgl). In a major part of the country, water level is in the range of 5 to 10 metre (MoJS, 2020).

A similar situation prevails with respect to sanitation; India’s other major development deficit, one that is closely related to the question of water resources and the prevention of pollution. Rural India registered a dramatic decline in recourse to open defecation from the 2000 level of close to 90 per cent to 36 per cent in 2017. In urban India the number has dropped to 4.75 per cent in 2017 from 26.5 per cent in 2000. Overall in 2017, in rural India 59.5 per cent had access to basic service in sanitation, while the corresponding figure for urban India was 72 per cent. It may be noted that, for a number of reasons, behavioural change associated with sanitation practices may not immediately follow the provision of adequate infrastructure and physical facilities to which the government is devoting attention (WHO/UNICEF JMP, 2017). Further, under Swachh Bharat Mission (Urban) to make the country open defecation free (ODF), more than 6.2 million individual toilets and 0.59 million community and public toilets have been constructed (SBM, 2020). As on December 2020, under the mission, 4,340 cities have been declared ODF, while 100 per cent door-to-door waste collection has been achieved in over 83,434 wards. Similarly, under the Swachh Bharat Mission (Grameen), about 107.29 million household toilets have been constructed in rural areas and all States/UTs have declared themselves open defecation free (SBM, 2020a).

1.7.1 Irrigation

The National Commission for Integrated Water Resources Development (NCIWRD) in its 1999 Report assessed the percentage of water demand for irrigation for the years 2010 and 2025 at 78 and 72 per cent respectively of the total water demand in India. The net irrigated area in the country is 68.385 million ha.

PMKSY was launched during the year 2015-16 with the motto of '*Har Khet Ko Paani'* for providing end-to-end solutions in irrigation supply chain, *viz.* water sources, distribution network and farm level applications. PMKSY includes Accelerated Irrigation Benefit Programme (AIBP), Command Area Development and Water Management (CADWM), Surface Minor Irrigation (SMI), and Ground Water Irrigation schemes of the Department of Water Resources, River Development & Ganga Rejuvenation (DoWR, RD&GR).

Under AIBP, 99 major and medium irrigation projects having combined ultimate irrigation potential of 7.543 million ha are under implementation; and under CADWM, development of the command area of these 99 projects has been taken up, targeting 4.435 million ha of Culturable Command Area (CCA). These 99 prioritized projects are funded through creation of 'Long Term Irrigation Fund' under National Bank for Agriculture and Rural Development (NABARD) for mission mode completion of projects. Irrigation deprived areas having adequate replenishable groundwater resources are covered under the groundwater irrigation scheme. The beneficiaries under this scheme are small and marginal farmers only, with priority to women farmers.

Government of India vide Gazette Notification dated 9 October 2018, has notified the minimum environmental flows for River Ganga that has to be maintained at various locations on the river. The order applies to the Upper Ganga River Basin starting from originating glaciers and through respective confluences of its head tributaries, finally meeting at Devprayag up to Haridwar and the main stem of River Ganga up to Unnao district of Uttar Pradesh. CWC has been entrusted the responsibility of monitoring the compliance by project authorities on maintenance of desired e-flows. Monitoring of e-flows is being carried by Upper Ganga Basin Organization (UBGO), CWC since 1 January 2019.

The Ministry of Agriculture and Farmers Welfare (MoA&FW) implements 'Per Drop More Crop' (PDMC) component of PMKSY, focusing on enhancing water use efficiency at farm level through precision/micro-irrigation by providing financial assistance to the States. The scheme also supports micro level water storage or water conservation/management activities to supplement micro-irrigation. As on 31

October 2019, a total of 2,833 watershed projects have been completed covering over 39.07 million ha (MoA&FW, 2019a). For the current year 2020-21, annual allotment of INR 40,000 million has already been allocated and conveyed to the State Governments. The state governments have identified the beneficiaries to be covered under the programme. Fund release to some of the states is already under process. Further, micro-irrigation fund corpus of INR 50,000 million has been created with NABARD. The objective of the fund is to facilitate the states in mobilizing the resources for expanding coverage of micro-irrigation by taking up special and innovative projects and also for incentivising micro-irrigation beyond the provisions available under PMKSY-PDMC to encourage farmers to install micro- irrigation systems. So far, micro-irrigation funds have been released to the States of Andhra Pradesh and Tamil Nadu for INR 6161.4 million and for INR 4787.9 million, respectively through NABARD. The area covered under these projects is 0.1021 million ha in Andhra Pradesh and 0.176 million ha in Tamil Nadu. During the last five years (2015-16 to 2019-20), an area of 4.696 million ha has been covered under micro-irrigation through PMKSY-PDMC (PIB, 2020e).

Table 1.7: Details of prioritized Major Irrigation Projects covered under PMKSY AIBP

S. No.	State	No. of prioritized major irrigation projects under PMKSY-AIBP	Ultimate irrigation potential (mha)	Irrigation potential created up to March 2020 (mha)	No. of prioritized major irrigation projects completed
1.	Andhra Pradesh	8	262.49	194.544	1
2.	Assam	3	114.29	90.492	1
3.	Bihar	2	37.27	14.79	0
4.	Chhattisgarh	3	44.63	41.83	2
5.	Goa	1	21.05	11.826	0
6.	Gujarat	1	1792	1665.9	0
7.	Jammu & Kashmir	4	25.71	22.44	1
8.	Jharkhand	1	236.85	107.93	0
9.	Karnataka	5	268.81	262.09	3
10.	Kerala	2	38.10	29.456	0
11.	Madhya Pradesh	14 (Total 21 including 7 phases)	927.61	788.02	13
12.	Maharashtra	26	812.63	541.41	9
13.	Manipur	2	36.99	25.54	1
14.	Odisha	8	330.33	182.73	5
15.	Punjab	2	27.44	92.0	2
16.	Rajasthan	2	342.39	342.328	2
17.	Telangana	11	583.98	324.66	3
18.	Uttar Pradesh	4	1653.04	1387.37	1
Grand total		99 (Total 106 including 7 phases)	7555.39	6125.36	44

Source: MoJS, 2019.

1.8 Forests

Forests and trees are revered and worshipped in India and are a source of livelihood to millions of her people. India is among the top 10 biodiverse countries with recorded around 47,153 species of plants and around 91,000 species of animals. A large number of country's plants and animals are yet to be taxonomically identified, named and described. In spite of the large human population, India has still retained a largely intact biodiversity. It is recognized that there has been remarkable faunal continuity in the Indian subcontinent over the past 1,00,000 years in contrast to the extinctions in other continents (Roberts et al., 2014). This has been achieved in spite of the fact that the cumulative numbers of modern humans (*Homo sapiens*) to have ever lived on this planet have lived in the Indian subcontinent over this period (Joseph, 2019).

India is among a few countries in the world where, despite ongoing developmental efforts, forest and tree cover is increasing. A comparison with some other emerging and advanced economies shows that India's growth in forest cover has been positive. In terms of canopy density classes, area covered by Very Dense Forest (VDF) is 99,278 km^2 (3.02 per cent), Moderately Dense Forest (MDF) is 3,08,472 km^2 (9.39 per cent) and Open Forest (OF) is 3,04,499 km^2 (9.26 per cent) (Figure 1.18). The forest and tree cover has reached 80.73 million ha which is 24.56 per cent of the geographical area of the country. The total forest cover of the country, as per the latest assessment (FSI, 2019) is 7,12,249 km^2 which is 21.67 per cent of the total geographic area of the country. There has been an increase of 3,976 km^2 (0.56 per cent) of forest cover, 1,212 km^2 (1.29 per cent) of tree cover and 5,188 km^2 (0.65 per cent) of forest and tree cover put together, at the national level as compared to the previous assessment of 2017 (FSI, 2019).

India accounted for 2 per cent of the total global forest area in 2015, as per the Global Forest Resources Assessment (FRA) by Food and Agriculture Organization (FAO). Forest plays a crucial role in adaptation and mitigation to climate change. Forests help to store more carbon than any other terrestrial ecosystem (FSI, 2019). India has among the lowest rates of gross deforestation, both in absolute terms, in per capita terms, and in annual rates. India does not figure in the top 10 countries in terms of absolute rates of deforestation. Annual rates of deforestation have also been consistently coming down in the country in recent decades (Reddy et al., 2015).

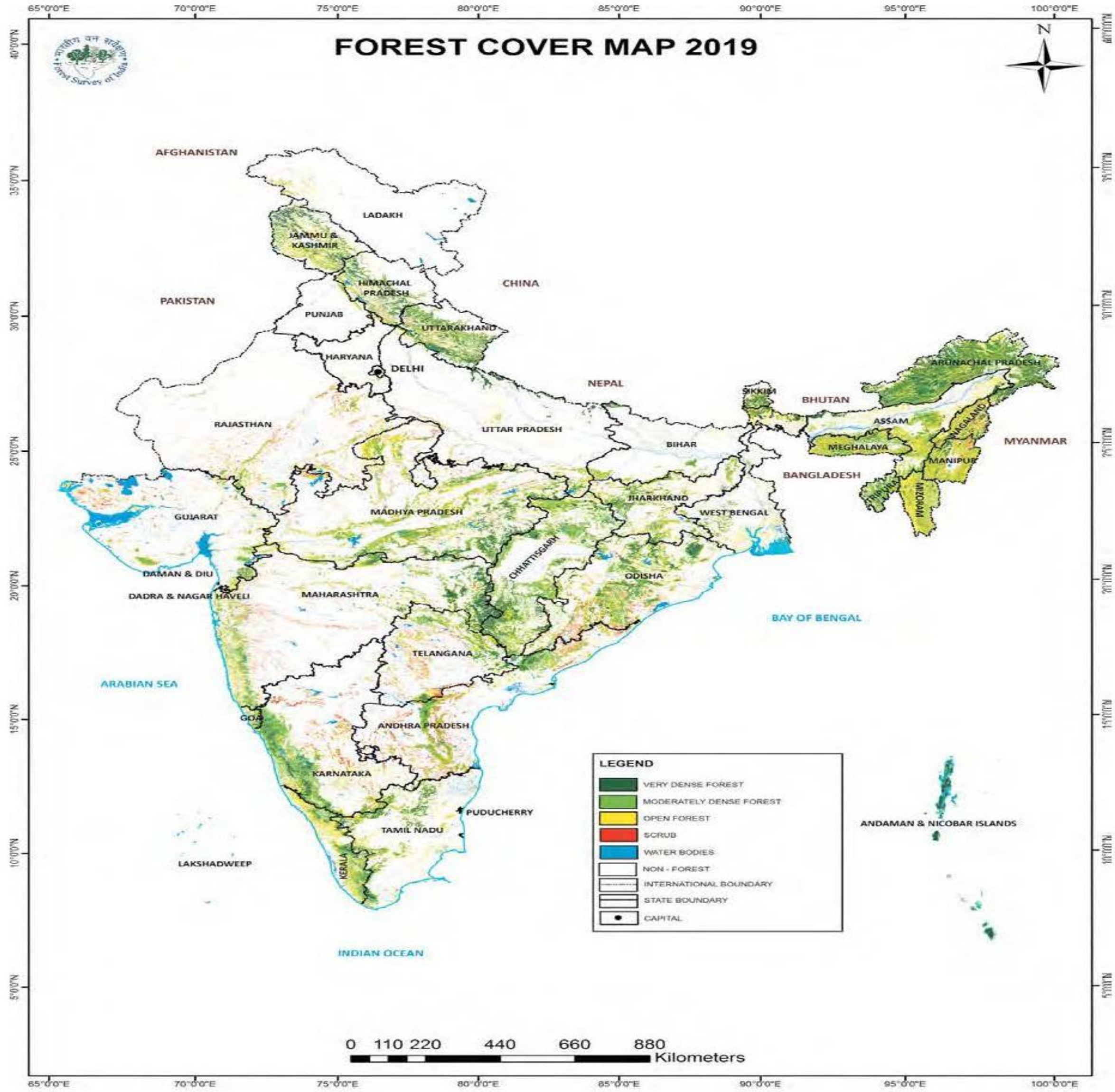


Figure 1.18: Forest cover map of India 2019. Source: FSI, 2019.

Protected areas

India has greatly expanded its network of Protected Areas (National Parks, Wildlife Sanctuaries, Conservation Reserves and Community Reserves) over the years. The 870 notified Protected Areas (in 2019) cover 5 per cent of the total land area of the country, a target which was set some decades ago. About 13.2 per cent of the land area is also under government control in the form of Reserve Forests and State Forests (many of which are also under PAs) which cannot be diverted for other use without an elaborate process of permits. India has over 20 per cent of the total geographical area under biodiversity conservation, thereby exceeding the global Aichi Target of 17 per cent (MoEFCC, 2018). Recently, there have been calls for extending the no-use protected area coverage at global scale of 30 per cent for land and 30 per cent for oceans (Waldron, 2020). Given India's very large human population, high dependence of people on forest products and insufficient land under direct government control, it would not be possible for the country to meet a 30 per cent target for Protected Areas. India would prefer to use a more inclusive sustainable landscapes approach to build resilience for biodiversity under a changing climate. However, India would expect that countries with large area under natural lands and low human populations would contribute to a greater than 30 per cent share of lands under protection in order to achieve any global target which may be agreed upon in the future to conserve biodiversity in the face of climate change.

Change in forest cover is a dynamic process. A change matrix (Table 1.8) gives a quantitative account of class wise change and also the flux of changes among the classes between the current and previous assessments. The values shown in green colour represent improvement whereas those shown in red colour indicate impairment or loss of forest cover in the three density classes, scrub and non-forest areas.

Table 1.8: Forest cover change matrix for India between 2017 and 2019 assessments

Class	2019 Assessment					(area in km²)
	VDF	MDF	OF	Scrub	NF	Total ISFR 2017
Very Dense Forest	97,309	626	50	2	171	98,158
Moderately Dense Forest	1,755	3,03,781	699	109	1,974	3,08,318
Open Forest	127	2,244	2,89,358	1,069	8,999	3,01,797
Scrub	2	48	1,732	41,831	2,366	45,979
Non Forest	85	1,773	12,660	3,286	25,15,413	25,33,217
Total ISFR 2019	99,278	3,08,472	3,04,499	46,297	25,28,923	32,87,469
Net change	1,120	154	2,702	318	-4,294	

(0) Gain
(0) Loss
Source: FSI, 2019.

1.8.1 Forest cover mapping using remote sensing

The biennial assessment of forest cover of the country used mid-resolution Satellite data based on interpretation of LISS-III data from Indian Remote Sensing satellite (ResourceSat-II) with a spatial resolution of 23.5 meters with the scale of interpretation 1:50000 to monitor forest cover and forest cover changes at District, State and National level. Satellite data for the entire country was procured from National Remote Sensing Centre (NRSC) for the period October 2017 – February 2018. The satellite data interpretation was followed by rigorous ground truthing. Information from other collateral sources was also used to improve the accuracy of the interpreted image. For the first time, ortho-rectified satellite data was used for forest cover mapping due to its better positional accuracy as it removes effects of image perspective (tilt) and relief (terrain) and scale distortions in the image to represent features in their true positions for accurate measurement of distances, angles and areas (PIB, 2019a).

1.8.2 Fire prone forest areas

In contrast to the huge emissions from forest fires in regions such as Western USA and Canada, Siberian Arctic, Amazonian basin, Indonesian rainforests, and south-eastern Australia, the emissions from forest fires in India contribute a mere 1.0-1.5 per cent of all global emissions from wildfires. Forest fire regimes however are expected to change with climate change. This is an important issue in the Western Himalayan states of Himachal Pradesh and Uttarakhand. Increasing temperatures would desiccate vegetation and increase their flammability

Fire prone forest areas of different severity classes have been mapped using grids of 5 km x 5 km based on the frequency of forest fires and published in the India State of Forest Report, 2019. The analysis reveals that 21.4 per cent of the forest cover of the country is extremely highly fire prone. However, as reported by the States, an area of 93,273 ha or only 13.1 per cent of the country's forest cover has been affected by fire in 2019 (MoEFCC, 2020b).

1.8.3 Mapping of wetlands within forest

Wetlands within forest areas form important ecosystems and add richness to the biodiversity in forest areas, both of faunal and floral species. During 2019-2020, India added 13 Ramsar Sites to the List of Wetlands of International Importance, thus increasing the overall national wetlands network from 26 to 39 sites, and area from 0.63 million ha to 1.07 million ha (Ramsar Sites Information Service, 2020). India also introduced the regulatory framework for wetlands in the form of Wetlands (Conservation and Management) Rules, 2017 which have been framed under the Environment (Protection) Act, 1986 and guidelines for implementation in 2020. These rules supersede those issued in 2010, and provide for decentralized regulation through creation of wetlands authorities within states and union territories, and their wise use as the basis of regulation and management decisions. Due to importance of wetlands, Forest Survey of India (FSI) has carried out an exercise at the national level to identify wetlands of more than 1 ha within Recorded Forest Area (RFA). There are 62,466 wetlands covering 3.8 per cent of the area within the RFA/GW of the country.

1.8.4 Climate change impacts and vulnerability of Indian forests

India's forests are very diverse, ranging from tropical wet evergreen forests in the Andaman & Nicobar Islands, the southern Western Ghats and the Northeastern States, through tropical dry deciduous forests across large swathes of the country to temperate forest and dry alpine scrub in the Northwestern Himalaya (Figure 1.19). As per FSI (2019), very dense forests cover 3 per cent, moderately dense forests 9.4 per cent and open forests 9.3 per cent of India's geographic area (Table 1.9). Additionally, the carbon stock in India's forests has been estimated to be 7,124.6

million tonne in 2019, showing an increase of 42.6 million tonne C or 156.2 $MtCO_2$ equivalent as compared to the estimates of the previous assessment of 2017. Soil organic carbon accounts for 56.2 per cent of total carbon stock in forests.

The high dependence of local communities on forest resources and commercial interests such as mining on forested land make India's forests especially vulnerable in the context of a changing climate. There is a need to understand the vegetation dynamics for proper assessment of impacts of climate change on forest ecosystems. Species responses to climate change include both their direct responses to changes in the abiotic environment (e.g., air temperature, moisture availability, atmospheric CO_2 concentration), but also indirect responses through alterations in biological interactions (e.g., pollinators, herbivores, seed dispersers, soil microbes). Various approaches have been used for better understanding of climate change impacts on forest ecosystems at local, to regional to global scales. Large-scale modelling approaches, which include dynamic vegetation models, environmental niche models and species distribution models, typically focus on direct responses of species to changes in the environment and are used to assess the vulnerability of different vegetation types and fauna across the country to climate change. At the same time, smaller-scale ecological studies provide ground-level information on how biological interactions and species-environment relationships might get altered due to climate change. Besides native vegetation, studies on the impacts of alien invasive plant species are important because climate change can exacerbate their impacts on native flora and fauna. In this report, climate change impacts and vulnerability assessments are reported for the forest sector in India at the national-scale as well as at the regional-scale based on a number of studies which were commissioned as well as other research reports.

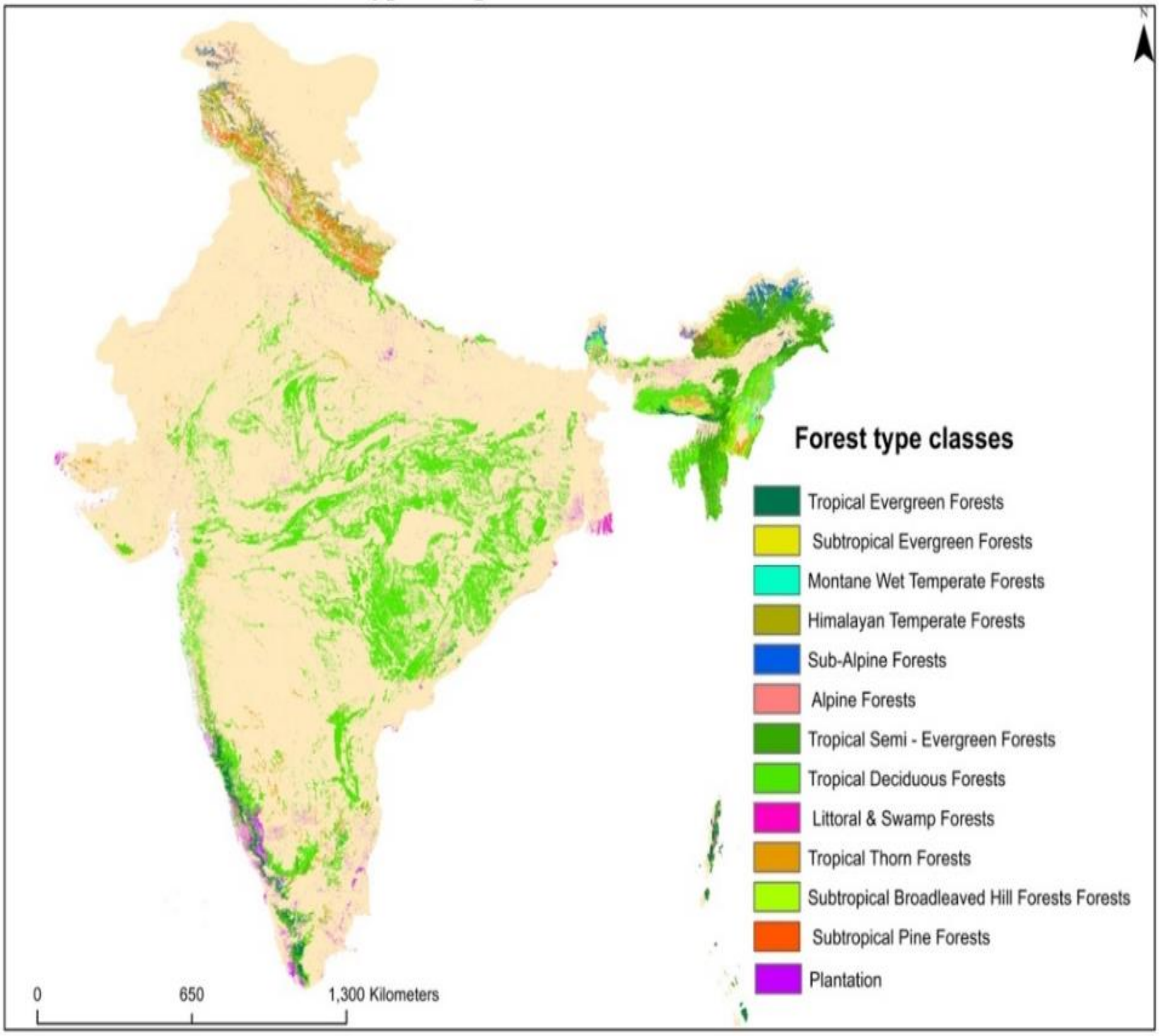


Figure 1.19: Forest types of India. Source: FSI, 2019.

Table 1.9: Forest and tree cover of India

Class	Area (km^2)	Per cent geographical area
Very dense forest	99,278	3.02
Moderately dense forest	3,08,472	9.39
Open forest	3,04,499	9.26
Total forest cover	7,12,249	21.67
Scrub	46,297	1.41
Non-forest	25,28,923	76.92
Total geographical area	32,87,469	100.00

Source: FSI, 2019.

A dynamic vegetation model (Lund-Postdam-Jena or LPJ Model) and multi-model ensemble of high resolution downscaled (CORDEX/IITM) climate projections were used for assessment of impacts of climate change on Indian forests (Ravindranath &

Bala, 2019). In addition to this, a vulnerability profile for the forest sector was developed at the national level.

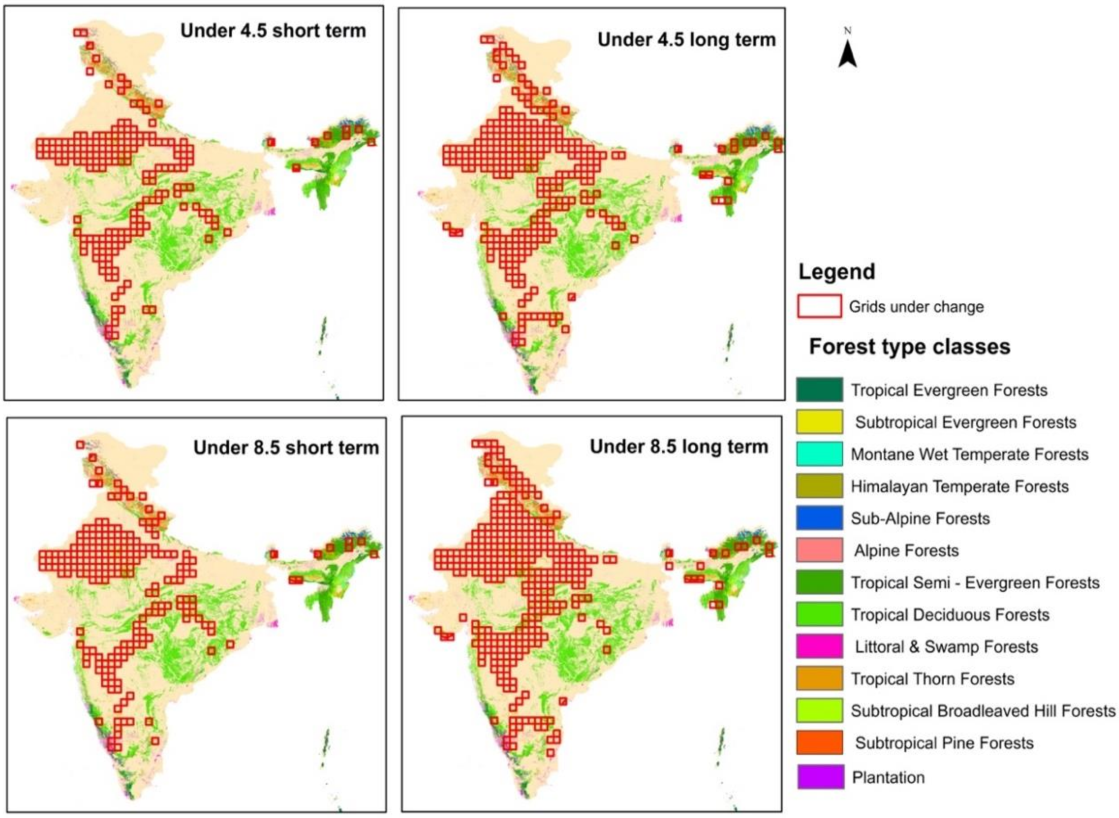


Figure 1.20: Projected impacts of climate change on different forest types and regions of India. Grids in red indicate change in vegetation type in the near term (2030s) and the long term (2080s). Source: Ravindranath & Bala, 2019.

On the national level, 18-28 per cent forests grids are expected to be impacted by projected climate change under different emission scenarios in the short (2030s) and long (2080s) term. The impacts are anticipated to be high on Himalayan and north-eastern forest ecosystems, particularly in the long term, while the Western Ghats are likely to be less impacted particularly in the short-term scenario (Ravindranath and Bala, 2019). Another national-scale study on the relationship between forest cover and annual precipitation suggests that while the forest cover in most of the wetter climatic regimes (including the Western Ghats and Western Himalaya) were highly resilient to alterations in the precipitation regime, the drier regions of trans-Himalaya were highly vulnerable to the same (Das et al., 2019). The LPJ-model simulations show an increase in mean net primary productivity (NPP) with increase shown as high as 30-50 per cent under RCP 8.5 scenario. All-India mean vegetation carbon is expected to increase by 92 per cent and 114 per cent under RCP 4.5 and RCP 8.5 scenarios, respectively in the long term. The increase in vegetation carbon is expected over most parts of India while the increase is relatively low in the western Indian region. A marginal increase in soil carbon is projected over most parts of India with a range of 1.7-7.2 per cent under different RCP scenarios.

Vulnerability is the degree to which a system is susceptible to and unable to cope with adverse effects. Biological richness (BR), Disturbance Index (DI), Canopy Cover (CC) and Slope (S) of forest ecosystems were used as vulnerability indicators. Approximately 40 per cent of forested grids are assessed as coming under ‘High’ and ‘Very High’ vulnerability classes. At the national level, 23 per cent, 37 per cent, 24 per cent and 16 per cent forest grid points show low, medium, high and very high inherent vulnerability, respectively. The forest grid points with high and very high inherent vulnerability are widely distributed across the peninsular states of Tamil Nadu, Andhra Pradesh and Karnataka, the central Indian States of Maharashtra, Madhya Pradesh and Jharkhand, and in West Bengal, and the North-Eastern States of Assam, Nagaland, Mizoram, Manipur and Tripura.

Indian Western Himalaya

The Indian Western Himalayan (IWH) region consists of different vegetation types along an altitudinal gradient, including subtropical forests, coniferous forests, alluvial grasslands and alpine meadows. The IWH is especially vulnerable to climate change like most of the other high-altitude regions of the world. Some of the plant species inhabiting this region are witnessing shifting of their boundaries. This was evaluated at a regional scale using forest grids of size 0.5 x 0.5 degree, equivalent to the available resolution of climatic variables under various climate change scenarios, for the impact and vulnerability assessment (Kumar et al., 2019). Undisturbed forests, in the IWH region, with high species diversity and large canopy cover are the least vulnerable and most resilient to climate change. A study on net primary productivity (NPP) in relation to climatic variability in Western Himalaya suggests that NPP is primarily driven by the precipitation regime and, as a consequence, three quarters of the forest area in Uttarakhand State is vulnerable to climate change (Kumar et al., 2019).

Central Indian forests

Central India has extensive tropical deciduous forest with domination of Teak (*Tectona grandis*) or Sal (*Shorea robusta*). Land use and land cover change (LULC) analysis was carried out for area under different forest types in Satpura Tiger Reserve (STR) and Kanha Tiger Reserve (KTR) during 1990-2016 (Sinha et al., 2019). In STR, an increase in the area under grassland and decrease under open forests was seen, whereas in KTR, the area under grassland was seen to have reduced and area under forests increased during this 27 year period. The LPJ model showed an increase in NPP in KTR under both RCP 4.5 and 8.5 emission scenarios. In case of STR, decrease in NPP was seen for RCP 4.5 whereas an increase was seen under RCP 8.5 scenario.

The study also examined the relationship between climate variables with vegetation indicators (NDVI/EVI) to understand the sensitivity of teak and sal forest for the period 2000 to 2015. This indicated that these dominant tree species are more sensitive to change in temperature than rainfall, with Sal being more sensitive to minimum temperature and Teak to change in maximum temperature. Conversely, a study of Teak forests across tropical Asia suggests that land use/land cover change and elevation were the primary determinants of the distribution of Teak, followed by mean annual precipitation (MAP), precipitation seasonality, and temperature (Deb et al., 2017). Changes in MAP, precipitation seasonality and mean annual actual evapotranspiration under climate change are predicted to result in shifts in the distribution of Teak across India (Deb et al., 2017). A niche modelling study of Sal in central India suggests that given the sensitivity of this tree species to moisture availability, its distribution is likely to shift in the northern and eastern directions as a consequence of increasing temperatures (Chitale & Behera, 2012).

Tropical dry forests

Tropical dry forests occupy large areas of the country including the eastern rain-shadow slopes of the Western Ghats in peninsular India. The dry forests of Mudumalai (Tamil Nadu) in the Ghats have been monitored for over three decades through permanent forest plots established since the 1980s (Sukumar et al., 1992); this study has provided unprecedented empirical data on the sensitivity of tree species dynamics to climatic variables. The effect of key environmental variables, including fire, rainfall and temperature on species recruitment, mortality and growth was estimated using machine-learning approaches.

The time since last fire burn, precipitation, and minimum and maximum temperatures were the strongest predictors across all three processes, with recruitment, survivorship and growth of several species lower during periods of low precipitation and immediately following fires. Recruitment increased, and growth and survival largely decreased, with increasing temperatures. One of the important findings from this study is that tropical dry forests are relatively resilient to carbon stock changes with either stability during periods of extreme stress such as drought and fire, and overall increase seen over a three decadal period. This underscores the role of tropical dry forests in carbon sequestration under a changing climate.

Grassland ecosystems of India

Grass ecosystems represent an important ecological component of vegetation across India but have historically received less attention than India's forests. Different categories of grassy ecosystems include coastal grasslands, riverine alluvial grasslands, montane grasslands, Terai grasslands, tropical savannas and wetlands. Indian grasslands are affected by climate change in addition to many local threats including land-use conversion, overgrazing and invasive species. In recent decades, woody-shrubs have established in grassland ecosystems globally thereby altering their structure and function. Land cover data from Moulds et al. (2018) and satellite-derived information on vegetation phenology (leaf-area index (LAI) time-series data obtained from MODIS) were used to interpret loss of grasslands and woody-shrub expansion across India's grasslands. This study showed that approximately 35 per cent of grassland habitat in the country has been lost during 1980-2010. Also, approximately 20 per cent of grassland ecosystems are experiencing woody-shrub encroachment. Among the individual types, alpine grasslands seem to be relatively intact while losses are seen in the terai grasslands and sub-Himalayan region, across the peninsula, and in the northwestern arid region. Other studies concur with the prediction of increasing woody encroachment into grassy biomes in India primarily as a consequence of increasing atomospheric CO_2 concentrations which favour the growth of the former over the latter plant category (Manish et al., 2016, Kumar et al., 2020). This would also have impacts on a number of wildlife species which are specialized to living on grasslands.

Box 2: Climate Change and Alien Invasive Plants in India

Alien invasive plant species are a major threat to biodiversity and ecosystem functioning in several forests in India. Studies from around the world suggest that climate change can have a significant impact on the spread of invasive species. Some of the major alien invasive plants in India include *Lantana camara* (a tropical American shrub that has invaded many dry forests and savannas in India), *Parthenium hysterophorus* (a tropical American herbaceous plant that invades open landscapes including croplands), and *Mikania micrantha* (a tropical American climber that is particularly invasive in wetter forests of north-eastern India and the southern Western Ghats). A study of 11 alien invasive plant species in a Western Himalayan landscape concluded that the distribution of most species is likely to increase under future climate-change scenarios (Thapa et al., 2018). A recent niche-modeling study on invasive *Lantana camara* and *Cassia tora* suggests that both species could experience a shift in their distributions in the northern and north-eastern directions in India under climate change (Panda et al., 2018). A local-scale study on the dynamics of *Lantana camara* over a two-decade period suggests that Lantana responses to rainfall fluctuations may be mediated by the presence fire, allowing Lantana to spread even during low-rainfall periods (Ramaswami & Sukumar, 2013). A global-scale study modeling the spread of *Mikania micrantha* suggests that parts of central and northern India would become climatically suitable for the species under climate change (Banerjee et al., 2019). Species distribution modeling of *Parthenium hysterophorus* suggests that it could expand into currently uninvaded regions such as Western Himalaya (Ahmad et al., 2019). Similarly, a niche-modeling study suggests that another South American herbaceous invasive plant, *Ageratum conyzoides*, is likely to expand in range in north-eastern India (Ray et al., 2019).

Box 3: Climate change and forest fires in India

Recent analysis by FSI showed that about 36 per cent of country’s forests are highly prone to fires (FSI, 2019). Although wildfires are largely casued by human action, they need favourable environmental factors including weather conditions for them to spread. A hybrid process-based and Neural Net Fire Model developed under the

‘Third National Communication’ project was used to show wildfires under RCP 4.5 and 8.5 scenarios, after independent calibration with the Global Fire Emissions Database (GFED4.1s) and Climate Change Initiative (CCI) data. The CCI dataset appears to better capture the spatial patterns of burned area in the subcontinental part of India while severely underestimating burned area in Northeast India. The GFED dataset better captures fire prone areas in Northeast India but fails to capture the spatial variability in burned area. The CCI-trained model predicts a drastic increase (82.2–195.0 per cent in subcontinental India and 27.5–83.5 per cent in Northeast India) in burned area in future. By contrast, the GFED-trained model predicts only a modest increase (17.6–34.5 per cent increase in the subcontinent and 9–14.9 per cent decrease in the Northeast). Therefore, reconciliation of different burned area datasets is crucial to reduce uncertainty in future fire projections (Figure 1.21). A study on the incidences of forest fire in the Western Himalayan states of Himachal Pradesh and Uttarakhand suggests that the predicted increase in April temperatures and decrease in mean annual preciptiation under future climate change scenarios is likely to result in increased fire incidences (Ahmad et al., 2018). Carbon emissions from forest fires in India are negligible on a global scale. For all types of fires in India, a modeling effort in Rao et al. (2019) estimates this to be ~87 Tg/year over a 110 year period (1901-2010). National Remote Sensing Centre estimated emissions of 98 Tg/year for the year 2014 from forest fires (Reddy et al., 2015).

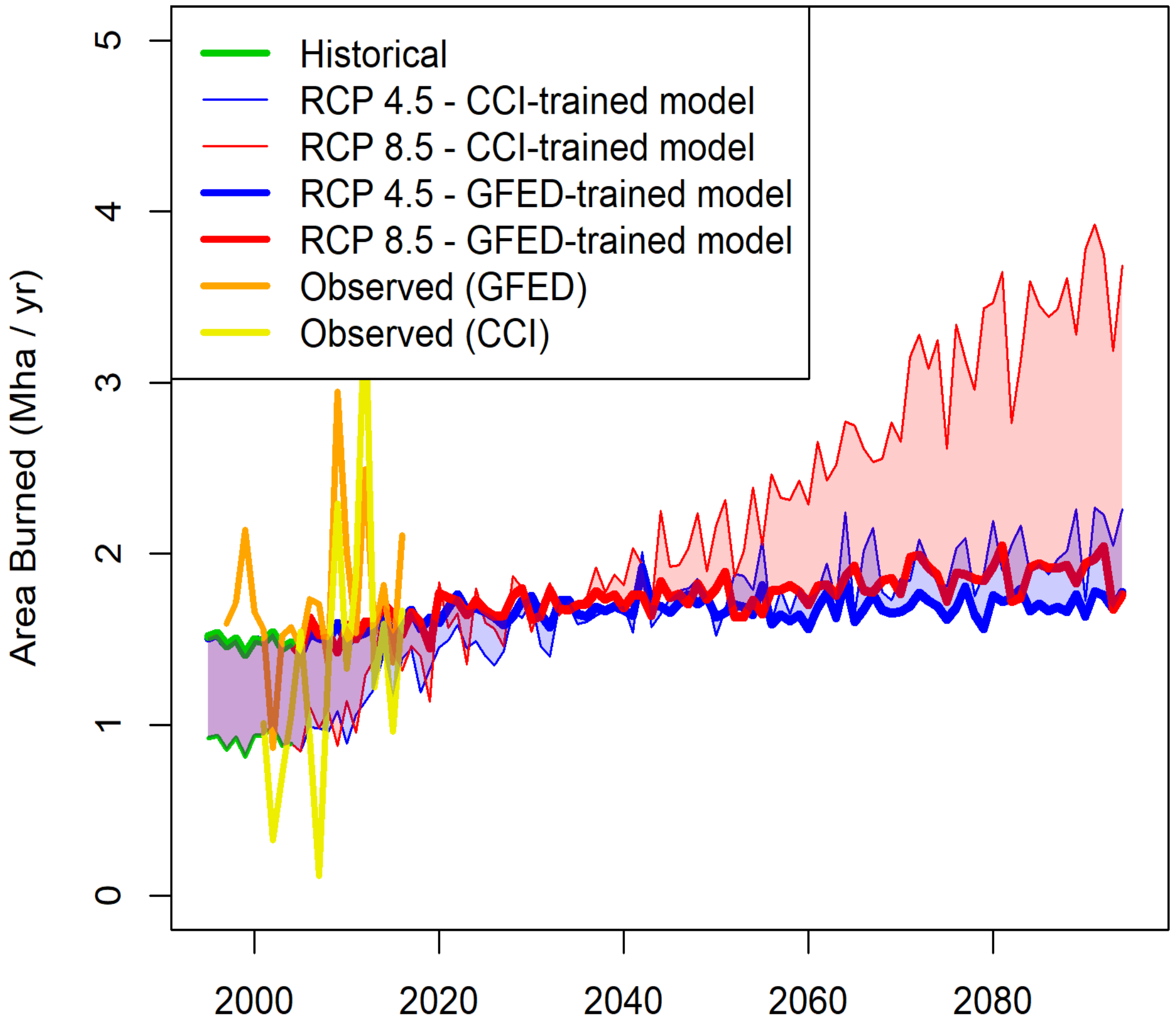


Figure: 1.21 Time series of projected burned area for India from the two (GFED-trained and CCI-trained) models, showing burned area (Mha/yr) for the historical period (1975-2005) and projections for the future (2006-2100), under the RCP 4.5 and RCP 8.5 scenarios. Also shown is the observed burned area from the GFED dataset between 1997-2016 and the CCI dataset between 2001-2016. Source: Joshi et. al., 2020.

1.9 Agriculture

Agriculture plays a vital role in India's economy. Of the total workforce, 54.6 per cent was engaged in agricultural and allied sector activities (Census 2011). The share of agricultural and allied sector activities in the economy's total Gross Value Added (GVA) at current prices is 18.0 per cent and 17.1 per cent, respectively, for years 2017-18 and 2018-19 (MoSPI, 2020d). With a net sown area is approximately 140 million ha, which has remained the same in recent years, food grain production in 2019-20 rose to 295.67 million tonne along with significant increase in production of horticultural crops, milk, meat, fish and eggs.

Agriculture is the most significant sector of vulnerability to climate change for India and correspondingly the most significant sector of adaptation. It is critical to the livelihood of millions of the population, and growth, particular for the small and marginal farmers, is critical to their climbing out of poverty and deprivation and the attainment of the basic standard of living. The farmers of India in general, and especially those of the marginal, small and medium sections in particular, have traditionally always had to struggle with the impact of climate variability. Climate change is now an additional burden, as a consequence of anthropogenic emissions to which their contribution has been minimal. The burden of mitigation due to emissions arising primarily out of industrial and related sectors cannot be passed on to this section of the population, not only in India, but across the developing world.

According to the latest round of the Agricultural Census, with data for 2015-16 (AGCENSUS, 2019), the following key highlights are to be noted:

- The number of operational holdings has risen from 138.35 million in 2010-11 to 146.45 million in 2015-16, an increase of 5.86 per cent.
- The total operated area in the country has decreased from 159.59 million ha in 2010-11 to 157.82 million ha in 2015-16 showing a decrease of 1.11 per cent.

14 out of 36 States/UTs in the country accounted for about 91.01 per cent of the total number of operational holdings and about 88.19 per cent of the total area operated in the country. These States were Andhra Pradesh, Bihar, Chhattisgarh, Gujarat, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Rajasthan, Tamil Nadu, Telangana, Uttar Pradesh and West Bengal.

- The average size of operational holding has declined to 1.08 ha in 2015-16 as compared to 1.15 ha in 2010-11.

- The percentage share of female operational holders has increased from 12.79 per cent in 2010-11 to 13.96 per cent in 2015-16 with the corresponding figures of 10.36 per cent and 11.72 per cent in the operated area. This shows increase in participation of females in the management and operation of agricultural lands.

- The small and marginal holdings taken together (less than 2 ha) constituted 86.08 per cent of the total holdings in 2015-16 against 85.01 per cent in 2010-11 while their share in the operated area stood at 46.94 per cent in the current census as against 44.58 per cent in 2010-11.

- The semi-medium and medium operational holdings (2-10 ha) in 2015-16 were only 13.35 per cent with 43.99 per cent operated area. The corresponding figures for 2010-11 census were 14.29 per cent and 44.82 per cent.

- The large holdings (10 ha and above) were merely 0.57 per cent of total number of holdings in 2015-16 and had a share of 9.07 per cent in the operated area as against 0.70 per cent and 10.59 per cent respectively for 2010-11 census.

This data clearly highlights, apart from quantifying the predominance of small and marginal farmers, the absence of any serious incidence of "industrial agriculture", and the increasing "feminization" of Indian agriculture. This data substantiates the social and economic vulnerability associated with Indian agriculture. The small and marginal holders, and even some sections of the semi-medium and medium category, particularly women, require significant income support, especially outside the main cropping season. This is provided through the Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS). GoI pays special attention to the needs of this section in all the schemes for agriculture through preferential treatment and special considerations. These sections are also the most vulnerable to the impact of extreme events, though the intervention of the Government through special relief helps to diminish the severity of the impact.

The Production of food grains, horticultural crops and increase in the growth rate of agriculture GVA and allied sector (as per the figures released by Central Statistics Office) from 2016-17 to 2019-20 are in Table 1.10. The consistent increase in production of both food grains and horticulture in India indicates resilience to climate change made possible by development of climate resilient varieties, appropriate farming system and other interventions.

Table 1.10: Growth rate of GVA of agriculture and allied sector

Year	Food Grains (million tonne)	Horticulture crops (million tonne)	Growth rate of GVA of agriculture and allied sector (at 2011-12 prices)
2016-17	275.11	300.64	6.8
2017-18	285.01	311.70	5.9
2018-19	285.21	310.74	2.4@
2019-20	295.67*	320.48**	(3.7%) #

Source: MoA&FW, 2020a.

*Third Advance estimates of production of food grains

**Second advance estimate of production of horticulture crops

@Revised estimates of national income released by NSO on 31 January, 2020

#Second advance estimates of national income released by NSO on 28 February, 2020

Net sown area and net irrigated area in the country is 140.13 million ha and 68.385 million ha respectively. The total micro-irrigation area covered under the Centrally Sponsored Schemes on micro-irrigation from 2005-06 to 2019-20 (as on November 2019) is 8.747 million ha (drip 4.589 million ha and sprinkler 4.158 million ha) (MoA&FW, 2019b).

1.9.1 Programmes to promote agriculture

Given the importance to agriculture sector, GoI has taken several steps for its development in a sustainable manner. Steps have been taken to improve soil fertility through the Soil Health Card Scheme; to provide improved access to irrigation and enhanced water efficiency through PMKSY; to support organic farming through

Paramparagat Krishi Vikas Yojana (PKVY); and to support the creation of a unified national agriculture market to boost the income of farmers. Further, to mitigate risk in agriculture sector, a scheme “Pradhan Mantri Fasal Bima Yojana” (PMFBY) was also launched in 2016 (MoA&FW, 2018). The scheme also aims at supporting sustainable production in agriculture sector by way of providing financial support to farmers suffering crop loss/damage arising out of unforeseen events.

Mission for Integrated Development of Horticulture (MIDH) promotes holistic growth of horticulture sector, duly ensuring backward and forward linkages. A total of 384 districts in 19 States and 4 UTs are covered under MIDH. Sixteen National Level Agencies (NLAs) have also been included for providing support for developmental efforts, which require inputs at the National level. The Mission includes various activities of Coconut Development Board, Horticulture Development Board and Development of Commercial Horticulture through production and post-harvest management, capital investment subsidy for construction, expansion, modernization of cold storages for horticulture produce, technology development and transfer for horticulture produce. This includes provision for National Beekeeping and Honey Mission (MoA&FW, 2018).

The PM-KISAN Scheme – Pradhan Mantri Kisan Samman Nidhi was introduced in February 2019 to increase the income of farmers by providing income support to the land holding farmer’s families and to enable them to afford the expenditure related to agriculture and allied activities as well as the domestic requirements. Provision to transfer INR 6,000 per year to the beneficiary farmer’s account in four-monthly equal instalment of INR 2,000 has been made.

Bharatiya Prakritik Krishi Paddhati Programme (BPKP) is being promoted from 2020-21 under existing sub-scheme of PKVY. It is aimed at promoting traditional indigenous practices and is largely based on on-farm biomass recycling with major stress on biomass mulching, use of cow dung-urine formulations; time to time working for soil aeration and exclusion of all synthetic chemical inputs directly or indirectly. BPKP has same components as PKVY with more emphasis on capacity building and awareness generation. According to the information presented by the Department of Agriculture, Co-operation and Farmers Welfare, an amount of INR 12,200/ha is provided for cluster formation, capacity building, incentives to farmers and certification. During 2020-21, an area of 0.308 million ha was taken up by the states under BPKP.

1.9.2 National Mission for Sustainable Agriculture (NMSA)

We report here the components of the NMSA that are related to adaptation and climate resilience.

1.9.2.1 Rainfed Area Development (RAD)

RAD is being implemented as a component of NMSA in a cluster approach, depending on the type and extent of natural resources/assets/commodities already developed or supported. RAD focuses on Integrated Farming System (IFS) for enhancing productivity and minimizing risks associated with climatic variability. Under this system, crops/cropping systems are integrated with activities like horticulture, livestock, fishery, agro-forestry and apiculture to enable farmers not only in maximizing farm returns for sustaining livelihood, but also to mitigate the impacts of drought, flood or other extreme weather events, by providing alternate or additional income opportunities from allied activities. RAD is being implemented since 2014 across all States and UTs except Punjab and Goa.

Year-wise area brought under IFS under the RAD programme of NMSA, since inception till 2018-19 is as follows:

Table 1.11: Area under the Integrated Farming System (IFS)

Area under the IFS (ha)				
2014-15	2015-16	2016-17	2017-18	2018-19
87,011	78,896	79,999	76,719	104,990

Source: DAC&FW, 2020.

1.9.2.2 Paramparagat Krishi Vikas Yojana (PKVY) and Mission for Organic Value Chain Development for North eastern Region

PKVY was implemented in 2015 to promote chemical-free organic farming in cluster approach with Participatory Guarantee System (PGS) certification. The scheme aims at maintaining soil health, reducing cost of cultivation, empowering farmers through Institutional building, and also supports farmers in providing value addition and marketing linkage to their organic products. Under the scheme assistance is provided to the farmers for cluster formation, capacity building, procuring inputs, processing, packaging, labelling, branding and marketing of organic products. An area of 0.379 million ha was covered under organic farming in 2018-19.

Realizing the potential of organic farming in the North eastern region of the country, Ministry of Agriculture and Farmers Welfare launched a Central Sector Scheme entitled “Mission Organic Value Chain Development for North Eastern Region (MOVCDNER)” for implementation in the States of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura, during 2015-16 to 2017-18. The scheme aims at development of certified organic products in a value chain mode to link growers with consumers and to support the development of entire value chain starting from inputs, seeds, certification and creation of facilities for collection, aggregation, processing, marketing and brand building initiative. The scheme was approved with an outlay of INR 4 billion for three years. Major components of MOVCDNER are: Value Chain Production, Value Chain Processing, Value Chain Marketing, and Value Chain Support Agencies.

1.9.3 Key progress in agriculture towards climate resilience

In the country, extensive research has been carried out for the development of drought and heat tolerant genotypes in chickpea, pigeon pea and mung bean; and development of drought tolerant onion.

India also has developed eco-friendly flood/drought tolerant seeds such as Rice variety CR Dhan 201 a, medium duration (110-115 days), semi-dwarf, non-lodging variety suitable for water limited/aerobic conditions with an average productivity of 3.8 t ha^{-1}. This variety was released for states of Chhattisgarh and Bihar for aerobic conditions.

ICAR-National Rice Research Institute (NRRI) has developed CR Dhan 801 and CR Dhan 802 possessing submergence as well as drought tolerance ability in the background of mega variety 'Swarna'.

Mung bean variety IPM 205-7 (Virat) is early maturing (52-55 days), suitable for summer cultivation in Punjab, Haryana, Uttar Pradesh, Karnataka, Tamil Nadu, Madhya Pradesh and Gujarat.

DBW 14 (Raj 3765 / PBW 343): Early maturing wheat variety for late sown, irrigated condition of North Eastern Plains Zone (NEPZ). This variety was first indigenously developed through shuttle breeding approach and is suitable for rice-wheat system of eastern India.

Besides developing these two varieties, more than 250 climate resilient varieties developed by ICAR/SAUs have been evaluated for adaptation under vulnerable agro-ecologies (MoA&FW, 2020b).

1.9.3.1 National Innovations in Climate Resilient Agriculture (NICRA)

The goal of NICRA is to enhance the resilience of Indian agriculture, covering crops, livestock and fisheries to climatic variability and climate change through the development and application of improved production and risk management technologies, to demonstrate site specific technology packages on farmers' fields for adapting to current climate risks, and to enhance the capacity of scientists and other stakeholders in climate resilient agricultural research and its application.

The project has been implemented in 151 districts involving over one hundred thousand farm families across the country. The interventions in the village *panchayats* are finalized following a participatory approach through the Village Climate Risk Management Committee (VCRMC) to assess the climate-related problems in the village and baseline survey. The programme was launched formally in all the villages by involving the state line department functionaries and leaders of the *panchayats* to ensure local ownership of the project from the beginning and convergence of related schemes currently in operation in the *panchayat*.

The project comprises four components:

- Strategic research through network as well as sponsored/competitive grants mode;
- Technology demonstrations on farmers' fields to cope with current climate variability;
- Knowledge management and
- Capacity building of different stakeholders.

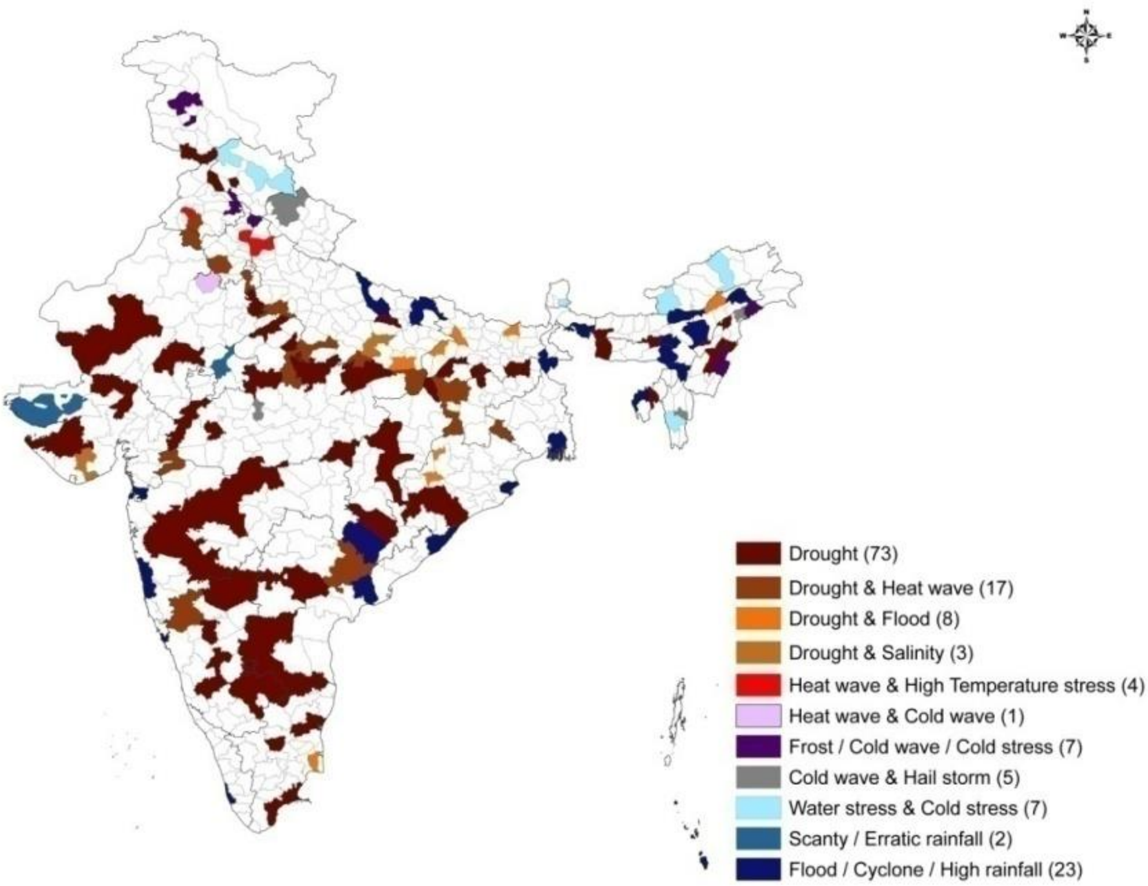


Figure 1.22: Map of 151 NICRA-KVK districts along with the climate vulnerabilities addressed along with number of districts covered

Under the technology demonstrations component, participatory demonstration of climate coping technologies are being done on farmers' fields. Improved practices like water harvesting, direct seeded rice, community nurseries, green manuring, deep placement of fertilizers and feed supplements for livestock are being demonstrated in 151 vulnerable districts of the country with interventions in NRM, crops, livestock and fisheries. These demonstrations are quite successful and have attracted the attention of development departments in several States and triggered horizontal out scaling on a significant scale.

The demonstrations are taken up in farmers' fields across 151 climatically vulnerable districts of the country by choosing one representative village from each district. During 2018-19, 663 demonstrations were conducted on *in-situ* moisture conservation and *ex-situ* water harvesting structures. During 2018-19, 2,332 training programmes were conducted in 121 KVKs, benefitting 39,104 farmers for creating awareness on climate change and sustainable crop production under variable climate (MoA&FW, 2019c). As a part of institutional interventions, 121 Custom Hiring Centres (CHCs) of farm machinery have been set up and this became the first Pan-India pilot programme to promote small scale mechanization in the country.

Knowledge management (portal development) and communication: A dedicated knowledge portal will be designed as knowledge portal on climate change and agriculture (KPCCA). This will be done partly by outsourcing through competitive bidding and also through internal cooperation among ICAR institutes and SAUs who have expertise in the field. Efforts are being made to develop the management portal which will act as a repository for all climate change related activities with latest information. Some of the major achievements so far in the project are establishment of state-of-the-art climate change research infrastructure *viz.* free air temperature enrichment facility (FATE), free air CO_2 enrichment (FACE), carbon dioxide temperature gradient chamber (CTGC), temperature gradient tunnels (TGT), high throughput plant phenomics, rainout shelters, eddy covariance towers, gas chromatography, satellite data reception facility, automatic weather stations (AWS) and research vessel for marine fisheries which are being used to study the impact of climate change and variability on crops, livestock, fisheries and natural resources like soil and water.

1.9.4 Soil as an ecosystem

Soil is a major carbon reservoir comprising more carbon than the atmosphere and terrestrial vegetation combined. Soil carbon includes both inorganic carbon as carbonate minerals, and as soil organic matter. Soil organic carbon (SOC) is the engine of any soil and plays an important role in maintaining fertility by holding nitrogen, phosphorus and a range of other nutrients.

Soil health and quality remain a matter of great concern for GoI. Of the several programmes being run by the GoI for monitoring soil health, some date back to 1955-56. Soil Health Card (SHC) scheme is a flagship programme launched in February 2015. The scheme is managed by Integrated Nutrient Management (INM) Division in the MoA&FW, GoI. During the 1st Cycle (2015-16 to 2016-17), 25.349 million soil samples were collected and 107.389 million soil health cards were distributed to farmers and during the 2nd Cycle (2017- 18 to 2018-19), as on 23

August 2019, 27.232 million soil samples have been collected and 107.952 million soil health cards have been distributed to farmers (EnviStats India Vol II, 2020).

1.9.5 Livestock

The 20th Livestock Census was conducted with the in participation with all States and UTs. The enumeration was done both in rural and urban areas. Various species of animals (Cattle, Buffalo, Mithun, Yak, Sheep, Goat, Pig, Horse, Pony, Mule, Donkey Camel, Dog, Rabbit and Elephant)/poultry birds (Fowl, Duck, Emu, Turkey, Quail and other poultry birds) possessed by the households, household enterprises/non-household enterprises and institutions were counted at their site. The 20th Livestock Census is indeed a unique attempt as for the first time such a major initiative has been taken to digitise household level data through online transmission from the field. National Informatics Centre (NIC) has developed mobile application software and was used for data collection as well as online transmission of data from the field to the NIC server. As per the 2019 census, the total livestock population is 535.780 million in the country showing an increase of 4.6 per cent over Livestock Census-2012; and the total poultry in the country is 851.810 million in 2019, with a registered increase of 16.8 per cent. Furthermore, the growth rate of dairy sector in terms of total milk production in the country was 36.6 per cent from 2013-14 to 2018-19. To overcome the shortage of feed and fodder in the country, MoA&FW has been implementing the Centrally Sponsored Scheme National Livestock Mission with a sub mission on Feed and Fodder Development since 2014-15 (PIB, 2019b).

Table 1.12: Number of livestock and poultry (in thousands)

Year	Total Livestock	Total Poultry
2003	4,85,002	4,89,012
2007	5,29,696	6,48,829
2012	5,12,057	7,29,209
2019	5,35,780	8,51,810

Source: PIB, 2019b.

Livestock income has become an important secondary source of income for millions of rural families and has assumed an important role in achieving the goal of doubling farmers' income. Livestock sector has grown at a compound annual growth rate of 7.9 per cent during last five years. Government has launched a new Central Sector Scheme "National Animal Disease Control Programme (NADCP) for control of Foot & Mouth Disease (FMD) and Brucellosis" with a financial outlay of INR 133.43 billion for five years from 2019 to 2024. This will result in increased domestic production and increased exports of milk and livestock products.

India continues to be the largest producer of milk in the world. Milk production in the country was 187.7 million tonne in 2018-19 and registered a growth of 6.5 per cent over the previous year. The per capita availability of milk has reached a level of 394 grams per day during 2018-19. Egg production in the country, which was 95,217 million in 2017-18, increased to 103,318 million numbers in 2018-19 (DEA, 2020).

1.9.6 Pest incidence: Recent locust infestation in India

The recent locust infestation, that was successfully controlled, provided valuable learnings for dealing with the threat of pest incidence on a large scale, potentially exacerbated by global warming. Starting from 21 May 2019 till 17 February 2020, a total of 4,03,488 ha area was treated for controlling the infestation, including the efforts of the Agriculture Department of the States of Rajasthan, Gujarat and Punjab in the cropped areas of the States, covering 3,93,933 ha in 11 districts of Rajasthan, 9,505 ha in 2 districts of Gujarat and 50 ha area in 1 district of Punjab (PIB, 2020f). Eighty-nine teams of the fire brigade for pesticide spraying, 120 survey vehicles, 47 control vehicles with spray equipment and 810 tractor mounted sprayers were deployed as required on different days. Ministry of Civil Aviation also approved special permission for drone operations under a “conditional exemption to Government entity (DPPQS) for the use of Remotely Piloted Aircraft System for anti-locust operations”. A Bell helicopter was also deployed in Rajasthan for use in the scheduled desert area as needed. The Indian Air Force also assisted in anti-locust operations by deploying a Mi-17 helicopter (MoA&FW, 2020). In India, more than 2,00,000 km^2 area comes under the purview of the Scheduled Desert Area, that is susceptible to locust attacks. Locust Warning Organization and 10 Locust Circle Offices (LCO) of the Government of India are situated in Rajasthan (at Jaisalmer, Bikaner, Phalodi, Barmer, Jalore, Churu, Nagaur, Suratgarh) and Gujarat (Palanpur and Bhuj). These are responsible for monitoring, survey and control of the desert locust in the Scheduled Desert Area in coordination with state governments.

1.10 Energy profile

In terms of energy consumption, India uses only 6 per cent of the world’s primary energy, but sustained economic growth is placing an enormous demand on its energy resources. India’s per capita energy consumption grew from 19,669 MJ (mega joules) in 2011-12 to 24,453 MJ in 2018-19(P). In 2018-19(P), primary energy supply added up to 906.09 million tonne of oil equivalent (Mtoe). Both power and industry sectors are large consumers of energy in the country. The estimated consumption of raw coal by industry has increased from 587.81 MT during 2009-10 to 968.25 MT during 2018-19(P) with a CAGR of 5.12 per cent. The maximum use of natural gas is in the fertilizers industry (27.84 per cent) followed by power generation (22.30 per cent), and 17.10 per cent natural gas is used in transport/distribution network (MoSPI, 2020a). India’s energy intensity and its reduction is a cornerstone of India's mitigation policies and is discussed at the appropriate location in Section 3.4.

1.10.1 Primary energy supply

India is striving to meet the basic need of access to energy at an affordable price while addressing the concerns of climate change. Enhancing energy supply and access to energy for all are key components of the national development strategy. In 2018-19(P), Primary Energy Supply added up to 9,06,089.14 kilo tonne of oil equivalent (ktoe). The share of coal accounted for 64.13 per cent, and the contribution of crude oil was 29.40 per cent (Table 1.13).

As per present estimates, India has a renewable energy potential of about 1,097,465 MW for commercially exploitable sources *viz.* wind – 3,02,251 MW (at 100 m mast height), small hydro - 21,134 MW; bio-energy - 22,536 MW, solar power - 748,990 MW and 2,554 MW from industrial waste. The share of wind and solar energy in total potential of renewable energy is 28 per cent and 68 per cent respectively (MoSPI, 2020a).

Table 1.13: Share of different fuels in total primary energy supply

S. No.	Fuel	Primary energy supply for 2018-19 provisional (in ktoe)
1	Coal	5,81,156.76
2	Crude Oil	2,66,435.82
3	Oil Products	-30,408.05
4	Natural Gas	56,675.60
5	Wind, Hydro and Nuclear	32,558.99
6	Electricity	-329.98

Source: MoSPI, 2020a.

1.10.2 Primary energy demand

Energy consumption in India is characterized by low per capita level and a large disparity between urban and rural areas. It is expected that the energy basket would shift with an increase in income.

As compared to India’s population, energy resources are meagre. In the year 2018-19(P), India’s per capita energy consumption was 24,453 MJ (Table 1.14) which is just one-third of the world average. Per capita energy consumption of India grew by 24.32 per cent from 2011-12 to 2018-19(P).

To meet its energy needs, India is highly dependent on the import of crude oil. Net imports of crude oil have increased from 159.26 Mt during 2009-10 to 226.50 Mt during 2018-19(P) (MoSPI, 2020a).

Table 1.14: Per capita energy consumption in India

S. No.	Year	Per capita energy consumption in (MJ)
1	2011-12	19,669
2	2012-13	20,790
3	2013-14	20,916
4	2014-15	21,871
5	2015-16	22,227
6	2016-17	22,630
7	2017-18	23,587
8	2018-19(P)#	24,453

#P = Provisional, Source: Per capita energy consumption in India. MoSPI, 2020a.

1.10.3 Energy future and energy security

Despite the growth in the renewable energy sector in India, the country's industrial growth is still significantly dependent on fossil fuels, coal being the predominant source of energy. The power sector and industry are the main consumers of primary energy from coal and natural gas. The growth of 5.12 per cent in coal production between 2009-10 and 2018-19 was accompanied by an increase in coal imports by over 12 per cent in the same time period, signalling a higher growth in demand than could be supplied by domestic production. India will therefore need to focus on enhancing domestic production of coal to be able to reduce import dependence in this sector (MoSPI, 2020a). However, India's per capita coal consumption is still lower (0.73 tonne/person) than that of most developed countries and other emerging economies as well (USA: 1.91 tonne/person; Germany: 2.62 tonne/person; Australia: 4.52 tonne/person; China: 2.70 tonne/person) (IEA, 2019).

The current situation created by COVID-19 will change the demand, supply, and import scenario in ways that is not yet known or easy to forecast. For India, coal is the only reliable source of energy that is domestically available in abundance. India also has indigenous capacity to use this resource while maximizing economic benefits from the same for its population. All other sources of energy, conventional and non-conventional, currently require significant dependence on imported technology and/or fuels. Natural gas, oil, uranium, solar photovoltaics, and battery technology for energy storage are the main sources and technologies for energy supply other than coal. While at India's current stage of development cannot replace coal fully in the industrial sector, even in the power sector, an over-reliance on these without the capacity to manufacture them domestically, would be an economic disadvantage for the country. It would also lead to higher costs for consumers in the country in the absence of any mechanism for compensation by developed countries that are responsible for emissions currently in the atmosphere.

1.11 Transport

The development of transportation infrastructure is an important element in ensuring economic growth. The EIA report on Global Transportation Energy Consumption noted that while the OECD countries currently account for 55 per cent of the total energy consumed by the transportation sector globally, the non-OECD countries show higher incremental growth in demand from this sector. This is due to the changing economic situation in developing countries, where increased urbanization, diversification of employment, and increase in incomes is the driving factor in the growth of the transportation sector and consequently of the energy demand from the same. The energy demand from the transportation sector in developed countries corresponds to a high level of economic prosperity and a lack of investment in enhancing green transportation alternatives and reducing energy consumption from the sector. On the other hand, developing countries such as India have a dynamically changing economy with faster growing secondary and tertiary sectors, leading to essential growth in transportation infrastructure and services.

The transport sector currently accounts for 10 per cent of the total energy consumption in India. This is much lower than energy consumed by the transport sector in other countries (USA: 28 per cent; Germany: 28 per cent; UK: 18 per cent and China: 20 per cent). Energy consumption from passenger transport in developed countries accounts for over 50 per cent of the energy consumed by the transport sector as a whole in most OECD countries (Australia and New Zealand have a slightly lower contribution) (International Energy Outlook, 2016).

In India, passenger vehicles account for less than 30 per cent of the total energy consumed by the transportation sector (data for 2012 from International Energy Outlook, 2016). The highest contributor to energy consumption in this sector is freight transport. Air transport is also a relatively low consumer of energy in India. This indicates the essential character of transportation emissions in India, in the context of development needs.

However, GoI is aware that with rising income levels and growth of urban agglomerations, the growth in demand for passenger transportation in India is likely to increase significantly. Policies and programs implemented in the past decade have been driven by this understanding and efforts are being made to achieve growth and provide clean and affordable transportation services with minimal environmental impact. Programs for Bus Rapid Transit System (BRTS) implemented under the Jawaharlal Nehru Urban Renewal Mission, provided funds for increasing the number of CNG (compressed natural gas) buses in cities, thus incentivizing bus transport to improve urban air quality, while reducing overall emissions from this sector.

The investments made in large public transportation systems such as metros in many cities across the country also aim to reduce the potential increase in private transportation. India has operational metro systems in the cities of Kolkata, Delhi, Gurugram, Noida, Greater Noida, Bengaluru, Mumbai, Jaipur, Lucknow, Hyderabad, Chennai, Kochi, Nagpur, Ahmedabad, Ghaziabad, Faridabad, Ballabhgarh and Bahadurgarh (MoHUA, 2019a). With an increasing supply of renewable energy in power generation, large public transportation systems such as metro and suburban railway lines can alleviate the potential impact of increased demand for passenger transportation on the environment. The Government has introduced the Faster Adoption and Manufacturing of Hybrid & Electric Vehicles in India (FAME India) Scheme for promotion of electric/hybrid vehicles (xEVs) in India.

CNG is being widely used in transport across the country. City Gas Distribution (CGD) networks have been declared as a "public utility". At present (October 2019), 1,838 CNG stations are making available CNG to meet the requirement of 3.454 million CNG vehicles in the country. Government is meeting 100 per cent gas requirement of CNG (Transport) segment of the CGD networks across the country (PIB, 2019d).

Indian Railways with over 68,000 route kms is the third largest network in the world under single management. During the year 2018-19, IR carried 1,200 million tonne of freight and 8,400 million passengers making it the world's largest passenger carrier and 4th largest freight carrier. Revenue Earning Freight load carried by IR during 2018-19 was 1221.5 million tonne as against 1159.6 million tonne during 2017-18, registering an increase of 5.34 per cent. Passengers originating was 8,439 million in 2018-19 as compared to 8285.8 million in 2017-18, registering an increase of 1.85 per cent in 2018-19 over the previous year (DEA, 2020). The continued widespread use of railways for both passenger and freight transportation, in contrast to the situation in developed countries, contributes to sustainable development and growth in India.

Box 5: Assessing Mitigation Impact of Transport Sector Decarbonization

An inter-model comparison exercise was used to understand the impact of policies in decarbonization of the Indian transport sector. The study results concluded that by 2030 and 2050 increased fuel efficiency and a modal shift towards public transportation will have the maximum potential for CO_2 emissions reduction. Although electrification provides emission reduction benefits in the long run, it isn't substantial once upstream emissions from the power sector are accounted for. Hence, ambitious electrification targets need to be accompanied by decarbonization of the power sector also.

Source: CSTEP, CEEW, IRADe, PNNL, and TERI, 2019

1.12 Urbanization

India is one of the fastest growing countries in the world with rapid urbanization. There were about 377 million people residing in the urban habitats of India (Census 2011), comprising about 31 per cent of the total population which is expected to reach 606 million by 2030.The Pradhan Mantri Awas Yojana Urban (PMAY (U)) was launched in June, 2015 to provide pucca house with basic amenities to all eligible urban poor. The States/UTs were mandated to conduct demand survey to estimate the housing demand in their respective cities/towns. So far, a validated demand of 11.2 million houses has been registered.

Urban habitats and cities are the epicentres of economic growth which has contributed significantly to the Indian economy. Over 60 per cent of India's current GDP comes from the cities and towns. The share of construction sector in the economy's total GVA (at constant prices) is 7.7 per cent and 7.8 per cent, respectively, for years 2017-18 and 2018-19 and the share of construction sector in the country's GDP at current prices is 7.0 per cent and 7.1 per cent for years 2017-18 and 2018-19 respectively. (MoSPI, 2020d). Therefore, the investment made under PMAY(U) not only provides pucca house to the eligible families to achieve the goal of 'Housing for All' but also triggers multiplier effect on the overall economy. PMAY-U is one of the largest housing schemes of the world covering complete urban India. PMAY(U) is being implemented through four verticals. The scheme of PMAY(U) is rapidly moving towards achieving the vision for providing a pucca house to every household by 2022. Under the Mission, 4,427 cities have been included till March 2020 wherein 10.5 million houses have been approved, and 6.5 million have been grounded for construction. Of which 3.44 million houses have been completed and delivered (MoHUA, 2020).

The Smart Cities Mission (SCM) and Atal Mission for Rejuvenation and Urban Transformation, both Centrally Sponsored Schemes, were launched on 25 June 2015. Under SCM, 100 Smart Cities have been selected through a two-stage competition. A total of 5,151 projects worth INR 2,050,180 million have been included by selected 100 cities in their Smart City Proposals.

As regards AMRUT, in total 500 cities have been included in the AMRUT covering approximately 60 per cent of urban population in the country. The thrust areas of AMRUT are water supply, sewerage & septage management, storm water drainage, green spaces and parks, and non-motorised urban transport (MoHUA, 2019).

Provision of climate-resilient, comfortable housing meeting basic standards is a sector requiring further efforts as part of human development and the attainment of SDG goals. The Census of India, 2011, reported the presence of 187 million houses covering 192 million households. Of these, only 50 per cent was categorised as "good''. With respect to the construction material for roofs, walls and floors, concrete roofs covered only 20 per cent, burnt brick walls only 43.7 per cent, and tiled or cement floors only 34 per cent (Census, 2011). This data shows the enormous challenge of adaptation in India, of which the provision of safe, durable and resilient housing is one of the foundational components. In an inter-country comparison, the OECD study on Economic Survey of India, 2019 (OECD, 2019) reported that cost of housing is a significant barrier and that it had risen faster than the rate of growth of GDP per capita and was higher than in other comparable countries. The challenge is compounded by an intensification of the housing shortage in urban areas, a consequence of the current rate of urbanisation.

1.13 Employment

As per Periodic Labour Force Survey estimates, the share of regular wage/salaried employees has increased by 5 percentage points from 18 per cent in 2011-12 to 23 per cent in 2017- 18 as per usual status. In absolute terms, there was a significant jump of around 26.2 million new jobs in this category with 12.1 million in rural areas and 13.9 million in urban areas (DEA, 2020).

Various steps are being taken for generating employment in the country like encouraging private sector of economy, fast-tracking various projects involving substantial investment, and increasing public expenditure on schemes such as Prime Minister’s Employment Generation Programme (PMEGP), MGNREGS, Pandit Deen Dayal Upadhyaya Grameen Kaushalya Yojana (DDU-GKY) and Deendayal Antodaya Yojana-National Urban Livelihoods Mission (DAY-NULM). As a result of these policy interventions, the nature of employment has changed significantly.

1.14 Major economic transformations

1.14.1 India’s jump in World Bank’s Ease of Doing Business Report 2020

India ranks 63rd among 190 countries, improving by 14 ranks from its rank of 77 in 2019. India has improved its rank in 7 out of 10 indicators and has moved closer to international best practices. The 2020 edition of the Report acknowledges India as one of the top 10 improvers, third time in a row, with an improvement of 67 ranks in 3 years. It is also the highest jump by any large country since 2011.

1.14.2 India’s remarkable jump on the Global Innovation Index (GII)

In the past 4 years India’s rank in the GII has improved from the 81st rank in 2015 to the present 52nd rank in GII 2019 report. India became the first developing country to launch the GII in association with World Intellectual Property Organisation (WIPO) and Confederation of Indian Industry (CII) (MoCI, 2019).

Economic transformation of a developing country like India crucially depends on the performance of its agriculture and allied sectors. This sector plays a significant role in rural livelihood, employment and national food security. It happens to be the largest source of livelihood in India. Mechanization is an essential input to modern agriculture to increase the productivity by making judicious use of other inputs and natural resources, besides reducing the human drudgery and cost of cultivation. With the shrinking land and water resources and labour force, the onus rests on mechanization of production and post-harvesting operations. There is a linear relationship between availability of farm power and farm yield and government has decided to enhance farm power availability from 2.02 kW per ha (2016-17) to 4.0 kW per ha by the end of 2030 to cope up with increasing demand for foodgrains.

1.14.3 Digital India

Digital India is a flagship programme of the GoI with a vision to transform the country into a digitally empowered society and knowledge economy, with direct climate-related co-benefits. GoI is promoting extensive use of technology for ensuring efficient service delivery and responsive governance.

The use of digital technology is actively promoted in the education sector, weather advisories, connecting agricultural markets through e-NAM, and connecting gram swaraj through mobile applications. The use of digital technology is promoted in financial transactions and digital payments by leveraging the power of JAM (Jan Dhan, Aadhar, and Mobile) of "just achieving maximum”. Digitalization, e-commerce, internet banking and mobile banking services assist rural populations and have become significant channels for the government to transfer financial benefits to the vulnerable population during the ongoing pandemic. In the fight against COVID-19, the government launched the Aarogya Setu Application to connect essential health services with the people by proactively informing application users regarding risks, best practices, and relevant advisories (MoEIT, 2019a).

The Digital India programme is centred on three key vision areas: digital infrastructure as a core utility to every citizen, governance and services on demand, and citizens' digital empowerment. Some relevant illustrations from each of these visions areas are provided below.

BharatNet: As on December 2019, 3,80,988 km of optical fibre has been laid connecting 1,40,668 gram panchayats of which 1,28,376 gram panchayats are ready for service.

Common Services Centre (CSC): CSCs are internet-enabled centres operated by local entrepreneurs, called Village Level Entrepreneurs (VLEs) that provide e-Services to rural citizens. These CSCs offer over 350 digital services. The number of functional CSCs (urban & rural) across the country is 0.0364 million, out of which 0.0262 million CSCs are functional at the Gram Panchayat level.

Digital Locker: Digital locker provides an ecosystem with a collection of repositories and gateways for issuers to upload documents to these digital repositories. As of

December 2019, there are 32.3 million registered users of DigiLocker with 3.69 billion authentic documents having been issued. There are 144 issuers and 42 requestor organizations that have been on boarded.

Government e-Market Place (GeM): To facilitate online procurement of goods and services required by various government departments, organisations, and PSUs, Government e-Marketplace (GeM) has been implemented. There are 14,85,806 products, and more than 19,415 services available on the portal.

BHIM: Bharat Interface for Money (BHIM) is an application that makes payment transactions simple, easy, and quick using Unified Payments Interface (UPI). BHIM-UPI platform has shown transaction growth of 589 per cent during the financial year 2018-19 (5,391.5 million) as compared to the financial year 2017-18 (915.2 million). BHIM-UPI currently has 144 member banks offering this service to their customers (MoEIT, 2019b).

1.15 Sustainable Development Goals

India is aiming to combine the 'sustainability' aspect to economic growth through well-designed equitable growth initiatives including electrification of rural households, augmenting the use of renewable sources, eliminating malnutrition, eradicating poverty, access to education for all girls, provide sanitation and housing for all, equipping young people with skills to compete in the global labour market, and enabling access to finance and financial services. As noted before, mega-diverse developing countries like India are undertaking considerable efforts for holding onto and enhancing their forests and biodiversity with little or no international support. In India forests are not mere sinks for carbon sequestration, but they serve as perennial sources sustaining lives and livelihoods, are even revered and worshipped and contribute to uplifting the very human spirit and endeavour of millions, who live in close harmony with them. When compared with several developed and developing countries, it is noteworthy that India has among the lowest rates of gross deforestation in absolute terms, in per capita terms, and in annual rates.

The Sustainable Development Goals (SDGs) constitute a befitting framework in the short-term (up to 2030) to answer the developmental challenges in proceeding to a sustainable future, free from social, economic, and environmental inequalities and thereby ensuring a greener and healthy planet for future generations. India’s achievement in the composite SDG index score has improved from 57 in 2018 to 60 in 2019 (NITI Aayog, 2020b).

Increased focus on sustainability requires various actions towards building individual and institutional capacity, accelerating knowledge and enhancing technology transfer and deployment, enabling financial mechanisms, implementing early warning systems, undertaking risk management and addressing gaps in implementation and upscaling.

While considerable and noteworthy progress has been made by India towards achieving the various SDG goals, significant gaps still remain in achieving the goals related to overcoming poverty and malnutrition. Further, substantial effort is still required for strengthening food security, providing adequate housing, and ensuring better access to basic social services such as education and health.

While developmental efforts and public welfare are at the core of the government's policies and programmes, India continues to face challenges in the provision of poverty eradication, safely managed drinking water, solid waste management, and drainage. Significant gaps also remain in ensuring expansion of economic and social opportunities for all individuals and groups resulting in decent and dignified employment and improved incomes and standard of living.

Improving gender equality is also an area of focus. India also needs substantial investment in order to develop sustainable and resilient physical infrastructure (e.g., all-weather roads) and digital infrastructure to overcome its current infrastructure deficit under the changing climate regime.

For a country with 1.3 billion people, improving access, affordability and quality of sanitation, nutrition and health services has been a ceaseless endeavour. There is a nationwide nudge provided by the Clean India Campaign and the National Nutrition Mission. In India, all States/UTs have declared themselves open defecation free (SBM, 2020a), recording a jump from the 2014 figure of 38 per cent villages with sanitation (NITI Aayog, 2020b). Similarly, child and maternal mortality and stunting levels have also reduced. India's infant mortality rate (IMR) was at 32 per 1,000 live births in 2016-18, and the maternal mortality ratio (MMR) declined from 122 in 2015-17 to 113 in 2016-18 (7.4 per cent decline), as per the Special Bulletin on MMR released by the Registrar General of India (PIB, 2020g). The SDG goal is to reduce IMR to 12 per 1000 live births and MMR to 70 per 1,00,000 live births by 2030 (WHO, 2020).

Global Goalkeeper Award, 2019 – The Hon'ble Prime Minister of India received the 'Global Goalkeeper' Award by Bill and Melinda Gates Foundation, for Swachh Bharat Abhiyan on 24 September 2019 in recognition of his prioritization and leadership on sanitation as a national priority, directly contributing to the global progress towards Sustainable Development Goal 6 through the Swachh Bharat Mission. India contributed to reducing the global open defecation burden by over 50 per cent (PMO, 2019). In last five years, record toilets were constructed benefitting the poor and women of the country the most, in addition to boosting economic activity in villages. India called for increasing the global sanitation coverage through mission mode movements like Fit India Movement and Jal Jeevan Mission.

The SDG progress of the States/ UTs is measured on a set of 100 indicators spread across 16 goals. The Index also includes a qualitative assessment on SDG goal 17. As per the SDG Index 2019, Kerala, Himachal Pradesh, Tamil Nadu, Andhra

Pradesh, Telangana, Karnataka, Goa, Sikkim, Chandigarh and Puducherry are the front runners. The composite score for India has improved from 57 in 2018 to 60 in 2019. This positive stride towards achieving the target is largely driven by significant country wide performance in five goals - 6 (Clean Water and Sanitation), 7 (Affordable and Clean Energy), 9 (Industry, Innovation and Infrastructure), 15 (Life on Land) and 16 (Peace, Justice and Strong Institutions) - where India has scored between 65 and 99 (Niti Aayog, 2019a).

India has taken several steps in measuring the progress of Sustainable Development Goals (SDGs) since the adoption of the 2030 Agenda for SDGs. In this endeavour, Ministry of Statistics and Programme Implementation (MoSPI) has developed a monitoring framework, namely the National Indicator Framework (NIF) on SDGs based on national priorities and needs for tracking the progress made towards achieving SDGs after a series of consultations with different stakeholders. At present, there are 302 indicators in the NIF covering all the 17 Goals. MoSPI has brought out the “SDG NIF Progress Report 2020 (Version 2.1)” on 29th June 2020 covering all 17 SDGs with time series data from 2015-16 (or the baseline year) to 2019-20 (or latest available year). The report provides an overview of the progress made on SDGs and will help policy makers in identifying thrust areas where interventions need to be focused (MoSPI, 2020c).

Box 6: Sustainable Development Goals Progress 2020

SDG 7: Affordable and Clean Energy

- Nearly 99.77 per cent of households are electrified up to March 2020.
- The percentage of households using clean cooking fuel has increased to 98.10 per cent in 2018-19 from 63.11 per cent in 2015-16.
- The renewable energy shares in the total installed electricity generation increased from 13.40 per cent in 2015-16 to 19.2 per cent in 2018-19.

SDG11: Sustainable Cities and Communities

- In 2019, 34.93 per cent cities have master plans, whereas in 2015 only 33.17 per cent cities had master plans.
- In 2019-20, 95.97 per cent of wards had 100 per cent door to door waste collection system as compared to 40.91 per cent in 2015-16.
- During 2019, on an average 34.4 persons were injured per lakh population in road accidents as compared to 36.2 persons in 2018. Further, during the third Global Ministerial Conference on Road Safety at Stockholm during 19-20 February 2020 it was decided to deliver a 50 per cent reduction in deaths and injuries over the next decade on our way to Vision Zero by 2050.

SDG 13: Climate Action

- There are 33 States and UTs with strategies for enhancing adaptive capacity and dealing with climate extreme weather events in India in 2017-18.
- Despite having no binding mitigation obligation under UNFCCC in the pre-2020 period, India has achieved 21 per cent reduction in emission intensity of its GDP by 2014 in line with the voluntary declaration.

Source: MoSPI, 2020b.

1.16 India’s efforts in combating climate change

India submitted its NDC under the Paris Agreement on a “best effort basis” keeping in mind the developmental imperatives of the country. In its NDC, India promised to reduce its emission intensity of GDP by 33 to 35 per cent below 2005 levels by the year 2030; 40 per cent of cumulative electric power installed capacity would be from non-fossil fuel sources by 2030 and create an additional carbon sink of 2.5 to 3 billion tonnes of CO_2 equivalent through additional forest and tree cover by 2030. The Paris Agreement is to be implemented in post-2020 period in line with the guidelines adopted under Paris Agreement Work Programme.

India has strived to ensure that it follows a growth path that delivers sustainable development and protects the environment by investing in various schemes aligned with its NDC, like Swachh Bharat Mission, National Smart Grid Mission and Atal Mission for Rejuvenation and Urban Transformation. Notwithstanding the economic actualities, India’s mitigation strategies have emphasized on clean and efficient energy system, enhanced energy efficiency, resilient urban infrastructure, safe, smart and sustainable green transportation network, planned afforestation, as well as holistic participation across all sectors.

There has been a significant leap forward for renewable energy with India undertaking one of the world’s largest renewable energy expansion programmes in the world. India had announced 175 GW targets for renewable by 2022 and has already achieved 89 GW by September 2020. Further, the Hon'ble Prime Minister of India in his address at the UN Climate Action Summit in September 2019 has stated that “India's renewable energy capacity would be increased too much beyond 175 GW and later till 450 GW”.

As a Party to the UNFCCC, India submitted its Second Biennial Update Report (BUR) to the UNFCCC towards fulfilment of the reporting obligation under the Convention. As per BUR-2, the emission intensity of India’s GDP has reduced by 21 per cent over the period of 2005-2014 which is the result of India’s proactive and sustained actions on climate change. India is on track to achieve its nationally determined contributions. In 2016, the net national GHG emissions after including LULUCF were 25,31,069 $GgCO_2$ equivalent (around 2.531 billion tonne of CO_2

equivalent). India's NAPCC identifies a number of measures that simultaneously advance the country's development and climate change related objectives of adaptation and mitigation through focused National Missions. It was also meant to focus on key adaptation requirements and creation of scientific knowledge and preparedness as climate change acts as a "risk multiplier" for the vulnerable groups, worsening existing social, economic and environmental stresses. India has decided to revise the NAPCC in line with the NDCs under the Paris Agreement to make it more comprehensive in terms of priority areas.

1.16.1 High Performance Computing (HPC)

India's first multi petaflop supercomputer 'Pratyush' was established as a national facility for improving weather and climate forecasts and services under the umbrella of the MoES, GoI at IITM, Pune. This HPC 'Pratyush', having a peak computing performance of 4.0 Peta Flops (PF), is ranked as India's number one HPC. It has been ranked 39th in position worldwide based on its computational capacity, as per record on www.top500.org in the list published in June 2018. After commissioning 10 Peta Flops of HPC, India developed earth system models and contributed associated simulations for inclusion in IPCC AR6 report for the first time. HPC Pratyush is part of the MoES's newly augmented HPC facility of 6.8 PF computational power, with the other leg of the facility of 2.8 PF installed at NCMRWF, Noida. This HPC facility at Indian Institute of Technology Madras (IITM) is being used by IITM and other MoES institutes (like INCOIS, IMD, NIOT, NCAOR, NCESS) for carrying out research and improving their respective weather and climate forecasts and their applications. More information about HPC Pratyush is available at: http://pratyush.tropmet.res.in. This facility has helped in improving the prediction of CFS model for forecasting monsoon on different space and time scales. IITM's efforts in improving and providing reliable capabilities for seasonal, extended range and short range prediction of monsoon rainfall, heat/cold waves prediction, winter fog forecast for north India, air quality forecast and early warning for Delhi, lightning, and cyclones have been much appreciated, which could not have been possible without this HPC facility.

Figure 1.23: Inauguration of HPC Pratyush

1.16.2 India at COP 25, calls upon more countries to join the International Solar Alliance (ISA)

The 25th Session of the Conference of the Parties (COP 25) to UNFCCC was held under the Presidency of Chile in Madrid, Spain on 02-15 December 2019. Some of the key issues discussed at COP-25 were Pre-2020 implementation and ambition gaps, Article 6 under the Paris Agreement, Enhanced Transparency Framework (Monitoring, Reporting and Verification), Warsaw International Mechanism (WIM) for Loss and Damage associated with climate change impacts, adaptation related matters wherein India has been stressing on parity between mitigation and adaptation and technology development and transfer. At COP-25, India also called upon more countries to join the ISA to reduce dependence on fossil fuels to meet the growing energy requirement, even as it acknowledged the phenomenal progress made by the Alliance and the growing solar energy capabilities the world over (DEA, 2020).

1.17 India and the COVID-19 pandemic response

On 30 January 2020, Director-General World Health Organization (WHO) declared that the outbreak of novel coronavirus (2019-nCoV) constituted a Public Health Emergency of International Concern (PHEIC) as per the advice of International Heath Regulations (IHR) Emergency Committee.

On 30 January 2020, a laboratory confirmed case of 2019-nCoV was reported in Kerala (Andrews et al., 2020). The Prime Minister’s Office and the Ministry of Health and Family Welfare (MoH&FW) closely monitored the 2019-nCoV situation and intensified preparedness and response efforts. Surveillance was strengthened and enhanced at points of entry, in health facilities and in the community including contact tracing and follow up around the confirmed cases. The National Centre for Disease Control (NCDC) activated the Strategic Health Operations Centre (SHOC) to provide command and control functions and a helpline was opened to answer public queries. Since beginning of January 2020, WHO India as a member of the Joint Monitoring Group and through other means provided MoH&FW, NCDC, Indian Council of Medical Research (ICMR) and Ministry of Information and Broadcasting with technical advice, guidance and resources for enhanced vigilance, preparedness and response to 2019-nCoV at both national and sub-national level.

As on 28 June 2020, there were 2,03,051 Active Cases, 3,09,712 Cured/ Discharged, Migrated and 16,095 Deaths in India. Gap between recoveries and active cases had crossed 1,00,000 and recovered cases exceeded the active cases by 1,06,661 as of 28 June 2020 (WHO, 2020a).

As of 6 September, MoHFW estimated that active cases were 8,62,320, total deaths at 70,626 and discharged cases at 31,80,865. These correspond to a total of 41,13,811 cases since the inception of monitoring. The COVID-19 health impact in

India has been notable for the low fatality rate in comparison to many other countries across the world. However, as in almost all countries globally, the response to COVID-19 has led to severe stress on the health care system, and on the provision of routine health care and health development activities alongside the need to fight the pandemic.

The nature of the unprecedented stress to not only health system but all other aspects of national life is illustrated by the extraordinary efforts required to repatriate India's stranded nationals from all over the world. Thus, India launched the *Vande Bharat Mission* (VBM) on 7 May 2020 after intensive inter-ministerial consultations and approval at the highest level. As on 16 November 2020, more than 2.4 million stranded Indian nationals abroad had safely returned to India involving more than 11,000 flights of Air India, chartered flights, now, under Air Bubble arrangements. Around 0.2 million Indian nationals have returned via land crossings from Nepal, Bhutan, Bangladesh and Myanmar; 8,000 people have returned from Iran, Sri Lanka and Maldives by 8 naval ships.

The impact of the pandemic therefore has acted to increase vulnerability among those sections of the population who are already vulnerable to health shocks. The COVID-19 pandemic has also created a new category of health vulnerability among sections of the population that are economically on a sound footing but suffer from a variety of lifestyle diseases including cardiac ailments, obesity and related problems and diabetes. These conditions have become co-morbidities in the context of COVID-19 and have increased the vulnerability of such sections.

Apart from the health sector, the pandemic response has had a major impact on the economy as a whole, through the series of measures such as lockdowns, imposition of containment zones and even curfews that have been undertaken to protect the population from the immediate large-scale impact of the virus, while preparing the infrastructure and facilities required for dealing with eventual large-scale spread of the virus. These economic measures have had a serious contractionary impact on the economy, especially over the period late March to early September. The National Statistical Office (NSO) has published estimates for GDP and GVA for the national economy, for the first quarter April-June 2020. The official statement noted that:

GDP at Constant (2011-12) Prices in Q1 of 2020-21 is estimated at INR 26.90 trillion, as against INR 35.35 trillion in Q1 of 2019-20, showing a contraction of 23.9 per cent as compared to 5.2 per cent growth in Q1 2019-20. Quarterly GVA at Basic Price at Constant (2011-12) Prices for Q1 of 2020-21 is estimated at INR 25.53 trillion, as against INR 33.08 trillion in Q1 of 2019-20, showing a contraction of 22.8 per cent.

GDP at Current Prices in the year Q1 2020-21 is estimated at INR 38.08 trillion, as against INR 49.18 trillion in Q1 2019-20, showing a contraction of 22.6 per cent as compared to 8.1 per cent growth in Q1 2019-20. GVA at Basic Price at Current

Prices in Q1 2020-21, is estimated at INR 35.66 trillion, as against INR 44.89 trillion in Q1 2019-20, showing a contraction of 20.6 per cent.

GoI has had to announce a series of significant economic measures affecting all sectors to meet the crisis. The package of such measures so far announced, as of 30 August 2020, amounts to a total of INR 20.97 trillion as the COVID-19 economic stimulus package. This amounts to about 10 per cent of India's GDP. A significant part of this sum relates to provision of employment through India's flagship employment guarantee scheme, MGNREGS and a significant package of measures for the MSME sector. Further measures may be expected as necessary for the continued revival of the economy.

Despite these measures, the unprecedented economic impact of the pandemic is expected to have a serious influence for some time, though the nature of the recovery and its characteristics are much debated in the academic and policy literature. Since the MSME sector has been the most severely affected, progress on India's NDC in energy efficiency may potentially be impacted. However, currently quantitative estimates are not reliably available to comment on this further.

While there are significant learnings for the future from the pandemic response, the view that such emergency measures perhaps should be undertaken even with respect to global warming cannot be given serious consideration. The pandemic will be brought under control soon after vaccines become available (which are being pursued by a serious global effort), but global warming arises from structural, deep-rooted causes, that are difficult to change as the experience of the developed countries has shown in their inability to reduce emissions based on the demands of science. GHG mitigation and sustainable development are not curable by magic bullets such as vaccines.

Among the significant learnings from the pandemic relevant to the multilateral processes related to global warming is the importance of global cooperation. India has consistently emphasized this in both statements and declarations as well as in practical terms. India has stepped up production of masks, personal protective equipment, and other related materials required for pandemic related health activity and has provided materials to other countries as well. Amidst uncertainties in the nature of pharmaceuticals required, India has provided key supplies as feasible of drugs such as hydroxycholoroquine. It is also collaborating with other institutions world-wide in knowledge exchange and generation and production activity for front-line drugs as well as trials of vaccines once these are readied.

Consistent information and knowledge flow are also a key requirement for the kind of international cooperation that confronting global warming will require. This the pandemic has established beyond doubt.

In the short-term, while India has made every effort to maintain its climate action on track successfully through this period, notions such as India can go completely "green" immediately or take dramatic steps such as ceasing all new coal commitments from now, in 2020, are beyond even the realm of speculation. The foremost priorities will lie in restoring the economy to its normal condition, restore normalcy in business, commercial and social life, before climate action can take dramatic new steps forward. The scale of GDP loss and reduction in GVA speak to this issue clearly and unambiguously.

The significance of the principles of equity and common but differentiated responsibilities has also to be upheld and the economic impact of COVID-19 on the Indian economy shows that this fully applies even in the experience of the pandemic.

The pandemic has also had some impact on the climate sector and related activities. India's scientific community has had to be drafted on a large-scale in the COVID-19 response for some months. In the meanwhile, field activities in various sectors, as well as the implementation of the government schemes and projects relevant to climate action have been variously slowed down or even brought to a complete halt in this period. This may also slow down the process of restoring climate action on the pre-pandemic or on an increased scale, as well as potentially introducing delays in India's reporting requirements under the UNFCCC and its Agreement and Protocol.

References

AGCENSUS. (2019). Agriculture Census 2015-16, All India Report on Number and Area of Operational Holdings, Agriculture Census Division, Department of Agriculture, Co-Operation & Farmers Welfare, Government of India.

Andrews, M. A., Areekal, B., Rajesh, K. R., Krishnan, J., Suryakala, R., Krishnan, B., Muraly, C. P., & Santhosh, P. V. (2020). First confirmed case of COVID-19 infection in India: A case report. The Indian journal of medical research, 151(5), 490–492. https://doi.org/10.4103/ijmr.IJMR_2131_20

Azam, M. F., Wagnon, P., Berthier, E., Vincent, C., Fujita, K., & Kargel, J. S. (2018). Review of the status and mass changes of Himalayan-Karakoram glaciers. Journal of Glaciology. 64 (243), 61-74.

Ahmad, R., A. A. Khuroo, M. Hamid, B. Charles, & I. Rashid. (2019). Predicting invasion potential and niche dynamics of Parthenium hysterophorus (Congress grass) in India under projected climate change. Biodiversity and Conservation. 28:2319–2344.

Ahmad, F., & L. Goparaju. (2018). Climate change and its impact on forest fire in the state of Himachal Pradesh and Uttarakhand states of India: Remote sensing and GIS analysis. Contemporary Trends in Geoscience. 7:229–246.

Bahuguna, I. M., Rathore, B. P., Brahmbhatt, R., Sharma, M., Dhar, S., Randhawa, S. S. & Ajai. (2014). Are the Himalayan glaciers retreating? Current Science, 1008-1013.

Bolch, T., Kulkarni, A., Kääb, A., Huggel, C., Paul, F., Cogley, J. G. & Bajracharya, S. (2012). The state and fate of Himalayan glaciers. Science. 336(6079), 310-314.

Banerjee, A. K., A. Mukherjee, W. Guo, Y. Liu, & Y. Huang. (2019). Spatio-temporal patterns of climatic niche dynamics of an invasive plant Mikania micrantha Kunth and its potential distribution under projected climate change. Frontiers in Ecology and Evolution, 7 (291), 1-16. DOI: 10.3389/fevo.2019.00291

Census. (2011). Office of the Registrar General & Census Commissioner, Ministry of Home Affairs, Government of India. Retrieved from https://censusindia.gov.in/census_And_You/housing.aspx

CSTEP, CEEW, IRADe, PNNL & TERI. (2019). Comparison of Decarbonisation Strategies for India's Land Transport Sector: An Inter Model Assessment. New Delhi: TERI. Retrieved from https://shaktifoundation.in/wp-content/uploads/2019/11/Intermodel-Study_Final-Report.pdf

Chitale, V., & M. Behera. (2012). Can the distribution of sal (Shorea robusta Gaertn. f.) shift in the northeastern direction in India due to changing climate? Current Science, 1126–1135.

CWC. (2020a). Communication received from the Central Water Commission on the Damage due to Floods / Heavy rains during 2010 to 2018, email dated 3 November 2020.

CWC. (2020b). Shoreline Change Atlas. Coastal Protection and Development Advisory Committee. Central Water Commission. Retrieved from http://cwc.gov.in/cpdac/shoreline-change-tlas

DAC&FW. (2020). Communication from area under Integrated Farming System (IFS), dated 16 November 2020.

Dobhal, D. P. & Mehta, M. (2008). Snout fluctuation of Dokriani Glacier (1962-2007) vis-à-vis the impact of climate change. Himalayan Geology, 29(3), 23-25.

DEA. (2020). Economic Survey of India 2019-20, Volume 2. Ministry of Finance, Department of Economic Affairs, Government of India. pp. 320. Retrieved from https://www.indiabudget.gov.in/economicsurvey/doc/echapter.pdf

Deb, J. C., S. Phinn, N. Butt, & C. A. McAlpine. (2017). Climatic-induced shifts in the distribution of teak (Tectona grandis) in tropical Asia: Implications for forest management and planning. Environmental Management 60:422–435.

EnviStats India. (2020). Volume I and II Environment Accounts. Ministry of Statistics and Programme Implementation, Government of India.

FSI. (2019). India State of the Forest Report 2019. Forest Survey of India, Ministry of Environment, Forest and Climate Change, Government of India.

Gurung, D. R., Giriraj, A., Aung, K. S., Shrestha, B. R., & Kulkarni, A. V. (2011a). Snow-cover mapping and monitoring in the Hindu Kush-Himalaya. International Centre for Integrated Mountain Development (ICIMOD).

Gurung, D. R., Maharjan, S. B., Shrestha, A. B., Shrestha, M. S., Bajracharya, S. R., & Murthy, M. S. R. (2017). Climate and topographic controls on snow cover dynamics in the Hindu Kush Himalaya. International Journal of Climatology. 37(10), 3873-3882.

Huss, M., Hock, R. (2018). Global-scale hydrological response to future glacier mass loss. Nature Climate Change, 8, 135–140. https://doi.org/10.1038/s41558-017-0049-x

IMD. (2019). Rainfall Normals (1961-2010). India Meteorological Department.

IMD. (2019). Annual Climate Summary -2019. Retrieved from http://www.imdpune.gov.in/Links/annual_summary_2019.pdf

IMD. (2020). Observed rainfall variability and changes over 29 States and UT. Met Monograph No.:ESSO/IMD/HS/Rainfall Variability/01(2020)/25-53.

IEA. (2019). Coal Consumption: Coal Information Overview, Statistics Report 2020; Population Information: World Population Prospects

Immerzeel, W. W., Lutz, A. F., Andrade, M. et al. (2019). Importance and vulnerability of the world's water towers. Nature. doi:10.1038/s41586-019-1822-y

IOMENVIS. (2017). Centre for Coastal Zone Management and Coastal Shelter Belt, Ministry of Environment, Forest and Climate Change, Government of India. Retrieved from http://iomenvis.nic.in/index2.aspx?slid=758&sublinkid=119&langid=1&mid=1

International Energy Outlook. (2016). Transportation sector energy consumption. Retrieved from https://www.eia.gov/outlooks/ieo/pdf/transportation.pdf

Joseph, T. (2019). Early Indians, Juggernaut, Delhi.

Joshi, J., Sabnis, M., & Sukumar, R. (2020). Climate change and forest fires in India. Centre for Ecological Sciences, Indian Institute of Science. Report prepared under the Third National Communication to UNFCCC for Ministry of Environment, Forest and Climate Change, Government of India.

Kulkarni, A. V., & Karyakarte, Y. (2014). Observed changes in Himalayan glaciers. Current Science. 237-244.

Kulkarni, A.V. and Shirsat, T. (2019). Snow and Glacier hydrology. In Water future of India: status of science and Technology (Eds P.P. Mujumdar and V. M. Tiwari), IISc press, pp.75-116.

Kulkarni, Anil V., Bahuguna, I. M., Dobhal, D. P., Meloth, Thamban., Negi, H. S., Shirsat, Tejal., & A. R., Arya. (2020). State of Himalayan Cryosphere. Divecha Centre for Climate Change Indian Institute of Science.

Kumar, M., Savita, H. Singh, R. Pandey, M. P. Singh, N. H. Ravindranath, & N. Kalra. (2019). Assessing vulnerability of forest ecosystem in the Indian Western Himalayan region using trends of net primary productivity. Biodiversity and Conservation 28:2163–2182.

Kumar, D., M. Pfeiffer, C. Gaillard, L. Langan, C. Martens, & S. Scheiter. (2020). Misinterpretation of Asian savannas as degraded forest can mislead management and conservation policy under climate change. Biological Conservation 241:108293.

Lutz, A. F., Immerzeel, W. W., Shrestha, A. B., & Bierkens, M. F. P. (2014). Consistent increase in High Asia's runoff due to increasing glacier melt and precipitation. Nature Climate Change, 4(7). 587-592.

Manish, K., Y. Telwala, D. C. Nautiyal, & M. K. Pandit. (2016). Modelling the impacts of future climate change on plant communities in the Himalaya: a case study from Eastern Himalaya, India. Modeling Earth Systems and Environment 2:92.

Manoj, M. R., Satheesh, S. K., Moorthy, K. K., Gogoi, M. M., & Babu, S. S. (2019). Decreasing trend in black carbon aerosols over the Indian region. Geophysical Research Letters, 46. 2903– 2910. https://doi.org/10.1029/2018GL081666

MoA&FW (2018). Annual Report 2018-19. Ministry of Agriculture and Farmers' Welfare. Retrieved from http://agricoop.nic.in/sites/default/files/AR_2018-19_Final_for_Print.pdf

MoA&FW. (2019a). Lok Sabha, Unstarred Question No. 454. Ministry of Agriculture and Farmers Welfare. Schemes for Irrigation. http://agricoop.nic.in/sites/default/files/AR_2018-19_Final_for_Print.pdf

MoA&FW. (2019b). Lok Sabha, Unstarred Question No. 3535. Conservation of Water in Agriculture. Ministry of Agriculture and Farmers’ Welfare. Retrieved from http://164.100.47.194/Loksabha/Questions/QResult15.aspx?qref=10174&lsno=17

MoA&FW. (2019c). Lok Sabha, Unstarred Question No. 2307. Effects of Climate Change on the Agriculture Sector. Ministry of Agriculture and Farmers Welfare.

Retrieved from http://164.100.47.194/Loksabha/Questions/QResult15.aspx?qref=8750&lsno=17

MoA&FW. (2020a). Lok Sabha, Unstarred Question No. 1973. Growth Rate in Agriculture Sector. Ministry of Agriculture and Farmers' Welfare. Retrieved from http://164.100.24.220/loksabhaquestions/annex/173/AU1973.pdf

MoA&FW. (2020b). Lok Sabha, Unstarred Question No. 364. National Innovations on Climate Resilient Agriculture. Ministry of Agriculture and Farmers Welfare. Retrieved from http://164.100.47.194/Loksabha/Questions/QResult15.aspx?qref=11410&lsno=17

MoA&FW. (2020). Communication received from the Ministry of Agriculture and Farmers Welfare on the desert locust situation, email dated 7 October 2020.

MoCI. (2019). Year End Review -2019 of Ministry of Commerce & Industry. Ministry of Commerce & Industry, Government of India. Retrieved from https://pib.gov.in/PressReleasePage.aspx?PRID=1596654

MoEFCC. (2018). Achievement of Aichi Biodiversity Targets 11 and 16, Success stories from India. Ministry of Environment, Forest and Climate Change. Retrieved from http://nbaindia.org/uploaded/pdf/Aichi%20target%20design%20low%2014-11-2018.pdf

MoEFCC. (2019a). Lok Sabha, Unstarred Question No. 3194. Ministry of Environment, Forest and Climate Change. Coastal Regulation Zone. Retrieved from http://164.100.47.194/Loksabha/Questions/QResult15.aspx?qref=9648&lsno=17

MoEFCC. (2019b). Lok Sabha, Unstarred Question No. 4369. Ministry of Environment, Forest and Climate Change. Impact of Climate Change on Coastal Areas. Retrieved from http://164.100.47.194/Loksabha/Questions/QResult15.aspx?qref=4751&lsno=17

MoEFCC. (2019c). Lok Sabha, Unstarred Question No. 4492. Ministry of Environment, Forest and Climate Change. Quality of Water in Rivers. Retrieved from http://164.100.47.194/Loksabha/Questions/QResult15.aspx?qref=4780&lsno=17

MoEFCC. (2019d). Implementations of India's National Biodiversity Action Plan (2019). Ministry of Environment, Forest and Climate Change, Government of India. http://nbaindia.org/uploaded/pdf/IndiaNationalBiodiversityActionPlan2019.pdf

MoEFCC. (2020a). Lok Sabha, Unstarred Question No. 3261. Ministry of Environment, Forest and Climate Change. Threat of Rising Sea Level. Retrieved

from
http://164.100.47.194/Loksabha/Questions/QResult15.aspx?qref=14653&lsno=17

MoEFCC. (2020b). Lok Sabha, Unstarred Question No. 1090. Ministry of Environment, Forest and Climate Change. Forest Fire. Retrieved from http://164.100.24.220/loksabhaquestions/annex/173/AU1090.pdf

MoES. (2020). Lok Sabha, Unstarred Question No. 2698. Ministry of Earth Sciences. Natural Disasters. Retrieved from http://164.100.47.194/Loksabha/Questions/QResult15.aspx?qref=13796&lsno=17

MoES. (2020a). Coastal Processes & Shoreline Management. National Centre for Coastal Research (NCCR), Ministry of Earth Sciences, Government of India. Retrieved from https://www.nccr.gov.in/?q=activities/coastal-process

MoES. (2020b). Communication received from the Ministry of Earth Sciences, Government of India on Status of Coastal erosion and Shoreline Management in India, email dated 18 December 2020.

MoEIT. (2019a). India's Trillion Dollar Digital Opportunity, Digital India. Ministry of Electronics and Information Technology, Government of India.

MoEIT. (2019b). Lok Sabha, Unstarred question No 2582. Digital India. Ministry of Electronics and Information Technology, Government of India. Retrieved from http://164.100.24.220/loksabhaquestions/annex/172/AU2582.pdf

MoFAH&D. (2019a). Rajya Sabha, Unstarred Question No. 732. Fishing capacity in ocean. Ministry of Fisheries, Animal Husbandry and Dairying. Retrieved from https://rajyasabha.nic.in/rsnew/Questions/QResult.aspx

MoFAH&D. (2019b). Lok Sabha, Unstarred Question No. 2442. Optimal Harvesting of Marine Fisheries. Ministry of Fisheries, Animal Husbandry and Dairying. Retrieved from
http://164.100.47.194/Loksabha/Questions/QResult15.aspx?qref=8887&lsno=17

MoFAH&D. (2019c). Lok Sabha, Unstarred Question No. 4979. Ministry for Fisheries. Ministry of Fisheries, Animal Husbandry and Dairying. Retrieved from http://164.100.47.194/Loksabha/Questions/QResult15.aspx?qref=5462&lsno=17

MoFAH&D. (2019d). Lok Sabha, Unstarred Question No. 557. Sustainable Practices in Fisheries. Ministry of Fisheries, Animal Husbandry and Dairying. Retrieved from http://164.100.47.194/Loksabha/Questions/QResult15.aspx?qref=601&lsno=17

MoFAH&D. (2020). Lok Sabha, Unstarred Question No. 1481. Performance of Fisheries Sector. Ministry of Fisheries, Animal Husbandry & Dairying. Retrieved from http://164.100.24.220/loksabhaquestions/annex/173/AU1481.pdf

Mohapatra, M., Srivastava, A. K., Balachandran, S., Geetha, B. (2017). 'Observed

Climate variability and change over the Indian region’, [Eds. Rajeevan et al] Springer. p.89.

MoHUA. (2019). Lok Sabha, Unstarred Question No. 4272. Smart City Mission and AMRUT. Ministry of Housing and Urban Affairs, Government of India. Retrieved from http://164.100.24.220/loksabhaquestions/annex/171/AU4272.pdf

MoHUA. (2019a). Lok Sabha, Unstarred Question No. 3991. Metro rail facility. Ministry of Housing and Urban Affairs, Government of India. Retrieved from http://164.100.24.220/loksabhaquestions/annex/172/AU3991.pdf

MoHA. (2018). International Cooperation on Disaster Management. Ministry of Home Affairs, Government of India. Retrieved from https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1556471

MoHUA. (2020). 1 Year of transforming urban landscape, Ministry of Housing and Urban Affairs, Government of India. Retrieved from http://mohua.gov.in/upload/5c987f9e0fcecUTBook25March20191compressedcompressedcompressedmin11.pdf

MoJS. (2020). Lok Sabha, Starred Question No. 367. Groundwater Depletion. Ministry of Jal Shakti, Government of India. Retrieved from http://164.100.47.194/Loksabha/Questions/QResult15.aspx?qref=15501&lsno=17

MoJS. (2020a). Roadmap to overcome floods. Lok Sabha Unstarred Question No. 3216. Ministry of Jal Shakti, Department of Water Resources, River Development & Ganga Rejuvenation, Government of India. Retrieved from http://164.100.24.220/loksabhaquestions/annex/173/AU3216.pdf

MoJS. (2019). Rajya Sabha, Unstarred Question No. 1647. Irrigation projects under PMKSY. Ministry of Jal Shakti, Department of Water Resources, River Development & Ganga, Government of India. Retrieved from https://rajyasabha.nic.in/rsnew/Questions/QResult.aspx

MoSPI. (2020a). Energy Statistics 2020. National Statistical Office Ministry of Statistics and Programme Implementation Government of India. Retrieved from http://www.mospi.gov.in/sites/default/files/publication_reports/ES_2020_240420m.pdf

MoSPI. (2020b). Sustainable Development Goals, National Indicator Framework, Progress Report 2020, version 2.1. Ministry of Statistics and Programme Implementation, Government of India. Retrieved from http://www.mospi.gov.in/sites/default/files/publication_reports/Sustainable_Development_Goals_National_Indicator_Framework_Progress_Report_2020_Version2.1.pdf

MoSPI. (2020c). Email communication dated 21 October 2020. Ministry of Statistics and Programme Implementation, Government of India.

MoSPI. (2020d). Press Note. First Revised Estimates of National Income, Consumption Expenditure, Saving and Capital Formation, 2018-19. Retrieved from http://www.mospi.gov.in/sites/default/files/press_release/Press_Note_NAD_31012020.pdf

Moulds, S., Buytaert, W. & Mijic, A. (2018). A spatio-temporal land use and land cover reconstruction for India from 1960–2010. Scientific Data 5:180159.

NITI Aayog. (2019a). SDG India, Index & Dashboard 2019-20. Retrieved from https://niti.gov.in/sites/default/files/SDG-India-Index-2.0_27-Dec.zip

NITI Aayog. (2019b). Annual Report 2019-20. Retrieved from https://niti.gov.in/sites/default/files/2020-02/Annual_Report_2019-20.pdf

NITI Aayog. (2020b). India VNR 2020. Retrieved from https://niti.gov.in/sites/default/files/2020-07/26281VNR_2020_India_Report.pdf

Negi, H. S., Kanda, N., Shekhar, M. S., & Ganju, A. (2018). Recent wintertime climatic variability over the North West Himalayan cryosphere. Current Science. 114(4), 760-770.

OECD. (2019). OECD Economic Surveys: India 2019, Organization for Economic Cooperation and Development. OECD Publishing, Paris. Retrieved from https://doi.org/10.1787/554c1c22-en

PIB. (2019a). Total Forest and Tree Cover rises to 24.56 per cent of the total geographical area of the Country. Ministry of Environment, Forest and Climate Change, Government of India. Retrieved from https://pib.gov.in/PressReleseDetailm.aspx?PRID=1597987

PIB. (2019b). 20th Livestock Census; Total Livestock population increases 4.6% over Census-2012, Increases to 535.78 million. Ministry of Fisheries, Animal Husbandry & Dairying, Government of India. Retrieved from https://pib.gov.in/PressReleasePage.aspx?PRID=1588304

PIB. (2019d). Promotion of Electric Vehicles. Ministry of Heavy Industries & Public Enterprises, Government of India. Retrieved from https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1576608

PIB. (2020e). Ministry of Agriculture & Farmers Welfare. Micro-Irrigation Fund corpus of INR 5000 crore also created with NABARD for special and innovative projects and incentivising micro-irrigation beyond the provisions under PMKSY-PDMC. Retrieved from https://pib.gov.in/PressReleseDetailm.aspx?PRID=1630606

PIB. (2020f). Ministry of Agriculture & Farmers Welfare. 200 Locust Circle Offices and temporary camps conducting survey & control operations. Retrieved from https://pib.gov.in/PressReleasePage.aspx?PRID=1627276

PIB. (2020g). States achieving the SDG target increase from 3 to 5. Ministry of Health and Family Welfare, Government of India. Retrieved from https://pib.gov.in/PressReleseDetailm.aspx?PRID=1639376

Pratap, B., Dobhal, D. P., Bhambri, R., Mehta, M., & Tewari, V. C. (2016). Four decades of glacier mass balance observations in the Indian Himalaya. Regional Environmental Change. 16(3), 643-658.

Panda, R. M., M. D. Behera, & P. S. Roy. (2018). Assessing distributions of two invasive species of contrasting habits in future climate. Journal of Environmental Management 213:478–488.

PMO. (2019). PM receives 'Global Goalkeeper Award' for Swachh Bharat Abhiyan. Retrieved from https://pib.gov.in/PressReleasePage.aspx?PRID=1586104#:~:text=Prime%20Minister%20Shri%20Narendra%20Modi,UNGA)%20session%20in%20New%20York

Rathore, B. P., Bahuguna, I. M., Singh, S. K., Brahmbhatt, R. M., Randhawa, S. S., Jani, P. & Rajawat, A. S. (2018). Trends of snow cover in Western and West–Central Himalaya during 2004–2014. Current Science 114(25), 800-807.

Reddy, C. S., Jha, C. S., Dadhwal, V. K., Krishna, P. H., Pasha, S. V., Satish, K. V., Dutta, K., Saranya, K., Rakesh, F., Rajashekar, G., & Diwakar, P.G. (2015). Quantification and monitoring of deforestation in India over eight decades (1930–2013). Biodiversity and Conservation 25, 93-116.

Roberts et al. (2014). Continuity of mammalian fauna over the last 200,000 y in the Indian subcontinent. Proceedings of the National Academy of Sciences April 2014, 111 (16) 5848-5853; doi: 10.1073/pnas.1323465111

Ramsar Sites Information Service. (2020). Retrieved from https://rsis.ramsar.org

Ravindranath, N. H. & Bala, G. (2019). Impact, vulnerability and adaptation to climate change in the forest sector in India. Report prepared as input to Third National Communication of Ministry of Environment, Forest and Climate Change. Indian Institute of Science, Bangalore.

Ramaswami, G. & Sukumar, R. (2013). Long-term environmental correlates of invasion by Lantana camara (Verbenaceae) in a seasonally dry tropical forest. PLoS ONE. 8(10): e76995. DOI:10.1371/journal.pone.0076995.

Ray, D., M. D. Behera, & J. Jacob. (2019). Comparing invasiveness of native and non-native species under changing climate in North-East India: ecological niche modelling with plant types differing in biogeographic origin. Environmental Monitoring and Assessment 191:793.

Sharma, P., Patel, L. K., Ravindra, R., Singh, A., Mahalinganathan, K., & Thamban, M. (2016). Role of debris cover to control specific ablation of adjoining Batal and Sutri Dhaka glaciers in Chandra Basin (Himachal Pradesh) during peak ablation season. Journal of Earth System Science. 125(3), 459-473.

Singh, Anoop Kumar., Kumar, Dhirendra., Kumar, Vinit., Singh & Sen, Dhruv. (2020). Study of temporal response (1976–2019) and associated mass movement event (during 2017) of Meru glacier, Bhagirathi valley, Garhwal Himalaya, India. Quaternary International. Volume 565, 12-21.

Sharma, A. K., Singh, S. K., & Kulkarni, A. V. (2013). Glacier inventory in Indus, Ganga and Brahmaputra basins of the Himalaya. National Academy Science Letters, 36(5), 497-505.

Singh, S. K., Rathore, B. P., & Bahuguna, I. M. (2014). Snow cover variability in the Himalayan–Tibetan region. International Journal of Climatology, 34(2), 446-452.

SBM. (2020). Swachh Bharat Mission Urban. Retrieved from http://swachhbharaturban.gov.in/

SBM. (2020a). Swachh Bharat Mission (Grameen). Retrieved from https://sbm.gov.in/sbmdashboard/

Sukumar, R., Dattaraja, H.S., Suresh, H. S., Radhakrishnan, J., Vasudeva, R., Nirmala, S. & Joshi, N.V. (1992). Long term monitoring of vegetation in a tropical deciduous forest in Mudumalai, southern India. Current Science 62: 608-616.

Sinha, B. et al. (2019). Developing climate change adaptation strategies for Sal and Teak dominated landscapes of central India. Report prepared as input to Third National Communication of Ministry of Environment, Forest and Climate Change. Indian Institute of Forest Management, Bhopal.

Transforming India. (2020). myGOV. https://transformingindia.mygov.in/?sector=farmer-welfare&type=en#scrolltothis

Thapa, S., V. Chitale, S. J. Rijal, N. Bisht, & B. B. Shrestha. (2018). Understanding the dynamics in distribution of invasive alien plant species under predicted climate change in Western Himalaya. PLOS ONE, 13:e0195752.

WHO. (2020). South-East Asia. World Health Organization. Retrieved from https://www.who.int/india/emergencies/coronavirus-disease-(covid-19)/india-situation-report

WHO. (2020a). Sustainable Development Goal 3: Health. Retrieved from https://www.who.int/topics/sustainable-development-goals/targets/en/

WHO/UNICEF JMP. (2017). Progress on Drinking Water, Sanitation and Hygiene: 2017 Update and SDG Baselines. Geneva: World Health Organization (WHO) and the United Nations Children's Fund (UNICEF), 2017. Licence: CC BY-NC-SA 3.0 IGO.

WHO/UNICEF JMP. (2019). Progress on household drinking water, sanitation and hygiene 2000-2017. Special focus on inequalities. New York: United Nations Children's Fund (UNICEF) and World Health Organization, 2019.

WMO. (2020). Cyclone Amphan highlights the value of multi-hazard early warnings. World Meteorological Organization. Retrieved from https://public.wmo.int/en/media/news/cyclone-amphan-highlights-value-of-multi-hazard-early-warnings

Waldron, A. (2020). Working paper analysing the economic implications of the proposed 30% target for areal protection in the draft post-2020 Global Biodiversity Framework. https://www.conservation.cam.ac.uk/files/waldron_report_30_by_30_publish.pdf

A reduction of 24% in emission intensity of India's GDP (excluding agriculture emissions) was achieved between 2005 and 2016.

Reduction in emission intensity
2005-2010: 12%
2005-2014: 21%
2005-2016: 24%

India is decoupling economic growth from emissions.

India's annual and cumulative emissions in absolute and per capita terms have been significantly low, and far less than its equitable share. India is not responsible for the problem of global warming, but we are and will be part of its solution.

Chapter 2
National Greenhouse Gas Inventory

Nishar, R. (2020). City View, Mumbai, Maharashtra.

Key Points

Chapter 2 National Greenhouse Gas Inventory

- India's GHG emissions in 2016 were 2,838,889 Gigagram of CO_2-equivalent (CO_2e) without Land Use, Land-Use Change and Forestry (LULUCF). The LULUCF sector remained a net sink. With the inclusion of both GHG emissions and removals from the LULUCF sector, net national emissions were 2,531,069 Gg of CO_2e.
- The energy sector contributed 75 per cent of emissions, followed by 14 per cent from agriculture, 8 per cent from IPPU and 3 per cent from waste. Total national emissions (including LULUCF) have increased by 9.75 per cent from 2014.
- In 2016, the CO_2 emissions from electricity production were the largest category, accounting for 39.53 per cent of total emissions occurring in the country, followed by CO_2 emissions from road transport accounting for 8.57 per cent and methane emissions from enteric fermentation accounting for 7.84 per cent.
- The top five key categories of emissions remained the same during the period 2014 to 2016, but their share in the total emissions was reduced.
- The share of CO_2 emissions from electricity production in total GHG emissions (without LULUCF) was 39.53 per cent in 2016 compared to 41.35 per cent in 2014. Similarly, CH_4 emissions from enteric fermentation were 7.84 per cent in 2016 compared to 8.71 per cent in 2014 while CO_2 emissions from iron and steel industries reduced to 4.75 per cent in 2016 from 5.90 per cent in 2014. It may be noted here that the access to electricity, the population of livestock and the production of iron and steel are all on the ascendance.
- The total emissions of the energy sector were 21,29,428 Gg CO_2e in 2016, increasing by 11.50 per cent from 2014. This sector constituted 93 per cent of total national CO_2 emissions in 2016. This was primarily from fossil fuel combustion, comprising energy industries and construction, manufacturing industries, transport and other sectors.
- The transport sector is largely oil-dependent and accounted for 9.67 per cent of the country's GHG emissions (without LULUCF).
- The industrial processes and product use (IPPU) category emitted 2,26,407 Gg of CO_2e in the year 2016 and accounted for 8 per cent of the total GHG emissions. Within IPPU, cement production is the largest emission source, accounting for about 47 per cent of total IPPU sector emissions.
- The agriculture sector in the year 2016, emitted 4,07,821 Gg of CO_2e, which amounted to around 14 per cent of the emissions of India for that year, registering a decrease of 2.25 per cent since 2014.
- The LULUCF sector was a net sink of 3,07,820 Gg CO_2e during 2016, registering an increase in the sink activity of the sector. Cropland dominates the CO_2

emissions/removal estimates for India for the year 2016. Forest land, Cropland and Settlement categories were net sinks while Grassland was a net source of CO_2. About 15 per cent of India's CO_2 emissions were offset by the LULUCF sector.

- The waste sector emitted 75,232 Gg CO_2e to total GHG emissions in 2016. The waste sector was dominated by emissions from wastewater handling which account for more than 79 per cent of the sectoral emissions and remaining 21 per cent emissions from solid waste disposal.
- India's annual and cumulative emissions in absolute and per capita terms have been significantly low, and far less than its equitable share. India is therefore entitled to increased emissions in the pursuit of development, based on the principles of equity and common but differentiated responsibilities and respective capabilities, principles that are foundational to global action against climate change and are enshrined, by mutual international agreement, in the United Nations Framework Convention on Climate Change.

Chapter 2
National Greenhouse Gas Inventory

2.1 General aspects

The chapter contains information on India's GHG inventory for 2016 including descriptions of methods, data sources, uncertainties, QA/QC activities carried out, along with trend analysis. In order to ensure the transparency, consistency, comparability, completeness and accuracy of the inventory, the chapter also contains information from the previous inventory submission.

As required by 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 of 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.

This chapter presents the estimates of anthropogenic GHG emissions from sources and removals by sinks for the inventory year 2016. The GHGs included in this report are CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6. It also contains a description of institutional arrangements for the inventory preparation, brief descriptions of the process of inventory preparation, methodologies and data sources used and the key sources in the inventory. In the end, there is information about the progress of QA/QC work, the general uncertainties in the inventory and on the completeness of inventoried emissions.

This inventory is organized according to the IPCC Guidelines, and covers the following sectors: Energy; Industrial Processes and Product Use (IPPU); Agriculture; Land Use, Land-Use Change and Forestry (LULUCF); and Waste. GHG removals by sinks occur in the LULUCF sector as a result of management activities in protected areas and reforestation. India has applied the Revised 1996 IPCC Guidelines (IPCC, 1996), 2003 IPCC Good Practice Guidance for Land Use, Land-Use Change, and Forestry (IPCC, 2003) and the 2006 IPCC guidelines (IPCC, 2006) for GHG Inventories. The 2006 IPCC guidelines have been followed to the extent possible, as per the extant capacities.

India's submission of its BURs is in keeping with its view of the paramountcy of the multilateral process under the UNFCCC to face the challenge of global warming. The uniform and timely submission of BURs of developing countries however cannot be considered on par with the submission of the Biennial Reports of the developed countries, who are to take the lead in climate action. It is also necessary to emphasize that these BRs, and the proposed Biennial Transparency Reports under the Paris Agreement, are no substitute for real climate action. For a large country like India, the preparation of the inventory is a considerable financial burden, that requires the mobilization of significant expertise for its preparation. 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 reporting requirements that have come to be part of not only the global climate regime but also a number of other environmental agreements and protocols should not lead to a situation where the undertaking of real action suffers from an over-emphasis on reporting.

2.2 Institutional Arrangements

Preparation of the national inventory involved the participation of India's scientific and research institutions, in addition to various government agencies. MoEFCC coordinates the preparation of the inventory, including by convening different expert institutions that collate sectoral information and conduct studies to obtain country-specific emission factors. The MoEFCC awards studies to expert institutions and establishes contact with other government agencies responsible for official statistics and data. After establishing these agreements, the technical team in charge of the inventory conducts technical discussions with the partners, monitors the updating and availability of information, and carries out quality control.

Twelve Indian institutions carried out the inventory preparation exercise in the areas of their respective sectoral expertise. Many of these institutions/experts have been a part of the inventory preparation exercise since India's Initial National Communication (MoEF, 2004). Various Ministries and Government departments, public sector undertakings provided inputs for preparation of the national inventory. Figure 2.1 lists the institutions engaged in inventory preparation in different sectors.

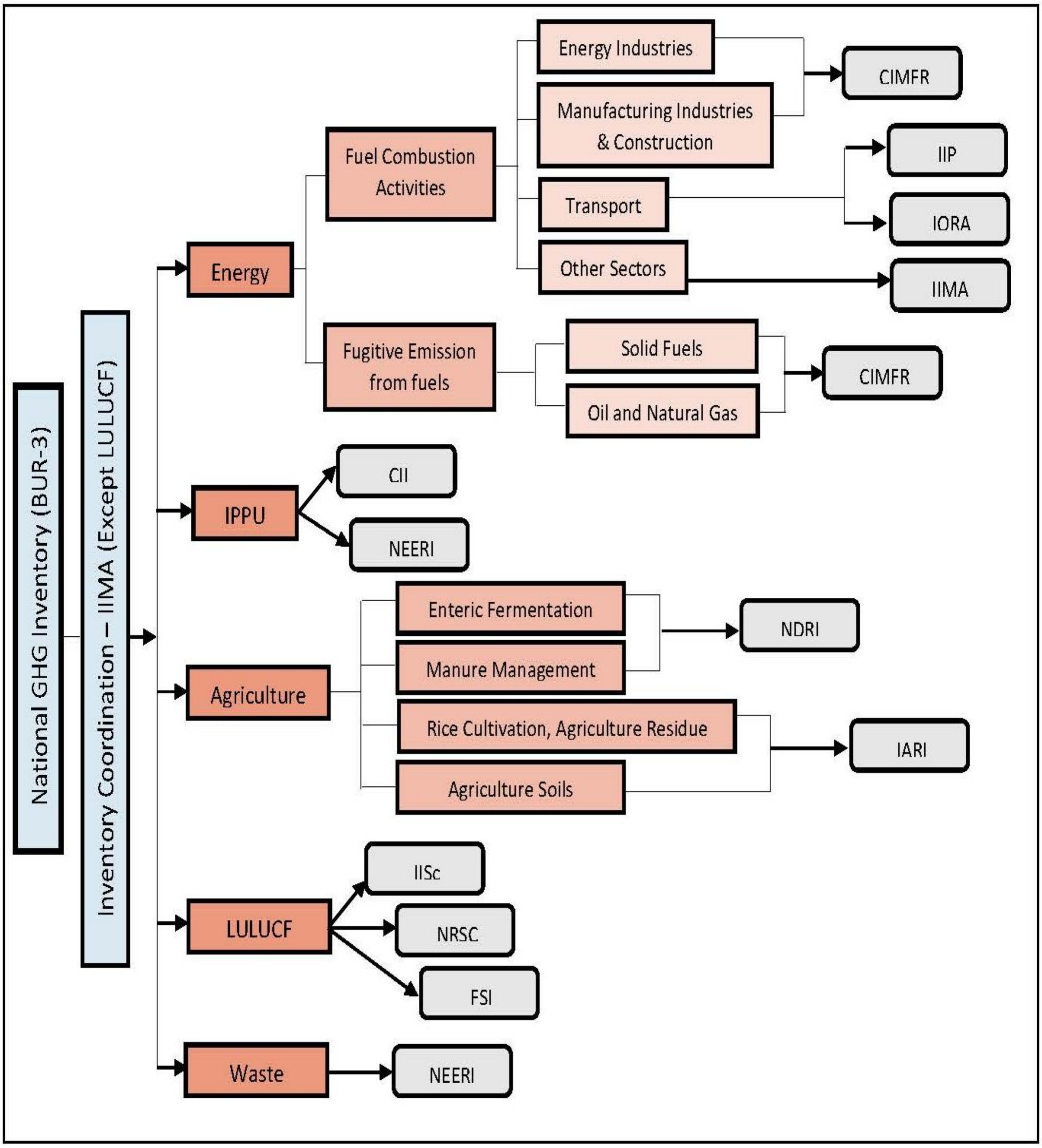


Figure 2.1: Institutions involved in GHG Inventory preparation

CII:	Confederation of Indian Industry, New Delhi
CIMFR:	Central Institute of Mining and Fuel Research, Dhanbad
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
IORA:	IORA Ecological Solutions, New Delhi
NDRI:	National Dairy Research Institute, Karnal
NEERI:	National Environmental Engineering Research Institute, Nagpur
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. A system of methodological tiers has been developed by IPCC to represent different levels of methodological complexity. Tier 1 uses an IPCC default value, Tier 2 uses country specific emission factors that are based on either measurements or IPCC Tier 2 emission factors, and Tier 3 is the most demanding in terms of complexity and data requirements. Tier 3 may include models and inventory management systems tailored to address national circumstances, repeated over time, and 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 in the Third 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	NO		NO		NO	
E. Production of halocarbons	NO		NO		NO	
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	D	T1	D
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. Waste-water 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 is a quantified measure of the globally averaged relative radiative forcing of a particular GHG (see Table 2.2). It is defined as the accumulated radiative forcing within a specific time horizon caused by emitting 1 kilogram (kg) of the gas, relative to that of the reference gas CO_2. Direct radiative effects occur when the gas itself absorbs radiation. Indirect radiative forcing occurs when chemical transformations involving the original gas produce a gas or gases that are GHGs, or when a gas influences other radiative important processes such as the atmospheric lifetimes of other gases. All calculations in the present report use the Global Warming Potential (GWP) of GHGs for 100 years, IPCC AR2 (IPCC, 1995).

Table 2.2: Global Warming Potentials Used

Gas	GWP (100 year)
CO_2	1
CH_4	21
N_2O	310
HFC-23	11700
HFC-134a	1300
CF_4	6500
C_2F_6	9200
C_4F_{10}	7000
C_6F_{14}	7400
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, 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. The quality system includes several procedures such as training of personnel, inventory planning and preparation, QA/QC procedures, peer-reviewed publications, data storage, and follow-up and improvements. The QA/QC plan also includes a scheduled timeframe describing the different stages of the inventory from its initial development to 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).

MoEFCC and other government agencies which take part in the climate-reporting work have to ensure that the methodologies applied in the reporting and inventories of emissions and removals attain the quality required to maintain the highest level of accuracy in climate reporting. The government agencies have to follow internal routines to plan, prepare, check and act/follow up the quality assurance and control work and consult one another with the aim of developing and maintaining a coordinated quality system. All Tier 1 general inventory level QA and QC procedures listed in the IPCC GPG section are used (IPCC, 2006a). In addition, the emission of every category is checked and compared with previous years. The time series for all data have been studied carefully in search for outliers and to make sure that levels are reasonable.

Quality Control

Quality control is the check that is made during the inventory preparation on different types of data, emission factors and calculations that have been made. The quality control takes place according to general requirements (Tier 1) which applies 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:

- Check whether assumptions and criteria for the selection of activity data, emission factors, and other estimation parameters were documented, compare with international agency estimates.
- Check for transcription errors in data input and references.
- Check that emissions and removals are calculated correctly.
- Check that parameters and units are correctly recorded and that appropriate conversion factors are used.
- Check the integrity of database files.
- Check for consistency in data between source categories.
- Check that the movement of inventory data among processing steps is correct.
- Check that uncertainties in emissions and removals are estimated and calculated correctly.
- Check time series consistency.
- Check completeness.
- Compare the reference and sectoral approach.

- Conduct trend checks.
- Review of internal documentation and archiving.

Quality Assurance

According to IPCC Good Practice Guidance, good practice for QA procedures requires an objective review to assess the quality of the inventory and to identify areas where improvements should be made. Furthermore, it is good practice to use QA reviewers who have not been involved in preparing the inventory. In India, MoEFCC is responsible for reviewing the inventory with regard to quality and areas for improvement. The following are the responsibilities/tasks to perform in order to prepare the national GHG inventory.

- Determining information needs to comply with the methodological requirements stipulated by the 2006 IPCC Guidelines.
- Preparation and sending of information queries to select data sources using official correspondence, telephone, and e-mail.
- Identification of potential data sources, including organizations and independent experts.
- Data collection (activity data and emission factors) for all source/sink categories for Energy, IPPU, Agriculture, Waste and LULUCF Sectors.
- Analysis of the information, so obtained for the possibility of its immediate use for calculation of emissions and reductions.
- Reliability check of input data through the comparison of the same or similar data from alternative data sources and time-series assessment in order to identify changes that cannot be explained.
- Data processing and archiving.
- Assessment of consistency of the methodologies applied, inventory improvement recalculations.
- Reliability check of results, elimination of errors.
- Development and implementation of QC procedures under supervision of MoEFCC.
- Implementation of Quality assurance conducted by MoEFCC staff and relevant experts
- Key category analysis.
- Uncertainty assessment.
- Final validation done by expert’s group and the steering committee through MoEFCC.
- Preparation of the final version of the inventory report.
- Documentation and archiving of all data used in preparation of the national inventory report.
- Submission of the inventory report by MoEFCC to UNFCCC Secretariat.

2.5 National Greenhouse Gas Emissions

In 2016, India’s total GHG emissions excluding LULUCF amounted to 2,839 $MtCO_2e$ and including LULUCF amounted to 2,531 $MtCO_2e$. Total national emissions (including LULUCF) have increased by 9.75 per cent with respect to 2014 and by 106 per cent since 1994 (Figure 2.2 and Table 2.3). The main contributors of the total GHG emission are CO_2 emissions generated due to burning of fossil fuels, methane emissions from livestock and increasing aluminium and cement production. The LULUCF sector was a net sink during the inventory period 2016.

Table 2.3: Sector-wise National GHG emission in $MtCO_2e$ for 1994-2016

GHG Sources and Removals	1994	2000	2007	2010	2014	2016
	Mt CO_2e					
Source	INC	SNC	SNC	BUR-1	BUR-2	BUR-3
Energy	744	1027	1374	1510	1910	2129
Industrial Processes and Product Use	103	89	142	172	202	226
Agriculture	344	356	373	390	417	408
LULUCF	14	-223	-177	-253	-301	-308
Waste	23	53	58	65	78	75
Total (without LULUCF)	1214	1524	1947	2137	2607	2839
Total (with LULUCF)	1229	1301	1772	1884	2306	2531

Source: (MoEF, 2004); (MoEF, 2012); (MoEF, 2010); (MoEFCC, 2015); (MoEFCC, 2018).

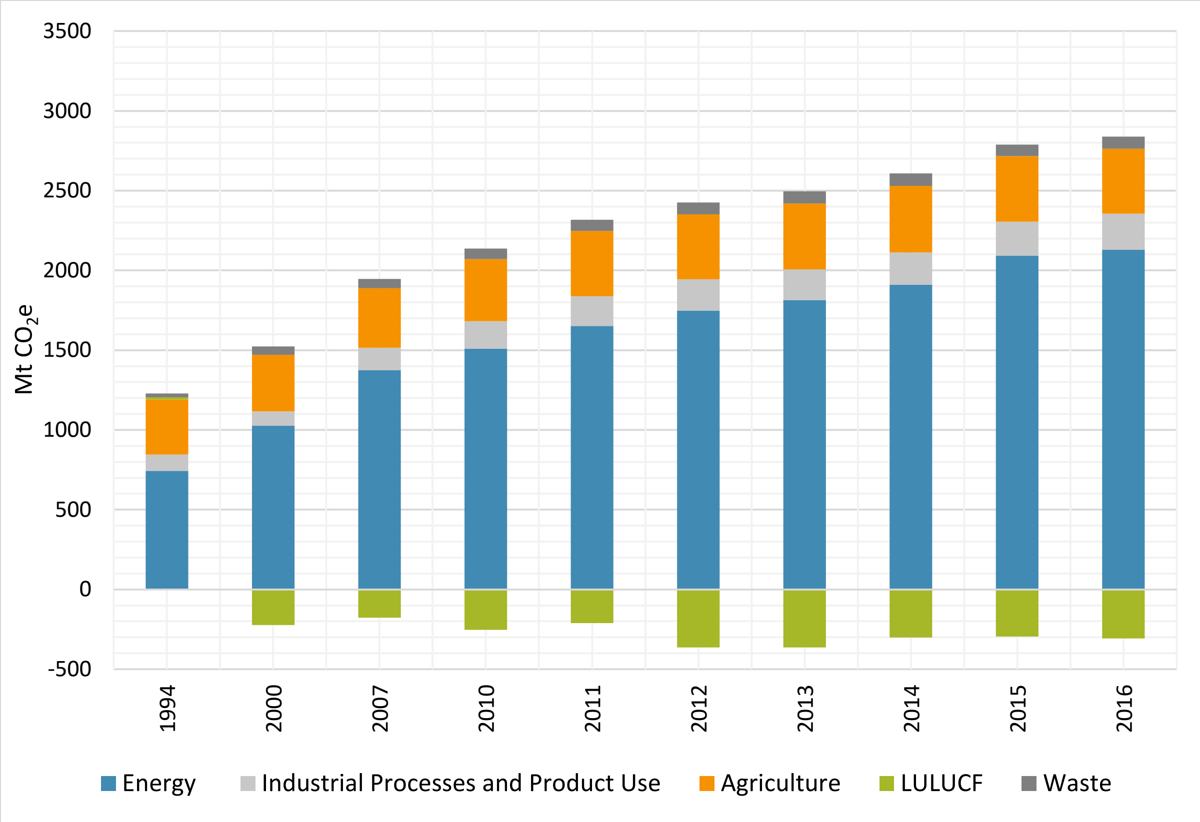


Figure 2.2: Sector-wise National GHG emission in Mt CO_2e for 1994-2016.
Source: (MoEF, 2004); (MoEF, 2012); (MoEF, 2010); (MoEFCC, 2016); (MoEFCC, 2018).

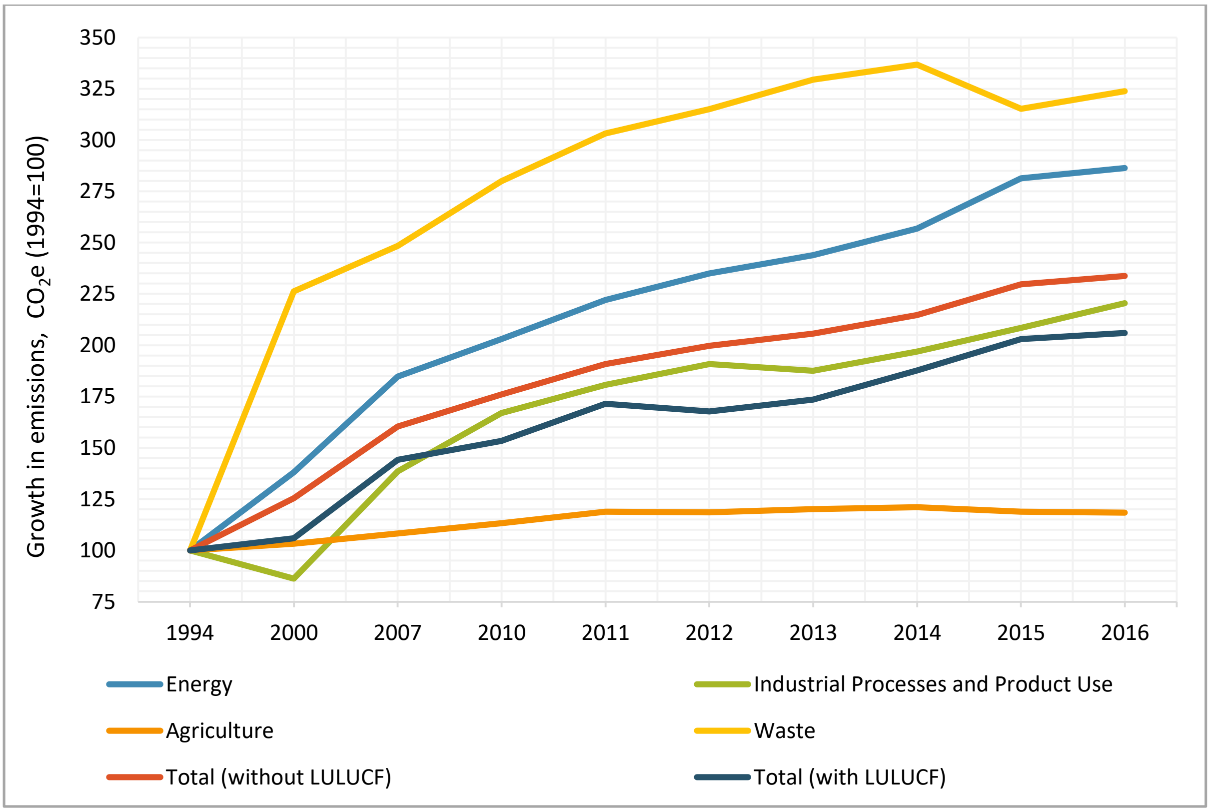


Figure 2.3: Growth in emissions of greenhouse gases, relative to 1994, illustrated by source categories, 1994-2016. Index 1994 = 100.
Source: (MoEF, 2004); (MoEF, 2012); (MoEF, 2010); (MoEFCC, 2016); (MoEFCC, 2018).

Activity data and country specific emission factors used in the inventory preparation have been listed in a tabular format in the sector-wise emission section. India has used IPCC 2006 guidelines default emission factors wherever emission factors have not been indicated. India has experienced substantial economic growth since 1994, generating a general growth in GHG emissions. Examining the overall trend from 1994 to 2016, CO_2e emissions (without LULUCF) increased by 134 per cent. The waste sector has the highest growth of 224 per cent over the period of 1994 to 2016 due to the increase in population and industrial activities, but its contribution to overall emissions always remains around 3 per cent, as their absolute contribution is very low. Energy sector has the second-highest growth of 186 per cent for the same period due to continuous increase of fossil fuel combustion. IPPU sector has growth of 120 per cent and Agriculture sector has 18 per cent growth for same period. (Figure 2.3). Removals of GHGs from LULUCF sector has reported growth of 38 per cent between 2000 and 2016.

2.5.1 Summary GHG Emission in 2016

In 2016, India emitted 28,38,889 Gg of CO_2e GHGs from Energy, IPPU, Agriculture and Waste sectors. LULUCF sector remained a net sink in 2016, accounting for the removal of 3,07,820 GgCO_2e of emissions. Considering total emissions and removals, net national emissions in 2016 were 25,31,069 GgCO_2e. The energy sector contributed the most to the overall emissions with 75 per cent, followed by agriculture sector 14 per cent, IPPU by 8 per cent and Waste by 3 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 emission in Gg for 2016.

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	2064840	NO	2072	68	NO	NO	NO	NO	2129428
IPPU	166227	NO	187	11	2	4	1	0.004	226407
Agriculture	0	NO	14423	339	NO	NO	NO	NO	407821
LULUCF	21289	330765	55	2	NO	NO	NO	NO	-307820
Waste	NO	NO	2820	52	NO	NO	NO	NO	75232
Memo Items	789305	NO	1	0.13	NO	NO	NO	NO	789359
Total without LULUCF	2231068	---	19502	469	2	4	1	0.004	2838889
Total with LULUCF	2252356	330765	19557	471	2	4	1	0.004	2531069

Abbreviation: NO – Not Occurring.

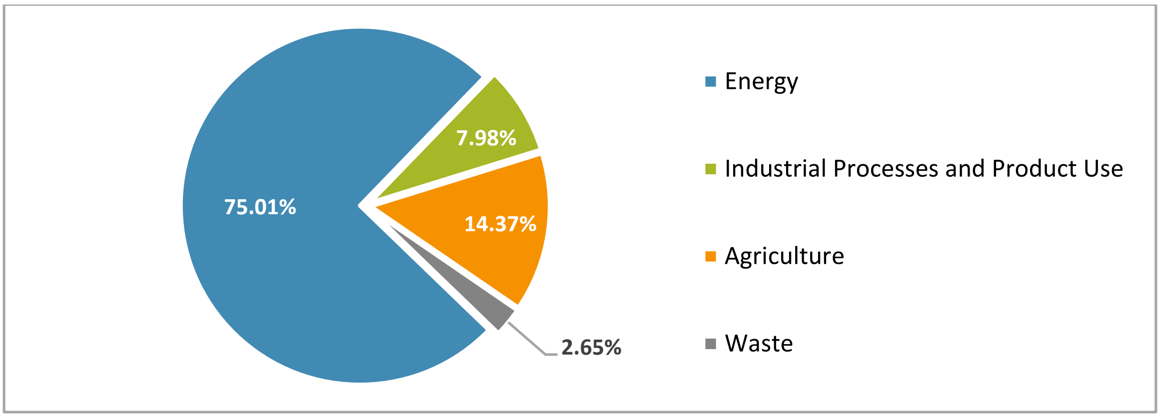


Figure 2.4: Distribution of GHG emissions (GgCO_2e) by sector, 2016

Energy sector emissions comprises of emissions from electricity production (1A1a-CO_2), contributing 40 per cent of the total emissions; road transport (1A3b-CO_2), 9 per cent of the total emissions; non-specific industries (1A2m-CO_2), 5 per cent of the total emissions; iron and steel (1A2a-CO_2), 4 per cent of the total emissions; residential (1A4b-CO_2), 3 per cent of the total emissions; refinery (1A1b-CO_2), 2 per cent of the total emissions; commercial/institutional (1A4a-CO_2), 2 per cent of the total emissions and cement (1A2f-CO_2), 2 per cent of the total emissions. Emissions from enteric fermentation (3A1-CH_4) are 8 per cent of the total emissions, while rice cultivation (3C7-CH_4), agricultural soils (3C4-N_2O) and manure management (3A2-N_2O) contribute 3, 3 and 1 per cent of the total emissions respectively. In the Industrial processes and product use sector, cement production (2A1-CO_2), aluminium production (2C3-CF) and lime production (2A2-CO_2) contribute 4, 1 and 1 per cent of total emissions respectively (Figure 2.5). Figure 2.5 shows the top 15 key emission categories for India for 2016 in terms of CO_2e.

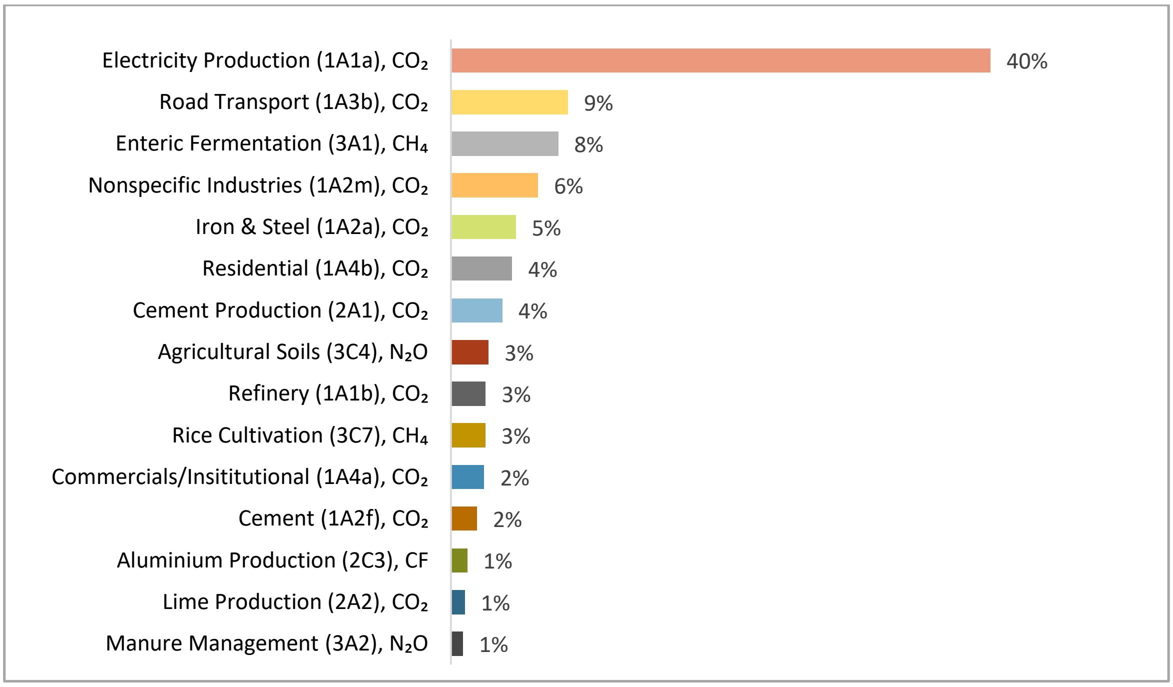


Figure 2.5: Greenhouse gas emissions by category, GgCO_2e, 2016.

2.6 Emission trends by gas

In 2016, GHG emissions excluding LULUCF at the national level by type of gas were as follows: emissions of CO_2 accounted for 22,31,068 Gg (78.59 per cent); CH_4 emissions accounted for 4,09,537 $GgCO_2e$ (14.43 per cent) and N_2O emissions accounted for 1,45,469 $GgCO_2e$ (5.12 per cent). In the case of fluorinated gases, emissions of HFC were 19,259 $GgCO_2e$ (0.68 per cent), CF_4 emissions 24,158 $GgCO_2e$ (0.85 per cent), C_2F_6 emissions 9,298 $GgCO_2e$ (0.33 per cent) and SF_6 emissions 100 $GgCO_2e$ (Figure 2.6).

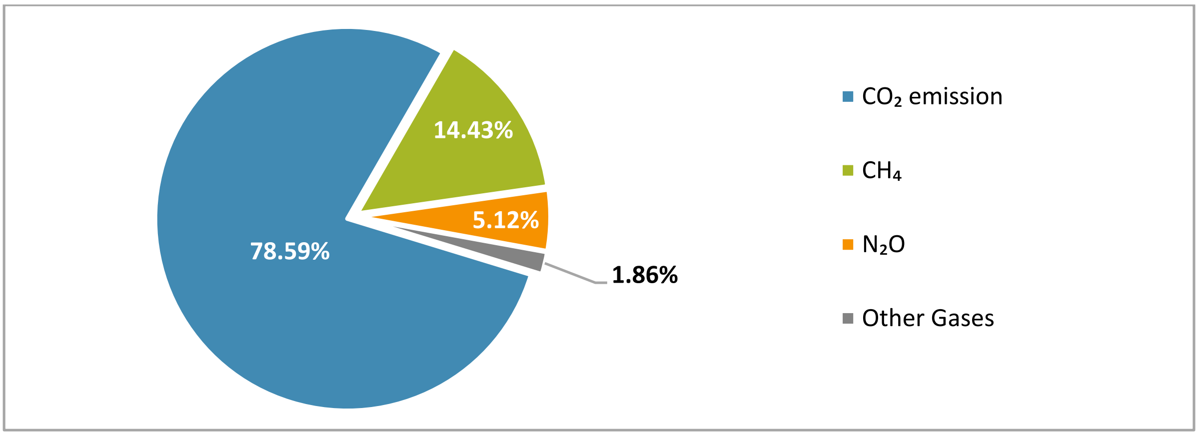


Figure 2.6: Gas-wise emission for the year 2016

2.7 Emission trends by sources

2.7.1 Energy sector

The Energy sector, which includes the consumption of fossil fuels in the country and their associated fugitive emissions, is the main GHG emitting sector in the country, contributing to 75 per cent of the total GHG emissions in 2016 (excluding LULUCF). The total emissions from the energy sector were 21,29,428 Gg CO_2e in 2016, increasing by 11.5 per cent since 2014, mainly due to the steady increase in the country's energy consumption, including the consumption of coal and natural gas for power generation and the consumption of liquid fuels for transportation. Figure 2.7 shows the relative distribution of GHG emissions across the energy sector.

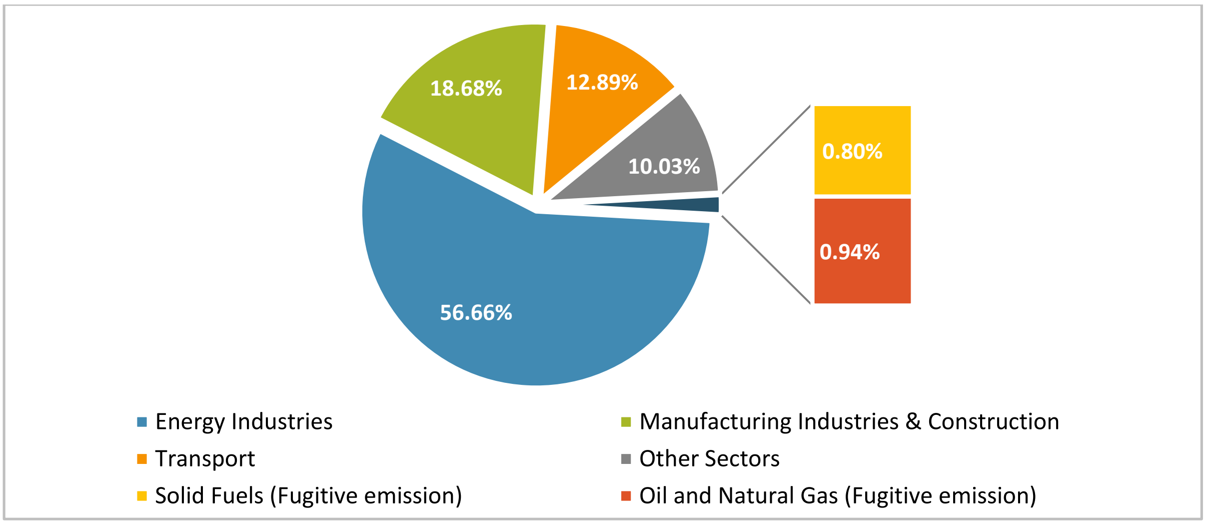


Figure 2.7: Distribution of CO_2e emissions (Gg) across the Energy Sector Categories in 2016

Energy sector emitted 93 per cent of the total national CO_2 emissions in 2016. This was primarily from fossil fuel combustion activities, comprising energy industries, manufacturing industries, transport and other sectors. Within the energy sector, 98.25 per cent of total emissions are from fuel combustion activities. Fugitive emissions contributed to 1.75 per cent of the total GHG emissions from the energy sector.

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 were 20,92,250 $GgCO_2e$ emission in the year 2016, which has increased by 2,20,541 Gg (12 per cent) from 2014 levels. Within the category, energy industries are the largest contributor with a 58 per cent (12,06,587 $GgCO_2e$) of total emissions, followed by 19 per cent (3,97,739 $GgCO_2e$) from manufacturing industries and construction, 13 per cent (2,74,434 $GgCO_2e$) from transport and 10 per cent (2,13,490 $GgCO_2e$) from other sectors in 2016 (Figure 2.8).

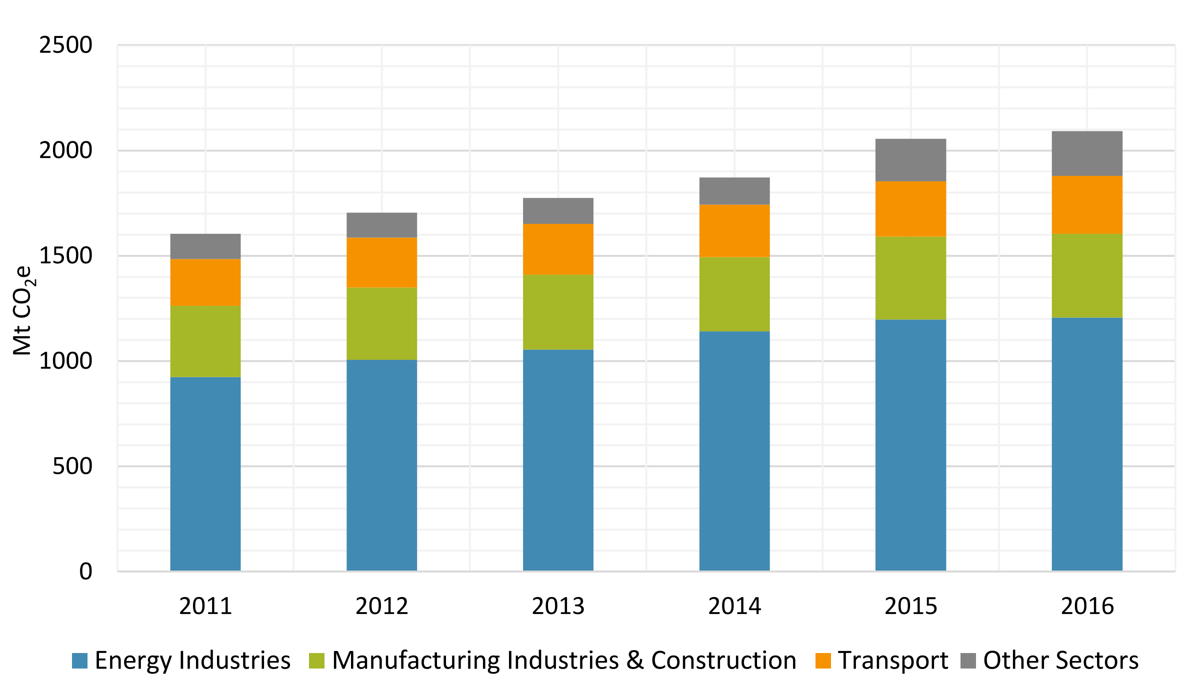


Figure 2.8: Fuel combustion activities: GHG emissions ($MtCO_2e$) per subcategory, 2011-2016

Energy industries (1.A.1)

This subcategory considers GHG emissions due to fossil fuels combustion for energy production industries and fuel extraction. Electricity production is accounted for approximately 40 per cent of the total national emissions without LULUCF in 2016, which is the highest emitting category in India. In 2016, these emissions accounted for 11,27,732 $GgCO_2e$, increasing 4 per cent (44,294 $GgCO_2e$) since 2014. Within this subcategory, the main activities are electricity and heat production contributing 93.5 per cent, followed by 6 per cent from petroleum refining and 0.5 per cent from manufacture of solid fuels and other energy industries. The consumption patterns of the fuels in energy industries have been shown in Table 2.5 and Figure 2.9. The Table 2.6 shows the overall country-specific emission factors used in energy industries' emission estimation. It may be noted that for specific categories, namely power generation, iron and steel industries, cement and a few other industries, sector-specific conversion factor and carbon emission factors have been estimated (Table 2.8).

Table 2.5: Category wise fuel consumption in the energy industries (1A1) in 2015 and 2016.

Fuel consumption (TJ)	Electricity and heat production (1A1a)		Petroleum refining (1A1b)		Manufacture of solid fuels and other energy industries (1A1c)	
	2015	2016	2015	2016	2015	2016
Liquid fuels	172487	144706	-	-	-	-
Gaseous fuels	494610	529086	1145934	1254148	-	-
Solid fuels	11182062	11226259	-	-	572464	496792

Abbreviations: NA – Not Applicable, IE – Included elsewhere.

Sources: (CEA, 2015, 2016, 2017); (MoC, 2015, 2016, 2017); (CMIE, 2019); (MoC, 2015a, 2016a, 2017a); (MoPNG, 2014, 2015, 2016); (MoSPI, 2015, 2016) (MoPNG, 2015a, 2016a, 2017a); (CEA, 2015a, 2016a, 2017a).

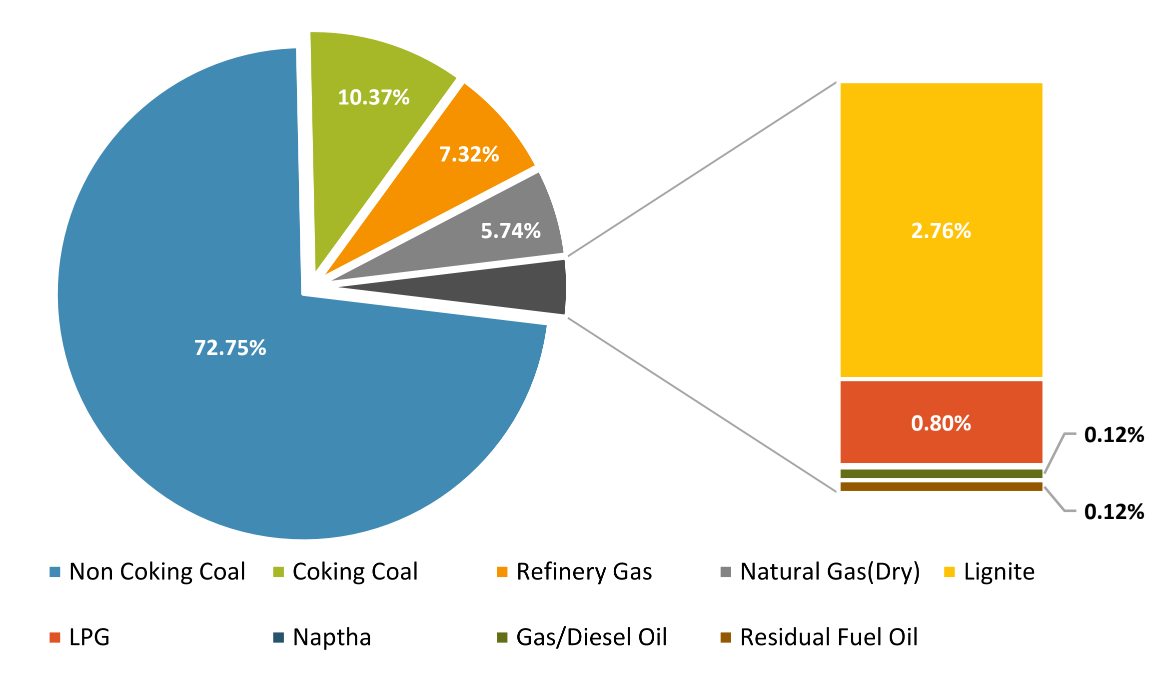


Figure 2.9: Share of fuel consumption for energy industries for the year 2016

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	--	--

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 2016, GHG emissions accounted for 3,97,739 GgCO_2e, which was 18.68 per cent of total CO_2e emissions from the energy sector, category emission was increasing by 13.02 per cent (45,830 GgCO_2e) since 2014. Although there has been an increase in the overall emission in the sector, there has been downward trend for the Iron & Steel, Chemical, Pulp & Paper, Textile/Leather and Bricks categories. Cement, Nonferrous Metal and Nonspecific categories played key role in increasing emissions from 2014 to 2016. Within the subcategory, Non-specific Industries contribute the most with 45.68 per cent, followed by 34 per cent by Iron and Steel industry, 13.49 per cent by Cement industry, 1.94 per cent by Non-ferrous metals, 1.51 per cent by Fertilizer industry, 1.03 per cent by Mining and Quarrying and less than 1 per cent by Chemical, Pulp and Paper, Textile/Leather and Bricks and engineering sectors individually (Figure 2.10 and Table 2.7).

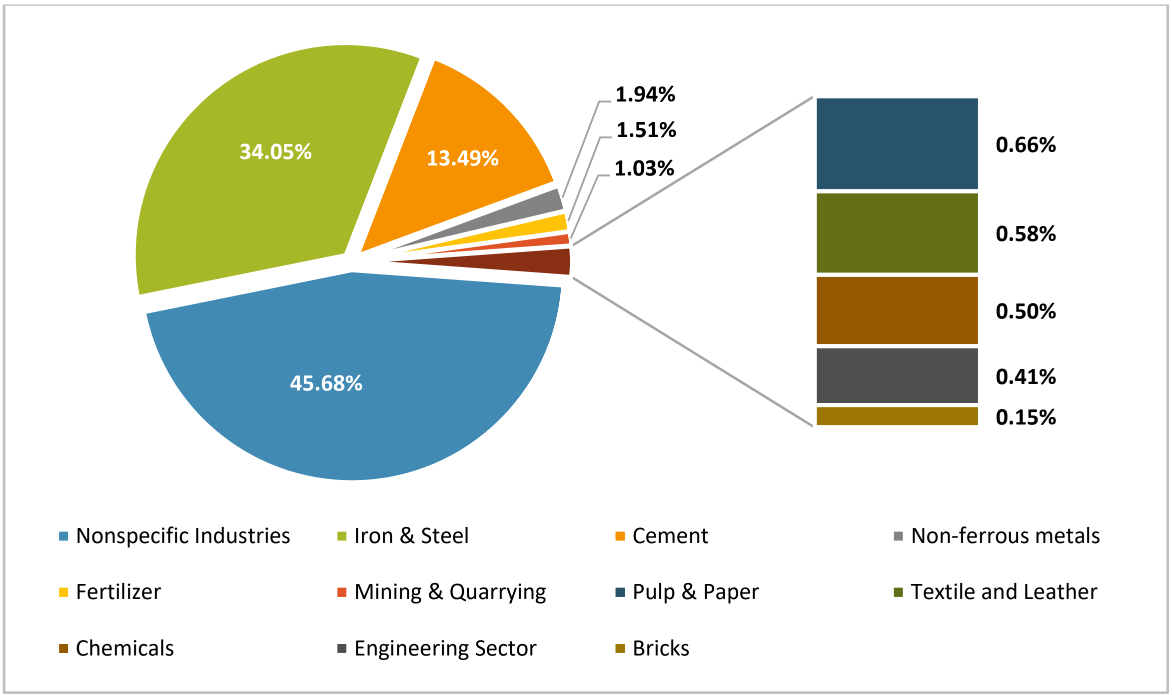


Figure 2.10: Distribution of CO_2e emissions (Gg) across the manufacturing industries & construction categories in 2016

Table 2.7: Category wise fuel consumption in the manufacturing industries & construction (1A2) in 2015 and 2016.

Fuel consumption (TJ)	Liquid fuels		Solid fuels		Gaseous fuels	
	2016	2015	2016	2015	2016	2015
Iron & steel (1A2a)	45,951	45,951	1,392,348	1,486,452	38,394	21,439
Cement (1A2f)	7889	8796	546,182	502,486	-	-
Non-ferrous metals (1A2b)	11,169	9916	70,640	8117	-	-
Pulp & paper (1A2d)	-	-	26,721	28,958	-	-
Chemicals (1A2c)	15,158	14,351	8428	9533	-	-
Mining & quarrying (1A2i)	54,994	51,070	-	-	-	-
Textile and leather (1A2l)	4737	5054	18,809	25,976	-	-
Bricks (1A2k)	-	-	5903	5708	-	-
Fertilizer (1A2e)	20,672	19,496	47,205	50,122	-	-
Engineering sector (1A2h)	22,071	19,035	-	-	-	-
Nonspecific industries (1A2m)	211,930	200,722	16,18,257	1,582,322	184,194	219,314

Sources: (MoPNG, 2015a, 2016a, 2017a); (CMIE, 2019); (MoS, 2015, 2016, 2017).

India specific emission factors of coal have been derived from the analysis of a large number of coal samples of different categories found in India. Summary of sector specific and country-specific values are presented in Table 2.8.

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						
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						

Transport (1.A.3)

This subcategory includes GHG emissions generated by fossil fuels burning in all activities of national transportation (aerial, terrestrial, railways and navigation), excluding military operations (maritime and aerial). Emissions from the transport sector are 2,74,434 GgCO_2e which is about 13 per cent of the total GHG emissions from the energy sector in the country for the year 2016, and also the second highest emission category for India without LULUCF. It has increased by 10 per cent (24,261 GgCO_2e) from 2014 levels, mainly due to higher fuel consumption and improvement of the road infrastructure in the country.

The road transport sector accounted for 90 per cent of the total GHG emissions from the transport sector, followed by civil aviation (6 per cent), railways (3 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. For railways, data has been sourced from the statistics published by the Ministry of Railways (MoR), GoI.

Table 2.9: Category wise fuel consumption in the road transport (1A3b) in 2015 and 2016.

Fuel consumption (TJ)		2015	2016
Road transport	Petrol	930,506	1,043,945
	Diesel	1,932,352	1,971,517
	Light distillate oil	9	-
	Fuel oil	1817	1492
	Compressed natural gases	103,440	113,520
	Liquefied petroleum gases	8084	7912
Off Road (Tractors)	Diesel	237,527	241,918

Sources: (MoPNG, 2015a, 2016a, 2017a), (PPAC, 2019).

The Railways sector consumes electricity, diesel, petrol, furnace oil and nominal amounts of coal. To avoid double counting, GHG emissions due to consumption of electricity 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) in 2015 and 2016.

Fuel consumption (TJ)	2015	2016
Coal	39.63	34.42
Wood	0.16	0.06
High speed diesel	103,948.56	102,180.42
Light diesel oil	0.78	0.62
Petrol	2.59	2.41
Kerosene	108.63	97.52

Source: MoR, 2015, 2016, 2017.

For the aviation sector, comprising of domestic and international aviation, segregated Aviation Turbine Fuel (ATF) consumption data for both the 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 India, 1,81,312 TJ and 1,96,273 TJ of aviation turbine fuel were consumed in 2015 and 2016, respectively.

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

Table 2.11: Category wise fuel consumption in the navigation (1A3d) in 2015 and 2016

Fuel Consumption (TJ)	2015	2016
Fuel oil	9098	9384
High speed diesel oil	31,677	29,528
Light diesel oil	104	250

Source: MoPNG, 2015a, 2016a, 2017a.

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 2016, the other sectors together emitted 2,13,490 Gg of CO_2e, of which approximately 60 per cent was contributed by the residential sector, about 32 per cent by the commercial sector and rest 8 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 2015 and 2016

Fuel consumption (TJ)	Commercial/ institutional (1A4a)		Residential (1A4b)		Agriculture/Forestry /Fishing (1A4c)	
	2015	2016	2015	2016	2015	2016
Coking coal	59,150	66,248	44,954	49,686	-	-
Non coking coal	49,99,77	57,52,80	26,81,12	32,53,80	-	-
Natural gas	32,473	34,522	26,16,86	33,01,67	8900	8845
Liquefied petroleum gases	69,247	84,005	81,27,09	89,25,98	325	359
Other kerosene	2803	3373	29,12,26	22,79,35	-	-
Gas/diesel Oil	-	-	-	-	26,545	26,428
Residual fuel Oil	-	-	-	-	2277	2119

Source: (MoPNG, 2015a, 2016a, 2017a); (PPAC, 2019); (IEA, 2020); (MoC, 2015a, 2016a, 2017a).

Comparison with reference and sectoral approach

A comparison of CO_2 emissions results obtained with the reference approach and the sectoral approach allows 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.

The reference approach was also used to estimate CO_2e emissions from fuel combustion for the year 2016. The difference in estimates of CO_2 emissions from fuel combustion using the sectoral and reference approaches was around 7 per cent in 2015, and 6 per cent in 2016. It is proposed to work on refining the GHG estimates in future communications and reduce the gap. 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 2016.

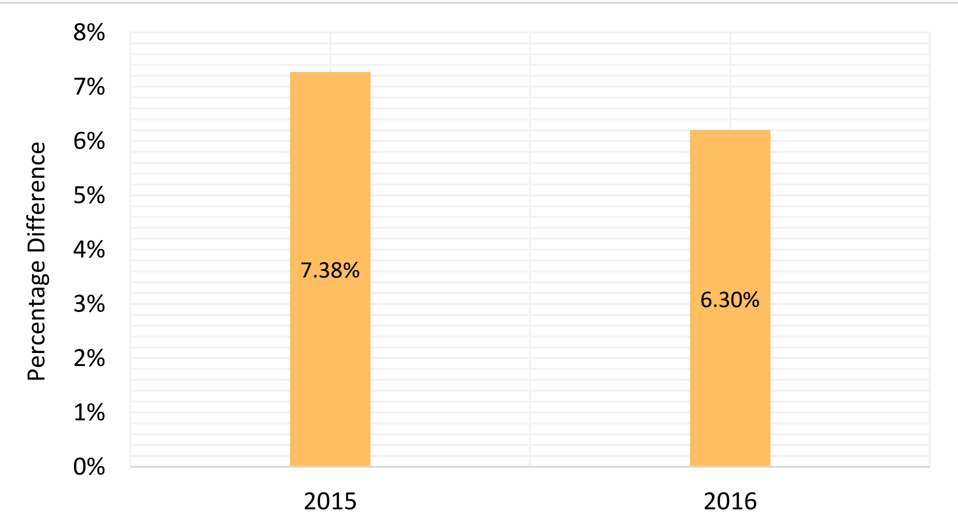


Figure 2.11: Percentage difference between CO_2 emission with the Sectoral approach and the Reference approach, 2015-2016

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 2016 were 37,179 GgCO_2e, of which 46 per cent were from coal mining and post mining operations and 54 per cent were from oil and natural gas production and handling systems. Fugitive emissions to the atmosphere have registered a decrease of 2 per cent between 2014 and 2016, mainly due to reduction in oil and gas production and gas processing levels.

Solid fuels (1.B.1)

Methane is the major GHG emitted during coal mining and handling. For estimating methane emissions, activity data on coal production from surface and underground mines was collected. Emissions from surface mining increased by 7 per cent and underground mining decreased by 3 per cent over the period 2014-2016. Underground coal production data from underground mines is available under different categories (like Degree I, II and III). Due to a very few number of 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.

Emission factors for fugitive methane emissions (both underground and above ground mining) is the amount of methane generated per tonne of coal production. Several measurements were conducted for the determination of fugitive methane emission factors for coal mining and handling activities. The list of country-specific emission factors for fugitive methane emission from coal mining and handling activities is presented in Table 2.13. 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 (m^3/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 2015 and 2016

Operation (Mining / Post mining)	**Coal production (million tonne)**			
	Surface mining	Underground mining		
		Degree - I	Degree - II	Degree - III
Mining and handling (2015)	607.83	54.91	9.61	0.39

Mining and handling (2016)	626.41	56.59	9.9	0.4

Sources: (MoC, 2015a, 2016a, 2017a); (DGMS, 2015).

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, 2019).

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. Emission due to leakage/venting and flaring decreased by 8.2 per cent, while total emission from oil and gas systems decreased by 6.75 per cent over the period of 2014-2016. The data on flaring activities from the oil and gas sector to estimate CO_2 emissions needs further refinement in future reporting. As per the assessment, the associated fugitive CO_2 emissions are much less and considered as insignificant.

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 system in India is presented in Table 2.15.

Table 2.15 Methane emissions from oil & gas systems in India (Gigagram) (2015-2016)

Year	Wells	Oil Production	Refinery Throughput	Gas Production	Gas Processing	Gas distribution	Leakage	Flaring	Total Emission
2015	53	12	15	117	336	274	166	0.6	975
2016	55	12	17	112	330	267	162	0.6	955

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 7.98 per cent of GHG emissions (without LULUCF) in 2016. The same year, their emissions reached 2,26,407 $GgCO_2e$, increasing by 12 per cent since 2014 mainly due to the increase in the production of lime, aluminium, ethylene and ammonia (Figure 2.12). List of country-specific emission factors used in the IPPU sector are listed in the Table 2.20.

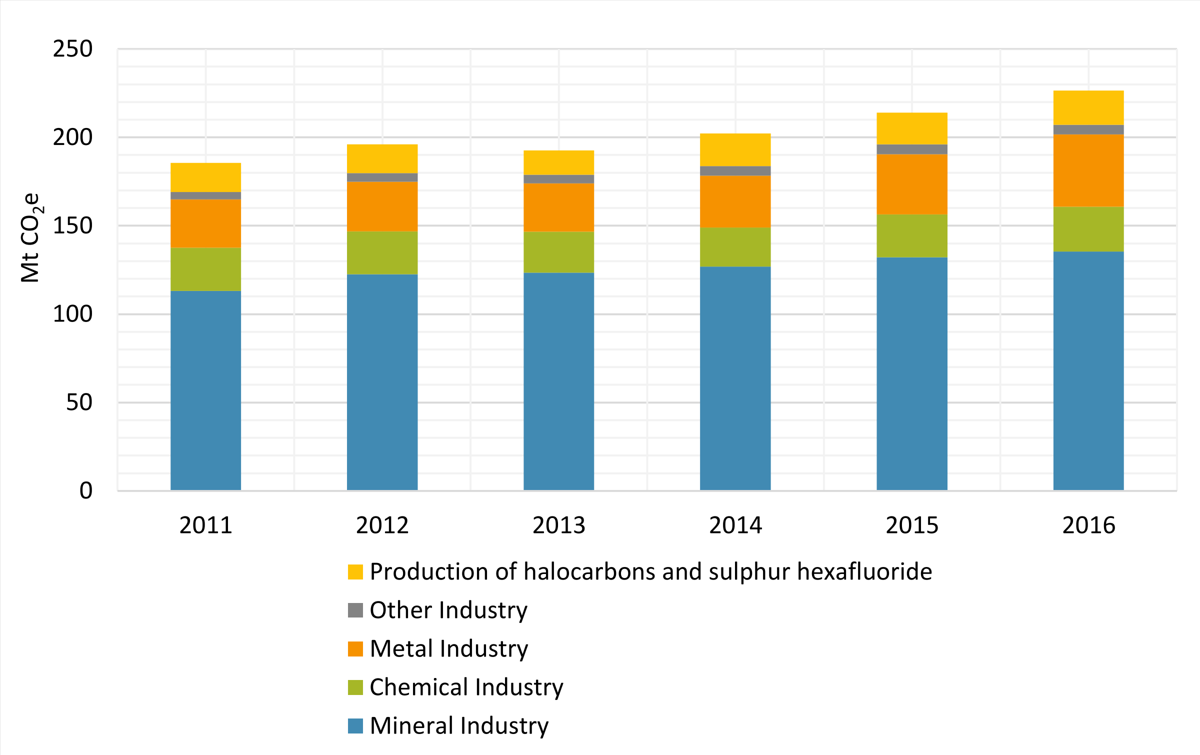


Figure 2.12: Industrial Processes and Product Use: GHG emissions ($MtCO_2e$) per subcategory, 2011-2016

The category includes the emission estimates of CO_2, CH_4, N_2O, HFC-23, CF_4, C_2F_6, and SF_6. In 2016, the main GHG emitted by the sector was CO_2, representing 73.4 per cent of the total GHG emissions in the sector, followed by CF_4 with 10.67 per cent, HFC with 8.51 per cent, C_2F_6 with 4.11 per cent and N_2O with 1.52 per cent. CH_4 amounts to 1.73 per cent of the emissions and SF_6 to 0.04 per cent (Figure 2.13).

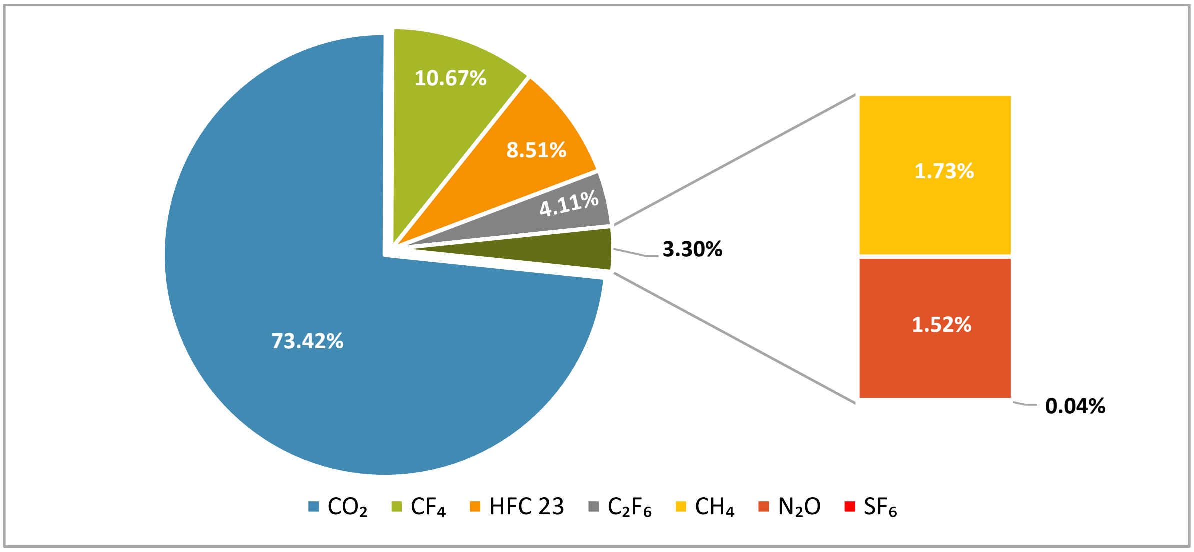


Figure 2.13: Gas wise distribution of emissions from IPPU sector in 2016

Mineral industries (2.A)

This category includes CO_2 emissions related to the processes resulting from the use of carbonated raw materials in the production and use of a variety of industrial mineral products. There are two broad pathways for release of CO_2 from carbonates: calcination and the acid-induced release of CO_2. The process-related CO_2 equivalent emissions for the year 2016 from Cement, Lime, Glass and Ceramics are 1,06,591 Gg (79 per cent), 28,480 Gg (21 per cent), 377 Gg (0.28 per cent) and 20 Gg (0.01 per cent) respectively.

In India, about 97 per cent of the total production of limestone during 2016-17 was of cement grade and 3 per cent of other grades (IMYB, 2019). GHG emissions associated with use of limestone in cement manufacturing sector have been accordingly apportioned to avoid any double counting.

Table 2.16: Types of production in the mineral industries (2A) during 2015 and 2016.

Production/consumption (million tonne)	2015	2016
Clinker production	207.19	201.42
Quick lime production	173.47	178.72
Dolomitic lime production	2.67	2.07
Glass (Float, Sheet, Bottles) production	2.469	2.465
Mass of calcium carbonate consumed	0.0204	0.0220
Mass of dolomite consumed	0.0218	0.0235

Sources: (CMA, 2015, 2016, 2017); (MoM, 2015, 2016); (AIGMF, 2015, 2016); (MoM, 2015, 2016).

Chemical industries (2.B)

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

In 2016, GHG emissions from this sector accounted for 25,358 GgCO_2e, an increase of 14.36 per cent since 2014. This is due to increase in production of ammonia, nitric acid, ethylene and carbon black. For the same period emissions from methanol and acrylonitrile decreased. Within the category, ammonia production was the highest, with total CO_2 emissions of 11,539 Gg in 2016, followed by emissions from ethylene production 7,883 GgCO_2e, emissions from nitric acid production is 3,202 GgCO_2e, emissions from soda ash production 888 GgCO_2e, emissions from carbon black production 829 GgCO_2e, emissions from EDM & VCM production 288 GgCO_2e, emissions from caprolactam production 242 GgCO_2e, emissions from ethylene oxide production 188 GgCO_2e, emissions from methanol production 125 GgCO_2e, emissions from carbide production 93 GgCO_2e and titanium dioxide production 81 GgCO_2e (Figure 2.14).

Table 2.17: Types of production in the chemical industries (2B) during 2015 and 2016.

Production (million tonne)	2015	2016
Ammonia production	14.75	14.93
Nitric acid production	1.532	1.589
Caprolactam production	0.0862	0.0867
Calcium carbide production	0.0843	0.0846
Titanium dioxide production	0.0558	0.0584
Soda ash production	2.646	2.749
Carbon black production	0.463	0.518
Methanol production	0.174	0.173
Ethylene production	3.593	3.948
Ethylene dichloride production	0.279	0.281
Vinyl chloride monomer production	0.072	0.791
Ethylene oxide production	0.187	0.209
Acrylonitrile production	0.01000	0.00048

Sources: (MoC&F, 2015, 2016); (FAI, 2019); (CMIE Prowess, 2019); (MoC&F, 2015a, 2016a); (AMAI, 2015, 2016)

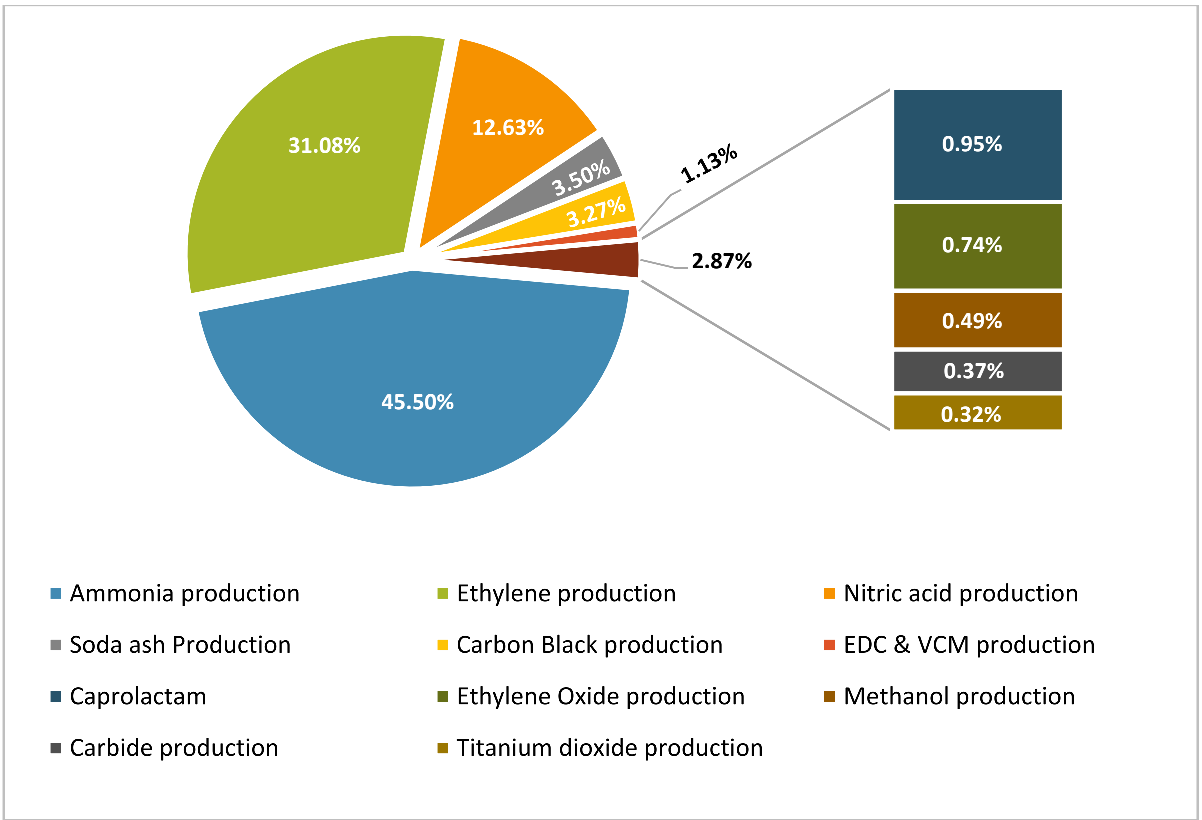


Figure 2.14: Distribution of CO_2e emissions (Gg) across the Chemical Industries Categories in 2016

Metal industries (2.C)

This category includes GHG emissions resulting from the production of metals such as ferroalloys, lead, zinc, aluminum and magnesium. Metallurgical coke related process emissions in Iron & Steel making have been reported under the energy sector. The total CO_2 equivalent emissions from metal industries for 2016 are 40,814 Gg, which was 39.6 per cent higher than 2014 levels. This may be attributed to the increased production of aluminium. Aluminium industry emissions cover 93 per cent of the emissions of the metal industries in India and also a key emission category in India. Magnesium production is the single estimated source of SF_6 for 2016 emitting 100.95 $GgCO_2eq$.

Table 2.18: Types of production in the metal industries (2C) during 2015 and 2016.

Production (million tonne)	2015	2016
Ferro chromium	0.944	0.944
Ferro manganese	0.518	0.518
Ferro silicon	0.090	0.090
Silico manganese	0.264	0.292
Aluminium	2.272	2.761
Lead	0.140	0.142
Zinc	0.752	0.693
Magnesium	0.0002	0.0002

Source: (MoM, 2015, 2016); (Brown, et al., 2019); (MoC&F, 2015a, 2016a).

Non-energy product use (2.D)

This category estimates emissions from first use of fossil fuels as a product for primary purposes other than, i) combustion for energy purposes, 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 2016 were 2,061 $GgCO_2e$, an increase by 5.64 per cent since 2014.

Emissions from the use of waxes result primarily when the waxes or derivatives of paraffin are burnt during use (for example, candles), and when these are incinerated with or without heat recovery or in wastewater treatment (for surfactants). Total GHG emission from paraffin wax for non-energy purposes was 106 $GgCO_2e$ in 2016, decrease by 52.39 per cent since 2014.

Table 2.19: Types of production in the non-energy product use (2D) during 2015 and 2016.

Production (million tonne)	2015	2016
Lubricant production	3.506	3.495
Paraffin wax consumption	0.167	0.172

Source: MoPNG, 2015a, 2016a, 2017a.

Production of halocarbons (2.E)

This category estimates emission from production of halocarbons which generated 19,259 GgCO_2e (HFC23) in 2016, increasing by 3.68 per cent since 2014. Production of Hydrochlorofluorocarbon was 0.0533 million tonne in 2015 and 0.0569 million tonne in 2016.

Other industry (2.H)

This category estimates emission from Pulp & Paper industries, which generated 3,341 GgCO_2e in 2016, showing an increase of 2.63 per cent compared to 2014 emissions. Production of paper was 17.45 million tonne in 2015 and 17.08 million tonne in 2016.

Table 2.20: Country specific emission factor 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 factor developed during INC
2.B.2 Nitric Acid	N_2O	4 – 11 kg N_2O/tonne HNO_3	Company specific and based on CDM database
2.B.7 Soda Ash	CO_2	250 kg CO_2/tonne natural soda ash produced 70 kg CO_2/tonne of Soda Ash produced and 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 Monitoring Report of Gujarat Fluorochemical Ltd. (Major producers 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 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 results 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 nitrous oxide from manure management and agriculture soil. The Agriculture sector represented 14 per cent of the total GHG emissions (4,07,821 GgCO_2e) in 2016, a decrease of 2.25 per cent since 2014 (Figure

2.15). The share of agriculture in the total pie of emissions is decreasing. In absolute terms agriculture sector had registered growth in previously reported inventory years i.e. between 1994 to 2000, 2000 to 2010 and 2010 to 2014. This is the first instance between two inventory years (2014 and 2016) where it has registered an absolute decrease.

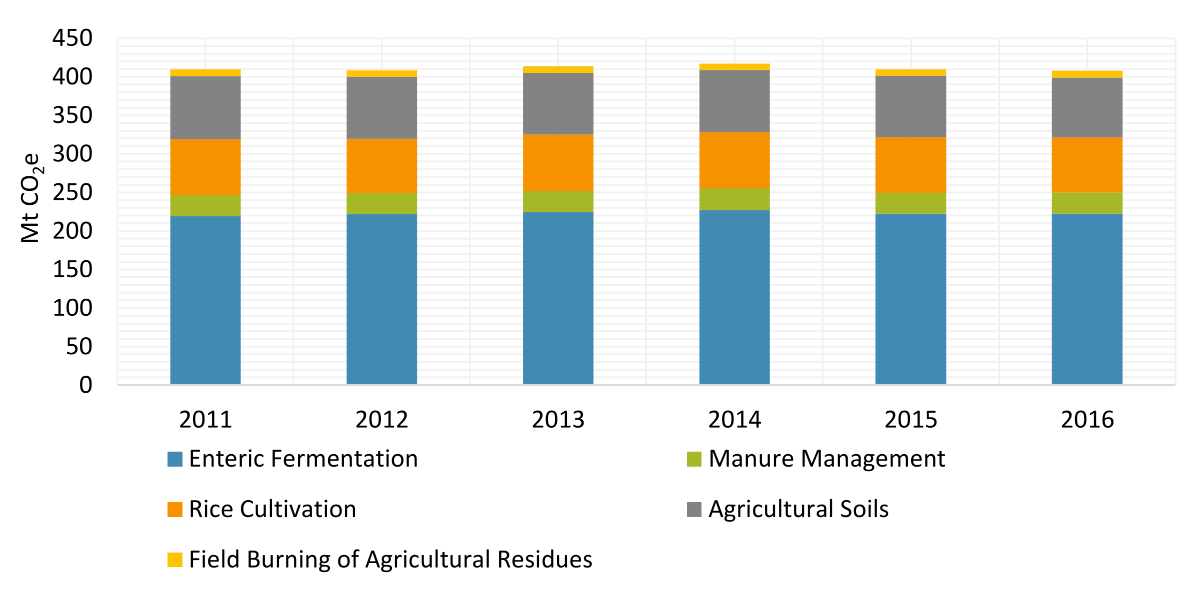


Figure 2.15: Agriculture: GHG emissions ($MtCO_2e$) per subcategory, 2011-2016

Agricultural activities contribute to emissions of GHGs (CH_4 and N_2O) through a variety of processes. The main sources of CH_4 and N_2O emission in India are animal husbandry and crop production. Animal husbandry in India is dominated by cattle, buffalo, sheep, goat and pig. With regard to categories, 54.60 per cent of GHG emissions corresponds to enteric fermentation, followed by 19.07 per cent from agricultural soils (15.88 per cent from direct N_2O and 3.20 per cent from indirect N_2O), 17.49 per cent from rice cultivation, 6.68 per cent from manure management and 2.17 per cent corresponding to field burning of agricultural residues in 2016 (Figure 2.16).

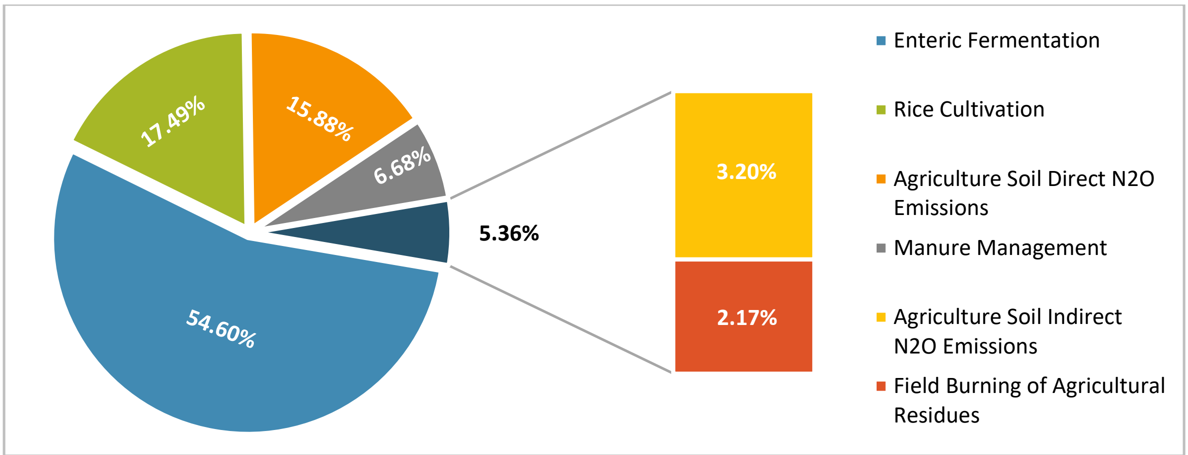


Figure 2.16: Distribution of CO_2e emissions (Gg) across the Agriculture sector Categories in 2016

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 produce moderate amounts as well.

In 2016, emissions from this category accounted for 2,22,655 $GgCO_2e$, a decrease of 1.98 per cent since 2014, largely due to decrease in animal population, consisting of a 1.74 per cent decrease in indigenous cattle, 7.13 per cent decrease in crossbred pig, 2.54 per cent decrease in indigenous pig and 11.09 per cent decrease in other animals (animal population is responsible for more than 60 per cent of total emissions from the sector) (DoAHD&F, 2014), (DoAH&D, 2019). There was a 7.13 per cent increase in crossbred cattle, 0.30 per cent in buffalo, 2.82 per cent in goat and around 2.27 per cent in crossbred and 4.89 per cent in indigenous sheep (Figure 2.17 and Figure 2.18).

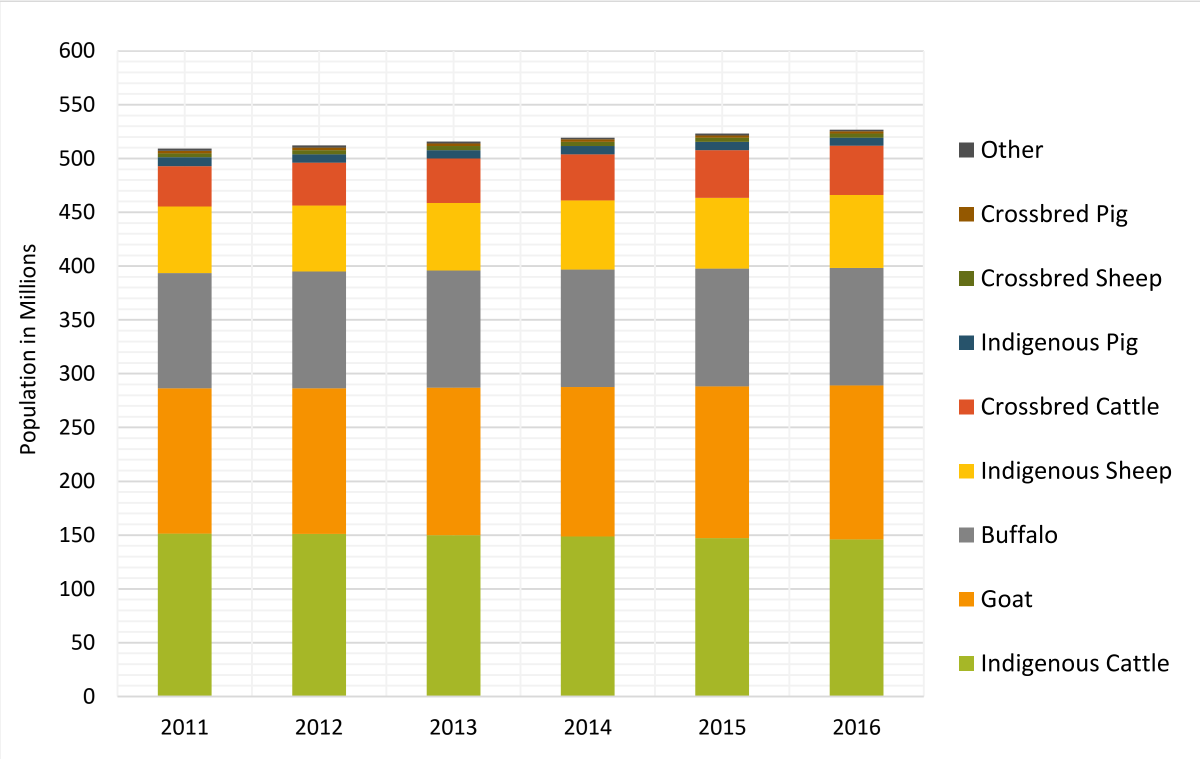


Figure 2.17: Population in millions by livestock category, 2011-2016

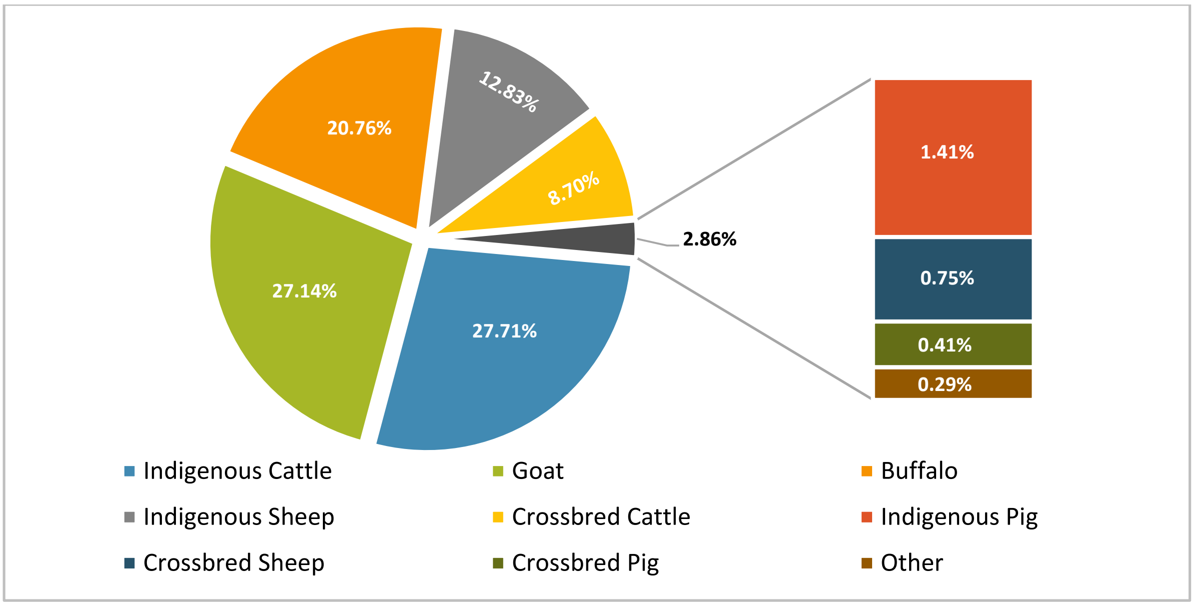


Figure 2.18: Population in percentage by livestock category, 2016

Manure management (3.B)

This category includes CH_4 and N_2O emissions of manure decomposition under conditions of low oxygen or anaerobic conditions. In 2016, the GHG emissions from this category accounted for 27,227 $GgCO_2e$, a decrease by 3.11 per cent over the period of two years (2014-2016). Within the category, for methane emissions, buffalo account for most of the emissions, representing 40.22 per cent of the subcategory, followed by indigenous cattle with 36.39 per cent, Crossbred cattle with 15.80 per cent, while the rest cover around 7.60 per cent of emissions (Figure 2.19).

Table 2.21: Dung generation and country-specific emission factors across various livestock category in 2015 and 2016

Dung generation (kilo tonne)	2015	2016
Crossbred cattle	39,749	41,176
Indigenous cattle	1,02,821	1,01,327
Buffalo	1,21,354	1,21,302
Goat	11,203	11,300
Crossbred sheep	544	546
Indigenous sheep	8,153	8,344
Crossbred pig	129	124
Indigenous pig	606	597
Others	1,334	1,247
Methane Emission Factors (Gram/ kg DMI)		**2015-2016**
Crossbred cattle		14 - 23*
Indigenous cattle		14.24 - 19.21*
Buffalo		9.25 - 21*
Goat		10.5 – 12.54*
Sheep		10.84 – 13.5*

*Emission factor varies according to type of feed and age of animal

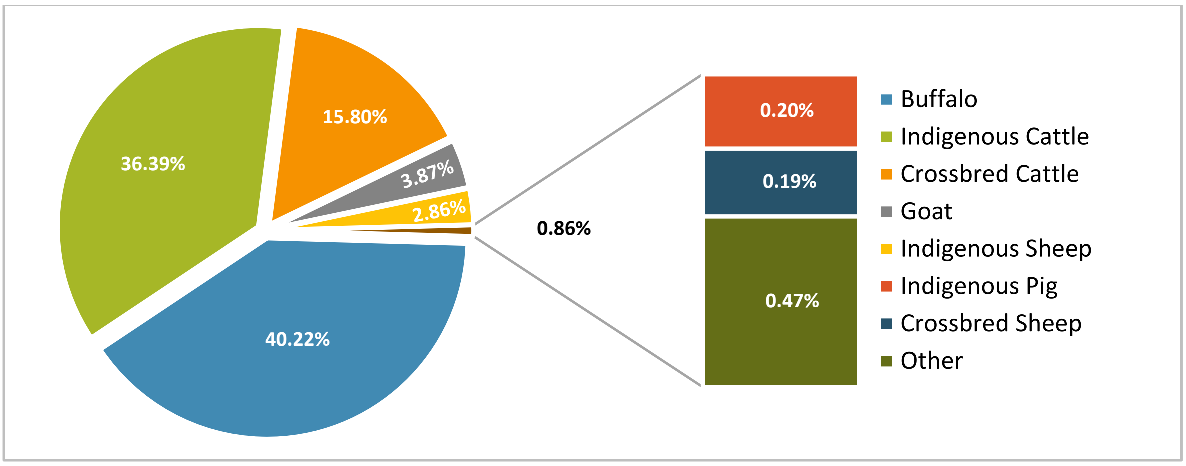


Figure 2.19: Methane emissions from manure management by livestock category, 2016

Indirect emissions result from volatile nitrogen losses that occur primarily in the forms of ammonia and NO_x during storage as solid. Within the category, for methane emissions, buffalo account for most of the emissions, representing 42.42 per cent of the subcategory, followed by indigenous cattle with 35.43 per cent, crossbred cattle with 14.40 per cent and remaining with 7.75 per cent of the emissions (Figure 2.20).

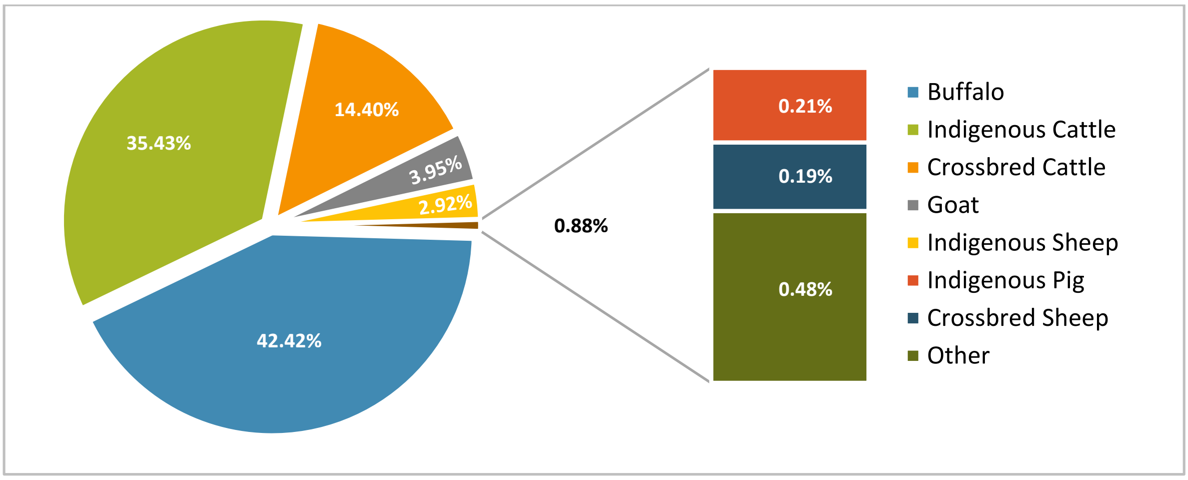


Figure 2.20: Nitrous Oxide emissions from manure management by livestock category, 2016

Rice cultivation (3.C)

This category includes emissions of methane by the anaerobic decomposition of soil organic material in flooded rice paddies. In 2016, GHG emission from this category accounted for 71,322 $GgCO_2e$, a decrease of 2.09 per cent from 2014. This change in trend of rice cultivation is directly related to reduction in area under rice.

In 2016, the total area under rice cultivation in the country was 43.19 million ha, and 3,396.27 Gg of methane was emitted. Emissions from different ecosystem types under different water regimes were estimated separately and are presented in Figure 2.21. Of the total land under rice cultivation, 33.19 per cent is drought-prone, 16.44 per cent is single aeration, 15.89 per cent is continuous flooding, 13.02 per cent is upland, 12.42 per cent is multiple aeration, 5.90 per cent is flood prone and 3.15 per cent is deep water rice system.

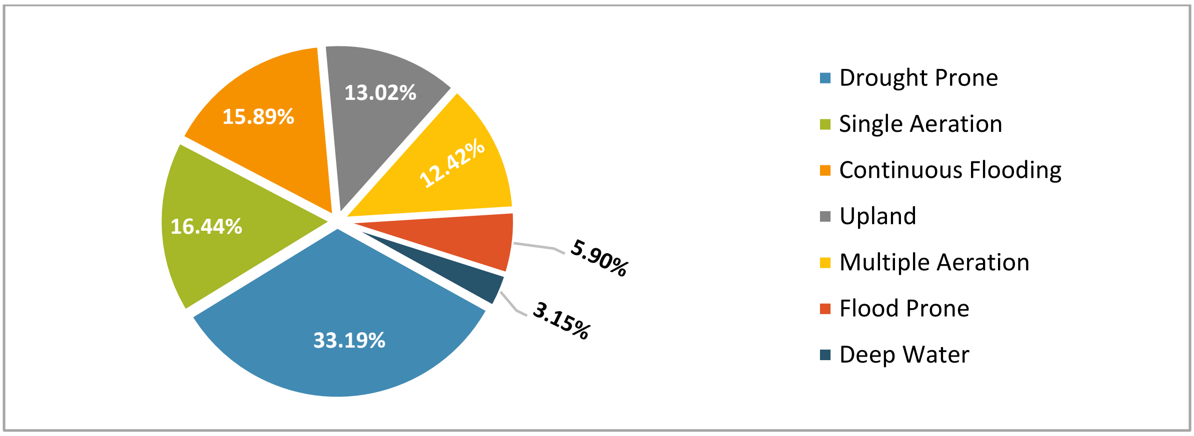


Figure 2.21: Rice area (in per cent) under different types of water regimes, 2016

Agriculture soils (3.D)

Agriculture soils sub-sector is the largest single source of N_2O emissions in the national inventory. There are two pathways of N_2O emissions from soils - direct and indirect. Direct N_2O emission has been estimated using net N additions to soils (synthetic or organic fertilizers, deposited manure, crop residues) and mineralization of N in soil due to cultivation/land-use change on mineral soils. 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 2016, GHG emissions from this category accounted for 77,781 $GgCO_2e$, a 3.41 per cent decrease from 2014. Similar to emissions from enteric fermentation, there has been a decrease in emissions in this sub-sector also due to the reduction in synthetic fertiliser based nitrogen consumption (3.67 per cent). Within the category, direct emissions of N_2O from agricultural soils represent 83.24 per cent of the emissions, while indirect emissions of N_2O from agricultural soils represent 16.76 per cent of total emissions.

Table 2.22: Activity data used in agriculture soil (3D) during 2015 and 2016

Million tonne	2015	2016
Nitrogen consumption*	17,372	16,735
Nitrogen from compost	0.2969	0.2969
Nitrogen from crop residue	2.287	2.354
Manure nitrogen other than poultry	1.149	1.153
Nitrogen input from below ground biomass	2.079	2.125

*Source: (FAI, 2019); (Bandyopadhyay et al., 2001); (Gadde et. al., 2009); (Jain et al., 2014).

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

Parameter	Country specific coefficients
EF1 (N_2O emission from applied fertilizer)	0.58 %
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 %
$Frac_{GASF}$ (Gas loss through volatilization from inorganic fertilizer)	15 %
$Frac_{GASF-AM}$ (Gas loss through volatilization from manure)	15 %
$Frac_{leach}$ (Leaching loss of N from applied fertilizer and manure)	10 %

Source: (Pathak et al., 2002); (Bhatia et al., 2005); (Bhatia et al., 2013).

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 cropland. Generally, residues from eight crops (rice, wheat, cotton, maize, millet, sugarcane, jute, rapeseed and mustard) are burned in the field as these are widely produced in the country.

Emissions from field burning of agricultural residues were 304.31 Gg of CH_4 and 7.89 Gg of N_2O. In CO_2 equivalent terms, 8,836 Gg of emission occurred in 2016, showing a 2.88 per cent increase from 2014 levels.

Table 2.24: Country specific emission factor used in field burning of agriculture residues (3F)

Crop	Residue to crop ratio	Dry matter fraction	Fraction burnt
Rice	1.5	0.86	0.08 - 0.8
Wheat	1.7	0.88	0.1 - 0.23
Maize	1.5	0.88	0.1
Jute	2.15	0.8	0.1
Cotton	3	0.8	0.1
Sugarcane	0.4	0.88	0.25
Rapeseed & mustard	3	0.8	0.1
Millets	1.5	0.88	0.1

Source: (Andreae, M. O. & Merlet, P., 2001); (Gadde, B. et al., 2009); (Jain et al., 2018).

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 that consistently absorbs CO_2 in the country, making it one of the most relevant for its mitigation potential. This sector removed 15 per cent of the country's carbon dioxide emissions in 2016. In the same year, its emissions reached -3,07,820 $GgCO_2e$, increasing its status as a sink by 2.2 per cent since 2014 (Figure 2.22). The emissions in this sector arise only from a single land use category - grassland. With respect to total CO_2 removals in 2016, 76.18 per cent corresponds to cropland, followed by 23.28 per cent of forest land and 0.54 per cent of settlements (Table 2.25).

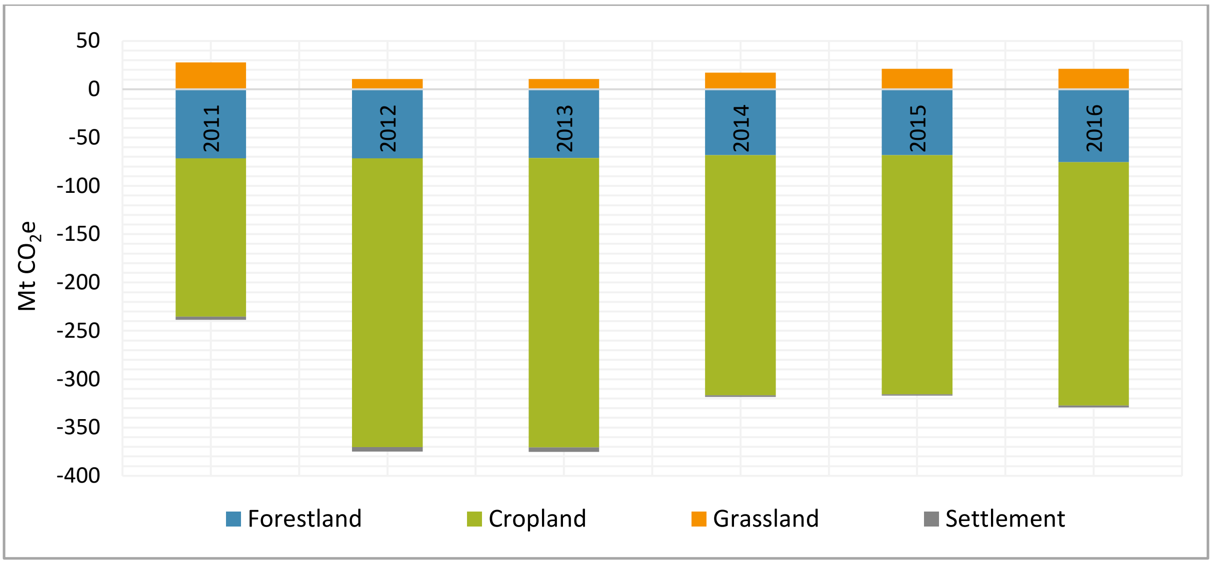


Figure 2.22: LULUCF: GHG emissions/removals (Mt CO_2e) per subcategory, 2011-2016

Table 2.25: Total GHG balance for the 2016 in GgCO_2e

Land Category	Net CO_2	CH_4	N_2O	Total
Forest Land	-77,000	1155	502	-75,343
Cropland	-2,51,975	-	-	-2,51,975
Grassland	21,289	-	-	21,289
Settlements	-1,790	-	-	-1,790
Total	-3,09,477	1155	502	-3,07,820

Land use change from 2005 to 2016 was assessed across five classes *viz.* – Forest Land, cropland, grassland, settlements and other land, based on remote sensing data supplemented with ground-based observations. The land use and land-use change estimates for the period 2005-2016 are given in Table 2.26. It can be observed that the land area under forests has increased marginally and so has the area under cropland, grassland and settlements.

Table 2.26: Land use change for India for the period 2005-2016 (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

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

Forest land (4.A)

This category includes GHG emissions and removals generated as a result of changes in living biomass, dead organic matter and soil organic carbon in Forest land that remains as such and in Land converted to forest land. In 2016, the GHG emissions recorded -75,343 GgCO_2e, increasing its status as a sink by 10.45 per cent since 2014.

The activity data and emission factors for carbon stock estimation are derived from forest cover assessment and national forest inventory. For the activity data, biennial forest cover assessment which is a wall-to-wall mapping exercise based on satellite data (Approach 3) has been used. In addition, forest type information has also been used for stratification of forest cover into different forest types and canopy densities. For estimation of emission factors, the data collected during the national forest inventory has been used (Tier 2). IPCC GPG 2003 methods have been used for estimation of carbon stock in different pools i.e., above ground biomass, litter, deadwood and soil organic carbon (SOC) except below ground biomass which has been calculated using default values of the IPCC (IPCC, 2003).

The area under forest land remaining forest land for the year 2016 is 69.40 million ha, and the land area converted to forest land during the year 2016 is estimated to be 1.63 million ha. Forest sector in India is a net sink. Wildfires have an important effect on the trends in GHG emissions and removals. In the year 2016, more than 3.25 million ha (mild, moderate and heavy fire) area has been affected by fires with an impact on the net balance of GHG emissions, contributing 1,657 GgCO_2e.

Table 2.27: Activity data and emission factors used in forest land category (4A) during 2015 and 2016

Area (million ha), Carbon Stock (million tonne)	2015	2016
Total area under forest	70.83	71.03
Area of forest land remaining forest land	67.77	69.40
Area of land converted to forest land	3.05	1.63
Carbon stock change in forest land remaining forest land	-97.38	114.53
Carbon stock change in land converted to forest land	116.38	-93.53
Area subjected to mild fires	1.767	1.321
Biomass burnt (t/ha) in mild fire area	1.33	1.33
Area subjected to moderate fires	1.119	1.205
Biomass burnt (t/ha) in moderate fire area	4.01	4.01
Area subjected to heavy fires	0.690	0.730
Biomass burnt (t/ha) in heavy fire area	11.11	11.11

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

Cropland (4.B)

This category includes CO_2 emissions and removals generated in arable and plowable land, rice fields and agroforestry systems, where the vegetation structure is significantly different, with a lower threshold than that of forest land, and it is not expected that this will exceed in the future. In 2016, croplands recorded sequestration of -2,51,975 $GgCO_2e$, a 1.35 per cent increase from 2014, thereby making it the biggest contributor in this category.

The area under cropland, which is the net sown area, was estimated to be 164.40 million ha during 2016. The net sown area has increased from 160.65 to 164.40 million ha between years 2005 and 2016. The net sown area is sensitive to a number of factors such as rainfall, and market prices. In India, the area under cropland includes both net sown and fallow land area.

The approach adopted for estimating carbon stock changes in cropland is as follows:

i. Change in biomass carbon stock in cropland
ii. Soil organic carbon stock
iii. Biomass and soil carbon rates of change and stocks in cropland

The large sink potential of cropland is due to the following:

i. The mean annual increment in SOC in cropland is 0.367 tC/ha/year over 164.40 million ha, contributing to higher carbon sink from cropland.
ii. Larger area under this land category compared to other land categories including Forest Land e.g., Cropland accounts for about 50 per cent (164.40 million ha) of the total geographic area (328.73 million ha) as compared to about 22 per cent by forest land (71.03 million ha).
iii. The soil carbon in forest land is quite stable and does not change much over the years. However, cropland carbon is dynamic and as a result of management practices such as manure and fertilizer application, change in soil carbon in cropland is substantially higher.

Table 2.28: Activity data and emission factors used in cropland category (4B) during 2015 and 2016

Area (million ha), carbon stock (million tonne)	2015	2016
Total area under cropland	163.85	164.40
Change in biomass carbon stock	7.37	8.38
Change in soil organic carbon stock	60.13	60.34
Rate of change in SOC (tonne carbon/ha/year)	0.367	0.367

Grassland (4.C)

This category includes GHG emissions and removals generated in land that are not considered arable land or forest land, and all the grassland of wild land for recreational areas, as well as agricultural systems and silvopastoral lands according to national definitions. The lands are largely used for livestock grazing. The area under grassland is estimated to be 22.42 million ha for the year 2016 compared to 20.35 million ha in 2005. In 2016, the GHG emissions balance accounted for 21,289 $GgCO_2e$, an increase of 23.66 per cent since 2014. This can be attributed to lower rates of conversion of land to grasslands. Within the category, emissions/removals are not available for land converted to grassland category due to non-availability of data. More studies are needed to refine the data, especially of soil carbon fluxes in grassland.

Table 2.29: Activity data and emission factors used in grassland category (4C) during 2015 and 2016

Area (million ha), Carbon Stock (million tonne)	2015	2016
Total area under grassland	21.65	22.42
Change in biomass carbon stock	0.97	1.14
Change in soil organic carbon stock	-6.71	-6.95
Rate of change in SOC (tonne carbon/ha/year)	-0.31	-0.31

Settlements (4.E)

The category includes GHG emissions and removals generated in land where there are human settlements, urban areas and infrastructure, unless it has already been included in other categories. The area under settlements increased from 8.6 to 9.57 million ha during the period 2005 to 2016. In this category, only CO_2 emissions and removals from biomass carbon is considered from settlements remaining settlements. Most of the expansion occurs in and around cities and villages which are dominated by marginal cropland and grassland. Further, area under forests in India is increasing which indicates there is no net conversion of forestland to settlements. The settlements land category was a net sink of CO_2 during the period 2005-2016. In 2016, the balance of GHG emissions accounted for -1,790 $GgCO_2e$ increasing by 13.09 per cent since 2014.

Table 2.30: Activity data and emission factors used in settlement category (4E) during 2015 and 2016

Area (million ha), carbon stock (million tonne)	2015	2016
Total area under settlements	9.56	9.57
Change in biomass carbon stock	0.43	0.49
Rate of change in SOC (tonne carbon/ha/year)	0.045	0.051

2.7.5 Waste

The waste sector, which includes the GHG emissions from microbiological processes that occur in the organic matter of solid waste under anaerobic degradation, and the anaerobic treatment of domestic and industrial wastewater represented 2.65 per cent of GHG emissions in 2016. In the same year, its emissions were 75,232 $GgCO_2e$, decreasing by 3.83 per cent since 2014 (Figure 2.23). More than three-fourth (78.96 per cent) of the emissions from the waste sector come from wastewater treatment and discharge, followed by 21.04 per cent of the solid waste disposal.

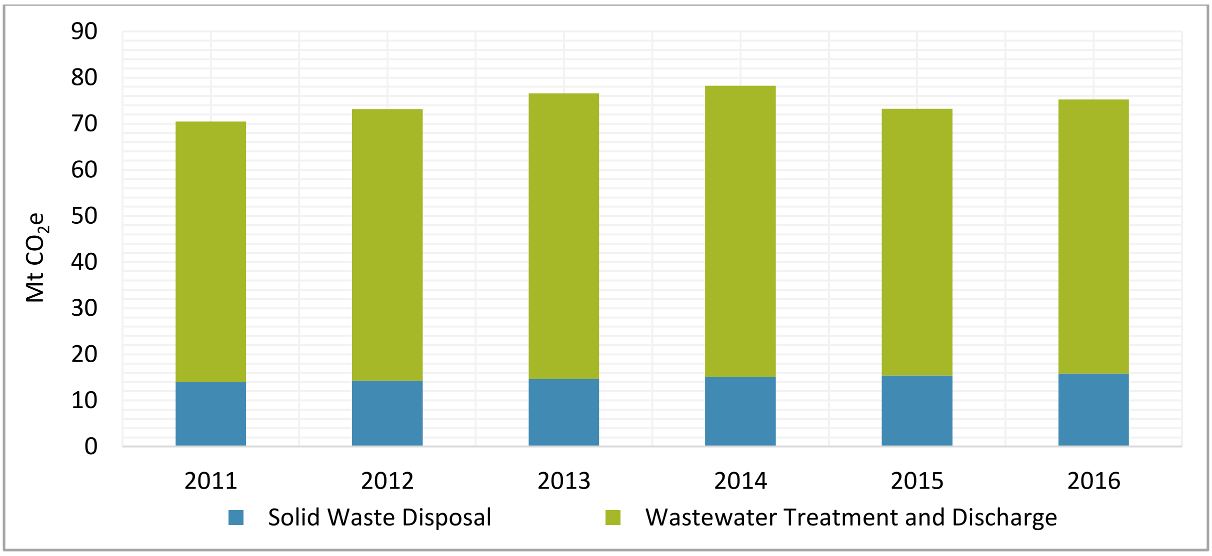


Figure 2.23: Waste: GHG emissions (Mt CO_2e) per subcategory, 2011-2016

Solid waste disposal (5.A)

The category includes CH_4 emissions in the treatment and disposal of municipal, industrial and others solid wastes, which are handled on solid waste disposal sites (SWDS). Solid waste disposal covers managed, unmanaged and uncategorized waste that has been deposited in landfills. In 2016, GHG emissions accounted for 15,832 GgCO_2e, increasing by 5.09 per cent since 2014, as a result of an increase in population. In 2016, 59,372 Gg of MSW reached landfills in India, resulting in 754 Gg of Methane and 58,093 Gg of MSW generated 736 Gg of CH_4 in 2015.

IPCC methodology for estimating CH_4 emissions from MSW landfill sites is based on the first order decay (FOD) method. MSW is relatively scattered and moreover shallow depths of disposal do not induce anaerobic conditions. A fraction of methane is released and utilized for gas recovery. As methane recovery is not practiced at most disposal sites, default value of R is considered zero in estimation.

Wastewater treatment and discharge (5.D)

The category includes GHG emissions of the treatment or disposal of wastewater by anaerobic means, such as of 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 by means of drains. In 2016, GHG emissions from this category accounted for 59,401 GgCO_2e, decreasing by 5.95 per cent since 2014 due to increase in coverage of the network of domestic water treatment. Within the category, domestic wastewater treatment and discharge contributes 65.39 per cent, while industrial wastewater treatment and discharge amounts to 34.61 per cent. Emission from domestic wastewater treatment and discharge increased by 5.90 per cent and industrial wastewater treatment and discharge emission decreased by 22.38 per cent since 2014.

Industrial wastewater includes industrial sectors, such as 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. Production in all 16 sectors results in generation of wastewater with significant organic load having the potential to release methane emissions, which is dependent on the type of wastewater treatment. The analysis reveals that the pulp & paper and meat and poultry sectors are critical sectors with the highest GHG emission per tonne of product or per unit volume of treated wastewater.

The value of Biochemical Oxygen Demand (BOD) is taken to be 45 kg per capita per day from ENVIS (Environmental Information System) Centre on Hygiene, Sanitation, Sewage Treatment Systems and Technology, whereas the range is 27-41 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 2.31: Activity data and country-specific emission factors used in the wastewater treatment and discharge category (5D) in 2015 and 2016

<table>
<tr><th colspan="3"></th><th>2015</th><th colspan="2">2016</th></tr>
<tr><td colspan="3">Country population (billion)</td><td>1.292</td><td colspan="2">1.313</td></tr>
<tr><td colspan="3">Average protein consumption (kg/ per capita/ year)</td><td>22.02</td><td colspan="2">22.02</td></tr>
<tr><td colspan="3">Maximum CH_4 producing capacity, B_o, kg CH_4/kg BOD</td><td>0.25</td><td colspan="2">0.25</td></tr>
<tr><td rowspan="9">Type of latrine</td><td colspan="2">Septic tank</td><td colspan="3">0.3</td></tr>
<tr><td colspan="2">Open space</td><td colspan="3">0.06</td></tr>
<tr><td colspan="2">PIT latrine</td><td colspan="3">0.3</td></tr>
<tr><td colspan="2">P latrine</td><td colspan="3">0.258</td></tr>
<tr><td colspan="2">Night soil (Open pit)</td><td colspan="3">0.06</td></tr>
<tr><td colspan="2">Night soil (Human)</td><td colspan="3">0</td></tr>
<tr><td colspan="2">Night soil (Animal)</td><td colspan="3">0.06</td></tr>
<tr><td colspan="2">Open</td><td colspan="3">0</td></tr>
<tr><td colspan="2">Sewer</td><td colspan="3">0.06</td></tr>
<tr><th>Industry production (million tonne)</th><th>2015</th><th>2016</th><th>Wastewater generation (M^3 / Tonne)</th><th>COD Kg/M^3</th><th>Methane correction factor</th></tr>
<tr><td>Alcohol</td><td>0.231</td><td>0.231</td><td>11</td><td>84</td><td>0.8</td></tr>
<tr><td>Coffee</td><td>0.327</td><td>0.353</td><td>15</td><td>9</td><td>0.8</td></tr>
<tr><td>Dairy products</td><td>0.033</td><td>0.039</td><td>6</td><td>2.24</td><td>0.5</td></tr>
<tr><td>Fruits and juices</td><td>0.300</td><td>0.300</td><td>20</td><td>5</td><td>0.8</td></tr>
<tr><td>Poultry</td><td>7020</td><td>7318</td><td>0.02</td><td>5</td><td>0.8</td></tr>
<tr><td>Organic chemicals</td><td>1.589</td><td>1.638</td><td>67</td><td>3</td><td>0.3</td></tr>
<tr><td>Petroleum</td><td>36.95</td><td>36.01</td><td>0.6</td><td>1</td><td>0.3</td></tr>
<tr><td>Plastic and resins</td><td>0.005</td><td>0.005</td><td>0.6</td><td>3.7</td><td>0.3</td></tr>
<tr><td>Pulp and paper</td><td>10.61</td><td>11.17</td><td>57</td><td>5.9</td><td>0.8</td></tr>
<tr><td>Sea food processing</td><td>0.946</td><td>1.135</td><td>13</td><td>2.5</td><td>0.3</td></tr>
</table>

Soap and detergents	2.936	3.009	3	0.85	0.3
Starch production	0.488	0.487	5.5	10	0.8
Sugar refining	27.39	22.20	0.4	2.5	0.8
Tannery	0.603	0.618	32	3.1	0.8
Vegetable oils	9.180	10.75	2	0.2	0.2
Vegetable	0.211	0.211	20	5	0.8

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

2.8 Key categories

According to 2006 IPCC Guidelines, it is good practice to identify key categories, as it helps prioritize efforts and improve the overall quality of the national inventory. A "key category" is defined as a source or sink category, that is prioritized within the national inventory system because its estimate has a significant influence on a country's total inventory of direct GHGs in terms of the absolute level of emissions, the trend or the uncertainty in emissions and removals (IPCC, 2006).

Table 2.32 presents the result of the level assessment using Approach 1 that identified 23 categories without LULUCF and 25 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 2.32: Key category level assessment with and without LULUCF for 2016

	2016 Without LULUCF			**2016 With LULUCF**		
Sr. No.	**IPCC Code, Category, Gas**	**Gg CO_2e**	**Level %**	**IPCC Code, Category, Gas**	**Gg CO_2e**	**Level %**
1	1A1a Electricity production, CO_2	1122230	39.53%	1A1a Electricity production ,CO_2	1122230	35.15%
2	1A3b Road transport, CO_2	243344	8.57%	3B2 Cropland, CO_2 Removal	251975	7.89%
3	3A1 Enteric fermentation, CH_4	222655	7.84%	1A3b Road transport, CO_2	243344	7.62%
4	1A2m Nonspecific industries, CO_2	180838	6.37%	3A1 Enteric fermentation, CH_4	222655	6.97%
5	1A2a Iron & steel, CO_2	134731	4.75%	1A2m Nonspecific industries, CO_2	180838	5.66%
6	1A4b Residential, CO_2	126942	4.47%	1A2a Iron & steel, CO_2	134731	4.22%
7	2A1 Cement production, CO_2	106591	3.75%	1A4b Residential, CO_2	126942	3.98%
8	3C4 Agricultural soils, N_2O	77781	2.74%	2A1 Cement production, CO_2	106591	3.34%
9	1A1b Refinery, CO_2	71824	2.53%	3C4 Agricultural soils, N_2O	77781	2.44%
10	3C7 Rice cultivation, CH_4	71322	2.51%	3B1 Forestland, CO_2 Removal	77000	2.41%
11	1A4a Commercials/Institutional, CO_2	68653	2.42%	1A1b Refinery, CO_2	71824	2.25%
12	1A2f Cement, CO_2	53468	1.88%	3C7 Rice cultivation, CH_4	71322	2.23%
13	2C3 Aluminium production, CF	33455	1.18%	1A4a Commercials/Institutional, CO_2	68653	2.15%
14	2A2 Lime production, CO_2	28480	1.00%	1A2f Cement, CO_2	53468	1.67%
15	3A2 Manure management, N_2O	24715	0.87%	2C3 Aluminium production, CF	33455	1.05%
16	4D1 Domestic and commercial wastewater, CH_4	22827	0.80%	2A2 Lime production, CO_2	28480	0.89%

17	4D2 Industrial wastewater, CH_4	20559	0.72%	3A2 Manure management, N_2O	24715	0.77%
18	2E Production of halocarbons and Sulphur hexafluoride, HFC	19259	0.68%	4D1 Domestic and commercial wastewater, CH_4	22827	0.71%
19	1A3a Civil aviation, CO_2	16117	0.57%	3B3 Grassland, CO_2	21289	0.67%
20	4D1 Domestic and commercial wastewater, N_2O	16015	0.56%	4D2 Industrial wastewater, CH_4	20559	0.64%
21	4A Managed waste disposal on land, CH_4	15832	0.56%	2E Production of halocarbons and sulphur hexafluoride, HFC	19259	0.60%
22	1B2b Natural gas, CH_4	14889	0.52%	1A3a Civil aviation, CO_2	16117	0.50%
23	1B1aii Above ground mining, CH_4	11742	0.41%	4D1 Domestic and commercial wastewater, N_2O	16015	0.50%
24				4A Managed waste disposal on land, CH_4	15832	0.50%
25				1B2b Natural gas, CH_4	14889	0.47%
Total		**2704268**		**Total**	**3042790**	

Analysis of the trend of emission contributions from each category is undertaken to identify where the greatest absolute changes (either increases or reductions) have taken place over a given time. The Table 2.33 presents India's National GHG inventory over the period of 2011-2016 with and without LULUCF based on the trend assessment Tier 1 methodological approach.

Table 2.33: Key category trend assessment with and without LULUCF for 2011-2016

	2011-2016 without LULUCF			**2011-2016 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	0.0424860	24.69%	1A4a Commercials/Institutional, CO_2	0.0375768	20.70%
2	1A1a Electricity production, CO_2	0.0272412	15.83%	3B2 Cropland, CO_2 Removal	0.0238378	13.13%
3	3A1 Enteric fermentation, CH_4	0.0164336	9.55%	1A1a Electricity production, CO_2	0.0209186	11.52%
4	1A4b Residential, CO_2	0.0158699	9.22%	3A1 Enteric fermentation, CH_4	0.0152686	8.41%
5	1A2b Nonferrous metals, CO_2	0.0112782	6.55%	1A4b residential, CO_2	0.0137378	7.57%
6	3C4 Agricultural soils, N_2O	0.0074817	4.35%	1A2b Nonferrous metals, CO_2	0.0100061	5.51%
7	1A1b Refinery, CO_2	0.0063585	3.69%	3C4 Agricultural soils, N_2O	0.0068818	3.79%
8	3C7 Rice cultivation, CH_4	0.0061210	3.56%	3C7 Rice cultivation, CH_4	0.0056529	3.11%
9	2C3 Aluminium production, CF	0.0053251	3.09%	1A1b Refinery, CO_2	0.0054426	3.00%
10	1A2a Iron & steel, CO_2	0.0047874	2.78%	1A2a Iron & steel,CO2	0.0046537	2.56%
11	1B2b Natural gas, CH_4	0.0031461	1.83%	2C3 Aluminium production, CF	0.0046366	2.55%
12	1A3b Road transport, CO_2	0.0025648	1.49%	3B1 Forestland, CO_2 Removal	0.0042197	2.32%
13	1A2m Nonspecific industries, CO_2	0.0021026	1.22%	3B3 Grassland, CO_2	0.0031155	1.72%
14	4D2 Industrial wastewater, CH_4	0.0019729	1.15%	1B2b Natural gas, CH_4	0.0028414	1.57%
15	3A2 Manure management, N_2O	0.0019188	1.12%	4D2 Industrial wastewater, CH_4	0.0018148	1.00%
16	1A2m Fertilizer, CO_2	0.0013342	0.78%	3A2 Manure management, N_2O	0.0017790	0.98%
17	2B1 Ammonia production, CO_2	0.0012454	0.72%	1A3b Road transport, CO_2	0.0015641	0.86%
18	1A1c Manufacturing of Solid Fuel, CO_2	0.0010342	0.60%	1A2m Nonspecific industries, CO_2	0.0013371	0.74%
19	2A1 Cement production, CO_2	0.0009344	0.54%	1A2m Fertilizer, CO_2	0.0012040	0.66%

20	4D1 Domestic and commercial wastewater ,N_2O	0.0008130	0.47%	2A1 Cement production, CO_2	0.0011447	0.63%
21	1B2b Venting and flaring, CH_4	0.0007636	0.44%	2B1 Ammonia production, CO_2	0.0011414	0.63%
22	4D1 Domestic and commercial wastewater ,CH_4	0.0007254	0.42%	1A1c Manufacturing of solid fuel, CO_2	0.0008999	0.50%
23	2C3 Aluminium production, CO_2	0.0007131	0.41%	4D1 Domestic and commercial wastewater ,N_2O	0.0007700	0.42%
24	1B1ai Underground mining, CH_4	0.0007033	0.41%	4D1 Domestic and commercial wastewater ,CH_4	0.0007122	0.39%
25	1A5a Biomass burnt for energy,N_2O	0.0006761	0.39%	1B2b Venting and flaring, CH_4	0.0006891	0.38%
26				1B1ai Underground mining, CH_4	0.0006412	0.35%
	Total	**0.164030**		**Total**	**0.172488**	

2.9 Uncertainty assessment

According to the IPCC Guidelines (2006), uncertainty estimates are an essential part of a comprehensive inventory of GHG emissions and removals. The uncertainty analysis should be considered as a means to prioritize national efforts aimed to increase the accuracy and precision of future inventories and to guide decisions on the methodology selected. The overall inventory uncertainty was estimated using the Tier 1 methodological approach. An estimate of the overall quantitative uncertainty (±6.96 per cent level uncertainty and ±7.90 per cent trend uncertainty) in various categories is shown in Table 2.34. 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 2.34: Overall Inventory Uncertainty in India for 2016

Sr. No.	IPCC Category	Category Number, Name	Gas	2011 emissions or removals (Gg CO_2 equivalent)	2016 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	1122230	10.00%	5.00%	11.18%	0.001953	0.025694	48.43%	0.18169%	6.84884%	0.46940%
2	Energy	1A3b Road transport	CO_2	193898	243344	5.00%	3.00%	5.83%	0.000025	0.002502	10.50%	0.01061%	0.74255%	0.00551%
3	AFOLU	3A1 Enteric fermentation	CH_4	219244	222655	5.00%	50.00%	50.25%	0.001553	0.019805	9.61%	1.40046%	0.67942%	0.02423%
4	Energy	1A2m Nonspecific industries	CO_2	143739	180838	20.00%	5.00%	20.62%	0.000172	0.002046	7.80%	0.01447%	2.20726%	0.04872%
5	Energy	1A2a Iron & steel	CO_2	119844	134731	5.00%	5.00%	7.07%	0.000011	0.005214	5.81%	0.03687%	0.41112%	0.00170%

6	Energy	1A4b Residential	CO_2	80343	126942	20.00%	5.00%	20.62%	0.000085	0.012301	5.48%	0.08698%	1.54943%	0.02408%
7	IPPU	2A1 Cement production	CO_2	88810	106591	5.00%	5.00%	7.07%	0.000007	0.000953	4.60%	0.00674%	0.32526%	0.00106%
8	AFOLU	3C4 Agricultural Soils	N_2O	81701	77781	15.00%	15.00%	21.21%	0.000034	0.009624	3.36%	0.20416%	0.71203%	0.00549%
9	Energy	1A1b Refinery	CO_2	48648	71824	25.00%	100.00%	103.08%	0.000680	0.005275	3.10%	0.74600%	1.09583%	0.01757%
10	AFOLU	3C7 Rice cultivation	CH_4	72670	71322	15.00%	20.00%	25.00%	0.000039	0.007638	3.08%	0.21604%	0.65290%	0.00473%
11	Energy	1A4a Commercials/Institutional	CO_2	23023	68653	20.00%	5.00%	20.62%	0.000025	0.017453	2.96%	0.12341%	0.83797%	0.00717%
12	Energy	1A2f Cement	CO_2	43121	53468	5.00%	5.00%	7.07%	0.000002	0.000276	2.31%	0.00195%	0.16315%	0.00027%
13	IPPU	2C3 Aluminium production	CF	19950	33455	5.00%	75.00%	75.17%	0.000078	0.003890	1.44%	0.41259%	0.10209%	0.00181%
14	IPPU	2A2 Lime production	CO_2	24011	28480	10.00%	5.00%	11.18%	0.000001	0.000404	1.23%	0.00286%	0.17381%	0.00030%
15	AFOLU	3A2 Manure management	N_2O	24600	24715	10.00%	75.00%	75.66%	0.000043	0.002340	1.07%	0.24814%	0.15083%	0.00084%
16	Waste	4D1 Domestic and commercial wastewater	CH_4	20114	22827	15.00%	50.00%	52.20%	0.000018	0.000783	0.99%	0.05536%	0.20897%	0.00047%
17	Waste	4D2 Industrial wastewater	CH_4	21580	20559	15.00%	50.00%	52.20%	0.000014	0.002537	0.89%	0.17938%	0.18820%	0.00068%
18	IPPU	2E Production of halocarbons and sulphur hexafluoride	HFC	16392	19259	10.00%	20.00%	22.36%	0.000002	0.000355	0.83%	0.01003%	0.11754%	0.00014%
19	Energy	1A3a Civil aviation	CO_2	13504	16117	5.00%	3.00%	5.83%	0.000000	0.000184	0.70%	0.00078%	0.04918%	0.00002%
20	Waste	4D1 Domestic and commercial wastewater	N_2O	14815	16015	15.00%	75.00%	76.49%	0.000019	0.000921	0.69%	0.09772%	0.14660%	0.00031%
21	Waste	4A Managed waste disposal on land	CH_4	13932	15832	15.00%	50.00%	52.20%	0.000008	0.000534	0.68%	0.03773%	0.14493%	0.00022%
22	Energy	1B2b Natural gas	CH_4	23814	14889	5.00%	100.00%	100.12%	0.000028	0.006164	0.64%	0.87172%	0.04543%	0.00762%
23	Energy	1B1aii Above ground mining	CH_4	10089	11742	5.00%	100.00%	100.12%	0.000017	0.000267	0.51%	0.03773%	0.03583%	0.00003%
Total				**2317287**	**2838889**				**0.004838**					**0.006236**
Total Uncertainties						**Uncertainty in Total Inventory**			**6.96%**		**Trend Uncertainty**			**7.90%**

2.10 Time series information

Consistent time series information of the GHG inventory starting from the last (second) national communication (inventory year 2000) to 2016 has been presented in the bar chart (see Figure 2.24). A summary table (Table 2.35) 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) in 2018.

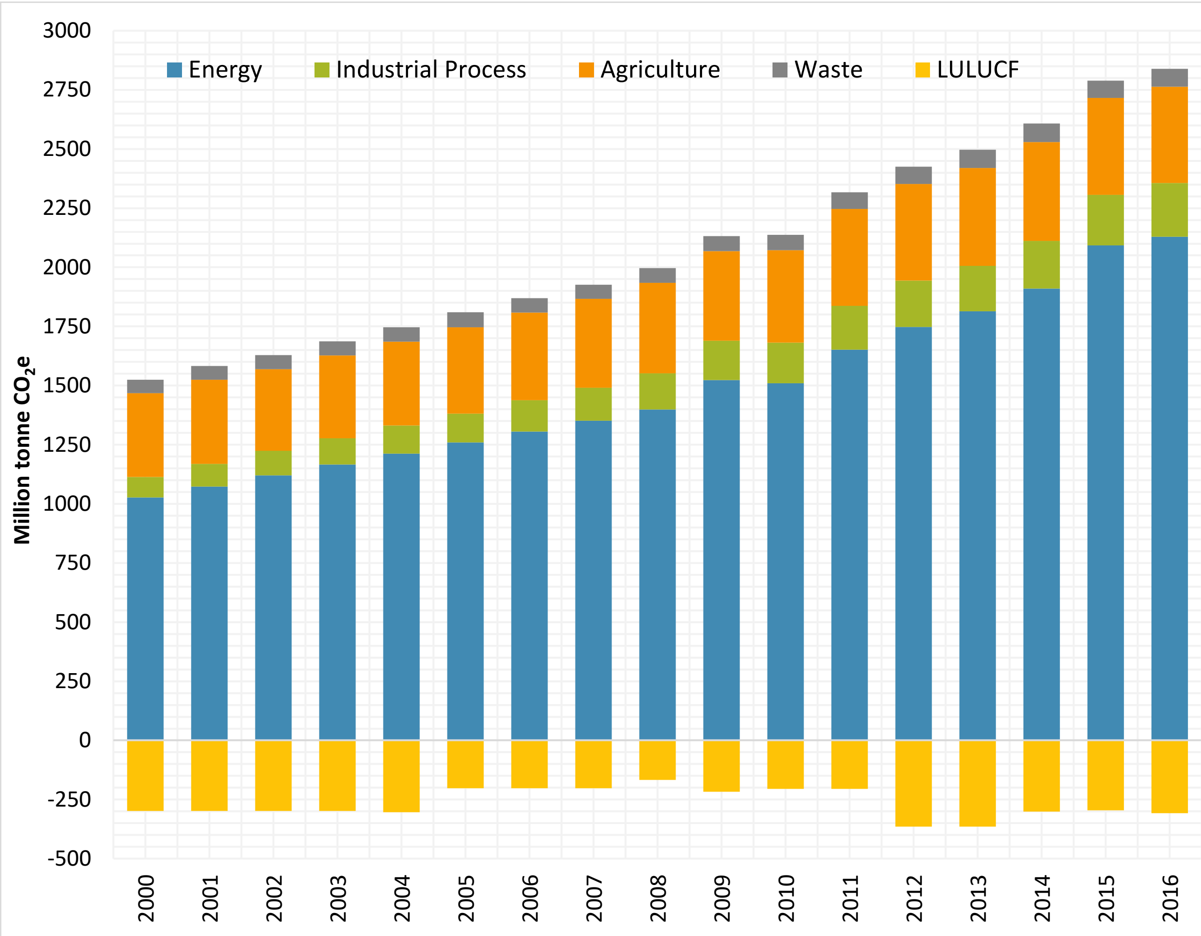


Figure 2.24: Time series information of GHG emissions

Table 2.35: India's total emissions, 2011-2016

GHG sources and removals	2011	2012	2013	2014	2015	2016
	GgCO₂ Equivalent					
1. Energy	1651928	1747686	1813559	1909766	2092102	2129428
A. Fuel combustion activities	1604503	1704639	1774788	1871709	2055017	2092250
1. Energy Industries	924258	1005813	1053981	1140983	1197123	1206587
2. Manufacturing industries &	338816	343603	356771	351910	394092	397739

construction						
3. Transport	221202	236020	241253	250173	261517	274434
4. Other sectors	120228	119202	122783	128643	202286	213490
B. Fugitive emission from fuels	47426	43047	38771	38057	37084	37179
1. Solid fuels	16388	16086	15568	16547	16614	17121
2. Oil and natural gas	31037	26961	23203	21511	20470	20058
C. CO_2 Transport and storage	NO	NO	NO	NO	NO	NO
2. Industrial Processes and Product Use	185543	196023	192616	202278	214020	226407
A. Mineral industry	113193	122469	123369	126856	132075	135468
B. Chemical industry	24387	24419	23190	22175	24269	25358
C. Metal industry	27289	28033	27356	29242	34068	40814
D. Non-energy Products From Fuels and Solvent Use	4283	4812	4955	5428	5581	5507
E. Production of halocarbons and sulphur hexafluoride	16392	16290	13745	18576	18027	19259
3. Agriculture	409374	408435	413683	417218	409703	407821
A. Enteric fermentation	219244	221666	224280	227157	222396	222655
B. Manure management	27221	27484	27766	28101	27220	27227
C. Rice cultivation	72670	70600	72884	72843	71834	71322
D. Agricultural soils	81701	80112	80047	80529	79715	77781
E. Prescribed burning of Savannah	NO	NO	NO	NO	NO	NO
F. Field burning of agricultural residues	8539	8573	8706	8589	8538	8836
4. LULUCF	-210913	-364221	-364569	-301193	-296092	-307820
A. Forest Land	-71438	-71438	-71222	-68215	-68033	-75343
B. Cropland	-163990	-298869	-299410	-248610	-247521	-251975
C. Grassland	27746	10614	10649	17216	21039	21289
D. Wetlands	NE	NE	NE	NE	NE	NE
E. Settlements	-3231	-4529	-4586	-1583	-1578	-1790
F. Other Land	NA	NA	NA	NA	NA	NA
G. Harvested wood products	NE	NE	NE	NE	NE	NE
H. Other	NA	NA	NA	NA	NA	NA
5. Waste	70442	73208	76539	78227	73247	75232
A. Solid waste disposal on land	13932	14307	14685	15065	15448	15832
B. Waste-water handling	56509	58900	61854	63162	57799	59401
Memo items	768201	783702	797485	812068	755291	789359
International bunkers	6399	6207	5083	4981	5281	6095
Aviation	3623	3791	3742	3714	3830	4396
Marine	2776	2416	1341	1267	1451	1699
CO_2 from biomass	761802	777494	792401	807087	750010	783265
Total (without LULUCF)	2317287	2425352	2496397	2607488	2789072	2838889
Total (with LULUCF)	2106374	2061131	2131828	2306295	2492980	2531069

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 decision 17/CP.8, India's national GHG inventory for 2016 is presented in Tables 2.36 (Table 1 and Table 2).

Table 2.36: India's National GHG Inventory for 2016 (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**	**NO_x**	**NMVOCs**	**SO_x**
Total national emissions and removals	2252356	330765	19557	471	X	X	X	X
1. Energy	2064840	NA	2072	68	X	X	X	X
A. Fuel combustion (sectoral approach)	2064840		302	68	X	X	X	X
1. Energy industries	1200736		16	18	X	X	X	X
2. Manufacturing industries and construction	395893		6	6	X	X	X	X
3. Transport	269976		41	12	X	X	X	X
4. Other sectors	198236		239	33	X	X	X	X
5. Other (please specify)	NO		NO	NO	X	X	X	X
B. Fugitive emissions from fuels	NO		1770		X	X	X	X
1. Solid fuels			815		X	X	X	X
2. Oil and natural gas			955		X	X	X	X
2. Industrial processes	166227	NO	187	11	X	X	X	X
A. Mineral products	135468				X	X	X	X
B. Chemical industry	21344		27	11	X	X	X	X
C. Metal production	7249		0.45	NO	X	X	X	X
D. Other production	NO				X	X	X	X
E. Production of halocarbons and sulphur hexafluoride								
F. Consumption of halocarbons and sulphur hexafluoride								
G. Other (Pulp and paper)	2167		159	NO	X	X	X	X
1. Lubricant	2061		NO	NO	X	X	X	X
2. Paraffin wax	106		NO	NO	X	X	X	X
3. Pulp & paper	NO		159	NO				
3. Solvent and other product use	NO			NO			X	
4. Agriculture	NO		14423	339	X	X	X	X
A. Enteric fermentation			10603					
B. Manure management			120	80			X	
C. Rice cultivation			3396				X	
D. Agricultural soils			NO	251			X	
E. Prescribed burning of savannahs			NO	NO	X	X	X	
F. Field burning of agricultural residues			304	8	X	X	X	
G. Other (please specify)	NO		NO	NO	X	X	X	
5. Land-use change and forestry	21289	-330765	55	2	X	X	X	X
A. Changes in forest and other woody biomass stocks	NE	NE						
B. Forest and grassland conversion	NO	-77000	NO	NO	X	X		
C. Abandonment of managed lands		NE						
D. CO_2 emissions and removals from soil	21289	-251975						

E. Other (please specify)	NO	-1790	55	2	X	X		
6. Waste			2820	52	X	X	X	X
A. Solid waste disposal on land			754		X		X	
B. Waste-water handling			2066	52	X	X	X	
C. Waste incineration					X	X	X	X
D. Other (please specify)			NO	NO	X	X	X	X
7. Other (please specify)	NO	NA	NO	NO	X	X	X	X
Memo items								
International bunkers	6040		0.62	0.13	X	X	X	X
Aviation	4348		0.51	0.12	X	X	X	X
Marine	1692		0.11	0.01	X	X	X	X
CO_2 emissions from biomass	783265							

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 a, b**			**PFCs a, b**			**SF_6 a**
	HFC-23	**HFC-134**	**Other (to be added)**	**CF_4**	**C_2F_6**	**Other (to be added)**	
Total national emissions and removals	1.646	NO	NA	3.717	1.011	NA	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	1.646	NO	NA	3.717	1.011	NA	0.004
A. Mineral products							
B. Chemical industry							
C. Metal production	NA	NO	NA	3.717	1.011	NA	0.004
D. Other production							
E. Production of halocarbons and sulphur hexafluoride	1.646	NA	NA	NA	NA	NA	NA
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.

References

AIGMF. (2015, 2016). *Annual Report.* All India Glass Manufacturers' Association.

AMAI. (2015, 2016). *Annual Report.* Alkali Manufacturers Association of India. Retrieved from http://ama-india.org/

Andreae, M. O. & Merlet, P. (2001). Emission of trace gases and aerosols from biomass burning. *Global Biogeochemical Cycles*, 955-966. doi:https://doi.org/10.1029/2000GB001382

Bandyopadhyay, S. K., Pathak, H., Kalra, N., Aggarwal, P. K, Kaur, R., Joshi, H. C., Choudhary, R. and Roetter, R. P. (2001). Yield Estimation and Agro-Technical Description of Production Systems. In Land Use Analysis and Planning for Sustainable Food Security: With an Illustration for the State of Haryana, Aggarwal, P. K., Roetter, R. P., Kalra, N., Van Keulen, H., Hoanh, C. T. and Van Laar, H. H. (Eds.), *Indian Agricultural Research Institute*, New Delhi, India, & International Rice Research Institute, Los Banos, Wagningen University and Research Centre, Wagningen, 161–189.

Bhatia, A., Pathak, H., Jain, N., Singh, P. K., Singh, A. K. (2005). Global warming potential of manure amended soils under rice-wheat system in the Indo-Gangetic plains. Atmos. Environ. 39, 6976–6984. https://doi.org/10.1016/j.atmosenv.2005.07.052

Bhatia, A., Jain, N., Pathak, H. (2013). Methane and nitrous oxide emissions from Indian rice paddies, agricultural soils and crop residue burning. Greenhouse Gases: Science and Technology 3, 196-211.

Brown, T. J., Idoine, N. E., Wrighton, C. E., Raycraft, E. R., Hobbs, , S. F., Shaw, R. A. & Bide, T. (2019). World Mineral Production 2014-18. *British Geological Survey*, 1-101. Retrieved from http://www.bgs.ac.uk/mineralsUK/statistics/worldStatistics.html

CEA. (2015, 2016, 2017). *Annual report of Central Electricity Authority (2014-15, 2015-16, 2016-17).* Ministry of Power, Goverment of India. Retrieved from http://www.cea.nic.in/annualreports.html

CEA. (2015a, 2016a, 2017a). *Performance Review of Thermal Power Stations (2014-15, 2015-16, 2016-17), Central Electricity Authority.* Ministry of Power, Goverment of India. Retrieved from http://cea.nic.in/reports.html

Census. (2011). *Primary Census Abstracts, Registrar General of India.* Ministry of Home Affairs, Government of India. Retrieved from http://www.censusindia.gov.

CMA. (2015, 2016, 2017). *Annual Report (2014-15, 2015-16, 2016-17).* Cement Manufactures Association. Retrieved from https://www.cmaindia.org/

CMIE. (2019). *Industry Outlook and Economic Outlook.* Centre for Monitoring Indian Economy Pvt. Ltd. Retrieved from https://www.cmie.com/

CMIE Prowess. (2019). *CMIE Prowess Database*. Retrieved from Centre for Monitoring Indian Economy Pvt. Ltd: https://prowessiq.cmie.com/

CPCB. (2015). *Inventorization of Sewage Treatment Plants.* Central Pollution Control Board, Ministry of Environment and Forests, Goverment of India. Retrieved from https://nrcd.nic.in/writereaddata/FileUpload/NewItem_210_Inventorization_of_Sewage-Treatment_Plant.pdf

CSE. (2014). *Paper Through Time - Tracking the Industry's Progress, .* Centre for Science and Environment. Retrieved from https://www.cseindia.org/paper-through-time-8533

DGMS. (2015). *Statistics of Mines in India Volume I, Directorate General of Mines Safety.* Ministry of Labour & Employment, Government of India. Retrieved from http://www.dgms.gov.in/

DoAH&D. (2019). *20th Livestock Census 2019.* Ministry of Fisheries, Animal Husbandry & Dairying. Retrieved from http://www.dahd.nic.in/about-us/divisions/statistics

DoAHD&F. (2014). *19th Livestock Census 2012.* Ministry of Agriculture. Retrieved from http://www.dahd.nic.in/about-us/divisions/statistics

FAI. (2019). *Fertiliser Association of India*. Retrieved from https://www.faidelhi.org/statistics/statistical-database

FAO. (2016). *World statistical compendium for raw hides and skins, leather and leather footwear 1999-2015.* Rome: Food and Agriculture Organization of the United Nations. Retrieved from http://www.fao.org/3/a-i5599e.pdf

FSI. (2005, 2007, 2009, 2011, 2013, 2015, 2017, 2019). *India State of Forest Report (2005, 2007, 2009, 2011, 2013, 2015, 2017, 2019), Forest Survey of India.* Ministry of Environment Forest and Climate Change. Retrieved from https://www.fsi.nic.in/forest-report-2019?pgID=forest-report-2019

Gadde, B., Menke, C. & Wassmann, R. (2009, November). Rice straw as a renewable energy source in India, Thailand, and the Philippines: Overall potential and limitations for energy contribution and greenhouse gas mitigation. *Biomass and Bioenergy, 33*(11), 1532-1546. doi:https://doi.org/10.1016/j.biombioe.2009.07.018

IEA. (2020). *Extended world energy balances.* IEA World Energy Statistics and Balances (database). doi:https://doi.org/10.1787/data-00513-en

IMYB. (2019). *Indian Minerals Yearbook 2019,* Indian Bureau of Mines, Ministry of Mines.

IPCC. (1995). *Second Assessment Report of the Intergovernmental Panel on Climate Change.* Intergovernmental Panel on Climate Change.

IPCC. (1996). *Revised IPCC Guideline for Estimation of National Greenhouse Gas Emission Inventory.* United Nations Framework Convention on Climate Change.

IPCC. (2003). *Good Practice Guidance for Land Use, Land-Use Change and Forestry.* United Nations Framework Convention on Climate Change.

IPCC. (2006). *2006 IPCC Guidelines for National Greenhouse Gas Inventories.* Japan: Institute for Global Environmental Strategies.

IPCC. (2006a). Quality Assurance/Quality Control and Verification. In *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (pp. 1-31). Retrieved from https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/1_Volume1/V1_6_Ch6_QA_QC.pdf

IPCC. (2020). IPCC Emission Factor Data Base (EFDB). Retrieved from https://www.ipcc-nggip.iges.or.jp/EFDB/main.php

Jain, N., Bhatia, A. & Pathak, H. (2014). Emission of air pollutants from crop residue burning in India, *Aerosol and Air Quality Research*, 14 (1), 422-430.

Jain, N., Sehgal, V. K, Singh, S. & Kaushik, N. (2018). Estimation of surplus crop residues in India for biofuel production, TIFAC-IARI Joint Report, TIFAC-DST

Publication, New Delhi, 434.

MoC. (2015, 2016, 2017). *Coal Directory of India (2014-15, 2015-16, 2016-17), Coal Controller's Organization.* Ministry of Coal, Goverment of India. Retrieved from http://www.coalcontroller.gov.in/pages/display/16-coal-directory

MoC. (2015a, 2016a, 2017a). *Provisional Coal Statistics of India (2014-15, 2015-16, 2016-17), Coal Controller's Organization.* Ministry of Coal, Goverment of India. Retrieved from http://www.coalcontroller.gov.in/pages/display/20-provisional-coal-statistics

MoC&F. (2015, 2016). *Indian Fertilizer Scenario, Department of Fertilizers.* Ministry of Chemicals & Fertilizers, Government of India. Retrieved from http://fert.nic.in/page/fertilizers-scenario

MoC&F. (2015a, 2016a). *Chemicals and Petrochemicals Statistics at a glance.* Ministry of Chemicals and Fertilizers, Government of India. Retrieved from https://chemicals.nic.in/document-report/reports

MoEF. (2004). *Initial National Communication (INC).* Ministry of Environment and Forest. Retrieved from http://envfor.nic.in/

MoEF. (2010). *India: Greenhouse Gas Emission 2007, Indian Network for Climate Change Assessment (INCCA) Report.* New Delhi: Ministry of Environment and Forests. Retrieved from http://envfor.nic.in/

MoEF. (2010). *Technical EIA Guidance Manual for Distilleries, IL&FS Ecosmart Limited.* Ministry of Environment and Forests, Goverment of India. Retrieved from http://environmentclearance.nic.in/writereaddata/form-1a/homelinks/TGM_Distillery_010910_NK.pdf

MoEF. (2012). *Second National Communication (SNC).* New Delhi: Ministry of Environment and Forests. Retrieved from http://envfor.nic.in/

MoEFCC. (2016). *First Biennial Update Report (BUR-1).* New Delhi: Ministry of Environment, Forest and Climate Change. Retrieved from http://envfor.nic.in/

MoEFCC. (2018). *Second Biennial Update Report (BUR-2).* New Delhi: Ministry of Environment, Forest and Climate Change. Retrieved from http://envfor.nic.in/

MoM. (2015, 2016). *Indian Minerals Yearbook, Indian Bureau of Mines.* Ministry of Mines, Government Of India. Retrieved from https://ibm.gov.in/index.php?c=pages&m=index&id=107&mid=24021

MoPNG. (2014, 2015, 2016). *Annual Report (2014-15, 2015-16, 2016-17).* Ministry Of Petroleum and Natural Gas, Goverment of India. Retrieved from http://petroleum.nic.in/more/indian-png-statistics

MoPNG. (2015a, 2016a, 2017a). *Indian Petroleum & Natural Gas Statistics (2014-15, 2015-16, 2016-17).* Ministry Of Petroleum and Natural Gas, Goverment of India. Retrieved from http://petroleum.nic.in/more/indian-png-statistics

MoR. (2015, 2016, 2017). *Indian Railways Annual Statistical Statement (2014-15, 2015-16, 2016-17).* Ministry of Railways, Goverment of India. Retrieved from http://www.indianrailways.gov.in/index.html

MoS. (2015, 2016, 2017). *Annual Report (2014-15, 2015-16, 2016-17).* Ministry of Steel, Goverment of India. Retrieved from https://steel.gov.in/annual-reports

MoSPI. (2014). *Nutritional Intake in India, 2011-12, National Sample Survey Office.* National Statistical Office, Ministry of Statistics and Programme Implementation, Government of India. Retrieved from http://mospi.nic.in/sites/default/files/publication_reports/nss_report_560_19dec14.pdf

MoSPI. (2015, 2016). *Energy Statistics (2015, 2016), National Statistical Office.* Ministry of Statistics and Programme Implementation, Government of India. Retrieved from http://www.mospi.gov.in/download-reports?main_cat=NzI2&cat=All&sub_category=All

NEERI. (2010). *Inventorisation of Methane Emissions from Domestic & Key Industries Wastewater - Indian Network for Climate Change Assessment.* National Environmental Engineering Research Institute . Retrieved from http://moef.gov.in/wp-content/uploads/2018/04/M-Karthik.pdf

Pathak, H., Bhatia, A., Prasad, S., Singh, S., Kumar, S., Jain, MC., Kumar, U. (2002). Emission of nitrous oxide from rice-wheat systems of Indo-Gangetic plains of India, Environmental Monitoring and Assessment 77 (2), 163-178

PPAC. (2019). *Petroleum Planing & Analysis Cell* . Retrieved from Ministry of Petroleum & Natural Gas, Government of India: https://www.ppac.gov.in/content/147_1_ConsumptionPetroleum.aspx

Singh, A. K. (2019). Better accounting of greenhouse gas emissions from Indian coal mining activities - A field perspective. Environmental Practice, 21(1), 36-40.

UNFCCC. (2002, October 23). *Guidelines for the preparation of national communications from Parties not included*. Retrieved from United Nations Framework Convention on Climate Change: https://unfccc.int/files/meetings/workshops/other_meetings/application/pdf/dec17-cp.pdf

Appendix

Detailed Greenhouse Gas Emissions from India, in 2016, 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 without LULUCF (Gg)	**2231067.52**		**19501.77**	**469.25**	**1.646**	**3.717**	**1.011**	**0.004**	**2838888.58**
TOTAL with LULUCF (Gg)	**2252356.39**	**330765.45**	**19556.79**	**470.87**	**1.646**	**3.717**	**1.011**	**0.004**	**2531069.02**
1. ENERGY (Gg)	2064840.50		2072.38	67.96					**2129428.48**
A. Fuel Combustion Activities	2064840.50		301.97	67.96					**2092249.93**
1. Energy Industries	1200735.63		15.94	17.80					**1206586.83**
a. Electricity production	1122229.67		12.19	16.92					**1127732.23**
b. Refinery	71823.97		3.25	0.13					**71931.17**
c. Manufacturing of solid fuel	6681.99		0.50	0.75					**6923.43**
2. Manufacturing Industries & Construction	395893.24		5.79	5.56					**397739.15**
a. Cement	53467.87		1.22	0.53					**53658.08**
b. Iron & steel	134731.33		1.57	2.12					**135420.48**
c. Nonferrous metals	7667.24		0.10	0.11					**7704.35**
d. Chemicals	1974.69		0.05	0.02					**1982.48**
e. Pulp & paper	2620.45		0.03	0.04					**2633.43**
f. Food & beverages	NE								
g. Nonmetallic minerals	NE								
h. Mining & quarrying	4082.09		0.16	0.03					**4095.79**
i. Textile/leather	2299.56		0.03	0.03					**2309.87**
j. Bricks	605.79		0.01	0.01					**608.66**
k. Fertilizer	5979.79		0.11	0.08					**6007.88**
l. Engineering Sector	1626.85		0.07	0.01					**1632.20**
m. Nonspecific Industries	180837.58		2.44	2.57					**181685.93**
n. Glass Ceramic	NE								
3. Transport	269975.76		41.19	11.59					**274433.69**
a. Road transport	243344.18		40.25	10.98					**247593.77**
b. Civil Aviation	16116.57		0.23	0.52					**16283.73**

Detailed Greenhouse Gas Emissions from India, in 2016, 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
c. Railways	7582.10		0.51	0.06					**7611.89**
d. Navigation	2932.91		0.20	0.02					**2944.30**
4. Other sectors	198235.86		239.05	33.01					**213490.26**
a. Commercials/Institutional	68653.23		0.94	0.98					**68975.54**
b. Residential	126942.39		4.07	0.82					**127282.50**
c. Agricultural/fisheries	2640.25		0.10	0.02					**2647.85**
d. Biomass burnt for energy			233.95	31.20					**14584.37**
B. Fugitive Emission from fuels			1770.41						**37178.55**
1 Solid fuels			815.26						**17120.52**
a. Above ground mining			559.14						**11742.03**
b. Underground mining			256.12						**5378.48**
2 Oil and Natural gas			955.14						**20058.04**
a. Oil			83.02						**1743.35**
b. Natural gas			709.01						**14889.17**
c. Venting and flaring			163.12						**3425.52**
2. Industrial Processes and Product Use	**166227.02**		**186.68**	**11.11**	**1.646**	**3.717**	**1.011**	**0.004**	**226406.78**
A. Minerals	**135467.75**								**135467.75**
1. Cement production	106590.64								**106590.64**
2. Lime production	28479.65								**28479.65**
3. Limestone and dolomite use	NE								
5. Glass	377.14								**377.14**
6. Ceramics	20.31								**20.31**
B. Chemicals	**21343.75**		**27.15**	**11.11**					**25358.14**
1 Ammonia production	11538.97								**11538.97**
2 Nitric acid production				10.33					**3202.31**
3. Carbide production	93.10								**93.10**
4. Titanium dioxide production	80.99								**80.99**

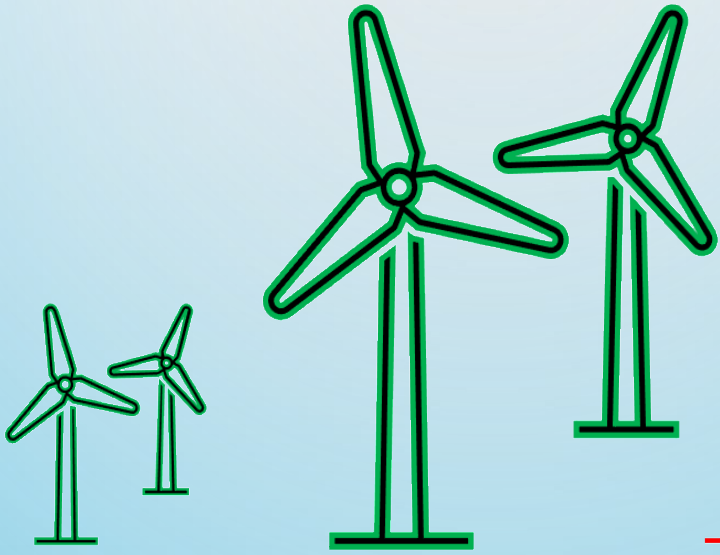
Detailed Greenhouse Gas Emissions from India, in 2016, by Sources and Removals by Sinks (Emissions are in Gigagrams).									
	CO_2 emission	CO_2 removal	CH_4	N_2O	HFC 23	CF_4	C_2F_6	SF_6	CO_2 equivalent
5. Soda ash production	888.11								**888.11**
6. Methanol production	116.16		0.40						**124.54**
7. Ethylene production	7633.81		11.84						**7882.54**
8. EDC & VCM production	287.73								**287.73**
9. Ethylene Oxide production	180.47		0.37						**188.33**
10. Acrylonitrile production	0.38		0.00						**0.38**
11.Carbon Black production	524.03		14.53						**829.11**
12. Caprolactam				0.78					**242.03**
C Metal Production	**7248.75**		**0.45**			**3.717**	**1.011**	**0.004**	**40813.95**
1s Iron & Steel production	IE								
2 Ferroalloys production	2686.53		0.45						**2695.99**
3 Aluminium production	4473.16					3.717	1.011		**37928.52**
4. Lead production	55.68								**55.68**
5. Zinc production	32.81								**32.81**
6. Magnesium production	0.57							0.004	**100.95**
D. Non-energy product use	**2166.78**								**2166.78**
1. Lubricant	2060.80								**2060.80**
2. Paraffin wax	105.98								**105.98**
E. Production of halocarbons and sulphur hexafluoride					**1.646**				**19259.45**
H. Other			**159.08**						**3340.72**
1. Pulp & paper			159.08						**3340.72**
3. AGRICULTURE	**0.00**		**14422.82**	**338.52**					**407820.88**
A. Enteric fermentation			10602.63						**222655.25**
B. Manure management			119.60	79.73					**27226.77**
C. Rice cultivation			3396.27						**71321.71**
D. Agricultural soils				250.91					**77780.76**
Direct N_2O Emissions				*208.86*					*64747.28*

Detailed Greenhouse Gas Emissions from India, in 2016, 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**
Indirect N_2O Emissions				*42.04*					*13033.48*
F. Field burning of agricultural residues			304.31	7.89					**8836.39**
4. LULUCF	21288.87	330765.45	55.02	1.62					**-307819.56**
A. Forest Land		77000.00	55.02	1.62					**-75342.98**
B. Cropland		251975.00							**-251975.00**
C. Grassland	21288.87								**21288.87**
D. Settlement		1790.45							**-1790.45**
F. Other land		NA							
5. WASTE			2819.90	51.66					**75232.44**
A. Solid waste disposal on land			753.90						**15831.84**
1. Managed waste disposal on land			753.90						**15831.84**
B. Waste-water handling			**2066.00**	**51.66**					**59400.60**
1. Industrial wastewater			979.00						**20559.00**
2. Domestic and commercial wastewater			1087.00	51.66					**38841.60**
Memo Item (not accounted in total Emissions)	789304.54		0.62	0.13					**789359.05**
International Bunkers	**6040.02**		**0.62**	**0.13**					**6094.54**
Aviation	4347.61		0.51	0.12					**4395.74**
Marine	1692.42		0.11	0.01					**1698.80**
CO_2 from Biomass	**783264.51**								**783264.51**

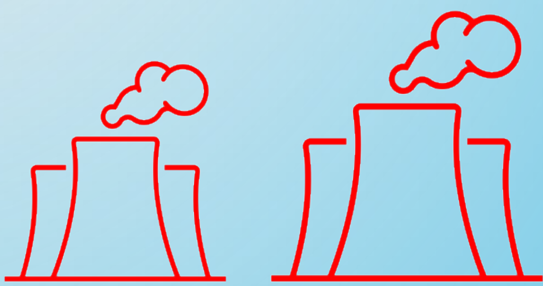
Abbreviations: IE – Included Elsewhere; NE – Not Estimated; NO – Not Occurring, NA – Not Applicable.

*****

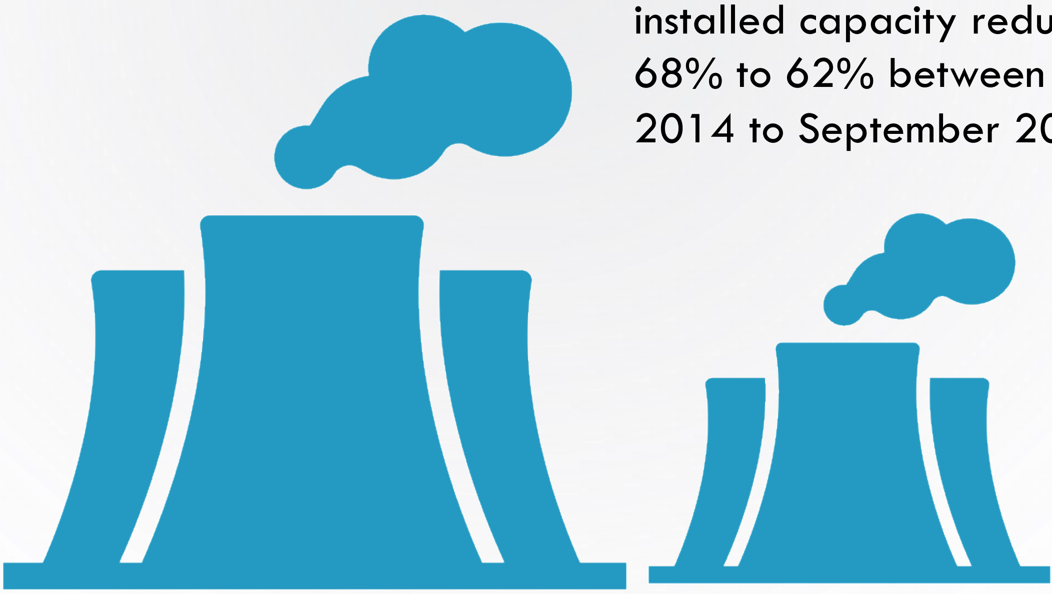
Generation from renewable energy sources doubled



Generation from non-renewable sources increased by 19%



Share of fossil-fuel based electricity generation in total installed capacity reduced from 68% to 62% between March 2014 to September 2020



Chapter 3
Mitigation Actions

Freepik. (2020). Ecology comparative illustration vector.

Key Points

Chapter 3 Mitigation Actions

- Based on the National GHG Inventory, India has successfully reduced the emission (excluding emissions from agriculture sector) intensity of its GDP by 24 per cent between 2005 and 2016.
- Thus, India is one of the very few countries on track to fulfilling its declared voluntary mitigation action up to 2020. This has been corroborated by independent scientific studies of global climate action by experts across different countries.
- Annex-I Parties as a whole, however, have reduced emissions from 1990 to 2018 only by 12.5 per cent without LULUCF (and 16.6 per cent with LULUCF). This is in contrast to the benchmark of 25-40 per cent reduction below 1990 levels by 2020 called for by the Fourth Assessment Report of the IPCC. Within this category, the non-EIT Parties have reduced their annual emissions over this period by only 1.5 per cent (without LULUCF).
- India in its NDCs enhanced its ambition to reduce the emission intensity of its GDP by 33-35 per cent below 2005 levels by 2030. India is on track to meeting this enhanced commitment as well. Through proactive measures and planned action, India has been increasingly making efforts to i) increase the share of non-fossil fuel in overall energy mix, ii) improve energy efficiency measures, iii) enhance CO_2 removal through increasing forest and tree cover, without compromising on the developmental priorities of the country.
- India's power sector priorities include ensuring energy security, improving access and affordability of modern energy resources for all, diversifying energy resources, enhancing resource use efficiency, reducing T&D losses in power transmission, and enhancing the contribution of renewable energy.
- India has set a target of achieving 175 GW of renewable energy capacity by 2022 which will be enhanced to 450 GW subsequently.
- As on 30 November 2020, India's total renewable energy installed capacity (excluding hydropower above 25 MW) had reached over 90 GW and constituted over 24 per cent of the country's installed power capacity. With inclusion of large hydro, the total installed capacity is ~136 GW and the share of renewable energy in electric installed capacity is over 36 per cent.
- The adoption of energy efficiency schemes/ programmes led to overall energy savings of 23.728 Mtoe for the year 2018-19.
- Schemes such as UJALA have led to a GHG emission reduction of 180.08 $MtCO_2$ from 2014-15 to November 2020. Under the Street Lighting National Programme (SLNP), 11.25 million LED street lights have been installed up to September 2020, leading to a cumulative emissions reduction of 14.82 $MtCO_2$ between 2015-16 and 2019-20.

- The Perform, Achieve, and Trade (PAT) scheme for improved energy efficiency in industry saved 31 $MtCO_2$ of emissions in PAT-I (2012-15), and 61.34 $MtCO_2$ of emissions in PAT-II (2016-19).
- Under the Buildings Energy Efficiency Programme (BEEP), EESL has completed building energy efficiency projects in 10,344 buildings including railway stations and airports. This has resulted in estimated energy savings of 224 million kWh per year with avoided peak demand of 75.64 MW and emission reduction of 0.18 $MtCO_2$ per year.
- In the transport sector, 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. These Bharat Stage norms are equivalent to Euro 4 and Euro 6 emission norms.
- Under the Department of Heavy Industry administered Faster Adoption and Manufacturing of (Hybrid) Electric Vehicles in India (FAME India) Scheme, the deployment of about 0.28 million hybrid and electric vehicles is supported in Phase I. FAME under Phase II has expanded with an outlay of INR 100,000 million for a period of 3 years, starting from April 2019.
- The Pradhan Mantri Krishi Sinchayee Yojana (Prime Minister's Agricultural Irrigation Scheme) aims at convergence of investments in irrigation at the field level and expansion of cultivable area and improvement of water use efficiency, resulting in an emissions reduction of 11.979 $MtCO_2$ during the period 2017-18 to 2018-19.
- A number of other schemes in crop production, such as crop diversification from paddy, direct seeding of rice and system of rice intensification, and other agricultural sectors such as livestock, horticulture and fisheries are all contributing to the lowering of emissions. This effort is despite the fact that agricultural emissions are survival emissions for India and the sector, in this country, contributes to food and nutrition security for the second largest population in the world.
- LULUCF sequestered 330.76 Mt of CO_2, which is about 15 per cent of India's total CO_2 emissions from all sectors in 2016. The net change of the carbon stock in forests was an increase of 42.6 million tonne between the assessments of 2017 and 2019.
- In spite of the large human population, and at a time when many countries of the world are losing their forests due to various anthropogenic causes, India has been able to retain a larger proportion of forest cover and protect its biodiversity.
- In the waste sector, the current focus of India is the rapid expansion of the modernization of sanitation facilities and infrastructure and waste management system in general. These actions are indispensable for further mitigation actions in the waste sector.

- Both historically and in the contemporary period, India has consumed far less than its fair share of the global carbon budget, while developed countries have consumed significantly greater than their fair share so far (for both 1.5º and 2º warming). In per capita energy use and per capita consumption of various fuels, India is consistently and significantly below the world average.
- Despite every effort at decoupling development from emissions, India's emission will rise. This is a consequence of India's current stage of development and available technologies. This is also in keeping with the preamble of the UNFCCC which notes, *inter alia*, that "the largest share of historical and current global emissions of greenhouse gases has originated in developed countries, that per capita emissions in developing countries are still relatively low and that the share of global emissions originating in developing countries will grow to meet their social and development needs".

Chapter 3

Mitigation Actions

3.1 India's declared voluntary action until 2020

Climate change is a global collective action problem. It is therefore necessary to contextualize India's contribution keeping in view the mitigation actions of other countries, especially the Annex-I Parties of the UNFCCC. Such contextualization will be in accordance with the Article 3.1 of the Convention which calls for climate action "on the basis of equity in accordance with common but differentiated responsibilities and respective capabilities" of each Party. In the absence of such contextualization, it will not be possible to provide the correct metrics to assess India's progress in mitigation.

India is currently home to 17.8 per cent of the global population (MoSPI, 2018). India's per capita GHG emissions (including LULUCF) in 2016, based on the national inventory reported in Chapter 2, were 1.96 t CO_2e which is less than one third of the world's per capita GHG emissions (6.55 t CO_2e) (CAIT database, 2020) for the same year. Historically, between 1850 and 2017, India has only contributed about 4 per cent to global cumulative emissions (Gütschow et al., 2019a). Even after 1990, entering a period of rapid economic growth, India's contribution to global cumulative emissions has only been 4.9 per cent. In contrast, the 28 Annex-I parties account for 37 per cent of the global cumulative emissions between 1990 and 2017 despite being home to only 13.5 per cent of the global population. India's responsibility towards mitigation of GHG emissions is therefore low, by any equitable measure of responsibility. As the Indian economy continues to grow rapidly, meeting India's developmental needs will require scaling up of infrastructure and energy use. India's commitments under the Convention and the Paris Agreement are such as to ensure efficient growth that will allow for development and contribute to mitigating GHG emissions.

Under the provisions of Article 12, paragraphs 1(b) and 4, and Article 10, paragraph 2(a), of the Convention, India made a voluntary declaration in 2010 to reduce the greenhouse gas emission intensity of its GDP by 20-25 per cent by 2020 from 2005 levels. Agriculture sector emissions are excluded from the assessment of emission intensity, considering that these are survival emissions for a country like India. In keeping with this pledge, an emission intensity reduction of 24 per cent has been achieved between 2005 and 2016 (excluding emissions from the agriculture sector). In 2015, India further enhanced this ambition in its NDCs to reduce the emission intensity of GDP by 33-35 per cent by 2030 from 2005 level (UNFCCC, 2016). Effective policymaking, implementation, strengthening of institutions and building of capacities have aided the reduction in emission intensity of India's GDP. The Government of India has taken various steps to implement the provisions of the Convention in keeping with national circumstances by widening the efforts across sectors. The planned and implemented policies and measures mitigate emissions of GHGs across sectors either directly or indirectly.

Effective measures to increase the share of cleaner and renewable energy in the total energy mix by replacing fossil fuels are also being carried out across sectors and across all States and UTs by providing them with targets for capacity addition of RE technologies in a set timeframe. Non-fossil fuel sources such as solar, wind, nuclear and modern energy technology-based sources such as waste to energy and biofuels have already been deployed at a steadily increasing rate and have contributed to the reduction in emissions intensity. Through proactive measures and conscious action, the country has been increasingly making efforts to improve energy efficiency and enhance tree and forest cover in India, without compromising on its developmental priorities.

Coal will however continue to play a critical role in India's fuel and energy mix. Unlike those countries who are pro-active in planning for phase-out of coal, only to replace them by oil and gas, India is transparent in its need for coal for its energy security, lacking any major domestic oil and gas resources. India will however use coal responsibly as testified by the number of clean coal initiatives that are being undertaken.

This chapter focuses on the actions undertaken for mitigation, capturing the initiatives and targets and charting the progress of the measures undertaken, over a wide range of sectors across the entire economy.

3.2 National Action Plan on Climate Change

The second BUR elaborated the objectives and progress of the National Action Plan on Climate Change (NAPCC) which was launched in 2008 to address climate change-related concerns and promote long term sustainability. Eight missions which form the core of the NAPCC have been listed below with an update on the progress of each of the missions.

Table 3.1: Implementation of NAPCC

Mission	**Target / Deliverables**	**Key achievements**
National Solar Mission	(i) Achieve 100 GW of solar power by 2022. (ii) The target of 100 GW solar power is to be achieved in seven years starting from 2014-15, with 40 GW of grid-connected rooftop projects and 60 GW of large and medium land-based solar-power projects. (iii) Enabling the policy framework for implementation of the mission. (iv) Promoting 2 GW of off-grid solar applications, including 20 million solar lights by 2022.	• The cumulative capacity of 36.05 GW has been commissioned till September 2020. Around 36 GW of solar energy capacity is under installation, and an additional 19 GW capacity has been tendered. Consequently, the total capacity that is already commissioned or in the pipeline is about 91 GW.

Mission	Target / Deliverables	Key achievements
	(v) Creating a conducive environment for developing solar manufacturing capability in the country. (vi) Supporting research, development and capacity building activities.	• Under the PM-KUSUM solar pumpsets scheme, a total of 25.75 GW of solar power capacity is expected to be developed by 2022. Currently, 0.256 million solar pumps have been set up till March 2020 (MNRE, 2020). • 40 solar parks in 17 States with an aggregate capacity of 22.61 GW have been approved and 7.94 GW solar projects have been commissioned inside such parks (MNRE, 2020).
National Mission for Enhanced Energy Efficiency (NMEEE)	(i) Mandating specific energy consumption reduction in large energy-consuming industries, with a system for companies to trade energy-savings certificates. (ii) Energy incentives, including reduced taxes on energy-efficient appliances. (iii) Financing a public-private partnership to reduce energy consumption through demand-side management programmes in municipal buildings and the agricultural sector. (iv) NMEEE includes four initiatives: Perform, Achieve and Trade; Energy Efficiency Financing Platform; Market Transformation for Energy Efficiency; and Framework for Energy Efficient Economic Development.	• PAT Cycle I (2012-13 to 2014-15) emission reduction of 31 $MtCO_2$ was achieved. • PAT Cycle II (2016-17 to 2018-19), emission reduction of 61.34 $MtCO_2$ was achieved. • PAT Cycle III (2017-18 to 2019-20) concluded on 31 March 2020, results of this cycle are awaited. • PAT cycles IV, V and VI have been notified.
National Mission for Green India (GIM)	(i) To increase forest/tree cover by 5 million ha of forest/non-forest lands and improved quality of forest cover on another 5 million ha (a total of 10 million ha). (ii) Improved ecosystem services including biodiversity, hydrological services and carbon sequestration as a result of treatment of 10 million ha. (iii) To increase forest-based livelihood income of about 3 million households living in and around the forests. (iv) To enhance annual CO_2 sequestration by 50 to 60 million tonne in the year 2020.	• An amount of INR 894.20 million has been released between 2017 and 2019 (MoEFCC, 2019). • The afforestation activities have been carried out over an area of 1,42,684 ha during the period 2015-16 to 2019-20.

Mission	Target / Deliverables	Key achievements
National Mission on Sustainable Habitat (NMSH)	(i) Development of sustainable habitat standards that lead to robust development strategies while simultaneously addressing climate change-related concerns. (ii) Preparation of city development plans that comprehensively address adaptation and mitigation concerns. (iii) Preparation of comprehensive mobility plans that enable cities to undertake long-term, energy-efficient, and cost-effective transport planning. (iv) Capacity building for undertaking activities relevant to the mission.	• Evolution of the standards with respect to water supply and sewerage sector (MoHUA, 2012). • Under the Energy Conservation Building Code (ECBC), 335 demonstration buildings have been supported with technical assistance for compliance in the States/UTs. Cumulative built up area of 0.16 billion m^2 ensuring an approximate energy saving of 0.17 billion units. • Under the Smart Cities Mission (SCM), 1,987 projects have been already completed while 4,375 projects are under implementation. SCM requires cities to have at least 10 per cent energy coming from solar and at least 80 per cent buildings to be energy efficient and green. (MoHUA, 2020). • As on 12 November 2020, 3,085 projects of INR 130.7 billion have been completed under the AMRUT mission (MoHUA, 2020a).
National Water Mission (NWM)	(i) Creating a comprehensive water database in the public domain and assessing the impact of climate change on a water resource. (ii) Promoting citizen and state action for water conservation, augmentation, and preservation. (iii) Focusing attention on overexploited areas. (iv) Increasing water-use efficiency by 20 per cent. (v) Promoting basin-level integrated water resources management.	• Financial assistance of INR 5 million to major states and INR 3 million to small states/UTs as a grant for the formulation of State Specific Action Plans (SSAPs) for the water sector. • The National Institute of Hydrology is also acting as Nodal agency to get the State Specific Action Plan for the water sector for 16 States and UTs namely, Bihar, Haryana, Himachal Pradesh, Kerala, Punjab, Rajasthan, Uttar Pradesh, Andaman & Nicobar Islands, Chandigarh, Dadar & Nagar Haveli (+ Daman & Diu), Delhi, Goa, Jammu & Kashmir, Jharkhand, Lakshadweep, Puducherry (NWM, 2020).

Mission	Target / Deliverables	Key achievements
		• Five States have completed the first phase of SSAP.
National Mission for Sustainable Agriculture	(i) To make agriculture more productive, sustainable, remunerative, and climate resilient. (ii) To conserve natural resources through appropriate soil and moisture conservation measures. (iii) To adopt comprehensive soil health management practices. (iv) To optimize the utilization of water resources through efficient water management. (v) To develop the capacity of farmers and stakeholders.	• A total of 33,487 ha of the area has been brought under the System of Rice Intensification (SRI) in 2018. • Total of 41,526 ha has been brought under the Direct Seeded Rice (DSR) system in 2018. • 23 million trees have been planted till 2018-19, covering an area of 52,003 ha (DAC&FW, 2020). • During 2018-19 & 2019-20 under the National Bamboo Mission, an area of 14,236 ha was covered along with other envisaged value chain development and skill development activities. • 16,826 Custom Hiring Centres (CHCs) of in-situ crop residue management machinery have been established in 2018-19 and 2019-20 to reduce crop residue burning.
National Mission for Sustaining Himalayan Ecosystems (NMSHE)	(i) To understand the complex processes affecting the Himalayan ecosystem. (ii) To continuously assess the health status of the Himalayan Ecosystem. (iii) Enable policy bodies in their policy-formulation functions. (iv) Assist states in the Indian Himalayan region with their implementation of actions selected for sustainable development. (v) Networking and strengthening of knowledge institutions. (vi) Start of new centres relevant to climate change in the existing institutions in the Himalayan States. (vii) Regional cooperation with neighbouring countries in Glaciology.	• Climate Cells/Centres have been established in 11 out of the 12 Himalayan States for building the institutional capacity of Himalayan States in the area of climate change adaptation (MoST, 2018). • Indo-Swiss Capacity Building Programme on Himalayan Glaciology was also organized to help build capacities and contributed to the training of 51 researchers. • Common Framework for Climate Vulnerability and Risk Assessment developed to understand the vulnerability profile of the entire Himalayan region (MoST, 2018), by DST in collaboration with SDC and scientists from IISc, IIT Guwahati and IIT Mandi.

Mission	Target / Deliverables	Key achievements
National Mission on Strategic Knowledge for Climate Change (NMSKCC)	(i) Formation of knowledge networks among the existing knowledge institutions engaged in research and development relating to climate science and facilitate data sharing and exchange. (ii) Establishment of global technology watch groups with institutional capacities to carry out research on risk minimisation technology selection for developmental choices. (iii) Development of national capacity for modelling the regional impact of climate change on different ecological zones within the country. (iv) Establishing research networks and encouraging research in the areas of climate change impacts. (v) Generation and development of the conceptual and knowledge basis for defining sustainability of development pathways. (vi) Providing an improved understanding and awareness of the key climate processes and resultant climate risks. (vii) Creating institutional capacity for research infrastructure.	• 116 Training programmes have been launched and 14,000 people have been trained. • A total of 23 major R&D programmes have been spread over the country. • 7 Human Capacity Building and National Knowledge Network programmes in the areas of climate change science, adaptation and mitigation have been launched. • 8 Global Technology Watch Groups in the areas of renewable energy technology, advance coal technology, enhanced energy efficiency, green forest, sustainable habitat, water, sustainable agriculture and manufacturing have been set up (DEA, 2020).

State Action Plans on Climate Change (SAPCC)

The broader intent of the SAPCCs has been to ensure that state-level priorities on climate change adaptation and mitigation actions converge with the NAPCC missions as well as existing policies and programmes. Thirty-three SAPCCs have been approved and are being implemented since 2009. With the intent of strengthening the existing SAPCCs using recent scientific assessments and projections, MoEFCC issued guidelines to all the states for their revision in 2018. These guidelines seek to incorporate local and regional dimensions for assessing vulnerability, broader participatory approaches, efficient monitoring and evaluation systems and, clear financial roadmaps in the revised SAPCCs. The revised SAPCCs encourage a focused and structured approach towards strengthening climate action in priority sectors through sectoral plans.

The work done by India at sub-national levels with the SAPCC, first in 2012 and now with the revision underway according to the revised framework, reflects not just a concentrated effort by the country towards a more transformative narrative in the climate discourse but also highlights the recognition of sub-national actors as key influential stakeholders in national climate action.

3.3 Mitigation actions in power sector

The power sector in India is fuelled by diverse conventional sources such as coal, lignite, natural gas and oil, nuclear power as well as renewables such as wind, hydro, solar, biomass, waste, and biofuels. The rising electricity demand in the country has necessitated the expansion of installed generating capacity. India has had substantial growth in the transmission and distribution infrastructure to meet the rising demand. Enabling government policies and initiatives have led to a reduction in energy shortages, peak supply shortages, and building of surplus generation capacity.

The power sector in India has witnessed steady transformation over the past few years, with an increasing focus on clean and sustainable power generation sources. In 2015-16, the Indian government set a target of achieving 175 GW of renewable energy capacity by 2022, with a further increase proposed up to 450 GW (PIB, 2020i). In recent years, policies and programmes have been developed and implemented in the energy sector with a focus on addressing climate change concerns. India's NDC has declared a target of 40 per cent of cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030. The share of non-fossil fuel-based electricity generation installed capacity has already reached 38.18 per cent in November 2020 (CEA, 2020c). There has been an increasing focus on the use of renewables in power generation which is further aided by enabling government policies. The power generation capacity share of renewables (excluding large hydro and nuclear) grew from 4.98 per cent as on March 2006 to about 23.92 per cent by September 2020 (CEA, 2020c).

3.3.1 Renewable energy (RE)

The renewable energy (RE) sector in India is experiencing a period of rapid expansion, buoyed by strong government focus and policy support.

India's RE target is made up by 100 GW from solar PV power, 60 GW from wind power, 10 GW from bioenergy, and 5 GW from small hydropower.

As of November 2020, installed renewable power capacity (excluding hydro above 25 MW) has already crossed 90 GW, contributing to about 24 per cent of the country's installed electricity capacity. Besides, comparison between 2005 and 2020 shows that reliance on other sources like gas and diesel for meeting power demand has declined over the years. The share of renewable energy continues to progressively increase in the electricity mix with renewable energy generation in India crossing 100 billion units.

The cumulative renewable power installed capacity (excluding hydro above 25 MW) has increased by 2.6 times from 35 GW on 31 March 2014 to 90.39 GW on 30 November 2020 and constitutes over 24 per cent of the country's installed power capacity. With the inclusion of large hydro, the total installed capacity would be ~136 GW and the share of renewable energy in installed capacity would be over 36 per cent (PIB, 2020l). The share of non-fossil sources in installed capacity of electricity generation increased from 32.31 per cent in March 2014 to 37.99 per cent in September 2020 (CEA. 2020e).

Table 3.2: Installed power generation capacity in India

	As on 31.03.2006		As on 31.03.2012		As on 31.03.2017		As on 30.09.2020	
Fuel	**MW**	**Share**	**MW**	**Share**	**MW**	**Share**	**MW**	**Share**
Coal	68,519	55.13%	1,12,022	56.05%	1,92,163	58.80%	2,05,855	55.18%
Gas	12,690	10.21%	18,381	9.20%	25,329	7.75%	24,957	6.69%
Diesel	1,202	0.97%	1,200	0.60%	838	0.26%	510	0.14%
Hydro	32,326	26.01%	38,990	19.51%	44,478	13.61%	45,699	12.25%
RES	6,191	4.98%	24,503	12.26%	57,244	17.51%	89,229	23.92%
Nuclear	3,360	2.70%	4,780	2.39%	6,780	2.07%	6,780	1.82%
Total	1,24,287	100.00%	1,99,877	100.00%	3,26,833	100%	3,73,029	100%

*Figures at decimal may not tally due to rounding off
Source: CEA, 2020e.

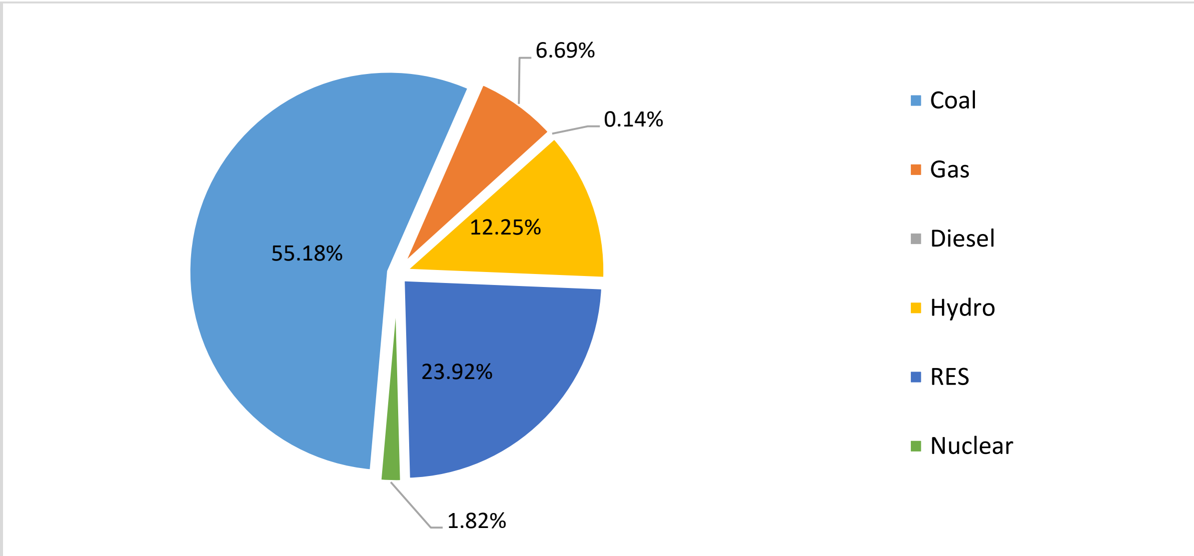


Figure 3.1: Installed power generation capacity, September 2020

Renewable Energy Sources (RES), apart from adding capacity into the grid are also increasingly being used for captive power generation. Generation from renewable energy sources has doubled between 2014-15 and 2018-19, while the generation from non-renewable sources has increased by 19 per cent during the same period. This has been actively promoted by the "must-run" status of renewable energy generation. The status of renewable energy-based power in the country is presented below.

Table 3.3: Year-wise details of RE generation

Years	RES Generation (billion units)
2014-15	61.72
2015-16	65.78
2016-17	81.55
2017-18	101.84

Years	RES Generation (billion units)
2018-19	126.76
2019-20	138.34
2020-21 (till October 2020)	89.52

Table 3.4: Installed capacity of renewables in India as on 30 September 2020

	Target for 2020-21	**Achievement** (Apr-Sept 2020)	**Total Installed Capacity**
1. Grid-Interactive Power (Capacities in MW)			
Wind power	3,000	380.40	38,124.15
Solar power – Ground mounted	9,000	721.93	32,834.42
Solar power – Rooftop	2,000	700.98	3,216.28
Small hydro power	100	56.80	4,739.97
Biomass power/cogeneration	200	173.37	9,373.87
Biomass (non-bagasse, cogeneration/captive power plant)	50	97.24	772.05
Waste to Power (WtP)	30	21.00	168.64
Total	**14,380**	**2,151.72**	**89,229.38**
2. Off-grid/ grid power (capacities in MW equivalent)			
Waste to Energy (WtE)	10	6.53	204.73
SPV systems	500	27.07	1,005.46
Total	**510**	**33.60**	**1,210.19**
3. Other non-renewable technologies (capacity in Nos)			
Biogas plants	0.60	0.09	50.50

Source: MNRE, 2020c.

Installed capacity of renewable energy sources as on 30 November 2020 stands at 90.39 GW. This includes solar power installed capacity of 36.91 GW, wind power 38.43 GW, bioenergy 10.31 GW and small hydro 4.74 GW. Solar and wind power dominated the installed capacity generation of power from renewables with a share of 36 per cent and 43 per cent respectively in FY 2019-20. The solar and wind sectors have seen rapid growth owing to policy and regulatory support, at both the central and state levels. State regulators have been periodically issuing policies and regulations for renewable energy with a special focus on solar. Cumulative capacity addition grew at CAGR of 125 per cent for solar and 12 per cent for wind between FY 2010 and FY 2020 for development in the country (PIB, 2020b).

Table 3.5: On grid solar capacity growth in India

Solar capacity growth in India		
Year	**Yearly installation (GW)**	**Cumulative capacity (GW)**
2010	0.005	0.010
2011	0.028	0.038
2012	0.862	0.900
2013	0.746	1.646
2014	1.001	2.647
2015	1.096	3.743
2016	3.019	6.762

Solar capacity growth in India		
Year	**Yearly installation (GW)**	**Cumulative capacity (GW)**
2017	5.526	12.288
2018	9.363	21.651
2019	6.529	28.180
2020 (September 2020)	7.871	36.051

Source: MNRE, 2020d.

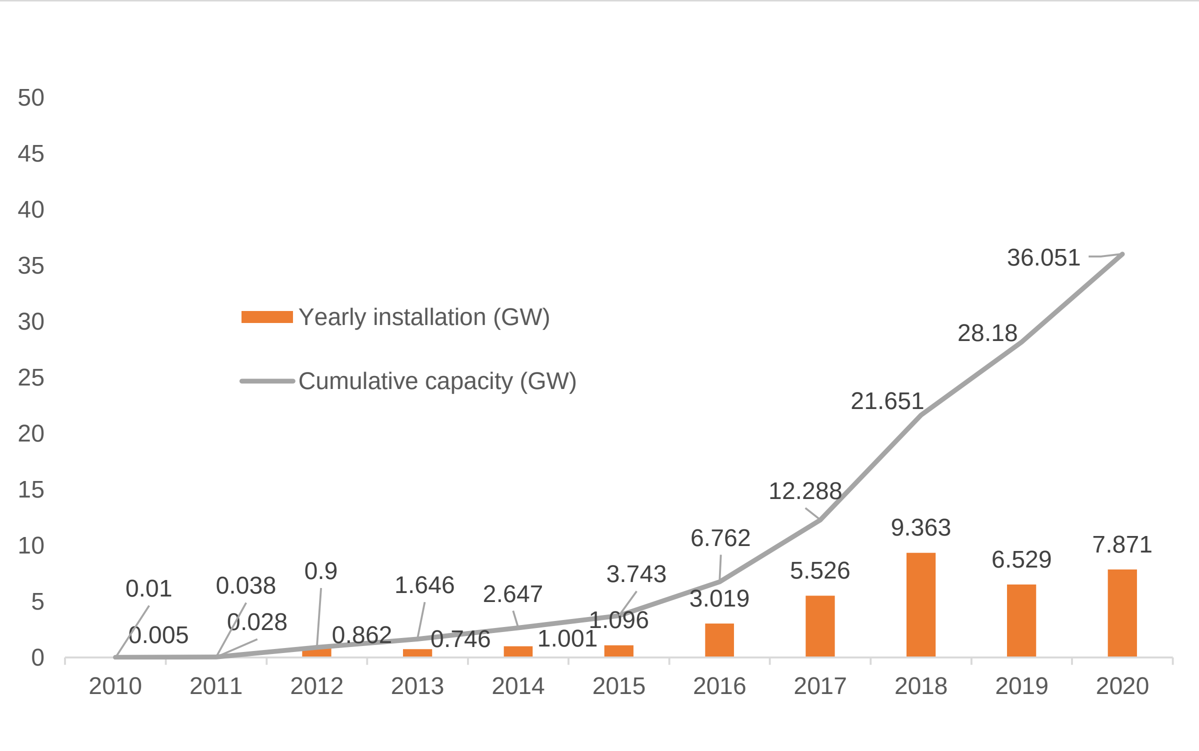


Figure 3.2: Solar capacity growth in India

The cumulative installed capacity of wind power in the country was 38.12 GW (as on 30 September 2020), the fourth highest in the world, after China, USA, and Germany.

Table 3.6: Wind Capacity Growth in India

Wind Capacity Growth in India		
Year	**Yearly installation (GW)**	**Cumulative capacity (GW)**
2010	1.6	11.8
2011	2.4	14.2
2012	3.2	17.4
2013	1.7	19.1
2014	2.1	21.2
2015	2.9	24.1
2016	3.5	27.6
2017	5.5	33.1
2018	1.8	34.9
2019	1.5	35.6
2020 (September 2020)	2.52	38.12

Source: CEA, 2020

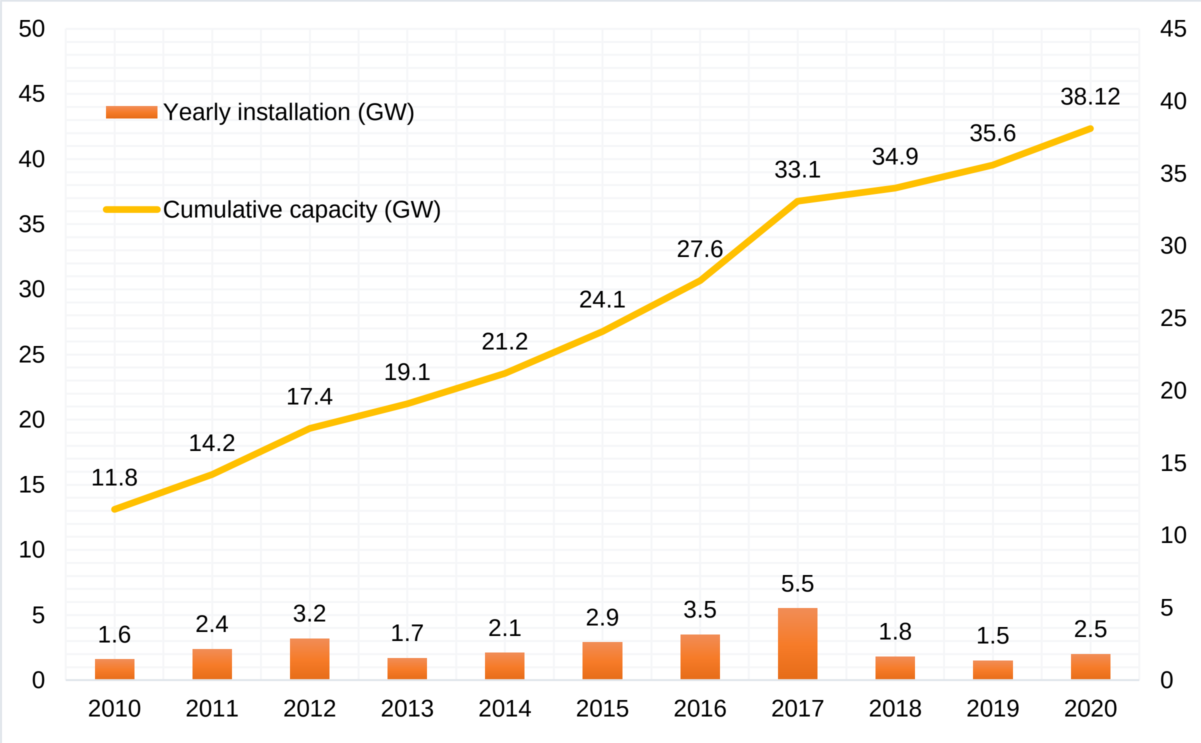


Figure 3.3: Wind capacity growth in India

The per-unit cost for solar and wind energy has decreased substantially, further incentivizing their deployment. The lowest tariff discovered through bidding process for solar is INR 2.36 / kWh (Mercom, 2020) and for wind INR 2.43 / kWh (PIB, 2018). The rapidly decreasing tariff for fresh deployment implies however that return on investment may be lowered and that longer time scales may be required for recovering initial investments. Early entry into renewables by India also implies that older projects provide power at higher tariff. As a consequence, India's mitigation costs are higher due to the "must-run" status of renewable power generation and the commitment to renewable power obligations of its DISCOMs. These enhanced costs of mitigation have not been supported in any form by Annex 2 Parties, particularly through climate finance.

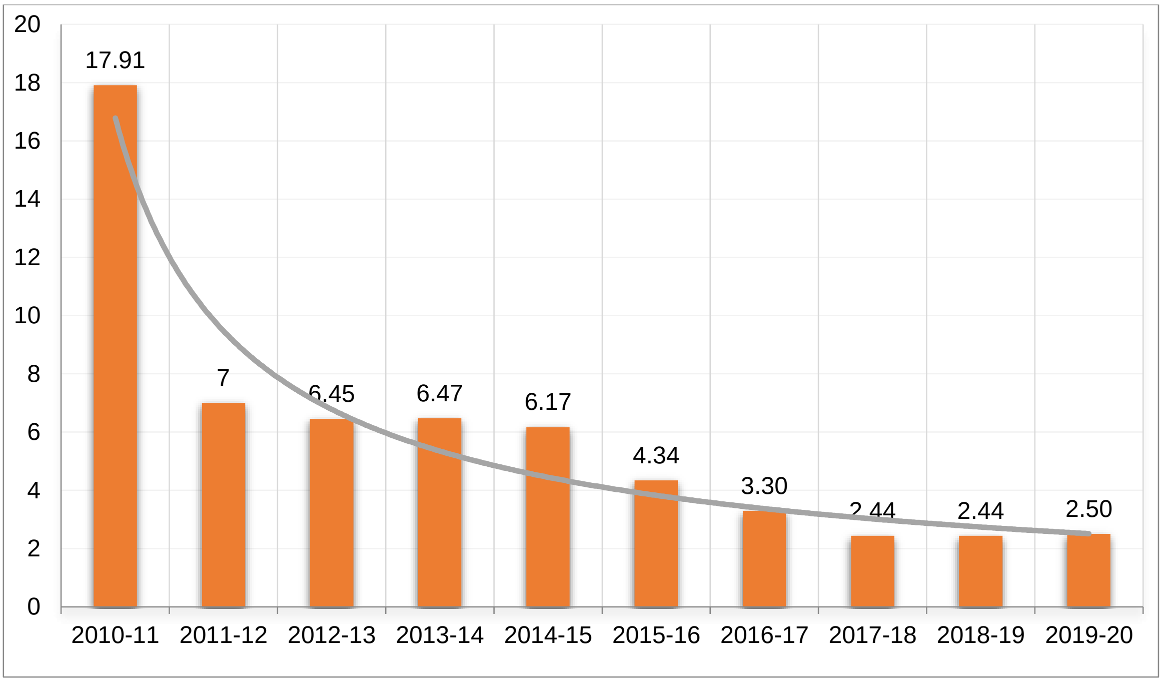


Figure 3.4: Solar tariff in India

Round-The-Clock (RTC) Power Procurement

MNRE has announced guidelines for procuring round-the-clock power from grid-connected renewable energy projects supported by conventional thermal power projects. The guidelines require that the generator shall supply dispatchable RE Power complemented with thermal power, in RTC manner, adhering to at least 85 per cent availability annually and at least 85 per cent availability during the peak hours. Peak hours are four hours out of the daily 24 hours and are to be clearly specified by the procurer beforehand in the bidding documents. The generator has to offer power such that at least 51 per cent of the annual energy offered corresponds to renewable energy and the balance is offered from thermal sources (MNRE, 2020b). The e-Reverse Auctioning for 400 MW RE projects with RTC supply conducted by SECI Limited in May 2020 resulted in a historic first-year tariff of INR 2.90 / kWh. This is for firm, schedulable and affordable RTC supply through 100 per cent RE power.

Distribution

Improved grid connections, improved financial health of DISCOMs and competitive auctions are critical elements to sustain progress in the growth of renewables in the country (IEA, 2020a; 2020b). Transmission and distribution (T&D) losses in India are high due to the wide spatial distribution of electricity consumers who are very often unable to pay the full cost of electricity. Government of India has assisted the State /DISCOMs in reducing the technical as well as commercial losses by providing the funds for strengthening and augmentation of distribution system, and also by introducing Aerial Bundled (AB) cables and various antitheft means under its ongoing schemes such as DDUGJY, Integrated Power Development Scheme (IPDS) and Saubhagya. Recovering costs is therefore difficult for utilities resulting in financial stress and difficulties in strengthening the distribution network. However, the GoI has made significant progress in the last few years in addressing this problem. The ongoing developments under the financial restructuring reform UDAY (Ujwal DISCOM Assurance Yojana) intend to strengthen the financial and operational status of DISCOMs, thereby reducing the overall AT&C losses in the country (UDAY, 2020).

The Table 3.7 depicts the good practices followed by some states to reduce their AT&C losses.

Table 3.7: Good practices to reduce AT&C losses

States	Good practice
Rajasthan	Enhanced community participation and anti-theft vigilance squad
Gujarat	Continuous efficiency improvement measures
Haryana	Elimination of manual intervention in meter reading, reward scheme for vigilance work
Assam	GIS mapping and systematic augmentation of the distribution system
Kerala	Computerization of billing, better manpower deployment
Manipur	Installation of prepaid meters

Source: UDAY, 2020.

Renewable Purchase Obligations (RPOs)

In continuation of the RPO targets, MoP has notified annual targets for a further period of three years from 2019-20 to 2021-22. Under the new targets, by 2021-22, RPOs amount to 21 per cent, of which 10.50 per cent must be from solar (MNRE, 2018).

Table 3.8: Long-term Trajectory of RPO

Long-term RPO trajectory	2019-20 (%)	2020-21 (%)	2021-22 (%)
Non-solar	10.25	10.25	10.50
Solar	7.25	8.75	10.50
Total	17.50	19.00	21.00

Source: MoP, 2018.

Renewable Energy Certificates (RECs) By an order dated 30 December 2019, the validity period of the RECs has been extended to 31 March 2020. The inventory of RECs as on June 2020 in the REC Registry is given below (POSOCO, 2020).

Table 3.9: Inventory of RECs

Solar REC	2,14,063
Non Solar REC	56,94,609
Total (Solar + Non Solar)	59,08,672

3.3.2 Nuclear power in India

In the overall cost of electricity generated from nuclear fuel, the cost of fuel is a much smaller component compared to the other components (DAE, 2020). Besides, spent fuel is a resource for fuel to be used in fast breeder reactors (FBR).

Further, the fuel discharged from nuclear reactors also contains a fissile component that can be recovered by reprocessing and recycled, preferably in FBRs, thereby further multiplying the fissile material. Thus, if the import of energy is a necessity, from strategic considerations, nuclear fuel is a preferable option.

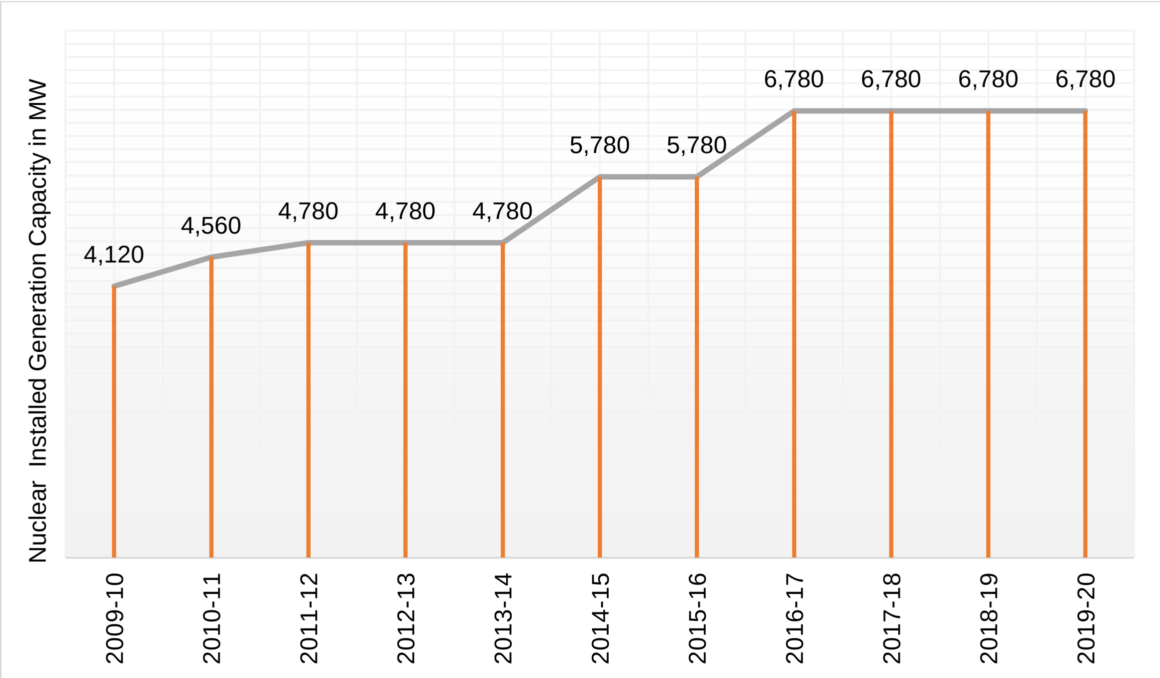


Figure 3.5: Nuclear power installed generation capacity from 2009-2019
Source: MoSPI, 2020a.

Thermal capacity addition after the 10th Plan (2002-03 to 2006-07) has increased significantly but capacity addition from hydro and nuclear has not been able to keep pace with the targets. At present, the Nuclear Power Corporation India Limited (NPCIL) is operating 22 commercial nuclear power reactors with an installed capacity of 6,780 MW as on September 2020, which is around 2 per cent of the power generation capacity from all sources in the country (CEA, 2020d).

Currently, NPCIL has eight reactors under various stages of construction, totalling 6,200 MW capacity. Given that nuclear projects are given priority and considered as must run projects on account of their inherent advantages, the government has committed nuclear capacity addition of 3,300 MW during 2017-22 and a further capacity addition of 6,800 MW during the 2022-27 period. The existing nuclear power capacity of 6,780 MW is proposed to be increased to 22,480 MW by 2031 (PIB, 2020e).

To ensure better utilization of nuclear energy, two public sector enterprises of the DAE, Nuclear Power Corporation of India Limited (NPCIL) and Bharatiya Nabhikiya Vidyut Nigam Limited (BHAVINI) are already in place for generation of power from nuclear energy. The generation targets are set on an annual basis, as a part of the MoU between the NPCIL and DAE. NPCIL's target achieved for the year 2018-19 is 37,812.81 million units (MU). NPCIL's target set for generation in the year 2019-20 was 39,600 MU. The generation in the year up to October 2019 was 28,339 MU (DAE, 2019).

3.3.3 Green energy corridor project

In order to facilitate renewable power evacuation and reshape the grid for future requirements, Green Energy Corridor (GEC) projects have been initiated. The first component of the scheme, the Inter-state GEC with target capacity of 3,200 circuit kilometre (ckm) transmission lines and 17,000 MVA capacity sub-stations, was completed in March 2020. The second component, Intra-state GEC with a target capacity of 9,700 ckm transmission lines and 22,600 MVA capacity sub-stations is expected to be completed by May 2021. The present efforts are focused on strengthening institutions, resources and protocols, and investing judiciously in grid infrastructure. In addition, Renewable Energy Management Centres (REMCs) are also being set up under the GECs. Presently, 55 GW of Renewable (Solar and Wind) is being monitored through eleven REMCs. This places India among a league of a few nations, which have state-of-the-art management centres for renewable energy integration (PIB, 2020).

3.3.4 Clean coal technology initiative

Coal (including lignite) based power accounts for about 55 per cent (205.4 GW) of India's installed capacity as of March 2020. More than 73 per cent of total generation comes from coal/lignite based power plants. The status of various clean coal technologies being adopted is as follows:

i) *Supercritical technology*: Already, 66 supercritical units with a total capacity of 45,550 MW have been installed, and 51,260 MW of supercritical capacity was under construction as of March 2018. The National Electricity Plan of India of 2018 included plans to build 94 GW of new coal fired capacity (mainly supercritical coal units) between 2017/18 and 2026/27. Currently, 22 have been permitted, while 50 are under construction (IEA, 2020a). A total of 4,240 MW in 2017-18, 4,240 MW in 2018-19 and 6,220 MW in 2019-20 of supercritical power units were commissioned (CEA, 2020a).

ii) *Coal to Gas:* Coal gasification is an alternate use of coal considering the environmental concerns of burning coal in thermal power plants. India's effort to gasify coal is affected due to the non-availability of technologies to gasify high ash Indian coal. There is a need to develop efficient low-cost gasification technology and support from technology providers of USA and China to transfer these technologies at reasonable cost. India aims for 100 million tonne (MT) coal gasification by 2030 with investments worth over INR 4 trillion. Encouraging use of clean sources of fuel, government has provided for a concession of 20 per cent on the revenue share of coal used for gasification. This is to boost the production of synthetic natural gas, energy fuel, urea for fertilisers and production of other chemicals (PIB, 2020f). Coal gasification aims at production of methanol, petro chemicals and ammonia and will support a hydrogen economy. CIL being experts in the mining of coal, may join hands with oil PSUs to make these efforts viable (MoC, 2020). CIL is also taking up more projects for surface coal gasification with relatively lower carbon footprints. The upcoming projects of Coal Bed Methane (CBM) extraction will also reduce the liberation of CH_4 into the atmosphere during coal mining, which will be taken up in future (MoC, 2020).

Table 3.10: Summary of supercritical and sub-critical units under construction in the country (As on 30 June, 2020)

Sector	Supercritical (MW)	Sub-Critical (MW)	Total (MW)	No. of Supercritical Units	No. of Sub-Critical Units	No. of Supercritical Projects	No. of Sub-Critical Projects	Total No. of Projects
Central	17,620	1,500	19,120	25	5	11	7	18
State	16,580	1,180	17,760	23	4	14	2	16
Private	9,240	14,490	23,730	14	39	7	19	26
Total	43,440	17,170	60,610	62	50	32	28	60

Source: CEA, 2020b.

iii) *Ultra Supercritical Plants*: Two units of 660 MW based on Ultra Supercritical Technology have already been commissioned (MoP, 2020a). These units have efficiency of 42.75 per cent on LHV basis. As per the design parameters steam pressure for these units is 270 kg/cm^2 and the temperature of SH/RH is 600^{o}C / 600^{o}C. Plants based on ultra super critical technology emit about 7.6 per cent less CO_2 as compared to conventional sub-critical units. 0.58 $MtCO_2$ can be avoided annually with the operation of a plant of 1,320 MW capacity.

iv) *Advanced Ultra Supercritical (AUSC) Technology:* AUSC technology refers to an advanced coal-based power generation system that works at higher temperatures (above 700^{o}C) and pressures for improved efficiency, reducing coal consumption and CO_2 generation. As mentioned in BUR-2, the initiative envisages the development of indigenous capabilities in the field of AUSC technology with 17 per cent less CO_2 emissions compared to a typical subcritical plant (500 MW). A consortium of Bharat Heavy Electricals Limited (BHEL), NTPC Limited and IGCAR (Indira Gandhi Centre for Atomic Research) was formed in 2010, under the aegis of the office of the Principal Scientific Adviser to the GoI, which has catalysed the development of the AUSC technology.

Efficiency improvements due to supercritical technology

With a growing emphasis on enhancing the efficiency of power generation along with reducing emissions, coal-based thermal stations are adopting supercritical technology. Supercritical units are about 1.8 per cent more efficient than subcritical technology-based power plants (IEA, 2020b). The average emission rate from coal-based power plants has been on a declining trend owing to the commissioning of a greater number of efficient supercritical technology-based units coupled with the introduction of Perform Achieve and Trade (PAT) scheme which aims at improving the efficiency of power plants.

The National Electricity Plan 2018 mentions that as of 31 March 2017, around 60 units based on supercritical technology have been commissioned in the country. The plan also indicates that 23 GW of coal-fired capacity is set to retire during 2017-22 and another 26 GW during 2022-27.

Table 3.11: Impact of supercritical technology-based power generation on CO_2 emissions

Total supercritical generation capacity as on September 2020 (in MW)	56,810
Actual generation from these units till September 2020 (in MUs)	14,51,591.25
CO_2 emission rate of subcritical unit (kg CO_2/kWh)	0.853
CO_2 emission rate of supercritical unit (kg CO_2/kWh)	0.816
Reduction in CO_2 emission due to adoption of supercritical units (in million tonne)	53.7088

Source: CEA, 2020f.

Fossil energy-based power plants have a thermal generating capacity of 2,50,061 MW as on 30 June 2020. India has 60 GW of capacity of subcritical and supercritical units under construction, with 72 per cent being supercritical, while in installed capacity less than one-third is supercritical (CEA, 2020b). India's subcritical coal-fired fleet is relatively young with an average age of 15 years. In addition to clean coal technology initiatives, other initiatives have also been taken to reduce emissions from thermal power stations. The power generators have been provided an opportunity to optimally utilize generation from renewable sources and help in reducing emissions.

3.4 Energy efficiency-related mitigation actions

Energy efficiency is one of the cornerstones of India's mitigation policy, and especially significant in relation to India's status as a rapidly developing economy. The trend in energy intensity of the Indian economy is captured in Table 3.12.

Table 3.12: Trends in energy intensity (2012-2019)

Year	Energy Intensity (MJ/ INR)
2011-12	0.2747
2012-13	0.2787
2013-14	0.2670
2014-15	0.2632
2015-16	0.2508
2016-17	0.2388
2017-18	0.2352
2018-19 (P)	0.2321

Source: MoSPI, 2020b.

It is clear that energy intensity has been declining steadily over the years, as a consequence of structural changes, rapid growth of renewables and active and strong implementation of policies directed towards this goal.

In section 3.4, energy efficiency-related measures and initiatives in the power and industry sector are discussed. To improve energy efficiency in various sectors, the

Bureau of Energy Efficiency (BEE) was constituted under the Energy Conservation Act, 2001. EESL is a joint venture of NTPC Limited, Power Finance Corporation (PFC), Rural Electrification Corporation (REC), and Power Grid Corporation of India Limited (PGCIL) under the Ministry of Power. BEE and EESL under MoP, have initiated energy efficiency initiatives in the areas of industry, household lighting, commercial buildings, standards and labelling of appliances. The adoption of energy efficiency schemes/ programme has led to overall energy savings of 23.728 Mtoe for the year 2018- 19 (BEE, 2019). Cleaner fuel use by industry has led to steady decline and increase in the consumption of petroleum products and LPG respectively (Figure 3.6 and Figure 3.7).

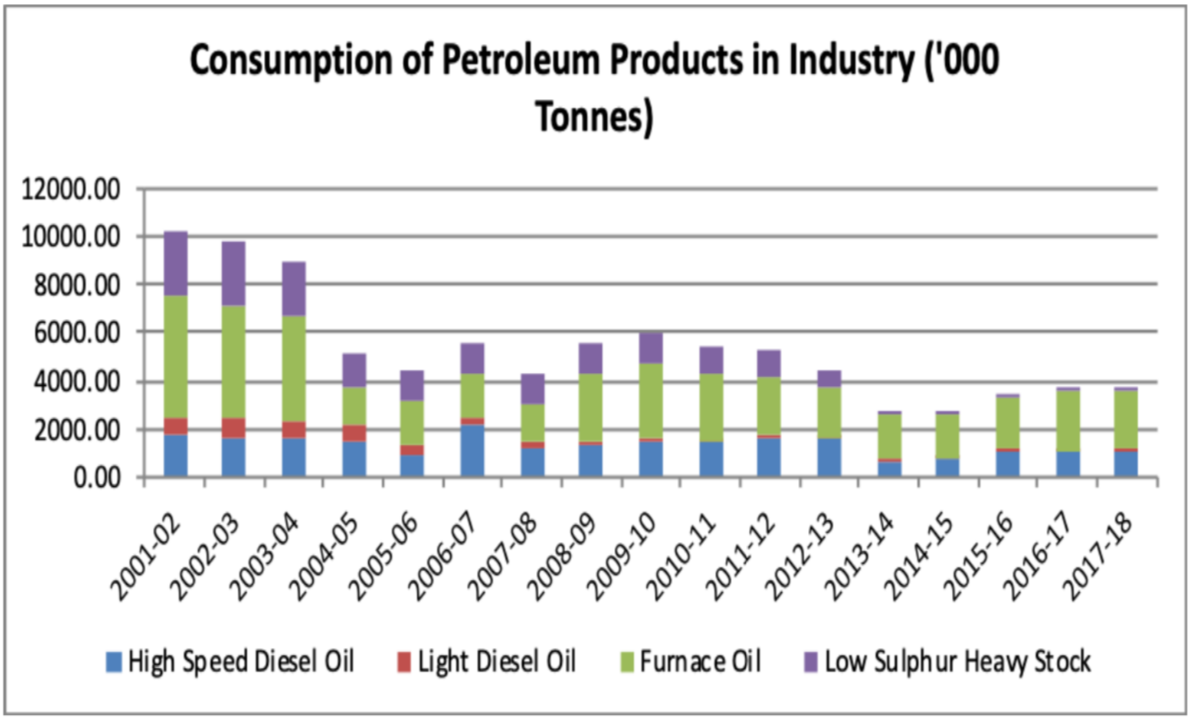


Figure 3.6: Consumption of petroleum products in the industry sector
Source: MoSPI, 2018.

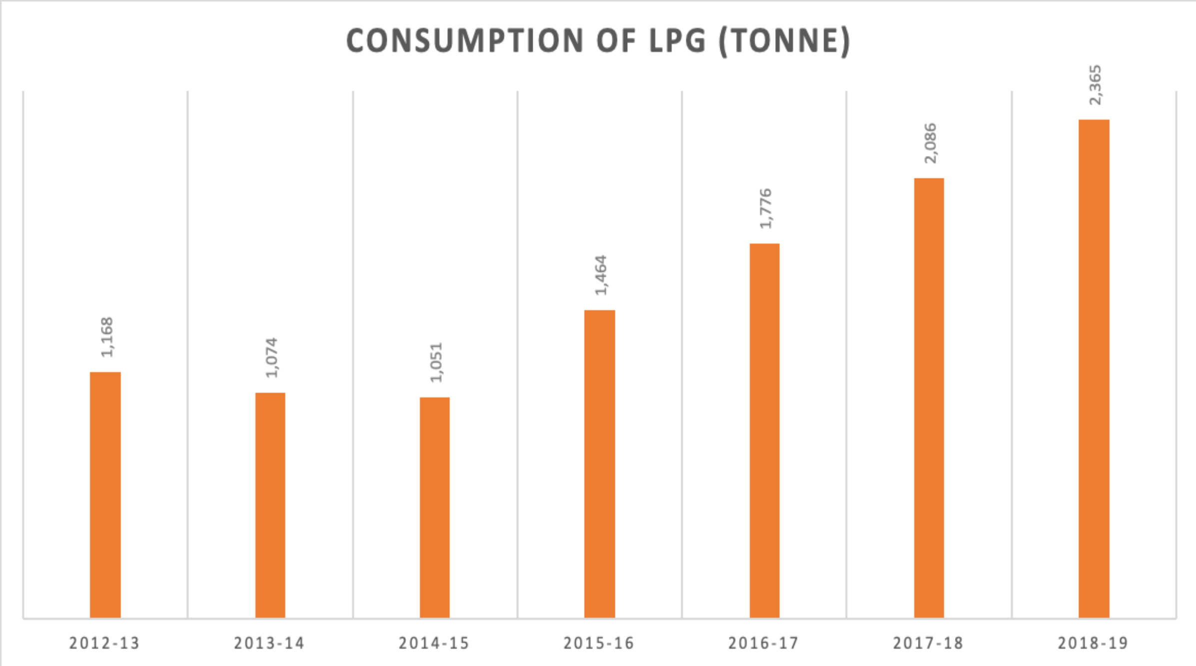


Figure 3.7: LPG consumption in industry
Source: MoSPI, 2019.

3.4.1 Perform, Achieve and Trade (PAT) Scheme

As reported in the second BUR, during the first cycle of PAT (2012-15), an energy saving of 8.67 Mtoe was achieved against the target of 6.686 Mtoe assigned for 478 designated consumers. This translated into avoiding about 31 $MtCO_2$ of emissions.

PAT Cycle II

PAT II (2016-17 and 2018-19) was implemented with the objective of widening the reach by increasing the sectors under the scheme and the number of Designated Consumers (DCs) under it. Three new sectors were added, making it a total of 11 sectors under the scheme and an additional 89 DCs. With a reduction target of 11.20 Mtoe, the cycle commenced from April 2016. This cycle resulted in the total savings of about 13.28 Mtoe, translating into 61.34 $MtCO_2$. The monetary savings estimated is approximately INR 3,14,450 million. The DCs had made approximately INR 437.21 billion of investments to achieve this target. Subsequent to PAT cycle II, the PAT cycle III, IV, V and VI have been notified. Under PAT cycle –VI, 135 DCs have been given a target of 1.277 Mtoe. Details are provided in Table 3.13. PAT cycle III was completed on 31 March 2020, with the evaluation of 116 new DCs and the monitoring and verification of the energy savings in progress (MoP, 2020a).

Table 3.13: Details of PAT Cycles

S. No.	PAT Cycles	Cycle Period	Notified on
1	PAT Cycle I	2012-13 to 2014-15	30 March 2012
2	PAT Cycle II	2016-17 to 2018-19	31 March 2016
3	PAT Cycle III	2017-18 to 2019-20	30 March 2017

4	PAT Cycle IV	2018-19 to 2020-21	28 March 2018
5	PAT Cycle V	2019-20 to 2021-22	29 March 2019
6	PAT Cycle VI	2020-21 to 2022-23	13 April 2020

Table 3.14: Energy savings and achievement of PAT cycle-II

Sector	Total DCs	Reduction Target from the DCs analyzed (Mtoe)	Energy Savings Achieved (Mtoe)
Aluminum	12	0.25	0.573
Cement	111	1.05	1.56
Chlor-Alkali	24	0.102	0.136
Fertilizer	37	0.443	0.383
Iron and Steel	71	2.267	2.913
Pulp and Paper	29	0.121	0.315
Textile	99	0.079	0.126
Thermal Power Plant	154	2.851	3.519
Petroleum Refinery	18	1.009	1.48
Railways	22	0.077	0.196
DISCOM*	44	2.99	2.077
Grand Total	**621**	**11.20**	**13.28**

Source: MoP, 2020a.

* For the DISCOM sector, BEE has assigned T&D loss reduction targets. After the completion of PAT Cycle-II, it is expected that the total loss reduction of the 44 DISCOMs would be around 10,723 MU.

3.4.2 Standards and Labelling Scheme

The Standards and Labelling (S&L) scheme was initiated with the key objective of providing consumers an informed choice regarding energy savings and thereby the cost-saving potential of various energy-consuming appliances. S&L scheme covers the star labelling program for 26 appliances, out of which 10 appliances are under the mandatory regime and the remaining 16 appliances under the voluntary regime. Sustained efforts have led to the following milestones in FY 2018-19. The energy saving achieved under the scheme in the year 2018-19 amounts to 55.69 billion units translating to an abatement of 45.67 $MtCO_2$ in emission (MoP, 2020a).

3.4.3 Market Transformation for Energy Efficiency (MTEE) Achievements

This initiative is meant to accelerate the shift to energy efficient appliances in designated sectors through innovative measures to make such products more affordable. Under this initiative, refrigerators, ceiling fans, air-conditioners, water heaters, and motors were identified as the priority products for initial S&L development. Ceiling fans have been covered in the first phase. The second phase will include appliances like air conditioners and refrigerators. The programme also supports the Make in India initiative through accelerated market transformation and innovative measures. Two programmes were developed under this scheme: Bachat Lamp Yojana (BLY), now renamed as the Unnat Jyoti by Affordable LEDs for All (explained in section 3.4.6), and Super-Efficient Equipment Programme (SEEP).

Promoting Market Transformation for Energy Efficiency in MSMEs

According to the National Sample Survey (NSS) 73rd round, conducted by the Ministry of Statistics & Programme Implementation during the period 2015-16, the number of MSMEs was estimated at 63.38 million, employing about 110.98 million persons. Most of the enterprises are micro (99.47 per cent), and small and medium-sized enterprises constitute only 0.53 per cent of total units. The MSME sector in India is generally still using first-era technologies/processes, resulting in higher energy intensity (MoP, 2020a).

To promote technology up-gradation and modernization, GoI has been employing several measures aimed at fostering a regime that could remove barriers for accelerated technology up-grades focusing on energy efficiency and innovation. The key objectives of the present government interventions are to:

- Enhance training and capacity building programmes, including strengthening of training delivery institutions. Enhancing skills will also encourage a faster generation of employment as a result of improved capacity for growth;
- Promote the adoption of clean and emerging technologies to not only reduce energy intensity (and therefore increase cost competitiveness) but also to upgrade the quality of output;
- Encourage innovation through setting up a large number of business incubators in educational institutions of repute;
- Promote market-based energy efficiency measures which are inclusive;
- Accelerate market for EE technologies and adoption of EE measures though attractive financial support (ex., Credit Linked Capital Subsidy Scheme (CLCSS), for technology upgradation)

The Global Environment Facility (GEF) entrusted the United Nations Industrial Development Organization (UNIDO) with the implementation of the project “Promoting Market Transformation for Energy Efficiency in Micro, Small and Medium Enterprises”, in close cooperation with the Ministry of MSME, GoI (MoP, 2020a).

This project aims to develop and promote a market environment for introducing energy efficient technologies and enhancing the use of renewable energy technologies in process applications in energy-intensive MSMEs in 5 sectors (brass, ceramics, dairy, foundry, and hand tools). The project is being implemented in 12 energy intensive SME clusters and has scaled up its activities in another 12 energy intensive clusters. Energy Management Centres established in the clusters under this project are supporting MSMEs to reduce their energy consumption by inculcating the habit of periodical energy audits, and thereby promoting the adoption of best operating practises in daily operations among MSMEs (MoP, 2020a).

Similarly, another project, "Financing of Energy Efficiency at MSMEs" recently concluded. The project was jointly implemented by GEF, World Bank, and BEE under the Programmatic Framework for Energy Efficiency in India to increase demand for energy efficiency investments in target micro, small and medium enterprise clusters and to build their capacity to access commercial finance. The project has built confidence among MSMEs for adopting clean and energy efficient technologies by preparation of DPRs, carrying out energy audits, development of sectoral benchmarks, and capacity building of MSMEs. The project has been instrumental in the implementation of ISO-50001 in 50 MSMEs.

Energy conservation guidelines for MSMEs have also been developed for 24 energy intensive MSME sectors for quick adoption of best operating practices (BOPs) in their processes and EE equipment to improve their energy efficiency and productivity. A digital knowledge portal “SIDHIEE" (Simplified Digital Hands-on Information on Energy Efficiency in MSMEs) has also been developed for MSMEs. The portal hosts a wealth of information on energy efficient technologies, best industrial practices, and success stories including 50 multimedia tutorials on energy efficient technologies. Implemented as part of the larger MSME energy efficiency programme of the BEE, this programme will engage in focused efforts in 5 targeted clusters to increase demand for energy efficiency products and services and mobilize a large group of “decision-ready” units in partnership with the local industrial associations, energy professionals, local service providers and leading vendors of energy efficiency equipment. These energy efficiency demand creation activities will then be linked with the lending programmes of various financial institutions in the specific cluster.

Additionally, BEE and UNIDO are also engaged in conducting annual 'Innovation Challenge' competitions that will identify innovative low carbon technologies and solutions to improve efficient end-use of energy, which in turn will help to reduce greenhouse gas emissions in the long run.

Considering the urgent need to develop, demonstrate and disseminate energy efficient technologies at the cluster level, the “National Programme on Energy Efficiency and Technology Upgradation in SMEs” was evolved by the BEE to address the various challenges faced by MSMEs in India. The objective of the program is to improve the energy efficiency of SME sector in India through accelerated adoption of energy efficient technologies, knowledge sharing, capacity building and the development of innovative financial mechanisms.

Table 3.15: List of clusters where demonstration projects have been implemented under “National Programme on Energy Efficiency and Technology Upgradation of MSMEs”

Sr. No.	Sector	Cluster
1	Textile	Pali, Rajasthan
2	Food processing	Indore and Ujjain, Madhya Pradesh
3	Bricks	Varanasi, Uttar Pradesh
4	Forging	Ludhiana, Punjab

Source: BEE, 2020.

Table 3.16: Energy savings and emission reduction in 2018-19

Name of Scheme/Initiative	Total energy savings (Mtoe)	Emission reduction ($MtCO_2$)
BEE-SME Programme	0.001	0.004

BEE-UNIDO-GEF Programme	0.009	0.047
BEE-WB-GEF Programme	0.012	0.073
Total	0.022	0.124

Source: BEE, 2020.

3.4.4 Energy Efficiency Financing Platform (EEFP)

EEFP provides a platform to interact with financial institutions (FIs) and project developers for implementation of energy efficiency projects. It is an awareness generation and capacity building platform for various stakeholders. For capacity building of FIs, BEE signed an MoU with Indian Banks' Association for the Training Programme on Energy Efficiency Financing. The MoU was signed in 2015 and the training programme was launched in June 2015. Workshops were held in two phases; Phase 1 included 4 Training of Trainer (ToT) workshops and 2 direct training workshops. In Phase 2, 22 direct training workshops on energy efficiency financing were held at different locations (17 States covered) across India for financial institutions. In these workshops, a total of 682 participants from 72 banks and NBFCs received training on EE financing (MoP, 2020a).

3.4.5 Framework for Energy Efficient Economic Development (FEEED)

One of the key elements of the NMEEE is the FEEED, which focuses on developing fiscal instruments to promote energy efficiency financing. FEEED is designed to provide comfort to lenders with the provisions of risk guarantee for performance contracts through Partial Risk Guarantee Fund for Energy Efficiency (PRGFEE) and equity infusion through the Venture Capital Fund for Energy Efficiency (VCFEE). The PRGFEE is a risk-sharing mechanism to provide financial institutions with partial coverage of risk involved in extending loans for energy efficiency projects, and VCFEE is a trust fund to provide last mile equity capital to the borrowers. Through PRGFEE, Energy Service Companies (ESCOs) will be able to receive partial guarantee while seeking a loan for an energy efficiency project. To operationalize the fund, PRGFEE rules have been notified and presently five financial institutions have been empanelled under PRGFEE, namely Andhra Bank, Yes Bank, Tata Cleantech Capital Limited (TCCL), IDFC Bank, and IndusInd Bank. These institutions are eligible to get a risk guarantee of up to 50 per cent of the loan amount or INR 100 million per project whichever is less (MoP, 2020a).

3.4.5.1 Venture Capital Fund for Energy Efficiency (VCFEE)

The Fund was constituted under the provisions of the Indian Trust Act 1882, and its Rules got notified on 31 March 2017. The Rules mandate that the fund shall provide last mile equity support to specific energy efficiency projects, limited to a maximum of 15 per cent of total equity required, through Special Purpose Vehicles or INR 20 million, whichever is less. The support under VCFEE will be provided to government buildings, private buildings (commercial multi-storey residential buildings), and municipalities (MoP, 2020a). The GoI has approved about INR 2.1 billion for the VCFEE. The fund helps to create the volume in EE deal flow by the fund manager of VCFEE through advertising and soliciting opportunities in energy efficiency area.

Energy Service Companies (ESCOs) and companies that plan to undertake EE projects in the energy performance contracting mode are the key potential beneficiaries of the VCFEE.

3.4.6 Efficient lighting in India

In the last few years, technological advancements in lighting have led to the development of energy-efficient lighting systems that consist of one or more components such as low loss ballasts; constant wattage high-intensity electronic ballasts; Energy-efficient luminaires; and better monitoring and control mechanisms.

Under the Unnat Jyoti by Affordable LED for All (UJALA) scheme, LED bulbs, LED Tube lights, and Energy efficient fans continue to be provided to domestic consumers for the replacement of conventional and inefficient variants. Under Street Lighting National Programme (SLNP), conventional street-lights are being replaced with smart and energy efficient LED street lights across India.

The programme is being implemented by Energy Efficiency Services Limited (EESL), a Joint Venture (JV) of PSUs under the MoP, GoI. Till November 2020, over 366.85 million LED bulbs, 7.207 million LED tube lights, and 2.340 million energy efficient fans had been distributed by EESL across India (MoP, 2020a). This has resulted in cumulative emission reduction of 180.08 $MtCO_2$ from 2014-15 to November 2020. Through the scheme, EESL has also been able to engage with the common man at a significant scale. So far, more than 90 million consumers have availed the benefit of using these LED bulbs, thus making it the largest non-subsidy based LED lighting programme in the world.

Under SLNP, up to September 2020, EESL has installed over 11.25 million LED street lights in Urban Local Bodies and Gram Panchayats across India. This has resulted in cumulative energy savings of 18.071 billion units and emission reduction of 14.82 $MtCO_2$ from 2015-16 to 2019-20. Under SLNP, 1,508 Urban Local Bodies (ULBs) have been enrolled and out of these ULBs, work has been completed in 972 ULBs. This is the largest installation of LED street lights across the world. UJALA and SLNP are voluntary adoption schemes which run without any budgetary support from the GoI and are based on a sustainable business model where the cost is repaid by consumer/Urban Local Bodies (ULB) from savings in energy and maintenance expenditure over some time through savings in electricity bills (MoP, 2020a).

MNRE under its Off-grid and Decentralized Solar PV Applications Programme has been promoting installation of LED based solar street lights throughout the country. During the recent years, MNRE has launched Atal Jyoti Yojana (AJAY) Phase-I and Phase-II Schemes and Off-grid and Decentralized Solar PV Applications Phase-III Scheme.

Considering the success of Phase-I of AJAY, the Phase-II was launched in December 2018 with expansion of Phase-I and Solar LED Street Lights (SSLs) of higher illumination (12 W LED with 75 Wp solar panel). Under Phase-II in addition to States covered under Phase-I, North-eastern States including Sikkim, Hilly States/UTs, Island UTs and aspirational districts in balance States were covered as given below:

- PCs of Phase-I state – 1,000 nos. SSLs in each PC
- PCs of other States/UTs fully covered – 2,000 nos. SSLs in each PC
- PCs of Aspirational Districts – 500 to 2,000 nos. SSLs in each PC depending upon its coverage in that Aspirational District

Under AJAY Phase-I and II, EESL installed over 0.15 million SSLs in rural areas of Uttar Pradesh, Assam, Bihar, Odisha, Jharkhand, Madhya Pradesh, Uttarakhand, Rajasthan and Gujarat (EESL, 2020). A total of 0.304 million SSLs were to be installed under AJAY Phase-II. Before closure of sanctions under the scheme on 31 March 2020, sanctions have been received for installation of 0.144 million SSLs of which 62,736 SSLs have been installed till 10 August 2020. Under Off-grid and Decentralized Solar PV Applications Scheme Phase-III, about 0.172 million solar street lights have been sanctioned out of which over 15,000 have been installed and balance are under installation.

3.4.7 Demand Side Management Programmes (DSM)

Demand Side Management (DSM) has been recognized as one of the major interventions to achieve energy efficiency.

3.4.7.1 Agriculture Demand Side Management (AgDSM)

The agricultural sector constitutes around 18.5 per cent of India's total energy consumption. The total power consumption in the sector is expected to rise by an estimated 54 per cent between 2015 and 2022. Energy is utilized mainly for two purposes; irrigation and running the machinery. The irrigation component is estimated to utilise 70 per cent of the total energy consumption as a result of the usage of 2.1 million pump sets in the country. Poor quality pump sets used for irrigation are both inefficient and unreliable, causing water waste and higher energy consumption (MoP, 2020a).

A DSM management programme has been designed and implemented, replacing energy inefficient agricultural pump sets with BEE rated 5-star energy efficient pump sets. Through this initiative a potential energy saving of 52 billion units has been estimated, avoiding a peak demand of 48,000 MW. This programme was initiated by BEE to reduce energy consumption in the agricultural sector. Currently, replacement of 2,496 pump sets is underway at Rajanagaram Mandal in the East Godavari district under the Eastern Power Distribution Company of AP Limited, Andhra Pradesh. The achievement in the state has been estimated to be approximately 30 per cent. This not only resulted in a reduction in State subsidy but also increased the overall efficiency of the power sector. A total replacement of 2.1 million pump sets is envisioned under this programme and measures are being taken to achieve this target (MoP, 2020a).

Table 3.17: Activities and initiatives under the AgDSM programme

Programme	Activities	Agencies responsible for the on-ground implementation	Target	Progress of programme
Agriculture Demand Side Management	Stakeholder consultation and capacity building for DISCOMs, SERCs, SDAs and manufacturers to use energy efficient pump-sets for all new connections	State Designated Agencies (SDAs) Indian Council for Agriculture Research Krishi Vigyan Kendras	To mandate the use of energy efficient pump sets in all States/UTs	• A total of 74,136 pumps have been installed by EESL under the programme in Andhra Pradesh and Uttar Pradesh, resulting in energy savings of 191 million kWh and emission reduction of 0.14 $MtCO_2$ per year. • Haryana, Punjab, Kerala, Odisha, Karnataka, Maharashtra, Puducherry (UT), Uttarakhand, Himachal Pradesh and Tamil Nadu made mandatory the use of star labelled energy efficient pumps-sets (EEPS) (above 3-star rated) for new agriculture connections. • Uttar Pradesh and Jharkhand have initiated the process for mandating the EE pump-sets in their respective States.
	Creating awareness among farmers by using print media and channels.		To provide training and awareness programme to the farmers and other stakeholders covering maximum KVKs out of the total 706.	Conducted nearly 210 number of training and awareness programmes in 72 Krishi Vigyan Kendras (KVKs) resulting in training and capacity building of around 8,000 farmers.
	Conducting awareness workshop for farmers through KVKs.			

Programme	Activities	Agencies responsible for the on-ground implementation	Target	Progress of programme
	Organizing training workshops for technicians on best practices on over-hauling and maintenance.			

Source: MoP, 2020a.

3.4.7.2 Municipal Demand Side Management (MuDSM)

Frequent changes and rising peaks in power load due to water pumping and street lighting is characteristic of the energy consumption in the municipality sector. Municipalities consume a significant amount of energy owing to the limited diffusion of energy efficiency technology and demand-side management (DSM) initiatives. Recognizing this immense energy saving potential in the municipal sector, BEE initiated the Municipal Demand Side Management (MuDSM) project. The programme has improved the overall energy efficiency of the Urban Local Bodies (ULBs) and has led to substantial savings in electricity consumption, and resulted in cost reduction/savings for the ULBs (MoP, 2020a). These initiatives have led to an emission reduction of 4.631 $MtCO_2$ in 2018-19 (BEE, 2019).

Table 3.18: Activities and initiatives under the MuDSM programme

Programme	Activities	Agencies responsible for the on-ground implementation	Target	Progress of programme
Municipal Demand Side Management	Capacity building workshops for ULBs, public water bodies, urban development department and other implementing agencies in cities under the Atal Mission for Rejuvenation and Urban Transformation (AMRUT) project.	State Designated Agencies (SDAs) Urban Local Bodies (ULBs) Urban Development Directorate (UDDs) Municipal Corporations (MCs)	To train, create awareness and build the capacity of the officials at the ULBs, UDDs, MCs on energy efficiency measures.	So far, 37 capacity building programme has been organized in nine States.
	Conducting training programs for pump technicians and operator of municipal systems.			

Source: MoP, 2020a.

3.4.8 Capacity building of DISCOMs

Capacity building and other support are essential for the DISCOMs to implement DSM in their respective areas. The BEE has launched a programme for capacity building of DISCOMs. This will help in the capacity building of DISCOMs and the development of various mechanisms to promote DSM in their respective States.

Between 2012-17, BEE selected 34 DISCOMs for their capacity building initiative and provided necessary support for the implementation of DSM related activities (MoP, 2020a).

Activities & Achievements from 2017-18 to 2019-20

The objective of the initiative is to carry out the load management programme, development of DSM action plan, and implementation of DSM activities in their respective areas. The following activities have been initiated so far under this programme in FY 2017-20 (MoP, 2020a).

- The 28 DISCOMs remaining outside the program have now been included for participation.
- A Tripartite MoU has been signed between BEE, DISCOMs and respective SDAs.
- DSM Cell has been established by 25 DISCOMs for 2nd phase DISCOMs.
- The PMCs would carry out load research studies and development of DSM Action Plan for each of the new DISCOM. The PMCs have already initiated the preliminary data collection of load research activity in their respective zone.
- Load Research Studies for 17 DISCOMs have been completed and Draft LR Reports have been submitted to DISCOMs for approval. Preparation of DSM action plans is under process.
- DSM regulations have been notified for 29 States and UTs. Remaining states are pursuing to notify their DSM regulations for their respective states.
- All the activities are to be completed by April 2021.

3.4.9 Zero Defect Zero Effect (ZED)

In order to prepare the MSMEs to create a value chain for the new regime, measures have been developed to ensure quality and competitiveness of Indian MSMEs. The ranking system provides an opportunity to the units for continuous improvement of their processes to move up the maturity assessment model (Bronze-Silver-Gold-Diamond-Platinum). The Rating is a weighted average of the scores obtained on each parameter and the rating provided will be valid for a period of 4 years. Surveillance audit will be carried out by QCI. A total of 25,873 MSMEs participated in the 628 awareness programmes organised. In addition to this, 117 training sessions were conducted which resulted in the skill development of 3,173 professionals (MoMSME, 2020).

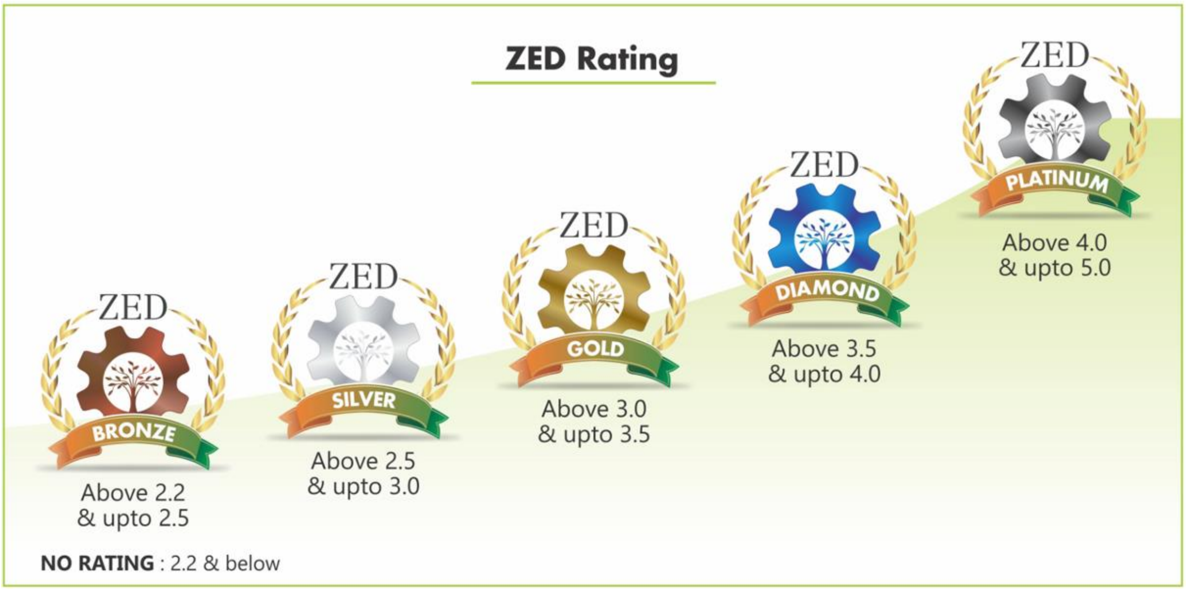


Figure 3.8: ZED Ranking

Developments under ZED

Quality Council of India (QCI), an autonomous body set up by the Ministry of Commerce & Industry, GoI has signed a MoU with the Government of Gujarat (Industries and Mines Department) for promotion & implementation of ZED Certification Scheme. The MoU was signed in Ahmedabad, Gujarat on 25 February 2019 (MoMSME, 2020).

QCI has signed a MoU with the Government of Odisha (MSME Department) for promotion & implementation of ZED Certification Scheme. The MoU was signed in Bhubaneswar, Odisha on 3 December 2018.

The MSMEs will be assessed and rated only on defined enabler & outcome parameters on operational level indicators which include the following:

- Manufacturing capabilities
- Design capabilities
- Quality/environment/safety assurance systems
- People development and engagement systems
- Standardization and measurement systems for quality and environment
- Learning and improvement systems
- Legal compliances

3.4.10 Carbon Capture, Storage/Utilization

CO_2 capture is still at a nascent stage of implementation in India, with only a few sectors such as refineries and steel having implemented small-scale carbon capture projects. Some industries which have initiated the process of setting up CCS facilities include National Aluminium Company (NALCO), ONGC, Bharat Heavy Electrical

Limited. (BHEL), and Andhra Pradesh Power Generation Corporation (APGENCO) (Global Cement, 2019). Dalmia Cement also announced setting up of a large-scale carbon capture unit (CCU) at one of its plants in Tamil Nadu as a move towards becoming carbon neutral by 2040. From the various technologies available for CO_2 capture, the post-combustion solvent capture and stripping with amine-based pressure swing adsorption system is the most common. A range of different end-uses is available for the utilization of captured CO_2 which can be broadly categorized as mineralization (which includes carbon mineralization, concrete curing, and bauxite residue carbonation), biological (in the form of algae cultivation) and chemical (CO_2 to methanol and ethanol, and urea yield boosting). Carbon capture and geological sequestration is the process of capturing waste CO_2 from large point sources such as fossil fuel power plants and transporting it to a storage site (normally an underground geological formation). Typically, CO_2 sequestration projects are expensive and therefore not implemented in isolation in India. A dialogue has been initiated between US-DoE and DST on clean coal technologies, supercritical carbon dioxide (sCO_2) power cycles and carbon capture utilisation & storage (CCUS) technologies. One of the notable outcomes of the dialogue is the participation of India in the multilateral platform for Accelerating CCUS Technologies (ACT) through which avenues have been generated for possible US - India collaboration (DST, 2020).

3.4.11 Energy access and clean fuels

Energy access and clean fuels constitute two key areas of concern of the GoI, as these are closely related to fundamental aspects of the well-being of the population, especially women. Two of the flagship schemes of the GoI are discussed in this section.

3.4.11.1 Pradhan Mantri Ujjwala Yojana (PMUY)

PMUY was launched in 2016, to safeguard the health of women and children by providing families that fall Below the Poverty Line (BPL) with clean cooking fuel (LPG), to avoid cooking in smoke-filled kitchens using biomass. The primary objective is to reduce and gradually move away from dependence on biomass as the primary cooking fuel. Under this scheme, with a cap of INR 1,600 per LPG connection, cash support for connection is provided to BPL families. As a move to empower the female members of these households, especially in rural areas, the LPG connections are issued in their names. The target for this scheme was raised from 50 million households to 80 million households. The target of providing 80 million LPG connections under the scheme has already been achieved as on 7 September 2019 i.e. 7 months ahead of the scheduled target (March 2020). Till December 2020, a total of 287.4 million households have LPG connections (including PMUY beneficiaries) (PPAC, 2020).

An energy efficient domestic cook stove burner has been designed for use with piped natural gas (PNG) by CSIR-IIP, Dehradun in collaboration with PCRA, New Delhi. These burners have up to 30% improved thermal efficiency (PPAC, 2020a).

3.4.11.2 Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY)

A scheme of Government of India for rural areas, the Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY) was launched by MoP on 3 December 2014. Under the DDUGJY, electrification of inhabited un-electrified census villages taken up in 2018-19 in 1,515 villages (MoP, 2019). Under the scheme, during the XIth five year plan, 570 projects of INR 2,88,690 million were sanctioned and a grant of INR 2,28,542 million had been released against these projects as on 31 December 2019. During the XII Plan, 560 projects of INR 2,37,356 million had been sanctioned and a Grant of INR 1,59,502 million had been released against these projects as on 31 December 2019 (MoP, 2020).

3.4.11.3 Saubhagya Scheme

Pradhan Mantri Sahaj Bijli Har Ghar Yojana (SAUBHAGYA) was launched in September 2017 with the objective of universal household electrification by providing last mile connectivity and electricity connections to all remaining un-electrified households in rural and urban areas by 31 March 2019. Electricity connections to 26.284 million households (99.93 per cent) have been provided from 11 October 2017 to November 2020 (REC, 2020).

3.5 Building sector

In this section, the initiatives aimed at reducing the emissions from the building sector have been highlighted. India has been improving the energy efficiency of buildings through mandatory building energy codes and voluntary rating schemes, as well as through policies and programmes to improve the efficiency of appliances and equipment. India has developed its building-energy rating system GRIHA (Green Rating for Integrated Habitat Assessment), based on 34 criteria such as site planning, conservation and efficient utilization of resources. As on October 2020, India has 1,825 GRIHA registered projects with approximately 52.5 million sq. meter of ‘green’ built-up area. India currently has about 7.61 billion sq. ft. green building footprint, 6,055 registered projects, and 780 certified projects [Indian Green Building Council (IGBC) only] as on 15 October 2020.

3.5.1 National Building Code of India (NBC), 2016

This comprehensive building code is a national instrument providing guidelines for regulating construction activities across the country. It serves as a model code for adoption by all agencies involved in building construction works. An addendum to the NBC has incorporated the ECBC, through a new chapter named ‘Approach to Sustainability’ which gave ECBC a broader coverage.

3.5.2 Energy Conservation Building Code (ECBC)

The updated version of ECBC provides current as well as futuristic advancements in building technology to reduce building energy consumption further and promote low-carbon growth. So far, 17 States and UTs have notified the ECBC. Around 335 demonstration buildings have been supported with technical assistance for ECBC compliance in the States/UTs, out of which 50 buildings are constructed, with a cumulative built-up area of 0.16 billion sq. m ensuring an approximate energy saving of 0.17 billion units. GHG emission reduction of 0.14 $MtCO_2$ is estimated annually which will scale up to 3.4 $MtCO_2$ in the 25 years' lifespan of the buildings (BEE, 2020).

As per a study conducted by USAID, if ECBC is implemented rigorously throughout India it has the approximate potential of saving 300 billion units of energy and over 15 GW of peak demand reduction which would result in a saving of around INR 350 billion. Subsequently, GHG emission reduction of over 250 $MtCO_2$ is estimated.

An MRV Framework for ECBC for Large Commercial Buildings under the Initiative of Climate Action Transparency (ICAT) is in place. As per 2018 data, 15 States and 2 UTs (Rajasthan, Odisha, Uttarakhand, Punjab, Haryana, West Bengal, Uttar Pradesh, Assam, Kerala, Karnataka, Andhra Pradesh, Telangana, Gujarat, Maharashtra, Himachal Pradesh, Puducherry and NCT of Delhi) have notified and adopted the code (UNEP DTU, 2020).

3.5.3 Building Energy Efficiency Programme (BEEP); retrofitting project

EESL is implementing the Buildings Energy Efficiency Programme to retrofit commercial buildings in India into energy efficient complexes. Through these future ready solutions, EESL is creating a market for clean energy in India. GoI has issued an instruction to all its Departments and Ministries in August 2017 to ensure that all the buildings become energy efficient. Till date, EESL has completed building energy efficiency projects in 10,344 buildings including Railway stations and Airports (EESL, 2020a). Energy Audits show energy saving potential up to 30-50 per cent in these buildings. The major interventions in these buildings are in the area of lighting and air-conditioning systems (MoP, 2020a). This has resulted in estimated energy savings of 224 million kWh per year with avoided peak demand of 75.64 MW, GHG emission reduction of 0.18 $MtCO_2$ per year and estimated annual monetary savings of INR 1,940 million in electricity bills.

3.5.4 Star rating system for existing commercial buildings

In order to promote a market pool for energy efficient buildings, Bureau of Energy Efficiency developed a voluntary Star Rating Program for buildings which is based on the energy usage in the building over its area expressed in $kWh/m^2/year$. This program rates buildings on 1-5 scale, with 5 star labelled buildings being most efficient. Star Labels for day use office buildings, BPOs, Hospitals and Shopping Malls have been developed. A total of 264 buildings have been star rated under different categories of commercial buildings till August 2020 (BEE, 2020).

3.5.5 Eco Niwas Samhita for residential buildings

Rapid rise in residential building stock, coupled with increase in electricity use for space conditioning, is resulting in increase in electricity consumption in residential buildings. Projection done by NITI Aayog indicates that the electricity consumption for the residential sector is expected to increase 6-13 times by 2047 (NITI Aayog, 2015). Another important aspect is thermal comfort, which is of utmost importance in all kinds of housing, but more so in case of affordable housing, so as to ensure health and well-being of the occupants. BEE envisaged a phased approach for the development of the residential building energy conservation code. Making houses energy efficient is certainly a way of avoiding long-term futile electricity consumption liability in residential buildings.

The Eco Niwas Samhita (ENS), Part-I Building Envelope (ECBC for residential sector) was developed and launched in 2018. It has been developed to set minimum building envelope performance standards to limit heat gains (for cooling dominated climates) and to limit heat loss (for heating dominated climate) as well as for ensuring adequate natural ventilation and day lighting. The code is applicable to all residential use building projects built on plot area greater than 500 sq. m. The code has been developed with special consideration for its adoption by the ULBs into building bye-laws (BEE, 2020).

Eco Niwas Samhita (ENS), Part-2 of the code, aims to provide energy efficiency standards for electro-mechanical systems of residential buildings. ENS Compliance tool has also been developed by BEE to ensure ease of compliance and adoption by ULB's, home owners and developers. In addition to this, ENS cells were established in Delhi, Uttar Pradesh, Punjab, Karnataka and Maharashtra for implementation of the residential Code. Many stakeholder workshops and trainings have also been conducted across India to appraise participants of the code and its benefits.

3.6 Transport sector

The transport sector is rapidly growing in India, contributing significantly to the GDP of the country. However, the sector is largely oil-dependent and accounts for 12.1 per cent (without LULUCF) of the country's CO_2 emissions. In 2019-20, 3.43 million passenger vehicles[1], 0.75 million commercial vehicles and 21.03 million two-wheelers were produced (IBEF, 2020). The transport sector in India accounted for 24 per cent of the commercial energy demand in 2016 and it was the second-largest energy consumer after the industry sector (TERI, 2018). IR is among the largest rail networks globally. In 2018-19, the IR transported 8,400 million passengers and 1,200 million tonne of freight. Despite its extensive network, the railways are faced with issues of capacity constraints and limitations of infrastructure. While India is operating in the same global context as other countries who have adopted an EV policy, its unique mobility pattern necessitates an EV policy that is tailor-made to India's particular needs. India is a member country of the Electric Vehicles Initiative (EVI), a multi-government policy forum dedicated to accelerating the introduction and adoption of electric vehicles worldwide. As a member, the focus is on aggressive upgradation of standards to target global benchmarks in safety, emissions, and efficiency. In this

[1] Passenger cars are motor vehicles with at least four wheels, used for the transport of passengers, and comprising no more than eight seats in addition to the driver's seat.

direction, one of the major regulatory announcements recently was the leapfrogging over Bharat Stage (BS)-V automobile emission norms and the advanced introduction of BS-VI from 1 April 2020.

3.6.1 Emission Standards and Auto Fuel Policy 2003

The Auto Fuel Policy, 2003 aims at addressing issues of vehicular emissions and vehicular technologies by cost-effectively applying fuel quality standards, ensuring efficient fuel supply measures. The Central Motor Vehicles Rules, 1989 was amended in 2018 ensuring new motor vehicles conforming to emission standard BS-IV (10 ppm Sulphur), manufactured before the 1 April 2020. (MoRTH, 2016).

BS-VI standards have come into effect for all vehicles manufactured on or after 1 April 2020. The standards specify mass emission standard, type approval requirements, on-board diagnostic (OBD) system, and in-service and durability levels for each vehicle category and sub-classes therein. BS-VI standards are far-reaching in scope with significant changes from the BS III and IV emission standards. These include particularly, the tightening of particulate matter (PM) mass emission limits, the introduction of particle number (PN) limits and reduction in nitrogen oxide content for light- and heavy-duty vehicles (LDV, HDV) fitted with gasoline direct injection (GDI) and compression ignition (CI), or diesel engines (ICCT, 2016).

India has a vast network of more than 0.25 million km of National Highways and State Highways contributing to environmental and carbon footprint during construction, maintenance and operation. The Indian Roads Congress (IRC) is in the process of developing guidelines for green rating of highways as an attempt to reduce the environmental footprint of roads and highway projects, taking into account the environment friendly, innovative techniques such as recycling of materials, use of local soil stabilizers, inlay instead of overlays on existing roads, groundwater recharge and use of renewable resources. The use of energy efficient locally available materials and additives, and efficient road designing can reduce the GHG emissions from roads both in the construction as well as the operation period. To determine whether a particular construction methodology or a design is emission efficient, it is necessary to estimate GHG emissions before and after the adoption of the construction methodology/design on a project-to-project basis (CRRI, 2020).

3.6.2 Fuel efficiency standard

India's dependence on imported fossil fuels is rising continuously due to limited domestic petroleum resources. India is ranked as the fourth-largest petroleum consumer in the world following China, USA, and Russia. The country's energy demand continues to climb as a result of its dynamic economic growth and modernization. Keeping in view the growing demand for fossil fuel and rapidly growing motor vehicle fleet in India, GoI set a target of 10 per cent reduction on import by 2022. BEE is working on the Development of fuel efficiency norms for Vehicles that could moderate the rising demand for fuel (MoP, 2020a).

Corporate Average Fuel Economy (CAFE) Norms for Passenger Cars: This is applicable to all motor vehicle types approved in India for petrol, diesel, liquefied petroleum gas or compressed natural gas and electric, for passenger vehicles with Gross Vehicle Weight (GCW) not exceeding 3,500 kilograms.

The CAFE norms came into force from the fiscal year 2017-18, effective to 2021-22, while the second phase would be effective from the fiscal year 2022-23. The standards relate the Corporate Average Fuel Consumption (in litres/100 km) to the Corporate Average Curb Weight of all the cars sold by a manufacturer in a fiscal year.

According to the first phase, the average weight used for calculation 1,037 kg in 2017-18, and the average fuel consumption standard would have to be less than 5.49 litres/100 km for this average weight. The second phase assumes average weight of 1,145 kg in 2022 and requires the average fuel consumption to be less than 4.77 litres/100 km. It may be noted that the standards apply to the corporate average fuel consumption i.e. the average of the standard fuel consumption of all vehicles sold by the manufacturers in the fiscal year, and not to the fuel consumption of an individual model. The fuel consumption is measured under standard conditions by the test agencies notified under Rule 126 of CMVR,1989 over the national driving cycle. CAFE Norms were established for Heavy Duty Vehicles (HDV) in 2017 and for light commercial vehicles in 2019. This initiative has led to an emission reduction of 2.650 $MtCO_2$ in 2018-19 (BEE, 2019).

Fuel Economy Norms for Heavy-Duty Vehicles: In August 2017 the GoI finalized fuel efficiency norms for commercial vehicles (CVs) with a GVW of 12 tonne or greater. Manufacturers must demonstrate compliance with the rule by evaluating vehicles over the Constant Speed Fuel Consumption (CSFC) test procedure. In the CSFC protocol, trucks and buses are driven at a constant speed on a test track at 40 and 60 km per hour (km/h). Meanwhile, Ministry of Road Transport and Highways has revised the safe axle weight limits, and subsequently, the norms for HDVs were put under review to meet the revised GVW range. A steering committee meeting was constituted to discuss the amendments in the notification of HDV Norms in the light of the revision of the GVW range and finally it was decided that Phase-1 norms as notified dated 17 August 2017 by BEE will be implemented after applying the correction factor for BS-VI and revision of axle loads.

Fuel Economy Norms for Light & Commercial Vehicles: In addition to norms for CVs greater than 12 tonne, the development of fuel efficiency standards for CVs between 3.5 and 12 tonne has been completed. The norms for this lighter segment of CVs are centred around CSFC testing. The norms have been finalised and notified by the Ministry of Power on 16 July 2019 in the Gazette of India (MoP, 2020a).

The technical committee which has been directed to develop correction factor for HDVs has also been advised to develop correction factor for L&MCVs compliant with BS-VI emission norms. The developed correction factor will then be applied on line equations of BS-IV FE norms.

Standard and Labelling (S&L) Program for Agricultural Tractors: A steering committee formed under the chairmanship of JS (R), MoPNG was constituted in March 2018 for developing & monitoring fuel economy norms for light and medium commercial vehicles to monitor the development of fuel economy norms for tractors. The committee has finalised the labelling bandwidth and draft schedule to implement the voluntary phase of the program.

S&L Program for Tyres: BEE has constituted a technical committee under chairmanship of ED, Petroleum Conservation Research Association (PCRA) for the development of S&L program for tyres in India. The scope of work of technical committee was to study the tyre market in India, national and global test standards, international practices in terms of fuel efficiency standards and accordingly develop labelling standards for all vehicular tyres manufactured or imported in India. The committee has finalised the labelling bandwidth and the draft schedule to implement the voluntary phase of the program to be released by BEE.

3.6.3 Ethanol Blended Petrol Programme (EBP)

GoI has notified the National Policy on Biofuels-2018, which inter-alia aims to develop alternate fuels and reduce import dependency on petroleum. Under the EBP programme, ethanol blending in petrol is being undertaken by the Oil Marketing Companies (OMCs) in the whole country except island UTs of Andaman & Nicobar and Lakshadweep. Further, Government has directed Indian Oil Corporation Limited to blend 15 per cent methanol in petrol (M15) for retail sale in Assam and North-eastern States on a pilot basis (MoPNG, 2019). Increased ethanol blending in petrol has many benefits including reduction in import dependency, support to agricultural sector, more environmentally friendly fuel, lesser pollution and additional income to farmers. Ten million litres of E10 (E10 is indicative of 10 per cent ethanol blending) can save around 20,000 tonne of CO_2 emissions. These efforts will be carefully evaluated for potential increase in ozone gas emission and only with adequate safeguards in place will much of the vehicle fleet migrate to E10.

During the Ethanol Supply Year (ESY) 2019-20 about 1,703 million litres of ethanol was supplied by sugar mills and grain-based distilleries to oil marketing companies, thereby achieving 5 per cent blending target. Government notified the National Policy on Biofuels (NPB) in June 2018 which *inter alia* envisages 20 per cent blending of ethanol in petrol and 5 per cent blending of biodiesel in diesel by 2030.

However, to increase indigenous production of ethanol the Government since 2014 took multiple interventions like re-introduction of administered price mechanism; differential ethanol price based on raw material utilized for ethanol production; opening of alternate route for ethanol production; amendment to Industries (Development & Regulation) Act, 1951 which legislates exclusive control of denatured ethanol by the Central Government for smooth movement of ethanol across the country; reduction in Goods & Service Tax (GST) on ethanol meant for EBP programme from 18 per cent to 5 per cent; extension of EBP programme to whole of India except islands of

Andaman & Nicobar and Lakshadweep w.e.f from 1 April 2019; interest subvention scheme for enhancement and augmentation of the ethanol production capacity by Department of Food and Public Distribution (DFPD); and long term policy on ethanol procurement.

Green Initiatives by MoRTH during FY 2018-19:

The year 2018-19 was declared by the Ministry of Road Transport & Highways (MoRTH) as the year of construction. This was a year for consolidating the gains that have accrued from major policy decisions taken in the previous four years, a time for monitoring of ongoing projects, tackling roadblocks and adding to the already impressive pace of work achieved in the previous year (MoRTH, 2018).

- Electric, ethanol and methanol vehicles have been exempted from permits. Keeping in view the need for promoting electric mobility and alternate fuels, Ministry of Road Transport & Highways, vide notification S.O 5333 (E) dated 18 October 2018, has exempted Battery Operated Vehicles, as well as vehicles driven on methanol fuel or ethanol fuel, from the requirement of permit for carrying passengers or goods.
- A system has been developed and tested by this Ministry for linking of Pollution Under Control (PUC) data with the VAHAN database. An advisory dated 01 October 2018 has been issued to all the States by the Ministry wherein all the PUC vendors have been directed to comply with the guidelines and facilitate electronic uploading of emissions test data to VAHAN database.
- To give a distinct identity to the electric vehicles, it has been decided that the registration mark will be exhibited on a number plate with green background. A notification to this effect was issued on 7 August 2018 vide G.S.R 749(E).
- The Ministry issued a notification regarding the blending of Gasoline with methanol in order to reduce vehicle exhaust emissions and also to reduce the import burden on account of crude petroleum from which gasoline is produced. The Hon'ble PM had announced an ambitious target of reducing 10 per cent import dependence of oil and gas by 2022. Methanol can be used as an alternative transportation fuel thereby reducing import dependence to some extent.
- Requirement of PUC certificate for vehicle insurance/ renewal of insurance: MoRTH has requested IRDA and the MDs/Chairpersons of all general insurance companies to ensure that no third-party insurance policy is issued or renewed without ascertaining the availability of a valid PUC. This has been done following orders of the Supreme Court of India.
- The Ministry has notified emission standards for Construction Equipment Vehicles and Tractors vide G.S.R 598 (E) dated 30 September 2020. These standards would be implemented w.e.f. 1 April 2021 and 1 October 2021 (CEV Stage -IV / TREM Stage IV) respectively and from 1 April, 2024 [BS

(CEV/Trem)-V]. This would help in ensuring environment friendly construction and mining activities.

- The Ministry notified the insertion of the item ‘Quadricycle’ as a ‘non-transport’ vehicle under the Motor Vehicles Act 1988. A quadricycle is a vehicle of the size of a 3-wheeler but with 4 wheels and fully covered with maximum speed of 70 km/h. This makes it a cheap and safe mode of transport for last mile connectivity.

3.6.4 Harit Path Mobile Application by NHAI

The Harit Path (Green Way) Mobile app has been made operational from 21 August 2020. Till 13 November 2020 geotagging process has been started in over 300 Projects and more than 0.3 million plants have been geo-tagged. Regular training is given to all concerned officers and professionals for swift implementation of geotagging of plants using Harit Path app (MoRTH, 2020a). It would aid in regular monitoring and maintenance of plantations across National Highways (NHs) to ensure sustainability of green corridor along the highways. NHAI planted over 2.5 million plants in 25 days along the stretches of the national highways between 21 July and 15 August 2020. The drive takes the total cumulative number of plantations done during the current year to 3.52 million. Maximum number of over 0.5 million plants have been planted in Uttar Pradesh, followed by over 0.3 million in Rajasthan and 0.2 million in Madhya Pradesh along the national highways. Moreover, to ensure 100 per cent survival of the plants, avenue plantation of minimum height of 1.5 meter has been emphasized along the national highway. The highway contractors will be responsible for proper upkeep and maintenance of the plantation and liable to replace the missing/dead plants. Payments of the contractors are also linked with performance and growth of the plants (PIB, 2020d).

3.6.5 Green National Highways Corridor Project

This project has been approved by the World Bank and will help to build safe, green and resilient national highway corridors in the Indian States of Rajasthan, Himachal Pradesh and Andhra Pradesh. The project got approved with total cost of US$1227 million with maturity of 14.5 years and grace period of 5 years. Four themes have been selected under this project, namely economic policy, human development and gender, urban and rural development, environment and natural resource management. Natural resource efficiency gains in construction of project highways, reduction of fatalities on project highways, safety and green highway technologies applied on 2,500 km of non-project highways, Green National Highways Policy and guidelines developed and implemented, National Highways Climate Adaptation Policy (NHCAP) and guidelines developed and implemented, reduced carbon emissions in construction of project highways and reduced vehicle operating costs on project highways will be the indicators of this project (World Bank, 2020).

3.6.6 National Electric Mobility Mission Plan (NEMMP)

As mentioned in the second BUR, NEMMP aims to deploy 4,00,000 passenger battery electric cars (BEVs) by 2020. If these BEV adoption rates continue beyond 2020, India could save 4.8 billion barrels of oil and 270 million tonne of CO_2 emissions by 2030. As a part of NEMMP, the Government had also launched a scheme for Faster Adoption and Manufacturing of (Hybrid and) Electric Vehicles in India (FAME), aimed at incentivizing all vehicle segments, i.e., 2-wheelers, 3-wheelers auto, passenger 4-wheelers vehicles, light commercial vehicles, and buses.

Presently, Phase-II of FAME India Scheme is being implemented for a period of 3 years from April 2019 with a total budgetary support of INR 1,00,000 million. In the first phase of the Scheme about 0.28 million hybrid and electric vehicles are supported by way of demand incentive amounting to about INR 3,590 million (PIB, 2020j).

Phase-I of the Scheme was implemented through four focus areas namely demand creation, technology platform, pilot project and charging infrastructure. Under demand creation focus area of the scheme, about 0.28 million electric/ hybrid vehicles (xEVs) were supported with a total demand incentive of (approx.) INR 3,590 million for purchase of xEVs under this scheme. Also, 425 buses were sanctioned to various cities and States under this Scheme. In addition to the above, several projects were approved/sanctioned under technology platform, pilot project and charging infrastructure focus areas of the scheme. In the Phase-I of the Scheme demand incentive support resulted in saving of about 50 million liters of fuel and reduction of about 124 million kg of CO_2 (PIB, 2019a).

Based on the outcomes and the experience gained during Phase-I of FAME India scheme, Phase-II of FAME India scheme was begun in March 2019, for a period of three years with a total budgetary support of INR 1,00,000 million. Under Phase-II of FAME India Scheme, about 10,000 EVs are supported by the way of demand incentive amounting to about INR 250 million. So far, 16 OEMs for e-2W, e-3W & e-4W have registered themselves in the Phase-II of FAME India scheme. In addition, there are about 6 OEMs manufacturing electric buses in the country (DEA, 2020).

Phase-II will mainly focus on supporting electrification of public and shared transportation and aims to support, through subsidies, 7,000 e-Buses, 0.5 million e-3 -wheelers, 55,000 e-4-wheeler Passenger Cars and 1 million e-2-wheelers. In addition, creation of charging infrastructure will be supported in select cities and along major highways to address range anxiety among users of electric vehicles. This phase of FAME Scheme envisages support for setting up of adequate public charging infrastructure to instill confidence among EV users, through active participation and involvement of various stakeholders including government agencies, industries and PSEs. A budget provision of INR 10,000 million for a period of 3 years (2019-20 to 2021-22) has been earmarked for establishment of charging infrastructure under this Phase of FAME Scheme. EESL has commissioned 488 captive chargers (308 AC &

180 DC chargers) across India. This has resulted in estimated annual fuel saving of 2,519 kilo liters and reduction in GHG emission of about 0.00675 $MtCO_2$ per year (EESL, 2020b).

The projected share of EVs in 2030 has been estimated to reach 37 per cent in Japan, over 30 per cent in Canada and USA, 29 per cent in India, and 22 per cent in aggregate of all other countries. With the projected size of the global EV market, the expansion of battery manufacturing capacity will largely be driven by electrification in the car market.

The sale of electric two-wheelers in India rose from 54,800 units in 2018 to 1,26,000 units in 2019 (TERI, 2019). Under the first phase of the Faster Adoption and Manufacturing of Hybrid & Electric Vehicles (FAME I) scheme, 88 models of electric two-wheelers were eligible for a subsidy. Until September 2018, around 90 per cent of the beneficiaries under FAME I were lead-acid powered electric scooters. From October 2018, subsidies for lead-acid battery vehicles were discontinued, but incentives for lithium-ion battery vehicles remained. As from April 2019, the second phase of the FAME scheme encompasses strict speed, range and energy efficiency requirements that would exclude 90 per cent of the remaining advanced batteries-driven models from the FAME subsidy scheme (IEA, 2020). States of Karnataka, Telangana, Maharashtra, Uttar Pradesh, Kerala, Uttarakhand, Andhra Pradesh, Delhi and a few more have rolled out their EV/Draft EV policies. These States are proposing several fiscal incentives to car and battery manufacturers, charging infrastructure companies and consumers. A dedicated National Mission on Transformative Mobility and Battery Storage has been approved in 2019 (PIB, 2019b).

3.6.7 Rail transport

About 90 per cent of global passenger movements on conventional rail takes place in the following countries and regions, with India leading at 39 per cent, followed by the People's Republic of China (China) (27 per cent), Japan (11 per cent) and the European Union (9 per cent). Construction of non-urban rail infrastructure in India is particularly notable as it supports large volumes of passengers. With increasing dependence on railways, the electrification of IR is an important step towards not only enhancing the efficiency of the system but also mitigating GHGs from its operations due to efficiency gains. Today, the conventional rail system in India comprises a total route length of over 67,415 km, with a total of over 8,439 million passengers in 2018-19 (Indian Railways, 2019).

Some of the key initiatives and targets set by the Indian Railways are as follows:

- Enhance the share of railways in the overall land based freight transport from the present around 35 per cent to 45 per cent by the year 2030
- Swachh Rail, Swachh Bharat Campaign to promote cleanliness across the entire railway.

- Mission Electrification: Currently, 40,886 route km (RKM) (64 per cent) of broad gauge (BG) routes has been electrified. Balance 22,745 RKM are planned to be electrified in next 3 - 4 years.
- To utilize at least 10 per cent of its energy requirement from renewable sources, thus contributing to India's solar and wind energy missions.
- No single use plastic material utilized from 150th Gandhi Jayanti on 2 October 2019.
- Policy for the use of Biodiesel with a target of 5 per cent biodiesel blending in high speed diesel (HSD).
- As an initiative to reduce, recycle and dispose plastic waste generated in stations in an eco-friendly manner, comprehensive policy guidelines have been brought out for installation of Plastic Bottle Crushing Machines (PBCMs) by Zonal Railways. At present, around 500 PBCMs have been installed at 370 stations including several district headquarters railway stations over IR.
- All passenger carrying BG coaches, from April 2020 onwards, are fitted with bio-toilets and direct discharge of human waste from trains has thus been eliminated.
- Committed to improve water use efficiency by 20 per cent by 2030.
- Adoption of good practices for green buildings, industrial units and other establishments for the management of resources and infrastructure to achieve environmental sustainability in the growth of IR.

Mass-transit and urban transport projects have also been initiated under the National Urban Renewal Mission. Today rail passengers in India travel 1.2 trillion km, more than the distance travelled by cars; and about one-third of total surface freight volumes are transported by rail, a very high share by global standards. By far, coal is the predominant commodity carried on freight trains today in India (IEA, 2019a).

The track length in terms of the total passenger kilometre has increased by 130 per cent since 1945, and freight activity in terms of tonne kilometre has increased by 150 per cent (IEA, 2019b). Track lengths have been growing slower than rail activity growth. However, there has been an upgrade of the track quality to permit higher speeds and heavier axle load operation. With an increasing dependence on railways, electrification of Indian Railways (IR) is an important step towards not only enhancing the efficiency of the system but also mitigating GHGs from operations. Mission Electrification indicates that the energy consumption of IR is going to increase substantially in the coming years. Along with the transition to electric locomotives, the railways have also taken initiatives such as the production of all Electric Multi-Unit (EMU) trains with three-phase technology having regeneration capability.

Dedicated Freight Corridor (DFC)

The burgeoning demand for additional capacity of rail freight transportation led to the conception of dedicated freight corridors along the Eastern and Western Routes. This led to the establishment of "Dedicated Freight Corridor Corporation of India Limited (DFCCIL)", to undertake planning & development, mobilization of financial resources and construction, maintenance and operation of the dedicated freight corridors. DFCC was incorporated as a company under the Companies Act 1956 on 30 October 2006 (MoR, 2020).

Key highlights of the initiatives in 2018-19 are:

- Successful trial run of goods train in Bhadan to Khurja section (194 kms) of EDFC-1 was conducted on in November 2018.
- Trial run of freight train in Madar-Kishangarh Balawas section (306 km) of WDFC was conducted in December 2018.
- Track linking with mechanized track laying machine is in progress at 7 locations.
- Track linking of 774 km has been done in the year taking the cumulative linking to 1,898 km.

Metro Rail

Currently there is 700 km of metro rail track in operation in 18 cities while 900 km Metro/RRTS is under construction in 27 cities. Standards have been issued for Light Urban Rail Transit System named ‘Metrolite’ as well as for 'Metro Neo' - rubber tyer electric coaches powered by overhead traction system. These systems are expected to cater to the need for mass rapid transit system of the cities with lower projection of ridership and also to serve as feeder system in cities which have high capacity metro system (MoHUA, 2020a).

3.6.8 Civil Aviation

In the 37th Session of the International Civil Aviation Organization (ICAO) General Assembly held in 2010, it was resolved to keep the global net CO_2 emissions from international aviation from 2020 onwards at the same level, i.e. “Carbon Neutral Growth from 2020”. Despite the lack of consensus, the matter was pursued by the ICAO Assembly at its 38th Session, held in 2013, when it was decided through Resolution A38-18 to develop a Global Market Based Measure (GMBM) for international aviation. As a follow up on this decision, the ICAO Council undertook a project to develop the GMBM through the Committee on Aviation Environmental Protection (CAEP) and Environment Advisory Group (EAG). The final product was called “Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)” and was presented to the 39th Assembly held in October, 2016 and the same was adopted by the Assembly through Resolution A39-3 (MoCA, 2020).

The CORSIA scheme established by the ICAO is based on ICAO’s aspirational goal of carbon neutral growth in international aviation beyond 2020 which has not found support from a number of developing countries. The scheme provides for a global carbon offsetting mechanism and aeroplane operators will be required to purchase and cancel “emissions units” to offset the increase in CO_2 emissions covered by the scheme. CORSIA aims to address any increase in total CO_2 emissions from international civil aviation using the average annual emissions between 2019 and

2020 as reference and lays down a formula for calculating the offsetting requirement of individual aeroplane operators in the subsequent years. As a result of the COVID – 19 impact on the aviation sector, ICAO suggested that 2019 emissions be used for the determination of CORSIA's baseline emissions instead of using the average of 2019 and 2020 (MoCA, 2020).

India and CORSIA

Though India has always supported global emission control initiatives. It has, however, from the very beginning been concerned about the implications of the CORSIA scheme on the developing countries. This is because the civil aviation market in these countries is rapidly developing from a low base as compared to the aviation market in the developed countries which has reached its maturity level and has a much slower growth rate. Therefore, considering 2019 as the baseline year for offsetting requirement will not be fair to developing countries as it will impose very heavy carbon offsetting costs on the airlines of these countries in the subsequent years and adversely impact the growth of the entire aviation sector in the developing world. Furthermore, the Paris Agreement clearly recognizes that the developing countries have not yet reached their peak emissions and therefore it does not mandate carbon neutral growth specific to any particular sector. The CORSIA scheme also does not conform to the CBDR-RC principle of UNFCCC. Further, CORSIA estimates and implements the offsetting requirements airline-wise (MoCA, 2020).

Member countries are responsible for monitoring and enforcing the obligations under the scheme. It would therefore be appropriate if offsetting obligations are estimated at country level. This is also consistent with the UNFCCC principles wherein each country is responsible for its share of production of greenhouse gases. Accordingly, the responsibility for its mitigation also lies with the country concerned.

Accordingly, India has filed reservations at the 40th ICAO Assembly and proposed the following (MoCA, 2020):

- CORSIA baseline should be fixed closer to when India and a number of other like-minded countries join the CORSIA scheme in 2027.
- CORSIA Emissions unit eligibility criteria developed by ICAO should be consistent with the principles developed by UNFCCC.
- Member State driven principle of stabilising aviation emissions and attribution of responsibility of emission reduction to Member States instead of airline operators.

3.6.9 Shipping

India has 13 major ports, and 200 notified non-major (minor/intermediate) ports along the coastline and sea-islands. Recognizing their fuel efficiency, environmental friendliness, and cost-effectiveness, the Government is promoting the growth of Coastal Shipping and Inland Water Transport. The Ministry of Shipping (MoS) has initiated the Green Port project to make ports across India cleaner and greener. This includes monitoring environmental pollution, setting up wastewater treatment plants, garbage disposal plant, and energy generation from renewable sources (MoS, 2020).

3.6.9.1 Coastal Shipping

Coastal shipping is a fuel efficient, cleaner mode of transportation that can ease traffic congestion. Despite having an extensive network of inland waterways in the form of rivers, canals, backwater, and creeks, freight transportation by waterways is highly under-utilised in India. Waterways currently contribute around 6.4 per cent of India's transportation modal mix, which is significantly lower than in developed economies. Investment in dedicated waterway infrastructure will go a long way in promoting coastal shipping as a mode of freight transportation. Port, railway networks, and waterway infrastructure need to be developed in conjunction to facilitate a seamless, efficient freight transport system. Some of the measures to ensure this include the development of coastal berths, bunkering, and storage at ports, and supportive infrastructure for transportation in the hinterland for ensuring last-mile connectivity (MoS, 2020).

India has seen a steady growth of 11.3 per cent of cargo movement on coastal routes from 2015-16 to 2018-19. In 2018-19, approximately 120 million tonne per annum (MTPA) of coastal cargo was transported as compared to the earlier tonnage of 94.5 MTPA in 2016-17. This is expected to increase to 250 MTPA by 2025. The accelerated adoption of coastal shipping has been beneficial to the environment as it is relatively less polluting with certain initiatives such as the Gogha-Dahej Ro-Ro ferry services projected to save up to 15,202 kilolitre (kl) per year, translating to annual avoided emissions of approximately 48,800 $MtCO_2$ (MoS, 2020).

To boost and upgrade port facilities to meet global benchmarks and to make coastal shipping a viable alternative for freight transportation, the Ministry of Shipping (MoS) has taken numerous initiatives towards ease of doing business. Some of the initiatives are listed below (MoS, 2020):

- Licensing relaxation for coastal shipping trade (Cabotage) with MoS introducing licensing relaxations to foreign flag vessels for carrying trans-shipment containers, empty containers, fertilizers and agricultural, fisheries, animal husbandry and horticultural commodities on coastal routes for special vehicles like Ro-Ro, hybrid Ro-Ro, Ro pure car and truck carriers, LNG vessels and over-dimensional or project cargo, the licensing relaxations have been extended till 2020.
- Coastal Berth Scheme (CBS), where financial assistance of up to 50 per cent of total project cost or maximum funding limit has been provided to the implementing agency for the creation of infrastructure to promote movement of cargo/passengers by sea/National waterways. The scheme was extended up to March 2020 and the scope was extended to cover the cost of dredging at major ports. A total of 39 projects and INR 15,690 million has been sanctioned under

the CBS or total financial assistance of INR 6,367.6 million and INR 3,508.4 million has been released to major ports/state maritime boards and State Governments.

3.6.9.2 Sagarmala: Port-led Prosperity

Approximately 95 per cent of India's merchandise trade (by volume) passes through sea ports. Many ports such as JNPT, Mundra port, Sikka port and Hazira port in India are evolving into specialized centres of economic activities and services and are vital to sustain future economic growth of the country. Indian ports still have to address infrastructural and operational challenges before they graduate to the next level. For example, operational efficiency of Indian ports has improved over the years but still lags behind the global average. Turnaround time (TAT) at major ports was approximately 2.5 days in 2018-19, whereas global average benchmark is 1-2 days. Some of the private sector ports in India like Mundra and Gangavaram, have been able to achieve a turnaround time of around 2 days. Secondly, last mile connectivity to the ports is one of the major constraints in smooth movement of cargo to/from the hinterland. Around 87 per cent of Indian freight uses either road or rail for transportation of goods (MoS, 2019).

The vision of the Sagarmala Programme is to reduce logistics cost for exports and imports and domestic trade with minimal infrastructure investment. This includes:

- Reducing cost of transporting domestic cargo through optimizing modal mix.
- Lowering logistics cost of bulk commodities by locating future industrial capacities near the coast.
- Improving export competitiveness by developing port proximate discrete manufacturing clusters.
- Optimizing time/cost of EXIM container movement.

3.6.9.3 Green Port Project

The MoS has been developing green ports and the status of implementation and progress so far is given below:

Table 3.19: Status of implementation and progress of green ports

No.	Activity	Status
1	Preparation of Environment Management and Monitoring Plan (EMMP) or Green Plan	50 per cent of ports have developed their plans
2	Acquiring equipment required for monitoring environmental pollution	100 per cent target achieved
3	Setting up sewage/ waste-water treatment plants/ garbage disposal plants	Some of the services have been outsourced and ports have planned to provide sewage/waste treatment plans which are under implementation
4	Plantation	Large plantation activities have been carried out around port areas

No.	Activity	Status
5	Setting up projects for energy generation from renewable energy sources	Most of the ports have conducted feasibility studies for renewable energy
6	Improve the quality of harbor water	Regulation of the discharges and effluents in the harbor water and minimization through Swachh Bharat initiatives
7	Implementation of sustainable practices in terminal design, development, and operation	10 per cent of the ports have initiated sustainable practices in terminal operation

Source: MoS, 2020.

3.6.9.4 Renewable power activities in major ports

Some of the green initiatives carried out in shipping sector are listed below (MoS, 2020):

- DPT (Kandla) has installed a 20.7 MW wind farm.
- VO Chidambaranar port trust – 500 kW solar plant, 150 kW solar rooftop in the pipeline, 5 kW ground solar PV in 2020.
- New Mangalore port trust (NMPT) – 5.19 MW solar power plant.
- Paradip port trust proposed to install 100 MW solar power plant.
- Mormugao port trust has installed 240 kW solar power plant.
- Mumbai port trust has installed 401 kW solar power, 1030 kW rooftop solar in the project pipeline.
- Vishakhapatnam port trust has an installed capacity of 10.77 MW solar power.
- Chennai port trust has installed a 500 kW solar power plant.
- Jawaharlal Nehru port trust has an installed capacity of 822 kW rooftop solar panels and 2 MW floating solar plant.
- Kamarajar port has installed 250 kW solar power with a project pipeline of 20 MW wind power along the coast.

3.7 Agriculture sector

As per the guidelines, for the BUR, only the sectors covered in voluntary declarations have to be reported here. India's voluntary declaration does not mention the activities in the agriculture sector. However, India has undertaken several climate-friendly initiatives to proactively promote sustainable development of the sector. These initiatives are discussed in the following sections.

The agriculture sector in India plays a crucial role in ensuring food and nutritional security and engages almost two-third of the workforce in gainful employment. Several industries such as sugar, textiles, jute, food, and milk processing depend on agricultural production for the requirement of raw materials. The sector contributes to 14.45 per cent of the total GHG emissions in India. 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 taken several initiatives to make the sector resilient to climate change and variability, given the importance of the sector for meeting the growing requirements of the population in the country. Agriculture and allied sectors including livestock, fishery, and forestry contribute to about 16 per cent in the 2018-19 GVA (2011-12 series) (MoAFW, 2018).

3.7.1 National Mission for Sustainable Agriculture (NMSA)

As described in the second BUR, the NMSA is the effort by the Government to transform the agricultural sector into an ecologically sustainable, climate resilient production system through various adaptation and mitigation measures. Several interventions have been proposed and these have been described earlier. However, an update on each of the mitigation initiatives is described below. Adaptation initiatives have been described in Section 1.9.2 of Chapter 1.

3.7.1.1 Sub-Mission on Agroforestry (SMAF)

SMAF under NMSA is implemented since 2016-17 as part of the recommendation of the National Agroforestry Policy, 2014. The 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 protect and stabilize ecosystems and promote resilient cropping and farming systems to minimize the risk during extreme climatic conditions and to increase tree cover to promote ecological stability, especially in the vulnerable regions. Emission reduction of 0.1318 $MtCO_2$ was achieved in years 2017-18 and 2018-19 (CRIDA, 2020).

3.7.1.2 National Bamboo Mission (NBM)

The restructured NBM was launched in 2018-19. The mission focuses on the development of 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 & 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 to supplement farm income as well as fulfil quality raw material requirement of industries. The mission would also help in increasing the green cover and enhance the carbon sequestration potential (CRIDA, 2020).

Table 3.20: Area planted under NBM

Year	Plantation Achieved (ha)
2018-19	7,366
2019-20 (till 31.12.2019)	6,870

Source: DAC&FW, 2020.

3.7.2 Pradhan Mantri Krishi Sinchayee Yojana (PMKSY)

The scheme has been operational from 2015-16 across the country. Efforts are made to replace flood methods of irrigation with micro-irrigation systems which reduce electricity consumption required for pumping of water. The micro-irrigation system is energy and water-efficient technology that delivers the water directly to the root zone.

The adoption of water-efficient irrigation technologies helps save water and has the potential to improve the quality and quantity of agriculture produce. Area covered under micro-irrigation under PMKSY-PDMC between 2017-18 and 2019-20 is 3.38 million ha.

Table 3.21: Area covered under micro-irrigation.

Year	Drip (in ha)	Sprinkler (in ha)	Total (in ha)
2017-18	5,41,156	5,07,778	10,48,934
2018-19	5,75,504	5,83,015	11,58,519
2019-20	6,22,768	5,49,799	11,72,567
Total	**17,39,428**	**16,40,592**	**33,80,020**

Source: DACF&W, 2020.

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

The Department of Agriculture, Co-operation & Farmers Welfare is implementing PDMC component of PMKSY which is operational from 1 July 2015 in the country. PMKSY- PDMC mainly focuses on enhancing water use efficiency at farm level through precision/micro-irrigation (drip and sprinkler Irrigation). Besides, promoting precision irrigation and better on-farm water management practices to optimize the use of available water resources, this component also supports micro level water storage or water conservation/management activities as other interventions to supplement source creation (DAC&FW, 2020).

3.7.3 Solarisation of Agriculture

A major recent initiative, the PM-KUSUM (Pradhan Mantri Kisan Urja Suraksha evam Utthan Mahabhiyan) scheme, has been launched for de-dieselisation of farm sector and enhancing farmers' income by providing energy and water security and also to decarbonize the farm sector.

The scheme aims at achieving 30.8 GW solar capacity through installation of small solar power plants of capacity up to 2 MW on barren/fallow/pasture/marshy land of farmers, replacement of 2 million diesel pumps by standalone solar pumps and solarisation of 1.5 million grid connected agriculture pumps by 2022. Under the scheme feeder level solarisation is also possible by installing single solar plant for feeding power to single or multiple agriculture feeders for providing day time reliable power to all farmers connected to the grid. The scheme will also provide the benefits of reliable day time power and reducing electricity subsidy burden of State/DISCOMs. Further, in order to strengthen domestic solar manufacturing, use of domestically manufactured solar cells and modules for standalone solar pumps and solarisation of grid connected pumps is mandatory under the scheme (MNRE, 2020).

This scheme will result in savings of 27 $MtCO_2$ emissions per annum across the country (PIB, 2019). Further, it will also result in reduction in consumption of coal by 9.34 million tonne per annum. As a result of the replacement of diesel pumps with solar pumps, there will be estimated savings of 1.2 billion tonne of diesel (PIB, 2019).

Convergence of PMKSY and PM-KUSUM demo by Krishi Vigyan Kendra (KVK) and National Commission on Plasticulture Applications in Horticulture (NCPAH).

The scheme gives preference to farmers looking to install standalone solar agriculture pumps and those who are using micro-irrigation systems covered under micro-irrigation schemes or those who opt for micro-irrigation system in order to minimize the water usage for irrigation purpose. Accordingly, while releasing central assistance under the scheme of PMKSY-PDMC, States are advised to converge with PM-KUSUM scheme for promotion of micro-irrigation systems. Solar pumps are also to be combined with micro-irrigation following the guidelines of the scheme and in coordination with respective implementing agencies.

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 KVKs has been approved by the extension division of ICAR under PMKSY-PDMC (DAC&FW, 2020).

3.7.4 Crop diversification programme

Given the high water requirement of paddy crop and consequent decline in groundwater and high energy requirement in the traditional green revolution states such as Punjab, Haryana, and Uttar Pradesh, diversification from paddy to other crops was envisaged. The main objectives of the programme are to demonstrate and promote the improved production technologies of alternate crops and to restore soil fertility through the cultivation of leguminous crops. Due to the stagnancy in crop yields, the decline in soil quality, the incidence of pests and diseases due to continuous paddy cultivation in the three States, Punjab, Haryana, and Uttar Pradesh, diversion of paddy cultivation to other crops has become essential. This enables the reduction of the CH_4 emissions associated with paddy production. The budgetary allocation for this programme during 2018-19 was INR 1.328 million. A total area of 81,816 ha has been diversified from paddy to other crops in 2017-18 and 2018-19 (DAC&FW, 2020).

3.7.5 System of Rice Intensification (SRI)

SRI is a promising and resource-saving method of rice cultivation. Studies have shown a significant increase in rice yield, with substantial savings of seeds (80-90 per cent), water (25-50 per cent), and cost (10-20 per cent) compared to conventional methods (Uphoff, 2011), and reduction in CH_4 emissions. As part of the National Food Security Mission (NFSM), SRI is being implemented in 193 districts of 24 States.

Similarly, under National Food Security Mission (NFSM) - Bringing Green Revolution to Eastern India (BGREI) – rice cultivation is being implemented in 120 districts of 7 eastern Indian States. The main objectives of the National Food Security Mission (NFSM) - Rice are to increase the productivity of rice by area expansion and productivity enhancement in a sustainable manner in identified districts of the country, restoring soil fertility and productivity at the individual farm level, enhancing the farm income and enhancing post-harvest value addition at farm gate for better price realisation to farmers through efficient market linkage. The extent of coverage of the SRI system under NFSM & BGREI is shown in Table 3.22 (DAC&FW, 2020).

Table 3.22: Area covered (ha) with SRI system of cultivation

Year	Target envisaged for coverage of SRI system of cultivation (ha)	Target achieved for coverage of SRI system of cultivation (ha)
2017-18	61,658	52,377
2018-19	37,499	33,487

Source: DAC&FW, 2020.

3.7.6 Direct Seeded Rice (DSR) cultivation

DSR is one of the methods of rice cultivation with the objective of doing away with the raising nurseries, puddling, and transplanting. Unlike transplanted paddy cultivation, standing water is not maintained in the DSR system and the field is maintained at saturation and a higher cultivable area can be attained under limited water conditions. Due to alternate wetting and drying cycles, the methane emissions can be reduced significantly. The quantum of water application gets reduced significantly and increases saving in energy due to reduced quantum of water application. 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 extent of coverage of the area with DSR is given in Table 3.23 (DAC&FW, 2020).

Table 3.23: Area covered under DSR cultivation

Year	Target envisaged for coverage of DSR system of cultivation (ha) under NSFM and BGREI	Target achieved for coverage of DSR system of cultivation (ha) under NSFM and BGREI
2017-18	53,085	58,438
2018-19	44,376	41,526

Source: DAC&FW, 2020.

3.7.7 Avoiding crop residue burning

Burning of paddy crop residues in Punjab and Haryana for the timely sowing of wheat is a prevalent practice. Delay in wheat sowing may result in reduced wheat yields due to the growing temperatures at the time of wheat harvest in March-April. Farm equipment that enables timely sowing in the standing paddy residues was made available to the farmers directly and also through Custom Hiring Centres (CHCs) and Farm Machinery Banks (FMBs) to enable sowing of the wheat crop without burning of paddy residues. Crop residue burning poses a more serious problem for local air pollution than for climate change and increase in global warming (PIB, 2020a).

In order to support the efforts of the governments of Haryana, Punjab, Uttar Pradesh and the NCT of Delhi to address air pollution and subsidize machinery required for in-situ management of crop residue, a Central Sector Scheme (100 per cent funded by the Central Government) on ‘Promotion of Agricultural Mechanization for In-Situ

Management of Crop Residue' in the States of Punjab, Haryana, Uttar Pradesh and NCT of Delhi has been implemented during 2018-19 and 2019-20 (DAC&FW, 2020).

The objectives are as follows:

- Prevent air pollution and loss of nutrients and soil micro-organisms caused by burning of crop residue.
- Promote in-situ management of crop residue by retention and incorporation into the soil through the use of appropriate mechanization inputs.
- Create awareness among stakeholders through demonstration, capacity building activities.
- Differentiated Information, Education and Communication (IEC) strategies for effective utilization and management of crop residues.

Accordingly, total funds of INR 5,843.3 million and INR 5,941.4 million have been released during 2018-19 & 2019-20 under this scheme to State governments of Punjab, Haryana, Uttar Pradesh and NCT of Delhi & Indian Council of Agricultural Research (ICAR), to provide subsidy at 50 per cent to individual farmers and 80 per cent for CHCs of in-situ crop residue management machines and equipment.

A total of 55,764 and 56,398 crop residue management machines were provided to individual farmers and CHCs during 2018-19 and 2019-20, respectively. As per the analysis of paddy residue burning in Punjab, Haryana and Uttar Pradesh in 2019, using satellite remote sensing carried out by Consortium for Research on Agroecosystem Monitoring and Modelling from Space (CREAMS) Laboratory, 18.8 per cent and 31 per cent reduction in number of burning events were observed in the year 2019 as compared to that in 2018 and 2017, respectively. The scheme is being continued during the year 2020-21. In 2018-19, INR 5,483.30 million has been released to the concerned State governments (DAC&FW, 2020).

For sustainable use of crop residue, after successfully demonstrating biomass co-firing at NTPC Dadri, NTPC Limited has started commercial-scale biomass co-firing at Dadri. NTPC Limited has already fired over 7,000 tonne of biomass pellets and awarded 280 Tonne Per Day (TPD) purchase orders for four years (approximately 0.4 million tonne). Further, in line with the advisory of CEA, NTPC Limited has invited tenders for about 20 MMTPA of biomass pellets/ torrefied pellets to be delivered to its 17 power plants in the next 4 years. (MoP, 2020a).

3.7.8 Neem-coated urea produced

As a matter of policy, all urea, both imported and indigenously produced, available in the country is neem coated since 2016. Total mitigation of 7.529 $MtCO_2$ was achieved in 2017-18 and 2018-19, with a total production of 47.99 million tonne (DAC&FW, 2020). Neem-coated urea has higher use efficiency and lower loss of nitrogen due to inhibition of nitrification process in soil compared to prilled urea. For the year 2019-20, the season-wise assessed requirement and production of Neem-coated urea is shown in Table 3.24.

Table 3.24: Production of neem-coated urea

Year	Assessed requirement (in million tonne)	Production of urea (in million tonne)
Kharif 2019	16.407	11.813
Rabi 2019-20	18.204	12.642
Total	**34.611**	**24.455**

Source: DAC&FW, 2020. *Kharif = Summer or monsoon crops; Rabi = Winter crops.

3.7.9 Mission for Integrated Development of Horticulture (MIDH)

The horticulture sector consists of a wide range of crops such as fruits, vegetables, flowers, spices, and nuts of which the fruit crops produce relatively higher biomass and are retained in the field for a relatively long period. This helps in sequestering carbon both above and below the ground. The area brought under the mission from 2016-17 to 2018-19 has been reported in Table 3.25. The quantum of carbon sequestered is estimated to be 108.96 $MtCO_2$ from 2017-18 to 2018-19.

Table 3.25: Area brought under Mission for Integrated Development of Horticulture (million ha)

Area brought under MIDH	2016-17		2017-18		2018-19	
	Target	Achievement	Target	Achievement	Target	Achievement
	1.42	1.28	1.46	1.43	2.18	1.54

Source: DAC&FW, 2020.

3.7.10 Balanced ration for livestock

The main objective of the Ration Balancing Programme (RBP) is to educate milk producers on feeding balanced ration to their animals so that the nutrients required by their milch animals are fulfilled in an optimum manner, thereby improving milk production efficiency and the economic return. The achievement under the scheme in 2018-19 has been reported in Table 3.26. The emission reduction as a result of the RBP initiatives was 0.061 $MtCO_2$ from 2017-18 to 2018-19.

Table 3.26: Animals covered with Ration Balancing Programme (RBP)

Year	Target envisaged (million no.)	Target achieved (million no.)
2017-18	2.54	3.05
2018-19	2.0	1.87

Source: DoAH&D, 2020.

3.7.11 Bypass Proteins for animals

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. High yielding milch animals like crossbreds and graded buffaloes specially require more undegradable protein in the form of bypass protein for enhancing milk production potential of the animal. As such protein supplements are more expensive and optimizing the use of protein supplements within the ruminant system can improve milk productivity, income to the farmers, and lower greenhouse gas emissions. Commercial bypass protein technology was available with different seed meals and these bypass proteins reduce the degradability in the rumen. The main purpose of the establishment of the bypass protein units is to improve the availability of the protein and essential amino acids from feed to cattle.

3.7.12 Mitigation reduction due to various activities

The mitigation envisaged due to various initiatives of the GoI as well as the private initiatives are presented below in Table 3.27.

Table 3.27: Emission reduction and carbon sequestration ($MtCO_2$ equivalents) due to various mitigation actions of agriculture sector

Nature of mitigation intervention	2017-18	2018-19	Total
Expansion of area under horticulture systems	61.724	47.245	108.96
SRI Cultivation as alternative to transplanted paddy	0.0150	0.009	0.0248
DSR Cultivation	0.058	0.041	0.099
Crop diversification from paddy to other crops	0.026	0.012	0.0388
Micro-irrigation (Drip and Sprinkler)	5.551	6.428	11.979
Balanced ration for livestock	0.038	0.023	0.0615
Bypass protein	0.039	0.039	0.0779
Avoidance of crop residue burning	0.062	0.263	0.3255
Neem-coated Urea	3.764	3.764	7.5291
Solar pumps distribution under National Solar Mission	0.644	0.891	1.5348
Agriculture Demand Side Management	0.163	0.163	0.3258
National Sub-mission on Agro-forestry (SMAF)	0.043	0.088	0.1318
National Bamboo Mission (NBM)	-	0.1873	0.1873

Source: CRIDA, 2020a.

3.8 Forestry sector

As per India State of Forest Report 2019, forest and tree cover have reached 80.73 million ha which is 24.56 per cent of the geographical area of the country. The annual increase in carbon stock is estimated at 21.3 million tonne which is 78.1 $MtCO_2$eq. The percentage of quantification was found largest in soil organic carbon which is 56.20 per cent followed by aboveground biomass (31.67 per cent), belowground biomass (9.84 per cent), litter (1.80 per cent), and deadwood (0.50 per cent). In the India State of Forest Report (ISFR) 2019, the total carbon stock in forest was estimated as 7,124.6 million tonne, showing an increase of 42.6 million tonne as compared to the last assessment in 2017 (PIB, 2020c). The total forest carbon stocks in Indian forests showed an increment of 502.6 million tonne from the year 2005 (ICFRE, 2020).

According to the Economic Survey 2019-20, India as a responsible nation, with the introduction of various schemes, has been continuously moving towards economic growth, keeping in mind the imperatives of sustainable development. India is among a few countries in the world where, despite ongoing developmental efforts, forest and tree cover are increasing considerably. The report further highlighted that the States/UTs showing gain in forest cover are Karnataka (1,025 km^2), Kerala (823 km^2), Andhra Pradesh (990 km^2) and Jammu & Kashmir (371 km^2) whereas those showing loss in forest cover include Manipur, Arunachal Pradesh, Mizoram and Meghalaya.

3.8.1 Forest (Conservation) Act, 1980

Forest (Conservation) Act, 1980 laid the foundation for protection and conservation of the country's natural forests. Forest (Conservation) Act of 1980 governs diversion or use of forest land for non-forestry purposes such as industrial or developmental projects. The Act of 1980 maintains and protects forest cover by ensuring that any forest land being diverted to non-forestry purposes, should be afforested with the forest equal to the size of the original forest. Afforested land cannot become a forest overnight and the newly afforested land will take around 50 years to start delivering the comparable ecosystem goods and services that the diverted land gave just before diversion.

To compensate for the losses suffered in the interim, the Net Present Value (NPV) of the diverted forest and the value recovered from the "user agency" are computed. The NPV for every patch of forest is computed by an expert committee. At present, the NPV value varies depending upon the quality of forests. It ranges from INR 0.43 million per ha for low-quality to INR 1.04 million per ha for very dense forests. An expert committee has recommended increasing the NPV value of INR 0.98 million for poor quality forests and INR 5.55 million for very dense forests (Verma et al., 2014).

The Act has strictly regulated and restricted the diversion of forest land for non-forestry purposes. Between 1951 and 1980, 0.14 million ha per annum of forest land was diverted for non-forest purposes, whereas between 1980 and 2019, this figure declined to 0.024 million ha per annum on an average (MoSPI, 2020).

As of 31 March 2019, 1,283 cases have been registered for diversion, and the area approved is 20,693 ha in 30 states and UTs. The total number of registered plantation works is 3,36,468 and total projects registered on the e-green watch web-portal is 27,173.

Table 3.28: Diversion of forest land before and after the Forest (Conservation) Act, 1980

S. No.	Years	million ha per annum
1.	1951-1980	0.14
2.	1980-2019	0.024

Source: ICFRE, 2020.

3.8.2 Compensatory Afforestation Fund Management and Planning Authority (CAMPA)

CAMPA acts as a National Advisory Council under the chairmanship of the Union Minister of the MoEFCC for monitoring, providing technical assistance and evaluation of compensatory afforestation activities. MoEFCC has prepared the guidelines for utilization of CAMPA funds by the States through constitution of State-CAMPA. The assigned task of CAMPA is to work towards regenerating natural forests, conservation and protection of forests, monitoring & evaluation, wildlife conservation, protection and other related activities. To monitor the progress of works made under CAMPA funds, the e-green watch web portal is being developed. It is an integrated and online system that is completely reliable, transparent, and accountable. The real-time data is accessible to the stakeholders and the public at large. This allows online monitoring, evaluation of social and ecological audits by the researchers, and access to the public about the Annual Plan of Operations of State CAMPA. This will allow optimal leverage of funds to respective agencies for plantation and assisted natural regeneration, forest management and protection. Funds allocated for plantation work under CAMPA for the years 2015-16 to 2018-19 are given in Table 3.29 (ICFRE, 2020).

Table 3.29: Summary of funds allocated for plantation work (CA, non-CA) and area planted (ha) across different states of India

No.	Year	Area for Plantation works (ha)			Amount allocated (INR in million)*		
		Fresh Plantation works	Committed Plantation works	Total Plantation works	Fresh Plantation works	Committed Plantation works	Total Plantation works
1.	2015-16	449,375	9,33,188	1,382,564	1,734	1,580	3,314
2.	2016-17	916,605	6,79,457	1,596,062	1,030	1,136	2,166
3.	2017-18	71,311	4,86,465	557,776	1,045	800	1,845
4.	2018-19	3,461	3,16,731	320,192	117	288	406

*Calculations are based on sum of all registered estimates. Source: ICFRE, 2020.

3.8.3 Progress made under plantation programmes

3.8.3.1 Twenty Point Programme

As mentioned in BUR-2, this programme is meant to give a thrust to schemes relating to poverty alleviation, employment generation in rural areas, housing, education, health & family welfare, protection of the environment, and many other schemes having a bearing on the quality of life, especially in the rural areas. Under Twenty Point Programme, National Afforestation and Eco-Development Board (NAEB) is the nodal agency to coordinate and monitor the afforestation programmes. The following four points are considered by nodal agency for monitoring:

- Tree plantation
- Survival rate
- Wasteland reclaimed
- Hill, desert, coastal vegetation

The survival percentage is accounted during monitoring of targets and achievements.

Table 3.30: Area covered under plantation and planted seedlings in public and forest lands during period 2016-18 under twenty-point programme

Environment protection and afforestation (Point 15)	Year	Targets	Achievements	Per cent Achievements w.r.t the targets
Area covered under plantation (public and forest lands) (million ha)	2016-17	1.08	1.99	183
Seedlings planted (public and forest lands) (million numbers)	-	708.21	1404.28	198
Area covered under plantation (Public and Forest Lands) (million ha)	2017-18	1.47	1.68	115
Seedlings planted (public and forest lands) (million numbers)	-	957.13	1073.10	112
Area covered under plantation (public and forest lands) (million ha)	2018-19**	1.64	1.315	80
Seedlings planted (public and forest lands) (million numbers)	-	1067.17	1166.48	109

Source: ICFRE, 2020. **Source: MoSPI, 2020.

3.8.4 National Mission on Clean Ganga

The Forest Research Institute (FRI), Dehradun has drawn out an action plan for 'Forestry Interventions in Ganga', which envisages afforestation in 1,34,106 ha of the Ganga riverbank at an estimated cost of INR 22,937.3 million. Following are the details of the area planted from 2016 to 2019 under National Mission for Clean Ganga.

Table 3.31: Area planted under National Mission for Clean Ganga

States	2016-17		2017-18		2018-19	
	Area proposed in DPR (ha)	Area under plantation (ha)	Area proposed in DPR (ha)	Area under plantation (ha)	Area proposed in DPR (ha)	Area under plantation (ha)
Uttarakhand	32,633	1,596	8,736	4,097	13,487	6,093
Uttar Pradesh	9,197	1,573	2,579	620	2,436	-
Bihar	6,352	160	8,408	305	12,907	2,202
Jharkhand	1,305	228	274	56	360	168
West Bengal	15,425	527	10,121	508	5,886	1,205

Source: ICFRE, 2020.

3.8.5 National Green Highways Mission

India's road network of 5.90 million km is the densest and the second largest in the world, catering to 65 per cent of freight traffic and 85 per cent of passenger traffic. It comprises the primary network of 1,16,000 km of National Highways (NH) the secondary network of 1,60,000 km of State Highways (SH) and Major and Other District Roads (MDR & ODR), and a tertiary network of Rural Roads. Considering the importance of road network in economic growth, employment generation and poverty reduction on one hand and the need to facilitate Green Highways (Plantation, Transplantations, Beautification and Maintenance) Policy implementation, NHAI has strengthened green highways division with engagement of one retired experienced professional and one young professional in each Regional office covering all the states. In addition, about 700 young horticulture experts have been sanctioned, one in each project, to supervise plantation activities. NHAI earmarked INR 3,000 million in 2019-20 for the program and has made provision of INR 5,000 million for 2020-21. (MoRTH, 2020).

The status of the plants raised under National Green Highways Mission for the year 2016-19 is given in Table 3.32.

Table 3.32: Status of the plants raised under National Green Highways Mission

Year	Trees planted (in million)
2016-17	3.800
2017-18	3.826
2018-19	3.126
2019-20	3.620
2020-21 (November 2020)*	5.000
Total	**19.372**

Source: NHAI, 2020, *MoRTH, 2020

The GoI is implementing the Pradhan Mantri Gram Sadak Yojana (PMGSY) to provide connectivity to unconnected habitations. The PMGSY also employs green technologies like the use of waste plastic, fly ash, copper and iron slag, geotextile, cold mix, paneled concrete and cell filled concrete.

In 2017, GoI launched the Bharatmala Pariyojana covering a length of 26,000 km of economic corridors, 8,000 km of Inter Corridors and 7,500 km of feeder routers. Besides these, 28 cities have been identified for ring roads; 125 check points and 66 congestion points have been identified for their improvement. Further, in order to reduce congestion on proposed corridors, enhance logistic efficiency and reduce logistic costs of freight movements, 35 locations have been identified for development of multi-modal logistics parks (MoRTH, 2019).

The green corridors, relevant from both climate mitigation and adaptation perspective, are part of India’s efforts to address climate change. The project objective is to develop green and safe project NH corridors and enhancing the institutional capacity of MoRTH in mainstreaming green technologies. The proposed project will systematically institutionalize the development of green and safe NHs by implementing pilots, broadening the knowledge base and creating the capability to design, implement and maintain green and safe highways. Based on the foregoing, and in line with the objective, this operation will have the following three components (MoRTH, 2019):

- Component A: Green highway corridor improvement and maintenance (Total Cost: USD 1,001 million, including IBRD USD 423.95 million).
- Component B: Institutional capacity enhancement (Total Cost: USD 34.5 million, including IBRD USD 27.6 million).

- Component C: Road safety (Total Cost: USD 59 million, including IBRD USD 47.2 million).

3.8.5.1 Green Highways (Plantation, Transplantations, Beautification and Maintenance) Policy, 2015

As mentioned in the Second BUR, the policy was launched to promote the greening of NH corridors across the country with participation of the community, farmers, NGOs, private sector, institutions, government agencies, and the State Forest Departments.

3.8.6 Green India Mission

GIM is one of the eight missions outlined under the NAPCC. It aims at protecting, enhancing, and restoring India's forest cover. The mission acknowledges the influence of forests on environmental amelioration through climate change mitigation, water security, food security, biodiversity conservation, and livelihood security of forest-dependent communities. It hinges on a decentralized participatory approach by involving grass root level communities and organizations in decision making, planning, implementation, and monitoring.

Table 3.33: Financial year-wise physical and financial details for 2015-16 to 2019-20 under GIM

Financial Year	Physical (ha)		Financial (INR million)	
	Target	Achievement	Target	Achievement
2015-16	47,629	30,864	701	346
2016-17	20,198	27,264	413	511
2017-18	7,340	6,274	463	504
2018-19	29,958	32,335	794	712
2019-20	37,560	15,686	1,060	662
Total	**1,42,684**	**1,12,422**	**3,431**	**2,735**

Source: MoEFCC, 2020.

Progress/achievements; the State wise details for the year 2019-20 are given below:

Table 3.34: Progress/achievements; the Sate-wise details for the year 2019-20

S. No	States	Physical target (ha)			Amount released (INR million)
		Advance work	Creation work	Maintenance work	
1	Chhattisgarh	-	-	19,128	50.36
2	Manipur	-	-	8,798	41.67
3	Karnataka	-	600	760	22.10
4	Odisha	-	6,965	2,094	141.89
5	Madhya Pradesh	11,445	11,800	-	306.53
6	Sikkim	-	1,509.2	-	31.24
7	Kerala	-	2,281.64	347.64	163.18
8	Mizoram	-	-	17,084	177.09
9	Punjab	-	-	3,004	31.86
Total		**11,445**	**23,155.84**	**51,215.64**	**956.92**

Source: MoEFCC, 2020a.

Funds amounting to INR 956.92 million have been released so far under first and second instalments to seven States namely Chhattisgarh, Odisha, Karnataka, Sikkim, Madhya Pradesh, Manipur, Mizoram, Punjab, and Kerala in the year 2019-20.

The Directorate of GIM is implementing a World Bank-GEF funded "Ecosystem Services Improvement Project" (ESIP), in the States of Chattisgarh and Madhya Pradesh with financial implication of USD 24.64 million.

The main objectives are:

- Strengthening capacity of government institutions in forestry and land management programs in Madhya Pradesh and Chhattisgarh;
- Investments for improving forest quality in selected landscapes;
- Scaling up of sustainable land and ecosystem management in selected landscapes.

So far, INR 454.20 million has been utilized for the implementation of ESIP activities. The forest sector can significantly contribute to reducing GHG emissions in India in the coming years.

Table 3.35: Incremental annual mitigation potential ($MtCO_2$) of different sub-missions estimated using COMAP model

Sub-mission area	million ha	Incremental annual mitigation potential 2020 ($MtCO_2$)
Moderately dense forest cover, but showing degradation (MDF)	1.5	6.7
Eco- Restoration of degraded open forests (D/O)	3	27.0
Restoration of Scrublands + Grasslands (S/G)	1.2	5.4
Restoration of Mangroves +Wetland catchment (M/W)	0.2	1.6
Avenue, City forests, Municipal parks/ gardens, Households, Institutional lands+ Agro-forestry on fallows, Shelter belts, Roads, canals, tank bunds and schools (AF_SF_UF)	3.2	8.3
Others (Rehabilitation of Shifting Cultivation areas, Restoring /planting Seabuckthorn, Ravine Reclamation and Restoration of abandoned mining areas)	0.9	6.0
Total	10	55.0

Source: MoEF. n.d.

3.8.6.1 National Afforestation Programme (NAP)

Launched in the year 2002, the NAP is a major afforestation scheme under the National Afforestation and Eco-Development Board, MoEFCC, GoI. About 50,000 ha new area has been afforested along with creation and maintenance of previous years' plantations and an allocation of INR 1 billion in 2018-19. However, the NAP stands merged with GIM, vide order dated 30 January 2018 (MoEFCC, 2019a).

Currently, this programme is being implemented through a three-tier system with the State Forest Development Agency (SFDA) operating at the state level, Forest Development Agency (FDAs) at the district/forest division level and Joint Forest Management Committees (JFMCs) at the village level.

Under care and share concepts, community assets are developed, and plantations are taken up in 7 different models. In total, 29 SFDA projects are currently operating in the country.

During 2018-19, INR 1.59 billion allocated under GIM-NAP for utilization towards the following activities (MoEFCC, 2019a):

- Increased forest/tree cover on 6,163.8 hectare of forest/non-forest lands.
- Improved quality of forest/tree cover of forest/non-forest lands on 6,126.4 hectare of forest/non- forest lands.
- Afforestation under National Afforestation Programme 50,000 ha.

A total expenditure of INR 38.20 billion has been released to treat an area of 2.19 million ha since the inception of the NAP Scheme till 2018-19. The earmarked INR 1.59 billion in 2018-19 for the Green India Mission (National Afforestation Programme) was a 48.8 per cent increase in allocation over the previous years.

Table 3.36: Year-wise progress in terms of area covered and the amount released of National Afforestation Programme

Year	No. of new FDA projects approved	No. of new JFMCs involved	Project area approved (ha)*	Release (INR in million)**
2000-02	47	1843	71,068	475
2002-03	237	8197	4,04,799	1513
2003-04	231	7902	2,82,536	2080
2004-05	105	3404	1,06,743	2330
2005-06	94	2362	54,432	2481
2006-07	15	494	0	2928
2007-08	53	3979	4,93,061	3930
2008-09	13	6598	1,73,435	3456
2009-10	5	7756	1,03,556	3182
2010-11	26	-	57,126	3100
2011-12	26	-	1,41,448	3030
2012-13	27	-	55,529	1934
2013-14	26	-	80,583	2576
2014-15	25	-	74,435	2125
2015-16	-	-	35,986	942
2016-17	-	-	2,359	594
2017-18	-	-	39,847	760
2018-19	-	-	16,636	769
Total			**21,93,579**	**38,202**

Source: OGD Platform India, 2020.

*Area approved for advance soil work/preparatory plantations during the year for all ongoing FDA projects.
** Total (financial assistance provided during the year for planting, advance soil work and maintenance) for all ongoing FDA projects.

3.8.7 Other Initiatives

3.8.7.1 Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA), 2005

MGNREGA, enacted in 2005, is the foundation for MGNREGS which serves as the means to implement the Act. MGNREGS is one of the world's largest social security programmes with an investment of INR 480 billion during 2017-18. The bulk of the MGNREGS activities are focused on natural resources such as land, water and trees. Thus, it provides an opportunity for carbon sequestration, as a co-benefit. A study by the Indian Institute of Science estimated the carbon sequestration achieved by MGNREGS programme in 2017-18. The total mean carbon (biomass and soil organic carbon) sequestered at the national level, considering all the Agro-Ecological Regions (AER) and Natural Resource Management (NRM) activities, for the year 2017-18 (for cumulative number of works implemented) is estimated to be 62 $MtCO_2$. Among the NRM works, 'Drought Proofing' provides about 40% of the total carbon sequestration, considering all NRM works at the national level (IISc, 2020).

3.8.7.2 Nagar Van Scheme

On the occasion of the World Environment Day (5 June 2020) the government had announced implementation of the Nagar Van Scheme or Urban Forests Scheme to develop 200 Urban Forests across the country in next five years with a renewed focus on people's participation and collaboration between Forest Department, Municipal bodies, NGOs, corporates and local citizens. CAMPA has been allocated for financing Nagar Van or Urban Forests scheme. Following are the objectives under this scheme:

- To create 200 city forests in the country across cities with Municipal Councils.
- To create awareness on plants and biodiversity.
- Conservation education on important flora and fauna of the region including threat perception.
- Ecological rejuvenation of the cities- forests the green lungs will contribute to Environmental improvement of cities by reduction of pollution levels, cleaner air, noise reduction, water harvesting and reduction of heat islands effect.
- In-situ biodiversity conservation.
- Health benefits to citizens.
- Making cities climate resilient.

The Government will provide a one-time fund allocation supporting development and nonrecurring expenditure to the concerned agency in the selected cities for creation of a city forest. Cities' authorities will be encouraged to have a City Forest comprising area up to 100 ha in forest areas within their jurisdiction for deriving maximum ecological and environmental benefits. The minimum area should not be less than 20 ha. The outcome of the scheme will be carefully monitored to characterize and quantify GHG and air pollution reduction benefits in various air sheds.

3.8.7.3 Pradhan Mantri Van Dhan Yojana

Pradhan Mantri Van Dhan Yojana is an initiative targeting livelihood generation for tribals by harnessing the wealth of forest. The programme aims to tap into traditional knowledge & skill sets of tribals by adding technology & IT to upgrade it at each stage and to convert the tribal wisdom into a viable economic activity through value added products. This initiative was taken up by the Ministry of Tribal Affairs (MoTA) and Tribal Cooperative Marketing Development Federation (TRIFED), and the scheme was launched on 14 April 2018 (PIB, 2020h). The initiative aims to provide enhanced livelihood to 4.5 million tribal gatherers in one year. A Market Linked Tribal Entrepreneurship Development Program for forming clusters of tribal SHGs and strengthening them into Tribal Producer Companies (TPC) has been launched with participation from 27 States. The Ministry of Tribal Affairs has approved the Van Dhan Scheme Guidelines on 26 February 2019, while the scheme is to be implemented by TRIFED. Nearly INR 1,000 million have been sanctioned in 2019 for setting up 676 Van Dhan Vikas Kendras (VDVKs) in 18 States covering 2,00,740 beneficiaries for livelihood generation. The VDVKs will provide capacity building training and skill upgradation and value addition facility and setting up of primary processing. The VDVKs will be a significant milestone in financial development of tribals involved in the collection of Minor Forest Produce (MFPs) by helping them in the best use of natural resources and provide sustainable MFP-based living in MFP-rich districts. Under this scheme, TRIFED has conducted two national level advocacy workshops and 5 state level advocacy workshops. TRIFED is also developing robust web-based IT platform and mobile application for data collection, tracking, and monitoring of all the activities (MoTA, 2019).

3.8.7.4 Telangana Ku Haritha Haram

This is a flagship programme of the Telangana Government that envisages increase of the present 24 per cent tree cover to 33 per cent of the total geographical area of the State. This programme was launched in 2015-16. The target was to plant 2,300 million saplings in three years. Total area under block plantation achieved is 36,657.93 ha. The number of plants planted from 2016-2019 is 1127.97 million (GoT, 2019).

3.8.7.5 Maharashtra Harit Sena/ Green Army

Maharashtra State Forest Department has initiated the ‘Maharashtra Harit Sena’/ ‘Green Army’ which is a body of dedicated volunteers to participate in the plantation, protection, and other activities in forest, wildlife, and related sectors round the year. State Forest Department had set the target of planting 40 million, 130 million and 330 million saplings in the three consecutive years *viz*. 2017, 2018 and 2019. Under this mission, 500 million saplings planting target had been fixed for the period 2017-2019. For the year 2018, against the target of 130 million saplings, 158.87 million saplings were planted. For 2019 target of 330 million saplings, 167.67 million saplings have been planted by February 2020 (GoM, 2020a; GoM, 2020b).

3.8.7.6 Tripura Forest Environmental Improvement and Poverty Alleviation Project (TFIPAP)

This is an externally funded project from Japan International Co-operation Agency (JICA) with cost of 7,725 million Japanese Yen (JPY). The objective of the project is to restore degraded forests and improve the livelihood aspects of villagers, including tribal families engaged in traditional shifting cultivation, and promoting sustainable forest management through JFM, thereby improving the environment and alleviating poverty. Around 61,754 ha have been afforested and 8,533 ha have been brought under agroforestry. Over 2,504 check-dams of different configurations have been also laid for soil and water conservation. Plantation of broom grass, black cardamom and gandhaki has been undertaken for forest-based Income Generating Activities (IGA).

3.8.7.7 Bonn Challenge and India

A 2010 study undertaken by IUCN and World Resources Institute (WRI) produced a World of Opportunity Map, which found that globally there was more than two billion ha of degraded land offering opportunities for restoration. In September 2011, at a high-level event co-hosted by the German Ministry of the Environment and IUCN, the 2020 Bonn Challenge target was launched by leaders from around the world. The Bonn Challenge is a global effort to bring 150 million ha of deforested and degraded land into restoration by 2020 and 350 million ha by 2030 at the New York Declaration on Forests of the 2014 UN Climate Summit. Government of India made a Bonn Challenge pledge in 2015 at Bonn, Germany to bring under restoration 13 million ha of degraded land by 2020 and an additional 8 million ha by 2030 (ICFRE, 2020).

Government schemes are often implemented with a bottom-up joint forest management approach, with local communities playing a key role in Bonn Challenge. Private companies and non-governmental organisations may operate at smaller scales yet have the expertise at their disposal that can influence the success of these restoration efforts (IUCN, 2018).

In total 9.81 million ha of area was brought under restoration across India (from 2011 to 2016-17). Out of the total restoration efforts carried out across the country, 94.4 per cent (92,64,976 ha) was by government agencies, 3.6 per cent (3,52,667.9 ha) by NGOs and 2 per cent (1,93,290.3 ha) by private companies. Afforestation and reforestation activities/programmes carried out under Twenty Point Programme, NAP and GIM, were covered under restoration efforts made by government agencies. Some other relevant schemes and programmes which include National Agroforestry Policy, NBM, National Green Highways Mission, National Mission for a Clean Ganga, Nagar Van Yojana. are all included under the umbrella of the Twenty Point Programme to achieve the restoration targets of Bonn Challenge.

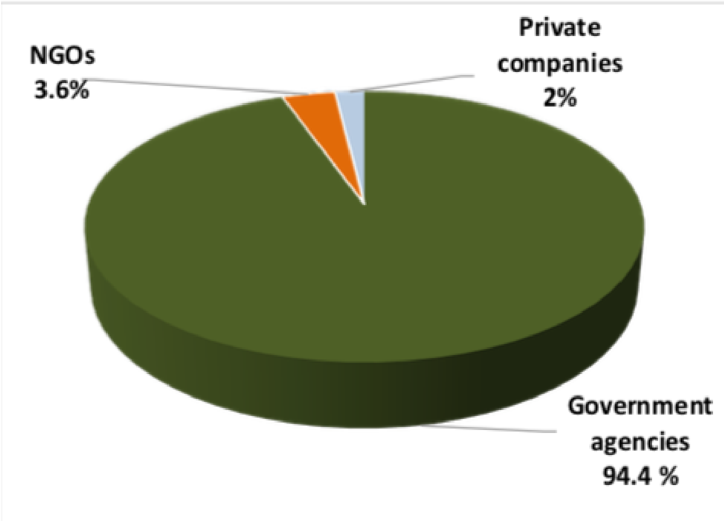


Figure 3.9: Restoration efforts by three leading agencies

Moreover, as part of Corporate Social Responsibility (CSR), 11 private companies have taken up restoration efforts in degraded areas. Out of the total restored area, 97.4 per cent is covered under mono plantation model (cash crops) and the remaining under mixed plantation model (exotic species). NGOs play a small but active role in restoration of degraded lands, including unique and threatened ecosystems such as grasslands and mangroves. Out of total restored area by NGOs, 91.5 per cent (3,22,610.9 ha) was restored by mixed plantation model, and a total of 30,067 ha (8.5 per cent) was restored using mono plantation model. Underlying the Bonn Challenge is the Forest Landscape Restoration (FLR) approach, which aims to restore ecological integrity at the same time as improving human well-being through multifunctional landscapes. Moreover, it is a practical means of realising many existing international commitments which includes CBD Aichi Target 15, the UNFCCC REDD+ goal, and the Rio+20 land degradation neutrality goal (IUCN, 2018). FLR has the potential to generate significant biodiversity benefits including restoration to re-establish connections between habitats apart from increasing habitat extent and quality. It has major potential as a climate mitigation mechanism through carbon storage. Economics of Land Degradation Initiative (ELDI) estimated that sustainable land management globally could create an additional 2.3 billion tonne of crop production per year worth approximately USD 1.4 trillion, thus addressing the prevalent food crisis (ELDI, 2020). This will create approximately USD 84 billion per year in net benefits that could bring direct additional income opportunities for rural communities (ICFRE, 2020).

Initiatives by PSUs and Private Sector

With the advent of social forestry, a promotional drive was launched for tree planting in wastelands, institutional lands and non-forest public and private lands. Many tree farming and agroforestry enterprises have sprung up all over the country and they are performing an important role as suppliers of forest raw material as well as market products (fuelwood, poles, small timber and bamboo). Currently various schemes/programmes have encouraged private agencies to participate in mitigation activities of the forestry sector of India. There is a growing realization now a days of the private sector to play a greater role in forestry sector.

The GIM mission document promoted a massive program for forestry on non-forest lands with participation of the community, farmers, NGOs, private sector, institutions, government agencies and the Forest Department. It also supported a dedicated program for nurseries aimed at raising "quality seedlings" to meet the demands of farmers which also facilitates transportation to villages to ensure available supply in an energy efficient manner. Quality Seedling Production (QSP) and transportation could be taken up by the private sector/farmers/women's SHGs on a competitive basis, with backup support from the Forest Department, research institutions and private sector agencies currently engaged in this field.

Coal/lignite PSUs have not only enhanced their production level over the years to meet the rising energy demand, but have also shown their sensitivity and care towards native environment by adopting various mitigation measures including reclamation of mined out areas and extensive plantation in and around coal bearing areas. Coal/lignite PSUs have brought 54,500 ha land under green cover by plantation of about 132 million trees thus creating carbon sink of about 0.27 MtCO_2 equivalent per year. PSUs have envisaged to bring about 20,000 ha of additional area (in and around coalfields) under plantation by 2030 involving plantation of about 50 million trees (MoC, 2020). Since inception, Coal India Limited (CIL) has planted around 99.6 million trees in an area of 39,842 ha till March 2020. In the present fiscal, around 800 ha of affected area is planned to be brought under green cover. These efforts not only lead to improved environment and enriched biodiversity but also create an effective carbon sink. In addition to this, CIL has developed 23 ecoparks/mine ecotourism projects till 2019-20 and has also planned to develop 10 new mine ecotourism projects, along with another 5 expansion mine ecotourism projects in the current fiscal.

3.9 Waste sector

The waste sector contributed 2.65 per cent to India's GHG emissions (without LULUCF) in 2016. Waste sector emissions mainly cover waste management activities such as solid waste disposal and wastewater treatment and discharge. In order to manage waste efficiently, government has significantly invested in solid waste management (SWM) programmes.

The current focus of the GoI is on the rapid expansion and modernization of sanitation facilities and waste management infrastructure in general. These are indispensable for future mitigation in the waste sector. India recognizes the dual benefits that can arise from efficient waste disposal leading to enhanced environmental benefits along with initiatives promoting conversion of waste to energy.

3.9.1 Waste management regulatory landscape

For efficient waste management, specific laws for different types of wastes have been enacted and amended from time to time to accommodate the changing environmental conditions. These are:

- Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989.
- Hazardous Wastes (Management, Handling & Transboundary Movement) Rules, 2016 (This supersedes 2008 version).
- Fly Ash Notification 1999, amended in 2016.
- E-Waste (Management) Rules, 2016 (This supersedes 2015 version).
- Bio-medical Waste (Management & Handling) Rules, 2016 (This supersedes 1998 version).
- Construction and Demolition Waste Management Rules, 2016.
- Municipal Solid Waste Management Rules, 2016 (This supersedes 2000 notification).
- Plastic Waste (Management and Handling) Amendment Rules, 2018 (This supersedes 2011 and 2016 versions).

Recently, the MoEFCC released the Draft Battery Waste Management Rules, 2020. The Draft Rules seek to replace the Batteries (Management and Handling) Rules, 2001, which provide details for handling and management of batteries under the Environment (Protection) Act, 1986.

3.9.2 Plastic Waste Management (PWM)

Approximately 3.3 million metric tonne of plastic waste is generated every year (CSE, 2020). Average plastic waste generation is approximately 6.92 per cent of Municipal Solid Waste (CPCB, 2018). MoEFCC notified the PWM Rules in 2016 which detail the improved waste management system, a part of the framework of "Extended Producer Responsibility" (EPR). EPR framework focusses on minimization of plastic waste by segregating plastic waste at source and involving informal sectors such as waste pickers, recyclers and waste processors. Responsibility of the waste generators/producers/brand owner for efficient management of plastic waste was detailed. A Guideline Document: Uniform Framework for EPR under PWM Rules, 2016 was released by the Ministry in June 2020. The Amendment to the Plastic Waste Management (PWM) Rules 2018, inter alia provided details on registration of Producers/Brand Owners and defined the term alternate use under PWM Rules.

3.9.3 Atal Mission for Rejuvenation and Urban Transformation (AMRUT)

- In AMRUT Mission for 500 Class-I cities approved by GoI, one of the eligible components is sewerage and sewage treatment plants, including recycling and re-use of wastewater (MoJS, 2016).
- The Mission focuses on a healthy and green environment for citizens and promoting use of non-motorized urban transport with the expected outcome of increased amenity values of cities by developing greenery and well-maintained open spaces which are child and elderly friendly, featured in all Mission cities. Efficient public transport or constructing facilities for non-motorized transport.
- Against the total planned size of INR 7,76,400 million of all the SAAPs, INR 14,360 million (2 per cent) was for non-motorized urban transport
- Construction of the components of non-motorized transport such as sidewalks, foot over bridges, multilevel parking.

3.9.4 Swachh Bharat Mission (SBM)

One of the implementation components of this flagship programme is SWM which includes setting up of wet waste processing facilities (municipal waste to compost, waste to biogas), and dry waste recycle and recovery facilities including for plastic waste, with Central support of 35 per cent of project cost (MoHUA, 2020a). The estimated potential to generate power from MSW is about 500 MW which would be increased to 1,075 MW by 2031, as urbanisation grows (UNCRD, 2018).

Indian Railways (IR) had earlier set a target to fit bio-toilets in the entire fleet of coaches by the year 2021-22. This target was achieved earlier than planned. All passenger carrying BG coaches, from April 2020 onwards, are fitted with bio-toilets and direct discharge of human waste from trains has thus been eliminated in line with Swachh Bharat Mission. More than 2,45,400 bio-toilets have been installed in about 68,800 passenger coaches by IR until June 2020.

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

NTPC Limited has commissioned 24 TPD thermal gasification based demonstration scale Waste to Energy (WtE) plants at Varanasi to support technology development in India. The MSW is first converted to producer gas, which is then used to generate approximately 200 kW of electric power. Further, NTPC Limited has also signed in principle MoU with Surat and East Delhi Municipal Corporations, Varanasi Municipal Corporation (VMC) and Indore Municipal Corporation (IMC) for setting up state-of-the-art WtE plants. The plants at Varanasi and Indore shall be based on conversion of MSW to torrified charcoal, which has high GCV and can be used in power plants along with coal (MoP, 2020a).

A total of 216 WtE plants with aggregate capacity of 370.45 MWeq. have been set up in the country to generate power or biogas/biomethane or Bio-CNG from agricultural, urban, industrial and municipal solid wastes (MNRE, 2020a). The 'SATAT' (Sustainable Alternative Towards Affordable Transportation) scheme for Compressed Bio Gas (CBG) in transportation and other usage was launched on 1 October 2018, which envisages production of 15 MMT of CBG from 5,000 plants by 2023 (PIB, 2020k).

Table 3.37: State/UT-wise number and installed capacity WtE plants set up in the country, as on 31 August 2020

States	Installed total WtE production capacity (MWeq)	Number of WtE plants
Andhra Pradesh	51.4	25
Bihar	1.0	1
Chhattisgarh	0.4	2
Delhi	52.0	3
Goa	0.3	1
Gujarat	21.6	21
Haryana	6.1	6
Himachal Pradesh	1.0	1
Karnataka	14.6	11
Kerala	0.2	1
Madhya Pradesh	20.3	11
Maharashtra	44.8	30
Punjab	18.2	13
Rajashtan	3.8	3
Tamil Nadu	24.1	35
Telangana	49.9	11
Uttar Pradesh	50.2	29
Uttarakhand	9.2	10
West Bengal	1.2	2
Grand Total	**370.45**	**216**

Source: MNRE, 2020a.

3.10 Relevant international comparisons

As discussed at the beginning of this chapter, it is necessary to provide a global comparative context to India’s contribution to climate change mitigation as warming of anthropogenic origin is indeed a global collective action problem. Hence, no individual national contribution can be adequately described without taking stock of its commitment and responsibilities under the Convention, and other Protocols and Agreements under it, flowing from Article 3.1 of the Convention. Further, in this regard, the following may be noted.

India's cumulative CO_2 emissions are much lower, compared to other countries in proportion to its population, and India has used a much lower share of the global carbon budget with respect to its population. The total global non-LULUCF emissions (of all GHGs) between 1850 and 1989 are estimated to be about 1,288 $GtCO_2eq$ (Gütschow et al., 2019b). Between 1990 and 2017 the world emitted another 1,053 $GtCO_2$ eq. According to IPCC Special Report on 1.5ºC Global Warming, for a 50 per cent probability of limiting temperature rise to below 1.5ºC, the world has a remaining carbon budget from 2018 (referring to the allowed cumulative emissions of all GHGs, both non-LULUCF and LULUCF, from 2018 to the year of net zero GHG emissions) of about 480 $GtCO_2eq$. For a 50 per cent probability of limiting temperature rise to below 2ºC, the world has a remaining carbon budget of about 1,400 $GtCO_2eq$ (Rogelj et al., 2019). Table 3.38 shows the per capita fair shares based on equal per capita division of the global carbon budget (with reference to populations in 2018), and actual emissions of select countries between 1850 and 2017. The difference between actual emissions and the fair shares of the global carbon budget of the major economies, shows quite clearly that only India has emitted less than its fair share in both time periods, 1850 to 1990 (before the adoption of the UNFCCC) and 1990 to 2017 (after the adoption of the UNFCCC).

Table 3.38: Per capita fair shares based on equal per capita division of the global carbon budget

	Fair share of global carbon budget between 1850 and 1989 [$GtCO_2eq$]	**Actual emissions between 1850 and 1989 [$GtCO_2eq$]**	**Fair share of global carbon budget between 1990 and 2017 [$GtCO_2eq$]**	**Actual emissions between 1990 and 2017 [$GtCO_2eq$]**
USA	56	380	46	192
Germany	14	82	12	29
Japan	22	36	18	38
Russian Federation	25	91	20	59
China	238	77	194	211
Brazil	36	16	29	23
India	230	45	188	51
World	1288	1288	1053	1053

Source: Data extracted from Gütschow et al., 2019a, 2019b.

Despite its far lower historical responsibility and the significant challenges it faces in terms of meeting its developmental requirements, India is already contributing significantly to climate change mitigation as detailed in this chapter.

To adequately assess India's effort, we note that the reduction in annual GHG emissions of the non-EIT Annex-I Parties from 1990 to 2018 is only 1.5 per cent without LULUCF emissions and 3.1 per cent with LULUCF emissions according to the report of the Subsidiary Body on Implementation (SBI) on "Compilation and synthesis of Fourth Biennial Reports of Parties included in Annex I to the Convention" (SBI, 2020). According to the same report, GHG emissions of Annex-I parties as a whole decreased by 12.5 per cent, excluding LULUCF and by 16.6 per cent including LULUCF between 1990 and 2018. The report also says that the emissions in 2020 of the non-EIT Parties are likely to actually rise 0.4 per cent over 1990 levels. The reduction in emissions of Annex-I parties therefore is highly inadequate compared to the recommended levels of emissions reductions in the Fourth Assessment Report (AR4) of the IPCC which stated that they were required to reduce emissions by 25-40 per cent by 2020 with respect to 1990 levels (Gupta et. al., 2007).

India's per capita consumption of fossil fuels is also one of the lowest among the major economies.

Table 3.39: Per capita fossil fuel consumption

Per capita fossil fuel Consumption (2018)	Coal consumption (tonne per capita)	Natural gas consumption (cu.m. per capita)	Oil consumption (tonne per capita)
USA	1.91	0.59	2.37
Germany	2.62	1.12	1.14
Australia	4.52	1.84	1.96
UK	0.20	1.20	0.89
China	2.70	0.20	0.42
India	0.73	0.04	0.16

Source: IEA, 2018.

With respect to its NDCs under the Paris Agreement, India is acknowledged to be one of the few countries on track to fulfilling its commitment according to several independent tracking initiatives (CAT, 2020). Despite the large developmental challenges before the country and relatively lower per capita income, India is still doing much more than its fair share to mitigate climate change.

While India is committed to contributing its fair share to the mitigation of climate change, it must be emphasized that India will need to depend on coal into the future for some time. The timeline for this phase will be aligned to India's requirements of fair access to the global carbon budget. India is a large country, home to more than 17 per cent of the world's population. To build infrastructure and ensure employment and development for all, India would need to augment industrial capacity and further mechanize agricultural production. This requires energy and India's energy consumption is therefore likely to increase substantially in the future.

While the GoI is doing its utmost to maximise use of renewable energy technologies, as discussed in detail in this chapter, this transition is not easy. This is on account of both technical and financial constraints. Supporting industrial production using renewable energy requires dependence on energy storage technologies. It also renders grid management more difficult given the diversity of energy sources in the country, their spatial distribution and the widely varying requirements of different states. Unlike many other nations, especially those whose energy requirements are similar to or higher than India's, we do not have domestic reserves of oil and natural gas which can substitute for coal in the short or medium term. The transition to renewable energy therefore is more challenging in the Indian context, necessitating coal use for the foreseeable future even as the country explores a way for transition to a clean energy system in a just and equitable manner[2].

India's performance on the Climate Change Performance Index (CCPI)

The CCPI evaluates and compares the climate protection performance of 57 countries and of the European Union (EU), which are together responsible for more than 90 per cent of global greenhouse gas (GHG) emissions. In 2020, India, for the first time was among the top ten in the year's CCPI with a rank of 9. The current levels of per capita emissions and energy use are still comparatively low and, along with ambitious 2030 targets, result in high ratings for the GHG Emissions and Energy. While India received an overall medium rating in the Renewable Energy category, India's 2030 renewable energy target is rated very high for its well below 2°C compatibility.

The Climate Action Tracker (CAT) rates India's existing target under the Paris Agreement "2°C compatible", as it is within the range of what is considered to be a "2°C compatible" fair share of global effort, even while it allows the country's total emissions to increase.

3.11 Emission reduction during COVID-19

A study published in Nature Climate Change in July 2020 estimated that "daily global CO_2 emission decreased by –17 per cent (–11 to –25 per cent for ±1σ) by early April 2020 compared with the mean 2019 levels". It also stated that at their peak, emissions in individual countries decreased by –26 per cent on average (Le Quéré et al., 2020). This decline is attributed to the response of Governments for the containment of COVID-19 across the world. In India, a nation-wide lockdown was declared on 25 March 2020, but a few economic activities, especially in the transport sector, were curtailed on 23 March 2020 in some regions of the country even before the nation-wide lockdown came into effect. Another study by Carbon Brief estimated that India's CO_2 emissions declined by 15 per cent year-on-year during March and are likely to have declined by 30 per cent in the month of April (Myllyvirta and Dahiya, 2020).

The nation-wide lockdown lasted till the end of May 2020 with progressive relaxations since then. The economic impact of India's response to COVID-19 has been severe as it has been in many other countries. In the first quarter of 2020-21, India's GDP contracted by over 23 per cent according to the estimates published by India's National Statistics Office. This has had a direct impact on India's energy sector. In 2019-20 itself the growth in India's energy supply dropped to less than 1 per cent. The sudden drop in energy demand in the month of March in 2020, the last month of the fiscal year 2019-20, due to COVID-19, is responsible for this significant reduction in the growth rate which was over 5 per cent in the previous year.

[2] Refer to Tongia R. (2020) and Parikh (2014) for the assessment.

Throughout this period however, India has continued to implement its policies to facilitate the supply of renewable energy. The renewable energy purchase obligations for the distribution companies continue to remain in place despite the severe economic situation in the sector. Other policies such as the "must run" status accorded to renewable energy plants, which ensures that all the energy generated by these plants is purchased by distribution utilities, continue to be implemented. This has resulted in very low load factors for India's thermal plants. On an average, only 48.5 per cent of India's total thermal capacity was utilised in the year 2020-21 (up to September 2020) (CEA, 2020e). The decision to utilise more renewable energy and back down thermal capacity even during the economic slowdown shows India's commitment to addressing climate change. This commitment is also substantial in monetary terms if the high opportunity costs of renewable power due to the foregoing of thermal options is taken into account. However, a full accounting of this extra cost incurred by India during the pandemic cannot be immediately estimated and will require further research. Furthermore, emission reductions observed in 2020 are likely to be temporary and do not reflect structural changes in the economic, transport or energy systems (Le Quéré et al., 2020).

3.12 Mitigation actions: nature, coverage, objectives, methodologies, steps taken, results and emission reductions achieved

In accordance with AWGCLA/2011/INF.1[3], information on Description of the mitigation action, methodologies and assumptions, objectives of the action and steps taken or envisaged, and Progress of implementation is provided in a set of Tables in the following section:

- Energy (Table 3.40)
- Agriculture (Table 3.41)
- Forestry (Table 3.42)
- Transport (Table 3.43)

Tables that follow provide the annual estimates of GHG mitigated from some of the major policies and programmes for the years 2015 and 2016. These tables are indicative and non-exhaustive. Some other national level policies and programmes that would have indirect mitigation benefits are mentioned in Chapter 6 (additional information). Their mitigation contributions could not be estimated.

---

[3] Framework Convention on Climate Change, Ad Hoc Working Group on Long-term Cooperative Action under the Convention, 18 March 2011

Table 3.40: Energy Sector

Name of Mitigation Action	Description	Nature	Coverage (sector)	Coverage (gases)	Objectives of the Action	Quantitative Goal/ Progress indicator	Methodology/ Assumption	Steps taken/ and Results achieved	Relevant National Mission/
National Solar Mission	It emphasises on reducing the cost of solar generation by extensive R&D, scaling up the project development and enabling policy environment	Regulatory	Renewable energy	CO_2	To create an enabling policy framework to make India a global leader in solar energy. To assist solar in attaining Grid parity by 2022.	To install 100 GW (60 GW Solar PV and 40 GW Solar Roof top) of solar capacity in India by 2022.	The CO_2 emission factor (CO_2EF) numbers are the average carbon content of the national power grid and have been obtained from CEA. The total CO_2 saved during 2011-2016 has been estimated using the following formula: Total CO_2 saved = Electricity generation from solar × baseline CO_2 emission factor	• As on September 30 2020, a total of 36.05 GW Grid connected Solar Power Projects have been commissioned. • Total cumulative emission reductions from grid connected solar power from 2014-15 till July 2018 is 60 $MtCO_2e$. The solar target of 100 GW is expected to abate over 170 $MtCO_2$ over its life cycle.	National Action Plan on Climate Change
Renewable Purchase Obligation (RPO)	A certain minimum percentage of power needs to be purchased, by the utilities and some large power consumers, from the renewable sources.	Economic, fiscal, Obligatory action	Renewable sector at the country level;	CO_2	To promote renewables and energy security	Ministry of Power notified RPO trajectory for solar and non-solar till 2021-22. Both RPO till 2021-22 to reach 10.5 per cent each totalling to 21 per cent (MNRE, 2020).	Many states have been setting their respective state yearly RPO target in line with the national agenda.	During 2019-20, only 4 States, namely Andhra Pradesh, Karnataka, Rajasthan and Tamil Nadu have achieved RPOs in full. Seven States, namely Gujarat, Mizoram, Nagaland, Madhya Pradesh, Telangana, Dadar & Nagar Haveli, and Maharashtra have achieved more than 55 per cent RPO compliance. Remaining States/UTs have achieved less than 55 per cent RPO compliance.	The Electricity Act 2003, National Tariff Policy 2016, National Action Plan on Climate Change (NAPCC) 2008

Name of Mitigation Action	Description	Nature	Coverage (sector)	Coverage (gases)	Objectives of the Action	Quantitative Goal/ Progress indicator	Methodology/ Assumption	Steps taken/ and Results achieved	Relevant National Mission/
Wind Energy	Target of 60 GW wind power by 2022.	Regulatory	Renewable energy	CO_2	To catalyse commercialization of grid interactive wind power.	Deployment of 60 GW by 2022 and cumulative 450 GW renewable energy by 2030.	The CO_2EF has been obtained from CEA. The total CO_2 saved during 2011-2016 has been estimated using the following formula: Total CO_2 saved = Electricity generation from wind × baseline CO_2 emission factor	As on 30 September 2020 installed capacity of wind energy was 38.12 GW. Wind power source has led to an emission reduction of 188.08 $MtCO_2$ during 2014-15 to July 2018.	National Action Plan on Climate Change
Other Renewables (Biomass, Bagasse and Other)	MNRE has been vested with the responsibility of developing Small Hydro Power (SHP) projects up to 25 MW station capacities. The estimated potential for power generation in the country from such plants is about 20,000 MW.	Regulatory	Renewable energy	CO_2, CH_4	Small Hydro Power, Bagasse and Biomass based power	Deployment of 15 GW by 2022 and cumulative 450 GW renewable energy by 2030.	The CO_2 EF has been obtained from CEA. The total CO_2 saved during 2011-2016 has been estimated using the following formula: Total CO_2 saved = cumulative generation from biomass, bagasse and other × baseline CO_2 emission factor	The present installed capacity of power projects based on Biomass combustion is 10.31 GW as on September 2020 This has led to an emission reduction of 92.5 $MtCO_2$ from 2014-15 to July 2018.	National Action Plan on Climate Change
T&D Losses reduction	By the end of 2013, each of the country's five regional grids was interconnected to operate at a synchronous frequency in an effort to transfer power from generation sources to load centres more efficiently.	Economic	Power sector	CO_2	Under Ujwal Discom Assurance Yojana (UDAY) scheme, it is targeted to reduce Aggregate Technical & Commercial (AT&C) losses to 15 per cent by 2018-19.	Reduction in transmission and distribution losses	The CO_2 emission factor has been obtained from CEA. The total CO_2 saved during 2011-2016 has been estimated using the following formula: Total CO_2 saved = Total electricity generation × T&D loss reduction for current year from previous year × Grid emission factor	It has led to an emission reduction of 889 $MtCO_2e$ during 2008-2017. The average percentage of inter-state transmission losses occurred during January 2016 to December 2018 is in the range of 2.02 per cent to 4.16 per cent. Emission reductions of 7.99 $MtCO_2$ for 2015 and 6.07 $MtCO_2$ for 2016 achieved.	Central Electricity Authority

Name of Mitigation Action	Description	Nature	Coverage (sector)	Coverage (gases)	Objectives of the Action	Quantitative Goal/ Progress indicator	Methodology/ Assumption	Steps taken/ and Results achieved	Relevant National Mission/
Supercritical Power Generation	Enhancement of energy efficiency through Supercritical technology. Only 1 per cent rise in efficiency reduces CO_2 emission by 2-3 per cent.	Economic	Energy efficiency	CO_2	To reduce the emission for each kWh of electricity generated	To improve thermal efficiency and reduce CO2 emissions	Total CO_2 saved = Total electricity generation from supercritical power plants X (emission factor of subcritical power plant – emission factor of supercritical power plant)	It is estimated that approximately 53.708 $MtCO_2$ has been avoided by September 2020 due to commissioning of super-critical coal power plants	National Mission for Enhanced Energy Efficiency (NMEEE)
UJALA	Unnat Jyoti by Affordable LEDs for All	Mitigation	Energy efficiency	CO_2	To promote efficient lighting, reducing energy consumption and energy savings.	Replacement of conventional domestic lights with LED lights across India	The CO_2 emission reduction value per unit has been taken from UJALA dashboard of Ministry of Power, Government of India.	A total of 366.85 million LEDs distributed till November 2020. It has led to a cumulative emission reduction of 178.36 $MtCO_2$ from 2014-15 to November 2020.	National Mission on Enhanced Energy Efficiency
Standards and Labelling (S&L)	Ensuring worst performing products are removed from the market, while labels encourage consumers to purchase increasingly more efficient products.		Energy efficiency	CO_2	Programme covers 26 appliances of which 10 appliances are under the mandatory regime. Labelling for variable capacity air conditioners and LED bulbs was made mandatory in January 2018. A recent inclusion to the list of appliances was the Deep freezer and Light Commercial Air Conditioner (LCAC) under voluntary scheme.	Replacement of conventional appliances and corresponding energy savings	Savings from the different appliances are evaluated by multiplying the sales volumes of the respective star rating with the energy saving potential i.e. Sales Volume x (Baseline energy consumption of the appliance – energy consumption of the star rated appliance sold). Energy saving was calculated considering the sales of the appliance on quarterly basis using standard annual operating hours defined by BEE. Emission reductions	Overall energy savings of 301 billion units from 2007 to 2018, the equivalent avoided generation is approximately 74 GW during this period. The energy saving achieved under the scheme in the year 2018-19 amounts to 55.7 billion units translating to an abatement of 45.67 $MtCO_2e$ emissions.	National Mission on Enhanced Energy Efficiency

Name of Mitigation Action	Description	Nature	Coverage (sector)	Coverage (gases)	Objectives of the Action	Quantitative Goal/ Progress indicator	Methodology/ Assumption	Steps taken/ and Results achieved	Relevant National Mission/
							were estimated using the following formula: Energy saved (MWh) X grid emission factor (tCO_2/MWh)		
SLNP	Deployment of LED street-lights that are approximately 50 per cent more energy efficient than incandescent bulbs and High-Pressure Sodium (HPS) lighting.	Mitigation	Energy efficiency	CO_2	To promote efficient lighting, reducing energy consumption and energy savings	Replacement of conventional street lights in India with Smart LED variants	The CO_2 emission reduction value per unit has been taken from SLNP dashboard of Ministry of Power, Government of India.	Till September 2020 over more than 11.25 million LED streetlights have been installed. The programme has led to a cumulative energy savings of 18,071 MU and emission reduction of 14.82 $MtCO_2$ generated from 2015-16 to 2019-20.	National Mission on Enhanced Energy Efficiency
PAT scheme	A market-based mechanism to facilitate energy efficiency improvements in large energy-intensive industries and facilities, by issuing energy saving certificates that can be traded.	Mitigation	Energy efficiency	CO_2	To reduce specific energy consumption in energy- intensive industries.	An energy savings target of 11.20 Mtoe was given during the second PAT cycle (2016-2019)	In order to calculate the reduction in the total CO_2 emission, Fuel-mix for each PAT sector is considered. Post that following assumptions were taken for calorific values, density of respective fuels and CO_2 conversion factors	Total energy savings of 13.28 Mtoe achieved in PAT cycle –II and total emission reduction of about 61.34 $MtCO_2$.	National Mission on Enhanced Energy Efficiency
Energy Efficient Buildings Programme	Large scale transformation to retrofit commercial buildings in India into energy efficient complexes	Mitigation	Energy efficiency	CO_2	To reduce cost and energy consumption, and significantly contribute to management of peak demand.	Retrofitting of EE appliances in large government/ private buildings	The value of CO_2 emissions saved has been taken from BEEP Dashboard, Ministry of Power, Government of India	Building energy efficiency projects completed in 10,344 buildings including Railway stations and Airports till May 2020. It has led to a cumulative emission reduction of 0.36 $MtCO_2$.	National Mission for Enhanced Energy Efficiency (NMEEE)

Name of Mitigation Action	Description	Nature	Coverage (sector)	Coverage (gases)	Objectives of the Action	Quantitative Goal/ Progress indicator	Methodology/ Assumption	Steps taken/ and Results achieved	Relevant National Mission/
Ujwal DISCOM Assurance Yojana	Ministry of Power, GoI launched Ujwal DISCOM Assurance Yojana (UDAY) which was approved by Union Cabinet on 5 November, 2015. It envisages Financial & Operational Turnaround of Power Distribution Utilities (DISCOMs) of the country.	Economic	Power sector	CO_2	1. Financial Turnaround 2. Operational improvement 3. Reduction in cost of generation of power 4. Development of Renewable Energy 5. Energy efficiency & conservation	Target at the end of UDAY period AT&C loss target - 15 per cent ACS - ARR gap target - zero	The CO_2EF has been obtained from CEA. The total CO_2 saved during 2011-2016 has been estimated using the following formula: Total CO_2 saved = Total electricity generation × T&D loss reduction for current year from previous year × Grid emission factor	The average percentage of inter-state transmission losses occurred during January 2016 to December 2018 is in the range of 2.02 per cent to 4.16 per cent. The reduction in losses have led to an emission reduction of 889 $MtCO_2$ during 2008-2017.	National Mission for Enhanced Energy Efficiency (NMEEE)
Pradhan Mantri Sahaj Bijli Har Ghar Yojana – Saubhagya	Under Saubhagya free electricity connections to all households (both APL and poor families) in rural areas and poor families in urban areas will be provided.	Mitigation	Power Sector	CO_2	Providing last mile connectivity and electricity connections to all un-electrified households in rural areas.	Households electrified	Providing Solar Photovoltaic (SPV) based standalone system for un-electrified households located in remote and inaccessible villages / habitations, where grid extension is not feasible or cost effective.	From October 2017 till November 2019, over 99.93 per cent households electrified	National Mission for Enhanced Energy Efficiency (NMEEE)
National Energy Efficient Fan Programme (NEEFP)	EESL provides BEE 5 Star rated ceiling fans which are 30 per cent more energy efficient as compared to conventional fans.	Mitigation	Energy efficiency	CO_2	To promote efficient use of energy by increasing the use of energy efficient appliances at the residential level.	Replacement of conventional Ceiling Fans with Energy Efficient fans	The CO_2 emission reduction value has been taken from National PAVAN dashboard of Ministry of Power, Government of India.	A total of 2.34 million EE fans have been distributed till November 2020, leading to cumulative emissions reduction between 2016-17 to November 2020 of 0.686 $MtCO_2$.	National Mission for Enhanced Energy Efficiency(NMEEE)
LED Tube light	EESL provides BEE 5 Star rated tube lights which are 50 per cent more energy efficient as compared to	Mitigation	Energy efficiency	CO_2	To promote efficient use of energy by increasing the use of energy efficient appliances at the residential level.	Replacement of Regular tube lights with BEE 5 Star rated tube lights	The CO_2 emission reduction value has been taken from National Tube light dashboard of Ministry of	A total of 7.2 million LED tube lights have been distributed till November 2020, leading to a cumulative emission reduction of 1.035 $MtCO_2$	National Mission for Enhanced Energy Efficiency (NMEEE)

Name of Mitigation Action	Description	Nature	Coverage (sector)	Coverage (gases)	Objectives of the Action	Quantitative Goal/ Progress indicator	Methodology/ Assumption	Steps taken/ and Results achieved	Relevant National Mission/
	conventional 40 W tube lights.						Power, Government of India.	between 2016-17 and November 2020.	
Energy Conservation Building Code 2017	The new code reflects current and futuristic advancements in building technology, market changes, and energy demand scenario of the country, setting the benchmark for Indian buildings to be amongst some of the most efficient globally	Mitigation	Energy efficiency	CO_2	Futuristic advancements in building technology to further reduce building energy consumption and promote low-carbon growth	It will achieve energy savings of about 300 billion Units by 2030	With the adoption of ECBC 2017 for new commercial building construction throughout the country, it is estimated to achieve a 50 per cent reduction in energy use by 2030. This will translate to energy savings of about 300 billion Units by 2030 and peak demand reduction of over 15 GW in a year. This will be equivalent to expenditure savings of INR 350,000 million and 250 $MtCO_2$ reduction. In 2018-19, this led to an emission reduction of 0.033 $MtCO_2$	0.290 $MtCO_2$ emission reduced till August 2020. (National Building Dashboard)	National Mission for Enhanced Energy Efficiency (NMEEE)
Agriculture Demand Side management (AgDSM)	Ag DSM promises immense opportunity in reducing the overall power consumption, improving efficiencies of groundwater extraction and reducing the subsidy burden of the states without sacrificing the service	Mitigation	Energy efficiency	-	To realize energy efficiency through reduction in overall power consumption, improving efficiencies of groundwater extraction, reducing subsidy burden on state utilities.	To promote the usage of energy efficient agricultural pumpsets: Haryana, Punjab, Kerala, Odisha, Karnataka, Maharashtra, Puducherry(UT), Uttarakhand, Himachal Pradesh and Tamil Nadu (above 3 star rated) made mandatory use	Energy Savings: This is calculated by considering the number of pumps installed and considering an overall efficiency factor of 30% to calculate the energy savings per pump. The number of hours the pump is used per day and number of days the pump is operational in a year is assumed to be 6	EESL has installed 74,136 pumps. This has resulted in estimated energy savings of 191 million kWh per year with avoided peak demand of 35 MW, GHG emission reduction of 0.14 $MtCO_2$ per year and estimated annual monetary savings of INR 960 million in consumer electricity bills.	National Mission for Enhanced Energy Efficiency (NMEEE)

Name of Mitigation Action	Description	Nature	Coverage (sector)	Coverage (gases)	Objectives of the Action	Quantitative Goal/ Progress indicator	Methodology/ Assumption	Steps taken/ and Results achieved	Relevant National Mission/
	obligation to this sector.					of star labeled energy efficient pumps sets (EEPS) for new agriculture connections. Conducted nearly 210 number of training and awareness programmes in 72 Krishi Vigyan Kendras (KVKs) resulting in training and capacity building of around 8,000 farmers	hours and 270 days respectively based on ground surveys carried out for AgDSM programme implementation in Andhra Pradesh. CO_2 emission savings: In order to calculate the reduction in total CO_2 emission, conversion factor of CO_2 for electricity is considered (1 MWh = 0.826 tCO_2)		
Energy Efficiency in Small and Medium Enterprises (SMEs) sector	Government of India has been employing several measures aimed at fostering a regime that could remove barriers for accelerated technology up-grades focusing on energy efficiency and innovation	Mitigation	Energy Efficiency in MSMEs	Carbon dioxide (CO_2)	To improve energy efficiency of SME sector in India through accelerating adoption of energy efficient technologies, knowledge sharing, capacity building and development of financial of innovative financial mechanisms.	Overall Goals- Energy Savings Avoided CO_2 emissions Monetary Savings Intermediate Goals No. of clusters/sectors covered No. of technologies/pilot implementations No. of people trained No. of knowledge materials developed	Energy Use and Technology Analysis Capacity building and Outreach awareness Implementation of EE measures Development of Innovative Financing Mechanisms	Total energy saving of 0.022 Mtoe and emission reduction of 0.124 MtCO2 in 2018-19.	Ministry of MSME-Technology Centre System Program Technology and Quality Upgradation Support to Micro and Small Enterprises Scheme (TEQUP) and Credit Linked Capital Subsidy Scheme (CLCSS) schemes of Ministry of Micro Small and Medium Enterprises

Name of Mitigation Action	Description	Nature	Coverage (sector)	Coverage (gases)	Objectives of the Action	Quantitative Goal/ Progress indicator	Methodology/ Assumption	Steps taken/ and Results achieved	Relevant National Mission/
						No. of Energy Audits carried out. Investment made in INR			

Note: Data in the table above is mainly drawn from various dashboards maintained by respective ministries, departments and agencies. These dashboards are in various stages of development thus may have potential uncertainties. Reducing these requires further research and capacity building in various sectors of the economy.

Table 3.41: Agriculture Sector

Name of Mitigation Action	Description	Nature	Coverage (sector)	Coverage (gases)	Objectives of the Action	Quantitative Goal/ Progress indicator	Methodology/ Assumption	Steps taken/ and Results achieved	Relevant National Mission/
System of Rice Intensification	This activity is a part of National Food Security Mission (NFSM) and Bringing Green Revolution to Eastern India (BGREI)	Adaptation with mitigation co-benefits	Agriculture	CH_4	Water conservation, reduction in production costs, reduction in emissions	1. The SRI method of cultivation is being promoted in 313 districts in India. 2. The SRI technique has potential to enhance rice yield ranging from 36-49 per cent with about 22-35 per cent less water than conventional transplanted rice.	Methane emission reductions due to SRI method of cultivation were estimated as reported by Jain et al. (2013). The N_2O emissions were not considered.	Area covered under SRI in 2017-18 and 2018-19 is 85,863 ha. It has led to reduction of 0.0248 $MtCO_2e$ in 2017-18 and 2018-19.	National Food Security Mission (NFSM) and Bringing Green Revolution to Eastern India (BGREI)
Direct Seeded Rice (DSR)	This activity is a part of National Food Security Mission (NFSM) and Bringing Green Revolution to Eastern India (BGREI)	Adaptation with mitigation co-benefits	Agriculture	CH_4	Water conservation, do away with rising of nurseries, puddling and transplanting, reduction in emissions	Area covered under DSR	DSR system reduces methane emissions and moderately enhances the nitrous oxide emissions. We considered both while calculating the emission reductions and the values as reported by Pathak et al. (2012) were used for emission reductions.	Area covered under DSR in 2017-18 and 2018-19 is 99,964 ha. It has led to reduction of 0.099 $MtCO_2e$ in 2017-18 and 2018-19.	National Food Security Mission (NFSM) and Bringing Green Revolution to Eastern India (BGREI)
Crop Diversification Programme	The programme is being implemented in the states of Punjab, Haryana and Uttar Pradesh since 2013-14.	Adaptation with mitigation co-benefits	Agriculture	CH_4	1. To divert the area of water guzzling paddy to alternate crops like pulses, oilseeds, maize, cotton and agroforestry with the objective of tackling the problem of declining soil fertility and depleting water table. 2. To demonstrate and promote improved production technologies of alternate crops for diversion of paddy cultivation.	The extent of area diversified from paddy to alternate crops	The avoided methane emissions due to diversion of paddy to other crops were quantified. Reduction in methane emissions as reported by Jain et al. (2013) were used for quantification of emission reductions.	It has led to an emission reduction of 0.0388 $MtCO_2e$ during 2017-18. Total 81,816 ha of area shifted from paddy to other crops in 2017-18 and 2018-19.	Rashtriya Krishi Vikas Yojana

Name of Mitigation Action	Description	Nature	Coverage (sector)	Coverage (gases)	Objectives of the Action	Quantitative Goal/ Progress indicator	Methodology/ Assumption	Steps taken/ and Results achieved	Relevant National Mission/
					3. To restore soil fertility through cultivation of leguminous crops that generate heavy biomass and consume lesser nutrients.				
Mission for Integrated Development of Horticulture	Centrally sponsored scheme to promote holistic growth of the horticulture sector through an area based regionally differentiated strategies.	Adaptation with mitigation co-benefits	Agriculture	CO_2	Enhancing the production of fruit and vegetables in the country, strengthening nutritional security in the country, providing technology support for high value fruits and vegetables, enhancing water use efficiency and doubling the farm income by growing high value fruits and vegetables.	The area brought under MIDH	Methodological guidance for calculation of emissions and removals of CO_2 by changes in above-ground and below-ground biomass on Land Converted to Forest Land of 2019 IPCC Guidelines for National Greenhouse Gas inventories. The average annual rate of carbon sequestration from literature. The quantity of carbon sequestered: multiplying the area with the annual rates of carbon sequestration. The below ground carbon pool was estimated using the IPCC default factor. Carbon content of the above ground and below ground biomass, same and the soil carbon and the dead wood and litter pools were not considered	It has led to an emission removal of 108.96 $MtCO_2$ in 2017-18.	Ministry of Agriculture
Balanced Ration for Livestock	Optimum feeding of animals through Ration Balancing Programme (RBP)	Adaptation with mitigation co-benefits	Livestock	CH_4	Improving animal productivity as well in reducing both, the cost of production and the emission of greenhouse gases per unit of animal product.	Animals covered under the Ration Balancing Programme	The quantum of methane emission reduction due to balanced ration is to the extent of 13.3 per cent (Garg et al., 2012) (Garg et al., 2013). The global warming potential of methane was taken as 21 (SNC, 2012). Methane emissions remains same irrespective of the location and the season.	It has led to an emission reduction of 0.0615 $MtCO_2e$ during 2017-18.	Ministry of Fisheries, Animal Husbandry and Dairying

Name of Mitigation Action	Description	Nature	Coverage (sector)	Coverage (gases)	Objectives of the Action	Quantitative Goal/ Progress indicator	Methodology/ Assumption	Steps taken/ and Results achieved	Relevant National Mission/
Feeding bypass proteins	Optimizing the use of protein supplement within the ruminant system	Adaptation with mitigation co-benefits	Livestock	CH_4	Enhancing the income to the farmers through increased production	Bypass units established	The quantum in methane reduction was estimated due to feeding bypass proteins. The global warming potential of methane was taken as 21 (SNC, 2012). Assumed as methane emission reduction is same in all the animals due to feeding bypass protein.	It has led to an emission reduction of 0.078 $MtCO_2e$ during 2017-18.	Ministry of Agriculture
Avoiding crop residue burning	Avoiding burning of paddy residues in the field	Adaptation with mitigation co-benefits	Agriculture	CH_4, N_2O	Reduction in emissions and air pollution	Farm equipment for timely sowing during standing paddy residues were made available to the farmers. Farm machinery banks were also established to support crop sowing in standing residues and baling of paddy residues.	Farm equipment for timely sowing during standing paddy residues were made available to the farmers. Farm machinery banks were also established to support crop sowing in standing residues and baling of paddy residues. Sub-Mission on Agricultural Mechanization (SMAM) and central sector scheme on promotion of agricultural mechanization for in-situ management of crops residue was launched to increase the reach of farm mechanization to small and marginal farmers and promoting 'Custom Hiring Centres' to offset the high cost of individual ownership.	During 2018-19 and 2019-20, 55,764 and 56,398 crop residue management machines, including tractor, power tiller was provided to the individual farmers. It has led to an emission reduction of 0.32559 $MtCO_2e$ during 2017-18.	Sub-Mission on Agriculture Mechanization (SMAM)
Agroforestry	Sub-Mission on Agroforestry (SMAF): It is a scheme under National Mission for Sustainable Agriculture (NMSA)	Adaptation with mitigation co-benefits	Agriculture	CO_2	1. To encourage and expand tree plantation in complementary and integrated manner with crops and livestock to improve productivity, employment opportunities, income generation and livelihoods of rural households, especially the small farmers.	Nursery Development for quality planting material (NDQPM), Peripheral and Boundary Plantation (PBP), Low Density Plantation on Farm Lands(LDPFL) and High Density Block Plantation (HDBP) are	Estimation of carbon sequestration in agroforestry system is based on methodological guidance for calculation of emissions and removals of CO_2 by changes in above-ground and below-ground biomass on Land Converted to Forest Land of 2019. Refinement to the 2006 IPCC Guidelines for National	Under SMAF 23 million trees have been planted since inception till 2018-19, covering an area of 52,003 ha. It has led to emission removal of 0.1318 $MtCO_2$ in the period 2017-18 and 2018-19.	Sub-Mission on Agroforestry (SMAF) under National Mission for Sustainable Agriculture (NMSA)

Name of Mitigation Action	Description	Nature	Coverage (sector)	Coverage (gases)	Objectives of the Action	Quantitative Goal/ Progress indicator	Methodology/ Assumption	Steps taken/ and Results achieved	Relevant National Mission/
					2. To ensure availability of quality planting material like seeds, seedlings, clones, hybrids and improved varieties. 3. To popularise various Agroforestry practices/models suitable to different agro-ecological regions and land use conditions. 4. To create database, information and knowledge support in the area of agroforestry.	part of the mission interventions. The implementation of the scheme will result in providing additional income opportunities for farmers, increase in tree cover will lead to higher carbon sequestration and compliment the national initiatives on climate change adaptation and mitigation and trees grown on farm land will help in enriching soil organic matter.	Greenhouse Gas Inventories. The average annual rate of carbon sequestration for various agroforestry systems under different plant densities were obtained from the literature and the quantity of carbon sequestered from these systems was estimated by multiplying the area with the annual rates of carbon sequestration.		
Plantation and value chain development of bamboo	National Bamboo Mission (NBM): It is a scheme under National Mission for Sustainable Agriculture (NMSA)	Adaptation with mitigation co-benefits	Agriculture	CO_2	1. To increase the area under bamboo plantation in non-forest Government and private lands to supplement farm income and contribute towards resilience to climate change as well as availability of quality raw material requirement of industries. The bamboo plantations will be promoted predominantly in farmers' fields, homesteads, community lands, arable wastelands, and along irrigation canals and water bodies. 2. To improve post-harvest management through establishment of innovative	Nursery Development of Quality Planting Material, Promotion of Bamboo Plantation for ensuring adequate stocks of selected genetically superior quality planting material, Promotion of Bamboo Treatment & Preserva tion units and development of value chain in bamboo, Promotion of Product Development / proces sing units, Promotion of Market Development	The bamboo plantations will increase the green cover area, leading to increased carbon sequestration	During 2018-19, an area of 7,366 ha was covered under bamboo plantation along with creation of 42 Bamboo Treatment Units, 184 Product Development / Processing Units, 46 Infrastructure Projects for Promotion and Development of Bamboo Market. It has led to emission removal of 0.1873 $MtCO_2$.	National Bamboo Mission (NBM) under National Mission for Sustainable Agriculture(NMSA)

Name of Mitigation Action	Description	Nature	Coverage (sector)	Coverage (gases)	Objectives of the Action	Quantitative Goal/ Progress indicator	Methodology/ Assumption	Steps taken/ and Results achieved	Relevant National Mission/
					primary processing units near the source of production, primary treatment and seasoning plants, preservation technologies and market infrastructure. 3. To promote product development keeping in view market demand, by assisting R&D, entrepreneurship & business models at micro, small and medium levels and feed bigger industry. 4. To rejuvenate the under developed bamboo industry in India. 5. To promote skill development, capacity building, awareness generation for development of bamboo sector from production to market demand. 6. To realign efforts so as to reduce dependency on import of bamboo and bamboo products by way of improved productivity and suitability of domestic raw material for industry, so as to enhance income of the primary producers.				
Micro-irrigation	Pradhan Mantri Krishi Sinchayee Yojana: It provides end-to-end solutions in	Adaptation with mitigation co-benefits	Agriculture	CO_2	The scheme is meant to expand cultivable area under assured irrigation, improve water use efficiency, enhance	Area covered under drip and sprinkler irrigation	The quantum in savings in energy was estimated. The magnitude of reduction of CO_2 emissions was estimated based on the savings in	It has led to an emission reduction of 11.979 $MtCO_2$ in 2017-18 and 2018-19.	Pradhan Mantri Krishi Sinchayee Yojana-Per Drop More Crop (PMKSY-PDMC)

Name of Mitigation Action	Description	Nature	Coverage (sector)	Coverage (gases)	Objectives of the Action	Quantitative Goal/ Progress indicator	Methodology/ Assumption	Steps taken/ and Results achieved	Relevant National Mission/
	irrigation supply chain and aims to use micro-irrigation technologies extensively to save water, increase production and productivity of crops in a sustainable manner and help in achieving food security.				adoption of precision-irrigation, enhance recharge of aquifers and introduce sustainable water conservation practices.		electricity consumption. The life of the micro-irrigation system is about 10 years.	During 2015-16 to 2019-20, INR 1,19,858.5 million released under PMKSY-PDMC. Area covered under drip and sprinkler irrigation fr om 2015-16 to 2018-19 is 3,620,374 ha under th e Per Drop More Crop co mponent of PMKSY(PM KSY- PDMC).	

Table 3.42: Forestry Sector

Name of Mitigation Action	Description	Nature	Coverage (sector)	Coverage (gases)	Objectives of the Action	Quantitative Goal/ Progress indicator	Methodology/ Assumption	Steps taken/ and Results achieved	Relevant National Mission/
Namami Gange (forestry intervention)	Afforestation and reforestation on identified diverse forest area	Mitigation and Adaptation	Forestry	CO_2	Review and assess the existing situation of Ganga River Basin, past river management and implications and lessons learned. • Identify and involve stakeholders and build consensus for design and development of strategies. • Assess ongoing forestry activities of the states engaged in the Ganga rejuvenation program. • Identify and prioritize critical areas/ field sites in the catchment for regeneration and improvement. • Assess the condition of riparian forests and potential of biological filters. Examine the possibilities of allied and other alternate income generation activities • Assess the potential of cultivation of	Plantation on 8,394,600 ha area	Conservative assessment subject to full implementation of proposed forestry intervention	94,52,412 seedlings planted during 2016-17 to 2018-19. Sink of annual emission removal of 0.076 $MtCO_2$ created. Since the launch of Namami Gange Programme an area of 30,761 ha has been planted or is being planted during the period 2016-20.	Co-benefits of Ganga rejuvenation programme

Name of Mitigation Action	Description	Nature	Coverage (sector)	Coverage (gases)	Objectives of the Action	Quantitative Goal/ Progress indicator	Methodology/ Assumption	Steps taken/ and Results achieved	Relevant National Mission/
					medicinal plants and restoration of 'Bhoj' (Betula utilis) forests and identify appropriate species • Identify research and monitoring needs and develop strategy for future research				
National Green Highways Mission	Avenue plantation on highways	Mitigation and Adaptation	Forestry	CO_2	• Develop a systematic framework for integrated green corridor development • Build resilient ecosystem in form of green corridors along national highway. • Make green highway mission self-sustainable • Develop green corridors with aesthetic appeal • Reduce impact of dust, air and noise pollution. • Provide shade on glaring hot roads. • Reduce soil erosion at embankment slopes • Reduce effect of wind and incoming UV rays	To develop 1,40,000 km long 'tree line' with plantation along both sides of the national highway in five years	1915.53 km length national highway awarded for avenue plantation	19.37 million seedlings were planted from 2016-20 (till November). Sink of annual emission removal of 0.156 $MtCO_2$ created.	National Green Highways Mission
Green Indian Mission	Afforestation and reforestation in degraded forests and non-forests area	Mitigation and Adaptation	Forestry	CO_2	• Increased forest/tree cover on 5 m ha of forest/non-forest lands and improved quality of forest cover on another 5 m ha (a total of 10 m ha) • Ecosystem services including biodiversity, hydrological services and carbon sequestration as a result of treatment of 10 m ha. • Increased forest-based livelihood income for 3 million forest dependent households • Enhanced annual CO_2 sequestration of 50-60 million tonne by the year 2020	10 million ha in 10 years (Annual targets), People's participation, Convergence with existing programs and other missions, REDD plus benefits, New stakeholders, Forest development agency	Incremental annual mitigation potential 2020 is 55 $MtCO_2$ Participatory approach	From 2015-18, 0.12 million ha was planted. Sink of annual emission removals of 1.07 $MtCO_2$ created.	National Action Plan on Climate Change

Name of Mitigation Action	Description	Nature	Coverage (sector)	Coverage (gases)	Objectives of the Action	Quantitative Goal/ Progress indicator	Methodology/ Assumption	Steps taken/ and Results achieved	Relevant National Mission/
Twenty-point Programme	Afforestation on public and forest lands	Mitigation	Forestry	CO_2	Protection of environment and afforestation	Yearly targets are monitored monthly	Yearly targets are fixed by MoEFCC designated as Nodal Ministry	Involvement of MoEFCC and State Forest Departments 4.985 million ha afforested from 2016 to 2019, resulting in sink of annual emission removals of 44.42 $MtCO_2$ created.	
Haritsena Maharashtra Mission	Afforestation to increase forest cover in Maharashtra	Mitigation	Forestry	CO_2	To plant 500 million trees by the end of 2019 In view of National forest policy, emphasizing on maintaining 33 per cent forest cover	To plant 500 million trees by the end of 2019	Participatory approach Yearly targets are mentioned	By the State Government of Maharashtra. 469.76 million seedlings have been planted up to 2018 resulting in sink of annual emission removals of 3.77 $MtCO_2$ being created.	
Telangana Ku Haritha Haram	Afforestation to increase forest cover in Telangana	Mitigation	Forestry	CO_2	In view of National forest policy, emphasizing on maintaining 33 per cent forest cover	To plant and rejuvenate 2,300 million saplings.	To increase green cover of the State from the present 25.16 to 33 per cent of the total geographical area	1127.97 million saplings have been planted up to 2019 resulting in sink of annual emission removals of 9.06 $MtCO_2$ being created by October 2019	
Tripura Forest Environmental Improvement and Poverty Alleviation Project (TFIPAP)	Environmental amelioration through afforestation, soil and water conservation, biodiversity conservation, and poverty alleviation and economic development of	Mitigation and adaptation	Forestry	CO_2	To restore degraded forests and improve the livelihood aspects of villagers, including tribal families engaged in traditional shifting cultivation, and promoting sustainable forest management through JFM, thereby improving environment and alleviating poverty	Plantations; 4,700 ha farm forestry and 5,300 ha agroforestry 8 Years	Participatory approach	By State government and Japan International Cooperation Agency (JICA). 61,754 ha have been afforested and 8,533 planted under agroforestry, resulting in sink of annual emission removals of 0.55 $MtCO_2$ and 0.076 $MtCO_2$, respectively being created.	

Name of Mitigation Action	Description	Nature	Coverage (sector)	Coverage (gases)	Objectives of the Action	Quantitative Goal/ Progress indicator	Methodology/ Assumption	Steps taken/ and Results achieved	Relevant National Mission/
	the forest dwellers								
Protected Areas (PAs)	Conservation of nature	Mitigation and adaptation	Forestry	CO_2	Conservation of nature	Protection of 16.50 million ha forest	Continued protection of PAs	Increase in 0.31 million ha from 2015 to 2019 resulting in sink of annual emission removal of 0.99 $MtCO_2$ being created.	
National Afforestation Programme	Includes afforestation and reforestation of degraded forests and non-forest areas.	Mitigation	Forestry	CO_2	Sustainable development and management of forest resources Increase and /or improve forest and tree cover	Area afforested, biomass growth rate, timber and fuelwood production	Carbon sequestration through forest and tree cover	MoEFCC, GoI approved scheme for afforestation. Since inception a total of INR 38740.2 million has been released till 2018-19 to various States and is being utilized for treatment/afforestation over 2.1 million ha sanctioned area. Seedlings planted in 0.24 million ha from 2013 to 2019 resulting in sink of annual emission removals of 2.14 $MtCO_2$ created.	National Afforestation and Eco- Development Board

Note: Given the highly significant diversity of landscapes and ecosystems across India (as in other regions across the world), and the corresponding diversity of vegetation types and species, lowering the uncertainties of the above estimates is the subject of ongoing knowledge generation and research and the corresponding development of capabilities which require support. These factors need to be accounted for in deriving the import of the quantification provided above. Advances in this respect will be incorporated in future**.**

Table 3.43: Transport Sector

Name of Mitigation Action	Description	Nature	Coverage (sector)	Coverage (gases)	Objectives of the Action	Quantitative Goal/ Progress indicator	Methodology/ Assumption	Steps taken/ envisaged and Results achieved	Relevant National Mission/
Ethanol Blended Petrol Programme	Oil Marketing Companies sell ethanol blended petrol with percentage of ethanol up to 10 per cent. Also, the Government has allowed procurement of ethanol produced from other non-food feedstocks, like cellulosic and ligno-cellulosic materials and including the petrochemical route.	Regulatory	Transport	CO_2	To push biofuels into the mainstream to supplement gasoline and diesel in transportation, as well as in stationary applications	Quantity of ethanol blended in petrol.	The data for gasoline consumption and ethanol blending in India have been taken from MoPNG and subsequent reports of the Government. The net calorific value (NCV) and CO_2 emission factor (CO_2EF) numbers are taken from IPCC. The total emissions saved have been estimated using the quantity of ethanol blended.	1. During the ethanol supply year 2019-20, 1,703 million litres of ethanol was blended in petrol which resulted in foreign exchange impact of about INR 37,350 million and carbon emission reduced to the extent of 3.39 MtCO_2. 2. During current ethanol supply year 2020-2021; contracts for supply of about 2,332 million litres of ethanol have so far been finalized. 3. The supply of BS-VI auto fuels has started throughout the country w.e.f. 1 April 2020. The BS-VI regulation has reduced diesel Sulphur content to a maximum of 10 ppm, enabling the introduction of advanced emission control technologies, including diesel particulate filters (DPF) to reduce PM in diesel vehicles and selective catalyst reduction (SCR) systems for reduction in NOx emissions.	Ministry of Petroleum & Natural Gas
National E-Mobility Programme	EESL procured 10,000 EVs to be deployed in Government Ministries and Departments, Setup charging	Economic	Transport	CO_2	Transport sector GHG emission reduction	Making India's passenger mobility shared, electric, and connected can cut the nation's energy demand by 64 per cent,	An e-car runs 80 kms a day for 26 days in a month. The E-cars are compared with diesel vehicles, that have an average of 15 km/litre. Emission reduction is tail pipe emission reduction.	1. It is estimated that replacing these 5,00,000 cars with EVs over the 3-4 year period will lead to fuel savings of about 832 million litres per year and 2.23 MtCO_2 reduction.	National Electric Mobility Mission Plan

Name of Mitigation Action	Description	Nature	Coverage (sector)	Coverage (gases)	Objectives of the Action	Quantitative Goal/ Progress indicator	Methodology/ Assumption	Steps taken/ envisaged and Results achieved	Relevant National Mission/
	infrastructure to sustain EV transition					and carbon emissions by 37 per cent in 2030.		2. 1514 e-cars deployed/under deployment by EESL. EESL has installed 488 captive chargers (308 AC & 180 DC chargers) across India. This has resulted in estimated annual fuel saving of 2,519 kilo liters and reduction in GHG emission of about 6,754 tonne of CO_2 per year. 3. 91 Public Charging stations commissioned by EESL across India.	

Table 3.44: Year wise Mitigation quantification for some major policies and programmes for 2015 and 2016

Policy	Sectors Affected	GHG	Objective and or Activity Affected	Instrument	Status of Implementation	Brief Description	Start Year of Implementation	Implementing Entity of Entities	Emission Mitigated ($MtCO_2e$)	
									2015	2016
National Solar Mission - 100 GW by 2022	Renewable Energy	CO_2, CH_4, N_2O	To establish India as a global leader in solar energy, by creating the policy conditions for its diffusion across the country as quickly as possible.	Regulatory	Adopted	The Mission has adopted a three-phase approach. The first phase (2010-2013) was designed to focus on capturing the low-hanging options in solar thermal; promoting off-grid systems to serve populations without access to commercial energy and modest capacity addition in grid-based systems. In the second (2013-2017) and third (2017-2022) phases, capacity will be aggressively ramped up to create conditions for scaled-up and competitive solar energy penetration in the country.	2010	National Action Plan on Climate Change, MNRE	5.41	9.48

Policy	Sectors Affected	GHG	Objective and or Activity Affected	Instrument	Status of Implementation	Brief Description	Start Year of Implementation	Implementing Entity of Entities	Emission Mitigated ($MtCO_2e$)	
									2015	2016
National Wind Energy Programme - 60 GW by 2022	Renewable Energy	CO_2, CH_4, N_2O	To catalyze commercialization of grid interactive wind power.	Regulatory	Adopted	The Twelfth Five Year Plan proposed a National Wind Energy Mission.	2010	National Action Plan on Climate Change, MNRE	26.98	35.63
Other Renewables - 15 GW by 2022	Renewable Energy	CO_2, CH_4, N_2O	Small Hydro and Biomass based power	Regulatory	Adopted	MNRE has been vested with the responsibility of developing Small Hydro Power (SHP) projects up to 25 MW station capacities. The estimated potential for power generation in the country from such plants is about 25 GW.	2010	National Action Plan on Climate Change, MNRE	21.02	19.41
T&D Losses reduction	Power Sector	CO_2, CH_4, N_2O	Loss reduction in national grid	Economic	Implemented	By the end of 2013, each of the country's five regional grids was interconnected to operate at a synchronous frequency in an effort to more efficiently transfer power from generation sources to load centers.	2009	Ministry of Power, CEA	8.03	6.07
Supercritical Power Generation	Energy Efficiency	CO_2, CH_4, N_2O	To reduce the emission for each kWh of electricity generated	Economic	Under implementation	Super Critical Technology is the most economical way to enhance efficiency, have used methodology and emission factors from http://cea.nic.in/reports/others/thermal/tpece/cdm_co2/user_guide_ver10.pdf based on ACM0013	2012	Ministry of Power	1.57	1.22
UJALA LED replacements Scheme: 750 million units by 2020	Energy Efficiency	CO_2, CH_4, N_2O	To promote efficient lighting, reducing energy consumption and energy savings.	Economic	Under implementation	UJALA scheme: Overall target of number of LED lights to be replaced in 3 years - 770 million, Expected annual energy savings - 105 bn kWh, Expected reduction of peak load - 20,000 MW, Annual estimated greenhouse gas emission reductions - 79 million tonne of CO_2	2015	National Mission for Enhanced Energy Efficiency, Ministry of Power	6.80	19.35

Policy	Sectors Affected	GHG	Objective and or Activity Affected	Instrument	Status of Implementation	Brief Description	Start Year of Implementation	Implementing Entity of Entities	Emission Mitigated ($MtCO_2e$)	
									2015	2016
Street Lighting National Programme	Energy Efficiency	CO_2, CH_4, N_2O	Reducing Energy consumption in lighting by replacing conventional street lights with LEDs, helping DISCOMs to manage peak demand	Economic	Under implementation	Street Lighting National Programme (SLNP) aims to replace India's 14 million conventional street lights in India with Smart LED variants by 2019.	2015	National Mission for Enhanced Energy Efficiency, Ministry of Power	0.28	0.85
PAT scheme	Energy Efficiency	CO_2, CH_4, N_2O	To reduce specific energy consumption in energy intensive industries.	Economic	Under implementation	A market-based mechanism to facilitate energy efficiency improvements in large energy intensive industries and facilities, by issuing energy saving certificates that can be traded.	2012	National Mission for Enhanced Energy Efficiency	7.77	15.33
Micro-irrigation	Agriculture	CO_2, CH_4, N_2O	National Water Mission under NAPCC	Regulatory	Under implementation	The CO_2 saved from the Drip irrigation system all over India.		Ministry of Agriculture	0.0002	0.0003
Ethanol Blended Petrol Programme	Transport	CO_2	To push biofuels into the mainstream to supplement gasoline and diesel in transportation, as well as in stationary applications	Regulatory	Under implementation	Oil Marketing Companies sell ethanol blended petrol with percentage of ethanol up to 10 per cent. Also, the Government has allowed procurement of ethanol produced from other non-food feedstocks, like cellulosic and ligno cellulosic materials including petrochemical route.	2008	National Policy on Biofuels, MNRE	3.24	3.63
Biodiesel policy	Transport	CO_2	Minimum level of biofuels become readily available in the market to meet the demand at any given time	Regulatory	Under implementation	To help achieve a proposed biodiesel blend of 20 per cent with conventional diesel by 2017.		Ministry of Petroleum and Natural Gas, MNRE	11.57	12.22

Policy	Sectors Affected	GHG	Objective and or Activity Affected	Instrument	Status of Implementation	Brief Description	Start Year of Implementation	Implementing Entity of Entities	Emission Mitigated ($MtCO_2e$)	
									2015	2016
Metro	Transport	CO_2, CH_4, N_2O	Provide Metro railway system in Indian cities	Economic	Under implementation	Metro Railway System and Services operational in 18 Cities in India. These include Kolkata, Delhi, Bengaluru, Gurugram, Mumbai, Chennai, Jaipur, Kochi, Hyderabad, Lucknow, Noida, Greater Noida, Ahmedabad, Nagpur, Ghaziabad, Faridabad, Ballabhgarh and Bahadurgarh.	2002	Ministry of Railways, MoUD, respective state governments	0.78	0.86
BRT	Transport	CO_2, CH_4, N_2O	Provide BRTS is some Indian cities	Economic	Under implementation	BRT is a bus-based public transport system designed to improve capacity and reliability relative to a conventional bus system	2006	MOUD and state government	0.039	0.035
Efficiency gains in Railways	Transport	CO_2, CH_4, N_2O	Fuel consumption reduction	Economic	Under implementation	Fuel consumption and Gross tonne km in passenger and goods trains have been measured		Ministry of Railways	-0.14	0.43
Star rated appliances (AC and Refrigerator)	Energy Efficiency	CO_2, CH_4, N_2O	To provide the consumer an informed choice about the energy saving and thereby the cost saving potential of the marketed household and other equipment.	Economic	Under implementation	The star rating plan is different for products manufactured/imported or assembled in different years. Manufacturers are required to place a label showing how much electricity the appliance will consumer under certain conditions.	2006	Ministry of Power, BEE	10.10	11.15

Endnote: *Reference dates and corresponding figures of mitigation achieved, in this chapter, may vary for different situations and schemes, especially as India's mitigation efforts are rapidly put into action. This is especially true for renewable energy deployment, where progress is particularly rapid.*

References

BEE. (2019). Impact of Energy Efficiency Measures for the Year 2018-19, Overall energy efficiency savings. Bureau of Energy Efficiency, Ministry of Power, Government of India. Retrieved from https://beeindia.gov.in/sites/default/files/BEE%20Final%20Report_1.pdf

BEE. (2020). Communication received from Bureau of Energy Efficiency on Star Rating for existing commercial buildings, Eco Niwas Samhita (for residential buildings), ECBC energy savings, National Programme on Energy Efficiency and Technology Upgradation in MSMEs and Energy savings and emission reduction in 2018-19 MSMEs, dated 21 September 2020.

CAIT database. (2020). Historical emissions, CAIT climate data explorer. Retrieved from http://cait.wri.org/

CAT. (2020). Country analysis. Climate Action Tracker. Retrieved from https://climateactiontracker.org/countries/india/

CEA. (2020). Monthly Renewable Energy Generation Report. Central Electricity Authority, Ministry of Power, Government of India. Retrieved from https://cea.nic.in/renewable-generation-report/?lang=en

CEA. (2020a). Review of Progress of Thermal Power Projects under execution in the country. Central Electricity Authority, Ministry of Power, Government of India. Retrieved from https://www.cea.nic.in/reports/quarterly/tpmii_quarterly_review/2020/tpmii_qr-06.pdf

CEA. (2020b). Review of Progress of Thermal Power Projects under execution in the country, April to June 2020. Central Electricity Authority, Ministry of Power, Government of India. Retrieved from https://cea.nic.in/wp-content/uploads/thermal_project/2020/10/tpmii_qr-06.pdf

CEA. (2020c). All India Installed Capacity (in MW) of Power Stations, Central Electricity Authority, Ministry of Power, Government of India. Retrieved from http://www.cea.nic.in/reports/monthly/installedcapacity/2020/installed_capacity-10.pdf

CEA. (2020d). Monthly overview reports. Central Electricity Authority, Ministry of Power, Government of India. Retrieved from http://cea.nic.in/reports/monthly/renewable/2020/overview-06.pdf

CEA. (2020e). Monthly reports of all India installed capacity and executive summary. Central Electricity Authority, Ministry of Power, Government of India. Retrieved from http://cea.nic.in/monthlyarchive.html

CEA. (2020f). National Electricity Plan, Central Electricity Authority, Ministry of Power, Government of India. Retrieved from https://policy.asiapacificenergy.org/sites/default/files/National%20Electricity%20Plan%20%28Volume%20I%29%20Generation.pdf

CPCB. (2018). Life Cycle Assessment (LCA) of plastics packaging products. Central Pollution Control Board, Ministry of Environment, Forest and Climate Change, Government of India. Retrieved from https://cpcb.nic.in/uploads/plasticwaste/LCA_Report_15.05.2018.pdf

CRIDA. (2020). Communication received from Central Research Institute for Dryland Agriculture, Hyderabad on Sub-Mission on Agro-Forestry (SMAF), National Bamboo Mission (NBM), Area covered under System of Rice Intensification (SRI), Neem-coated Urea production, dated 05 September 2020.

CRIDA. (2020a). Agricultural Sector-Mitigation and Gaps & Constraints. Report of study under NATCOM project. Central Research Institute for Dryland Agriculture, Hyderabad.

CSE. (2020). Plastic waste is India's and the world's most formidable environmental challenge today, and the COVID-19 pandemic has made matters worse. Centre for Science and Environment, New Delhi. Retrieved from https://www.cseindia.org/plastic-waste-is-india-s-and-the-world-s-most-formidable-environmental-challenge-10375

CRRI. (2020). Communication from Central Road Research Institute on Guidelines for green rating of highways, dated 31 July 2020.

DAC&FW. (2020). Communication from Department of Agriculture, Co-operation and Farmers Welfare on Pradhan Mantri Krishi Sinchayee Yojana- Per Drop More Crop (PMKSY- PDMC), Area brought under the Integrated Farming System (IFS) approach, Convergence of PMKSY and PM-KUSUM demo by KVK and National Commission on Plasticulture Applications in Horticulture (NCPAH), Area under micro-irrigation, Area Diversified (in ha) from Paddy to Other Crops, Direct Seeded Rice (DSR) cultivation, System of Rice Intensification (SRI), Avoiding Crop Residue Burning, Agricultural mechanisation, Production on Neem-coated Urea, Area under Mission for Integrated Development of Horticulture (MIDH), Area planted under bamboo in National Bamboo Mission (NBM), Area Covered with Directly Seeded Rice Cultivation and Area covered (ha) with SRI system of cultivation, dated 16 November 2020.

DAE. (2019). Utilisation of Nuclear Energy. Department of Atomic Energy. Lok Sabha Unstarred Question No. 535. Retrieved from http://www.dae.gov.in/writereaddata/lsusq535(1).pdf

DAE. (2020). Nuclear Power in India. Department of Atomic Energy. Retrieved from http://www.dae.gov.in/node/129

DEA. (2020). Sustainable Development and Climate Change, Economic Survey 2019-20, Volume II, Department of Economic Affairs, Ministry of Finance, Government of India. Retrieved from https://www.indiabudget.gov.in/economicsurvey/doc/vol2chapter/echap06_vol2.pdf

DoAH&D. (2020). Communication from Department of Animal Husbandry and Dairying, Government of India.

DST. (2020). Monthly Summary to the Cabinet for the month of July 2020, Department of Science and Technology, Government of India. Retrieved from https://dst.gov.in/sites/default/files/Monthly%20Summary%20July%2C%202020.pdf

EESL. (2020). Communication from Ministry of Power on Installation of LED lights under AJAY Phase I and Phase II.

EESL. (2020a). Completed building energy efficiency projects. Energy Efficiency Services Limited, New Delhi. Retrieved from https://www.eeslindia.org/img/news_m/EESL-successfully-completes-a-decade-of-helping-India-become-energy-efficient.pdf

EESL. (2020b). Electric vehicles and EV charging infrastructure. Retrieved from https://www.eeslindia.org/evandevci.html

ELDI. (2020). Economics of Land Degradation Initiative (ELDI) estimation of crop production per year, addressing food crisis, Economics of Land Degradation Initiative. Retrieved from https://www.eld-initiative.org/

Garg M. R., Kannan A, Phondba B. T., Shelke S. K. and Sherasia P. L. (2012). A study on the effect of ration balancing for improving milk production and reducing methane emission in lactating buffaloes under field conditions. Indian Journal of Dairy Science 65(3): 250-255.

Garg M. R., Sherasia P. L., Phondba B. T., Shelke S. K. and Patel C. T. (2013). Effect of Feeding Balanced Ration on Milk Production, Enteric Methane Emission and Metabolic Profile in Crossbred Cows under Field Conditions. Indian Journal of Dairy Science, 66(2): 113-119

Global Cement. (2019). Industries which have initiated the process of setting up CCS facilities. Retrieved from https://www.globalcement.com/news/item/9887-dalmia-cement-takes-steps-towards-carbon-capture

GoM. (2020a). Forest Department, Maharashtra. Government of Maharashtra. Retrieved from https://greenarmy.mahaforest.gov.in/index?option=thrthreecrorereport&lang=Mar

GoM. (2020b). 13 Crore Plantation Achievements Revenue Division/District wise (in Lakhs). Maharashtra Forest Department. Government of Maharashtra. Retrieved from https://mahaforest.gov.in/fckimagefile/Year%202018-%2013%20cr%20Plantation%20Achievements%20Revenue%20Division,District%20wise%20(in%20Lakhs)%20[Compatibility%20Mode](1).pdf

GoT. (2019). Telanganaku Haritha Haram. Government of Telangana. Retrieved from http://harithaharam.telangana.gov.in/Pages/Achivements.aspx

Gupta, S., D. A. Tirpak, N. Burger, J. Gupta, N. Höhne, A. I. Boncheva, G. M. Kanoan, C. Kolstad, J. A. Kruger, A. Michaelowa, S. Murase, J. Pershing, T. Saijo, A. Sari, 2007: Policies, Instruments and Co-operative Arrangements. In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [B. Metz, O.R. Davidson, P. R. Bosch, R. Dave, L. A. Meyer (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Gütschow, J., Jeffery, L., Gieseke, R., & Günther, A. (2019a). The PRIMAP-hist national historical emissions time series (1850-2017). Retrieved from https://doi.org/10.5880/PIK.2019.018

Gütschow, J., Jeffery, L., & Gieseke, R. G. (2019b). The PRIMAP-hist national historical emissions time series (1850-2017). Retrieved from https://doi.org/10.5880/pik.2019.018

IBEF. (2020). Indian Auto Components Industry Analysis. Indian Brand Equity Foundation. Retrieved from https://www.ibef.org/archives/industry/auto-components-reports/indian-auto-components-industry-analysis-march-2020

ICCT. (2016). Policy update on India Bharat Stage VI emission standards. International Council on Clean Transportation. Retrieved from https://theicct.org/sites/default/files/publications/India%20BS%20VI%20Policy%20Update%20vF.pdf

ICFRE. (2020). Communication from Indian Council of Forestry Research and Education on Mitigation actions, constraints, gaps and related financial, technical and capacity needs to address climate change concerns in forest sector in India, Total forest carbon stocks, Compensatory afforestation fund management and planning authority, Area covered under plantation and planted seedlings in public and forest lands under Twenty-point programme, Area planted under National mission for clean ganga, Bonn challenge and India and Income opportunities for rural communities, dated March 2020 and 3 September 2020.

IEA. (2018). Data and statistics. International Energy Agency. Retrieved from: https://www.iea.org/data-and-statistics/data-tables?country=WORLD

IEA. (2019a). Mass-transit and urban transport projects. International Energy Agency.

IEA. (2019b). Track length in terms of the total passenger Kilometer. Future of Rails Report. International Energy Agency.

IEA. (2020). FAME subsidy scheme, Global EV Outlook. International Energy Agency. Retrieved from https://webstore.iea.org/download/direct/3007

IEA. (2020a). Supercritical technology. Energy Policy Review. International Energy Agency and NITI Aayog.

IEA. (2020b). Efficiency improvements due to supercritical technology. Energy Policy Review. International Energy Agency and NITI Aayog.

IISc. (2020). Communication received from Indian Institute of Science on Mahatma Gandhi National Rural Employment Guarantee Act, dated 20 October 2020.

Indian Railways. (2019). Total route length, Indian Railways Year Book 2018-19. Indian Railways, Ministry of Railways. Retrieved from https://www.indianrailways.gov.in/railwayboard/uploads/directorate/stat_econ/Year_Book/Year%20Book%202018-19-English.pdf

IUCN. (2018). Bonn Challenge and India: Progress on Restoration Efforts across States and Landscapes. The International Union for Conservation of Nature Ministry of Environment, Forest and Climate Change, Government of India. Retrieved from https://portals.iucn.org/library/node/47751

Jain, N., Dubey, R., Dubey, D. S., Singh, J., Khanna, M., Pathak, H., Bhatia, A. (2013). Mitigation of greenhouse gas emission with system of rice intensification in the Indo-Gangetic Plains; Paddy and Water Environment 12 (3), 355-363.

Le Quéré and Corinne, R. B. G. (2020). Temporary reduction in daily global CO_2 emissions during the COVID-19 forced confinement. *Nature*, 647.

Mercom. (2020). SECI's 2 GW Solar Auction Gets India a New Record-Low Tariff of ₹2.36/kWh. Mercom India. Retrieved from https://mercomindia.com/seci-solar-auction-india-record-low/

MNRE. (2018). Annual Report 2018-19. Ministry of New and Renewable Energy, Government of India, Retrieved from https://mnre.gov.in/knowledge-center/publication

MNRE. (2020). Communication received from Ministry of New and Renewable Energy on PM-KUSUM scheme, Solar parks, Electric power installed capacity target from non-fossil fuel-based energy resources and RPO trajectory for solar and non-solar, e-mail dated 16 August 2020, 28 December 2020.

MNRE. (2020a). Lok Sabha Unstarred question no -1975, waste to energy plants. Retrieved from http://loksabhaph.nic.in/Questions/QResult15.aspx?qref=18302&lsno=17

MNRE. (2020b). Guidelines for Tariff Based Competitive Bidding Process for Procurement of Round-The Clock Power from Grid Connected Renewable Energy Power Projects, complemented with Power from Coal Based Thermal Power Projects. Retrieved from https://mnre.gov.in/img/documents/uploads/file_f-1595577684752.pdf

MNRE. (2020c). Physical Progress and Achievements. mnre.gov.in. Retrieved from https://mnre.gov.in/the-ministry/physical-progress

MNRE. (2020d). Solar, Grid-connected capacity growth (2010-2020). Retrieved from https://mnre.gov.in/solar/solar-ongrid#:~:text=A%20target%20of%20installing%20100,by%202022%20has%20been%20kept.&text=Recently%2C%20India%20has%20achieved%205,28.18%20GW%20in%20March%202019.

MoAFW. (2018). Agriculture and allied sectors contribution to GVA, Agriculture Statistics at a glance 2018. Ministry of Agriculture & Farmers' Welfare, Government of India. Retrieved from http://agricoop.gov.in/sites/default/files/agristatglance2018.pdf

MoCA. (2020). Communication received from Ministry of Civil Aviation on Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), e-mail dated 02 December 2020.

MoC. (2020). Communication received from Ministry of Coal on Coal Gasification and Initiatives by PSUs to improve green cover, e-mail dated 20 November 2020.

MoEF. (n.d.). National Mission for Green India (Under the National Action Plan on Climate Change). Ministry of Environment and Forests, Government of India, pp. 37.

MoEFCC. (2019). Green India Mission. Lok Sabha Unstarred Question No. 1106, Ministry of Environment, Forest and Climate Change. Retrieved from http://164.100.24.220/loksabhaquestions/annex/17/AU1106.pdf

MoEFCC. (2019a). Demands for grants (2018-2019), Ministry of Environment, Forest and Climate Change, Rajya Sabha. Retrieved from http://164.100.47.5/committee_web/ReportFile/19/103/313_2018_6_17.pdf

MoEFCC. (2020). Diversion of Forest Land Before and After the Forest Conservation Act. EnviStats. Retrieved from https://parivesh.nic.in

MoEFCC. (2020a). Annual Report 2018-19. Ministry of Environment Forest and Climate Change, Government of India.

MoHUA. (2012). Report of the Committee set up to frame National Sustainable Habitat Standards for the Urban Water Supply and Sewerage sector. Ministry of Housing and Urban Affairs. Retrieved from http://mohua.gov.in/upload/uploadfiles/files/uwss.pdf

MoHUA. (2020). 1 year of transforming urban landscape, Ministry of Housing and Urban Affairs, Government of India. Retrieved from http://mohua.gov.in/upload/5c987f9e0fcecUTBook25March20191compressedcompressedcompressedmin11.pdf

MoHUA. (2020a). Communication received from Ministry of Housing and Urban Affairs on AMRUT mission progress, Metro Rail and Swachh Bharat Mission, e-mail dated 1 December, 2020.

MoJS. (2016). Country Paper India. Sacosan VI, Ministry of Jal Shakti. Government of India. Retrieved from https://jalshakti-ddws.gov.in/sites/default/files/india%20country%20paper.pdf

MoMSME. (2020). Developments under ZED. Ministry of Micro, Small & Medium Enterprises, Government of India. Retrieved from https://zed.org.in/

MoP. (2018). Long term growth trajectory of RPOs for solar and non-solar for a period of three years. Retrieved from https://powermin.nic.in/sites/default/files/webform/notices/RPO_trajectory_2019-22_Order_dated_14_June_2018.pdf

MoP. (2019). Electrification of villages, Lok Sabha, Unstarred Question No. 2869, Ministry of Power, Government of India. Retrieved from http://164.100.24.220/loksabhaquestions/annex/172/AU2869.pdf

MoP. (2020). Deen Dayal Upadhyaya Gram Jyoti Yojana, Lok Sabha, Unstarred Question No. 753, Ministry of Power, Government of India. Retrieved from http://164.100.24.220/loksabhaquestions/annex/173/AU753.pdf

MoP. (2020a). Communication received from Ministry of Power on Biomass co-firing at NTPC Dadri, Ultra super critical plants, Standards and labelling scheme, Programme on Energy from Urban, Industrial and Agricultural Wastes/Residues, Street Lighting National Programme, Building Energy Efficiency Programme (BEEP) - retrofitting project, PAT cycles, Promoting Market Transformation for Energy Efficiency in MSMEs, Energy Efficiency Financing Platform (EEFP), Framework for Energy Efficient Economic Development (FEEED), Agriculture Demand Side Management (AgDSM), Municipal Demand Side Management (MuDSM), Capacity building of DISCOMs, Activities & Achievements from FY 2017-2020 under DSM Programme, Fuel efficiency standard and Fuel economy norms for light and commercial vehicles, e-mail dated 11 June 2020 and 21 September 2020.

MoPNG. (2019). Use of Alternative Fuel, Lok Sabha Unstarred Question No. 2271, Ministry of Petroleum and Natural Gas answered on dated 02 December 2019. Retrieved from http://164.100.24.220/loksabhaquestions/annex/172/AU2271.pdf

MoR. (2020). Dedicated Freight Corridor Corporation of India Limited, Ministry of Railway. Retrieved from https://dfccil.com/Home/DynemicPages?MenuId=3#:~:text=DFCC%20was%20incorporated%20as%20a,1956%20on%2030th%20October%202006.

MoRTH. (2016). The Gazette of India. Notification No/GSRE 187 dated 22 February 2016 regarding Mass Emission Norms for BS VI, Ministry of Road Transport and Highways, Government of India.

MoRTH. (2018). Green Initiatives during 2018-19, Ministry of Road Transport and Highways, Government of India. Retrieved from https://morth.nic.in/green-initiatives

MoRTH. (2019). National Highways Corridor Project. Ministry of Road Transport and Highways, Government of India. Retrieved from https://morth.gov.in/sites/default/files/ilovepdf_merged%20(5).pdf

MoRTH. (2020). National Green Highways Missions. Ministry of Road Transport and Highways, Government of India, Office Memorandum dated 11 November, 2020

MoRTH. (2020a). Communication received Ministry of Road Transport and Highways on Harit Path Mobile Application, dated 19 November 2020.

MoS. (2019). Indian freight usage, Sagarmala. Ministry of Shipping. Government of India. Retrieved from http://sagarmala.gov.in/about-sagarmala/background

MoS. (2020). Communication received from Ministry of Shipping on Renewable power activities in major ports, Green port project, Costal Shipping and ease of doing business initiatives, e-mail dated 20 November, 2020.

MoSPI. (2018). Statistical Year Book India 2018. Ministry of Statistics & Programme Implementation, Government of India.

MoSPI. (2019). Statistical Year Book India 2019. Ministry of Statistics & Programme Implementation, Government of India.

MoSPI. (2020). Communication received from Ministry of Statistics and Programme Implementation on Area covered under plantation and planted seedlings in public and forest lands from period 2016-18 under a twenty-point programme and Sagarmala – Port led Prosperity, e-mail dated 21 October 2020.

MoSPI. (2020a). Nuclear power installed generation capacity from 2009-2019, Energy Statistics 2020, National Statistical Office, Ministry of Statistics and Programme Implementation, Government of India.

MoSPI. (2020b). Envistats India, 2020, Volume I, National Statistical Office, Ministry of Statistics and Programme Implementation, Government of India

MoST. (2018). Climate vulnerability assessment for the Indian Himalayan region using a common framework. Department of Science and Technology, Ministry of Science and Technology, Government of India. Retrieved from https://dst.gov.in/sites/default/files/IHCAP_Climate%20Vulnerability%20Assessment_30Nov2018_Final_aw.pdf

MoTA. (2019). Market Linked Tribal Entrepreneurship Development Program, Ministry of Tribal Affairs, Government of India. Retrieved from http://164.100.117.97/WriteReadData/userfiles/TRIFED%20Final.pdf

Myllyvirta, L. & Dahiya, S. (2020). Analysis: India's CO_2 emissions fall for first time in four decades amid coronavirus, Carbon Brief. Retrieved from https://www.carbonbrief.org/analysis-indias-co2-emissions-fall-for-first-time-in-four-decades-amid-coronavirus

NHAI. (2020). Communication received from National Highways Authority of india (NHAI). Trees plated under National Green Highways Mission. e-mail dated 21 December 2020

NITI Aayog. (2015). A Report on Energy Efficiency and Energy Mix in the Indian Energy System (2030) Using India Energy Security Scenarios, 2047. NITI Aayog, Government of India. Retrieved from https://niti.gov.in/sites/default/files/energy/Energy-Efficiency-and-Energy-Mis-in-the-India-Energy-System-by-2030.pdf

NWM. (2020). National Water Mission Dashboard, State Specific Action Plan (SSAP) on Water Sector, National Water Mission. Retrieved from http://nwm.gov.in/?q=nwm-dashboard

OGD Platform India. (2020). Details of Funds Released and Afforestation Area Sanctioned under National Afforestation Programme, Ministry of Environment, Forest and Climate, Retrieved from https://data.gov.in/search/site?query=National+Afforestation+Programme

Parikh, K. (2014). Report of the Expert Committee on Low Carbon Strategies for Inclusive Growth, Niti Aayog Report. Retrieved from https://niti.gov.in/planningcommission.gov.in/docs/reports/genrep/rep_carbon2005.pdf

Pathak H., Sankhyan S., Dubey D. S., Bhatia, A. and Jain, N. (2012). Dry direct seeding of rice for mitigating greenhouse gas emissions: Field experimentation and simulation. Paddy Water Environment. DOI 10.1007/s10333-012-0352-0.

PIB. (2018). Year End Review 2018 – Ministry of New and Renewable Energy. Government of India. Retrieved from https://pib.gov.in/Pressreleaseshare.aspx?PRID=1555373

PIB. (2019). Kisan Urja Suraksha evam Utthaan Mahabhiyan. Press Information Bureau, Release ID: 1535274. Retrieved from https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1565274

PIB. (2019a). Promotion of Electric Vehicles, Ministry of Heavy Industries & Public Enterprises, Press Information Bureau, Release ID: 1595740. Retrieved from https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1595740

PIB. (2019b). National Mission on Transformative Mobility and Battery Storage approved by Cabinet. Press Information Bureau, Release ID: 1567807. Retrieved from https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1567807

PIB. (2020). Eleven Renewable Energy Management Centers (REMCs). Press Information Bureau. Retrieved from https://pib.gov.in/PressReleasePage.aspx?PRID=1604689

PIB. (2020a). Burning of Agricultural Residues Still a Major Concern Despite Reduction in Recorded Burning Events, Press Information Bureau. Retrieved from https://pib.gov.in/PressReleseDetail.aspx?PRID=1601249

PIB. (2020b). PM-KUSUM scheme 70 per cent government subsidy offered for installing solar pumps. Press Information Bureau. Retrieved from https://pib.gov.in/PressReleasePage.aspx?PRID=1639414

PIB. (2020c). India among few Countries globally to see considerable increase in forest and tree cover to 24.56 % of geographical area, Ministry of Finance. Press Information Bureau. Retrieved from https://pib.gov.in/PressReleseDetail.aspx?PRID=1601249

PIB. (2020d). Harit Path Application by National Highway Authority of India, Press Information Bureau. Retrieved from https://pib.gov.in/PressReleasePage.aspx?PRID=1647625

PIB. (2020e). Nuclear Power Plants. Press Information Bureau. Retrieved from https://pib.gov.in/PressReleseDetail.aspx?PRID=1605939

PIB. (2020f). India aims to achieve 100 MT coal gasification target by 2030: Pralhad Joshi. Press Information Bureau. Retrieved from https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1650096

PIB. (2020h). Year End Review of Ministry of Tribal Affairs. Press Information Bureau. Retrieved from https://pib.gov.in/PressReleasePage.aspx?PRID=1598001

PIB. (2020i). PM's address on 8th Convocation Ceremony of Pandit Deendayal Petroleum University, Press Information Bureau, Release ID: 1674707. Retrieved from https://pib.gov.in/PressReleseDetail.aspx?PRID=1674707

PIB. (2020j). Progress in the Sales of Electric/Hybrid Vehicles, Ministry of Heavy Industries & Public Enterprises, Press Information Bureau, Release ID: 1602607. Retrieved from https://pib.gov.in/PressReleseDetailm.aspx?PRID=1602607

PIB. (2020k). Financing for Compressed Bio-Gas plants to be brought under Priority Sector Lending. Press Information Bureau, Release ID: 1633560. Retrieved from https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1633560

PIB. (2020l). Prime Minister to inaugurate REINVEST- 2020 on 26 November 2020. Press Information Bureau, Release ID: 1633560. Retrieved from https://pib.gov.in/PressReleasePage.aspx?PRID=1674019

POSOCO. (2020). Power System Operation Corporation. recregistryindia.nic.in. Retrieved from REC Registry: https://www.recregistryindia.nic.in/index.php/publics/recs

PPAC. (2020). LPG Profile, Data on LPG Marketing, Petroleum Planning & Analysis Cell, Ministry of Petroleum & Natural Gas, Government of India. Retrieved from https://www.ppac.gov.in/WriteReadData/Reports/201911220459272617502WebVersionLPGProfile1.10.2019.pdf

PPAC. (2020a). High Thermal Efficiency PNG Stove. Petroleum Planning & Analysis Cell, Ministry of Petroleum & Natural Gas, Government of India. Retrieved from http://www.pcra.org/pcra_adm/writereaddata/upload/files/PNG%20pamphlet.pdf

REC. (2020). Pradhan Mantri Sahaj Bijli Har Ghar Yojana - Saubhagya Dashboard. Rural Electrification Corporation. Retrieved from https://saubhagya.gov.in/

Rogelj, J., Forster, P.M., Kriegler, E., Smith, C., Séférian, R. (2019). Estimating and tracking the remaining carbon budget for stringent climate targets. Nature 571, 335–342. https://doi.org/10.1038/s41586-019-1368-z; supplementary information available at https://static-content.springer.com/esm/art%3A10.1038%2Fs41586-019-1368-z/MediaObjects/41586_2019_1368_MOESM1_ESM.pdf

SBI. (2020). Compilation and Synthesis of the Fourth Biennial Report of Parties included in Annex I to the Convention, Retrieved from https://unfccc.int/documents/266353

SNC. (2012). India's Second National Communication (SNC) to the United Nations Framework Convention on Climate Change (2012). Ministry of Environments and Forests, Government of India.

TERI. (2018). Energy demand in transport sector, Teri energy & environment data diary and yearbook. The Energy and Resources Institute, New Delhi.

TERI. (2019). Faster Adoption of Electric Vehicles in India: Perspective of Consumers and Industry. The Energy and Resources Institute, New Delhi. Retrieved from https://www.teriin.org/sites/default/files/2019-11/Faster%20adoption%20of%20electric%20vehicles%20in%20India.pdf

Tongia R. S. A. (2020). Future of Coal in India: Smooth Transition or Bumpy Road Ahead? Brookings India, Notion Press, Singapore.

UDAY. (2020). UDAY Dashboard, Ministry of Power, Government of India. Retrieved from https://www.uday.gov.in/acs_arr_india.php

UNCRD. (2018). A 21st Century Vision on Waste to Energy in India: A Win Win Strategy for Energy Security and Swachh Bharat Mission (Clean India Mission). Ministry of Housing and Urban Affairs (MoHUA), United Nations Centre for Regional Development, Government of India and Ministry of the Environment, Government of Japan.

UNEP DTU. (2020). Initiative for Climate Action Transparency, United Nations Environment Programme Technical University of Denmark. Retrieved from https://unepdtu.org/new-project-responds-to-need-for-adaptation-transparency/

UNFCCC. (2016). India's Nationally Determined Contribution: Working towards Climate Justice, United Nations Framework Convention on Climate Change. Retrieved from https://www4.unfccc.int/sites/ndcstaging/pages/Party.aspx?party=IND

Uphoff, Norman. (2011). The System of Rice Intensification (SRI) as a System of Agricultural Innovation. Jurnal Ilmu Tanah dan Lingkungan. DOI: 10. 10.29244/jitl.10.1.1-6.

Verma, M., Negandhi, D., Wahal, A. K. & Kumar, R. (2014). Revision of rates of NPV applicable for different class/category of forests. Centre for Ecological Services Management, Indian Institute of Forest Management, Bhopal and Forest Survey of India, Dehradun. Retrieved from http://forestsclearance.nic.in/writereaddata/public_display/circulars/01_IIFM_NPV_07NOV.pdf

World Bank. (2020). Green National Highway Corridors Project. The World Bank and Ministry of Road Transport and Highways, Government of India. Retrieved from https://projects.worldbank.org/en/projects-operations/project-detail/P167350

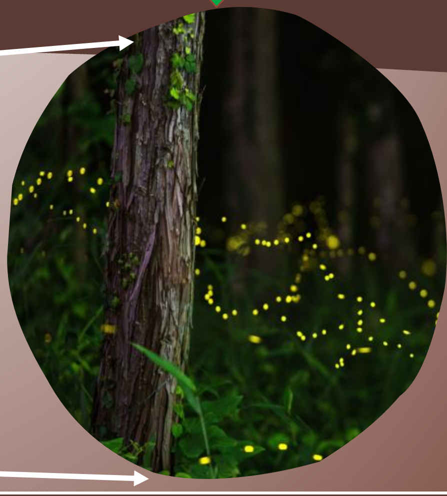
*****

w

Increase in forest and tree cover between 2015 and 2019 is greater than the combined area of these states

15% of our total Carbon dioxide emissions were removed from the atmosphere by our forest and tree cover in 2016

40% increase in carbon sequestration between 2000 and 2016



Forests are not dustbins of carbon!

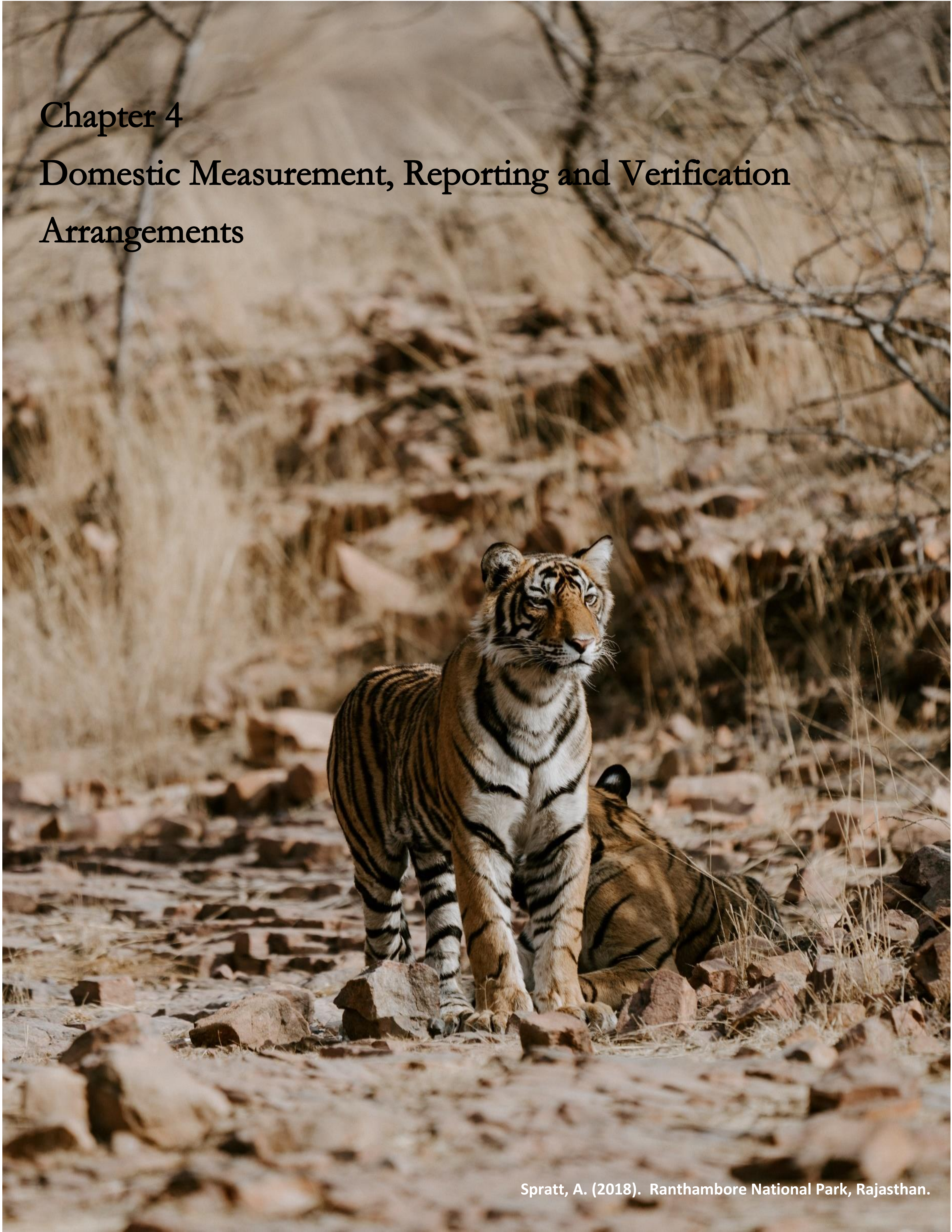
India's forests provide all the four types of ecosystem services: provisioning, regulating, supporting and cultural.

India's forests- teeming with wildlife.

Populations of Asiatic lion, elephant, rhino and tiger increased many fold.

Nearly 75% of the global wild tiger population found in India.

Chapter 4
Domestic Measurement, Reporting and Verification Arrangements



Spratt, A. (2018). Ranthambore National Park, Rajasthan.

Key Points

Chapter 4 Domestic Measurement, Reporting and Verification

- The operational design of measurement, reporting and verification in India is implemented in a decentralized manner, with efforts distributed at multiple levels of governance.
- The governance framework in the country mainly adopts a 3-tier system for administering and monitoring policy schemes and actions as the flow of information involves a bottom-up approach with several tiers of standard reporting.
- Enhancing transparency and accountability by making information accessible through online web-portals/ digital dashboards has led to effective tracking of schemes' performances, on a single platform. Government of India (GoI) has developed numerous dashboards in relevant sectors such as power, transport, agriculture, and forestry.
- India is evolving a robust and dynamic framework for MRV that can deliver, as is evident from the progressive character of its reporting to the UNFCCC, and as indeed the entire world needs to do to keep track of all efforts to meet the challenge of global warming.
- Further intensification of MRV under the Paris Agreement can potentially draw attention away from actual climate action efforts unless there is finance, technology transfer and capacity building support for the preparation of Biennial Transparency Reports by developing countries.
- MRV as a tool to promote good practices, learning, and increasing effort and ambition in mitigation will function only if developed countries go beyond their rhetorical insistence on MRV to its effective use for the stated purposes. Their pre-2020 mitigation performance indicates that as much learning on MRV awaits developed countries as it does the developing nations.

Chapter 4

Domestic Measurement Reporting and Verification

4.1 Introduction

The basic role of measurement, reporting, and verification (MRV) in climate change is to track national GHG emissions, monitor support, and understand the nature and impact of climate actions, in the context of national circumstances (UNFCCC, 2014). A well-designed MRV system must help in identifying good practices and put in place a learning process. It should recognise and create visibility of mitigation actions, thereby encouraging all countries to raise their ambition, in keeping with the UNFCCC principles of equity and common but differentiated responsibilities and respective capabilities.

MRV processes are beneficial however only in the context of the substantive content of the climate action being undertaken and the extent of their ambition. If the overall outcomes as revealed by the inventory process are not significant, the achievement of individual actions' previously set goals are not by themselves of value. The visibility of these actions may also lead to a misplaced emphasis on noting the number of such efforts rather than their quality. MRV processes are also, as in the case of the inventory, financially onerous, require considerable expenditure of human, technical and financial resources and a high degree of technical capacity. Moreover, as in the case of the inventory, the informal sector poses a particular challenge with its dispersed and complex variations, even for a particular class of activity.

The operational design of MRV in India is implemented in a decentralised manner, with efforts distributed at multiple levels of governance. The country's governance framework adopts a 3-tier system for administering and monitoring policy schemes and actions, with the flow of information based on a bottom-up approach from local to sub-national to national of standard reporting; while maintaining archives. The core elements of India’s MRV framework consist of efforts aimed at tracking the effectiveness of domestic sustainable development programmes and schemes, and are extended to monitor energy efficiency and emissions related indicators, as well as other climate co-benefits.

India has made significant efforts in strengthening its existing MRV arrangements. There has also been extensive work on updating and creating technical data repositories and dashboards and improving their access to the public. This chapter on MRV captures and updates India’s actions in enhancing transparency and builds upon developments that have been reported in the previous BUR (I and II) submissions.

The quality and performance of India's MRV arrangements are highlighted by the fact that the information provided through them is regularly used by independent third-party assessments of India's climate performance that rate India's climate actions highly.

Last, but not least, the very submission of this detailed Third Biennial Report, brought to its final form in the midst of the COVID-19 pandemic, speaks to the commitment and quality that is integral to India's MRV process in the interests of transparency and adherence to the multilateral processes of the UNFCCC.

4.2 Dashboards and portals

Enhancing transparency and accountability by making information accessible through online web-portals/digital dashboards has led to effective tracking of schemes' performance across all States on a single platform. The GoI has developed numerous dashboards, especially in energy-related sectors (power, renewables, industry, transport) that impact mitigation. Creating these web portals reiterates GoI's intention of moving towards a Digital India and simultaneously showcases good examples of transitioning towards transparency in governance (MeitY, 2019).

Energy sectors (Renewables/ Power/ Energy Efficiency/ Transport): Within the energy sectors, there has been a tremendous thrust on renewables (non-fossil energy) for meeting the country's target of 175 GW of renewable energy by 2022. The National Power Portal developed by the Central Electricity Authority (CEA) provides information on installed renewable capacity and its generation. It is also the major source of information for other power sector data such as daily power demand, category wise installed capacity, urban and rural distribution, and other related aspects. This portal also provides information on support disbursed for certain schemes such as the Integrated Power Development Scheme (IPDS), Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY) and links directly to other power sector dashboards like Transmission App for Real-time monitoring and Growth (TARANG), Payment Ratification and Analysis in Power Procurement for bringing Transparency in Invoicing of Generators (PRAAPTI), Ujwal DISCOM Assurance Yojana (UDAY), Urban Jyoti Abhiyaan (URJA), SAUBHAGYA or Pradhan Mantri Sahaj Bijli Har Ghar Yojana (CEA, 2019a). In addition to this, the national portal for Renewable Purchase Obligation (RPO) of MNRE (Ministry of New and Renewable Energy) monitors RPO compliance of States. It consists of a user interface where entities are obliged to provide data on RPO compliance (MNRE, 2019a).

Energy Efficiency Services Limited (EESL) has been anchoring many energy efficiency initiatives across the country. To showcase its progress, EESL has developed scheme-specific dashboards. The National Building dashboard (EESL, 2019a) provides information on a real-time basis on energy savings as well as a reduction in CO_2 emissions from retrofitted buildings by tracking energy demand as a proxy of consumption and the related emissions, contributing to MRV of energy efficiency efforts (EESL, 2019b). UJALA dashboard indicates the total LED distributed across the country and related energy savings and CO_2 emission reduction (EESL, 2019c). The Municipal Energy Efficiency Programme (MEEP) dashboard monitors the energy efficiency initiatives in water pumping in municipal areas. The SNLP dashboard showcases annual energy savings and emission reductions achieved from SLNP

(Street Lighting National Programme) across the country (EESL, 2019d); (EESL, 2019e).

Bureau of Energy Efficiency (BEE) has developed the online PATNet portal for all Designated Consumers (DCs) under the Performance, Achieve and Trade (PAT) scheme. DCs can upload their forms (mandatory submissions under PAT scheme) on PATNet and Energy Saving Certificates (ESCerts) can be electronically issued/entitled to purchase. Similarly, BEE has also developed an online portal for Standards and Labelling (S&L) programme. This portal facilitates manufacturers' submission of applications for star labelling of appliances/equipment online. Users can also search and compare various appliances/equipment through the online portal. Information on energy-saving tips is also made available to the consumers/manufacturers through the online portal.

BEE, in association with CLASP, has launched the National Energy End-use Monitoring (NEEM) dashboard. It is a comprehensive platform for collecting and analyzing data on energy end-use and appliance energy consumption at the household level.

In the transport sector, the Department of Heavy Industry is implementing Faster Adoption and Manufacturing of Hybrid and EV (FAME) India Scheme (phase I in 2015 and phase II in 2019) (NAB, 2019). This scheme is monitored by the FAME dashboard where the key outcomes and associated indicators, such as the total number of vehicles sold, accrued fuel savings, and CO_2 reductions per day, are displayed (NAB, 2019).

Agriculture, forestry, and waste sectors: Forestry and agriculture, together with the waste sector, pose huge challenges and opportunities for the country in climate action, especially in adaptation with important mitigation co-benefits. In these sectors, the GoI has consistently worked on enhancing transparency through digitisation and maintaining coherence across departments or jurisdictions for evaluation. Within the agriculture sector, the Department of Agriculture, Cooperation and Farmers' Welfare (DAC&FW) has developed a Farmers Portal. This portal contains data for estimating baseline emissions, such as livestock census, data on fertilizer use, crop varieties grown, total area, yield, and other necessary information (DAC&FW, 2018). An important initiative under the National Mission for Sustainable Agriculture (NMSA) consists of Soil Health Management through the Soil Health Card scheme since 2015 (DAC&FW, 2016). This scheme enables farmers to assess their soil health on several parameters, through the nutrient status of their soil based on 12 parameters namely primary nutrients (N, P and K); secondary nutrient (S); micronutrients (B, Zn, Mn, Fe, and Cu); and others (pH, EC and OC). It also provides recommendations on appropriate dosage of nutrients to be applied for improving soil health and its fertility for major crops of the area. This, in turn, helps in optimal utilisation of fertilisers. This scheme aims to optimise fertilizer usage and boosts productivity while reducing related emissions (MoAFW, 2019a). The scheme's dashboard monitors nitrogen, phosphorus, and potassium in soils across states. It maintains a record of soil health across locations over time to understand changes and other patterns (MoAFW, 2019b).

In the forestry sector, remote sensing data is widely used for activities such as mapping of forest cover, identification, and mapping of wetlands, and determination of forest biomass. The Bhuvan Geospatial portal includes images and other data relevant to the Green India Mission (GIM). Changes in land use and land cover are captured with the help of ISRO satellites (ISRO, 2019a). Another notable development in the forestry sector has been the Large Forest Fire Monitoring Programme (LFFMP) launched in 2019 (FSI, 2019). Using satellite data acquired through remote sensing technology, the Forest Survey of India (FSI) periodically maps forest cover and regularly monitors forest fires using real-time satellite data. This helps provide alerts to State/UT Forest Departments and other registered mobile users whenever forest fires are detected (ISRO, 2019b).

In the waste sector, the Swachh Bharat Urban, as well as Gramin dashboards, track progress towards achieving their programme targets such as the number of open defecation free villages; construction of community public toilets and other related aspects (MoHUA, 2019a; DDWS, 2019). Swachh Bharat Mission (SBM) is expected to deliver co-benefits such as emission reductions by waste management, and enabling conversion of waste into compost or other usable forms, such as energy.

NITI Aayog has launched the SDG India Index, which monitors the progress of all the States and UTs on the outcomes of Government interventions and schemes. It intends to provide a holistic view of the social, economic, and environmental parameters and identify priority areas in which investments are needed (NITI Aayog, 2020). The India SDG Dashboard of Ministry of Statistics and Programme Implementation (MoSPI) is a unified data repository on SDG Indicators as per the National Indicator Framework. The India SDG Dashboard aims to bring data to the fingertips of decision-makers at the national and sub-national levels, helping to accurately identify the gaps that need to be addressed and measure the success of the existing development programs (MoSPI, 2020a).

Table 4.1 showcases a list of the dashboards across various sectors and responsible agencies and highlights the availability of relevant information.

Table 4.1: Sector-wise dashboards and web-based portals in India

Sectors	Name	Agencies/ Institutions	Relevant indicators
Power	National Power Portal	CEA, MoP	Category wise installed capacity (conventional/non-conventional energy installed).
Renewables	Renewable Purchase Obligation	MNRE	RPO compliance data.

Building	National building dashboard	EESL	Real-time deemed energy savings, reduction in CO_2 emissions from retrofitted buildings by tracking energy demand and emissions.
Energy efficiency	National UJALA dashboard	EESL	Total LED distributed across the country along with energy savings and CO_2 emission reduction.
Energy efficiency	Municipal Energy Efficiency Programme	EESL	Energy savings, cost savings, CO_2 reduction.
Energy efficiency	Streetlight National Programme	EESL	Annual energy savings and GHG emission reductions.
Transport	Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India (FAME India)	Department of Heavy Industry	Total number of vehicles sold, fuel savings per day, and CO_2 reduction per day.
Agriculture	Farmers Portal	DAC&FW	Livestock census, amount of fertilisers and crops varieties.
Agriculture	Soil Health Card scheme	DAC&FW	Monitors 12 parameters (nitrogen, phosphorus and potassium, micro nutrient status, pH) in the soil across the States.
Agriculture	Pradhan Mantri Krishi Sinchayee Yojana (PMKSY)	DAC&FW	Year-wise area under micro-irrigation systems.
Agriculture	Agriculture Demand-side Management (AgDSM)	MoP	Energy savings per year, CO_2 reduction per year, and cost savings per year.
Forestry	Bhuvan Geospatial Portal	National Remote Sensing Centre (ISRO)	Land use and land cover changes.
Forestry	Large Forest Fire Monitoring Programme	FSI	Number of forest fires, area, the severity of a burn, canopy cover loss.
Waste	Swachh Bharat Urban/Gramin	Ministry of Housing and Urban Affairs (MoHUA)	Total waste generated and processed, open defecation free village, community public and toilets construction.
Cross-cutting	SDG India Index	NITI Aayog	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.

Cross-cutting	India SDG Dashboard	MoSPI	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.

4.3 Mobile Applications

Several mobile applications have been launched to widen the reach of government initiatives and monitor their implementation. Applications (Apps) facilitate real-time updates and transparent information dissemination to keep stakeholders and the public better informed. It empowers the public (stakeholders) to address any violations, verify compliance, and provide feedback on the initiatives. Table 4.2 showcases a list of mobile applications and responsible agencies and highlights their purpose.

Table 4.2: Mobile applications related to relevant government initiatives

App Name	Agencies/ Institutions	Purpose
National UJALA Dashboard	EESL	Real-time updates on the LED distribution across the country.
BEE star Label	BEE	Enable consumers to verify the accuracy of the Star Labels on products.
MERIT	MoP	Facilitate renewable integration and promote the use of green and clean power more transparently.
Grameen Vidyutikaran (GARV)	Rural Electrification Corporation Limited	Monitoring village and household electrification.
Vidyut pravah	MoP	Power availability in the country on a real-time basis - shortage including peak hour and total energy shortage.
mHariyali	MoHUA	Monitoring of plantations and provides geo-tagging of plants.
Harit Path	NHAI	Monitor plantation along national highways.
Swachhata	MoHUA	Posting civic-related issues relating to garbage (dumping and collection) and public toilets.
Bhuvan Hailstorm	DAC&FW	Monitor crop loss due to hailstorm, hailstorm occurrences, and their geographical locations
Kisan Suvidha	MoAFW	Provide updates on extreme weather, soil health cards, and market prices of commodities.
Meghdoot	IMD, ICAR	Share high-resolution weather forecast based agro advisories to farmers
Mausam	IMD	Provide information on observed weather, forecasts, radar images, and warning towards impending weather events.

4.4 Data repositories

Building a robust national data repository system is essential for developing baselines and estimating accurate GHG emission inventories (identifying emission sources, baseline projections, and forecasting trends). In India, there are a number of data repositories at various levels (sub-national and national) maintained by respective departments/ministries. These repositories store data in raw formats or publish them periodically in the form of reports. Most of the data repository institutions follow a standard approach of maintaining a level of uniformity in data collection, reporting, and archiving.

Open Government Data (OGD) Platform India - https://data.gov.in/ - is a platform for supporting the open data initiative of the GoI. It helps to quickly access the data from various government sectors and use government data to provide appropriate perspectives.

There are several existing data repository systems within the industry sector. The Annual Survey of Industries (ASI) conducted by the National Sample Survey Office (NSSO) collects data on several economic parameters including industrial energy use. ASI follows the Collection of Statistics Rules, 2011 under the Collection of Statistics Act, 2008 for collecting data, in which a Statistics Officer collates and verifies information from industrial/commercial units. Under a similar Act, units are penalised in case of false declarations or untimely submissions (NSSO, 2018). This information forms the crucial baseline data for estimating industrial emissions (NSSO, 2012). The Coal Directory of India, and Provisional Coal Statistics both provide baseline data for estimating emissions from industrial coal consumption (MoC, 2019). The Coal Controller's Organisation is the authority that collects monthly coal consumption data based on annual coal and lignite surveys under the Collection of Statistics Act, 2008 (CCO, 2019).

The Central Electricity Authority (CEA) maintains an extensive web-based reporting system for electricity generation from all sources (including coal and renewables) on a daily, monthly, quarterly and annual basis, along with reporting archives. (CEA, 2019b). While the mandate of the CEA pertains to the electricity sector, MoSPI provides comprehensive coverage of the energy sector in the form of an annual publication "Energy Statistics", which is an integrated and updated database of reserves, installed capacity, production, consumption, import, export and wholesale prices of different sources *viz.* coal, crude oil, natural gas and electricity including electricity from new and renewable energy sources. The data for Energy Statistics are sourced from different Ministries of the GoI. Energy Statistics also provides energy indicators with respect to economic dimensions and energy balance statistics with Total Primary Energy Supply (TPES) and Total Final Consumption (TFC) data. These provide the basis for strategic changes and policymaking. Data updated till 2018-19(P) can be found in the latest publication Energy Statistics 2020 (MoSPI, 2020b).

In the case of the transport sector, the Petroleum Planning and Analysis Cell (PPAC) maintains a databank for effective monitoring of trends and analysis in the hydrocarbons (petroleum and natural gas) sector in the country (PPAC, 2019). Indian Railways in their annual report regularly provides updates on the electrification status of railway routes across the country (IR, 2016).

The Indian Council of Agricultural Research (ICAR) has developed a centralised KRISHI repository which is an extensive database and knowledge management bank which includes several information systems – geoportals, crop-specific knowledge resources, crop pest surveillance, and advisory, livestock traceability, institutional publications and data inventory, and technologies (ICAR, 2015). Additionally, DAC&FW reports on various indicators of crop production for major crops including rice, wheat, maize, pulses, sugarcane, as well as basic data on the entire range of crops that are cultivated in the country (DAC&FW, 2019). Reporting of livestock needed for calculation of GHG emissions is prepared by the Department of Animal Husbandry and Dairying (DAHD, 2019). The District Agro Meteorological Units (DAMUs) are also being established in the Krishi Vigyan Kendra (KVKs) under the ICAR network to address micro-level variation in weather and climate, benefitting more farmers. Under the forestry sector, the FSI conducts a survey on forestry and forest resources and maintains the National Forest Inventory. It publishes its biennial report India State of Forest Report (ISFR) that contains information including forest cover, tree cover, mangroves, and carbon stock (FSI, 2018).

The Central Pollution Control Board (CPCB) and State Pollution Control Boards (SPCBs) monitor and evaluate the waste sector's performance in the country. All types of waste – municipal solid waste (MSW), plastic waste, hazardous and e-waste, and biomedical waste -- are under the purview of the CPCB monitoring framework (CPCB, 2017). It released a Consolidated Annual Report on the Status of Implementation of MSW Rules 2016, collected from various SPCBc or pollution control committees. Several indicators such as the quantity of solid waste generated, monitoring of landfill/waste processing sites, waste to energy plants set up, and monitoring activities carried out at waste processing/landfills sites are reported. A multi-tiered approach is adopted for reporting on these aspects in which municipalities prepare detailed project reports (DPRs) which are submitted to state pollution control boards or pollution control committees and are then reported to the CPCB (CPCB, 2018a). Table 4.3 lists repositories across various sectors, their reporting frequencies, and the information that they provide.

Table 4.3 Sector-wise data repositories in India

Sectors	Agency – Repository	Frequency	Relevant information
Energy	Central Electricity Authority Database	Monthly, quarterly, and annual reporting	Daily electricity generation from various fuel sources.

Energy	Energy Statistics - MOSPI	Annual	Energy sources database on installed capacity, production, consumption, import, export, and energy indicators.
Energy	Petroleum Planning and Analysis Cell (PPAC) - Reports and studies	Monthly	Monitoring of trends and analysis (consumption, production, import) for petroleum and natural gas.
Transport	IR - Annual Report	Annual	Electrification Status of Broad Gauge (BG) Railway Lines. Significant progress has already been made in this regard and IR is likely to electrify all BG rail lines by 2024 leading to mitigation.
Industry	Coal Directory of India, Provisional Coal Statistics - Coal Controller's Organization	Annual	Baseline data for estimating emissions from industrial coal consumption.
Industry	Annual Survey of Industries - National Sample Survey Office	Annual	Data on industrial energy use forms important baseline data for estimating industrial emissions.
Agriculture	Department of Animal Husbandry and Dairying	Annual	Reporting of livestock population needed for calculation of GHG emissions.
Agriculture	DAC&FW	Annual	All India crop situation database that reports on various indicators of crop production for major crops like rice, wheat, maize, pulses, and sugarcane.
Agriculture	KRISHI repository - ICAR	Varies but mostly on an annual basis	Geoportals, crop-specific knowledge resource, crop pest surveillance and advisory, livestock traceability, institutional publications and data inventory, technologies, form baseline data for estimating emissions.
Forestry	National Forest Inventory by Forest Survey of India	Biennial	Field inventory data from both forest and Trees Outside Forests (TOF) for more than 30,000 sample plots spread over the entire country is collected under the National Forest Inventory Programme of FSI. Every year field data on about 15,000 sample plots is being collected by FSI. The data is used for estimation of growing stock in forest and TOF, and the estimation of carbon stock in the country. Country-specific emission factors are also derived from the NFI data for different carbon pools.
Forestry	Forest Cover mapping by FSI	Biennial	FSI has been carrying out satellite-based mapping of forest cover since 1987. FSI assesses forest cover of the country using indigenous remote sensing satellite (ResourceSat-2) data having a spatial resolution of 23.5 meters. The repository of explicit satellite data is used as activity data for

			the estimation of carbon stock in the country's forest.
Forestry	Forest Fire monitoring by FSI	Annual	The forest fire alert system has been started by FSI in 2004. The system has undergone significant improvements in recent years to make it more user friendly and robust. Fire alerts are generated by FSI during the fire session and sent to the registered users of State Forest Departments (SFDs) through SMS on mobile and also through e-mails daily for taking timely action. In addition, pre-fire warning alerts are also generated by FSI and sent to the SFDs. In 2019, FSI has launched Forest Fire Alerts (version 3.0) which also includes monitoring of large forest fires based on satellite data.
Waste	Consolidated Annual Report on Status of Implementation of MSW rules 2016 by CPCB (Central Pollution Control Board) and SPCBs	Annual	Quantity of solid waste generated, monitoring of landfill/waste processing sites, waste to energy plants set up, monitoring activities carried out at waste processing/landfill sites are reported which are important baseline estimation parameters

4.5 Scheme specific MRVs

MRV is essential for any programme/scheme as it enables the assessment of the performance and effectiveness of the programmes being implemented. At the scheme level, the relevant legislation outlines key actors and their responsibilities, including authorities in charge (nodal agencies and implementing bodies), monitoring and evaluation mechanisms, and finance and additional support (technology, infrastructure, capacity building) required. In some cases, dedicated institutions are established to ensure compliance with schemes and standards.

Given below are some of the key scheme-specific MRVs:

- *Perform, Achieve and Trade (PAT) scheme:* In the case of the Perform, Achieve and Trade (PAT) mechanism introduced under the National Mission for Enhanced Energy Efficiency (NMEEE), the compliance and market design is clearly outlined with which designated consumers (DCs) are required to comply. Accredited Energy Auditors (AEAs) verify information submitted on energy consumption and production by the designated consumer, following stringent reporting procedures and guidelines, demonstrating a reliable MRV framework (BEE, 2012). PAT is a mechanism designed to achieve emissions reduction in energy-intensive industries based on the concept of reduction in Specific Energy Consumption (SEC). It refers to the calculation of SEC in the baseline year, and projected SEC in the target year, covering different forms of net energy going into the boundary of the designated consumers' plant, and the products leaving it over a particular cycle. SEC is calculated on a Gate-to-Gate basis. A robust monitoring and verification system has been developed by BEE for the PAT scheme to assess the savings achieved by the industries. The assessment is done only for the final year of the three-year cycle to establish whether the DC has achieved its target or not. This assessment is done by an accredited energy auditor firm empanelled by the Bureau. The PAT scheme also involves the concept of normalisation which is a process of rationalization of energy and production data of a DC to take into account the impact of quantifiable external variables that are beyond the control of a DC. One limitation faced by the monitoring and verification process is the non-availability of data on energy and production from the DCs in relatively less organized sectors such as pulp and paper and textiles. However, BEE in the future envisages the adoption of energy management systems and the adoption of ISO 50001:2011 (energy management systems) by the DCs for effective monitoring and verification to take place.

- *Standards & Labelling Programme:* BEE or its designated agency (IAME or SDA or any other agency), shall *suo moto* carry out check-testing of products as per the production schedule or regulation to ensure that production models meet the performance claims. The check-testing of labelled products shall be conducted in third party NABL accredited laboratories empaneled with BEE. BEE had envisaged conducting check-testing of around 3,000 labelled products by 2021 and also empanelment of labs to conduct the same. For the programme, the Bureau of Indian Standards along with the National Accreditation Board supports BEE in formulating national standards as well as in undertaking product and quality system certifications (BEE, 2011).

- The CPCB has been developing national standards for emission and discharge of environmental pollutants from industry. Schedule – I of the Environment (Protection) Rules, 1986 lists approximately 95 emission/ discharge standards for various industries' operations and processes (CPCB, 2020), to protect and improve the quality of the environment by preventing and abating environmental pollution. In order to track pollutant discharge, the CPCB has also directed highly polluting industries to install online continuous emissions monitoring systems (OCEMS) and report in real-time (CPCB, 2018b).

- Pro-Active Responsive facilitation by Interactive and Virtuous Environmental Single-window Hub (PARIVESH) is a web-based, role-based workflow application which has been developed for online submission and monitoring of the proposals submitted by project proponents seeking Environment, Forest, Wildlife, and CRZ Clearances from Central, State and district level authorities. It provides transparency and efficiency in the working environment, minimizes processing delay, helps in timely disposal of important issues, and enables one to work from anywhere, anytime, leading to paperless working, together with ease and flexibility in retrieving various reports.

- Under the Smart Cities Mission, a Climate Smart Cities Assessment Framework has been developed by the Ministry of Housing and Urban Affairs (MoHUA) for ranking cities on climatic parameters, including energy and green building, urban planning and green cover, biodiversity, mobility, and air quality. Extensive data aggregation efforts across cities and States were facilitated through online portals verified by the expert committee (MoHUA, 2019b).

- Green Energy Corridor, which ensures grid connectivity to renewable sources, is being implemented by respective State Transmission Utilities. MNRE, along with a member from CEA and Power Grid Corporation of India Ltd (PGCIL), monitors the project implementation every month (MNRE, 2019b).

- For Renewable Energy Certficates (RECs) an IT infrastructure "REC registry" has been set up by the central agency for accreditation, registration, issuance, and trading of RECs. This registry brings together different stakeholders such as RE generators, state agencies, State Electricity Regulatory Commissions (SERCs), and the Central Electricity Regulatory Commission (CERC) to perform their respective mandates and monitor compliance with regard to the purchase of RECs (POSOCO, 2018).

- Clean Development Mechanism (CDM), is a bilateral offset credit mechanism instrument under the Kyoto Protocol. The National CDM Authority is entrusted with the responsibility for receiving and evaluating projects for host country approval (MoEFCC, 2004). Project design documents, including different types of data along with calculations are available at the web portal allowing public scrutiny and transparency (UNFCCC, 2019).

- In 2018, India prepared its National Reducing Emissions from Deforestation and Forest Degradation (REDD+) Strategy to address deforestation and forest degradation and develop a roadmap for enhancing forest carbon stocks through the REDD+ initiative. A governance framework consisting of a National Governing Council (NGC-REDD+) for coordinating, implementing, and measuring the performance of REDD+ activities is formulated. Other key elements of REDD+ are the National Forest Reference Level, which serves as a benchmark for assessing the performance of REDD+ implementation, and National Forest Monitoring System to periodically communicate relevant and valid information (MoEFCC, 2018).

- The Twenty Point Programme (TPP), which promotes environmental protection and afforestation, is monitored by MoSPI. Scheme monitoring is carried out at multiple levels (Centre, State, District, and Block levels) and performance reports are submitted by State Governments and Central Nodal Ministries on a quarterly basis (MoSPI, 2018).

- Several initiatives are being taken up as part of the National Mission for Sustainable Agriculture, such as Rainfed Area Development, and sub-Mission on agroforestry including the National Bamboo Mission, in which several activities are being taken up which are contributing to mitigation. The progress of the scheme is monitored continuously and the extent of mitigation achieved is assessed.

4.6 Initiatives by non-governmental stakeholders

Non-governmental stakeholders are also playing an important role in strengthening the MRV process. They are supplementing India's efforts towards developing guidelines and reporting formats, collecting climate-related data sets, estimating national inventories, and engaging in the technical assessment of the programmes and policies. Some of the major initiates of the non-governmental stakeholders are as below:

- The GHG Platform India, a civil society initiative provides an independent estimation and analysis of India's GHG emissions across energy, industry, agriculture, forestry and other land use (AFOLU), and waste. This platform is a joint effort of several institutions including Vasudha Foundation, Council on Energy, Environment, and Water (CEEW), Centre for Study of Science, Technology & Policy (C-STEP), ICLEI – Local Government for Sustainability, and World Resources Institute (WRI) India (GHG Platform, 2016).

- The Renewable Energy Data Portal by Prayas (Energy Group) is an effort to collate and make renewable energy information available on a web portal (Prayas, 2015a). Prayas also manages the Electricity Supply Monitoring Initiative, a web portal that provides real-time, reliable data on electricity supply quality (Prayas, 2015b).

- The Centre for Energy Finance (CEF) is an initiative by CEEW to track the installed renewable capacity of States and rates these according to the CEF State Rating Tool. This rating system measures and compares the attractiveness of States for investment in utility-scale renewable energy projects on a scale of 0 to 5 (CEEW, 2019).

- The India GHG Program led by WRI India, Confederation of Indian Industry (CII), and The Energy and Resources Institute (TERI) aims to build institutional capabilities of Indian businesses and has developed a standardised approach to GHG accounting (India GHG Program, 2018).

- Carbon Disclosure Project (CDP), a not-for-profit organisation, has built an environmental disclosure system which is a collection of self-reported environmental (climate change) data from industries (CDP, 2017).

- CII-Climate Action Programme – CAP 2.0 aims to build the capability and capacity of Indian industry on climate action by recognising best practices. The programme collects data and information from large and small industry alike on various aspects of climate change mitigation and adaptation, which includes long-, middle- and short-term strategies and targets. The programme is a repository of verified information on various works being undertaken by Indian industry on climate change mitigation and adaptation along with critical data on energy, GHG, water (as risk), which are critical to a transparent and robust MRV system.

4.7 Transitioning to enhanced transparency

One of the key outcomes of COP24, the adoption of the Enhanced Transparency Framework (ETF), requires that all Parties adhere to common reporting formats, as well as disclosure of more detailed, additional, and authenticated data (UNFCCC, 2018). For its preparation, under the capacity building initiative for transparency, the Global Environment Facility (GEF) has approved India's project proposal – '*Capacity-building for establishing an Integrated and Enhanced Transparency Framework for Climate Actions and Support Measures*.' This project aims to create an enabling environment for domestic planners to follow the enhanced transparency framework guidelines through a coordinated mechanism. One of the important project outcomes would be to create a web-based National Institutional Coordination System (NICS) to coordinate stakeholders for climate reporting (CBIT, 2019).

Strengthening transparency in the form of dashboards, data repositories, and scheme-specific monitoring provisions has acted as a catalyst in planning and coordinating mitigation activities effectively. While these are essential steps, support is needed to enhance the institutions' capacity to report accurate data in a timely manner. Further, there is a risk of repetition and data overlap across MRV processes/activities. To prevent this, the future MRV framework needs to adopt standardised methodologies and templates across institutions. The MRV process must also have a provision to track the information and other contributions received from various international sources and monitor their impact as well as their contribution towards meeting the regional domestic and climate goals.

An accomplished MRV system enables the achievement of maximum mitigation through end-to-end information management of a given system. An integrated MRV system requires streamlined data management systems, improved technical skills, analytical capabilities, and most importantly, coordination amongst stakeholders. The development of a robust MRV system requires additional finance along with capacity building.

In terms of technical aspects, establishing robust energy management systems that can help develop strong reporting and verification systems is essential. The establishment of such energy management systems would require financial resources to achieve the necessary scale and speed. Further, to implement such activities, the need for an educated and skilled workforce is also necessary so that capacity building of professionals related to energy such as AEAS, technicians, retailers and others, can take place more effectively.

Thus, to meet future commitments and develop an integrated MRV system, India requires new and additional finance, technology, and capacity-building support.

4.7.1 The aims and ends of MRV and the ETF

While India adheres to all UNFCCC decisions on MRV and related issues of transparency and accountability, the international context leaves much room for concern. As noted earlier, the impact of MRV is an increasing burden for developing countries and is now at a stage when the ETF will require that scarce resources be diverted towards fulfilling reporting obligations. Accuracy, as demanded in the ETF, will constitute an expensive effort as diffused emissions from widely distributed sources, often located in traditional or informal sectors, are much harder to monitor or track (for instance gas stoves with piped or cylinder gas supply vs wood-burning cookstoves). The same problem arises with the varied landscapes with significant biodiversity, whose inventory of sinks and sources would necessitate considerable effort. Emissions from such diffuse or informal sectors also arise from the activity of the most vulnerable sections of the population. It is arguable whether equity considerations require such intense monitoring of these sectors, instead of focusing on eradicating their development deficits. This is particularly applicable to a number of developing countries, including India.

On the other hand, if MRV is to perform the function of promoting good practices, learning in mitigation, and increasing effort and ambition in mitigation, then decades of MRV advocacy by the Annex-I Parties must be deemed to have produced scant results by their own standards. More than 25 years after the Convention was signed, the emissions reduction in annual emissions of the non-EIT-Annex-I Parties is of the order of 1.5 per cent between 1990 and 2018, while for 1990-2020 these are likely to post an increase of 0.4 per cent (SBI, 2020). BRs and NATCOMs are not submitted generally on time, even by the most financially endowed nations. In the matter of finance, reaching agreement on MRV has proven increasingly fraught with divisions, and reporting standards sought by Parties are widely varying. In technology transfer, the global IPR regime provides little real information on the extent of innovation and technology development and its adequacy in the context of facing up to the global challenge.

MRV and ETF alone cannot produce climate action, nor does political science provide us the confidence that identifying individual country's lapses will promote greater compliance. While necessary MRV mechanisms must be in place, it would be erroneous to mistake MRV for real climate action that makes a difference.

References

BEE. (2011). *Energy Efficiency Standards and Labeling in India - Current Situation and Challenges.* Retrieved from https://eneken.ieej.or.jp/data/3694.pdf

BEE. (2012). *PAT Rules and Obligations of DCs under the PAT Scheme.* Retrieved November 23, 2019, from Bureau of Energy Efficiency, Ministry of Power.

https://beeindia.gov.in/sites/default/files/PAT%20Rules%20and%20Obligations%20of%20DCs%20under%20PAT%20Scheme_Abhishek%20Kumar_0.pdf

CBIT. (2019). *Capacity-building for establishing an Integrated and Enhanced Transparency Framework for Climate actions and support measures.* Retrieved from Project Identification Form (PIF) https://www.thegef.org/sites/default/files/web-documents/10194_CBIT_India_PIF.pdf

CCO. (2019). *Official website of Coal Controller's Organization, Ministry of Coal, Govt. of India*. November 28, 2019, Retrieved from http://www.coalcontroller.gov.in/pages/display/5-functionsresponsibilities

CDP. (2017). *India Inc. aligns with NDC and Paris Agreement to seize opportunities.* CDP India Climate Change Report. Retrieved from https://b8f65cb373b1b7b15feb-c70d8ead6ced550b4d987d7c03fcdd1d.ssl.cf3.rackcdn.com/cms/reports/documents/000/002/763/original/India-edition-climate-change-report-2017.pdf?1509623272

CEA. (2019a). *National Power Portal*. (M. o. Central Electricity Authority, Producer) November 23, 2019, Retrieved from https://npp.gov.in/

CEA. (2019b, May). *Central Electricity Authority, Ministry of Power*. (Central Electricity Authority, Ministry of Power) Retrieved November 23, 2019, Retrieved from: http://cea.nic.in/reports.html

CEEW. (2019). *CEEW Centre for Energy Finance.* Retrieved 11 28, 2019, from Council on Energy, Environment, and Water: Retrieved from http://cef.ceew.in/shared/CEEW_CEF_State_Risk_Rating_Tool_Methodology.pdf

CPCB. (2017, November). *Annual Report.* Retrieved November 23, 2019, from Central Pollution Control Board. Retrieved from https://cpcb.nic.in/uploads/MSW/MSW_AnnualReport_2016-17.pdf

CPCB. (2018a, April). *Consolidated Annual Report on Implementation of Solid Waste Rules 2016.* November 23, 2019, Retrieved from https://cpcb.nic.in/uploads/MSW/MSW_AnnualReport_2016-17.pdf

CPCB. (2018b, July). *Guidelines for Online Continuous Effluent Monitoring Systems (OCEMS)*. May 22, 2020, Retrieved from http://www.indiaenvironmentportal.org.in/files/file/Revised%20Guidelines%20for%20Real-time%20Effluent%20Quality%20Monitoring%20System.pdf

CPCB. (2020). *Central Pollution Control Board, Effluent/Emission*. Retrieved May 22, 2020, Retrieved from https://cpcb.nic.in/effluent-emission/

DAHD. (2019). *Department of Animal Husbandry & Dairying*. November 23, 2019, Retrieved from http://dahd.nic.in/

DAC&FW. (2016). *National Mission for Sustainable.* Ministry of Agriculture & Farmers Welfare, Department of Agriculture, Co-operation & Farmers Welfare. New Delhi: Ministry of Agriculture & Farmers Welfare. November 24, 2019, Retrieved from https://nmsa.dac.gov.in/pdfDoc/SHM_Guidelines472016.pdf

DAC&FW. (2018). *Farmer's Portal, Department of Agriculture & Cooperation and Farmers' Welfare, Ministry of Agriculture and Farmers Welfare*. (D. o. Welfare, Producer, & Ministry of Agriculture and Farmers Welfare) November 23, 2019. Retrieved from https://farmer.gov.in/

DAC&FW. (2019). *All India Crop Situation, Ministry of Agriculture & Farmers' Welfare*. (Department of Agriculture Co-operation & Farmers Welfare, MoA&FW, GoI) November 23, 2019. Retrieved from http://agricoop.nic.in/all-india-crop-situation

DDWS. (2019). *Department of Drinking Water and Sanitation, Ministry of Jal Shakti.* Retrieved November 2019, from Swachh Bharat Mission - Gramin (All India): Retrieved from https://sbm.gov.in/sbmReport/home.aspx

EESL. (2019a). *National Building Monitoring Portal*. (EESL). November 23, 2019, Monitoring Reports of National Building Program. Retrieved from https://beep.eeslindia.org/monitoring

EESL. (2019b). *National Buildings Dashboard*. (Energy Efficiency Services Limited, Government of India) November 23, 2019. Retrieved from https://www.eeslindia.org/content/raj/eesl/en/Programmes/Energy-Efficient-Buildings/dashboard.html

EESL. (2019c). *National UJALA Dashboard.* November 2019, from Energy Efficiency Services Limited: Distribution of LEDs, energy savings and CO_2 emission reduction.

EESL. (2019d). *MEEP - Dashboard.* Retrieved November 2019, from Municipal Energy Efficiency Programme, Energy Efficiency Services Limited. Retrieved from https://meep.eeslindia.org/dashboard/

EESL. (2019e). *SLNP - Dashboard.* November 2019, from Streetlight National Programme, Energy Efficiency Services Limited.

FSI. (2018). *State of Forest Report 2017*. (Forest Survey of India) Retrieved November 24, 2019, Retrieved from http://www.fsi.nic.in/forest-report-2017

FSI. (2019). *Large Forest Fires Monitoring Programme.* November 2019, from Forest Survey of India, MoEFCC. Retrieved from http://fi-re.in/smsalerts/dashboard.php

GHG Platform. (2016). *GHG Platform India, New Delhi*. November 28, 2019, Retrieved from http://www.ghgplatform-india.org/

ICAR. (2015). *Krishi Repository, Indian Council of Agricultural Research*. (Indian Council of Agricultural Research) Retrieved November 2019, from Indian Council of Agricultural Research. Retrieved from https://krishi.icar.gov.in/#

India GHG Program. (2018, July 10). India GHG Program. Retrieved from http://www.indiaghgp.org/program-overview

IR. (2016). *Indian Railways Statistical Publications 2015-16*. (Ministry of Railways (Railway Board)) November 23, 2019, Retrieved from http://www.indianrailways.gov.in/railwayboard/view_section.jsp?lang=0&id=0,1,304,366,554,1817,1818

ISRO. (2019a, November). *Bhuvan, Indian Geo-Platform of ISRO.* National Remote Sensing Center. Retrieved from http://wiienvis.nic.in/Database/GeospatialPortal_8282.aspx?format=Print ; http://bhuvan.nrsc.gov.in/bhuvan_links.php

ISRO. (2019b). *Department of Space, Indian Space Research Organisation.* Retrieved from https://www.isro.gov.in/earth-observation/forest-environment

MeitY. (2019). *Digital India*. (Ministry of Electronics & Information Technology) November 23, 2019, Retrieved from https://csc.gov.in/digitalIndia

MNRE. (2019a). *National Portal for RPO*. (Ministry of New & Renewable Energy (GoI)) November 22, 2019, Retrieved from https://rpo.gov.in/

MoAFW. (2019a). *Soil Health Card*. November 24, 2019, from the Ministry of Agriculture and Farmers Welfare. Retrieved from https://soilhealth.dac.gov.in/

MoAFW. (2019b). *Soil Health Dashboard*. (Ministry of Agriculture and Farmers Welfare). November 23, 2019. Retrieved from https://soilhealth.dac.gov.in/NewHomePage/StateWiseNPKChart

MoC. (2019). *Coal Controller's Organization, Ministry of Coal*. (M. o. Coal Controller's Organization, Producer) November 23, 2019 Retrieved from http://www.coalcontroller.gov.in/pages/display/16-coal-directory

MoEFCC. (2004, April). *National CDM Authority in India.* November 23, 2019, from MoEFCC. Retrieved from http://ncdmaindia.gov.in/ViewPDF.aspx?pub=notification.pdf

MoEFCC. (2018). *National REDD+ Strategy.* Ministry of Environment, Forest and Climate Change, Government of India, New Delhi. November 23, 2019, Retrieved from https://redd.unfccc.int/files/india_national_redd__strategy.pdf

MoHUA. (2019a). *Swachh Bharat Mission Urban, Ministry of Housing and Urban Affairs.* November 2019 Retrieved from from http://swachhbharaturban.gov.in

MoHUA. (2019b). *ClimateSmart Cities Assessment Framework.* MoHUA. November 23, 2019, Retrieved from https://smartnet.niua.org/csc/process.html

MNRE. (2019b). *Green Energy Corridor, Ministry of New and Renewable Energy*. November 24, 2019, Retrieved from https://mnre.gov.in/green-energy-corridor

MOSPI. (2020a). *Energy Statistics 2020.* Ministry of Statistics and Programme Implementation, Central Statistics Office. New Delhi: Ministry of Statistics and Programme Implementation. P. 111. October 12, 2020, Retrieved from http://www.mospi.gov.in/sites/default/files/publication_reports/ES_2020_240420m.pdf

MoSPI. (2020b). *Sustainable Development Goals - National Indicator Framework, Progress Report, 2020* (Version 2.1), Ministry of Statistics and Programme Implementation, Government of India. Retrieved from http://www.sdgindia2030.mospi.gov.in/dashboard/

MOSPI. (2018). *Twenty Point Programme - 206 progress report for the period April 2017-march 2018.* MOSPI, New Delhi. Retrieved from http://mospi.nic.in/sites/default/files/twenty_point_programme_2006/annual_report_of_tpp2006/QPR%20of%20TPP.pdf

NAB. (2019). *FAME India Scheme Phase II, Department of Heavy Industry*. (Ministry of Heavy Industries and Public Enterprises, GoI). November 23, 2019, Retrieved from Department of Heavy Industry: https://fame2.heavyindustry.gov.in/

NITI Aayog. (2020, August 31). *SDG India - Index & Dashboard 2019-20*. August 31, 2020, Retrieved from https://niti.gov.in/sdg-india-index-dashboard-2019-20

NSSO. (2018, November). *Instruction Manual Annual Survey of Industries (Concepts, Definitions and Procedures).* National Sample Survey Office, Industrial Statistics Wing, Data, and Field Operations Division. Kolkata: Ministry of Statistics and Programme Implementation, Government of India. November 28, 2019. Retrieved from http://www.csoisw.gov.in/cms/cms/Files/775.pdf

NSSO. (2012). *Annual Survey of Industries*. (National Sample Survey Office - Industrial Statistics Wing). November 23, 2019. Retrieved from http://www.csoisw.gov.in/CMS/cms/MapData.aspx

PPAC. (2019). *Petroleum Planning & Analysis Cell, Minister of Petroleum & Natural Gas*. (Petroleum Planning & Analysis Cell (Ministry of Petroleum & Natural Gas, Government of India)). November 23, 2019. Retrieved from https://www.ppac.gov.in/index.aspx

POSOCO. (2018). *Renewable Energy Certificate Mechanism in India.* Retrieved from Key learnings, Data analysis and Way forward: Retrieved from https://www.recregistryindia.nic.in/pdf/Others/Report_on_REC_Mechanism.pdf

Prayas. (2015a). *Renewable Energy Data Portal*. Retrieved 11 28, 2019, from Prayas (Energy Group) Retrieved from http://www.prayaspune.org/peg/re.html

Prayas. (2015b). *Electricity Supply Monitoring Initiative (ESMI)*. (P. (. group), Producer, & Prayas (energy group)) Retrieved 11 28, 2019, from Prayas (energy group), Pune. Retrieved from http://www.prayaspune.org/peg/resources/electricity-supply-monitoring-initiative-esmi.html

SBI. (2020). *Compilation and synthesis of fourth biennial reports of Parties included in Annex I to the Convention.* Subsidiary Body for Implementation FCCC/SBI/2020/INF.10 Report by the Secretariat of United Nations Framework Convention on Climate Change, Bonn. Retrieved from https://undocs.org/FCCC/SBI/2020/INF.10

UNFCCC. (2014). *Handbook on Measurement Reporting and Verification for developing country parties.* United Nations Climate Change Secretariat, UNFCCC. Germany: United Nations Climate Change Secretariat. November 28, 2019, Retrieved from https://unfccc.int/sites/default/files/non-annex_i_mrv_handbook.pdf

UNFCCC. (2018). *Preparations for the implementation of the Paris Agreement and the first session of the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement*. Retrieved from https://unfccc.int/sites/default/files/resource/l23_0.pdf

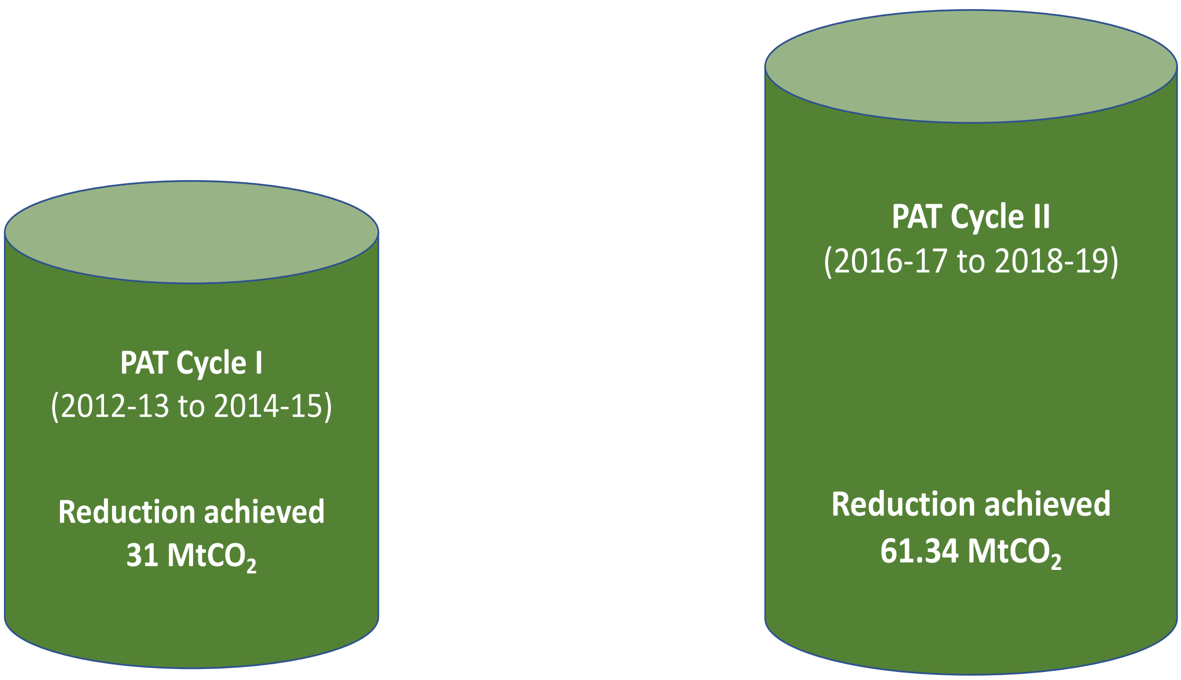
UNFCCC. (2019). *What is the CDM*. November 23, 2019, Retrieved from https://cdm.unfccc.int/about/index.html

*****

Perform Achieve and Trade (PAT)

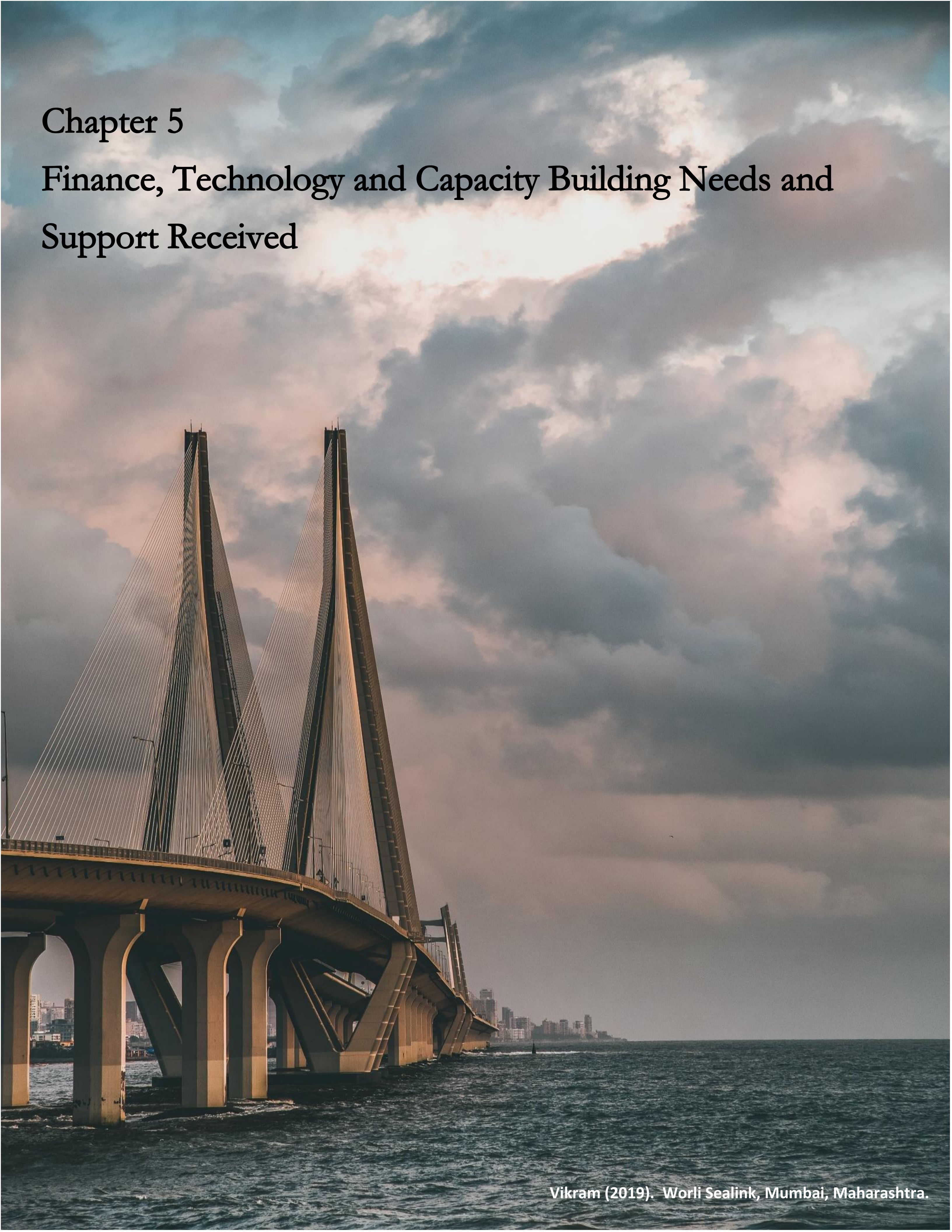
Dedicated scheme for energy efficiency in industries and other energy-intensive sectors under National Mission on Enhanced Energy Efficiency, one of the eight missions under the National Action Plan on Climate Change

Legislative measure under Energy Conservation Act, 2001



Chapter 5

Finance, Technology and Capacity Building Needs and Support Received



Vikram (2019). Worli Sealink, Mumbai, Maharashtra.

Key Points

Chapter 5 Finance, Technology and Capacity Building Needs and Support Received

- This chapter provides information on financial resources, technology transfer, and capacity-building needs for activities relating to climate change.
- India is a developing country with limited financial resources. Climate-induced events and disasters are growing, putting an enormous, additional burden on the country's developmental efforts. At the same time, India's financial needs to fulfil its obligations under the Convention and the Paris Agreement are growing significantly and require new, additional, and climate-specific financial resources.
- On the financial needs of India's NDCs, estimates have already indicated that India would need at least USD 206 billion (at 2014-15 prices) between 2015 and 2030 for implementing adaptation actions in key areas. Mitigation requirements for even moderate low-carbon development have been projected to be in the range of USD 834 billion until 2030 at 2011 prices.
- Green Climate Fund finance to India is inadequate and is likely to fall drastically short of meeting India's finance requirements.
- The funds for GEF-7 replenishment (2018-2022) are lower than GEF-6 and the funds under climate change focal area have also reduced. India's STAR allocation for climate change has declined by almost 50 per cent from GEF-6 (USD 87.88 million) to GEF-7 (USD 47.24 million). Despite being a developing country with a development deficit and limited financial resources, India has consistently contributed and continues to do so annually to the GEF Trust Fund as a resource providing party member.
- Despite the commitments and responsibilities of Annex-I Parties, their contribution to climate finance suffers on account of scale, scope and speed. They are largely not new and additional, highly inadequate in scale, misplaced in scope without balance favoring mitigation strongly over adaptation, and dominated by loans rather than grants. Annex-I Parties are tardy in implementation of the goal of providing USD 100 billion annually, the target year having been pushed back from 2020 to 2025.
- India's climate actions are largely financed from domestic sources, using both budgetary sources as well as a mix of market mechanisms, combined with fiscal instruments and policy interventions. The national initiatives include the Climate Change Action Programme (CCAP), and the National Adaptation Fund on Climate Change (NAFCC).

- India’s efforts at domestic mobilization of finance include the promotion of a green bond market that is the second largest emerging market for the period 2012-2019. A number of government agencies have contributed to the issuance of such green bonds including the Indian Renewable Energy Development Agency (IREDA) and the Indian Railway Finance Corporation (IRFC).
- Support to enhance capacity building is of much importance to India. All Government programs have a component on capacity building, or training or awareness creation or combinations thereof. Weather and climate forecasting and other services, and the establishment of robust energy management systems, are among key areas where capacity building is needed.
- Adequate financing is required for the adoption of viable cutting-edge technologies in India. The Government of India considers international cooperation essential and was instrumental in shaping Mission Innovation (MI) which is a global intergovernmental initiative of 25 countries on 5 continents working to accelerate clean energy innovations.
- Some of India’s identified major technology needs are in the areas of solar photovoltaic, offshore wind, advanced ultra-supercritical coal technology, biofuels, and cost-effective energy storage in order to pursue import substitution, cut high costs and dependence on international supply chains and to pursue early development and deployment of future technologies and practices.
- Since 2009-2011, patenting across a wide range of climate change mitigation technologies, from all developed countries, has fallen sharply. This raises concerns of the slowing down of climate related technology development, instead of taking the lead in such innovation, in the developed countries, in the absence of legally binding commitments to emissions reduction on their part.
- India has been contributing increasingly to South-South co-operation in climate change, especially with small island developing states and other countries in India's neighborhood. Since 2005-06, India's development partnerships have led to more than 307 Lines of Credit, aggregating to the value of USD 31.61 billion, being extended to 64 countries in various sectors.

Chapter 5
Finance, Technology and Capacity-building Needs and Support Received

5.1 Introduction

As required by Section V of Annex III to Decision 2/CP.17, this chapter provides updated information on financial resources, technology transfer, capacity-building, and technical support received by India from the Global Environment Facility (GEF), Parties included in Annex II to UNFCCC, the Green Climate Fund (GCF) and multilateral institutions, and other developed country Parties for activities relating to climate change, including the preparation of the current BUR. For the development and transfer of technology, the chapter provides information on nationally determined technology needs and support received.

The present chapter covers information on the finance, technology, capacity-building needs, gaps, and support received.

As India is a vast, diverse country battling several socio-economic and environmental challenges, the information in the chapter should be considered provisional, partial, and non-exhaustive.

India has been consistently reporting on constraints and gaps and related financial, technical and capacity-building needs periodically since 2004 with the submission of Initial National Communication to UNFCCC and thereafter, the Second National Communication in 2012, the First BUR in 2016, and the Second BUR in 2018. The country's identified constraints and gaps were reiterated further in the International Consultation and Analysis (ICA) conducted by UNFCCC for BUR-1 in 2017 and BUR-2 in 2019 and were documented in the respective Summary Reports prepared by the Team of Technical Experts (TTE). However, these clearly expressed, documented, and publicly available financial, technical, and capacity-building needs and requirements remain largely unmet. Therefore, this chapter should be read in conjunction with the information furnished by the GoI to UNFCCC since 2004.

5.1.1 Context

The reporting context of this BUR is significant both from the global and India's perspective. Globally, the year 2019 witnessed, on the one hand, an unprecedented increase in the concentration of greenhouse gases, particularly CO_2, heatwaves, and weather-related damages across the world. On the other hand, there is a growing volume of robust scientific evidence urging climate action. For India, the year 2019 was the seventh warmest year on the record (since nation-wide records commenced in 1901), while annual rainfall over the country was 109 per cent of its Long Period Average (LPA) value for the period 1961-2010 (IMD, 2020). Globally, India is the 2nd most affected country by floods, which have accounted for 44 per cent of all disaster events from 2000 and 2019. India experienced an average 17 flood events per year, affecting approximately 345 million people. According to the latest report published by the United Nations Office for Disaster Risk Reduction (UNDRR), India ranks third in the highest number of disaster events recorded over the last 20 years, almost 321 (UNDRR, 2020). According to Global Climate Risk Index 2020, India was one of the topmost affected countries due to climate change in 2018, incurring losses of USD 37 billion and 2081 deaths, both highest globally in absolute terms (Germanwatch, 2020). The economic loss was nearly twice that India lost between 1998 and 2017 USD 79.5 billion (UNISDR, 2018).

The super cyclonic storm Amphan with wind speeds of 190 kmph caused widespread damage in coastal areas of West Bengal and Odisha in May 2020. The GoI has announced an immediate interim relief and recovery package of INR 15 billion for both the States (PIB, 2020a, 2020b). The economic cost of loss and damage caused by weather-related events is huge for a developing country like India. Floods in the city of Mumbai and Chennai have caused loss of assets, livelihoods and access to basic services, which had short to medium term financial implications on households' attempt to rebuild lives and restore assets to pre-flood levels (Patankar, 2019). Moreover, small businesses, because of their limited technical and financial capacity for effective business continuity plans, are more vulnerable than large businesses during natural disasters such as floods. These findings make it important to assess the long-term economic impacts of extreme events on the poor and the need for a protective social safety net to prevent them from falling further into poverty and debt.

India is one of the worst-hit countries by the COVID-19 pandemic. The measures undertaken to control the pandemic have placed a severe strain on India’s economy and resources. The COVID-19 pandemic and the consequent lockdowns have had their impact on both demand and supply-side elements of the economy (TIFAC, 2020). It has adversely impacted the manufacturing and services sector, taken a toll on urban and rural employment and negatively impacted household income and consumption, especially of daily wage earners and those belonging to the unorganized sector. Close on the heels of the pandemic, India also had to grapple with several weather-related extreme events.

India is a developing country with limited financial resources that are being over-stretched to provide relief and rebuild disaster-hit populations, livelihoods and local and regional economies. Climate-induced events and disasters are growing, putting an enormous, additional, and unjustified burden on the country’s developmental challenges. This underlines the importance of strengthening scientific research, applying technology, and proactive planning to ensure the health and security of the people and sustainable development in the face of natural disasters and climate-induced extreme events. However, meaningful progress in this direction can only be made by India when the commitments by developed countries of providing new, additional, climate-specific finance, technology transfer and support to developing countries are fulfilled in a time-bound manner.

5.2 Financial needs and support received

Three cardinal points need to be recognized concerning the question of climate finance.

First, India has always emphasized the responsibility of the developed countries as enshrined in the Convention, and thus their commitment as signatories, that climate finance has to be new and additional to development finance. However, this commitment has neither been adhered to in practice, nor is it even possible to determine exactly the extent of non-compliance due to the plethora of issues that afflict international climate finance accounting. India has repeatedly drawn the international community's attention to this issue over several years (MoF, 2015).

Second, climate change mitigation and climate action are increasingly becoming a fashionable conditionality on all aid to developing countries, in the name of sustainable development. This tantamount to asking the victims of global warming to partake in solving the problem, while little is being done by those overwhelmingly responsible for the problem to curb their resource-intensive production systems and profligate lifestyles and the consequent emissions.

Third, India’s need in climate finance stems from both mitigation and adaptation. However, as the developed countries continually delay climate action to reduce GHG emissions rapidly and effectively, having reduced annual non-LULUCF emissions from 1990 to 2018 by a mere 12.5 per cent (with non-EIT (Economies In Transition) Parties contributing a mere 1.5 per cent) (SBI, 2020), they are constantly contributing to increasing the impact of global warming and thus the need for adaptation. This, in turn is constantly adding to India’s adaptation burden that is already considerable.

5.2.1 The International context in climate finance

The flow of climate finance needs to be contextualized in the light of the ongoing discussions and negotiations under the UNFCCC. This section deals with the immediate issues relating to the short-term commitments made by Annex-I Parties and the global performance in relation to these commitments. These issues have been succinctly summarized in the discussion paper of the Department of Economic Affairs, Ministry of Finance, GoI (DEA, 2018). The discussion paper points out serious shortcomings in the scope, scale, and speed of the climate finance made available to developing countries by Annex I countries, by multilateral development banks, and multilateral climate funds, including UNFCCC funds. Further, it notes various shortcomings in defining, tracking, and reporting climate finance.

The Report of the "Sub-Committee for the Assessment of the financial requirements for implementing India's Nationally Determined Contribution (NDC)", of the Department of Economic Affairs, Ministry of Finance, Government of India (DEA, 2020) notes that the scale of the climate finance made available to developing countries is currently inadequate to meet their mitigation goals and adaptation needs. At COP 15 at Copenhagen in 2009, the developed countries had collectively committed to jointly mobilizing 100 billion USD annually by 2020 to provide support to developing countries to mitigate and adapt to climate change. However, this goal is acknowledged to be inadequate in relation to developing countries' needs, including India's. The Adaptation Finance Gap Report 2016 of the UNEP estimated that the annual costs of adaptation alone could range from USD 140 billion to USD 300 billion by 2030 (UNEP, 2016). The report also noted that the currently available adaptation finance is significantly lower than the needs expressed in the NDCs, which have been estimated at over USD 50 billion per year for fifty non-Annex I countries for the period 2020 to 2030, and much lower than the estimated costs of adaptation.

On the question of speed, the Annex II countries have made remarkably slow progress in achieving even the annual 100 billion USD climate finance target (DEA, 2020). The Conference of Parties (COPs) 21 in Paris in 2015 addressed this by extending the target year for the USD 100 billion mobilization goal to 2025. The sources and governance of climate finance have been discussed at length and is an intensely debated issue at COP meetings. Even after 25 years of climate change negotiations, international and independent scholarly literature notes that there is still no adequate system for defining, categorizing, tracking, reporting, and ensuring transparency in international climate change finance (DEA, 2018; Khan et al., 2020; Weikmans and Roberts, 2019). Further, poorly harmonized accounting and reporting practices pose a challenge for tracking potential sectoral or geographical gaps in the financial means that are needed for mitigation and adaptation in developing countries (Weikmans and Roberts, 2019; DEA, 2018).

While acknowledging such gaps, the UNFCCC's Standing Committee on Finance (SCF) 2018 Biennial Assessment of climate finance flows reported that the climate-specific finance provided by Annex II countries to developing countries, as reported in their Biennial Reports, amounted to only 26.61 billion USD in 2014 and 32.98 billion USD in 2015, falling short of the 100 billion USD annual target (SCF, 2018). Concessional loans formed 52 per cent surpassing grants (47 per cent) as the dominant mode of provision of bilateral finance.

The total amounts channeled through UNFCCC funds and multilateral climate funds in 2015 and 2016 were only USD 1.4 billion and USD 2.4 billion, respectively. On the whole, this represents a decrease in UNFCCC and multilateral climate funds by 13 per cent over the previous 2013-2014 biennium. Of these flows, 51 per cent were in the form of grants and 44 per cent in concessional loans. Multilateral development banks' climate finance flow to OECD-Development Assistance (DAC) countries, minus

Republic of Korea, came to USD 1.7 billion in 2015 and USD 19.7 billion in 2016. However, most of this assistance is in the form of concessional loans (74 per cent) rather than grants, which comprised only 9 per cent of the assistance.

Regarding the scope of climate finance, despite the repeated calls for maintaining a balance between adaptation and mitigation finance, and such a provision being enshrined in the Paris Agreement (Article 9.4), climate finance has remained skewed towards mitigation. The SCF's Biennial Assessment Report 2018 finds that in 2015 and 2016, out of the annual average of 31.7 billion USD of bilateral climate finance, 50 per cent went to mitigation and 29 per cent to adaptation. In the same period, 53 per cent of multilateral climate funds (of the annual average of 1.9 billion USD) and 79 per cent of multilateral development banks (MDBs) climate finance (of annual average of 24.4 billion USD) went towards supporting mitigation. Support for adaptation constituted 25 per cent for multilateral climate funds and 21 per cent for MDBs climate finance (SCF, 2018).

Even the Adaptation Fund has pledged less than USD 1 billion (as of September 2019). The Adaptation Fund managed to mobilize only USD 90 million in New Pledges for 2019 at COP 25 from 11 different national and regional governments (Adaptation Fund, 2019).

Moreover, many developing countries lack the capacity and resources to effectively track climate finance and need support in the form of technical assistance and capacity building to develop such capabilities.

5.2.2 Financial needs

India's financial needs to fulfill its obligations under the Convention and the Paris Agreement are enormous and multiplying rapidly in the present-day context. This increases India's financial needs to pursue both a low-carbon development pathway, dealing with all development deficits, while simultaneously dealing with the growing impacts of extreme events and other consequences of global warming. Such a transition to a low carbon economy while continuously weathering climate-induced events and disasters is a costly affair that requires new, additional, and climate-specific financial resources.

India's submission of its INDCs had noted, in section 5.1, the following financial needs for its implementation. (i) Preliminary estimates indicated that India would need around USD 206 billion (at 2014-15 prices) between 2015 and 2030 for implementing adaptation actions in agriculture, forestry, fisheries infrastructure, water resources and ecosystems. (ii) Apart from this there will be additional investments needed for strengthening resilience and disaster management. (iii) An Asian Development Bank Study on assessing the costs of climate change adaptation in South Asia indicated that approximate adaptation costs for India in the energy sector alone would be roughly USD 7.7 billion in 2030s. The report also projected the economic damage and losses in India from climate change would be around 1.8 per cent of its GDP annually by 2050. (iv) Mitigation requirements were even more onerous. Estimates by NITI Aayog indicated that the mitigation activities for moderate low carbon development would cost around USD 834 billion till 2030 at 2011 prices.

India's INDC submission also noted that a substantial scaling up of the climate action plans would require greater resources and that a detailed and full scale assessment of international climate finance needs would be finalized at a later stage. It would depend on the gap between the actual cost of implementing India's plans and what could be made available from domestic sources. Overall, the INDC submission provided a preliminary estimate, suggesting that at least USD 2.5 trillion (at 2014-15 prices) would be required for meeting India's climate change actions between 2015 and 2030.

5.2.3 Support received

The Tables below provide information on climate finance committed to India through various channels: a) UNFCCC funds (GEF, Green Climate Fund (GCF), Adaptation Fund) and other multilateral climate funds (Clean Technology Fund (CTF)); b) climate-specific finance through bilateral and regional channels; c) Multilateral development banks (International Bank for Reconstruction and Development (IBRD) and International Development Association (IDA) of the World Bank group, Asian Development Bank (ADB) and New Development Bank. Improving the reporting in India's previous BURs, these Tables seek to provide more complete and disaggregated information on climate finance. However, the figures here are drawn only from the websites and other open sources of the entities involved. The claims of specificity to climate finance, either wholly or in part, are by the entities. These may not meet the criteria provided in the Convention and articulated by India to the global community.

The climate finance information from multilateral funds and multilateral development is prejudiced by many issues, raising serious questions of transparency as India noted some years ago (MoF, 2015), and the situation has not substantially changed since. For instance, in cross-cutting projects, the methodology followed for attributing the percentage of finance to mitigation and adaptation is not explicit, raising questions of transparency and comparability. In the case of non-energy infrastructure projects, it was not even clear how the contribution of climate finance was calculated; for example, in rural roads projects.

Data collection on bilateral channels was more difficult because of the lack of proper reporting by various overseas development agencies and the difficulties faced by government ministries in India. The Table on bilateral channels therefore is fairly indicative but not exhaustive.

For all the channels, only projects that have been approved for implementation and the approved amount (notwithstanding the actual disbursal) were included. Consequently, approved concept notes under GEF-7, for example, are not included in the Table.

As noted in the earlier section on international context for climate finance, the Tables clearly show that internationally available climate finance to India remains skewed towards mitigation rather than adaptation, and towards concessional loans instead of grants. More importantly, much of the finance made available by these sources, whether grants or loans, have perforce to be accompanied by co-financing that India has to generate internally, often from public funding. In many projects, the external funding is overshadowed by the domestic funding that is mobilized. These projects also, right from the inception stage to implementation and evaluation, generate valuable economic and market information for agencies and actors from developed countries that provide them, gratis, with perspectives on the Indian economy for future investment and participation in future projects.

In fact, as Table 5.1 clearly shows, the domestic mobilization fully overshadows the sum total of GCF and GEF funding. While GEF and GCF have provided grants to a total of 165.25 million USD, the corresponding domestic mobilization amounts to 1.374 billion USD. Thus, domestic mobilization amounts to 8.3 times the grants provided by GCF and GEF. In the one loan provided by GCF, the amount is matched by an equal amount of domestic private mobilization and 50 million USD of other private equity. In the case of CTF loans, since the implementing agencies are MDBs these have co-financing as a rule. Other finance, made available through MDBs, are largely packaged into other projects which as a rule require co-financing by GoI and State governments.

The GCF finance to India based on the latest available information, amounts to only USD 177 million (since inception), out of which only USD 77.8 million is grant-based finance. For the developing countries, the estimated costs for implementing NDCs would be much more than USD 4 trillion. GCF's first replenishment (2020-2023) process saw 28 countries pledging an amount of USD 9.7 billion, which is even quantitatively lower than the Initial Resource Mobilization (in 2014). If the current trend prevails, these funds will drastically fall short of meeting the requirements.

During the reporting period, besides the Small Industries Development Bank of India (SIDBI) and NABARD, three agencies from India have attained the status of GCF's direct access accredited entities. These are IDFC Bank Limited (IDFC Bank), IL&FS Environmental Infrastructure and Services Limited (IEISL) and Yes Bank Limited (Yes Bank).

GEF, the interim operating entity of the financial mechanism of UNFCCC, financed about USD 5.6 billion in the last 27 years for mitigation. The funds for GEF-7 replenishment (2018-2022) are lower than GEF-6 and the funds under climate change focal area have also reduced. Consequently, India's STAR allocation declined by almost 50 per cent from GEF-6 (USD 87.88 million) (GEF, 2014) to GEF-7 (USD 47.24 million) (GEF, 2018). India has about 8.45 per cent of total GEF-7 STAR indicative allocation under climate change.

During the reporting period, India has also accessed climate change-related projects through the World Bank (WB), Asian Development Bank (ADB), New Development Bank (NDB), Climate Investment Fund (CIF), Swiss Development Cooperation (SDC) and GiZ. A large number of these projects also involve co-financing by government of India, the state governments or other domestic sources of funding.

Finance accessed through Multilateral Development Banks (MDBs) from 2016 is listed in Table 5.2. A non-exhaustive and indicative list of finance accessed through bilateral arrangements is listed in Table 5.3. In both these Tables, as in Table 5.1, the claims to the funds being climate-specific, wholly or in part, are due to the entities and not, as India has pointed out, as specified in the Convention. In particular i) they are neither new nor additional as they are clearly bundled into ODA funding, ii) they are overwhelmingly dominated by loans and not grants, and iii) they are dominated by mitigation and not balanced adequately by adaptation as well.

Table 5.1: Climate finance received through multilateral climate funds

S. No.	Finance type (Grant/ Loan)	Funding institution	Project name	Support area (Mitigation, Adaptation, Cross cutting)	Sector	Funding amount (in million USD)	Co-Financing by India#	Date of approval
1	Grant	GCF*	Enhancing Climate Resilience of India's Coastal Communities	Cross-Cutting	Forestry and land use, ecosystem and ecosystem services,	43.42	86.85	20 October 2018
2	Loan	GCF	Line of credit for solar rooftop segment for commercial, industrial and residential housing sectors	Mitigation	Energy access and power generation	100.00		01 March 2018
3	Grant	GCF	Groundwater recharge and solar micro-irrigation to ensure food security and enhance resilience in vulnerable tribal areas of Odisha	Adaptation	Health and well-being, and food and water security	34.36	124.88	06 April 2017
4	Grant	GEF**	AVACLIM : Agro-ecology, Ensuring Food Security and Sustainable Livelihoods while Mitigating Climate Change and Restoring Land in Dryland Regions	Cross Cutting	Agriculture, natural resources, land degradation	0.03	---	06 September 2019
5	Grant	GEF	Cities-IAP: Sustainable Cities, Integrated Approach Pilot in India	Cross Cutting	Sustainable cities, Infrastructure	12.11	93.48	20 February 2017
6	Grant	GEF	Creating and Sustaining Markets for Energy Efficiency	Mitigation	Energy efficiency	18.86	201.96	31 May 2017
7	Grant	GEF	Grid-Connected Rooftop Solar Program	Mitigation	Solar energy	22.94	2.00	20 September 2016
8	Grant	GEF	Green-Ag: Transforming Indian Agriculture for Global Environmental Benefits and the Conservation of Critical Biodiversity and Forest Landscapes	Cross Cutting	Agriculture, biodiversity, land degradation	33.56	864.89	17 May 2018
9	Loan	CTF***	Development Policy Loan to Promote Inclusive Green Growth and Sustainable Development in Himachal Pradesh	Mitigation	Renewable energy	100.00		2019
10	Loan	CTF	Partial Risk Sharing Facility for Energy Efficiency	Mitigation	Energy efficiency	25.00		2019

S. No.	Finance type (Grant/ Loan)	Funding institution	Project name	Support area (Mitigation, Adaptation, Cross cutting)	Sector	Funding amount (in million USD)	Co-Financing by India[#]	Date of approval
11	Loan	CTF	Rajasthan Renewable Energy Transmission Investment Program (Multi-tranche Financing Facility / MFF)	Mitigation	Renewable energy	200.00		2019
12	Loan	CTF	Shared Infrastructure for Solar Parks	Mitigation	Renewable energy	50.00		2019
13	Loan	CTF	Grid-Connected Rooftop Solar Program	Mitigation	Renewable energy	125.00		2019
14	Loan	CTF	Innovations in Solar Power and Hybrid Technologies	Mitigation	Renewable energy	50.00		2019
15	Loan	CTF	Solar Rooftop Investment Program Guaranteed by India	Mitigation	Renewable energy	175.00		2019
16	Loan	CTF	Proposed Loan Power Grid Corporation of India Limited Solar Power Transmission Sector Project Guaranteed by India	Mitigation	Renewable energy	50.00		2019
17	Grant	Adaptation Fund****	Building Adaptive Capacities of Communities, Livelihoods and Ecological Security in the Kanha-Pench Corridor of Madhya Pradesh	Adaptation	Forestry	2.56		10 July 2016
18	Grant	Adaptation Fund	Building Adaptive Capacities of Small Inland Fishermen Community for Climate Resilience and Livelihood Security, Madhya Pradesh, India	Adaptation	Food security	1.79		04 October 2015
19	Grant	Adaptation Fund	Climate smart actions and strategies in north western Himalayan region for sustainable livelihoods of agriculture-dependent hill communities	Adaptation	Agriculture	0.97		10 September 2015
20	Grant	Adaptation Fund	Climate Proofing of Watershed Development Projects in the States of Tamil Nadu and Rajasthan	Adaptation	Water management	1.34		10 September 2015

S. No.	Finance type (Grant/ Loan)	Funding institution	Project name	Support area (Mitigation, Adaptation, Cross cutting)	Sector	Funding amount (in million USD)	Co-Financing by India#	Date of approval
21	Grant	Adaptation Fund	Enhancing Adaptive Capacity and Increasing Resilience of Small and Marginal Farmers in Purulia and Bankura Districts of West Bengal	Adaptation	Agriculture	2.51		10 October 2014
22	Grant	Adaptation Fund	Conservation and Management of Coastal Resources as a Potential Adaptation Strategy for Sea Level Rise	Adaptation	Coastal management	0.69		10 October 2014

*GCF data for India is for all commitments till date.
#As extracted from available sources. Absence of co-financing figures for some projects only indicates non availability of data and does not necessarily imply that no co-financing was provided.
**Only projects approved for implementation from GEF-6 onwards are included.
***The reporting date for all CTF finance is 2019. The project may have been approved earlier.
****Adaptation Fund finance received from the year 2014 onwards
Note: i) The information in the table is taken from the entity provided material on their website or other open sources. These are not from any database of the Government of India or a database verified by GoI.
ii) The classification of Support Area and Sector for each project is as designated and claimed by the agency and may not reflect accurately the nature of the project on the ground or the relative weight of different sectors in the project.
iii) Some CTF projects may also be listed in Table 5.2. This is not double counting but reflects co-financing by MDBs along with CTF.
iv) Several projects are classified and claimed as fully or partially climate-specific by the entities. These may not meet the criteria for climate finance as provided by the Convention and articulated by India to the global community for consideration as part of climate support and climate finance.

Table 5.2: Multilateral development banks climate finance for India from year 2016 onwards

S. No.	Finance type (Grant/Loan)	Funding institution	Project name	Sector	Total commitment (million USD)	Climate finance (%) as claimed by the concerned entity	Climate focus	Adaptation finance (million USD)	Mitigation finance (million USD)	Date of approval of project
1	Loan	IBRD *	Uttar Pradesh Core Road Network Development Project	Transport	400	30.85%	Cross cutting	88.3	35.11	29 March 2019
2	Loan	IBRD	Rajasthan State Highways Development Program II	Transport	250	30.50%	Cross cutting	54	22.5	29 March 2019
3	Loan	IBRD	Second Programmatic Electricity Distribution Reform DPL for Rajasthan	Energy and extractives	250	50%	Mitigation	0	125	07 May 2018
4	Loan	IBRD	Innovation in Solar Power and Hybrid Technologies	Energy and extractives	150	100%	Mitigation	0	150	29 March 2019
5	Loan	IBRD	AP Integrated Irrigation & Agriculture Transformation Project	Agriculture and food	172.2	90.66%	Cross cutting	148.82	7.3	23 October 2018
6	Loan	IBRD	Jharkhand Municipal Development Project		147	31.15%	Cross cutting	40.23	5.56	12 December 2018
7	Loan	IBRD	Jharkhand Power System Improvement Project	Energy and extractives	310	29.30%	Mitigation	0	90.84	10 January 2018
8	Loan	IBRD	Uttarakhand Disaster Recovery Project Additional Financing	Social, urban, rural and resilience	96	64.70%	Adaptation	62.11	0	21 February 2019
9	Loan	IBRD	Tamil Nadu Health System Reform Program	Health nutrition and population	287	3.71%	Adaptation	10.64	0	19 March 2019
10	Loan	IBRD	Uttarakhand Public Financial Management Strengthening Project	Governance	31.58	1.39%	Cross cutting	0.22	0.22	03 July 2019
11	Loan	IBRD	Dam Rehabilitation & Improvement Project - Restructuring and Additional Financing	Water	137	100%	Adaptation	137	0	28 February 2019
12	Loan	IBRD	Shimla Water Supply and Sewerage Service Delivery Reform Programmatic Development Policy Loan 1	Water	40	29.98%	Cross cutting	2.14	9.85	16 January 2019
13	Loan	IDA	The First Resilient Kerala Program Development Policy Operation	Social, urban, rural and resilience	250	90.63%	Cross cutting	210.95	15.62	27 June 2019

S. No.	Finance type (Grant/Loan)	Funding institution	Project name	Sector	Total commitment (million USD)	Climate finance (%) as claimed by the concerned entity	Climate focus	Adaptation finance (million USD)	Mitigation finance (million USD)	Date of approval of project
14	Loan	IBRD	Madhya Pradesh Rural Connectivity project	Transport	210	89.30%	Adaptation	187.54	0	14 March 2018
15	Loan	IBRD	National Agricultural Higher Education Project	Agriculture	82.5	4.82%	Cross cutting	1.99	1.99	3 August 2017
16	Loan	IBRD	Tamil Nadu Irrigated Agriculture Modernization Project	Agriculture	318	95.84%	Cross cutting	280.83	23.94	1 December 2017
17	Loan	IBRD	Maharashtra Project on Climate Resilient Agriculture	Agriculture	420	94.21%	Cross cutting	372.58	23.1	27 February 2018
18	Loan	IBRD	Uttarakhand Water Supply Program for Peri Urban Areas	Water	120	47.72%	Cross cutting	14.96	42.3	4 January 2018
19	Loan	IBRD	National Rural Economic Transformation Project (Additional Financing to National Rural Livelihoods Project)	Agriculture	250	23.53%	Cross cutting	26.75	32.07	26 April 2018
20	Loan	IBRD	Uttarakhand Workforce Development Project	Education	74	6.77%	Cross cutting	2.48	2.53	19 June 2018
21	Loan	IBRD	Atal Bhujal Yojana (ABHY)-National Groundwater Management Improvement	Water	450	83.28%	Cross cutting	150.12	224.65	5 June 2018
22	Loan	IBRD	Meghalaya Community-led Landscapes Management Project	Environment and natural resources	48	100%	Cross cutting	14.48	33.52	13 March 2018
23	Loan	IBRD	National Nutrition Mission (also known as ICDS Systems Strengthening and Nutrition Improvement Project: Additional Financing)	Health	200	36.38%	Adaptation	72.75	0	30 March 2018
24	Loan	IBRD	India Energy Efficiency Scale-up Program		220	100%	Mitigation	0	220	17 May 2018
25	Loan	IBRD	Additional Financing for PMGSY Rural Roads Project	Transport	500	40.87%	Cross cutting	185.41	18.93	25 May 2018
26	Loan	IBRD	India Energy Efficiency Scale-Up Program Guarantee		80	100%	Mitigation	0	80	17 May 2018

S. No.	Finance type (Grant/Loan)	Funding institution	Project name	Sector	Total commitment (million USD)	Climate finance (%) as claimed by the concerned entity	Climate focus	Adaptation finance (million USD)	Mitigation finance (million USD)	Date of approval of project
27	Loan	IBRD	Tamil Nadu Rural Transformation Project (TNRTP)	Agriculture	100	2.35%	Mitigation	0	2.35	1 December 2017
28	Loan	IBRD	Assam Agribusiness and Rural Transformation Project	Agriculture	200	26.89%	Cross cutting	36.71	17.06	31 August 2017
29	Loan	IBRD	Andhra Pradesh 24X7 Power for All	Energy transmission and distribution	240	20%	Mitigation	0	48	26 May 2017
30	Loan	IBRD	Jharkhand Opportunities for Harnessing Rural Growth Project	Other Agriculture; Fishing and Forestry	100	32%	Cross cutting	20	12	26 May 2017
31	Loan	IBRD	Madhya Pradesh Urban Development Project	Sanitation	116.2	35%	Cross cutting	37.184	3.486	12 April 2017
32	Loan	IBRD	Capacity Augmentation of the National Waterway- 1 (JAL MARG VIKAS) Project	Ports/ waterways	375	100%	Mitigation	0	375	12 April 2017
33	Loan	IBRD	Shared Infrastructure for Solar Parks Project	Energy transmission and distribution	75	100%	Mitigation	0	75	30 March 2017
34	Loan	IBRD	National Hydrology Project	Other water supply; sanitation and waste management	175	100%	Mitigation	0	175	15 March 2017
35	Loan	IDA	Bihar Rural Roads Project	Rural and inter-urban roads	235	45%	Adaptation	105.75	0	21 December 2016
36	Loan	IBRD	Grid-Connected Rooftop Solar Program	Renewable energy solar	500	100%	Mitigation	0	500	13 May 2016
37	Loan	IBRD	First Programmatic Electricity Distribution Reform Development Policy Loan for Rajasthan	Energy Transmission and Distribution	250	29%	Mitigation	0	72.5	25 March 2016
38	Loan	ADB	Demand Side Energy Efficiency Sector Project	Energy	200	100%	Mitigation	0	200	30 September 2016
39	Loan	ADB	Solar Rooftop Investment Program - Tranche 1	Finance	100	100%	Mitigation	0	100	7 October 2016

S. No.	Finance type (Grant/Loan)	Funding institution	Project name	Sector	Total commitment (million USD)	Climate finance (%) as claimed by the concerned entity	Climate focus	Adaptation finance (million USD)	Mitigation finance (million USD)	Date of approval of project
40	Loan	ADB	Climate Adaptation in Vennar Sub-Basin in Cauvery Delta	Agriculture, natural resources, and rural development	100	50%	Adaptation	50	0	7 June 2016
41	Loan	ADB	Kolkata Environmental Improvement Investment Program - Tranche 2	Water and other urban infrastructure and services	200	28%	Adaptation	56.47	0	16 August 2016
42	Loan	ADB	Visakhapatnam-Chennai Industrial Corridor - Project 1	Water and other urban infrastructure and services	245	8%	Adaptation	20	0	26 September 2016
43	Gran t	ADB	Visakhapatnam-Chennai Industrial Corridor - Project 1	Water and other urban infrastructure and services	5	100%	Adaptation	5	0	26 September 2016
44	Loan	ADB	Uttar Pradesh Major District Roads	Transport	300	4%	Adaptation	12.5	0	14 April 2016
45	Loan	ADB	Bihar New Ganga Bridge Project	Transport	500	40%	Adaptation	200	0	24 June 2016
46	Loan	ADB	Madhya Pradesh District Roads II Sector Project	Transport	350	3%	Adaptation	9.8	0	30 September 2016
47	Loan	ADB	Rajasthan Renewable Energy Transmission Program - Tranche 2	Energy	238	100%	Dual benefit	2	236	5 December 2016
48	Loan	ADB	Rajasthan Renewable Energy Transmission Program - Tranche 2	Energy	110	100%	Dual benefit		110	5 December 2016
49	Loan	ADB	Sustainable Coastal Protection and Management Investment Program - Tranche 2	Agriculture, natural resources, and rural development	65.5	76%	Adaptation	50	0	27 July 2017
50	Loan	ADB	Solar Transmission Sector Project	Energy	175	100%	Mitigation		175	29 March 2017
51	Loan	ADB	Solar Transmission Sector Project	Energy	50	100%	Mitigation		50	29 March 2017
52	Loan	ADB	Karnataka State Highways Improvement III Project	Transport	346	3%	Adaptation	10.5	0	8 December 2017

S. No.	Finance type (Grant/Loan)	Funding institution	Project name	Sector	Total commitment (million USD)	Climate finance (%) as claimed by the concerned entity	Climate focus	Adaptation finance (million USD)	Mitigation finance (million USD)	Date of approval of project
53	Loan	ADB	Karnataka State Highways Improvement III Project	Transport	107	3%	Adaptation	3.5	0	8 December 2017
54	Loan	ADB	Railway Sector Investment Program - Tranche 3	Transport	120	100%	Mitigation		120	13 December 2017
55	Loan	ADB	Rajasthan State Highway Investment Program - Tranche 1	Transport	220	1%	Adaptation	2.1	0	30 May 2017
56	Loan	ADB	Second Rural Connectivity Investment Program - Tranche 1	Transport	250	6%	Adaptation	14.35	0	4 December 2017
57	Loan	ADB	Assam Urban Infrastructure Investment Program - Tranche 2	Water and other urban infrastructure and services	149	39%	Adaptation	58	0	13 December 2017
58	Loan	ADB	Bihar Urban Development Investment Program - Tranche 2	Water and other urban infrastructure and services	84	10%	Adaptation	8		4 December 2017
59	Loan	ADB	Madhya Pradesh Urban Services Improvement Project	Water and other urban infrastructure and services	275	27%	Adaptation	75		18 May 2017
60	Loan	ADB	Himachal Pradesh Clean Energy Transmission Investment Program - Tranche 3	Energy	105	100%	Dual benefit	4.37	100.63	6 November 2018
61	Loan	ADB	Madhya Pradesh Irrigation Efficiency Improvement Project	Agriculture, natural resources, and rural development	375	11%	Adaptation	42.5		31 May 2018
62	Loan	ADB	Assam Integrated Flood and Riverbank Erosion Risk Management Investment Program - Project 2	Agriculture, natural resources, and rural development	60.16	4%	Adaptation	2.7		7 December 2018
63	Loan	ADB	Assam Integrated Flood and Riverbank Erosion Risk Management Investment Program - Project 2	Agriculture, natural resources, and rural development		NA	Adaptation	0.5		07 December 2018

S. No.	Finance type (Grant/Loan)	Funding institution	Project name	Sector	Total commitment (million USD)	Climate finance (%) as claimed by the concerned entity	Climate focus	Adaptation finance (million USD)	Mitigation finance (million USD)	Date of approval of project
64	Loan	ADB	Accelerating Infrastructure Investment Facility in India - Tranche 3	Finance	300	20%	Mitigation		60	23 October 2018
65	Loan	ADB	Second Rural Connectivity Investment Program - Tranche 2	Transport	110	6%	Adaptation	6.16		12 September 2018
66	Loan	ADB	South Asia Subregional Economic Cooperation Road Connectivity Investment Program- Tranche 2	Transport	150	29%	Adaptation	44.2		13 August 2018
67	Loan	ADB	Bihar State Highways III Project	Transport	200	8%	Adaptation	15.35		15 November 2018
68	Loan	ADB	West Bengal Drinking Water Sector Improvement Project	Agriculture, natural resources, and rural development	240	25%	Adaptation	60		29 August 2018
69	Gran t	ADB	West Bengal Drinking Water Sector Improvement Project	Agriculture, natural resources, and rural development	3	0%	Adaptation			29 August 2018
70	Loan	ADB	Infrastructure Development Investment Program for Tourism - Tranche 4	Water and other urban infrastructure and services	31	2%	Mitigation		0.49	28 September 2018
71	Loan	ADB	Karnataka Integrated Urban Water Management Investment Program- Tranche 2	Water and other urban infrastructure and services	75	14%	Adaptation	10.338		17 October 2018
72	Loan	ADB	Kolkata Environmental Improvement Investment Program-Tranche 3	Water and other urban infrastructure and services	100	55%	Dual benefit	40	15	13 August 2018
73	Loan	ADB	Tamil Nadu Urban Flagship Investment Program - Tranche 1	Water and other urban infrastructure and services	169	77%	Dual benefit	31.82	98.57	28 September 2018

S. No.	Finance type (Grant/Loan)	Funding institution	Project name	Sector	Total commitment (million USD)	Climate finance (%) as claimed by the concerned entity	Climate focus	Adaptation finance (million USD)	Mitigation finance (million USD)	Date of approval of project
74	Grant	ADB	Tamil Nadu Urban Flagship Investment Program - Tranche 1	Water and other urban infrastructure and services	2	100%	Dual benefit		2	28 September 2018
75	Grant	ADB	Demand-Side Energy Efficiency Sector Project – Additional Financing	Energy	13	100%	Mitigation		13	12 September 2018
76	Loan	ADB	Chennai-Kanyakumari Industrial Corridor: Power Sector Investment Project	Energy	451	35%	Dual-use	24.5	131.9	4 November 2019
77	Loan	ADB	Scaling Up Demand-Side Energy Efficiency Sector Project	Energy	250	43%	Mitigation		108.3	27 November 2019
78	Loan	ADB	Scaling Up Demand-Side Energy Efficiency Sector Project	Energy	46	100%	Mitigation		46	27 November 2019
79	Loan	ADB	Karnataka Integrated and Sustainable Water Resources Management Investment Program - Tranche 2	Agriculture, natural resources and rural development	91	15%	Adaptation	13.8		4 October 2019
80	Loan	ADB	Maharashtra Rural Connectivity Improvement Project	Agriculture, natural resources and rural development	200	17%	Dual-use	22.117	11.112	7 August 2019
81	Loan	ADB	Mumbai Metro Rail Systems Project	Transport	926	100%	Mitigation		926	26 February 2019
82	Loan	ADB	Rajasthan State Highway Investment Program - Tranche 2	Transport	190	7%	Adaptation	14.1		13 September 2019
83	Loan	ADB	Chhattisgarh Road Connectivity Project	Transport	350	9%	Adaptation	30.311		31 May 2019
84	Loan	ADB	Public-Private Partnership in Madhya Pradesh Road Sector Project	Transport	490	17%	Adaptation	82.2		04 November 2019

S. No.	Finance type (Grant/Loan)	Funding institution	Project name	Sector	Total commitment (million USD)	Climate finance (%) as claimed by the concerned entity	Climate focus	Adaptation finance (million USD)	Mitigation finance (million USD)	Date of approval of project
85	Loan	ADB	Tamil Nadu Urban Flagship Investment Program- Tranche 2	Water and other urban infrastructure and services	206	47%	Dual-use	25.03	71.72	26 November 2019
86	Loan	NDB	Canara Renewable Energy Financing Scheme	Renewable energy	250	100%	Mitigation		250	13 April 2016
87	Loan	NDB	REC Renewable Energy Sector Development Project	Renewable energy	300	100%	Mitigation		300	14 October 2019

*IBRD has approved some projects for India in late 2019 and 2020. However, they are not included in the table because the websites for the project have not yet updated the percentage of climate finance in the approved projects.

Note: (i) The information in the table is taken from the entity provided material on their website or other open sources. These are not from any database of the Government of India or a database verified by GoI.

(ii) In the projects above, the climate finance component is as designated and claimed by the agencies.

(iii) Several projects are classified and claimed as fully or partially climate-specific by the entities. These may not meet the criteria for climate finance as provided in the Convention and articulated by India to the global community for consideration as part of climate support and climate finance.

(iv) It is evident from the table that, as India has repeatedly noted, the majority of flows reported are not new and additional, are overwhelmingly loans and not grants and that too dominated by mitigation rather than adaptation.

(v)The classification of climate focus and Sector for each project is as designated and claimed by the agencies, and may not reflect accurately the nature of the project on the ground or the relative weight of different sectors in the project.

Table 5.3: Climate finance received by India from bilateral sources from the year 2014 onwards

S. No.	Finance flows type (Grant/Loan)	Funding institution	Country	Project name	Support area (Mitigation, Adaptation, Cross cutting)	Sector	Funding amount (in million USD)	Date of project approval
1	Loan	KfW/BMZ	Germany	Indo-German Solar Energy Partnership (IGSP)	Mitigation	Energy	EUR 550 million pledged so far*	2017

S. No.	Finance flows type (Grant/Loan)	Funding institution	Country	Project name	Support area (Mitigation, Adaptation, Cross cutting)	Sector	Funding amount (in million USD)	Date of project approval
2	Grant	BMZ	Germany	Indo-German Energy Programme – Green Energy Corridors (IGEN-GEC)	Mitigation	Energy	19	21 April 2015
3	Grant	BMZ	Germany	Indo-German Solar Partnership – PV Roof Top	Mitigation	Energy	10	29 September 2017
4	Grant	BMZ	Germany	Promotion of Solar Water Pumps	Mitigation	Energy	6	25 September 2017
5	Grant	BMZ	Germany	IGEN - Energy transition with power authorities	Mitigation	Energy	10	8 November 2019
6	Grant	BMZ	Germany	Sustainable industrial development	Mitigation	Industry	5	1 March 2019
7	Grant	BMZ	Germany	Climate Adaptation and Financing in Rural India (CAFRI)	Adaptation		5	18 November 2019
8	Grant	BMZ	Germany	Integration of Renewable Energies into the Indian Electricity System	Mitigation	Energy	2	18 November 2014
9	Grant	BMZ	Germany	Support to Institutionalising Capacity Building on Climate Change in Indie (I-CCC) Support to the National Institute for Climate Change Studies and Actions (NICCSA)	Cross cutting		4	16 January 2016
10	Grant	BMZ	Germany	Climate Smart Cities	Cross cutting	Urban/Infrastructure	5	15 June 2018
11	Grant	BMZ	Germany	Wetlands Management for Biodiversity and Climate Protection	Cross cutting	Environment	4	3 August 2018
12	Grant	BMZ	Germany	Energy Efficiency in Industry and Data (IGEN-EE)	Mitigation	Energy	4	27 May 2020
13	Grant	BMZ	Germany	Introduction of Climate-friendly Cooling and Storage Technologies	Mitigation	Energy	3	13 June 2019
14	Grant	BMZ	Germany	Protection of Aquatic Ecosystems in India's Northeastern Himalaya Region	Adaptation	Environment	5	20 December 2019
15	Grant	BMZ	Germany	InsuResilience - Climate Risk Insurance	Adaptation		3	13 March 2020

S. No.	Finance flows type (Grant/Loan)	Funding institution	Country	Project name	Support area (Mitigation, Adaptation, Cross cutting)	Sector	Funding amount (in million USD)	Date of project approval
16	Grant	EU	EU	Resource Efficiency Initiative (REI)	Mitigation	Transport/Infrastructure/Energy/Waste	3	13 December 2016
17	Grant	BMC	Germany	DKTI – Integrated and Sustainable Urban Transport Systems for Smart Cities in India	Mitigation	Infrastructure	10	22 December 2016
18	Grant	BMC	Germany	Environment, Climate and Water Security	Adaptation	Water	7	1 April 2019
19	Grant	BMU	Germany	Green Freight	Mitigation	Transport	4	20 December 2018
20	Grant	BMWi	Germany	Advice on and support of bilateral energy partnerships with developing and emerging countries	Mitigation	Energy	Multi-Country Project**	2 December 2015
21		BMZ	Germany	Cities Finance Facility (CFF)	Cross cutting	Urban/Infrastructure	Multi-Country Project**	17 August 2018
22		BMU	Germany	SDG Implementation	Cross cutting		Multi-Country Project**	10 August 2017
23		BMZ	Germany	Soil Protection, Combating Desertification, Sustainable Land Management SV BoDeN	Cross cutting	Land management	Multi-Country Project**	1 June 2020
24		BMZ	Germany	Sustainability and Value Addition in Agricultural Supply Chains		Agriculture	Multi-Country Project**	13 December 2018
25		BMZ	Germany	Concepts for sustainable solid waste management and circular economy	Mitigation	Waste	Multi-Country Project**	1 July 2016
26		BMZ	Germany	Soil protection and rehabilitation for food security	Adaptation	Agriculture	Multi-Country Project**	21 November 2014
27		BMZ	Germany	Sustainable Agriculture	Adaptation	Agriculture	Multi-Country Project**	1 January 2019
28		BMZ	Germany	Green Innovation Centres in the agriculture and food sector (GIC)	Cross cutting	Agriculture	Multi-Country Project**	29 August 2014
29		BMZ	Germany	Sustainable Mobility 2.0	Mitigation	Transport	Multi-Country Project**	1 June 2019
30		BMU	Germany	Global Carbon Markets	Mitigation		1	1 July 2018
31		BMZ	Germany	Indo-German Environment Programme in Rural Areas (IGEP-RA)	Adaptation	Cross cutting	USD 84.3 million as loan and USD 5.7 million as grant was disbursed	2015

S. No.	Finance flows type (Grant/Loan)	Funding institution	Country	Project name	Support area (Mitigation, Adaptation, Cross cutting)	Sector	Funding amount (in million USD)	Date of project approval
							under one of the three project components called UPNRM. Full funding details of the project is not available.	
32	Loan	JICA	Japan	Project for Community-Based Forest Management and Livelihoods Improvement in Meghalaya	Cross cutting	Forestry	91.9	27 March 2020
33	Loan	JICA	Japan	Project for Ecosystem Restoration in Gujarat	Mitigation	Forestry	121.6	27 March 2020
34	Loan	JICA	Japan	Program for Japan-India Cooperative Actions towards Sustainable Development Goals in India	Cross cutting	Cross cutting	132.6	18 January 2019
35	Loan	JICA	Japan	Project for Renovation and Modernization of Umiam-Umtru Stage-III Hydroelectric Power Station	Mitigation	Energy	48.6	29 October 2018
36	Loan	JICA	Japan	Project for Sustainable Catchment Forest Management in Tripura	Cross cutting	Forestry	108.6	29 October 2018
37	Loan	JICA	Japan	Project for Improvement of Himachal Pradesh Forest Ecosystems Management and Livelihoods	Cross cutting	Forestry	98.4	29 March 2018
38	Loan	JICA	Japan	Nagaland Forest Management Project	Cross cutting	Forestry	55.0	31 March 2017
39	Loan	JICA	Japan	Odisha Forestry Sector Development Project (Phase 2)	Cross cutting	Forestry	128.3	31 March 2017
40	Loan	JICA	Japan	Micro, Small and Medium Enterprises Energy Saving Project (Phase 3)	Mitigation	Industry	265.2	1 September 2014
41	Loan	JICA	Japan	New and Renewable Energy Development Project (Phase 2)	Mitigation	Energy	265.2	1 September 2014
42	Loan	JICA	Japan	Uttarakhand Forest Resource Management Project	Mitigation	Forestry	100.7	11 April 2014
43	Grant	IRDC	Canada	Uptake of climate change adaptation research results in South Asia	Adaptation	Health	Multi-Country Project**	

S. No.	Finance flows type (Grant/Loan)	Funding institution	Country	Project name	Support area (Mitigation, Adaptation, Cross cutting)	Sector	Funding amount (in million USD)	Date of project approval
44	Grant	IRDC	Canada	Climate adaptive action plans to manage heat stress in Indian cities	Adaptation	Cross cutting	0.7	
45	Grant	IRDC	Canada	South Asian Water (SAWA) Leadership Program on Climate Change	Adaptation	Cross cutting	Multi-Country Project**	
46	Grant	IRDC	Canada	Integrated Rural-Urban Water Management for Climate Based Adaptation in Indian Cities (iAdapt)	Adaptation	Water	0.7	15 January 2017
47	Grant	IRDC	Canada	Climate Adaptive Water Management Plans for Cities in South Asia	Adaptation	Water	Multi-Country Project**	
48	Grant	IRDC	Canada	Deltas, Vulnerability, and Climate Change: Migration as an Adaptation	Adaptation	Cross cutting	Multi-Country Project**	2016
49	Grant	IRDC	Canada	Himalayan Adaptation, Water, and Resilience	Adaptation	Cross cutting	Multi-Country Project**	12 April 2014
50	Grant	Danida	Denmark	India-Denmark Energy Partnership	Mitigation	Energy	7.9	1 January 2019
51	Grant	UKaid	UK	Infrastructure for Climate Resilient Growth in India	Cross cutting	Cross cutting	32.5	8 January 2016
52	Grant	UKaid	UK	Supporting Structural Reform in the Indian Power Sector	Mitigation	Energy	18.6	26 February 2016
53	Grant	UKaid	UK	Technical Assistance for Smart Cities (TASC)	Cross cutting	Cross cutting	6.5	8 January 2016
54	Invest ment	UK - Prospe rity Fund	UK	UK-INDIA Partnership on National Investment and Infrastructure Fund - Green Growth Equity Fund	Mitigation	Cross cutting	155.8	26 September 2018
55	Loan	UK	UK	UK Climate Investments (UKCI)	Mitigation	Cross cutting	Project covers India and Sub-Saharan Africa. Total project funding is USD 112.6 million. Contribution to India could not be accessed.	1 June 2015

S. No.	Finance flows type (Grant/Loan)	Funding institution	Country	Project name	Support area (Mitigation, Adaptation, Cross cutting)	Sector	Funding amount (in million USD)	Date of project approval
56	Grant	SDC	Switzerland	Indian Himalayas Climate Adaptation Programme	Adaptation	Cross cutting	3.1	1 January 2016
57	Grant	SDC	Switzerland	Clean Energy Policy (CEP)	Mitigation	Energy	0.7	1 June 2018
58	Grant	SDC	Switzerland	Clean Air Project in India (CAP India)	Mitigation	Cross cutting	2.7	1 November 2019
59	Loan	SDC	Switzerland	Capacity Building for Low Carbon and Climate Resilient City Development in India (CapaCITIES)	Mitigation	Cross cutting	4.8	16 July 2019
60	Loan	Horizon 20	EU	India-EU Water Partnership	Adaptation	Water	21.3	2019

All amounts have been converted to USD using annual average exchange rates for the year 2016 as published by IRS (https://www.irs.gov/individuals/international-taxpayers/yearly-average-currency-exchange-rates)
*Indo German Solar Energy Partnership: Germany has expressed willingness to provide concessional loans of 1 billion euros in 5 years. Loans worth 550 million euros have already been pledged. KfW has signed an agreement with SBI for a loan of 150 million euros in 2017.
**Project implementation in multiple countries including India. Specific financial flows to India could not be accessed.
Note: i) The information in the table is taken from the entity provided material on their website or other open sources. These are not from any database of the Government of India or a database verified by GoI.
ii) The classification of Support Area and Sector for each project is as designated and claimed by the agencies, and may not reflect accurately the nature of the project on the ground or the relative weight of different sectors in the project.
iii) Several projects are classified and claimed as fully or partially climate-specific by the entities. These may not meet the criteria for climate finance as provided by the Convention and articulated by India to the global community for consideration as part of climate support and climate finance.
iv) It is evident from the table that, as India has repeatedly noted, the majority of flows are not new and additional, are overwhelmingly loans and not grants and that too dominated by mitigation rather than adaptation.

CDM India project portfolio: GoI had set up a National CDM Authority (NCDMA) in December 2003 which has since then accorded Host Country Approval to 3,060 projects. Of these, 1,672 have been registered by the CDM Executive Board. Till 20th May 2020, Certified Emission Reductions (CERs) issued to Indian projects amount to 252 million (or 12.49 per cent of the total CERs issued) (UNFCCC, 2020). These projects are in the sectors of energy efficiency, fuel switching, industrial processes, municipal solid waste, renewable energy, and forestry which are spread across the country. The sector-wise details are presented in Table 5.4.

Table 5.4: Host country approval of the CDM Projects by the National CDM Authority

(as in March 2020)

Sector	Number of projects
Energy industries (renewable-/ non-renewable sources)	2,425
Energy distribution	9
Energy demand	228
Manufacturing industries	243
Chemical industries	18
Construction	0
Transport	13
Mining/mineral production	4
Metal production	5
Fugitive emissions from fuels (solid, oil and gas)	4
Fugitive emissions from (production and consumption of halocarbons and sulphur hexafluoride	6
Solvent use	0
Waste handling and disposal	73
Afforestation and reforestation	28
Agriculture	4
Total	**3,060**

In the context of the implementation of the Paris Agreement, it is important that the CERs allocated so far are duly honoured by the multilateral climate regime. Any failure to do so would severely undermine trust and faith in the multilateral climate regime in the years to come and would be a serious setback to global climate action and global cooperation.

The developing world, including India have also been aware that carbon offsets are part of the means through which the developed countries have sought to lessen their mitigation burden by seeking to reduce emissions in the former’s national territories in exchange for CER credits. However, India, in the spirit of international co-operation, is participating in international carbon offsets under the Kyoto Protocol. It may be reiterated though, that rapid and deep decarbonization of developed country economies cannot be held up on account of uncertainties with regard to carbon offset schemes under the Paris Agreement, nor can such uncertainties be presented as the rationale for delay in rapid mitigation action.

5.2.4 National Initiatives

India’s climate actions are largely financed from domestic sources, including government budgetary support as well as a mix of market mechanisms and fiscal instruments and policy interventions. The eight missions under the National Action Plan for Climate Change (NAPCC), namely solar power, energy efficiency, habitat, water, agriculture, forestry, Himalayan ecosystem, and knowledge management have specific budgetary allocations combined with other sources of funding.

Climate Change Action Programme (CCAP) is a GoI scheme that was approved in January 2014 at a total cost of INR 2,900 million for five years (MoF, 2020). The allocation of funds for the FY 2017-18 to 2020-21 is INR 1,724 million. Its objective is to create and strengthen the scientific and analytical capacity to assess climate change in the country, putting in place an appropriate institutional framework for scientific and policy initiatives and implementation of climate change-related actions. Demonstration projects have been approved to support the implementation of State Action Plans on Climate Change under Climate Change Action Programme (CCAP) of MoEFCC. These projects are Enhancing Adaptive Capacity to Climate Change through Conservation of Traditional Water Supply Sources (wells and *bawadis*) of Indore city, in Madhya Pradesh; Coastal habitat rehabilitation for climate change adaptation in Gulf of Mannar, South-eastern India; Improving ecosystem services and fisheries livelihood in Tamil Nadu; Technological adaptation for gainful utilization of paddy straw in Punjab; Enhancing Adaptive Capacity to Climate Change through Conservation of Traditional Water Supply Sources of Burhanpur city, in Madhya Pradesh.

National Adaptation Fund on Climate Change (NAFCC) is another scheme which was launched in 2015 with an initial outlay of INR 3,500 million to fund adaptation actions that are not otherwise covered under the ongoing schemes/ programs. The allocation of funds till 31 March 2020 is INR 4,706.80 million. Thirty projects worth INR 8,474.70 million have been approved by NAFCC and these projects are at different stages of implementation. These projects are being implemented in 26 Indian States in agriculture, water, forestry and coastal sectors to enhance 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 5.5.

Table 5.5: List of approved projects under NAFCC (NABARD, 2020) (as in March 2020)

S. No.	States/ UTs	Project title	Executing Entity	Project Outlay (INR in million)
1	Andhra Pradesh	Climate Resilient Interventions in Dairy Sector in Coastal and Arid Areas in Andhra Pradesh	Department of Animal Husbandry, Government of Andhra Pradesh	198.3

S. No.	States/ UTs	Project title	Executing Entity	Project Outlay (INR in million)
2	Arunachal Pradesh	Addressing Climate Change Vulnerability of Papum-Poma River for Conservation and Recharging of its Spring,	Environment and climate change centre, State Climate change cell	239.2
3	Assam	Management of Eco-system of Kaziranga National Park by Creating Climate Resilient Livelihood for Vulnerable Communities	Kaziranga National Park (KNP) under Department of Environment & Forests (DoEF), Government of Assam	245.7
4	Bihar	Scaling up Climate Smart Agriculture (CSA) through Mainstreaming Climate-Smart Villages (CSVs) in Bihar	Department of Agriculture, Government of Bihar	230.6
5	Chhattisgarh	Climate Adaptation Strategies in Wetlands along with Mahanadi River Catchment areas in Chhattisgarh	State Centre for Climate Change, Dept. of Forest, Govt. of Chhattisgarh	214.7
6	Gujarat	Climate change adaptation for natural resources dependent communities in Kachchh, Gujarat: strengthening resilience through water and livelihood security and ecosystem restoration	Gujarat Ecological Education and Research (GEER) Foundation	213.6
7	Haryana	Scaling up climate-smart agriculture through mainstreaming climate-smart villages in Haryana	Department of Agriculture, Government of Haryana	221.0
8	Himachal Pradesh	Sustainable Livelihoods of Agriculture-Dependent Rural Communities in Drought Prone District of Himachal Pradesh Through Climate Smart Solutions	Department of Environment, Science and Technology, Government of Himachal Pradesh	200.0
9	Jammu and Kashmir	Climate Resilient Sustainable Agriculture in Rain-Fed Farming (Kandi) Areas of Jammu and Kashmir	Agriculture Production Department, Government of Jammu and Kashmir	225.2
10	Jharkhand	Enhancing Climate Resilience of Forests and its dependent Communities in two landscapes of Jharkhand	Department of Forest, Government of Jharkhand	249.9
11	Karnataka	Conservation and Management of Indigenous Varieties of Livestock (Cattle and Sheep) in the wake of Climate Change in Karnataka	Department of Animal Husbandry and Veterinary Services, Government of Karnataka	242.2
12	Kerala	Promotion of Integrated Farming System of Kaipad and Pokkali in Coastal Wetlands of Kerala	Government of Kerala	250.0

S. No.	States/ UTs	Project title	Executing Entity	Project Outlay (INR in million)
13	Madhya Pradesh	Enhancing Adaptive Capacity to Climate Change through Development of Climate-Smart Villages in Selected Vulnerable Districts of Madhya Pradesh	Department of Environment, Government of Madhya Pradesh	248.8
14	Maharashtra	Efficient Water Management and Agriculture Technology Adoption for Climate Adaptive and Resilient Farming System in 51 villages of Nandurbar and Buldhana Districts of Maharashtra State	Department of Water Conservation, Government of Maharashtra through Vasundhara Watershed Development Agency (VWDA)	229.5
15	Manipur	Model Carbon Positive Eco-Village in Phayeng of Manipur	Directorate of Environment, Government of Manipur	100.0
16	Meghalaya	Rejuvenation and climate proofing of Spring - sheds for Livelihood, water and Food Security in Meghalaya	Directorate of Soil and Water conservation, Government of Meghalaya	229.2
17	Mizoram	Sustainable Agriculture Development through Expansion, Enhancement, and Modelling.	Department of Agriculture (Crop Husbandry), Government of Mizoram	103.8
18	Nagaland	Gene pool Conservation of Indigenous Rice Varieties under Traditional Integrated Rotational Farming System (Jhum optimisation) for Promoting Livelihood and Food Security as Climate Change Adaptation Strategy in Nagaland	Department of Agriculture, Government of Nagaland	248.0
19	Odisha	Conserve water through the management of run-off in the river basin to improve groundwater recharge to reduce vulnerability and enhance resilience for traditional livelihood in Nuapada	Department of Water Resources, Government of Odisha	200.0
20	Puducherry	Integrated Surface Water Management through rejuvenation of 20 tanks and 32 village ponds for Climate Change adaptation in Puducherry	Department of Science and Technology, Govt. of Puducherry	167.6
21	Punjab	Towards Climate Resilient Livestock Production System in Punjab	Punjab State Council for Science and Technology, Government of Punjab	174.0
22	Regional Project (in the states of	Climate Resilience Building among Farmers through Crop Residue Management	Department of Agriculture of the	1000

S. No.	States/ UTs	Project title	Executing Entity	Project Outlay (INR in million)
	Punjab, Haryana, UP and Rajasthan)		Respective State Government	
23	Rajasthan	Mukhya Mantri Jal Swavlamban Abhiyan for Climate Change Adaptation and Water Harvesting in Arthuna, Anandpuri and Sajjangarh Blocks of District Banswara in Rajasthan	Department of Watershed Development & Soil Conservation, Government of Rajasthan	249.7
24	Sikkim	Addressing Climate Change Vulnerability of Water Sector at Gram Panchayat Level in Drought Prone Areas of Sikkim	Rural Management and Development Department, Government of Sikkim	246.7
25	Tamil Nadu	Management and Rehabilitation of Coastal Habitats and Biodiversity for Climate Change Adaptation and Sustainable Livelihood in Gulf of Mannar, Tamil Nadu	Tamil Nadu Watershed Development Agency, Government of Tamil Nadu	247.4
26	Tamil Nadu	Climate Proofing of Rainfed Watersheds in Salem & Virudhunagar Districts of Tamil Nadu	Tamil Nadu Watershed Development Agency, Government of Tamil Nadu	238.0
27	Telangana	Resilient Agricultural Households through Adaptation to Climate Change in Telangana	Environment Protection Training and Research Institute (EPTRI), Government of Telangana	240.0
28	Regional project (in the states of Telangana, Rajasthan, and Maharashtra)	Restoration of degraded landscapes to the natural state of the ecosystem for climate resilience and livelihood improvement of vulnerable communities	Department of Forest of the Respective State Government	1261.0
29	Uttar Pradesh	Ecosystem services-based adaptation to climate change in the Bundelkhand region of Uttar Pradesh	Forest and Wildlife Department, Government of Uttar Pradesh	200.2
30	West Bengal	Rainwater Harvesting and Sustainable Water Supply to the Hilly Areas in Darjeeling as an Adaptive Measure to Potential Change Impacts	Municipal Engineering Directorate, Department of Municipal Affairs, Government of West Bengal	231.2
Total amount				8345.5

Aligning the financial system with sustainability: Cleaner forms of production also require a sound financial system geared to provide support. India has focused on this system since December 2007 as the Reserve Bank of India (RBI) sensitized banks to various international initiatives and advised them to dovetail their lending strategies in line with the developments in the field of sustainability. Green bonds are debt securities issued by financial, non-financial, or public entities where the proceeds are used to finance 100 per cent green projects and assets. India has the second-largest emerging green bond market after China for the period 2012-2019. Many government agencies have contributed to the issuance of such green bonds, including the Indian Renewable Energy Development Agency (IREDA) and the Indian Railway Finance Corporation (IRFC). In 2018, the State Bank of India (SBI) entered the market with a USD 650 million Certified Climate Bond (Climate Bonds Initiative, 2018).

India has a leadership role in developing post 2020 climate finance processes and market mechanisms to ensure they are effective from developing countries' perspectives. To scale up environmentally sustainable investments, India joined the International Platform on Sustainable Finance (IPSF) in October 2019. The Platform acknowledges the global nature of financial markets, which can potentially help finance the transition to a green, low carbon, and climate-resilient economy by linking financing needs to global sources of funding. The main objectives are to exchange and disseminate information to promote best practices in environmentally sustainable finance, compare the different initiatives, and identify barriers and opportunities to scale up environmentally sustainable finance internationally while respecting national and regional contexts.

To conclude**,** for a diverse and complex developing country like India, finance is a critical enabler for climate action. India's national and state-level climate actions hitherto have been financed mainly from domestic resources. A further substantial scaling up of India's climate action plans would require new, additional, and climate-specific financial resources and support.

5.3 Technology needs and support received

Connecting science, technology and innovation with societal outcomes is key to driving sustainable economic and social progress. This is also the guiding principle of the Government of India’s perspective on science and technology. Science and technology help provide a level playing field in making opportunities accessible to all citizens of India, such as the use of ICT. The ease of doing science is as vital as the ease of doing business. In this context, GoI is in the process of finalizing the "Scientific Social Responsibility Policy”, along the lines of “Corporate Social Responsibility” to strengthen the linkages between science and society organically by building synergy among all the stakeholders to usher in a cultural change in the conduct of science.

Transfer and grounding of the appropriate technologies and know-how is key to enhancing adaptation and mitigation measures. Adequate financing is required for the adoption of viable cutting-edge technologies. India cannot deploy climate technologies at a significant scale unless a facilitative global technology transfer regime is in place, and incremental and associated costs of these technologies are met from multilateral climate change funds. A collaborative mechanism needs to ensure that barriers such as intellectual property rights are removed to facilitate technology transfer from developed to developing countries. The availability of relevant technologies at concessional rates is a prerequisite to integrate technological advances seamlessly on a real-time basis while supporting industries to take technological risks by providing adequate finance and skill enhancement. India has not received technology transfer in line with the current provisions under the UNFCCC. In the following we will be discussing some aspects of technological innovation and investment in new technology deployment through collaborative efforts internationally and domestic efforts. However, such efforts imply the deployment of India's own resources, which have been diverted from other essential needs, when the assistance committed to by the developed countries is not forthcoming.

5.3.1 Mission Innovation

Innovation and technology are vital for combating climate change and ensuring climate justice. Energy security, reduced pollution, access to electricity and reduced emissions are goals deemed necessary for reducing and reversing the adverse impacts of climate change. Mission Innovation (MI) is a global initiative of 24 countries and the European Commission working to reinvigorate and accelerate global clean energy innovation with the objective to make clean energy widely affordable. MI was announced at COP 21 of UNFCCC on 30 November 2015. Department of Biotechnology (DBT) is the nodal agency for the MI initiative, and all the Innovation Challenges are being supported and funded by DBT and DST. DBT is also responsible for coordinating with other line ministries including MoPNG, MNRE, MoP, MoEFCC, MoES and Public Sector Undertakings. India is an active member of the eight MI Innovation Challenges (ICs), global calls to action aimed at accelerating Research, Development, and Demonstration (RD&D) for Clean Energy Development.

- IC1: Smart Grids - Enable future grids powered by affordable, reliable, decentralised renewable electricity systems.
- IC2: Off-Grid Access to Electricity - Develop systems that enable off-grid households and communities to access affordable, reliable renewable electricity.
- IC3: Carbon Capture - Enable near-zero CO_2 emissions from power plants and carbon-intensive industries.
- IC4: Sustainable Biofuels - Develop ways to produce at-scale widely affordable, advanced biofuels for transportation and industrial applications.
- IC5: Converting Sunlight - Discover affordable ways to convert sunlight into storable solar fuels.

- IC6: Clean Energy Materials - Accelerate the exploration, discovery and use of new high-performance, low-cost clean energy materials.
- IC7: Affordable Heating and Cooling of Buildings - Make low-carbon heating and cooling affordable for everyone.
- IC8: Renewable and Clean Hydrogen - Accelerate the development of a global hydrogen market by identifying and overcoming key technology barriers to the production, distribution, storage, and use of hydrogen at gigawatt scale.

By pooling financial resources and technical expertise from members, ICs are helping to build capacity, reduce duplication of effort, and drive RD&D in their respective areas. India is a co-lead in three challenges (Smart Grids, Off-Grid access to Electricity and Sustainable Biofuels). India as a member participates in the Mission Innovation Steering Committee, Business and Investor Engagement Sub-Group and Co-leads the Analysis and Joint Research Sub-Group of Mission Innovation.

Under the ambit of Mission Innovation, Clean Energy International Incubation Centre (CEIIC) has been set up by DBT and its Public Sector Undertaking BIRAC, in collaboration with Tata Trusts. CEIIC has provided end-to-end support to 25 start-ups so far, ranging from infrastructure, technology, angel funding, access to venture capitalists, mentorship, exposure to national and international organisations and experts. CEIIC in partnership with the Net-Zero Compatible Innovations Initiative (NCI), an extension of the Avoided Emissions Framework (AEF), Sweden, conducted process assessment on eight clean energy technology start-ups being incubated at CEIIC and showed that these alone have the potential to avoid more than 90 million tonne of GHG emissions per year by 2030.

National initiatives

Industry and buildings: Following the launch of MI, DST announced a new Initiative to Promote Habitat Energy Efficiency (I-PHEE), focusing on promoting R&D activities to improve the energy efficiency of buildings and cities. The initiative will also enhance knowledge and practice to save energy in the design, construction, and operation of human habitats. The program supports specific outcome-based research in energy-efficient building envelope technologies, low energy cooling systems, day-lighting and electric lighting, building automation, and controls for energy savings.

Transport: India has an ambitious programme to enhance transport fuel quality to reduce emissions by using better fuels and modern technology in vehicles. India earlier supplied fuels of BS-IV (Euro-IV) quality, which required an investment of INR 6,00,000 million (USD 9.1 billion). The direct jump to BS-VI (Euro VI) fuel quality with an additional investment of INR 2,80,000 million (USD 4.4 billion) in upgrading refineries. Vehicles have also been upgraded, with most vehicles having catalytic convertors and meeting at least BS-IV emission norms. The government has introduced bioethanol and biodiesel in transport fuels and CNG in diesel vehicles for reducing emissions. It has also announced the National Mission for Electric Mobility

(NMEM), which envisages an R&D programme labelled the Technology Platform on Electric Mobility (TPEM). DST has initiated steps to keep a close watch on innovations in the field of Electric Mobility to support vehicle manufacturers under the Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles (FAME) scheme of the Department of Heavy Industry (DHI).

Bio-based fuels and energy: The National Policy on Biofuels mandates a blending of biofuels of approximately 20 per cent in transport fuels. This is an ambitious target and several steps have been undertaken to broaden the feedstock base for biofuel production while R&D of new technology and feedstock is being supported to achieve this. Department of Biotechnology (DBT) has established five Bioenergy Centres in the country that integrate basic and translational science capabilities for biofuel development and scale-up. The major focus has been on fermentation technology and enzymes for cellulosic ethanol, algal biofuel, and waste to energy. Based on encouraging results of these Centres, demo scale technologies for cellulosic ethanol have been set up. Novel clean technologies have been developed to convert sewage into clean water and municipal solid waste into compressed biogas (CBG).

Capacity building in bioenergy: India and the USA have joined hands to support a fellowship that will allow a group of fellows and interns to pursue cutting edge research in various areas of bioenergy in US institutes of repute. This will help build capacity in clean and environmentally safe energy technologies. Ten post-doctoral fellows under the DBT- Energy Biosciences Overseas Fellowships are now placed in some of the centres of excellence on bioenergy. The DBT has established a network of more than 100 scientists working to realize the National Biofuel Policy's goals with high-quality research publications and patents for knowledge generation and technology development. The Bioenergy Program also includes establishing a network of programs on algal biofuels research. There are three repositories with more than 2,000 cultures that are available for the algal biofuel program. This has been identified as an area for both bilateral and multilateral cooperation.

Cleaner fossil energy: With MI, the Department of Science and Technology has developed plans to set up demand-oriented mission programs on clean coal technologies and has launched a national mission with plans to set up material research centres on advanced ultra-supercritical technologies. The national programme on upgrading the quality of transport fuels, as detailed above, has significantly helped in reducing vehicular emissions. Several institutes have taken up biomass pyrolysis combined with coal, pet coke and subsequent hydro treating of the oil to produce clean sulphur-free drop-in fuels.

A consortium has been formed by NTPC Limited, BHEL, and IGCAR –Kalpakkam for the indigenous development of Advanced Ultra Super Critical technology for high-efficiency thermal power plants in India.

CO_2 utilization: India does not have much experience or large projects on carbon dioxide capture, utilization, and storage. Some of the priority areas are:

- CO_2 to organic products with organo-catalysis
- Hydrogenation and reduction of CO_2 with molecular catalysts
- Reforming of CO_2 to Syngas
- Production of polycarbonates
- Catalytic hydrogenation of CO_2 to Methanol / Dimethyl Ether (DME)
- CO_2 to alkyl carbamates as fuel components

Electricity grid: DST is setting up a clean energy centre to integrate intermittent renewables with suitable energy storage in on-grid or off-grid situations. Research priorities for off-grid electricity systems are:

- Off-grid electricity systems utilising polygeneration and solar, wind, micro-hydel, biogas, and various other forms individually or hybridised for heating/cooling/ thermal applications.
- Augmenting the existing fossil fuels with renewable sources, including rooftop solar as an off-grid solution.
- Frequency and voltage stability of off-grid systems and developing a robust control algorithm.
- Development and demonstration of affordable and sustainable solutions/devices for a broad application spectrum.
- Village Distributed Energy Resources (DERs) grids.
- Hybrid distribution systems (AC and DC grids).
- Development of efficient DC appliances and smart centralized distribution control to ensure disciplined and efficient end-use of energy.

Energy storage: Ministry of Power is working on flow batteries, which have greater energy storage potential and are more efficient. A programme focused on developing materials for hydrogen storage has also been initiated by the DST and MNRE.

The world's first Clean Energy International Incubation Centre (CEIIC) was launched by GoI in partnership with the Tata Trusts in Delhi in September 2019 as part of MI. It provides USD 5 million to support start-ups/innovators from across MI members to test their technologies in the local market.

The Surya Jyoti Micro solar dome is one of the solutions developed by MI that can provide up to 17 hours of 60 W equivalent light, with a lifespan of up to 20 years ensuring access to lighting for communities located in remote areas. About 4,000 domes have been installed in the impoverished parts of Delhi, Mumbai, Kolkata, and Bengaluru, with 54 technicians from 14 States trained in the manufacturing process.

Other National initiatives

As the PAT scheme is being implemented on a rolling cycle basis, new Designated Customers (DCs) will be notified every year. Some of the best practices and technology upgrades that are commercially available in India and are implemented by industries under the PAT scheme are shown in Table 5.6.

Table 5.6: Technologies implemented under PAT

Sector under PAT	Technologies
Aluminum	• Calciner main burner nozzle replacement. • Use of cold sealing paste for pot relining. • Corro-coat coating of pump to increase its efficiency. • Solar heating system for hot mill emulsion. • Inert Anode Technology • Wetted Cathode Technology • Multipolar Cell Technology
Cement	• Alternative Fuels & Raw Materials (AFR) utilization technologies. • Waste heat recovery from pre-heater outlet. • Installation of Kiln Shell radiation recovery system in Kiln for CPP makes up water heating. • Calcium looping as Carbon Capture technology
Chlor Alkali	• Zero-gap technology. • Micro-turbine. • Feeding of 48 per cent hot Caustic Soda Lye direct to flaker plant. • Change-over of fuel from Furnace Oil (FO) to Hydrogen in process heating/steam requirement. • Utilizing Hydrogen in Captive Power Plant • PEM Fuel Cell Technology using Hydrogen • Hydrogen Compressed Natural Gas (HCNG) (Hydrogen blending with CNG) • Hydrogen Co-firing in Industrial Gas Turbines
Fertilizer	• Installation of VAM for chilling of gas at suction of Ammonia Synthesis gas compressor, process air compressor, CO_2 compressor & air compressor for Gas turbine. • Gas-based turbo-generator and associated HRSG. • CO_2 as feed for urea production • Changeover of feedstock from FO to NG, Naphtha to NG, Coal to NG • CO_2 Recovery units
Iron & Steel	• Installation of Top Recovery Turbine and Pulverized Coal Injection in Blast Furnace. • Commissioning of LD Gas recovery plant in Steel melting shop. • Direct Rolling in mini steel plants • Hot charging of DRI in EAF
Petroleum Refinery	• Commissioning of heat integrated, energy efficient crude distillation unit (CDU). • Implementation of Advance process control (APC) in CCR. • Replacement of third stage ejector system by Liquid ring vacuum pump (LRVP) in vacuum distillation unit (VDU). • Furnace efficiency improvement of CDU heater.

	• "indeDiesel Technology" - DHDT Hydro treatment for Euro-IV & V diesel (S<50 & 10 ppm, CN > 51) • "indeHex Technology"- Food Grade Hexane Hydro treatment of hexane for benzene removal (< 100 ppm) • "indJet Technology" - ATF Hydro treating - Selective Removal of Mercaptan Sulfur in ATF / desulphurisation of kerosene • NDMAX Technologies- A novel technology to produce high yield of light olefins / LPG and high-octane gasoline from various petroleum fractions • indSelectG Technology- Selective desulphurization of full range FCC & other cracked gasoline streams to meet BS-VI S spec with minimum loss of RON (~3 units) • One Divided wall column in place of 2 columns in FCC Naphtha splitter. • LP steam superheating with MP steam in shell and tube exchanger in place of direct mixing • Energy real-time optimizer (ERTO software). • Substituting N2 blanketing in place Fuel gas in Naphtha splitter receiver.
Pulp and Paper	• Super Batch Cooking. • Two Stage Oxygen Delignification – OxyTrac. • BCTMP Process (bleached chemi-thermomechanical pulp). • Super Batch Cooking. • Ultra-Low Intensity Refining. • Opti Batch Process. • Bio gas 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) i.e. 50°C to 250°C • Oxyfuel burning in lime kiln and black liquor boilers • Installation of Extended Delignification System for cooking of wood (to reduce steam consumption)
Indian Railways	• Energy efficient 3 Phase Electric Locomotives • Regenerative Braking System in Electric Locomotive • Installation of APU (Auxiliary Power Units) in Diesel Locomotives • Head on Generation (HOG) • Switching off Diesel and Electric Locomotive in siding if standing idle for more than 30 minutes • Conversion of Diesel locomotive to Electric Locomotive
Textile	• Pulser dyeing technique • Waste heat recovery in centrifugal comp • Wind recovery turbine from humidification exhaust • Microbial fuel cell technology to generate electricity from Textile wastewater treatment • Solar paint for the textile industries • Energy Recovery from H-Plant exhaust air by providing a special turbine which generates grid-connected electricity for lighting. • Power generation from sewage treatment of municipal bodies and industries
Thermal Power Plant	• Auxiliary Power Consumption (APC) optimization using efficient motors, Variable frequency drives (VFDs) and stage reduction in pumps • Utilization of low-temperature waste heat from flue gas for generating chilled water, desalinating water • Micro Oil ignition system (MOIS)

	• Super Critical technologies
Distribution Companies (DISCOMs)	• System improvement & automation technologies • Integrated Power Development Scheme (IPDS) • Re-conducting (Under BRGF Scheme) • Improvement in power factor of 33 KV feeders

5.3.2 Technology needs and requirements

Notwithstanding its efforts, financial resources, and trained workforce, India needs to adopt technologies developed elsewhere to suit its own needs to avoid reinventing the wheel, learn from innovators' collective wisdom, complement its national effort, and fast-track the development of environmentally friendly technologies appropriate to its conditions. India also needs technical know-how in several key areas.

India’s first and second BUR to UNFCCC presents a detailed list of climate technologies for mitigation. However, under the current climate change regime, none of the required technologies were either transferred, facilitated, or were made available to India. Some of India’s key technology needs identified are presented in Table 5.7.

Table 5.7: List of additional technology needs

S. No.	Area of Implementation	Technology/Remarks
1	Solar Photovoltaics	• Currently, crystalline Silicon (c-Si) technology contributes 95 per cent of global solar PV installations, and thin films contribute to the remained. Thus, c-Si is likely to contribute 400 GW by 2050 and is essential for India’s future clean energy trajectory. • India lacks technology and manufacturing for the upstream segment of the supply chain, i.e., polysilicon/ingot/wafer. Indian cell manufacturers import wafers, and similarly, cells are imported for module manufacturing. • c-Si technology has made vast advancements, and the Indian manufacturers have not been able to keep pace with technology changes. • Existing module manufacturing plants lack economies of scale, which prevents cost reduction • India lacks the crucial technologies needed to process/manufacture the raw materials for cell and module manufacturing. • Equipment (assembly line) used for cell, module, and BoM component manufacturing is not available in India and is imported. • India needs next-generation PV technologies, including Perovskites, Multi-Junction Solar Cells, Dye induction photovoltaics and organic/inorganic composites. • China, UK, USA are some of the key countries of the alliance for technology sourcing.
2	Offshore Wind	• Technology limitation exists in the survey space (oceanographic and geotechnical) • Heavily dependent on imports for rare earth metals

S. No.	Area of Implementation	Technology/Remarks
		• Potential to increase the capacity factor of domestic manufacturing units • Need for modelling and simulation tools, including HPC to improve generation forecasting and performance analysis. • Denmark, the UK, and Germany are the major technology providers
3	Advanced Ultra Supercritical Coal Technology (AUSC)	• Materials having characteristics of high creep rupture strength and corrosion resistance at elevated temperature and pressures are not available • Japan and South Korea are potential collaborators for technology transfer (welding technologies)
4	Light Emitting Diode bulb	• LED chip (Wafer Fabrication) is imported
5	Room Air Conditioners	• Rotary compressors - a key component in RAC are largely imported • Companies import ACs through ASEAN free trade agreement to avoid customs duty on compressors • Cost of the imported compressor is cheaper than those manufactured indigenously, owing to customs duty on high-grade steel (key raw material) • The local availability of propane and isobutane based refrigerants that have low Global Warming Potential footprints, is a constraint
6	Iron & Steel Manufacturing	Current technology mix dominated by the BF-BOF route, which uses coke, coal, and oxygen to produce steel. Through adoption of the following Energy efficiency measures and low carbon processes, an integrated steel plant can save emissions substantially. • Coke Dry Quenching (CDQ) • Waste Heat recovery generation from low TPD Sponge Iron Plants • Regenerative/ recuperative Burner for Reheating Furnace • Sinter Plant Heat Recovery (Steam Recovery from Sinter Cooler Waste Heat) • Sinter Plant Heat Recovery (Power generation from sinter cooler waste heat) • Coal Moisture Control (CMC) system (Top Charged) • Top Pressure Recovery Turbine (TRT) • Pulverized Coal Injection (PCI) system • Hot stove waste heat recovery • Converter gas recovery device • Ecological and economical arc furnace • Waste heat recovery from electric arc furnace • Regenerative Burner Total System for Reheating Furnace • Energy monitoring and management system • Cogeneration with Gas Turbine Combined Cycle (GTCC) • Low Grade Heat Recovery Using Organic Rankine Cycle • Hot Blast Superheating with Plasma technology • Advanced automation L-3 model online simulation of Blast Furnace • Gas Oxygen refining technology • Converter Gas Sensible Heat Recovery

S. No.	Area of Implementation	Technology/Remarks
		Further, the following technologies can be adopted as and when these technologies are available for adoption on commercial scale. • H2 based iron & steel making technologies • CCS/CCUS (Carbon Capture Storage/Carbon Capture, Utilisation and Storage) technologies, • HISARNA Technology which is being developed under ULCOS Programme.
7	Biofuels	• Large scale enzyme production and scaling up issues exist • Feedstock sourcing has been a perennial problem • Commercial production of Bio-methanol is cost-prohibitive
8	Hydrogen	• Technologies for type III and type IV cylinders, as well as hydride and carbon materials for hydrogen storage • Catalysts, membranes, and fuel cell manufacturing assemblies • Hydrogen supply chain infrastructure and dispensing stations • Green hydrogen utilization in the industry, including ammonia for fertilizers and iron and steel production.
9	Lithium-Ion Battery (LiB) & Flow Battery	• Raw materials and technology are barriers to large scale manufacturing of Lithium-Ion Batteries in India

Table 5.8: Technologies which need investment

1	Cement	• Proliferation of technology for waste heat recovery from preheater exhaust and cooler vent for co-generation of power • Wider adoption of grate cooler technology • Wider adoption of low-NOx multi-channel burners for combustion
2	Iron & Steel	• Injection of plastic waste in the blast furnace In addition to above, technologies listed in Table 5.7 (Iron & Steel) also stand included.
3	Agriculture	• Focus on data-driven agriculture practices through Precision Technologies, Satellite Imageries, Sensor-based technologies (optimization of Nutrients/ Restoration of degraded soils) • Smart Diagnostic Kits to prevent epidemics • Smart storage bags for harvests • Irradiation of perishable foods for preservation • Optimization of nutrient-use efficiency with novel sensor-based technologies. • Promotion of precision agriculture technologies coupled with hyper-spectral imaging. • Use of satellite imagery to identify pests, disease, and crop management through computer analysis using big data analytics.

To conclude, it is difficult to project future technology requirements in the rapidly and ever-evolving technology development realm. Access to relevant, affordable, and scalable technologies, along with technical skills, can prove to be a game-changer, provided adequate financial support is received.

The study of energy and industry transitions for the future can help indicate which low carbon technologies may dominate globally. Coupled with a roadmap for R&D and investment to scale, such technologies can be developed to scale and commercialised provided adequate additional financial support is available. A large section of the population is vulnerable to climate change impacts, and thus, adaptation is as relevant to India as mitigation. Most technologies for climate adaptation in sectors like agriculture, forestry, water and health are available in India on a very limited scale. These technologies need to be locally adapted and scaled up to ensure climate resilience according to the country's ecosystems and local population, an effort which also requires substantial financial support. The issue of technology, finance, and capacity-building needs to be addressed simultaneously and holistically following a comprehensive integrative approach.

5.3.3 Supply-side issues in technology transfer

Issues of innovation and technology transfer must be framed within the context of the principles of CBDR-RC. The principle as expressed in the UNFCCC (Article 4; Paragraphs 1, 5 and 7) explicitly notes the central role of the transfer of financial resources and technology from developed to developing nations for the latter's climate action. The Convention also acknowledges that "economic and social development and poverty eradication are the first and overriding priorities of the developing country Parties." The importance of technology transfer has also been noted and echoed by all the subsequent protocols, agreements, and decisions under the Convention, most notably the Kyoto Protocol, the Paris Agreement (Article 10), and the establishment of the Technology Mechanism consisting of the Technology Executive Committee (TEC) and the Climate Technology Centre and Network (CTCN).

One of the critical and contentious areas in the discussions on technology transfer is that of Intellectual Property Rights (IPR) regimes. While a section of commentators from the developed countries has argued for the sanctity of IPR enforcement in fostering innovation, others from developed as well as developing countries have questioned the efficacy of patent protection in clean energy innovation, diffusion and their role as barriers to technology transfer (Rimmer, 2018). Azad & Azad (2016) in their study, argue for moving away from a focus on domestic funding schemes to international ones and make the case for a climate-just future where developed countries fund developing countries' energy and environmental security "in a manner that protects developing countries' sovereignty and flexibility while still addressing their unique needs."

In the context of the UNFCCC, it is relevant to note that the responsibility to provide technology to developing countries also denotes the responsibility to develop technologies to accelerate innovation towards the gradual elimination of GHG emissions. No mitigation commitment will indeed be capable of being fulfilled in the manner that climate science requires if not accompanied by technology development.

However, despite IPR protection having been provided to developed countries in the UNFCCC, data and studies point to the inadequacy of investments in R&D and overall innovative activity in low-carbon technology by developed countries. IEA's recent report points to a plateauing of low-carbon energy R&D investment in IEA member countries (which include much of the developed countries) since 2012 (IEA, 2020a). The report also notes that energy-related R&D investments, including low-carbon technologies, are not growing in their share of GDP. They account for a declining share of total government R&D spending in IEA member nations and currently it is only about 4 per cent of all public R&D by these countries. A sector-wise analysis shows that energy has accounted for a shrinking share of public R&D spending in IEA member nations since 1985 (IEA, 2020b). Data from 1999-2018 on the public R&D budget of the major developed countries and IEA member countries show that public investment in renewable energy technologies has witnessed a marked decline since 2009-10 from USD 4.6 billion to 3.1 billion. These trends are shown in Figure 5.1.

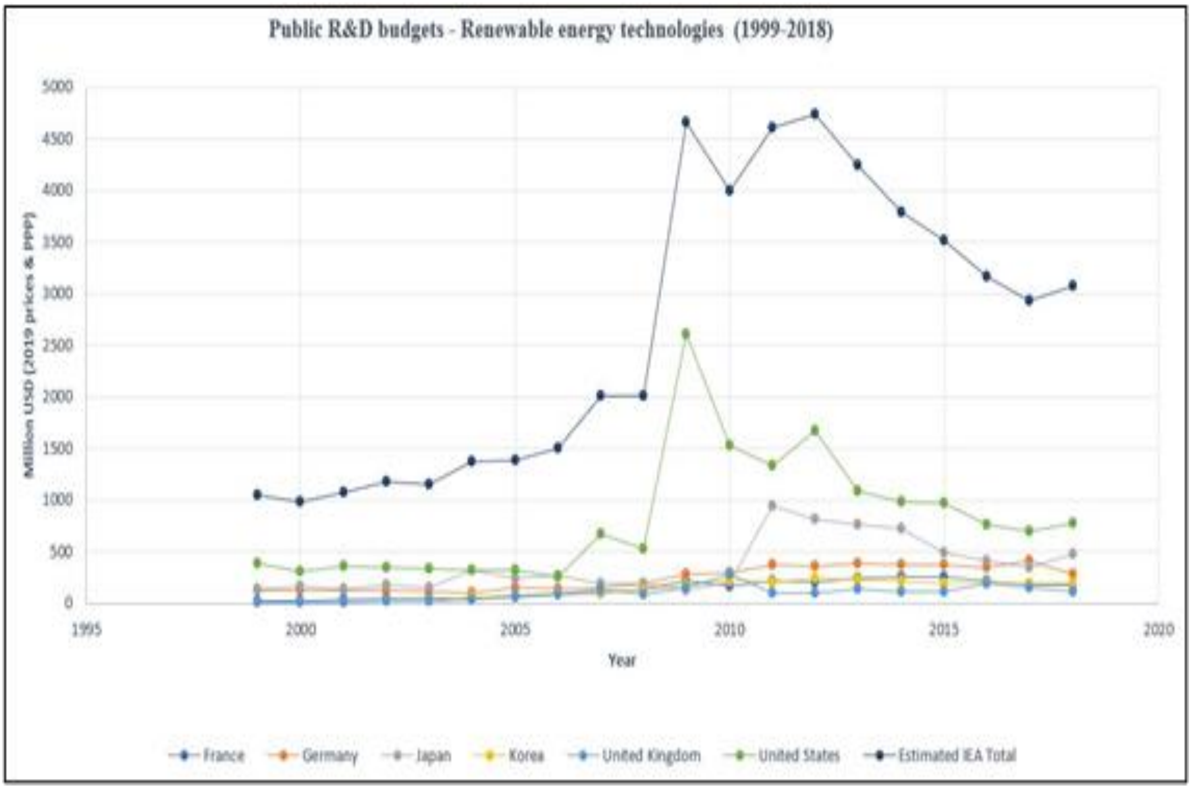


Figure 5.1: Trends in public R&D budgets related to renewable energy technologies 1999-2018. (Data from IEA, 2020b).
Source: Patil et al., 2020.

A clearer picture of the extent and focus of innovation can be obtained from patenting trends derived from global patent databases. Similar to public R&D spending, a declining trend can be observed in the volume of patenting activity in the key sectors of environment-related technologies such as energy, transportation, and buildings since 2011-12. This is based on the analysis of patent data from the OECD for major developed countries - USA, Japan, South Korea, and the European Union (Arohi Patil, Goutham, R. and Jayaraman, T., 2020, based on data extracted from OECD Stat and

PATSTAT Online). Furthermore, the percentage share of environment-related technologies in total annual patents filed has reduced from 11.4 per cent in 2011 to 7.2 per cent in 2016. Trends of priority patent applications in Solar PV and Energy Storage (battery) related technologies in the major developed countries during the period 1999-2016 are shown in Figure 5.2, 5.3 and 5.4. One can clearly see a marked decline in the number of patents in these three areas from developed countries since 2009-2010. While developing countries have been persistently lectured about the importance of storage development for solar power and the likely progress in this field, the consistent decline in patenting activity in energy storage technologies does not bode well for the availability of such technologies and their cost. Without such price reduction in these technologies, large-scale solar power deployment would be difficult in both developed and developing countries.

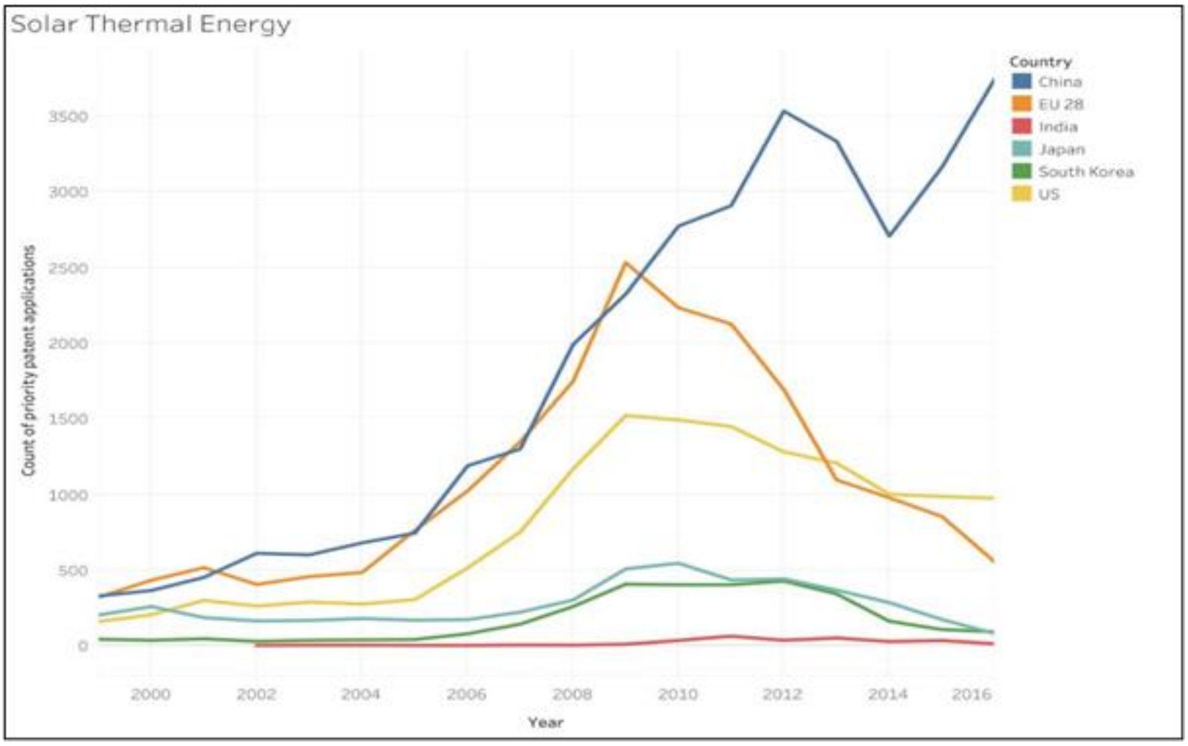


Figure 5.2: Solar thermal, count of priority patent applications, 1999 - 2016, based on priority date and inventor country. (Data extracted from OECD STAT and PATSTAT Online by the authors)

Source: Patil et al., 2020.

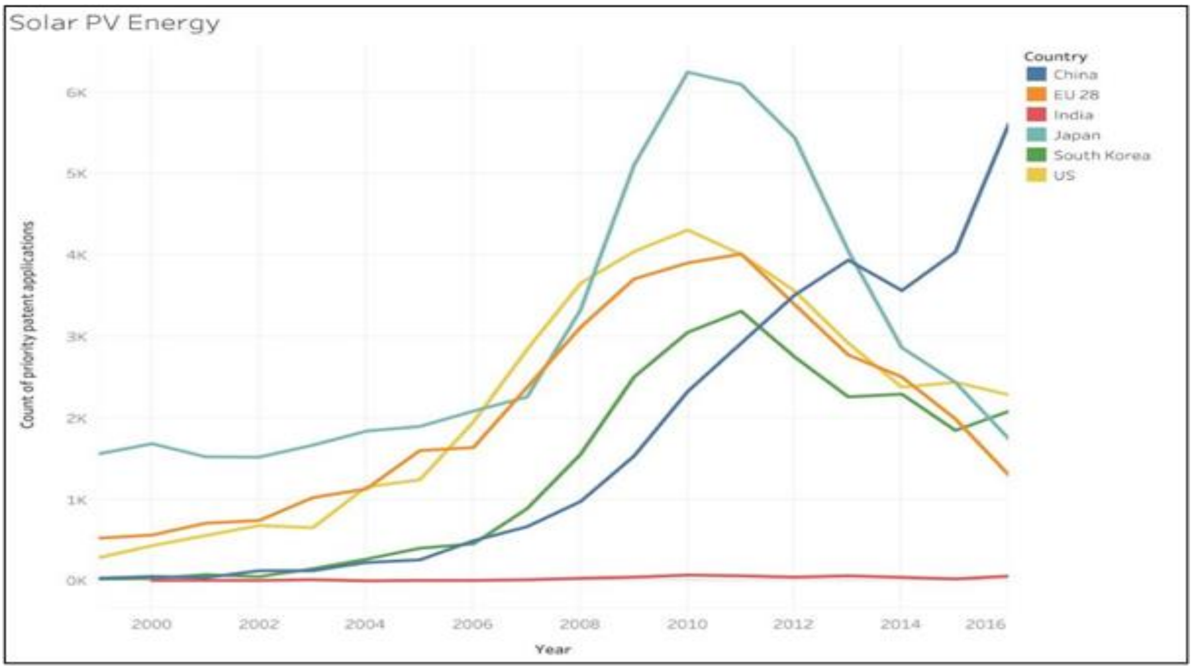


Figure 5.3: Solar PV, count of priority patent applications, 1999 - 2016, based on priority date and inventor country. (Data extracted from OECD STAT and PATSTAT Online by the authors)
Source: Patil et al., 2020.

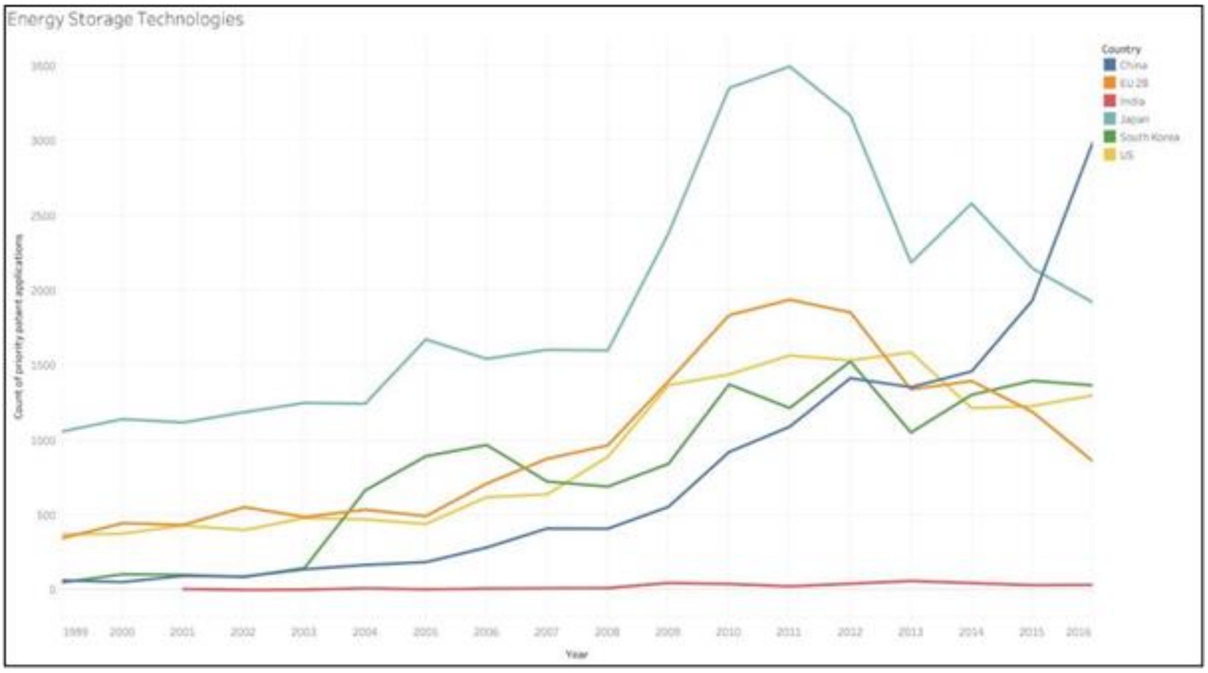


Figure 5.4: Energy storage technologies, count of priority patent applications, 1999 - 2016, based on priority date and inventor country. (Data extracted from OECD STAT and PATSTAT Online by the authors)
Source: Patil et al., 2020.

It is pertinent to note that the decline in patenting outputs and public spending on R&D begins around 2009, the year of the Copenhagen Accord. In this context, it may be noted that the Accord effectively signalled a withdrawal from legally binding emission reduction commitments by Annex-I Parties. A clear and significant slowdown in patenting from the developed world in green technology innovation is witnessed since then. It can be observed that major developed countries that bear much of the historical responsibility for cumulative global emissions and possessing the most capabilities have not been meeting their obligations of investing and driving innovations for low carbon technologies. While Annex I countries have consistently called for deep emission cuts by all countries, they appear to be not meeting their fair share in technology development and transfer. Calls for carbon neutrality that are not based on holding developed countries accountable for taking the lead in low carbon innovation and technology transfer is counterproductive to the principles of equity and CBDR-RC. This calls for developing countries, including India, to find a way to foreground the issue based on the principles of technology transfer laid down in the UNFCCC.

Another challenge concerning technology transfer is the lack of data on the low-carbon technology patents that have been commercialised for deployment. This is important because technological innovation can aid in climate change mitigation or adaptation only if it has been made available commercially for uptake and diffusion. Hence there is a need for establishing a database that tracks patents related to low-carbon technologies and their commercialisation status, disaggregated by countries.

India is the only country that regularly releases data on patents that are being worked, including the number of licenses granted, based on the requirements of Indian patent legislation. The mandated requirement of a working statement for every patent granted in India has been defined in section 146(2) of the Patents Act, 1970. The working statement requirement can be fulfilled by submitting the prescribed information at the Patent Office, each year within three months from the end of the calendar year, i.e., by 31 March of the subsequent year. This working statement is a declaration required from the patentee or the licensee, stating whether the patent has been commercially exploited/implemented/worked in India to meet the reasonable requirements of the public at a reasonable cost in the last calendar year, along with other details and reasons, as applicable. Non-compliance in providing the working statement may increase the risk of compulsory license and revocation of the patent in India. Other penalties are also attached to non-compliance.

Regrettably, developed countries' domestic patent legislation does not mandate such provisions, nor can these countries provide data on the working of relevant patents. Availability of information on patents and their working would provide a valuable guide to developing countries to focus on viable technologies at scale for decoupling their growth from emissions.

5.4 GHG inventory reporting: Constraints, gaps, and improvements

By and large, India uses the 2006 IPCC Guidelines to report GHG inventory for source and sink categories across five sectors, including the energy sector, IPPU, agriculture, LULUCF, and waste. A significant proportion of emissions from key sectors are estimated by applying a higher-tier method or using country- or plant-specific emission factors (EFs) and other parameters. Programs and studies for developing new EFs and improving inventory coverage and accuracy are ongoing; for example, a study to develop country- and sector-specific EFs and other fuel combustion parameters. Upgrading the emission inventory system is a dynamic process, and sustained efforts are being made to ensure that India's GHG emission inventory is of high quality, transparent, and consistent with the requirements of IPCC inventory guidelines. GoI plans to ride the tier ladder using key category analysis and uncertainty assessment, that will require new and additional financial, technical, and capacity support.

The capacity-building needs identified by India's BUR-2 and analysed during the technical analysis process by the TTE and published in the TA Summary Report remain unfulfilled. Constraints and gaps presented in the following sections are in addition to what has already been reported by India to the UNFCCC.

5.4.1 Energy sector

As the national reporting requirements become increasingly exhaustive, there is a need to use 2006 IPCC guidelines for estimating GHG emissions throughout the sub-sectors under the energy category. Such a requirement calls for the need to advance current methodologies, more granularity in the data to estimate GHG emissions and increase in sectoral coverage and data collection in all the fuel-consuming industries. This poses a severe financial constraint for India, especially in estimating fugitive emissions from the oil and natural gas sector, requiring upgrading the technologies used for inventory estimation. Estimation of new categories and new gases poses a critical capacity-building and financial challenge for India.

Presently, emission estimation is done from the activity data sourced from different government and sectoral reports. It is necessary to develop a mechanism for the streamlined collection of activity data from various sub-sectors and obtain information on fuel consumption to get a more disaggregated picture of the total GHG emissions.

Further, source-wise quality parameters of imported coal and data on grade-wise deliveries of entire coal supply to different sectors would be more conducive to emissions calculations. The country-specific NCV and CEF values need to be developed for gaseous and liquid fuels used in the energy and manufacturing industries.

The uncertainty is particularly high in residential energy, agricultural energy, cement, iron and steel, and food and beverage, posing yet another challenge. There is a need to continuously improve the accuracy of activity data generation, for which both financial and technical support is essential.

It is also required to develop EFs for different fuels, vehicle types, and traffic patterns for the transport sector, which will help in national GHG reporting with reduced levels of uncertainty and provide information on source apportionment for policy interventions in the future.

5.4.2 Industrial Processes and Product Use (IPPU) sector

India has developed and used plant and country-specific CO_2 and N_2O EFs for the sector's dominant categories like minerals, chemical, and metal industries. However, the information on activity data was not reported in BUR-2 due to the enormity of data sets in this sector. This poses a significant challenge for reporting under India's IPPU sector because most industrial units are small, unorganized, and scattered. There is a need to create an incentive mechanism for industrial units to provide data, but this will require financial support.

Substantial new and additional financial resources and capacity building is required for the emission estimation from gasification and pyrolysis; refrigeration and air-conditioning equipment for obtaining and rationalizing facility-level fuel statistics of energy and manufacturing sector industries; and, plant-wise estimations especially in the iron & steel sector.

Companies in the cement and iron & steel sector report their GHG emissions based on industry-specific corporate protocols, which are not entirely aligned with IPCC requirements for national inventory. Therefore, harmonizing corporate and national inventory reporting guidelines to lessen industry and government burden in reporting is needed. Capacity building of industry on corporate reporting and national inventory is a must for receiving transparent emissions data.

5.4.3 Agriculture sector

In the agriculture sector, CH_4 emission coefficients are estimated by calculating GHG emissions from manure systems, rice cultivation under different water regimes and organic amendments, burning of crop residue, N_2O emission from soils supporting rice-wheat systems, and application of nitrogenous fertilizers.

Some of the major constraints faced by this sector include: a) limited availability of crop production data for the latest inventory years. b) State-wise fertilizer consumption data for different crops is not available in the public domain; c) there are only a few N_2O measurements in major agricultural regions of the country, leading to relatively higher uncertainty in EFs; d) data on lime application in agriculture is not available, nor are the EFs for lime application in the sector available; e) urea application to soil methodology needs to be re-evaluated.

There is a need for more intensive measurements across the different agro-ecological zones in the country's major cropping systems to reduce the uncertainty levels. Bridging these technical and capacity gap will require substantial financial resources. Constraints and gaps related to the agricultural sector's mitigation actions can be broadly divided into two categories:

a) Constraints and gaps related to the availability of data on the coverage of mitigation actions

Some of the crucial constraints here are as follows:

1) Department of Agriculture, Co-operation and Farmers Welfare (DAC&FW) is implementing programs that aim at productivity enhancement and resource use efficiency, which have significant mitigation co-benefits but do not have the necessary information to quantify their extent. For example, several initiatives are being taken for promoting organic agriculture in the country, and significant areas have been brought under organic cultivation. However, the information about the quantity of fertilisers avoided or reduced is not available, and thus the extent of mitigation co-benefits could not be quantified. There is a need to focus efforts on obtaining information about the coverage of these management practices for future reporting.
2) Information about the extent of adoption of proven adaptation practices which have mitigation co-benefits is not available. The central and state governments are taking up demonstrations of proven adaptation practices as part of several ongoing programs that are simple and easy to adopt and have significant yield and economic benefits. Sections of farmers also adopt these practices due to the benefits they obtain independently without the government's support, which are not reported. The extent of adoption of these practices is significant; for example, the adoption of horticulture systems, and drip irrigation systems,
3) Similarly, some state governments have emphasized tree planting in private holdings, roads and community lands in programs like MGNREGS in a significant way. In the case of Andhra Pradesh, teak (*Tectona grandis*) planting is being taken up on a massive scale (about 50 million saplings per year) since 2012, and yet information about this programme is not available in a single platform for reporting purposes.
4) Lack of data about the extent of the area covered in some of the area-based development programs as in the case of watershed development.
5) Data on the afforestation activities taken up by industries as in the case of paper and plywood are not available in the public domain. A significant number of paper and plywood companies in India depend on wood produced in farmers' fields and contribute to their plantations by direct or indirect support.

b) Constraints related to the quantification of mitigation actions

1) Developing country-specific emission factors and sequestration rates is an important activity since it makes the quantification of mitigation actions more representative of the circumstances under which these actions were implemented and the estimates become scientifically more robust. Information about the rates of carbon sequestration in fruit tree systems is limited for Indian

conditions. Little information is available on allometric equations and biomass expansion factors for fruit tree species. Data is not available on the quantum of below-ground carbon or carbon sequestered by root systems, the annual increase in the rates of carbon accumulation in the above and below ground systems, the carbon content of plant parts, and the soil carbon. The quantum of carbon sequestered by tree systems is directly proportional to the biomass production by trees, which is largely driven by the area's rainfall and soil conditions. Representative values for different agro-ecological regions are needed as fruit tree systems are distributed throughout the country. In the absence of robust data, we have used the few currently available Indian data and utilized data from similar climatic conditions from other parts of the world. Filling these gaps will require substantial financial, technical and human resources.

2) In micro-irrigation systems, the quantum of emission reductions depends on energy savings, which in turn depend on the amount of irrigation applied as crops differ significantly in their water requirements. In the absence of crop-specific emission reductions data of the micro-irrigation systems, we have adopted a generic approach for estimating the reductions. In recent years, localized modifications to SRI have been made which consists of variable management practices like soil preparation, water management and transplantation method which determine methane emissions. There is a need to have system-specific emission coefficients under Indian conditions for accurate quantification of methane reduction.

5.4.4 Land Use, Land-use Change, and Forestry (LULUCF) sector

One of the significant challenges in the LULUCF sector is the limited data available for the rate of change of biomass and soil organic carbon (SOC) in different land use categories except for forestland. For forests, precise and periodic information on the area, emission factors and SOC are available from the Forest Survey of India (FSI).

Capacity building is required to capture the data requirements for estimating carbon stock using the gain and loss approach. Additional financial support is required to build capacity to adopt suitable carbon measurement models and generate EFs (such as stocks and fluxes of five carbon pools) in different land categories.

5.4.5 Waste sector

In the waste sector, data availability is one of the major challenges as data collation has not been regular or undertaken with reasonable scientific rigour. Although Swachh Bharat Mission-Urban (SBM-Urban) has a well-developed MIS portal where Urban Local Bodies (ULBs) provide field-level data on MSW generation as part of the Swachh Survekshan and Garbage Free certification exercises. However, this is not adequate.

More field studies and plant-level surveys are required to get industrial waste generation data.

The following measures are required to reduce the levels of uncertainty in methane emissions from the waste sector:

- The municipal corporation should keep up to date records of sources and characteristics of MSW reaching landfill sites;
- Weighing of MSW reaching landfill sites should be carried out regularly;
- Source segregation of waste should be facilitated;
- Physical analysis and chemical analysis should be carried out periodically to assess the various ingredients and chemical constituents present in MSW at landfill sites;
- Landfill sites should be adequately planned, constructed, and operated following MSW Rules;
- Cell-wise placement of waste should be facilitated at the landfill and type of waste disposed of in a particular cell should be recorded;
- Methane collection and recovery system should be provided at the landfill; and,
- Regular in-situ monitoring of methane emissions should be carried out.

These measures require substantial support in capacity-building, technical expertise, and financial resources. In other words, ridding the tier ladder in the waste sector would depend upon building cities' technological capabilities on better MRV and record-keeping of the waste generated in their respective jurisdiction.

To conclude, national GHG inventory preparation in its present form places a considerable burden on India in terms of time, effort, and the need for greater capacities and financial expenditure while distracting attention from the real effort required for climate action in the context of development deficits. This burden will compound significantly with the adoption of the ETF. Without adequate additional support from developed countries for climate action, it will become an unviable proposition for India to take up this burden.

Overall, the following table shows the existing gaps in reporting GHG inventory across various sectors.

Table 5.9: Constraint, gaps and requirements for GHG inventory

GHG inventory: Constraint, gaps and requirements	
Energy sector	Mechanism for streamlined collection of activity data from various sub-sectors
	Country-specific values of NCV and CEF need to be developed for gaseous and liquid fuels
IPPU	Increase activity data resolution, strengthen fuel testing capacities

	Additional financial and capacity building required for the emission estimation from gasification and pyrolysis
	Harmonize the corporate reporting and national inventory reporting requirements
Agriculture sector	More intensive measurements across the different agro-ecological zones, limitations on quantification of mitigation actions
LULUCF	Capacity building is required to capture the data requirements for calculation of the carbon stock using gain and loss approach data
	Additional financial support to build capacity for the adoption of suitable carbon measurement models and for generating EFs
Waste sector	More field studies and more plant-level surveys to get industrial waste generation data.

5.5 Capacity building needs and support received

Capacity building is one of the primary requirements for achieving the objectives of the Convention. It enables individuals, organizations, and societies to mitigate and adapt to climate change in the most cost-efficient and sustainable manner.

5.5.1 Needs related to minimising loss and damage due to weather-related disasters and other requirements

The capacity-building needs expressed by India through the national reporting process to the Convention since 2004 are still relevant but remain mostly unmet and continue to multiply. Thus, this section should be read in conjunction with the capacity building needs thus far identified by India and the ICA process of its BUR-1 and BUR-2, as well as with the preceding sections of this chapter. Additionally, some further capacity-building gaps especially related to minimizing loss and damage caused by weather-related extreme events and disasters, are as follows:

Weather and Climate Forecasting: While the extant weather and climate forecasting system in India is reasonably robust, some gaps remain with regard to meeting the growing demand for more accurate user-specific forecasts in different temporal and spatial scales. Further improvement of current services requires effective conversion of R&D results to fully operational products, services, and effective means to develop linkages with decision-makers and users. For cost-effective meteorological services to society, an indigenous system for the maintenance and calibration of installed AWS (automatic weather stations), ARG (automatic rain gauges), and DWR (Doppler weather radar) infrastructure needs to be in place. To ensure that no severe weather event goes undetected, a high-resolution observational system is required. Establishing, operating, and maintaining a robust network of observing systems through augmentation of an observational network at 25x25 km grid and upper air observations at 100x100 km complimented by multi-platform satellites, air-craft based profiler observations, doppler radars, and wind profilers are also needed.

Recent studies indicate an increasing trend in the socio-economic impact of extreme weather events such as floods, droughts, cyclones, hailstorms, thunderstorms, and heat and cold waves. Forecasting urban weather is becoming increasingly important to managing disasters, decision making in the public sector, and urban planning.

Accurate forecasts of the intensity of tropical cyclones (TCs) remains a gap area that sets the basis for improving model physics (cloud, convection, radiation). Forecast improvements are particularly needed for re-curving cyclones. There is considerable scope to improve the prediction skill in landfall of tropical cyclones and associated rainfall, storm surge, and winds.

Research suggests an increase in extreme weather events over India, which could be caused by global warming. It is required to improve capabilities in predicting anomalous/unprecedented extreme weather episodes by enhancing the forecast accuracy of these episodes, particularly for flash flood events over urban and complex topography.

There is still limited skill achieved in forecasting disastrous weather events over the Himalayan region. A denser observational network over the Himalayan region and better representation of land-surface and topography data in the high-resolution numerical models is needed to address these issues.

Weather and Climate Services: Challenges and uncertainties remain concerning the accuracy of monsoon predictions and precipitation forecasts across different timescales. Even though the seasonal prediction of district-level rainfall may not be feasible, attempts can be made to predict seasonal rainfall over a sub-division, especially over India's central plains. The extended range prediction system provides beneficial products at a time scale of 15-20 days. More work is needed to model the complex interactions between ENSO, IOD, and Indian Monsoon. A state-of-the-art climate data centre with an integrated advanced climate data services portal for rendering national and regional climate services is being established by the IMD. The climate data centre will provide a comprehensive set of improved and specialized climate services for the country by upgrading climate monitoring, climate prediction, climate data management, and climate application.

Energy Management System: Establishing a robust Energy Management System to develop a strong reporting and verification system is essential. An accomplished MRV system enables the achievement of maximum mitigation through end-to-end information management of a given system. Such an integrated MRV system requires streamlined data management systems, improved technical skills, analytical capabilities, and coordination among stakeholders. The development of a robust MRV system also requires additional finance and capacity building.

5.5.2 Support received

Individual projects funded by multilateral institutions such as GEF have a component on capacity building. The GEF-funded project on “Preparation of Third National Communication to the UNFCCC and Strengthening Institutional and Analytical Capacities on Climate Change” has supported the preparation of India’s third BUR. Under the GEF-7 cycle, the projects on "Capacity-building for establishing an Integrated and Enhanced Transparency Framework for Climate actions and Support Measures" worth USD 3.8 million, “Preparation of India’s Fourth National Communication (4NC), Fourth Biennial Update Report (BUR-4) and First Biennial Transparency Report (BTR1) to the UNFCCC and strengthening institutional and analytical capacities on climate change" worth USD 4.416 million have been supported. These projects have limited provision for developing or strengthening the infrastructural and technical capacities of the national institutions involved with the preparation of national GHG inventory and awarding studies to assess the impact of climate change on various mitigation and adaptation sectors.

India accessed the second phase of readiness and preparatory support grant (worth USD 0.3 million) from GCF with two objectives:

1. Accreditation support and building capacity of DAEs and State governments to develop fundable proposals based on the priorities identified in the country programme document with financing models that are innovative and can leverage various types of funds;
2. Systematically engaging businesses and financial institutions to invest in climate actions.

Bilaterally, India has entered into MoUs with several countries to exchange and strengthen expertise on climate change mitigation and adaption matters during this BUR reporting period. Some of the major MoUs signed are as follows:

- December 2018, between India and France in the field of new and renewable energy.
- September 2019, between India and Switzerland on technical cooperation in the field of climate change and environment.
- October 2019, between India and Saudi Arabia to set up a framework for cooperation between the two counties in the field of renewable energy.
- November 2019, between India and Guinea in the field of renewable energy.
- December 2019, between India and the United Kingdom for enabling energy self-sufficiency for IR.
- December 2019, between India and Brazil, setting up a framework to cooperate and promote investment in bioenergy.
- January 2020, between India and Brazil for cooperation in the oil and natural gas sector (including encouraging collaboration in oil energy and environmental issues).

5.5.3 National initiatives

GoI attaches great importance to knowledge management and capacity building for climate change and sustainable development. The Government programs invariably have a component on capacity building/ training/ awareness creation. Most of these programs have started accounting for climate variabilities in their respective sectors to ensure economic growth and sustainable development. Some of the significant domestic capacity-building initiatives are enumerated in the following paragraphs.

One of the eight national missions under NAPCC is the National Mission on Strategic Knowledge for Climate Change (NMSKCC). DST coordinates this mission focusing on building human and institutional science and technology capacities in climate change and developing strategic knowledge in the key areas of climate change science, adaptation, and mitigation.

Some of the significant achievements of NMSKCC includes:

- Establishment of 11 Centres of Excellence (CoEs) to address various aspects of climate change. These CoEs are located at Divecha Centre for Climate Change, IISc, Bangalore; IIT Bombay (Phase I & II), ICRISAT, Hyderabad (Phase I & II), IIT Madras (Phase I & II), IIT Delhi, IIT Kharagpur, BHU, Varanasi and NIMR, New Delhi;
- Initiated 23 major R&D programmes at key knowledge institutions and universities in different areas of climate science and adaptation;
- Launched six national network programmes; two each on Climate Modeling and Climate Change & Human Health and one each on Climate Change and Coastal Vulnerability, and Climate Change and Aerosols;
- Global Technology Watch Groups (GTWGs) in the areas of; a) Solar energy including other renewable energy anchored around National Institute of Advanced Studies (NIAS), Bangalore and participation of other groups at key national institutions; b) Clean Coal Technologies with IIT Madras taking the lead and several other institutions as partners; and c) six other areas (Enhanced Energy Efficiency, Sustainable Agriculture, Sustainable Habitat, Water, Manufacturing and Green Forestry) by TIFAC, New Delhi and State Climate Change Centres in 13 States – Madhya Pradesh, Punjab, Chhattisgarh, Karnataka, Kerala, Puducherry, Tamil Nadu, Telangana, Maharashtra, Odisha, Haryana. Bihar and Gujarat; and,
- Implementing human capacity building programs in six institutions across the country.

Some of the new activities undertaken by NMSKCC since April 2018 are as follows:

- CoE at Divecha Centre for Climate Change, IISc Bangalore, has been strengthened to study climate change impacts on the Himalayan glaciers, anthropogenic aerosols' impact on climate, and climate models for understanding past and future climate change.

- As part of the network programme on urban climate, five projects have been initiated to study various aspects of urban climate including, land surface, atmospheric processes, and hydrology with three pilot sites *viz.* Bengaluru (Inland), Bhubaneswar (Coastal), and Dehradun (Sub Himalayan).
- State Climate Change Cells established/strengthened in Bihar and Gujarat to undertake vulnerability assessment, training programmes, public awareness, and institutional capacity building.

BEE had launched a programme for capacity building of DISCOMs. During the financial year 2012-17, BEE had selected 34 DISCOMs for their capacity building and provided support for the implementation of DSM (demand side management related activities. During the second phase (FY 2017-20), the remaining 28 DISCOMs have been included under this programme.

Out of the 112 circle level programs, 42 training programs for the capacity building of circle level officials of DISCOMs have been completed. About 1500 (out of 4000) circle level officials have been provided training on DSM & EE. Trained workforce would be provided to the 28 new and existing 34 DISCOMs to implement this program's activities during 2017-20. To date, 100 consultants are positioned at various DISCOMs under this program for carrying out various DSM Activities. DSM regulations have been notified for 29 States and UTs. The remaining states are pursuing notification of their DSM regulations for their respective states.

MNRE’s Human Resource Development (HRD) scheme supports training for manpower at all levels, including promoting higher studies/research courses in R&D/academic institutions in renewable energy by providing fellowships to students/scholars. Support is also provided to R&D/academic institutes for upgrading their libraries and labs for conducting higher degree courses such as M.Sc, M.Tech, and Ph.D. in the field of new and renewable energy. The Ministry is also implementing *Suryamitra*, a skill development programme to create a trained workforce for installation, commissioning, operation, and maintenance of solar projects. The Ministry has initiated the "Indian Renewable Energy Idea Exchange (IRIX)," a multi-stakeholder collaborative platform to exchange and catalyse renewable energy innovation ideas. This platform aims to bring together industry experts, the renewable energy community, entrepreneurs, and policymakers to drive innovation in renewable energy at an exponential pace.

GoI has updated and revised the National Disaster Management Plan (NDMP) in 2019 to strengthen disaster preparedness and recovery. Considering the impact of climate change on the frequency and intensity of disasters, climate change risk management has been included as a novel and sixth thematic area for disaster risk management in the responsibility framework of the revised NDMP (NDMA, 2019).

To conclude, the late President of India, Dr. A.P.J. Abdul Kalam, said that “building capacity dissolves differences. It irons out inequalities”. Empowering people and institutions with knowledge, requisite infrastructure, and resources is fundamental to the creation of solutions to climate change. India is continuously making efforts to build and strengthen its human, technical, and infrastructure capacity and capabilities on energy efficiency, renewable energy, disaster management, and adaptation to meet its population's basic, developmental and aspirational needs. However, this is not adequate because, on the one hand, capacity-building needs are multidimensional, at every level of governance and are not a one-time activity. On the other hand, the reporting obligations under UNFCCC are increasing, while resources and support from developed countries for on-ground climate action are declining, and weather-based events/ disasters are becoming more frequent with significant loss to the economy and society. India’s efforts towards meeting the NDCs alone will require intensive and regular upgrading of infrastructure and technical workforce. Enhanced collaboration and networking with international partners are required to exchange best practices and knowledge systems on climate change mitigation and adaptation.

5.6 Support provided by India

India’s civilizational values on international cooperation, underpinned by the enduring conceptual framework of ‘*Vasudhaiva Kutumbakam*’ (The whole world is one family), has guided the country’s development partnerships, particularly in climate action.

Development partnership is a key instrument in India’s foreign policy, particularly concerning “Neighborhood First” and "Act East” policies. While India’s development cooperation initiatives have a long and enduring history, the nature and spread of such development assistance has, in recent years, expanded both geographically and sectorally. India’s development cooperation aligns with the development priorities of the partner countries as technically and financially feasible. The main instruments of India’s development assistance include LoC, grant assistance, small development projects (SDP), technical consultancy, disaster relief, humanitarian aid and capacity-building programmes. The focus of development assistance has been India’s neighbouring countries and Africa. However, India is also expanding its reach to South-East Asia, the Caribbean, Latin America, Mongolia, Russian Federation, and the Pacific Island countries. Since 2005-06, 307 LoCs amounting to USD 31.61 billion have been extended to 64 countries in various sectors (MEA, 2020a).

India has shown time and again that it can be a reliable partner for the world. Despite being a vast developing country, severely impacted by COVID-19 pandemic and climate change, India has kept supply chains open during this pandemic and supplied medicines and medical equipment to more than 150 countries. This has added to India’s reputation as the pharmacy to the world. As we move towards developing a COVID-19 vaccine, India, which accounts for 60 per cent of global vaccine production, has already committed its vaccine production and delivery capacity to help the world in fighting this crisis.

Further, in keeping with the commitment made by Hon’ble Prime Minister of India at CHOGM 2018, India has since opened a ‘Commonwealth Sub Window’ (of USD 50 million) to provide grant-in-aid assistance to Commonwealth members for projects related to SDG implementation and Climate Action. In the first year of its existence, the Fund has approved 11 projects in 9 Commonwealth countries. As part of the same, India is assisting seven Pacific Island countries with developing a climate early warning system. The project will enhance Pacific Island countries' ability to prepare, respond to, and recover from climate-related disasters.

India has also been engaging with SIDS more than ever before. Two summits under the Forum for India Pacific Islands Cooperation (FIPC) have been organised since 2014, and in September 2019, India organized the first India-CARICOM leaders’ meeting. India has been and will continue to be committed to tackling the impact of climate change and supporting SIDS efforts to achieve their developmental goals through both developmental and technical assistance. India has also more than doubled its support to the Commonwealth Small States Offices Program in New York (from USD 100,000 to USD 250,000) and Geneva (from USD 80,000 to USD 150,000) to support the small states and SIDS engagement with international bodies like the UN and WTO (MEA, 2020).

Solar projects: The International Solar Alliance is a major initiative of the Prime Minister in contributing to the implementation of the Paris Agreement through rapid and massive deployment of solar energy. The founding conference of the International Solar Alliance took place on 11 March 2018, in New Delhi. During this conference, India committed to extending nearly USD 1.4 billion worth of LoCs (MEA, 2018). These include six solar projects amounting to USD 500 million under EBID (ECOWAS Bank for Investment and Development) and 21 other solar projects amounting to USD 790 million. Under this, LoCs amounting to USD 200.92 million have been extended to Bangladesh, and USD 100 million have been extended to Sri Lanka for various solar projects. This year, new LoCs worth USD 140.33 million to the Democratic Republic of Congo, USD 35.80 million to Suriname, USD 122 million to Rwanda, USD 20.22 million to Guinea, USD 22 million, and USD 60.65 million to Mali were extended. These solar projects are under various stages of implementation.

Capacity-building support for Renewable Energy: The Indian Technical and Economic Cooperation (ITEC) programme is a visible symbol of India’s role and contribution to South-South Cooperation, which constitutes capacity building partnership with a footprint in 161 partner countries from Asia, Africa, East Europe, Latin America, the Caribbean as well as Pacific and Small Island countries. During 2019-20, 11,645 civilian training slots were offered under the ITEC programme to 159 partner countries in 98 premier institutions for various short-term, and medium-term 392 courses in institutions spread all over India. The civilian training programme, fully sponsored by GoI through more than 85 premier institutions, conducts over 370 courses encompassing a diverse array of skills and disciplines, including climate change and the environment for working professionals.

As part of ITEC and IAFS-III (India-African Forum Summit-III) programmes, MNRE facilitates specialized training programmes for African and other developing countries in the field of solar and wind energy. The training programmes conducted from September 2018 to February 2020 are listed in Table 5.10.

Table 5.10: List of trainings under ITEC and IAFS-III (MNRE, 2020)

S. No.	Programme/Course	Duration	No. of Participants	No. of Countries
1	International Training Programme on Solar Energy Technologies and Applications under ITEC	27 August to 14 September 2018	30	16
2	International Training Programme for Master Trainers from ISA member countries under ITEC	10 to 29 September 2018	29	9
3	Special International Training Course on Wind Resource Assessment and Wind Farm Planning under ITEC	19 September to 12 October 2018	17	11
4	International Training Programme for Renewable Energy Capacity Building under IAFS	24 September to 12 October 2018	16	8
5	International Training Programme for Master Trainers from ISA member countries under ITEC	15 October to 3 November 2018	24	11
6	Special International Training Course on Design, Installation and Maintenance of Small Wind Turbine under ITEC	14 November to 14 December 2018	31	14
7	Special International Training Course on Design, Installation and Maintenance of Small Wind Turbine for African countries under IAFS-III	15 November to 13 December 2018	NA	NA
8	International Training Programme on Solar Energy Technologies and Applications under ITEC	26 November to 14 December 2018	32	21
9	International Training Programme for Master Trainers from ISA member countries under ITEC	26 November to 15 December 2018	21	10
10	International workshop on Small Wind Turbine	30 November to 9 December 2018	120	36
11	International workshop on Small Wind Turbine	10 to 12 December 2018	250	36
12	Renewable Energy Capacity-building Programme for African countries	7 January to 25 January 2019	23	NA

S. No.	Programme/Course	Duration	No. of Participants	No. of Countries
13	ITEC programme in Solar Energy for Master Trainers from ISA member countries	21 January to 9 February 2019	24	NA
14	International Training Course on Wind Turbine Technology and Applications	31 January to 1 March 2019	28	16
15	International Training Programme on Solar Technologies and Applications	4 to 22 February 2019	27	NA
16	ITEC programme in Solar Energy for Master Trainers from ISA member countries	18 February to 9 March 2019	29	NA
17	Special International Training Course on Wind Resource Assessment and Wind Farm Planning	28 August to 20 September 2019	19	9
18	Special International Training Course on Design, Installation and Maintenance of Small Wind Turbine	28 August to 24 September 2019	26	9
19	Special International Training Course on Wind Turbine Technology and Applications	24 October to 21 November 2019	29	16
20	International Training Course on Wind Turbine Technology and Applications	23 October to 19 November 2019	28	18
21	Special International Training Course on Solar Resource Assessment and Development of Solar Power Plant	27 November to 20 December 2019	34	21
22	International Training Course on Wind Turbine Technology and Applications	29 January to 25 February 2020	29	18
23	ITEC Programme in Solar Energy for Master Trainers from ISA Member Countries	10 to 28 February 2020	30	15

Coalition for Disaster Resilient Infrastructure (CDRI): The Hon'ble Prime Minister of India launched the Coalition for Disaster Resilient Infrastructure during the 74th UN General Assembly at the Climate Action Summit in New York on 23 September 2019.

CDRI will provide technical and capacity support to encourage investments and partnerships for the development of disaster resilient infrastructure in the participating countries. The Coalition targets the creation of a mechanism to assist countries to upgrade their capacities, systems, standards, regulations and practices with regard to infrastructure development in accordance with their risk context and economic needs.

To conclude, ISA and CDRI are major initiatives by India which harness the country's domestic strengths and capacities to mobilize international multilateral efforts to answer global problems and challenges.

References

Adaptation Fund. (2019). Adaptation Fund Reaches Close to USD 90 Million in New Pledges for 2019 at COP 25 Climate Conference. AF NEWS.

Azad. A., and Azad, A. (2016). Energy Access, Climate Justice, and Financing

Innovation. Environmental Law institute.

Climate Bonds Initiative. (2018). Green bonds: The state of the market 2018. Available at: https://www.icmagroup.org/assets/documents/Regulatory/Green-Bonds/Public-research-resources/CBIGBMFinal032019-120319.pdf

DEA. (2018). 3 Essential "S" of Climate Finance - Scope, Scale and Speed: A Reflection. Department of Economic Affairs, Ministry of Finance, Government of India.

DEA. (2020). Report of the Sub-Committee for the Assessment of the financial requirements for implementing India's Nationally Determined Contribution (NDC), Department of Economic Affairs, Ministry of Finance, Government of India.

GEF. (2014). GEF-6 Indicative Star Allocations. GEF/C.47/Inf.08. Global Environment Facility Council Meeting. October 28-30, 2014, Washington, D.C. https://www.thegef.org/sites/default/files/council-meeting-documents/GEF-C.55-Inf.03-GEF-7-STAR.pdf

GEF. (2018). Initial GEF-7 Star Country Allocations. GEF/C.55/Inf.03. 55th Global Environment Facility Council Meeting. December 18-20, 2018. Washington, DC. https://www.thegef.org/sites/default/files/council-meeting-documents/GEF-C.55-Inf.03-GEF-7-STAR.pdf

Germanwatch. (2020). Global Climate Risk Index 2020. Who Suffers Most from Extreme Weather Events? Weather Related Loss Events in 2018 and 1999 to 2018.

Global Environment Facility. (2020). Special Climate Change Fund - SCCF. [online] Available at: https://www.thegef.org/ topics/special-climate-change-fund-sccf.

Green Climate Fund. (2020). Green Climate Fund. [online] Available at: https://www.greenclimate.fund/home

IEA. (2020a). Clean Energy Innovation, IEA, Paris. https://www.iea.org/reports/clean-energy-innovation

IEA. (2020b). India 2020-Energy Policy Review. P. 302. https://niti.gov.in/sites/default/files/2020-01/IEA-India%202020-In-depth-EnergyPolicy_0.pdf

IMD. (2020). Statement on Climate of India during 2019 (Press Release 6th January 2020; p. 3). Climate Research and Services (CRS), India Meteorological Department, MoES, GoI. https://mausam.imd.gov.in/backend/assets/press_release_pdf/Statement_on_Climate_of_India_during_2019.pdf

Khan, M., Robinson, S., Weikmans, R. et al. (2020). Twenty-five years of adaptation finance through a climate justice lens. Climatic Change 161, 251–269.

MEA. (2018). Press release on announcement of the first General Assembly of the International Solar Alliance [ISA]. Ministry of External Affairs, Government of India. Retrieved from https://mea.gov.in/press-releases.htm?dtl/30420/Press_release_on_announcement_of_the_first_General_Assembly_of_the_International_Solar_Alliance_ISA

MEA. (2020). Commonwealth Foreign Affairs Ministers Meeting. Ministry of External Affairs, Government of India. Retrieved from

https://mea.gov.in/SpeechesStatements.htm?dtl/33118/Statement_delivered_by_Shri_Vikas_Swarup_Secretary_West_at_20th_Commonwealth_Foreign_Affairs_Ministers_Meeting

MEA. (2020a). Communication received from Ministry of External Affairs, Government of India, email dated 18 November 2020.

MNRE. (2020). Support to Other Countries. Ministry of External Affairs, Government of India. https://mnre.gov.in/international-relations/support-to-other-countries

MoF. (2015). Climate finance, analysis of a recent OECD report: Some credible facts needed. New Delhi: Department of Economic Affairs, Ministry of Finance, Government of India. Retrieved from http://pibphoto.nic.in/documents/rlink/2015/nov/p2015112901.pdf

MoF. (2020). Economic Survey 2019-20 Volume 2. Ministry of Finance, Government of India.

NABARD. (2020). Projects sanctioned under National Adaptation Fund for Climate Change. https://www.nabard.org/content.aspx?id=585

NDMA. (2019). National Disaster Management Plan. Ministry of Home Affairs.

Patankar, A. (2019). Impacts of Natural Disasters on Households and Small Businesses in India. ADB-Economics Working Paper Series No. 603. https://www.adb.org/sites/default/files/publication/547031/ewp-603-disasters-households-small-businesses-india.pdf

Patil, A., Goutham, R., & Jayaraman, T. (2020). “Annex-I Countries – Trends in patenting and technology development”. A Component of the Interim Report on the NATCOM study on "Equity and CBDR&RC in the context of 2 deg warming - Implications for India". M S Swaminathan Research Foundation, Chennai.

PIB. (2020a). PM undertakes aerial survey of Cyclone Amphan affected areas in West Bengal. Released by Prime Minister’s Office. Release Id :208125 dated 22 May 2020. Press Information Bureau, Government of India.

PIB. (2020b). Prime Minister conducts aerial survey of areas of Odisha affected by Cyclone Amphan; announces Rs 500 crore financial assistance. Released by

Prime Minister's Office. Release Id :208139 dated 22 May 2020. Press Information Bureau, Government of India.

Rimmer. M. (Ed.). (2018). Intellectual Property and Clean Energy: The Paris Agreement and Climate Justice, Singapore: Springer, 33-67.

SBI. (2020). Compilation and synthesis of fourth biennial reports of Parties included in Annex I to the Convention. Subsidiary Body for Implementation FCCC/SBI/2020/INF.10 Report by the Secretariat of United Nations Framework Convention on Climate Change, Bonn. Retrieved from https://undocs.org/FCCC/SBI/2020/INF.10

SCF. (2018). UNFCCC Standing Committee on Finance. 2018 Biennial Assessment and Overview of Climate Finance Flows: Technical Report.

TIFAC. (2020). White paper on Make in India': Post COVID-19 - "Provide Local Solutions for Global Challenges" released on 10th July 2020.

UNDRR. (2020). Human cost of disasters, An Overview of the last 20 years: 2000-2019. UN Office for Disaster Risk Reduction

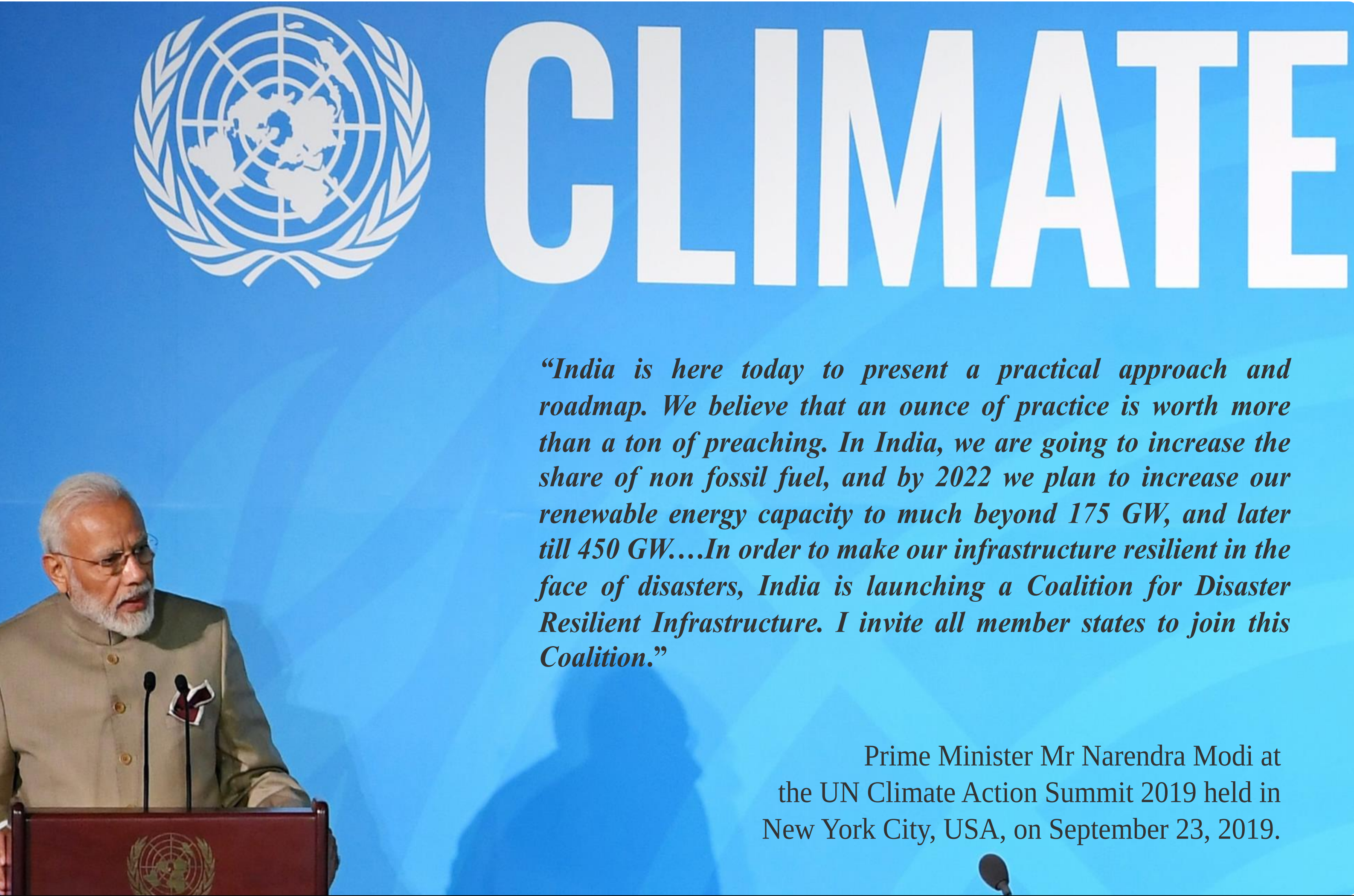
UNEP. (2016). The Adaptation Finance Gap Report 2016. United Nations Environment Programme (UNEP).

UNFCCC. (2020). Database of PAs and POAs. United Nations Framework Convention on Climate Change. https://cdm.unfccc.int/Statistics/Public/files/Database%20for%20PAs%20and%20PoAs.xlsx

UNISDR. (2018). Economic Losses, Poverty and Disasters: 1998-2017. UN Office for Disaster Risk Reduction.

Weikmans R. & Roberts, J. T. (2019). The international climate finance accounting muddle: is there hope on the horizon?, Climate and Development, 11:2, 97-111, DOI: 10.1080/17565529.2017.1410087

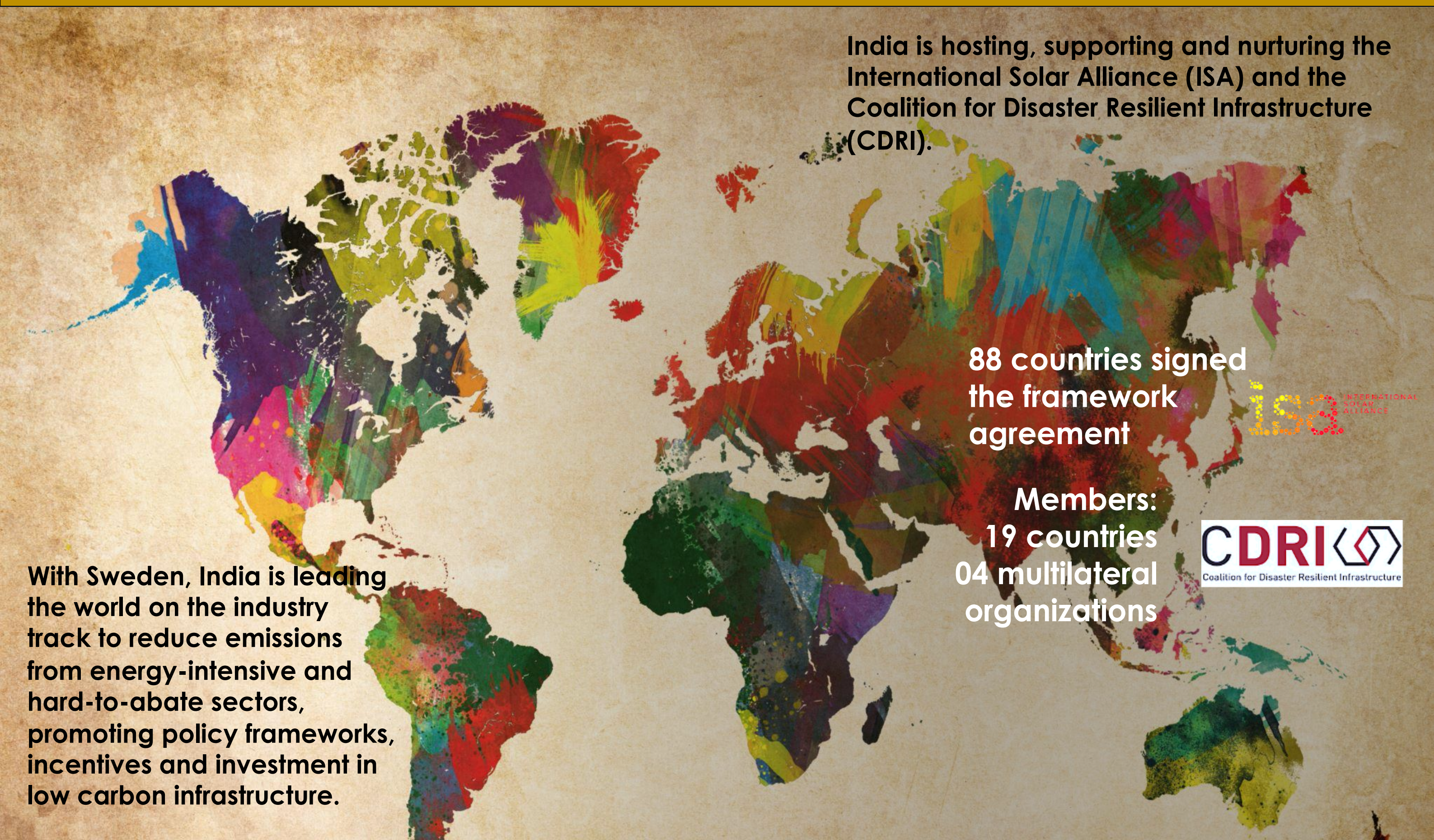
*****



"India is here today to present a practical approach and roadmap. We believe that an ounce of practice is worth more than a ton of preaching. In India, we are going to increase the share of non fossil fuel, and by 2022 we plan to increase our renewable energy capacity to much beyond 175 GW, and later till 450 GW….In order to make our infrastructure resilient in the face of disasters, India is launching a Coalition for Disaster Resilient Infrastructure. I invite all member states to join this Coalition."

Prime Minister Mr Narendra Modi at the UN Climate Action Summit 2019 held in New York City, USA, on September 23, 2019.

India's leadership in Climate Ambition.



India is hosting, supporting and nurturing the International Solar Alliance (ISA) and the Coalition for Disaster Resilient Infrastructure (CDRI).

88 countries signed the framework agreement

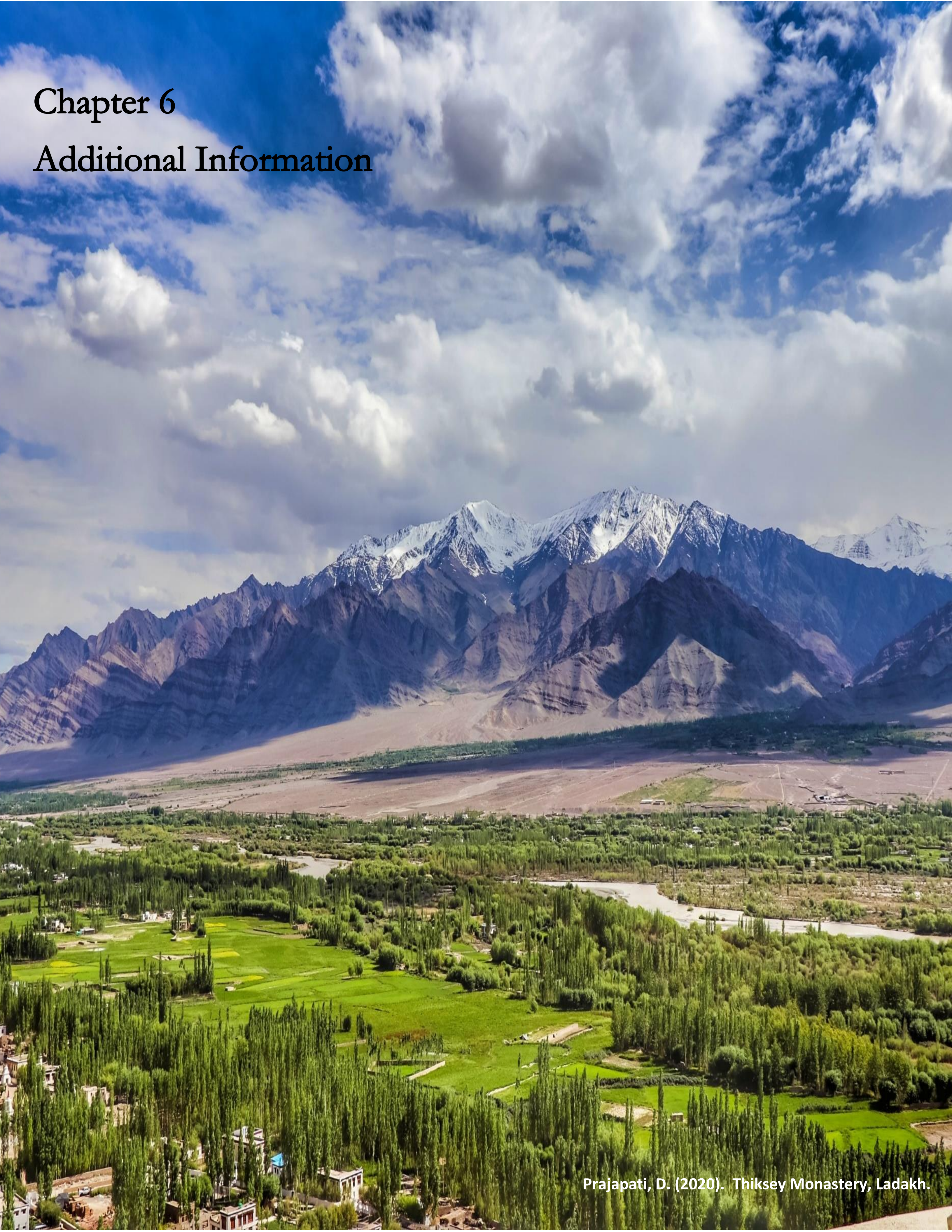
Members:
19 countries
04 multilateral organizations

Coalition for Disaster Resilient Infrastructure

With Sweden, India is leading the world on the industry track to reduce emissions from energy-intensive and hard-to-abate sectors, promoting policy frameworks, incentives and investment in low carbon infrastructure.

India's leadership in Global Cooperation.

Chapter 6
Additional Information



Prajapati, D. (2020). Thiksey Monastery, Ladakh.

Key Points

Chapter 6 Additional Information

- The chapter contains information and success stories especially from renewable energy, sustainable transportation, international cooperation and initiatives, and the engagement of the private sector.
- The Indian Renewable Energy Development Agency (IREDA) is in the process of setting up a dedicated "Green Window" to serve the unserved segments of renewable energy with allocation of approximately USD 20 million. State Rooftop Solar Attractiveness Index (SARAL) was launched in 2019 to incentivize rooftop solar by creating healthy competition among the States.
- Solarisation of the Sun temple towns of Konarak and Modhera, installation of the world's largest solar rooftop at the Brabourne stadium in Mumbai, building the world's largest solar park at Bhadla, the Rewa Solar Power Project are some of the prominent recent developments to promote solar energy.
- The world's first fully solar powered airport was developed in Kochi and the model is being adopted in other airports such as Kolkata and Mangalore.
- The Indian Railways (IR) is making significant efforts to become a "net zero" carbon emitter by 2030. IR had an installed solar power capacity of 103 MW which is proposed to be increased to 1,000 MW and wind generation capacity of 104 MW which is proposed to be increased to 200 MW by 2022.
- In the transport sector, there has been an expansion of urban rail, strengthening of electric mobility, pilot usage of biojet fuels in aircraft, pilot operations of hydrogen fueled buses and cars, and the operation of a fully solar-powered commuter ferry Aditya.
- The development of India's newest Union Territory of Ladakh as carbon-neutral Ladakh is an attempt to chart a new sustainable development pathway in an ecologically sensitive region where Nature dwarfs the human presence.
- The International Solar Alliance (ISA) is the result of an Indian initiative for collectively addressing key common challenges to scaling up of solar energy. With the signing and ratification of the ISA Framework Agreement by 15 countries, on 6 December 2017, ISA became the first international intergovernmental organization to be headquartered in India. The First Assembly of the ISA, held on 3 October 2018, adopted a resolution for an amendment to the Framework Agreement to expand the scope of membership of the ISA to all countries that are members of United Nations (UN). As on date, 88 countries have signed the Framework Agreement of the ISA. Of these, 70 countries have also ratified the same.

- India announced the formation of a global Coalition for Disaster Resilient Infrastructure (CDRI), at the UN Climate Action Summit 2019, to promote the resilience of new and existing infrastructure systems to climate and disaster risks.
- India participates actively in several bilateral cooperation arrangements on environment and climate change with other developing countries as well as with developed nations.
- There has been serious private sector engagement in the country to address the growing challenge of climate change with various climate-friendly initiatives. Several major Indian corporates have announced mitigation plans of varying intensities over different time frames.

Chapter 6
Additional Information

Following Decision 2/CP.17, Annex 3, Para 2 (g), the scope of BURs include providing an update on "Any other information that the non-Annex I Party considers relevant to the achievement of the objective of the Convention and suitable for inclusion in its Biennial Update Report (BUR)". In accordance with this provision, this chapter provides information additional to that which is provided in the preceding chapters. The chapter contains information and success stories from the renewable energy sector, sustainable transportation, international cooperation and initiatives, promotion of digital technology, and private sector engagement. A section on Gandhian principles of sustainable development is also included.

6.1 Promotion of clean and renewable energy

6.1.1 Renewable energy

The renewable energy sector in India is making rapid strides. India's substantially higher commitment to increasing the use of renewables in its total energy mix ensures greater energy security, improved energy access, and enhanced employment opportunities, while making the country one of the world's largest green energy producers. India ranked fifth in the world in renewable energy installed capacity and generation in 2018 according to IRENA (IRENA, 2020).

As part of NDCs to the UNFCCC, India has undertaken to install about 40 per cent of its total electricity power capacity from non-fossil fuel sources by 2030. As of 30 November 2020, a cumulative renewable energy capacity of over 90.39 GW had been installed in the country, and 49 GW is under implementation and 30 GW is under different stages of tendering. As on same date, the country had cumulative installed capacity of 142.87 GW from all non-fossil fuels sources (renewables + hydro + nuclear). This has been made possible through the concerted efforts of the GoI to promote renewable energy. Major achievements and policies have been covered in Chapter 3. This section discusses some interesting additional developments in the renewable sector, which may pave the way for more achievements in the near future.

6.1.1.1 Green energy finance

Indian Renewable Energy Development Agency Limited (IREDA) is in the process of setting up a dedicated "Green Window" to serve the unserved segments of renewable energy. An allocation of approximately USD 20 million is being considered for the Green Window, with plans of leveraging USD 80 million from both private domestic banks and international sources. India is one of the top three nations leading global renewable energy growth and requires USD 330 billion between 2018 and 2030 to meet its commitments under the Paris Agreement. The proposed green window is expected to lower the risk for traditional banks to finance green energy and provide room to tap into international capital to help India power its cities and villages (PIB, 2020a).

6.1.1.2 State Rooftop Solar Attractiveness Index (SARAL)

SARAL was launched by the GoI in 2019 to incentivise solar energy production from rooftops by creating healthy competition among the States. The index has been designed by the Ministry for New and Renewable Energy (MNRE), Shakti Sustainable Energy Foundation, Associated Chambers of Commerce and Industry of India and Ernst and Young (EY). SARAL captures five key aspects: the robustness of policy framework; environment for implementation; investment climate; consumer experience; and business ecosystem. It encourages each State to assess its progress and analyse the way forward for improving the programme's scope. This will help States to channel investments that can eventually help the sector grow. In addition, such an exercise is likely to create a more conducive environment for solar rooftop installations, while encouraging investment to accelerate the sector's growth. In 2019, the State of Karnataka ranked first in the Index, followed by Telangana, Gujarat and Andhra Pradesh (PIB, 2019i).

6.1.1.3 Ocean energy is renewable energy

In August 2019, GoI declared that ocean energy (such as tidal, wave, current, ocean and thermal energy conversion) shall be considered renewable energy and shall be eligible for meeting the non-solar Renewable Purchase Obligation (RPO) (PIB, 2019b).

6.1.1.4 Solarisation of Konark

Konark is located in Puri district of the State of Odisha and is home to the 13th century Sun Temple, a UNESCO World Heritage Site. GoI launched a scheme in May 2020 with the objective to develop the historical Sun Temple town of Konark in Odisha as “Surya Nagri", to convey a message of synergy between the modern use of solar energy and the ancient Sun temple, emphasizing the importance of promoting solar energy. The scheme envisages setting up of a 10 MW grid-connected solar project and various solar off-grid applications like solar trees, solar drinking water kiosks, off-grid solar power plants with battery storage with 100 per cent Central Financial Assistance of approximately INR 250 million, implemented by Odisha Renewable Energy Development Agency. It is expected to meet all the energy requirements of Konark town with solar energy (PIB, 2020b).

6.1.1.5 Solarisation of Modhera

GoI has launched another scheme to take forward the Prime Minister’s vision of solarisation of the sun-temple town of Modhera in Mehsana district in Gujarat. The Scheme envisages setting up of the renewable energy installations comprising 6 MW solar PV power plant, 15 MWh battery storage, rooftop solar PV systems, smart meters, solar electric vehicle charging stations in Modhera, with an investment of around INR

650 million, with up to 50 per cent central financial assistance from GoI through MNRE with the Government of Gujarat contributing the remaining 50 per cent. The scheme is expected to fulfill the domestic and agricultural electricity needs of all the households of Modhera with solar energy, thereby setting up a pilot demonstration project for a village/ town running entirely on solar energy (PIB, 2020c).

6.1.1.6 World's largest solar rooftop: Brabourne Stadium

One of the world's largest solar rooftops was installed on Brabourne Stadium at the Cricket Club of India (CCI) in Mumbai in August 2018. It consists of 2,280 solar panels of 360 watt peak (Wp) rating, each on the roof of the west and north stands of the stadium. The combined power generation capacity of these panels commissioned by Tata Power is 820 kW (kilowatt) (Tata Power, 2020). The CCI had already carried out a pilot project to install solar panels to generate 45 kW and a 6,000 liters per day solar water heating system in 2016. The rooftop panels are made with the latest technology of mono-crystalline PERC. The total roof area is 1.621 million sq. ft. of roof sheds with an estimated energy generation of 1.12 million units per annum displacing 840 tonne of CO_2 annually (The Hindu, 2018a).

Figure 6.1: Solar rooftop of Brabourne Stadium, Mumbai

6.1.1.7 World's largest Solar Park: Bhadla

Bhadla Solar Park is the world's largest solar park (as on March 2020), located in Bhadla, in Jodhpur district of Rajasthan. The park is spread over 10,000 acres (40 km^2) and has a capacity of 2,245 MW. The project is a joint effort between the NTPC Limited and the Solar Energy Corporation of India (SECI), both of which are public sector enterprises under the MNRE. Before Bhadla, Solar Park Pavagada, in Karnataka, with a capacity of 2,050 MW was the largest solar park (Austin R, 2019).

Figure 6.2: Bhadla Solar Park

6.1.1.8 Development of Ultra-Mega Renewable Energy Power Parks (UMREPPs)

UMREPPs will be developed under the existing Solar Park Scheme. The objective of the UMREPP is to provide land upfront to the project developer and facilitate transmission infrastructure for developing Renewable Energy (RE) based Ultra-Mega Power Projects (UMPPs) with solar/wind/hybrid and with storage system if required.

6.1.1.9 Grid-connected Rooftop Solar (RTS) Programme

Phase II of the grid-connected rooftop solar programme was approved in Februrary 2019, with a target for achieving a cumulative capacity of 40,000 MW from RTS Projects by 2022. In the Phase-II of the programme, Central Financial Assistance (CFA) for the residential sector has been restructured, and DISCOMs are incentivised to promote RTS.

6.1.1.10 Rewa Solar Power Project

The Hon'ble Prime Minister inaugurated the Rewa solar power project in Madhya Pradesh on 10 July 2020 and dedicated Asia's largest solar power project to the nation. The new 750 MW solar power plant project will reduce emissions equivalent to approximately, 1.5 million tonne of CO_2 per year. It exemplifies India's commitment to attaining the target of 175 GW of installed renewable energy capacity by 2022 (PIB, 2020i).

Figure 6.3: Rewa solar power project

The project comprises of three solar generating units of 250 MW each located on a 5 km^2 plot of land situated inside a solar park. The solar park was developed by the Rewa Ultra Mega Solar Limited (RUMSL), a joint venture company of Madhya Pradesh Urja Vikas Nigam Limited (MPUVN) and SECI.

The Rewa Solar Project was the first solar project in the country to break the grid parity barrier. Compared to prevailing solar project tariffs of approximately INR 4.50/unit in early 2017, the Rewa project achieved historic results: a first year tariff of INR 2.97/unit with a tariff escalation of INR 0.05/unit over 15 years and a levelized rate of INR 3.30/unit over the term of 25 years. The project is also the first renewable energy project to supply to an institutional customer outside the state, the Delhi Metro. The project will supply 24 per cent of energy to the Delhi Metro and the remaining 76 per cent to the State DISCOMs of Madhya Pradesh.

The Rewa project has been acknowledged in India and abroad for its robust project structuring and innovations. It has also received the World Bank Group President's Award for innovation and excellence and was included in the book titled "A Book of Innovation: New Beginnings" released by the Hon’ble Prime Minister (PIB, 2020h; Nag, 2020).

6.1.1.11 Solar energy in airports

Cochin International Airport Limited (CIAL) became the first airport in the world to be fully powered by solar energy in August 2015. The installed capacity (output) is 40 Megawatt Peak (MWp). The amount of power generated is 0.16 million units per day on an average, while power consumption is 0.15 million units on an average per day. In line with the GoI's policy to reduce GHG emissions, Airport Authority of India (AAI) has adopted a similar model at its other airports. For example, AAI has also set up solar power plants with a capacity of 38.787 MWp, including 15 MWp solar power plant at Kolkata Airport. Further, AAI has also identified Hubbali, Belgavi and Mangalore airports for operating on solar power. AAI has initiated airport GHG emission management under ACI-ACA (Airport Council International - Airport Carbon Accreditation) programme at Kolkata, Varanasi, Bhubaneswar and Trivandrum airports to measure carbon emission saved by clean renewable resources (MoCA, 2019).

6.1.1.12 Make in India in the Renewable Energy Sector

The MNRE in an order in 2018 prescribed the minimum percentage of local content required for all major categories of renewable energy projects like hydropower, wind power, off-grid/ decentralised solar power, grid-connected solar power, biomass gasifier, biomass cogeneration, municipal solid waste and waste to energy (biogas /bio-CNG). It has also stipulated that in such projects, apart from civil construction, preference shall be provided by Central Ministries/ Department and Central Public Sector Units to domestically manufactured/ produced goods (MNRE, 2020).

6.1.1.13 Renewable Energy Country Attractiveness Index

Ernst and Young Global Limited in its 53rd edition of the Renewable Energy Country Attractiveness Index (RECAI) report 2019 ranked 40 countries on attractiveness based on renewable energy investment and deployment opportunities. India ranked 4th in RECAI report 2019. The ranking is based on different parameters such as economic stability, investment climate, security and supply of energy, clean energy gap, affordability of energy, policy enablement through political stability and support for renewables, project delivery in terms of energy market access, infrastructure, finance and technology potential based on natural resource, power off-take attractiveness, potential support, technology maturity and forecast growth and pipeline. The status of the country on each of the parameters is rated, to arrive at an overall RECAI ranking (MNRE, 2019a).

6.1.1.14 Solar Dryer Cum Space Heating System (SoLDry) for UT of Ladakh

The UT of Ladakh is among the areas that receive the highest solar radiation in the country. On average, the region gets about 20 per cent more solar energy than other parts of the country. It is estimated that more than 50 per cent of the fruit and vegetable produce of Ladakh, including some of the world’s best varieties of apricot, is wasted due to lack of access to market. The National Institute of Solar Energy (NISE) successfully deployed 10 solar dryer units (5 in Leh and 5 in Kargil) on a trial basis in July 2018 to dry apricots and evaluate their performance in actual field conditions. Based on the system's satisfactory performance, the horticulture department of Jammu and Kashmir requested NISE to supply and install 670 Unit of solar dryer cum space heating system. Presently 300 systems are under installation in phase 1 (NISE, 2020).

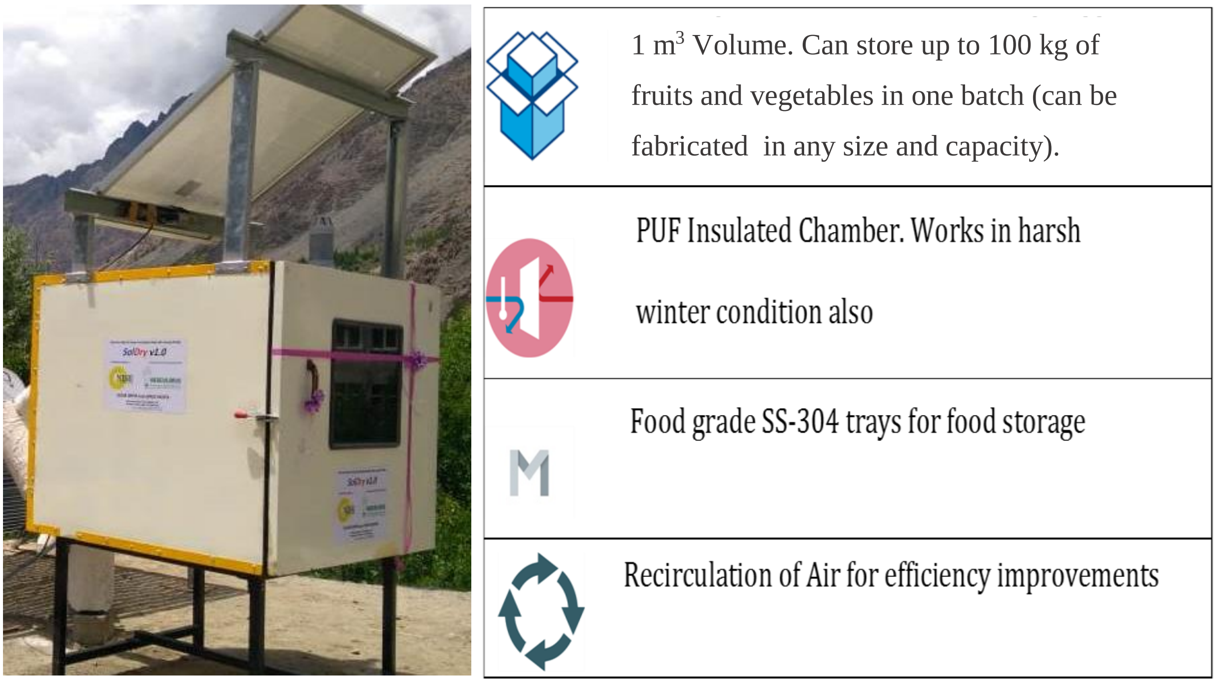


Figure 6.4: Installed solar dryer cum space heating system at Minjee village, Kargil

Household heating requirements:

In addition to heat for fruit drying, there is a potential to supply heat for room heating through solar energy. This need was assessed in tandem to evaluate the potential for hybrid systems. For room heating currently, the requirement of 50 kg of wood per day, costs them at least INR 60,000 to 70,000 per year.

6.1.1.15 Dispute resolution mechanism

MNRE set up a dispute resolution mechanism for wind/solar projects to consider the unforeseen disputes between solar/wind power developers and SECI/NTPC Limited, beyond contractual agreement. This mechanism will help in the smooth implementation of solar/wind energy projects in India, by expeditiously resolving unforeseen disputes that may arise beyond the scope of contractual agreements.

6.1.2 Sustainable transportation

6.1.2.1 Green Indian Railways (IR)

Indian Railways is the third largest rail network in the world covering 67,415 route km (RKM) of which 62,891 RKM is Broad Gauge (BG). IR consists of 16 zones and employs more than 1.3 million people. GoI considers "IR as the growth engine of nation's *vikas yatra*[1]" and is continuously striving towards making IR a greener and cleaner sustainable mass transport system. In 2020-2021, the union budget made provisions for setting up larger solar power capacity alongside the railway tracks on IR. This is expected to give a massive power boost to the national transporter while cutting down its annual electricity bills and contributing to the efforts of IR to become a "net zero" carbon emitter by 2030 (MoR, 2019). Some of the climate-friendly initiatives of IR are enumerated below (MoR, 2020a):

- Renewable Energy: Currently, the IR has an installed solar power capacity of 103 MW and wind generation capacity of 104 MW. To boost the usage of solar power, Indian Railway's Organisation for Alternate Fuels (IROAF) is installing flexible solar panels on coaches. With lithium-ion batteries, as many as 450 Diesel Electrical Multiple Unit (DEMU) trailer coaches are being installed with flexible solar panels. Also, 50 passenger coaches with existing batteries are being installed with flexible solar panels. The flexible solar panels can be easily installed on train coaches and are nearly 80 per cent lighter than conventional solar modules. IR has planned to source about 1,000 MW solar power and about 200 MW of wind power progressively by 2021-22 across zonal railways and production units. Details are as follows (PIB, 2020d).

Solar energy:

- 500 MW solar plants on the rooftop of railway buildings through developers' Power Purchase Agreement (PPA) with 25 years' agreements will be used to meet non-traction loads at railway stations. About 500 MW are also planned from ground based solar plants system for meeting traction and non-traction requirements.
- Out of this, 103 MW of solar plants have already been installed.
- LoA for about 245 MW solar plants are issued by Railway Energy Management Company Limited (REMCL), a company under the Ministry of Railways, which are under different stages of execution.
- Tenders for two Hybrid plants (solar + wind) of 140 MW (35 MW solar + 105 MW wind) and 109 MW (27 MW solar + 82 MW wind) capacity have been floated by REMCL, which will provide a total of 62 MW solar.

---

[1] *Vikas yatra* = Journey of development

- 400 MW ground based solar power in collaboration with Rewa Ultra Mega Solar (RUMS), a joint venture of Goverment of Madhya Pradesh & Solar Energy Corportaion of India (SECI).

Wind energy

- Out of the 200 MW target of IR, 103.4 MW of wind plants have already been installed.
- Windmill plant of 21 MW capacity (for non traction) in Tamil Nadu, 26 MW capacity (for traction) in Rajasthan and 6 MW capacity (for non-traction) and 50.4 MW capacity (for traction) in Maharashtra have been installed.
- Further, tenders for 187 MW capacity have been floated by REMCL as part of hybrid renewable energy plants.
- Electrification of the conventional rail network in India: In the wake of investments in network electrification over the past decades, India is aiming at fulfilling the “Mission Electrification” programme. To meet its ambitious electrification targets, IR set a plan to accelerate the pace of electrification from 2,000 km per year in 2016 to 4,000 km per year in 2017 and increasing to 6,200 km per year in 2019. So far IR have met these targets, with a commensurate increase in the budget outlay towards traction electrification. (IEA, 2019).
- Electric locomotive: In 2018, IR got its first ever 12,000 HP electric locomotive as part of “Make in India” deal. This marks a significant milestone in reducing the carbon footprint. Also, for the first time, a diesel locomotive was converted to electric by the Diesel Locomotive Works in Varanasi which can deliver 10,000 HP against 2x2,612 HP of two diesel locomotive – in other words, 92 per cent more than the diesel version. Also, Chittaranjan Locomotive Works rolled out a 5,400 HP electric locomotive with an aerodynamic design to haul premium superfast passenger trains (MoR, 2020).

Table 6.1: Planned electrification of remaining BG Routes of Indian Railways

Year	Target (Route kilometre)
2019-20	6,000
2020-21	6,000
2021-22	6,000
2022-23	6,500
2023-24 (up to 23 December)	4,310
Total	28,810

- Energy efficiency: IR is part of the Bureau of Energy Efficiency’s (BEE) Perform Achieve and Trade (PAT) scheme. Several energy conservation and efficiency measures are being undertaken. These include, *inter alia,* LED lights at all stations and in more than 60 per cent of other buildings; automation of pumps with GSM based technique; use of energy-efficient pumps; micro-controller based Automatic Platform Lighting Management System; use of 3 stars and above labelled electrical products and equipment; solar-based LED lighting system for level crossing gates; use of solar water heater; and provision of occupancy sensors in offices.

- Energy management: All 8 production units and 44 major workshops have been certified with ISO:50001– Energy management system showing IR's commitment to energy conservation and efficiency.
- Alternate fuels: IR is promoting, *inter alia,* blending of 5 per cent of biodiesel with high speed diesel (HSD); Compressed Natural Gas (CNG)-based dual fuel diesel engine for DEMU trains; solar energy-based electric supply in guard van on freight trains and; CNG as cutting gas. It is important to note that IR has undertaken 20 per cent CNG substitution in diesel engines of as many as 25 DEMU trains.
- Head on generation system: In 2019, IR started operating trains on the "Head on Generation" (HOG) system. The HOG system is environment-friendly, economical as well as advantageous in operation. The HOG system is likely to earn additional revenue for the national transporter by replacing the power cars with passenger coaches. Since there is no use of diesel, there is no air pollution due to the burning of fossil fuel.
- Green Ratings: IR renewed its MoU with CII on 13 September 2019 for the facilitation of green initiatives in IR. Green rating and energy efficiency studies have been carried out on IR production units and major workshops. After assessment over the last four years, 53 railway industrial units including workshops and production units have achieved GreenCo certification. Additionally, about 16 railway stations and 21 more establishments have achieved green certification.
- Roll-on-Roll-Off (Ro-Ro) initiative: In the Railway Budget for 2016-17, Minister of Railways announced that an action plan will be developed and implemented to expand the freight basket through either containerization or new delivery models. 'Roll-on-Roll-off' is one such new delivery model that can provide a multimodal transport mix. RORO services were started on Konkan Railway and then extended to ECR and NFR successfully in 2017. There is a plan to implement it in the national capital region which can decongest Delhi by loading commercial vehicles onto railway flat wagons at railway terminals/PFTs outside Delhi and unload them after carrying them across the city. This transport-mix plan will reduce air and noise pollution and more importantly reduce the carbon footprint of transportation (PIB, 2017).
- Implications for GHG and local pollutant emissions; Projection of High Rail Scenario: The High Rail Scenario is used to explore the potential benefits of such a transition to an increased reliance on rail in India. Following the significant increase in transport activity, total well-to-wheel GHG emissions from India's transport sector as a whole increased steadily in the High Rail Scenario, reaching about 1.4 $GtCO_2eq$ in 2050, which marks approximately a 270 per cent increase over 2017. Despite this, GHG emissions are 18 per cent lower (or 315 $MtCO_2eq$) in 2050 than in the base scenario. This is because the additional emissions from rail are more than offset by the decline in emissions from the

other modes. In 2050, the increase in GHG emissions from rail is projected at 34 $MtCO_2eq$. This is more than offset by reductions in light-duty vehicles (130 $MtCO_2eq$) and trucks (180 $MtCO_2eq$) (IEA, 2019).

- Other measures include the planting of more than 12.6 million saplings, installing rainwater harvesting system at 595 buildings covering an area of more than 200 m^2, more than 70 water recycling plants commissioned, more than 470 waterbodies being conserved and made functional, solid waste collection and management in 2019-2020.
- Indian Railways had earlier set a target to fit bio-toilets in the entire fleet of coaches by the year 2021-22. This target was advanced. All passenger carrying BG coaches, from April 2020 onwards, are fitted with bio-toilets and direct discharge of human waste from trains has thus been eliminated in line with Swachh Bharat Mission. IR is using technology jointly developed with the Defence Research and Development Organization (DRDO) to process waste from bio-toilets in an eco-friendly manner.
- Green powered railway stations: 23 railway stations on IR network have already been declared Green railway stations. These railway stations are meeting energy needs completely either through solar power or wind power. Some of these 100 per cent green powered stations are Roha, Apta, Pen in Central Railway zone, Dhamaraghat in East Central Railway zone, Shimla, Shri Mata Vaishno Devi in Northern Railway zone, Unhel, Ambli Road, Khanderi, Bajud, Sadanapura and Sachin in Western Railway Zone.

6.1.2.2 Delhi Metro Rail Corporation (DMRC)

DMRC has a well-laid out energy management policy as well as a solar policy. From June 2019, 60 per cent of daytime energy requirement of Delhi Metro is powered by solar energy from 1,590 acre ultra-mega solar park in Rewa in Gurh tehsil, Madhya Pradesh. In other words, more than 300 trains across DMRC operational network of 389 km serving 2.6 million passengers every day are now operating on green solar energy during the day. This initiative helps DMRC reduce CO_2 emissions by 0.0317 million tonne per annum (World Bank, 2019).

6.1.2.3 Expansion of urban rail

There is currently 700 km of metro rail track in operation in 18 cities, while 900 km Metro/Regional Rapid Transit Systems (RRTS) is under construction in 27 cities. Besides, the Metro Rail Policy approved in 2017 promotes the further deployment of metro systems in other large and densely inhabited cities. This will raise the total aggregated track length to 3,600 km by 2050, boost urban rail transport, and increase related passenger-km by a factor of seven by 2050 (8 billion passenger-km in 2017 to about 55 billion by 2050) (IEA, 2019).

6.1.2.4 Electric mobility

The Government of India approved the National Mission for Electric Mobility (NMEM) in 2011 and subsequently the National Electric Mobility Mission Plan 2020 (NEMMP 2020) was unveiled in 2013 by the Hon'ble Prime Minister. As part of the NEMMP 2020, the Government approved the scheme Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles (FAME) India in March 2015. Based on the outcome and experience of the FAME India Scheme, the second Phase of FAME Scheme was finalised and notified on 8 March 2019 with the approval of the Union Cabinet. The second phase of the scheme commenced from 1 April 2019 with an outlay of INR 1,00,000 million for a period of 3 years. This scheme has 3 components, namely

1) Demand incentives
2) Charging infrastructures
3) Administrative expenditure including publicity, IEC activities

The salient features of FAME India Scheme Phase II:

- This phase aims to generate demand by way of supporting 7,090 e-buses, 0.5 million e-3 wheelers, 55,000 e-4 wheeler passenger cars (including Strong Hybrid) and 1 million e-2 wheelers.
- With a greater emphasis on providing affordable and environment friendly public transportation options for the masses, the scheme will be applicable mainly to vehicles used for public transport or those registered for commercial purposes for all segment of vehicles.
- For e-2W segment, this scheme is also applicable to privately owned registered e-2W.
- Depending upon offtake of different categories of e-Vehicles, the provision has been made in the scheme for inter as well as intra segment-wise fungibility.
- The scheme is applicable to only those xEVs, which are fitted with advanced chemistry battery.
- The scheme is applicable to only those vehicles, which are defined as Motor Vehicle as per Central Motor Vehicles Rules (CMVR) and eligible to be registered with Road Transport Authority.
- In this phase, the demand incentive is linked to battery capacity i.e. INR 10,000/kWh for all eligible Vehicles except e-buses (for which the incentive is INR 20,000/kWh), subject to capping at certain percentage of cost of eligible vehicles (i.e. 40 per cent for e-Bus and at 20 per cent for all other categories of eligible vehicles).
- Demand incentive is extended to only those vehicles having ex-factory prices less than the threshold value.
- Further, keeping in view market and technology trends in batteries, a provision has been made for revision of demand incentives from time to time under the scheme.
- The incentive applies to vehicles manufactured in India as per phase manufacturing program issued by the department. Only OEMs that have achieved 40 per cent

localization level in case of 4W and Buses and 50 per cent localization in the case of 2W and 3W are only eligible to get incentives.

The achievements under the FAME India scheme Phase II are (DHI, 2020):

- OEMs and Vehicle Models: So far, as on 16 December 2020, 27 OEMs have registered their 79 Models (2W-31; 3W-32 and 4W-16) for availing the benefit of demand incentives under Phase-II of FAME Scheme. So far about 39,000 EVs have been sold to the eligible user of the electric vehicle.
- Sanction of electric buses: To promote electric mobility in public transport, proposalswere invited from cities and state transport corporations through an Expression of Interest for deployment of Electric Buses under Operation Cost Model Basis. After examining the proposal, 6,265 electric buses were sanctioned to cities/STUs/state goverments entities for intracity & intercity operations. These buses will run about 4.5 billion km distance during their contract period and are expected to save cumulatively about 1.5 billion litres of fuel over the contract period, which will result in avoidance of 3.4 million tonne of CO_2 emission.
- Sanction of Charging Infrastructure: Government of India also sanctioned 2,877 charging stations in 68 cities across 25 States/UTs. After ensuring the availability of land for charging stations, signing of necessary agreements/MoU with concerned partner organizations such as city municipal corporation, discom, oil companies. Letters of award for 1,717 charging stations have been issued as on 14 December 2020.

Some of the other initiatives undertaken by the GoI to promote Electric Mobility are as follows.

- GST on EVs is reduced to 5 per cent from 12 per cent.
- The government has extended an additional income tax deduction of INR 0.15 million on interest paid on loans to the buyers of Electric Vehicles.
- MoP has allowed sale of electricity as 'service' for charging of electric vehicles. This would serve as an incentive to attract investments into the charging infrastructure.
- Ministry of Road Transport and Highways (MoRTH) issued a notification regarding exemption of permit in case of battery-operated commercial vehicles.
- MoRTH has issued a notification for the green number plate for the use of Electric Vehicles.
- MoF has revised the custom duty on the EV components to promote local manufacturing of these components.
- As on February 2019, 3,14,204 electric vehicles are operating in India (MoHI&PE, 2019).

6.1.2.5 Delhi-Dehradun flights using biofuels

On 27 August 2018, India's first demonstration civil flight powered by indigenous biofuel was operated, marking a new chapter in the fast-growing domestic aviation sector. With this demonstration flight, India has become one of the few countries and probably the first among developing nations to use biofuel for planes. The biofuel was used in one of the engine blended with aviation turbine fuel (ATF) in 75:25 ratios (75 per cent ATF and 25 per cent biofuel). The 45-minute flight took off from Dehradun's Jolly Grant airport and successfully landed at Delhi airport. Dehradun-based Indian Institute of Petroleum (IIP) - one of the leading laboratories under the Council of Scientific and Industrial Research (CSIR) developed this biofuel using the seeds of the Jatropha plant (MoCA, 2020).

6.1.2.6 Fighter jets on biofuels

On 17 December 2018, for the first time, a transport aircraft flew with blended biojet fuel produced from Jatropha oil, unlocking the possibility of gradually expanding it to the entire service at some point. This has the dual benefit of reducing the carbon footprint as well as fossil fuel usage.

The fleet was formally certified to fly on a blended biojet fuel, which will be 10 per cent biofuel and 90 per cent conventional aviation fuel (The Hindu, 2018b).

6.1.2.7 Hydrogen Fuel bus and car project for Leh and New Delhi

NTPC Limited, India's largest power producer and a central PSU under the Ministry of Power (MoP), has invited a global expression of interest (EoI) to provide 10 hydrogen fuel cell (FC) based electric buses and an equal number of hydrogen fuel cell based electric cars in Leh and Delhi. The EoI has been issued by NTPC's wholly owned subsidiary, NTPC Vidyut Vyapar Nigam (NVVN) Limited.

The move to procure hydrogen fuel cell-based vehicles is a first of its kind project in the country, wherein a complete solution from green energy to the fuel cell vehicle would be developed.

The initiative, which has been undertaken with the support of the MNRE, will also harness renewable energy for the generation of hydrogen and develop its storage and dispensation facilities as part of pilot projects at Leh and Delhi. The move to launch hydrogen-powered vehicles aims at decarbonizing the transport and mobility segments.

A hydrogen fuel cell bus has been launched by Tata Motors in collaboration with Indian Space Research Organization (ISRO) and Indian Oil Corporation Limited (IOCL). Further, Hyundai also seeks to launch its first fuel cell SUV in India by 2021 and plans on building the required infrastructure for it in and around the Delhi-NCR area.

NTPC Limited has been taking various technology initiatives to provide a complete e-Mobility solution for public transport including creation of public charging infrastructure and providing electric buses to State/City transport undertakings. In this regard, 90 public charging stations in various cities and battery charging and swapping station at Faridabad for E-3-wheelers have already been commissioned. Similarly, e-Bus solution for Andaman and Nicobar Administration is under implementation (PIB, 2020e).

6.1.2.8 Fully Solar-Powered Commuter Ferry

The 'Aditya', India's first solar-powered ferry which commenced operations in 2017 in Kerala's Vembanad backwaters, has won the prestigious Gustave Trouvé Award for Excellence in Electric Boats and Boating. The Aditya, from Navalt Boats, is a sun-powered commuter ferry of great promise for the future of electric marine propulsion.

It saves 58,000 litres of diesel and ~INR 46,12,000 (USD 65,000) a year. The vessel was adjudged the world's best electric boat, capable of seating 75 people (Plugboats, 2020). It has been ferrying commuters on the Vaikom-Thavanakadavu route in Kerala. The ferry has a low operational cost. It needs just INR 180 per day as energy cost compared to over INR 8,000 required for a diesel ferry. It has so far transported over 1.1 million passengers over 70,000 km thus saving the State Water Transport Department (SWTD) over 0.1 million liters of diesel worth approximately INR 7.5 million. The ferry is considered a game-changer in India's solar-powered boat sector (The Hindu, 2020).

6.1.3 Carbon neutrality

UT of Ladakh and Carbon Neutrality

India's vision of carbon-neutrality is distinctive in approach and intent from that of developed countries or global civil society. India's development needs require carbon space, a strategic national resource. Nevertheless, India is committed to the preservation and enhancement of its carbon sinks.

The Hon'ble Prime Minister announced on 6 February 2020 in the lower house of Parliament, the government's resolve to develop Ladakh, the nation's newest UT, as a carbon-neutral region. Carbon neutrality for Ladakh is not a mitigation goal, but a development vision. The biggest challenge is to find a path of sustainability that will protect and enable this fragile but unique landscape to flourish while ensuring that the amenities and benefits of modernity reach its population. GoI has announced a Special Development Package for Ladakh for the year 2019-20 (INR 40,000 million) and 2020-21 (INR 30,000 million). Infrastructure development is a key thrust area in the initial years, spending 52 per cent during 2019-20 and 38 per cent during 2020-21.

Sikkim climate inventory and monitoring system

Sikkim, lying in north-eastern India within the sensitive Himalayan region, is highly vulnerable to climate change. Recognizing the importance of conservation, it has been conserving its forests through community and state programmes. As a result, it has maintained almost half of its geographical area under forest cover, making it a carbon-negative state. Also, initiatives such as the Sikkim Organic Mission has converted Sikkim into India's first fully organic state. Sikkim has been conferred with "Future Policy Gold Award" in 2018 by FAO in recognition of such endeavours (Sikkim Climate Inventory and Monitoring System, 2019).

6.2 Mission and activities in water resources: Ministry of Jal Shakti

In May 2019, the Ministry of Water Resources, River Development and Ganga Rejuvenation and Ministry of Drinking Water and Sanitation were merged to form the Ministry of Jal Shakti, further strengthening India's efforts towards resolving the mounting challenges faced by this sector. A few recent developments are discussed below:

Jal Shakti Abhiyan

The Jal Shakti Abhiyan (JSA) is a time-bound, mission-mode water conservation campaign. The JSA is envisaged in two Phases: Phase 1 from July to 15 September 2019 for all States and UTs; and Phase 2 from 1 October to 30 November 2019 for States and UTs receiving the retreating monsoon (Andhra Pradesh, Karnataka, Puducherry and Tamil Nadu). During the campaign, officers, groundwater experts and scientists from the GoI worked together with state and district officials in India's most water-stressed districts for water conservation and water resource management by focusing on the accelerated implementation of the following five targets:

I. Water conservation and rainwater harvesting
II. Renovation of traditional and other water bodies/tanks
III. Reuse and bore well recharge structures
IV. Watershed development and
V. Intensive afforestation.

Har Ghar Jal (Jal Jeevan Mission)

Jal Jeevan Mission (JJM) was launched in 2019 to provide Functional Household Tap Connection (FHTC) to every rural household by 2024. The programme focuses on service delivery at the household level, i.e., water supply on a regular basis in adequate quantity and of prescribed quality. This necessitates the use of modern technology in planning and implementation of water supply schemes, development of water sources, treatment and supply of water, empowerment of Gram Panchayat/ local community, service delivery, partnership with other stakeholders, convergence with other programmes, systematic monitoring of the programme and capturing service delivery data automatically for ensuring the quality of services. This will help in achieving the goal of JJM in its true letter and spirit. According to the Ministry of Jal Shakti, GoI, households with tap connections as on 1 September 2020 is 5,34,12,235 (28.21 per cent) out of 18,93,30,879 total households (MoJS, 2019a, 2019b).

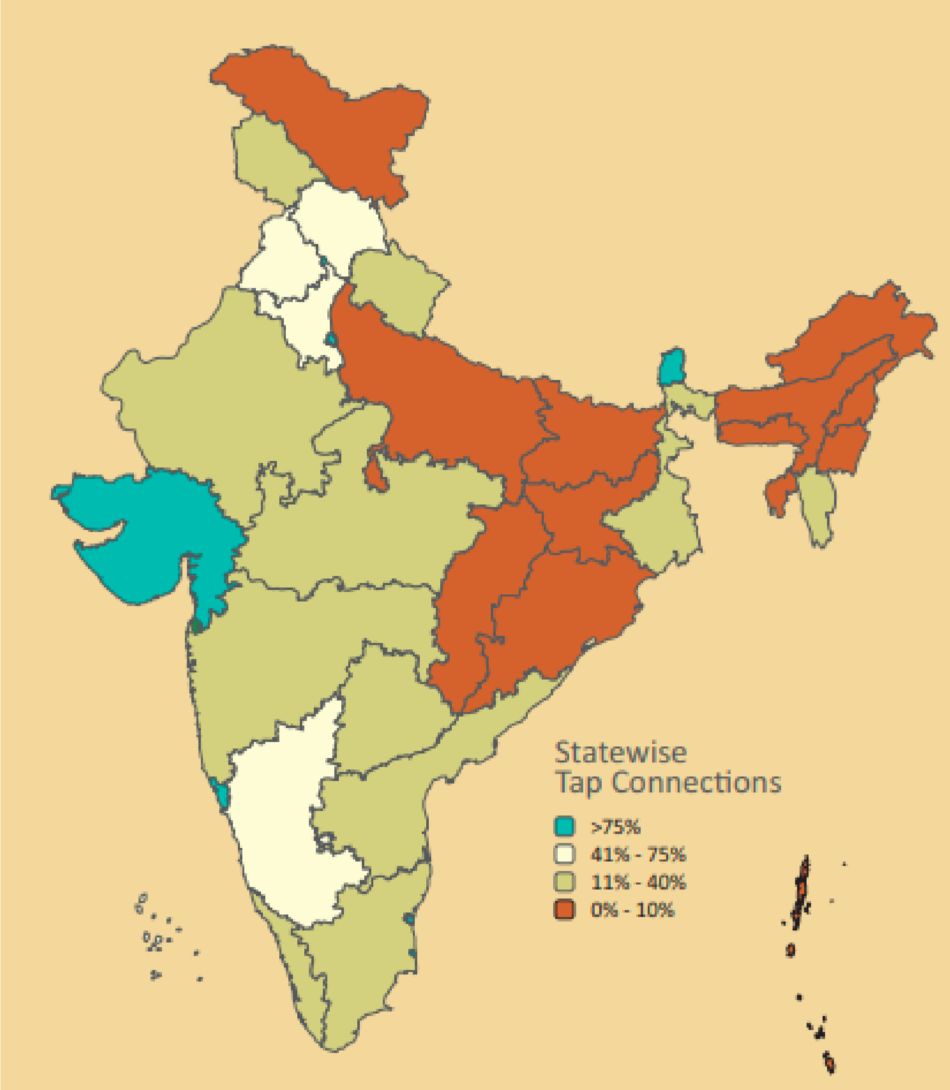


Figure 6.5: Status of household tap connections as on 1 April 2019
Source: (MoJS, 2020)

Atal Bhujal Yojana

This scheme is being implemented since April 2020 to promote community-led groundwater management to ensure the long-term sustainability of groundwater in 8,353 water-stressed gram panchayats in 78 districts of seven States- Gujarat, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan and Uttar Pradesh. This unique scheme will contribute significantly towards the water and food security of the country. The scheme has two components: i) institutional strengthening and capacity building component for strengthening institutional arrangements by providing robust database, scientific approach and community participation in the states to enable them to manage groundwater resources sustainably ii) incentive component for incentivizing the states for convergence amongst various schemes of the central and state governments and achievement of results as a measure of groundwater management (MoJS, 2020).

6.3 Initiatives in weather and climate services - Ministry of Earth Sciences (IMD, 2020; MoES, 2020)

Upgradation of Forecast System (UFS)

Upgradation and sustenance of the forecast system to an optimum level coupled with data integration, product generation, and dissemination of weather forecast and warning information is the primary objective of the UFS program being implemented through 2017-24 with a budgetary provision of INR 1.58 billion up to 2020.

Upgradation of Atmospheric Observation Network

India Meteorological Department (IMD) is implementing the program "Atmospheric Observations Network" during 2017-24 with a budgetary provision of INR 2.22 billion up to 2020. The program will improve and upgrade weather and climate services over the north-eastern region by establishing an additional state of art surface and upper air observatories for real-time observations. Building multi-processing, computing, and communication facilities for satellite meteorological applications are also part of this program.

Weather and Climate Services (WCS)

IMD is all set to acquire global leadership in weather and climate services driven by research and increasingly sophisticated modelling, information technology and observational infrastructure. The program WCS, aimed at providing efficient weather and climate services across the country to various sectors, is being implemented during 2017-24 with budgetary provision of INR 2.41 billion up to 2020. The agriculture and aviation sector have also benefitted considerably through better accuracy of forecasts .

IMD has started providing climate information for 77 smart cities, normal and climate extreme indices for 38 stations (initially), state-wise district climate trends for rainfall and temperature, pan India maps for normal maximum, minimum temperatures, and rainfall for all the months and seasons.

Gramin Krishi Mausam Seva (GKMS)

IMD is issuing district level weather forecast up to 5 days and the products comprising of quantitative forecasts for 7 weather parameters-rainfall, maximum temperature, minimum temperatures, wind speed, wind direction, relative humidity, and cloudiness. Based on the weather forecast, agromet advisories are prepared by 130 Agro-meteorological Field Units (AMFUs) twice a week (Tuesday and Friday) and communicated to the farming community. At present, 658 Agromet Advisory Service (AAS) district bulletins are being prepared and issued to cater to farmers' needs in the country (Figure 6.6). More than 42 million farmers are currently receiving crop-specific agro-meteorological advisories in vernacular languages through experimental block level agromet advisory bulletins published for 2,212 blocks.

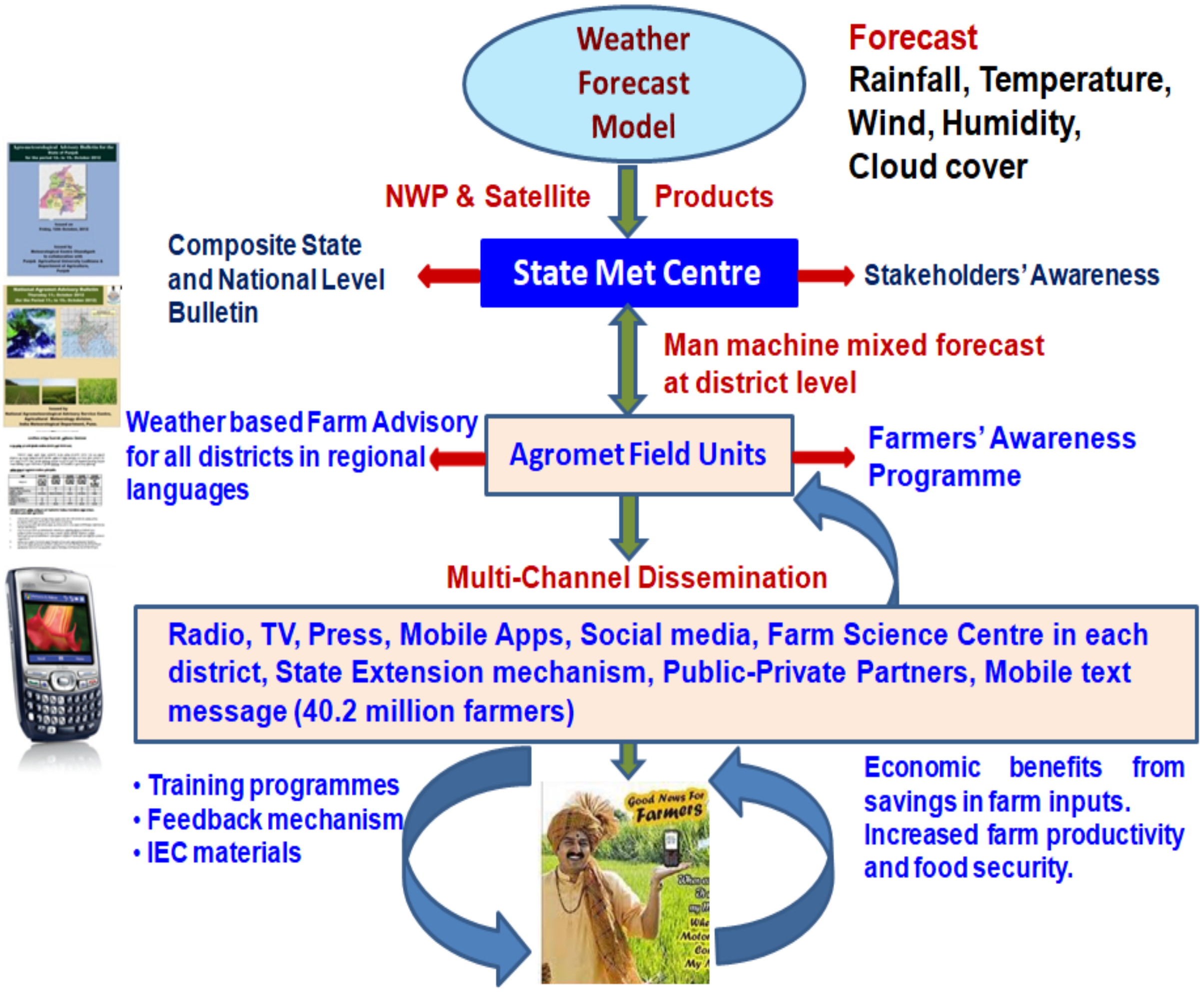


Figure 6.6: Agrometeorological Advisory Services (AAS) to Farmers

Centre for Climate Change Research (CCCR)

Ministry of Earth Sciences (MoES), GoI has established the Centre for Climate Change Research (CCCR) at the Indian Institute of Tropical Meteorology (IITM), Pune, in January 2009 to study the impact of climate change in the country. The centre is dedicated to research global and regional climate change with a particular focus on the Indian climate and the monsoons.

CCCR has developed an Earth System Model for future climate projections. For the first time, an Indian institute will be contributing to the Intergovernmental Panel on Climate Change (IPCC) Assessment Report (IPCC-AR6). Currently, efforts are ongoing to generate climate change scenarios. To better understand the regional climate change issues, CCCR has also undertaken the Coordinated Downscaling Experiment (CORDEX)-South Asia Program. It generates and collates from various partners, downscaled (regionalizing at high resolution) and latest climate projections from multiple models. CCCR has published the report titled "Assessment of Climate Change over the Indian region" which is available on Springer Open (Raghavan et al., 2020).

High Performance Computing (HPC) in India for weather forecast

MoES has augmented HPC System at a total cost of INR 4,389 million. The systems are installed at two sites – Indian Institute of Tropical Meteorology (IITM), Pune and the National Centre for Medium-Range Weather Forecasting (NCMRWF), Noida . The HPC system named Pratyush, housed at IITM has capacity of 4.0 petaflops ranks 39th in the world and Mihir, located at the NCMRWF has a capacity of 2.8 petaflops and ranks 66th on the list (MoES, 2019).

Very High Resolution Global Ensemble Prediction System of NCMRWF

NCMRWF, MoES, GoI has been providing probabilistic forecasting from its global ensemble prediction system since the year 2012. To provide accurate probabilistic forecast of high impact weather systems NCMRWF upgraded its global ensemble prediction system (NEPS-G) in June 2018 by increasing its horizontal resolution from 33 km to 12 km. Currently, NEPS-G has the highest resolution among all the global ensemble prediction systems running at different operational centers worldwide.

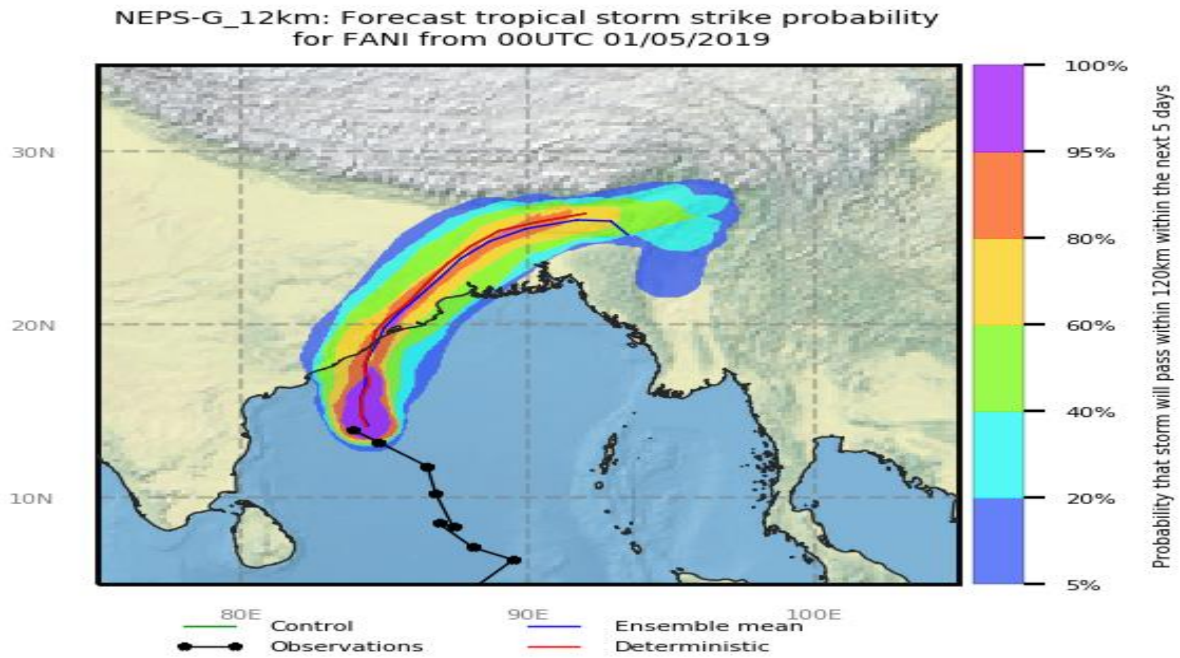


Figure 6.7: Forecast tropical storm probability for FANI

Various probabilistic forecast products including district-level location-specific forecast, tropical cyclone strike probability, probabilistic quantitative precipitation forecast, and extreme weather forecasting index from this forecasting system are helping the operational forecasters and the forecast users in decision making. Figure 6.7 shows the strike probability and the ensemble mean and control track of “Fani” predicted by NEPS-G based on the initial condition of 00UTC of 1 May 2019.

6.4 Initiatives in Ocean Services

6.4.1 Fishery advisory services for reducing of the consumption of fossil oils

Indian National Centre for Ocean Information Services (INCOIS) provides Potential Fishing Zone (PFZ) and Tuna Fishery Advisory services every day on an operational basis. It advises the fishermen on the most probable fish aggregation areas to directly navigate these areas reducing time and effort in finding the fish shoals. In addition to direct benefits to the fishermen, indirect benefits include a reduction in emission of CO_2. Several researchers and institutes have made independent studies towards the estimation of these environmental benefits. Central Marine Fisheries Research Institute (CMFRI), conducted a study in Raigad, Maharashtra during 2013-14. The study found that with 15 per cent adoption level, fishermen can save up to 9,00,000 litre of fuel (at 30 per cent less consumption), which translates to savings of INR 46.8 million (at 52/litre), diesel subsidy saving of INR 10.764 million and lesser GHG emission of approximately 2412 tonne. From 69 validation experiments conducted in Kerala, PFZ advisories' use resulted in diesel savings between 21.47 litres to 1293.53 litres, resulting in reduction of CO_2 emission from 3.45 to 0.06 tonne for every tonne of fish caught. The total diesel saved due to use of PFZ advisories by all these 69 experiments was found to be 20,665 litre and the total reduction in CO_2 emission is 55.052 tonne.

6.4.2 Ocean State Forecast, Warning and Advisory services (OSF)

INCOIS provides operational ocean information, forecast and advisory services. At present, under the Ocean State Forecast services, INCOIS provides forecasts of wave height, direction and period (of both wind waves and swell waves), sea surface currents, sea surface temperature, mixed layer depth , depth of the 20^{o} C isotherm (a measure of the depth of the thermocline), astronomical tides, wind speed and direction and oil-spill trajectory. This prior information on the state of the seas surrounding the Indian subcontinent is vital for the smooth operational activities of those venturing out into the sea and those at the seashore. The users can make informed decisions based on the forecast of sea state conditions saving life and property. The forecast is available separately for various oceanic basins in the Indian Ocean. These forecasts are generated operationally on HPC and disseminated in local languages by different modes- including the latest information and computational technology tools. It is estimated that about one million users are using these services through direct or indirect channels.

Warning services such as high wave alerts, rough sea alerts, swell surge alerts, perigian spring tide alerts and INCOIS-IMD joint bulletins are also in place. User-required customized products like 'Ocean state forecast along ship routes', ‘Search and Rescue Aid Tool (SARAT)’, ‘Oil spill trajectory prediction system’, ‘Sea state forecast for port and harbors, 'OSF-Web map services' and many other services have been developed and made operational. Water quality nowcasts and forecasts, impact-based forecast system and climate service - advisories on future sea level, wave surge, and productivity are being developed and will be operational in the near future. Dissemination of the

INCOIS services to open ocean is done using satellite communication in collaboration with ISRO (NAVIC) and AAI (GAGAN).

6.4.3 Climate change advisory services under the Deep Ocean Mission

INCOIS has initiated ocean climate change advisory services under the Deep Ocean Mission to assess and provide future projections of the impact of climate change on various coastal oceanographic parameters. This initiative will give quantitative indicators for the possible changes in sea level, coastal erosion, increasing intensity of cyclone, wind waves, storm surges and change in the marine water quality parameters at seasonal to decadal timescale for helping the planning for future marine system driven economy and offshore/coastal installations/constructions. These advisory services will be based on a suite of state-of-the-art numerical ocean models and an improved network of ocean observation. The proposed mission will be implemented during the financial period 2020-2025.

6.5 National disaster management plan (NDMP)

NDMP provides a framework and direction to the government agencies for all phases of disaster management cycle. The NDMP is a “dynamic document” in the sense that it will be periodically improved to keep up with the emerging global best practices and knowledge base in disaster management. It works in accordance with the provisions of the Disater Management Act 2005, the guidance given in the National Policy on Disaster Management (NPDM) 2009, and the established national practices.

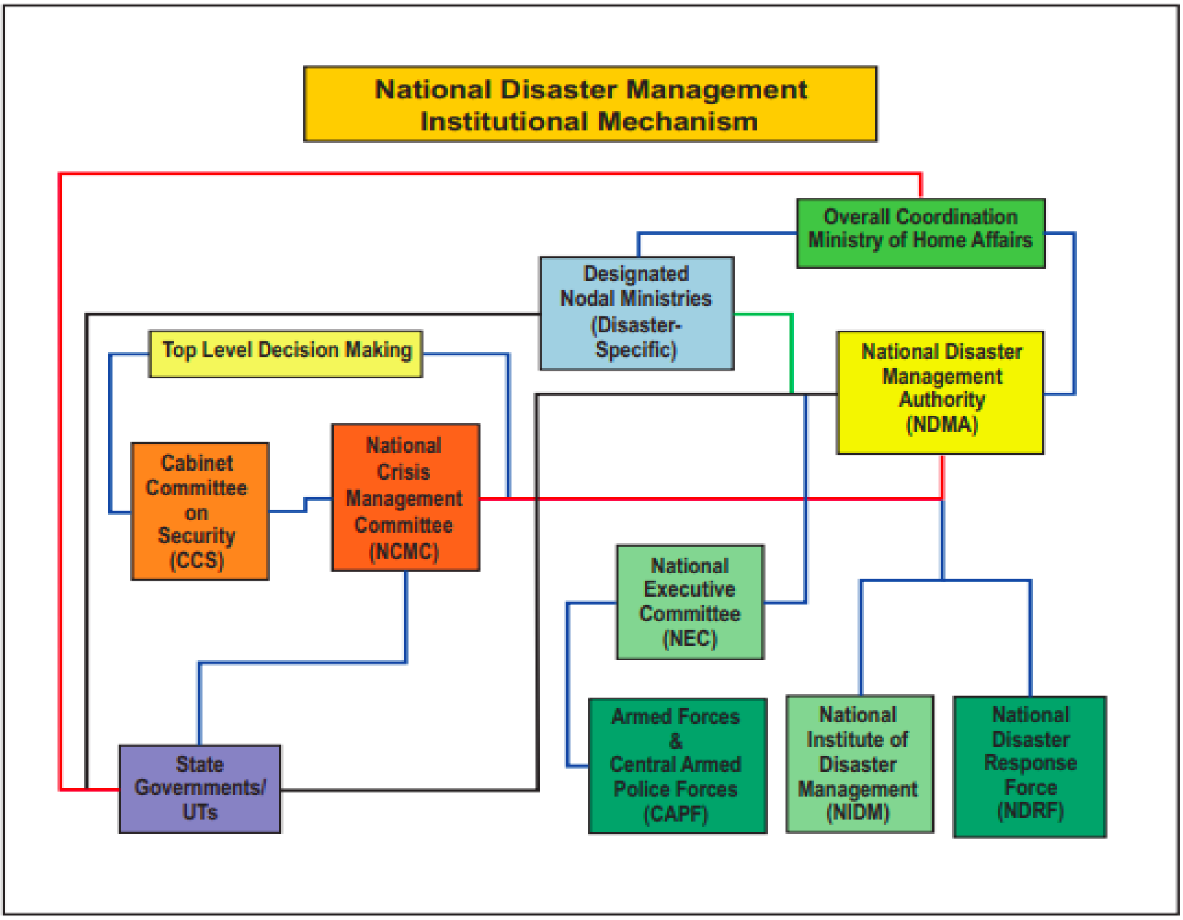


Figure 6.8: Institutional mechanism of National Disaster Management

The overall coordination of disaster management vests with the Ministry of Home Affairs (MHA). The Cabinet Committee on Security (CCS) and the National Crisis Management Committee (NCMC) are the key committees involved in the top-level decision-making regarding disaster management. The NDMA is the agency responsible for the approval of the NDMP and facilitating its implementation (NDMP, 2019).

6.5.1 National cyclone risk mitigation project (NCRMP)

GoI has approved Phase-II of NCRMP in July 2015 for six years up to March, 2021 covering States of Goa, Gujarat, Karnataka, Kerala, Maharashtra and West Bengal at an outlay of INR 26,910 million which with the World Bank funding of INR 21,576.30 million. The remaining amount of INR 533.37 million is being contributed by State Governments as their share. The sub-component of underground cabling has been included under NCRMP Phase-II (NCRMP, 2019).

6.5.2 Training for disaster response: *Aapda Mitra*

NDMA has been implementing a scheme for Training of Community Volunteers since May 2016 which is focused on training of 6,000 community volunteers (200 volunteers per district) in disaster response with a focus on flood in selected 30 most flood prone districts of 25 States/UT of India. The scheme is going to end on 31 December 2020. The scheme aims to provide the community volunteers skills required to respond to their community's immediate needs in the aftermath of a disaster thereby enabling them to undertake basic relief and rescue tasks during emergency situations such as floods, flash-floods and urban flooding. So far, 5,386 volunteers have been trained by 24 Project States (NDMA, 2020).

6.5.3 Vulnerability Atlas of India (VAI)

Building Materials and Technology Promotion Council (BMTPC) has prepared the VAI on flood, earthquake, landslide and cyclone, which was updated in 2019 (BMTPC, 2019)

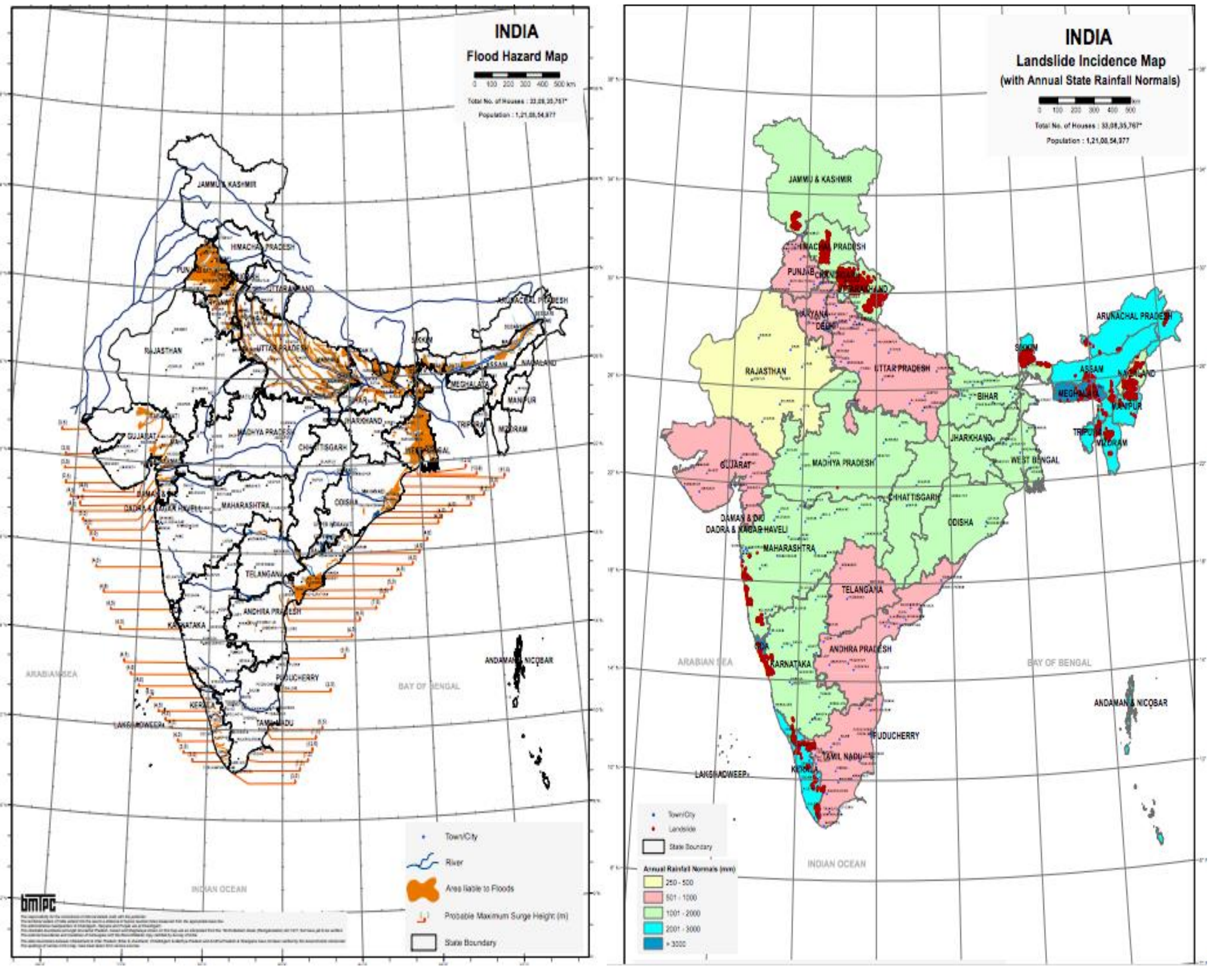


Figure 6.9: a) Flood hazard map; b) Landslide incidence map 2019

Climate change related landslide risk management: The data on past landslide events clearly indicates the high frequency as well as intensity of the hydro-meteorological hazards in the mountain region. These include heavy rainfall, landslides, riverine floods, cloud burst, glacial lake outburst floods (GLOFs) and droughts. Therefore, local communities require awareness, specialized training and right information to cope up with disasters in the mountains, while resources need to be mobilized and suitable investment made to build modern and adequate infrastructure.

6.5.4 Preparation of flood hazard atlas of flood prone states

As part of this initiative the NDMA has undertaken the flood risk assessment for all the flood prone districts in India in consultation with the States, and undertaken the task of preparing district level flood hazard atlas. The preparation of flood disaster maps and atlas was entrusted to the National Remote Sensing Centre (NRSC), Hyderabad. NRSC has prepared the atlas on the basis of data provided by the States, CWC, IMD and by the use of satellite imageries. The atlas will help in identification of flood hotspot areas and will be used for flood mitigation and adaptation programs with village level information.

6.6. Climate change and alien invasive plants in India

Alien invasive plants are rapidly spreading across many forests and grasslands in India. These include *Lantana camara, Mikania micrantha, Chromolaena odorata, Prosopis juliflora, Senna spectabilis, Parthenium hysterophorus* and wattles. Climate change is expected to facilitate the spread of woody invasive plants. A major increase in the alien invasive plant, *Lantana camara*, in forests of southern India beginning around 2003, has been shown to be related to a combination of a prolonged drought and intense fire during this period (Ramaswamy and Sukumar, 2013). Alien invasive plant species are also a major threat to biodiversity and ecosystem functioning in several forests in India. A study of 11 alien invasive plant species in a Western Himalayan landscape concluded that the distribution of most species is likely to increase under future climate change scenarios (Thapa et al., 2018). A recent niche-modeling study on invasive *Lantana camara* and *Cassia tora* suggests that both species could experience a shift in their distributions in the northern and north-eastern directions in India under climate change (Panda et al., 2017). A local-scale study on the dynamics of *Lantana camara* over a two-decade period suggests that Lantana responses to rainfall fluctuations may be mediated by the presence of fire, allowing Lantana to spread even during low-rainfall periods (Ramaswami and Sukumar, 2013).

6.7 Climate change and wildlife-human conflicts

Wildlife-human conflicts are a result of complex interactions between various ecological, behavioural and social factors. Though such conflicts have been present historically, they seem to be increasing in recent decades. Studying the role of climate variability/change and wildlife-human conflicts becomes even more important in countries like India which harbours four large global biodiversity hotspots, abundant wildlife numbers, human population and experiences high levels of wildlife-human conflicts. Most human mortality or attacks by wild mammals are associated with sloth bears, leopards, Asian elephants and lions. There are also recorded instances of livestock depredation due to snow leopards, tigers and lions, and damage to crops and property by Asian elephants, wild pigs and ungulates.

The Asiatic lion is found only in the Gir protected area (1,400 km^2) and the Greater Gir Landscape of 20,000 km^2 in Gujarat, western India. Lions prey mostly on buffaloes and wild ungulates, with attacks on people being very low (Jhala et al., 2019). The situation changed following a severe drought 1986-1987 when the number of people injured or killed by lions increased post-drought (Saberwal et al., 1994). A re-analysis of the data brought out the relationship between rainfall anomaly and lion attacks, with attacks increasing during years of lower than average rainfall. Increased attacks during post-drought years were a combination of change in human-behaviour (change in livestock grazing areas, and their protection), and reduced availability of natural prey resulting in lions moving closer to the villages with livestock. Changes in rainfall regimes, including increased variability in rainfall in western India, could result in the escalation of large carnivore and human conflicts.

A different pattern in elephant-human conflicts has been seen over a longer time period in Karnataka which has the largest population of wild Asian elephants in India. The district of Kodagu, located in the Western Ghats, has an abundant elephant population and experiences crop-damage from elephants throughout the State. To look at a possible relationship between crop raids and rainfall in this region, rainfall anomaly and frequency of raids by elephants were examined. The results surprisingly show that the correlation between the rainfall and crop-raiding is positive, suggesting that more rain contributes to higher frequency of crop raids by elephants. Higher rainfall results in enhanced productivity and yield of crops which might be more attractive to elephants to obtain greater quantity of forage per unit time and higher nutrition (Sukumar, 2003).

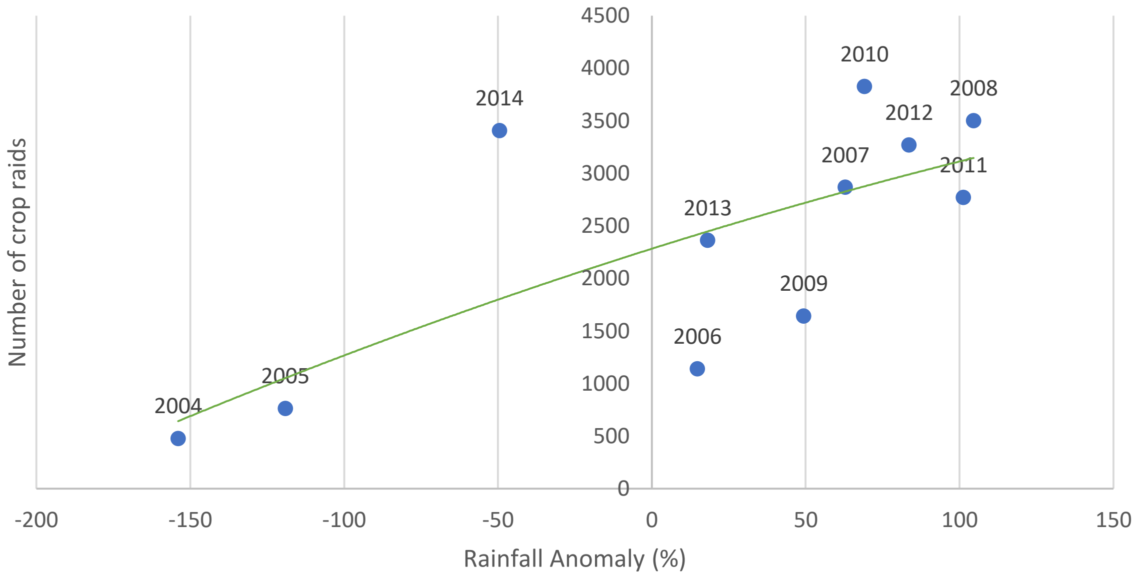


Figure 6.10: Number of crop raids by elephants and its relationship with Rainfall Anomaly calculated as a percentage deviation from long-term rainfall average (1871-2016) for the Kodagu District, Karnataka State, India.

Another study comes from modelling of possible shifts in elephant distribution in South Asia with future climate change (Kanagaraj et al., 2019). Using a large number of environmental variables for the region, MAXENT species distribution models and future climate projections from three Coupled Model Inter-comparison Project (CMIP5) Global Circulation Models for two RCPs of 2.6 and 8.5, the study derived elephant distributions for 2050 and 2070. A major conclusion was that shift in the range of elephants, especially in the Himalayan region, would happen towards higher elevations in states such as Arunachal Pradesh along moisture and seasonality gradients. As these regions of higher elevations are currently under settlements, there would be an escalation of elephant-human conflicts.

This highlights that climate variability cannot be ignored, and future studies should focus on understanding the effects of climate variability on human-wildlife conflicts and need to be cover large spatiotemporal scales. These investigations are essential for planning biodiversity conservation, especially in the context of a changing climate.

6.8 Mahatma Gandhi and Sustainable Development

6.8.1 Celebrating 150 years of Mahatma Gandhi's Birth Anniversary

The Government of India and people all over the country and around the globe celebrated the 150th birth anniversary of Mahatma Gandhi in 2019. Mahatma Gandhi's life and philosophy offers solutions and opportunities to negotiate the challenges of contemporary society, polity and economy. Mahatma Gandhi's five pillars of nonviolence: respect, understanding, acceptance, appreciation and compassion are basic to our existence. These are simple ideas and if inculcated, could make a difference to the world. For Mahatma Gandhi, human beings have been interconnected to all facets of the universe. He said, "the earth, the air, the land and the water are not an inheritance from our forefathers but on loan from our children. So, we have to handover to them at least as it was handed over to us". Another great message of Mahatma Gandhi was his strong belief on humanity, and he said "you must not lose faith in humanity. Humanity is an ocean; if a few drops of the ocean are dirty, the ocean does not become dirty". In September 2019, during the Climate Action Summit, the United Nations released a commemorative stamp to mark the 150th birth anniversary of Mahatma Gandhi.

A simple understanding of Mahatma Gandhi's cosmocentric approach to human beings is relevant to the challenge of climate change faced by the world today. Following the guidance of Mahatma Gandhi, India drafted its NDCs which was submitted to the UNFCCC in 2015. The first NDC focuses on propagating a healthy and sustainable way of living based on the traditions and values of conservation and moderation.

Figure 6.11: Celebrating 150 years of the Mahatma at India Pavillion in COP25

India hosted an 'India Pavilion' at COP25 in Madrid, which was a major attraction amongst the visitors that included delegates from different parts of the world and UN agencies. The theme of the pavilion was '150 years of celebrating the Mahatma'. It was designed to depict Mahatma Gandhi's life and messages around sustainable living (PIB, 2019d).

6.8.2 Energy Swaraj

Gandhian principles and ideology remain relevant to the energy context as well. Energy swaraj or localized energy self-sufficiency is conceptualized, wherein communities generate and produce their own energy needs while relying on renewable energy sources. The decentralization of energy is one of the important approaches to strengthen its access to remote rural communities while addressing the climate challenge. This initiative was launched by Indian Institute of Technology (IIT) Powai, Mumbai, Maharashtra. As part of Energy Swaraj initiative, IIT-Bombay has launched a Massive Open Online Course (MOOC) to train the trainers free of cost. Another initiative, "Solar Angels" is an attempt to make solar energy a people's movement. Solar Angels are individuals who have a regional and local presence and could help in conducting the event anywhere in the world within their vicinity.

IIT-Bombay launched the Student Solar Ambassador Program, the seed concept of the Gandhi Global Solar Yatra, aimed to sensitize the younger generation by organizing training workshops for students. On 2 October 2018 more than 5,700 students were trained in IIT-Powai from 132 schools and more than 0.13 million students from 853 schools trained all over India.

To commemorate the 150th Birth Anniversary of Mahatma Gandhi and to promote the Gandhian idea of sustainable living, MNRE in association with IIT Bombay, organised Global Student Solar Assembly where over 6,800 students from the National Capital

Region created Guinness world record by lighting the largest number of solar lamps together at Indira Gandhi Stadium Complex, New Delhi. Another Guinness World Record established during this event was the teaching of sustainability to the largest number of participants in a single place.

6.9 India as a responsible global partner

In this section, we detail a number of initiatives, partnerships, and collaborations launched in the arena of global climate action. These initiatives speak to India's commitment to global cooperation and the contribution of more than its due share to meet the global challenge.

6.9.1 Solar energy on the Global agenda

In August 2019, India's Union Cabinet approved the ratification of the amended Framework Agreement of ISA to open up the ISA membership to all countries that are members of the United Nations and make ISA a truly global organization. Thus, India put solar energy on the global agenda with the universal appeal for developing and deploying solar energy (PIB, 2019e). Depositary, the Ministry of External Affairs issued the notification on the universalization of ISA membership on 31 July 2020.

A first milestone was reached at the First World Solar Technology Summit, on 8 September 2020, with the signing of a tripartite MoU between the ISA, GoI, and the World Bank to implement the OSOWOG (One Sun, One World, One Grid) initiative (Isolaralliance, 2020).

The Third General Assembly of the International Solar Alliance (ISA) was virtually held on 14 October 2020. More than 53 member countries attended the meeting from across the world. Oman, and St. Vincent and the Grenadines have become the newest members of ISA. During the Third General Assembly, the ISA Member countries unanimously elected India as the President and France as the Co-president of the ISA Assembly for another term, i.e. up to 2022.

India's contribution to ISA

i. India has contributed to the ISA's efforts by overcoming the global resource asymmetry in the solar energy sector, facilitating its organizational work, and providing it with financial and other forms of support. The ISA is now the first intergovernmental organization to be headquartered in India. GoI is providing financial and material support to the ISA for the construction of its headquarters.

ii. In addition to the financial contribution for creating the ISA corpus fund, GoI is also assisting in the capacity building of ISA Member Countries under its ITEC training programme besides establishing a Project Preparation Facility through EXIM Bank for developing bankable Solar Energy projects in the ISA member countries.

iii. In 2018, GoI had announced nearly USD 1.4 billion worth of lines of credit covering 27 solar projects in 15 countries, which are currently in various stages of implementation.

6.9.2 The 3rd Global RE-INVEST

MNRE organized the 3rd Global RE-INVEST (Renewable Energy Investment Conference and Exhibition) 2020 on a virtual platform from November 26 to 28, 2020. The theme for RE-Invest 2020 was ‘Innovations for Sustainable Energy Transition’.The event was inaugurated by Prime Minister of India. The UK, Denmark, Germany, France, Australia and Maldives participated as partner countries. The MNRE also partnered for the event with the States of Gujarat, Himachal Pradesh, Madhya Pradesh, Rajasthan and Tamil Nadu.

6.9.3 One Sun One World One Grid

The Hon’able Prime Minister of India recently called for connecting solar energy supply across borders, with the mantra of 'One Sun One World One Grid' (OSOWOG). The vision behind the OSOWOG mantra is “The Sun Never Sets” and is a constant at some geographical location, globally, at any given point of time. With India at the fulcrum, the solar spectrum can be divided into two broad zones - far East which would include among others countries like Myanmar, Vietnam, Thailand, Lao, and Cambodia, and far West which would cover the Middle East and the Africa Region.

MNRE, GoI, has a critical role to play in synergizing over 140 countries, across the far east and the far west regions, to build consensus, launch energy policy imperatives and set up a framework for such a global cooperation. India, through the OSOWOG initiative, plans to take another leap towards building a global ecosystem of interconnected renewable energy resources that are seamlessly shared for mutual benefits and global sustainability.

The initiative is planned across three phases. In Phase I - Indian Grid interconnection with Middle East, South Asia and South East Asian (MESASEA) grids to share solar and other renewable energy resources; in Phase II - MESASEA grid getting interconnected with the African power pools to share solar and other renewable energy power of the countries; Phase III-Global interconnection to achieve the One Sun One World One Grid vision attracting investments in renewable energy sources (MNRE, 2020a).

6.9.4 Climate Action Summit, UN General Assembly (September 2019)

The Hon’ble Prime Minister of India, Shri Narendra Modi has always emphasized that to overcome a challenge like climate change, a global people’s movement to bring about behavioural change is one of the essential requirements. Addressing the Climate Action Summit on the sidelines of UN General Assembly in September 2019, he said: "the respect for nature, the judicious use of resources, reducing our needs and living within our means have all been important aspects of both our traditions and present-day efforts. Need, not greed has been our guiding principle, and therefore, India today has come not just to talk about the seriousness of this issue but to present a practical approach and a roadmap. We believe that an ounce of practice is worth more than a ton of preaching" (PIB, 2019c). At this summit, India pledged to increase the share of its non-fossil fuel to 450 GW. Together with other partners, India and Sweden are launching the Leadership Group within the Industry transition track. This initiative will provide a platform for governments and the private sector to cooperate in technology innovation to develop low carbon pathways for the industry. India also launched a global multi-stakeholder partnership, the CDRI, to promote disaster resilient infrastructure (PIB, 2019a).

6.9.5 Coalition for Disaster Resilient Infrastructure (CDRI)

The Hon'ble Prime Minister, Shri Narendra Modi launched a global multi-stakeholder partnership, the CDRI, at the UN Climate Action Summit 2019 held in New York City, USA, on 23 September 2019. CDRI formally came into existence on 20 March 2020, with the successful organization of its first Governing Council meeting at New Delhi wherein India and UK were nominated as the first Co-Chairs of the Coalition for a period of two years.

Under this Coalition, the global partnership of national governments, UN agencies and programmes, multilateral development banks, financing mechanisms, private sector, and knowledge institutions will promote the resilience of new and existing infrastructure systems to climate and disaster risks, thereby ensuring sustainable development. It also functions as inclusive multi-stakeholder platform led and managed by national governments, where knowledge is generated and exchanged on different aspects of disaster resilience of infrastructure and thus, contribute to each other's economic growth. At present, CDRI has 23 members, including 19 national governments and 4 multi-lateral organizations. The Government of India has given in-principle approval for support of approximately USD 70 million to CDRI for a corpus required to fund technical assistance and research projects on an on-going basis, setting up the Secretariat office and covering recurring expenditures over a period of 5 years from 2019-20 to 2023-24 (PIB, 2019d).

In setting up the CDRI, India has contributed niche expertise to the global discourse on building disaster risk resilience in infrastructure financing and project execution. India's role in stewarding the CDRI and disaster resilience capacity building has been appreciated not only by multilateral agencies like the UNDRR and the World Bank but also by the EU, France, Japan and the UK who are promoting their own national initiatives in this domain.

Vision of CDRI

- The CDRI seeks to rapidly expand the development and retrofit of resilient infrastructure to respond to the Sustainable Development Goals imperatives of expanding universal access to basic services, enabling prosperity and decent work. This will need to be implemented simultaneously with accelerated and expanded climate action and disaster risk reduction, from the local and national to regional and global scale.

- The CDRI supports the achievement of goals and targets enshrined in the Sustainable Development Goals, the Paris Climate Agreement, the Sendai Framework for Disaster Risk Reduction and the UN Agenda 2030 principles of leaving no one, no place, and no ecosystem behind.

6.9.6 India on Global Climate Forums

In 2019 and 2020, India participated in several multilateral and regional forums to discuss, promote, and develop a more robust understanding of climate action. Some of these forums are listed below:

- 10th session of Petersberg Climate Dialogue in Berlin, Germany from 13 to 14 May 2019.
- In July 2019, India formally joined the Climate and Clean Air Coalition, becoming the 65th country to join the partnership.
- 28th BASIC Ministerial meeting on Climate Change in Sao Paulo, Brazil from 14 to 16 August 2019.
- 141st Assembly of Inter-Parliamentary Union (IPU) in Belgrade, Serbia from 13 to 17 October 2019.
- 29th BASIC Ministerial meeting on Climate Change in Beijing, China on 26 October 2019.
- 25th session of Conference of Parties to UNFCCC and related meetings in Madrid, Spain from 2 to 13 December 2019.
- 11th session of Petersberg Climate Dialogue in Berlin, Germany from 27 to 28 April 2020 (conducted virtually).

6.9.7 India hosted Global events

During the reporting period of 2019-20, India hosted several global environment events. Some of the major events are listed below:

- 14th session of Conference of Parties to the United Nations Convention to Combat Desertification in New Delhi from 2 to 13 September 2019.
- 2nd Lead Author Meeting of the IPCC Working Group III Sixth Assessment Report in New Delhi from 30th September to 4 October 2019.
- 13th session of Conference of Parties to the Convention on Migratory Species in Gandhinagar, Gujarat from 17 to 22 February 2020.

6.9.8 Bilateral Cooperation on Environment and Climate Change

- *MoU between India and the UK on Cooperation in weather and climate sciences*

Signed on 28 January 2019, the partnership also includes an implementation agreement on weather and climate science for service partnership.

- *MoU between India and Argentina on Antarctic cooperation*
  Signed in February, 2019, the MoU will help scientific cooperation on projects in the fields of Earth sciences, as well as those related to the protection and conservation of the natural environment of Antarctica and the Southern Oceans (PIB, 2019f).

- *India and Norway launch initiative to combat Marine Pollution*
  MoEFCC established an initiative with the Norwegian Ministry of Foreign Affairs on the Marine Pollution. In January 2019, the Indian and Norwegian governments agreed to work more closely on oceans by signing an MoU and establishing the India-Norway Ocean Dialogue during the Norwegian Prime Minister's visit to India. A joint Task Force on Blue Economy comprising of government officials, researchers, and experts and the private sector was established to develop sustainable solutions within strategic areas of the blue economy, such as the maritime and marine sector and the energy sector. In this partnership, Norway and India will share experiences and competencies, and collaborate on developing clean and healthy oceans, sustainable use of ocean resources, and growth in the blue economy (PIB, 2019f).

- *MoU on Bio energy between India and Brazil*
  Signed on January 25, 2020, the partnership aims to share information on vehicular performance under different blending options and climatic conditions and positive externalities in reducing greenhouse gas emissions and improving the environment.

- *Memorandum of Cooperation by National Centre for Polar and Ocean Research (NCPOR) under Ministry of Earth Sciences (MoES) and the Canadian High Arctic Research Station (CHARS) operated by Polar Knowledge (POLAR), Canada*
  The MoU, signed on 26 February 2020 enables cooperation in Arctic and Antarctic research by facilitating access to research infrastructure, and sharing resources and data, and advance knowledge creation in the polar regions through joint development of work plans relating to specific shared research initiatives, access to infrastructure and logistical cooperation.

- *MoU for technical cooperation in Earth Observation and Earth Sciences between MoES and the National Oceanic and Atmospheric Administration of USA*
  The MoU signed on 23 October 2020 on the scientific and technical cooperation will support Earth Observations and Earth Sciences's development and improvement to understand better the regional meteorology and oceanography, improved data assimilation and modelling for better prediction and early warning of natural disasters.

- *MoU between India and Saudi Arabia on renewable energy*
  India has signed an MoU on Renewable Energy with Saudi Arabia in October 2019. The MoU aims at setting up a framework for cooperation in the fields of Solar, Wind, biogas, and geothermal energy.

- *MoU between India and Bahrain on renewable energy*
  MoU for cooperation in the field of renewable energy was signed between India and Bahrain in July 2018. It aims to establish the basis for a cooperative institutional relationship to encourage and promote bilateral technical cooperation on new and renewable energy based on mutual benefit, equality, and reciprocity between two countries. The cooperation will focus on small hydro, solar, wind, and bio-energy and capacity building. Two countries will establish a Joint Working Group (JWG) to identify areas of mutual interest and cooperation for the development of new and renewable energy technologies.

- *JWG between India and UAE*
  The Joint working group (JWG) on renewable energy cooperation has been established. The 2nd JWG meeting was held on 11 November 2020, wherein both sides discussed R&D collaboration, investment models, and cooperation for the development of new and renewable energy technologies.

- *India-Denmark green strategic partnership*
  On September 28, 2020, Prime Ministers of India and Denmark in a virtual summit agreed to elevate India-Denmark relations to a green strategic partnership. This partnership would build on and consolidate the existing agreement establishing a Joint Commission for Cooperation (signed 6 February 2009) between India and Denmark, which envisaged cooperation within the political field; economic and commercial field; science and technology; environment; energy; education and culture. In addition, it builds on and complements the existing Joint Working Groups on renewable energy, urban development, environment, agriculture and animal husbandry, food processing, science, technology and innovation, shipping, labour mobility, and digitization.

- *MoU between India and Myanmar on wildlife conservation*
  An MoU on Cooperation on Combating Timber Trafficking and Conservation of Tigers and Other Wildlife was signed on 27 Fenruary 2020. The halting of cross-border timber trafficking is an aspect of carbon sequestration in forests.

- *India-Germany Joint Declaration of Intent (JDI) on Marine litter*
  During the 5th Inter Governmental Consultations between India and Germany in November 2019 in New Delhi, a Joint Declaration of Intent (JDI) on Marine litter was signed between Indian Ministry of Housing and Urban Affairs (MoHUA) and

German Ministry of Environment, Nature Conservation and Nuclear Safety (BMU).

- *MoU between India and France*
  MoU between NISE, MNRE, GoI, and The French Alternative Energies and Atomic Energy Commission (CEA) was signed during Prime Minister's visit to France in August 2019. A Space Climate Observatory was launched by the French President in 2019. ISRO and the French space agency CNES are part of this observatory, further enhancing Indo-French cooperation on combating climate change.

- *Alliance on environment protection between India and Italy*
  In November 2020, India and Italy agreed to establish a new alliance on environment protection to enhance their cooperation in food safety and security, climate change, water management, resource efficiency and circular economy, waste management, biodiversity and land degradation, as part of the pillars of the Action Plan for an enhanced partnership between India and Italy (2020-2024). The two sides also signed the following MoUs:

  - MoU to enhance the development of green hydrogen between Snam S.p.A., Italy and Greenko Energies Private Ltd, India.
  - MoU to promote energy transition and cooperate on gas infrastructures development between Snam S.p.A., Italy and Indian Oil Corporation Limited. India.
  - MoU in the area of conversion of plastic recycling between NextChem (Maire Tecnimont Group), Italy and Indian Oil Cooperation, India.

- *India-Netherlands collaboration to decarbonisation and energy transition*
  A Statement of Intent (SoI) was signed between India and the Netherlands on 28 September 2020 to support the decarbonisation and energy transition agenda for accommodating cleaner and more energy. The SoI was signed by Chief Executive Officer (CEO), NITI Aayog, and Ambassador of the Netherlands to India. As part of the cooperation between the Government of the Netherlands and the State of Kerala in India, a 4-member Dutch Risk Resilience Team (DRR) visited Kerala from 8-23 March 2019 to work on the integrated river and flood management. A report on flood prevention in Kuttanad Region, Kerala, was jointly developed. Regular roundtables are being held between the two sides to take forward the cooperation.

- *MoU between India and Russia*
  A MoU between the National Centre for Polar and Ocean Research (NCPOR) and the Arctic and Antarctic Research Institute of Roshydromet (AARI) on cooperation in research and logistics in the Antarctic, was signed in Goa on 15 October 2019.

- *MoU between India and Portugal*
  India and Portugal signed a MoU for launching a 4 million euro joint fund for S&T research collaboration on 1 March 2019 between the Department of S&T and its Portuguese counterpart FCT. The proposals include projects for renewable energy and green technologies related themes and are now being evaluated by both sides.

- *MoU between India and Finland*
  India and Finland signed a MoU for developing cooperation between two countries in the field of Environment protection and biodiversity conservation on 26 November 2020. The MoU is a platform to advance Indian and Finnish partnerships and support and exchange best practices in areas like prevention of air and water pollution. Other thrust areas include waste management, promotion of circular economy, low-carbon solutions and sustainable management of natural resources including forests, climate change, and conservation of marine and coastal resources.

- *India-EU partnership*
  During the India-EU Summit held on 15 July 2020, both sides adopted a “joint declaration on resource efficiency and circular economy” to establish an India-EU Resource Efficiency and Circular Economy Partnership bringing together representatives of relevant stakeholders from both sides, including governments, businesses (including start-ups), academia and research institutes. The jointly adopted “EU-India Strategic Partnership: A Roadmap to 2025” during the Summit mentions that the two sides agree to strengthen cooperation on environmental matters through the Joint Working Group on Environment as well as the Environmental Forum to support India’s transition to a resource-efficient and circular economy, to address air and water pollution, and to find innovative solutions to tackling plastic and marine litter, as well as to promote the integration of environmental concerns and solutions into economic growth policies. Two sides agreed to strengthen cooperation on water-related matters through the Joint Working Group on Water and the EU-India Water Forum, as well as in the context of the India-EU Water Partnership (IEWP).

  India-EU Climate Change Dialogue: Climate change and clean energy part of the jointly adopted “EU-India Strategic Partnership: A Roadmap to 2025” mentions that the two sides agree to cooperate for the full implementation of the UNFCCC, and its legal instruments including the Paris Agreement, and of NDCs, as well as the formulation of long-term low greenhouse gas emission development strategies, in line with the principles of equity and CBDR-RC in light of different national circumstances.

6.9.9 India – UN Fund contribution to climate change

The India – UN Development Partnership Fund, realizing the paramount importance of supporting vulnerable communities in these countries, has provided support to climate actions and clean energy projects to the Global South countries. The partnership includes projects that support Pacific Island Countries' governments to prepare, respond, and recover from climate-related disasters by providing equipment, training, capacity building workshops, and international visits.

India – UN Fund has also supported clean energy projects as part of the efforts to reduce carbon footprint and reverse climate change. These projects support governments and communities of the Global South with renewable energy and energy-efficient technologies and provision of training and conducting workshops on the utilisation of these technologies. The Fund also supports projects in the Pacific Islands that utilise renewable energy technology such as solar photovoltaic elements or solar pumps for the valorization of natural resources, improvement of the living conditions, and the resilience of communities. Moreover, India – UN Fund supports disaster recovery efforts in countries that have suffered immense damage due to climate change induced hurricanes such as Antigua and Barbuda, Dominica, and Mozambique. In Chad, the India Fund project focused on increasing community capacity for resilience, adaptation, and land restoration.

Country-specific projects

1. Climate Early Warning Systems in seven Pacific Island Countries (Cook Islands, Kiribati, Marshall Islands, Federated States of Micronesia, Nauru, Solomon Islands, and Tonga) enables the governments of these countries to prepare, respond to and recover from climate-related disasters. This project provides equipment for measuring meteorological conditions, training to build capacity for monitoring and warning, and support to the coordination of data collection among partnering Pacific Island countries.

2. **Chad**: Increasing community capacity for resilience, adaptation, and land restoration.

3. **Gabon**: Early warning systems in vulnerable communities of coastal zones strengthen technical capacities of national institutions and local communities to ensure the conservation, sustainable use, adaptation, access, and benefit sharing of natural resources, biodiversity, and ecosystems in line with international conventions.

4. **The Gambia**: Use of drones for pre-and post-disaster assessments that include mapping of safe sites, unsafe areas, and evacuation routes; climate risk assessments; and rapid identification of damage to the most vulnerable communities and the physical environment.

5. **Haiti:** Installation of solar pumps that will contribute to the valorization of natural resources (soils, water and plants) and the improvement of farmers' living conditions, and the resilience of communities in the face of climate change.

6. India – UN Fund has supported disaster recovery efforts in **Antigua and Barbuda, Dominica, Mozambique** that has suffered immense damage due to hurricanes.

7. **Cameroon**: Renewable Energy and Energy-efficient Technologies to improve access to sustainable energy and energy efficiency in rural areas in the northern and north-eastern regions.

8. Promotion of renewable energy in 11 Pacific Island Countries (Fiji, Kiribati, Marshall Islands, Micronesia, Nauru, Palau, Solomon Islands, Timor-Leste, Tonga, Tuvalu, Vanuatu) via installing grid-connected solar photovoltaic cells.

9. **Tuvalu**: Clean energy through stand-alone photovoltaic solar home systems. Another project to support solar-powered refrigeration systems is underway in Marshall Islands.

6.10 Private sector engagement

India’s private sector is at the forefront of addressing the growing challenge of climate change. There are many examples of such initiatives carried out in collaboration with civil society organisations, government departments and agencies and local communities. In January 2019, over ten of the country’s top philanthropies came together and found the India Climate Collaborative (ICC), a first of its kind, India-focused platform that seeks to channel funding and increase visibility of India's climate action. The ICC marks the first-ever collective response by industry leaders, and besides them, the ICC also has over 45 organizations as members. It seeks to direct funding and visibility towards climate action in India (Mukul, 2020).

6.10.1 Reduction in carbon emissions by industries

The Climate Action Summit was convened by the Secretary-General of UN in New York on 23 September 2019 to boost climate ambitions and implement the Paris Agreement. India, along with Sweden, launched the Leadership Group for Industry Transition to accelerate the voluntary transition of all industry sectors, particularly in areas of hard to abate industrial sectors to low carbon pathways in line with the goals of the Paris Agreement. The Leadership Group is envisioned as a group of countries, companies, and other actors voluntarily committed to enhance climate action and to support the implementation of NDCs of the countries under the Paris Agreement while acknowledging the principles and provisions of UNFCCC and the Paris Agreement, including equity and CBDR-RC. So far, 12 countries, including India and Sweden, and 11 companies, three of which are from India, have joined as members of the Leadership Group (MoEFCC, 2020).

6.10.2 Renewable energy consumption in companies

In 2019, the 59 responding companies in India consumed 95 terrawatt hour (TWh) electricity, of which 5 per cent (4.4 TWh) came from RE sources; 23 companies have reported RE targets, a 44 per cent growth over 2018. Most companies have reported RE consumption targets, and three adopted 100 per cent RE consumption targets and have joined the RE100 initiative (CDP, 2020).

6.10.3 Infosys and Global Climate Action Award

In December 2019, Infosys became the first Indian corporate to receive the prestigious United Nations Global Climate Action Award in the "Climate Neutral Now" category at UNFCCC CoP-25 in Madrid, Spain. Infosys is one of the first companies of its kind to commit to carbon neutrality. They have provided a practical model for climate action while setting a benchmark for integrating sustainable development and climate action. Infosys is in the process of building new energy-efficient buildings and upgrading its existing buildings towards transitioning to 100 per cent renewable energy. It has placed an internal price on carbon against which it assesses all projects and investments and runs an offset programme that works with communities to reduce emissions and contribute to sustainable development. All emissions are tracked using software applications and audited by a third-party verifier. Infosys' approach to achieving carbon neutrality is based on three pillars: reducing energy consumption through energy efficiency, transitioning to renewable energy sources, and offsetting emissions beyond its control. Infosys has also promoted sustainable practices amongst its employees and vendors to reduce their carbon footprint (UNFCCC, 2019).

6.10.4 Climate-friendly initiatives undertaken by Indian corporates (CII, 2019)

Climate Actions by ACC Limited: Being a resource and energy-intensive industry with a high carbon footprint, ACC has been continuously working towards reducing its raw material consumption, fossil fuel intensity, energy intensity, and water and carbon intensity in cement manufacturing over eight decades. Currently, the Indian cement sector's CO_2 intensity of 588 kg/tonne is the lowest globally. ACC has achieved a carbon intensity of 504 kg/tonne of cement against India's national cement average of 588 kg/tonne. Some of ACC's cement products have carbon intensity as low as 300 kg/tonne of cement. To realize this, ACC has undertaken the following initiatives:

- Blended Cements: Company aggressively promotes Blended Cements like Portland Pozzolana Cement (PPC), Portland Slag Cement (PSC), and Composite Cement. These cement products use waste materials like fly ash from captive power plants, slag from the steel industry and chemical gypsum. During 2018, the company's blended cement portfolio stands at ~88 per cent.
- Adoption of latest low carbon technologies: Being the oldest cement company having a rich heritage of 83 years, ACC has adopted state-of-the-art technological interventions, innovative production techniques, and climate-resilient resource optimization measures.

- Innovative and premium products: ACC has developed various value-added solutions of products like such as ACC LeakBlock - a high-performance waterproofing compound that prevents water seepage, ACC Gold - cement which repels water, ACC Permecrete (Permeable Concrete helping in water harvesting) and ACC Thermocrete (Thermal Insulation Concrete).
- Water conservation and water harvesting: ACC has installed sewage treatment plants (STP), effluent treatment plants (ETP), and zero liquid discharge (ZLD) systems for effective re-utilization of wastewater at plants. In 2018, ACC met approximately half of the total water requirements through rainwater.
- Tree plantation: Each of its cement plants has its own success story of tree plantation, greening activities, horticulture, flower and fruit cultivation, and water conservation. This helps conserve the biodiversity and helps in sequestering carbon emissions (ACC Limited, 2020).

Climate actions by Dalmia Bharat Limited (DBL): The climate actions of the Dalmia group are recognized by the UN. The UN Secretary-General invited Dalmia Cement to share its climate actions and commitments during the UN General Assembly session at Climate Action Summit on 23 September 2019 in New York before 63 Heads of States. DBL tracks local and international developments regarding environment and climate change and assumes ambitious targets *viz*., RE100, EP100, and water positivity. DBL has leveraged global best practices *viz*. Internal Carbon Pricing (ICP) (current price is USD 11/tonne of emission) and Science-based targets (SBT) to reduce climate impacts for the present and future. DBL uses IEA ETP 2DS scenario for setting its emission reduction targets to reach the laudable aim of becoming a Carbon Negative company by year 2040. Under this, the company is ambitiously looking to replace the fossil fuel-based electricity by 2030, fossil fuels in the cement kiln by 2035, and CCU technology by 2040. Dalmia Cement is:

- First cement company to join RE 100 and EP 100 global initiatives.
- First India-headquartered cement group to join the caring for climate initiative of United Nation Global Compact (UNGC).
- First India-headquartered cement group to join Carbon Pricing Leadership Coalition.
- First cement company globally to commit to a carbon-negative footprint by 2040.
- Setting up the largest carbon capture facility globally in the cement sector.

Climate Actions by Mahindra Group: In Environmental, Social and Governance (ESG) disclosures like the CDP and Dow Jones Sustainability Index (DJSI) Mahindra Group has performed exceptionally well. Mahindra Group has planted 15 million trees in the past ten years with a survival rate of approximately 70 per cent (1.45 million trees planted in FY18). In 2018, it was the only Indian company at the UNFCCC conference in Bonn for Talanoa Dialogue. Twenty Mahindra Group companies are part of the SBT initiatives.

Mahindra Life Spaces is one of the founder members of the Sustainable Housing Leadership Consortium for sustainable housing with a green portfolio of more than 90 per cent in green buildings. Many of Mahindra companies are heading towards making existing buildings and plants green certified. The immediate benefits are savings in electricity bill up to 20 per cent, water bill up to 30 per cent, lighting load and reduction in Operating and Maintenance Cost. The group has also partnered with Ola Cabs to launch a fleet of 100 Electric Vehicles. Mahindra group is the first global signatory of EP100.

The group is exploring the use of Shadow Carbon Price on the Capital Purchasing decisions for equipment worth USD 7,50,000 and above. Mahindra's Igatpuri plant is a certified carbon neutral plant. In consolidation, the RTS number has reached approximately 12 MW. At the Nashik, Chakan, and Kandivali plants, technology for converting LPG to natural gas was introduced by which carbon emissions were reduced by 6,152 MT and financial savings of INR 113.4 million to date. Mahindra's electric mobility division rolled out two versions of its first-ever lithium-ion battery-powered electric three-wheelers - the Treo and Treo Yaari in the year 2018. Treo and Treo Yaari were showcased at MOVE 2018; the Global Mobility Summit organised by NITI Aayog.

Climate Actions by Tata Steel Limited: As a responsible corporate, Tata Steel recognises that, though steel is considered a ‘hard to abate’ sector globally, it will be an integral part of the solution to climate change because of its infinite recycling properties.

Tata Steel has taken the following steps to address the challenge of climate change through various initiatives such as:

- Tata Steel engages with the Cambridge Institute of Sustainability Leadership (CISL) for organizing a program to sensitize the implications of climate change to the board members and senior management of the organization.
- To streamline the focus on climate change and GHG emissions reduction across the organization through a common platform, a Centre of Excellence for GHG emissions reduction was formed in 2018.
- An internal carbon price of 15 USD/t is also fixed and is being used for evaluating capital projects. Carbon Capture and Use (CCU) Pilot Projects have also been initiated to reduce GHG reductions at the industry level.
- Initiatives towards Energy Efficiency: A separate “Energy Impact Centre” has been formed to focus on process optimisation initiatives. These initiatives include:
  - Power generation from by-product gases
  - Coke Dry Quenching (CDQ) facility for Waste Heat Recovery
  - Conversion to LED lighting
  - Use of VFD in power-intensive motors
  - Fuel rate reduction in Iron Making
- Focus on Renewable and Clean Energy: 3 MW Solar PV Power Plant wsa commissioned in July 2017. Tata Steel has the country’s first Solar PV Power Plant installed in an iron ore mine in Noamundi. The project executed by Tata Power Solar

will help in reducing CO_2 emission by about 3,000 tonne per annum. This project is one of its kind in using the mining sites for an effective application.

Climate Actions by Delhi International Airport Limited: Located in India's capital city, Delhi Airport is, managed and developed by Delhi International Airport Limited (DIAL), a joint venture consortium of GMR Group, AAI, and Fraport AG. Environment Sustainability Management is an integral part of DIAL's business strategy, which helps achieve credibility and business sustainability at Delhi Airport. DIAL has adopted the globally recognized Airport Carbon Accreditation Program of Airports Council International (ACI) for effective GHG management at Delhi Airport. Under this framework, Delhi airport became the first Carbon Neutral Airport in the Asia-Pacific region to receive "Carbon Neutral" Accreditation in 2016 (SLOCAT, 2016).

Some of DIAL's key initiatives towards climate change mitigation and adaptation are-

- Green building: DIAL has adopted "green building" principles for all new and existing infrastructure at Delhi Airport. Terminal 3 of Delhi Airport is a LEED India Gold-certified green building under the "new construction" category, and Platinum rated Green Building under IGBC "Existing Building" category.
- Renewable energy and emission management: DIAL has installed 7.84 MW solar PV plant in Delhi Airport's airside premises. DIAL has also adopted ISO 14064 standard for GHG accounting.
- Operational improvement measures and emission reduction process/technologies: Delhi Airport is the first airport in India to have implemented Airport Collaborative Decision Making (A-CDM). DIAL has installed Fixed Electrical Ground Power Unit (FEGPU) and Pre- Conditioned Air (PCA) as Bridge Mounted Equipment (BMEs) for ensuring reduced use of Auxiliary Power Unit (APU) requirement by Airlines. DIAL implemented Multimodal Connectivity, CNG fuelling station and dedicated fuel hydrant system. Delhi Airport has recently adopted taxibot for aircraft taxi procedure, which has led to a significant reduction in emission during aircraft taxing.
- Wastewater treatment and rainwater harvesting: DIAL has commissioned 16.6 MLD state-of-the-art "Zero Discharge" sewage treatment plant treats entire sewage water generated in Delhi Airport. DIAL has constructed more than 300 rainwater harvesting structures to improve the airport's groundwater level and in the surrounding area.

Climate Actions by Mumbai International Airport Limited: Mumbai International Airport Limited (MIAL) operating Chhatrapati Shivaji Maharaj International Airport (CSMIA) has become a Carbon Neutral Airport, i.e., ACA Level 3+ accreditation under the Airport Carbon Accreditation (ACA) programme of Airport Council International (ACI) in 2018. In 2018-19, MIAL surpassed its target set for 2030, i.e., of 35 per cent reduction of Scope 1 and 2 GHG emission intensity against its base year, just over a decade in advance.

MIAL guided by its GHG policy, carbon road map, sustainability vision, and strong management backup, has implemented a plethora of carbon reduction initiatives. This includes initiatives such as moving towards greener fuel like CNG, increasing electric vehicles, increasing onsite renewable generation, 100 per cent aero-bridges at T1 and T2 with fixed electric ground power and pre-conditioned air, A-CDM, green buildings, and waste management. Over and above MIAL's continuous reduction trajectory and purchase of carbon credits to neutralize non-avoidable direct and indirect GHG emissions enabled them to achieve carbon neutrality. MIAL is yearly offsetting its residual scope 1 and 2 emissions since 2016-17 by procuring carbon credits.

Key highlights:

- Scope 1 and Scope 2 GHG reduction ~36 per cent compared to the base year 2014-15.
- Scope 3 GHG reduction ~21 per cent compared to the base year 2014-15.

Climate Actions by Toyota Kirloskar Motor (TKM) Private Limited: TKM has comprehensively addressed climate change in its global strategy and set ambitious targets in this context as part of the Toyota Global Environmental Challenge 2050. TKM's commendable initiatives include the ecozone project and the engagement with school children on climate change, water, waste, and biodiversity through this initiative, management of canteen waste in onsite biogas plant, and the incentive-linked environmental rating system for dealers. TKM has already started addressing value chain (scope 3) emissions.

Key steps that TKM has taken towards low carbon development:

- The company's long-term environmental strategy (Toyota's Global Environmental Challenges 2050) recognises climate change. Strong focus is seen on "Green Mobility" solutions. The company is actively involved in R&D and mainstreaming of LC technology, especially hydrogen fuel cell vehicles and hybrids. TKM's preparedness to emerging regulatory requirements is robust (BS IV to BS VI, Electric Mobility, CAFE regulation).
- The GHG accounting for scope 1 and 2 emissions is well established. Total (Scope 1 + Scope 2) absolute and emissions intensity show a decreasing trend in the last 3 years.
- The company has an impressive renewable energy target of 80 per cent by 2021. It shows good progress with the achievement of 64 per cent of total energy supply from solar energy currently (8.5 MW of installed solar capacity and 18 MW of solar through PPAs) compared to 7 per cent in 2014.
- Initiatives to increase efficiency of raw material use exist. Zero waste to landfill is one of its initiatives (Toyota Bharat, 2020).

Climate actions by Tata Chemicals Limited: Tata Chemicals Limited has the following five climate adaptation initiatives, which are as follows:

A. Impact of Integrated Water Resource Management Program is shown in the picture below:

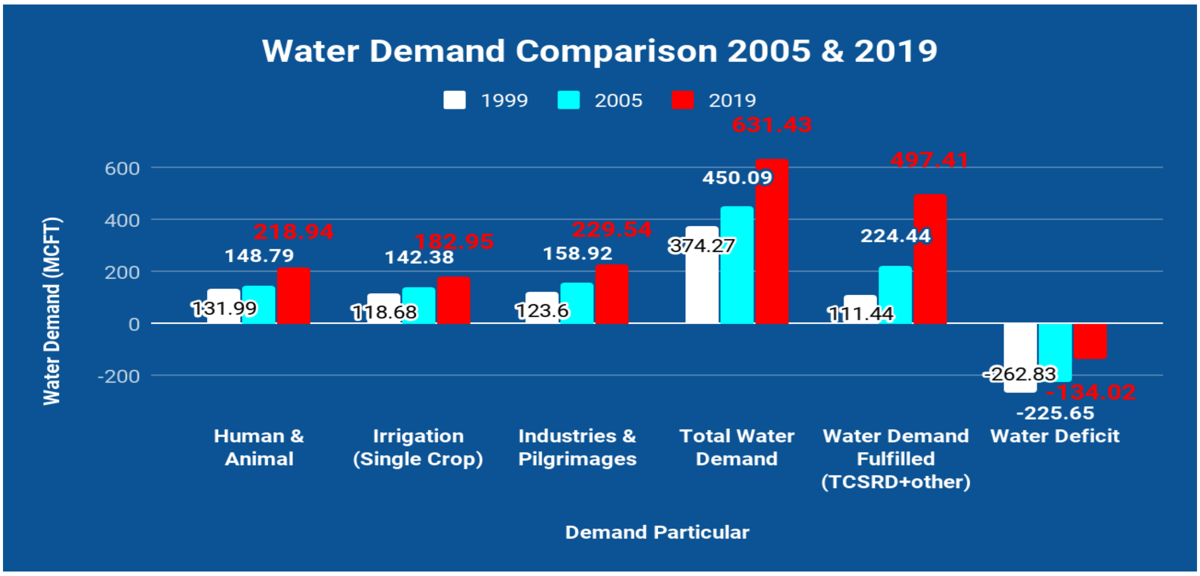


Figure 6.12: Water Demand Comparison 2005 & 2019

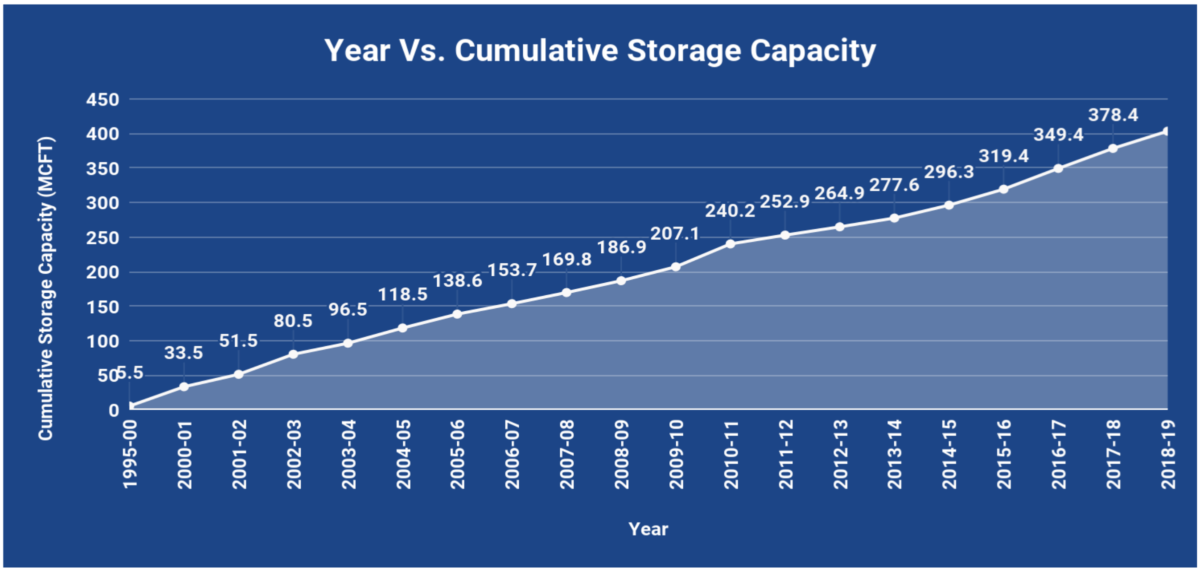


Figure 6.13: Year wise Cumulative Storage Capacity

B. Impacts of promotion of micro-irrigation through drip irrigation system:

Table 6.2: Number of drip and sprinkler installed

Year	Installation Number
2011-12	270
2014-15	625
2017-18	873
Total	1,768

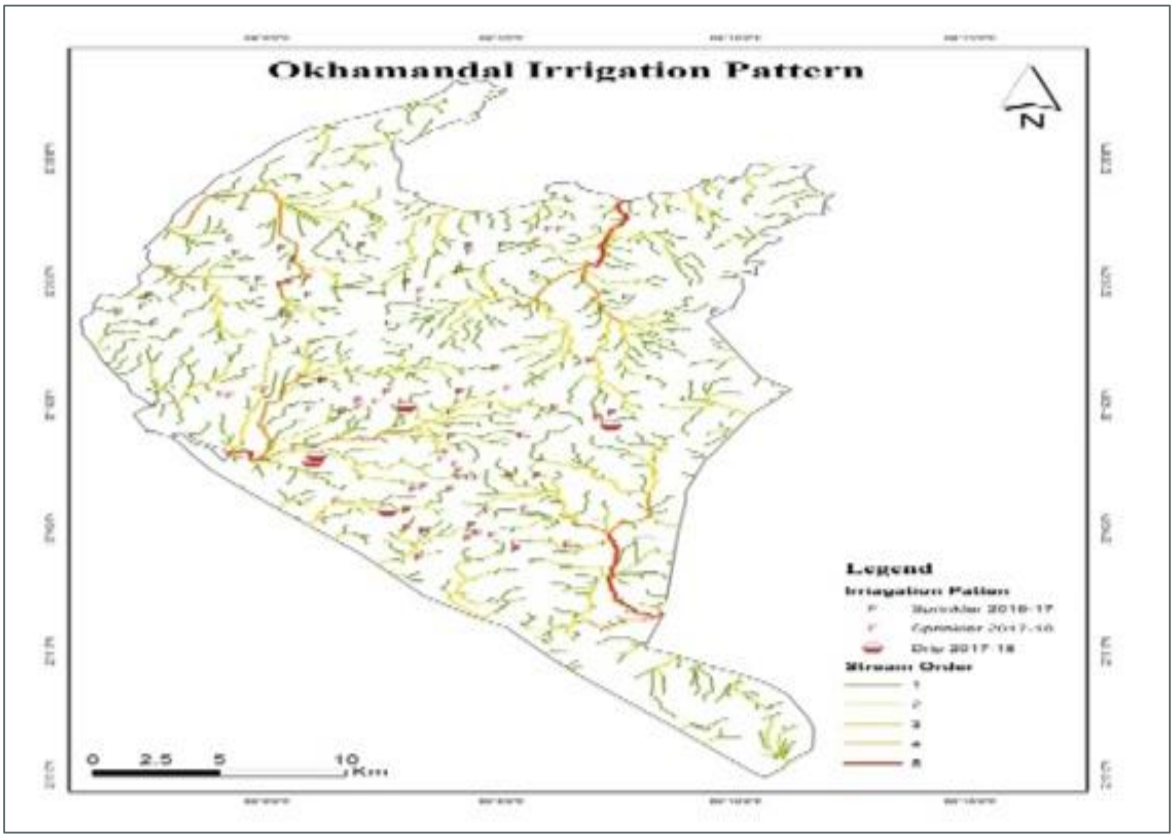


Figure 6.14: Okhamandal Irrigation Pattern

1. Sprinkler based irrigation system showed positive results in controlling crop diseases; hence reduction in the use of pesticides.
2. The water requirement in drip and sprinkler irrigation is 70 per cent and 50 per cent lesser, respectively, compared to traditional flood irrigation method.

C. Impacts of promotion of laser levelling:

1. Reduction in salinity in agricultural land.
2. Crop yield increased by 15 per cent compared to 2011 production level.
3. Around 9 per cent farmers cultivated Rabi crops - Chilli and Cumin resulting in higher income of INR 30,000/ha.

D. Impacts of ensuring safe drinking water by water harvesting:

1. Availability of safe drinking water to rural households.
2. Reduction in workload of women for carrying water from distant places

E. Tata Chemicals took the initiative towards environmental conservation, and the following is the data at a glance:

Table 6.3: Environmental initiatives by Tata Chemicals

Description	2018-19	Cumulative
No. of mangroves planted -Sundarbans -Mithapur	60,000	5,06,500 4,14,940
No. of eco-clubs promoted -Mithapur	40	40
Whale shark rescued (Mithapur)	20	710
No. of indigenous flora species introduced (Mithapur)	5	149
No. of fauna species recorded (birds and animals at Mithapur)	90	105

Climate-friendly action of Coal India Limited (CIL): The CIL is one of the world's largest coal-producing companies. It is a state-owned Maharatna Company operating 352 coal mines spread over 8 States of India. CIL also operates 12 coal washeries and also manages other establishments like workshops, hospitals and training centres. The CIL produces around 83 per cent of India's overall coal production and meets 40 per cent of country's primary commercial energy requirement. The CIL has been producing coal to meet the country's rising energy demand and been equally sensitive towards minimizing the adverse footprints of mining on environment and society. CIL has taken several initiatives for maintaining a sustainable environment in and around the mining areas (MoC, 2020):

- CIL has adopted a dedicated "Environment Policy" for the care of environment in its command areas. It has created Sustainable Development Cells (SDCs) at corporate level and in all subsidiary companies. The SDC cell is committed to addressing climate change, promote sustainable development by protecting the environment through integrated project planning, mitigation of pollution, conservation of natural resources, restoration of ecology, proper disposal of waste and inclusive growth.
- Reclamation of mined-out areas: Mined out areas, OB dumps, and other disturbed areas are concurrently reclaimed as soon as they get delinked from the active mining zone. Topsoil is segregated and stored in a clearly demarcated area for use within the mine as soon as the backfilling and concurrent reclamation starts. Three-tier biological reclamation in external and internal dumps is undertaken through expert agencies i.e., State Forest Development Corporations. Species for biological reclamation are selected in consultation with expert agencies like SFDC, ICFRE and NEERI. Satellite Surveillance: Status of land reclamation is monitored through satellite surveillance.
- Plantation in and around mining areas: Since inception, CIL has planted around 99.6 million trees in an area of 39,842 hectares till March 2020. In the present fiscal year, around 800 ha of the affected area will be brought under green cover. These efforts not only lead to improved environment and enriched bio-diversity but also create an effective carbon sink.
- Development of eco-parks in mining areas: CIL has developed 23 eco-parks/mine eco-tourism projects till 2019-20. These parks improve the land use

of mining areas and enrich the bio-diversity and create potential for earning to local inhabitants. CIL has planned to develop 10 new mine eco-tourism projects and another 5 expansion mine eco-tourism projects in the current fiscal.

Mitigation of air pollution: Regular environmental monitoring is carried out in all coal mines of CIL to assess the air quality and immediate remedial measures are taken in case of any deviation. Various measures taken in the mines of CIL are:

- Installation of fixed sprinklers/rain guns at/along/around the dust-generating sources *viz*., haul roads, stockyard, railway siding and coal handling plants;
- Mobile water sprinklers deployed along haul roads and other transportation roads, rain gun and fixed type sprinklers installed at various transfer points along conveyor route in coal handling plants and bunkers;
- Fog canons, for effective dust control;
- Installation of continuous ambient air quality monitoring stations (CAAQMS);
- Black-topping of roads, tarpaulin covering of trucks, and roadside avenue plantation is undertaken;
- Belt pipe conveyor (BPC) closed pipe shaped conveyor system to replace road transport;
- Vertical wind barrier systems are being developed in mega projects to arrest dust propagation,
- Large capacity mobile sprinklers/mist type of sprinklers deployed;
- Dust screens at railway sidings.

Mitigation of water pollution: Regular environmental monitoring is carried out in all coal mines of CIL to assess the water quality and immediate remedial measures are taken in case of any deviation. Various measures taken in the mines of CIL are:

- WETPs of sufficient capacity with Oil and Grease Trap for treatment and reuse.
- Sewage Treatment Plants of sufficient capacity for treatment of domestic sewage from townships / colonies.
- Provision of settling tank at surface.

Mine water utilization: Intersection of aquifers during mining results in the accumulation of water in mine pits, which needs to be pumped out for continuance of mining. CIL has taken several initiatives for gainful utilization of mine water and minimize the water footprint of mining. One of such initiatives is supply to the nearby community for domestic and irrigation purpose. During 2019-20, about 162.7 million kilolitres of mine water were supplied to the community, resulting in the supply of domestic/drinking water to about 0.750 lakh people and irrigation of 2,262 ha of land. Also, more than 330 numbers of rainwater harvesting projects are under operation in CIL as of 31 March 2020.

Reduction in carbon footprint and air pollution through projects of First Mile Connectivity (FMC): FMC Projects have been strategized for the mines having capacity of 4 MTY and above for easier handling and transportation of coal from pit head to destination. Total 49 FMC projects have been identified in CIL with an investment of about INR 1,54,890 million and the total Rapid Loading Capacity by 2024-25 will be 657.5 MTY. Out of these 49 projects, 35 projects for transporting 406 MTY capacity is being built in the first phase. The benefits by the implementation of FMC will be as follows:

- Reduction in air pollution from reduced vehicular exhaust emissions and road dust emissions.
- Lesser energy consumption and savings, carbon footprint and water budget of coal loading and transfer activities.
- Reduction in background sound level in the region.
- Better human health from a possible reduction in air pollution.
- Potential economic and social benefits of the mechanized Conveyor Belt and Silo Loading systems to the population living in the buffer zones of the mines.

Other sustainability initiatives:

- CIL is in process to venture into the Coal-to-Chemicals sector on stand-alone basis by setting up a Coal-to-Methanol plant of 2050 MTPD (0.676 MTPA) capacity at Dankuni Coal Complex (DCC). Coal from Raniganj coalfields shall be gasified to produce Syngas, which shall be subsequently converted into methanol. MOU has been signed between CIL and GAIL (India) Limited to explore areas of cooperation for setting up of coal-to-chemical plant in the vicinity of coalfields of CIL having high CV coal reserves.
- CIL is also taking up more projects of surface coal gasification with relatively lesser carbon footprints. The upcoming projects of Coal Bed Methane (CBM) extraction will also reduce the liberation of CH_4 (GHG) into the atmosphere during coal mining, which will be taken up in future.
- Hindustan Urvarak & Rasayan Limited (HURL), a joint venture among CIL, NTPC Limited, IOCL, FCIL and HFCL is setting up natural-gas based 1.27 MTPA urea plant at the premises of closed fertilizer plants of FCIL at Gorakhpur (U.P.) and Sindri (Jharkhand) and that of HFCL at Barauni (Bihar) with 29.67 per cent shareholding of CIL.
- Talcher Fertilizers Limited (TFL), a joint venture among RCF, CIL, GAIL and FCIL is setting up Surface Coal Gasification based integrated fertilizer complex at Talcher using coal. CIL has 29.67 per cent share in the said joint venture. Coal blended with pet-coke up to 25 per cent shall be gasified to produce Syngas which shall be converted into neem coated urea of annual capacity of 1.27 million metric tonne.
- Projects for sand segregation from waste have been commissioned in one of its kind. The segregated sand is mainly used to construct houses under government-sponsored housing projects such as Pradhan Mantri Awas Yojana. This initiative will reduce the burden on river bed mining.

- Subsidiary companies are also pursuing use of alternative energy sources. As of 31 March 2020-21, 4.85 MW Solar Power Projects (rooftop and ground mounded) have been installed in CIL.

6.10.5 Declaration of private sector on climate change

On 5 November 2020, a declaration on climate change was released which was signed by 24 key industry captains and MoEFCC at the virtual India CEO forum on climate change. Key industries like TATA, Reliance, the Adani group, Mahindra, Sun pharma and Dr. Reddy's, listed out various clean processes and initiatives they have taken and their agenda towards further decarbonisation post-2020 (PIB, 2020f).

6.10.6 Green bonds

Green bonds are debt securities issued by financial, non-financial or public entities where the proceeds are used to finance 100 per cent green projects and assets. Climate bonds remain focused on green bonds, linked explicitly to climate-change mitigation, adaptation and resilience. India has the second-largest emerging green bond market after China. NABARD is accredited as the National Implementing Entity under Green Climate Fund (GCF). GCF has been designated as an operating entity of the financial mechanism of the UNFCCC. NABARD has so far mobilized USD 50 million from the Fund to support the development of Solar Rooftop Units for clients of the country's commercial, industrial and residential housing sector. Several Government agencies have contributed to issuance: IREDA and the Indian Railway Finance Corporation (IRFC). In 2018, the SBI entered the market with a USD 650 million Certified Climate Bond (DEA, 2020). India's renewable energy sector requires significant financing, which presents one of the biggest green bond opportunities. The country needs USD 4.5 trillion within the next ten years to meet its renewable energy and urban sustainability targets, and green bonds can attract sizeable investment to fulfill this requirement (PTI, 2018). Agriculture and forestry, water resources, and disaster management are also the key sectors that are exploring the benefit of green bonds (Guha, 2019).

6.10.7 International Platform on Sustainable Finance (IPSF)

To scale up the environmentally sustainable investments, India joined the International Platform on Sustainable Finance (IPSF) in October 2019. The Platform recognises the global nature of financial markets, which can facilitate the transition to a green, low carbon, and climate-resilient economy by linking financing needs to the global sources of funding. The main objectives are to exchange and disseminate information to promote best practices in environmentally sustainable finance, compare the different initiatives and identify barriers and opportunities to scale up environmentally sustainable finance internationally while respecting national and regional contexts (DEA, 2020).

6.10.8 Corporate Social Responsibility (CSR) Programmes

CSR programmes being undertaken by several large companies in India suggest that they have started thinking about their impact on the environment and are striving to become responsible corporations. Data analysed by the Ministry of Corporate Affairs (MCA, 2020) for CSR expenditure of all Indian companies in 2014-15 showed that 14 per cent (INR 12,130 million) of total CSR spending in India was made on activities focusing on conserving the environment. It was the third highest expenditure on a social impact issue after education (32 per cent) and health (26 per cent) and was greater than the amount spent on rural development (12 per cent). These figures highlight that companies today have an increasingly broad understanding of the risks and opportunities that climate change poses to their strategies and operations and that larger issues of sustainability triggered by climate change are becoming an integral component of dialogues with the major stakeholders.

The enactment of Companies Act 2013 by the Ministry of Corporate Affairs (MCA), GoI was one of the world's largest experiments of introducing the CSR as a mandatory provision by imposing statutory obligation on companies to take up CSR projects towards social welfare activities. This has made India the only country which has regulated and mandated CSR for some select categories of companies registered under the Act. This CSR Initiative will push the nation towards achievement of SDGs and public-private partnership in transforming India.

Table 6.4: Details of CSR projects and funding

Year	Total no. of companies	Total amount spent on CSR (INR million)	Total no. of CSR projects	Development sectors entered by companies
FY 2014-15	16,548	100,660	9,365	29
FY 2015-16	18,291	145,170	18,468	29
FY 2016-17	19,546	143,330	23,073	30
FY 2017-18	21,411	137,080	23,833	29
FY 2018-19	24,902	186,530	30,619	29

Source: National CSR Data Portal, 2020.

NextGen's study to analyse the CSR expenditure of the top 100 companies for FY15-16 supports this trend. Among these companies, the top spenders in environment conservation were primarily from the following three sectors (Kumari & Bandyopadhyay, 2018):

- FMCG - ITC (INR 720 million), HUL (INR 220 million)
- Energy companies – NTPC Limited (INR 440 million), IOCL (INR 300 million)
- IT and financial services companies – Wipro (INR 480 million), Axis Bank (INR 280 million).

The idea is to work in collaboration and convergence and be part of the implementation, monitoring, and evaluation. The central point is not to take CSR “for granted.” Instead, CSR can be utilised to combat impending disasters, pandemics, and climate change.
Recently, MCA has stated that all COVID-19 related spending on health care can be classified as CSR spending. India Inc. has monetarily contributed to help fight the pandemic by contributing to PM CARES (a centrally created fund to fight the pandemic).

6.10.9 Small companies in the field of renewable energy sector

The private sector is primarily setting up renewable energy projects with Central/State organizations buying power at a rate either discovered through a transparent competitive bidding process or fixed by the concerned State Electricity Regulatory Commission. Most of the country's renewable energy projects are being set up by the private sector developers selected through a transparent bidding process. The Government has issued standard bidding guidelines to enable the distribution licensees to procure power at competitive rates in cost effective manner. Since renewable energy power plants are capital intensive, any power plant developer needs to mobilize capital for the same at the rate of INR 40-60 million per MW. To protect the interest of small developers as per central government guidelines, States/UTs can procure power from solar projects (less than 5 MW capacity) and wind projects (less than 25 MW capacity) not covered under competitive bidding guidelines through Feed-in–Tariff (FiT) (MNRE, 2019b).

6.11 Other environmental initiatives

6.11.1 Hydrogen economy

In the year 2005, India’s first National Hydrogen Road map was prepared, and MNRE has been undertaking a broad based research and development programme on different aspects of hydrogen and fuel cells including production of hydrogen from renewable energy sources, safe and efficient storage of hydrogen, and pilot projects on transportation, production, and refuelling. Between 2010 and 2020, around INR 1,000 million financial support was provided to research institutions, academia, and industry. MNRE supported projects have resulted in ongoing developmental work on fuel cell stacks, hydrogen-fuelled vehicles, hydrogen refuelling stations. Globally competitive technologies have also been developed for hydrogen production from biomass and storage in metal hydrides and carbon materials. Besides, major institutions, including DRDO, BARC, ISRO, and CSIR laboratories, have been developing cutting edge hydrogen and fuel cell technologies. The DST has also been supporting basic R&D in hydrogen and fuel cells.

The Department of Biotechnology (DBT) has been supporting R&D in hydrogen production through microbial fermentation. DBT has also constituted an expert working group for developing a biomass-to-hydrogen roadmap mission document.

6.11.2 Methanol economy

The Methanol economy program initiated by NITI Aayog aims to reduce the oil import bill, reduce GHG emissions, and convert Indian coal reserves and municipal solid waste into methanol, leading to independence from import while creating new jobs by setting up methanol production plants.

Methanol economy will result in a minimum 15 per cent reduction in fuel bill annually for the country by 2030. It will also create close to 5 million jobs through methanol production/ application and distribution services. Additionally, INR 60,000 million can be saved annually by a blending of 20 per cent DME (Dimethyl Ether – a derivative of methanol) in LPG. It will result in savings of INR 50 to INR 100 per cylinder to the consumer.

Under the Indian Methanol Economy program, five methanol plants based on high ash coal, five DME plants, and one natural gas-based methanol production plant with 20 MMT/ annum production in a joint venture with Israel, are planned to be set up. Cochin Shipyard Limited is building three boats and seven cargo vessels for the Inland Waterways Authority of India to use Methanol as a marine fuel for the inland waterways program.

Thermax Limited has successfully developed a 5 kW methanol-based reformer on a Direct Methanol Fuel Cell (DMFC). This module is being tested to replace DG sets in mobile towers. Kirloskar Oil Engines Limited has converted a 5 kW generator set to run on 100 per cent methanol and demonstrated successfully for direct electricity generation. Kirloskar is working towards converting generator sets of 150 - 300 KVA/kW capacity in collaboration with Dor Chemicals Limited, Israel.

As a part of the R&D program, work is in progress to set up coal to methanol plants in the country using the indigenous technology which is currently being demonstrated at BHEL (Hyderabad), Thermax, BHEL (Trichy), and IIT Delhi. Thermax with IIT Delhi is working on a 1 TPD demonstration plant while BHEL (Hyderabad) and BHEL (Trichy) are working on 1 TPD and 40 TPD demonstration plants, respectively. The Department of Biotechnology has sanctioned R&D project to produce Methanol from biomass to IISc Bengaluru and Praj Industries Pune. Phase I of the demonstration of syngas production from biomass was demonstrated in January 2019 (NITI Aayog, 2020).

To reduce import dependency, NITI Aayog had made an ambitious plan to produce methanol that can be blended (15 per cent) in gasoline to make M15 fuel for the automobile sector. Coal is one of the major feedstock for methanol production, and Coal India Limited has planned to set up coal to methanol plant at Dankuni Coal Complex in West Bengal. Tenders have been floated for inviting agencies to set up the plant on BOO basis.

6.11.3 Electricity from plastic waste

MoEFCC has notified Plastic Waste Management Rules, 2016 for environmentally sound management of plastic waste and preventing plastic pollution. The Ministry has also issued “Standard Guidelines for Single-Use Plastic” on 21 January 2019 to all States/UTs and Ministries. The guidelines entail waste management system improvements, legal options for States/UTs to prohibit single-use plastic items through regulatory measures, eco-friendly alternatives, social awareness, and public education. MNRE is implementing a 'Programme on Energy from Urban, Industrial, Agricultural Wastes/ Residues and Municipal Solid Waste' in the country for recovery of energy in the form of Biogas or Bio-CNG or power from urban, industrial, and agricultural waste/residues. The Ministry has set the following targets under the programme:

(i) Setting up of cumulative installed capacity of 200 MW for electricity generation from MSW where MSW fed into incinerator should be of non-biodegradable, non-recyclable, non-reusable, non-hazardous solid waste having a minimum calorific value exceeding 1,500 kcal/kg and excluding chlorinated materials like plastic and wood pulp.

(ii) Setting up of 57 MWeq of capacity for generation of energy in the form of Biogas/BioCNG from biodegradable waste (MNRE, 2019c).

6.11.4 India Cooling Action Plan

The India Cooling Action Plan (ICAP) was launched on 8 March 2019. The ICAP has a long-term vision with a 20-year time horizon and lists out actions that can inter alia help reduce cooling demand. Besides refrigerant-based space cooling technologies such as air conditioners, the ICAP provides for the use of non-refrigerant based technologies such as fans and coolers and not-in-kind technologies such as district cooling.

The India Cooling Action Plan seeks to (i) reduce cooling demand across sectors by 20 per cent to 25 per cent by 2037-38, (ii) reduce refrigerant demand by 25 per cent to 30 per cent by 2037-38, (iii) reduce cooling energy requirements by 25 to 40 per cent by 2037-38, (iv) recognize “cooling and related areas” as a thrust area of research under national S&T Programme, (v) training, and certification of 1,00,000 servicing sector technicians by 2022-23, synergizing with Skill India Mission. The Ministry has constituted a Steering Committee and six thematic working groups with representatives from other Ministries of GoI / State Governments to implement the ICAP (PIB, 2019g).

A first of its kind initiative, of bulk procurement of super-efficient air conditioners was launched for transforming the market to energy efficient air conditioners was under taken by Energy Efficiency Services Limited. The aim of the programme was to provide consumers with super-efficient air conditioners at comparable prices to average efficiency units. These air conditioners were over 40 per cent more efficient, perform at high ambient temperatures, are reliable over wide operating voltage range, and are backed up by five years of additional warranty. India has issued guidelines to encourage increasing temperature set points to 24°C in commercial buildings, saving 20 per cent in annual energy consumption compared to a 20°C set point. A first of its kind initiative, enabling more cooling at a lower cost - for both customers and climate, India has launched bulk public procurement that aims to deliver ACs that are comparably priced with average efficiency units but over 40 per cent more efficient. They also perform at high ambient temperatures, are reliable over a wide operating voltage range, and are backed up by five years of additional warranty.

6.11.5 Van Dhan Yojana

The Van Dhan Start-ups, established under the scheme initiated by Tribal Cooperative Marketing Development Federation of India Limited (TRIFED), MoTA has emerged as a source of employment for tribal gatherers and forest dwellers and also the home-bound labour and artisans. Under the Van Dhan Yojana, 1,205 Tribal Enterprises have been established to provide employment opportunities to 0.36 million tribal gatherers and 18,000 Self-Help Groups in 22 States. The slogan “Go Vocal for Local,” a Mantra in these troubled Pandemic times, has been adapted to include ‘Go Vocal for Local Go Tribal – Mera Van Mera Dhan Mera Udyam.’ The Startups scheme aims to treble the coverage to 1 million tribal gatherers through the COVID-19 relief plan of the MoTA under article 275(I) (PIB, 2020g). Started in 2019, startups have spread relatively quickly to 22 Indian States and almost became a competition once the states realised the value added by this initiative.

For States like Nagaland and Rajasthan, this scheme underlines the critical significance of this programme for tribal livelihoods, which ensures that the proceeds from these value-added products go to the tribals directly and offers a ray of hope for home-bound tribal labour and artisans through Van Dhan startups. The value-added products benefit largely from the packaging and marketing that these tribal enterprises provide. A total of 2,000 products have been identified throughout the country.

To help tribal enterprise scheme benefit, market linkages have been created to transform tribal gatherers into entrepreneurs. Many of these tribal enterprises are connected to markets and have received many orders already. Van Dhan Kendras have also been established across states for value addition and processing of forest produces. Real-time information of the Van Dhan Yojana across the country can be viewed at https://trifed.tribal.gov.in/vdvk/auth/login.php (PIB, 2020g).

6.11.6 Ladakh Geothermal project

A 500 KV geothermal pilot project at Puga hot water springs in Leh district of the Ladakh UT would come up by November 2020. A team of engineers from ONGC Energy Centre Delhi discussed their plans to explore geothermal energy in Puga Changthang on 13 November 2019. Puga hot water springs alone have the potential of generating 80 MW of geothermal energy. Puga geothermal energy project has immense potential, and it would be a game-changer for the UT of Ladakh in the long run. Several organizations have made efforts to explore this clean energy for decades in Ladakh. Presently, GoI under the MNRE has assigned ONGC to harness geothermal energy from Puga and other potential areas of UT Ladakh for which initial survey will start soon (The Tribune, 2019). A pilot project for exploratory drilling and setting up of 1 MWe power project from geothermal energy has been proposed by ONGC Energy Centre (OEC) in Puga valley, Union Territory of Ladakh. Depending upon experience generated, prospects for setting up larger capacity Geothermal plants will be explored.

6.11.7 Resource efficiency and circular economy

Circular economy is closely interlinked with climate change, and it would not be possible to achieve the climate change target of limiting temperature increase to 2^{o} Celsius without addressing its key issues. As part of the ambitious 'Circular Economy Package,' waste-management targets regarding reuse, recycling, and landfilling, strengthening provisions on waste prevention, and extended producer responsibility have been adopted.

The “Status Paper and Way Forward on Resource Efficiency and Circular Economy” and “Four Sectoral Strategy Papers on Resource Efficiency on Steel, Aluminium, Construction and Demolition Waste, Secondary Materials Management in Electrical and Electronics Sector” released by NITI Aayog in collaboration with MoEFCC and the European Union delegation to India, focussed on enhancing the resource-use efficiency in the Indian economy and industry, develop indicators for monitoring progress, and create an ecosystem for improving the resource security and minimizing environmental impacts.

NITI Aayog had undertaken a facilitator's role to mainstream the approaches and measures towards a resource-efficient and circular Indian economy. This was also in line with the Government’s commitment to the goals of sustainability. A few notable actions for the transformation of the RE Ecosystem in India include the formulation of the National Policy on RE/CE, establishment of Bureau of Resource Efficiency (BRE), mainstreaming RE and CE in existing flagship missions, a modern recycling industry with level playing between primary and secondary producers, R&D for development of scalable technologies for RE and CE, and development and promotion of skill and capacity building programmes for the informal sector (PIB, 2019h).

The Department of Biotechnology has supported R&D programs for development and demonstration of technologies for treatment of solid and liquid wastes, for recovering value in the form of energy and nutrients, while protecting the environment from pollution. The technologies supported include bio-methanation, constructed wetlands and restoration of degraded ecosystems to act as carbon sinks. Mapping of GHG generation potential of landfills, and studies on treatment of landfill leachate have also been supported.

6.11.8 Knowledge management initiatives

India Climate Change Knowledge Portal: On 27 November 2020, MoEFCC launched the "India Climate Change Knowledge Portal." It is a "single point Information resource" which provides information on the different climate initiatives taken by various line ministries enabling users to access updated status on these initiatives. The portal captures sector-wise adaptation and mitigation actions taken by the various line ministries in one place, including updated information on their implementation. The knowledge portal will help disseminate knowledge among citizens about all the major steps Government is taking at both national and international levels to address climate change issues (CCKP, 2020).

The eight major components included in the knowledge portal are:

- India's Climate Profile
- National Policy Framework
- India's NDC goals
- Adaptation Actions
- Mitigation Actions
- Bilateral and Multilateral Cooperation
- International Climate Negotiations
- Reports and Publications

India Energy Modelling Forum (IEMF):. While Indian researchers have been undertaking rigorous energy and climate policy modelling exercises, there had been no formalized and systematic process of having a modelling forum. Even then, various think-tanks/research organizations like TERI, IRADe, CSTEP, CEEW and NCAER have been consistently developing scenarios and contributing through modelling studies and analyses to provide required inputs to MoEFCC and other relevant ministries, including NITI Aayog. The India Energy Modelling Forum will accelerate the efforts in the following ways:

- Provide a platform to examine vital energy and environment-related issues;
- Inform decision-making process to the Indian government;
- Improve cooperation between modelling teams, government, and knowledge partners, funders;
- Facilitate the exchange of ideas, ensure production of high-quality studies;
- Identify knowledge gaps at different levels and across different areas;
- Build the capacity of Indian institutions.

NITI Aayog will initially coordinate the activities of the forum and finalizing its governing structure. The forum would include knowledge partners, data agencies and concerned government ministries.

6.11.9 Training of government officials on adaptation planning and implementation

One of the key activities undertaken by NMSHE is training programs of legislators and government officials in climate change adaptation. These training programmes' objective is to strengthen the capacities of state government officials at different levels on adaptation planning and implementation for responding to climate change risks.

DST, in partnership with the Swiss Agency for Development and Cooperation (SDC), NABARD Consultancy Services (NABCONS), and the State Climate Change Cell (SCCC) organized training programmes organised in the 12 Himalayan States under the NMSHE. The Training Programme intends to enable officials of the state at various levels of governance to plan strategies that will address state's climate change concerns and be all-inclusive, enabling them to manage the existing policies and programmes towards adaptation while improving their performance by enhancing knowledge, skill, and attitude. To ensure the sustainability of capacity building initiatives on climate change adaptation, these training programs aim to create a pool of master trainers for autonomous replication in each Himalayan State.

A pool of 153 Master trainers has been developed in 8 Himalayan States (J&K (50), Manipur (45), Arunachal Pradesh (14), Meghalaya (25), Nagaland (6), Sikkim (3), Mizoram (4), and Assam (5)). Close to 1,400 officials were trained in the 12 Himalayan States. A manual for climate change adaptation in the Indian Himalayan Region has been developed, which will serve as a guiding document to facilitate the integration of climate change adaptation in the region's overall development process. It is aimed at promoting, planning, and implementation of adaptation solutions towards climate change risks.

6.11.10 Educational and awareness initiatives

India recognises the role of education in environmental protection and its conservation. Several efforts have been made to reorient and reorganise the educational process and to raise awareness among the students on environmental issues. About 100 million students joined the Jal Shakti Abhiyan conversation campaign that is expected to save 36,500 million litres of water each year. Students across the country planted around 3.5 million saplings under the "one student one tree" campaign (The New Indian Express, 2020).

Many civil society organisations (CSOs) are also supporting initiatives that are creating environmental awareness among school children:

- The Green Schools Programme led by Centre for Science and Environment (CSE) honoured 172 schools with Climate Change Awards in 2019. These schools participated in a rigorous environmental audit exercise, where students had the opportunity to minimise the usage of resources in the school premises (The Times of India, 2020).

- Go Green Kids is an initiative by Green Yatra which aims to sensitise and educate children towards environmental protection and improvement. The initiative reached about 5 million students across the country and inspired them to reduce pollution and contribute to sustainable development (Green Yatra, 2020).
- Youths across the country participated in a series of events, a photography contest and a blog competition at the Youth Climate Conclave. This conclave was jointly organised by EU, GiZ, TERI, CEEW, and MoEFCC, and aimed at increasing awareness on climate change issues. In the final event, a simulation of the CoP) was held where participants took the roles of negotiators from major counties to negotiate climate policies on achieving the Paris Agreement goals (United News of India, 2020).

6.11.11 Gender mainstreaming in climate programmes

Considerations of gender in India's approach to tackling climate change at various phases have been incorporated in NAPCC, also translating into SAPCCs.

Programmes like Pradhan Mantri Ujjwala Yojana (PMUY) and MGNREGS significantly influence women empowerment socio-economic aspects and initiate women's involvement in decision-making processes. The gender-sensitive attributes of these schemes have ensured significant work participation from women.

Aajeevika - National Rural Livelihoods Mission (NRLM), which was launched by the Ministry of Rural Development (MoRD), GoI in June 2011, aims to create efficient and effective institutional platforms for the rural poor, enabling them to increase household income through sustainable livelihood opportunities and improved access to financial services. Gender barriers are being addressed in village cycle activities such as social mobilization, institution and capacity building, and livelihood planning.

References

ACC Limited. (2020). Sustainable Development. Retrieved from https://www.acclimited.com/sustainable/environment-and-energy

Austin, R. (2019). India's Mega-giant Bhadla Solar Park Sets New World Record. Retrieved from https://earthtechling.com/2019/10/bhadla-solar-park-worlds-largest-solar-farm/

BMTPC. (2019). Vulnerability Atlas of India. Retrieved from http://www.bmtpc.org/DataFiles/CMS/file/VAI2019/Index.html

CCKP. (2020). Climate Change Knowledge Portal, Ministry of Environment, Forest and Climate Change, Government of India. Retrieved from https://cckpindia.nic.in/

CDP. (2020). Communication received on private sector engagement from CDP India dated 14 April 2020.

CII. (2019). Success Stories Climate Actions by Indian Industry. CII-ITC Centre of Excellence for Sustainable Development, New Delhi. Communication received from CII, email dated 30 October 2019. Information presented as received from CII, not independently validated by government or company sources.

DEA. (2020). Department of Economic Affairs, Ministry of Finance, Government of India.

DHI. (2020). Communication received on Electric vehicles from Department of Hevay Industry, Government of India, email dated 24 December, 2020.

Green Yatra. (2020). Go Green Kids. Retrieved from http://www.greenyatra.org/go-green-kids.php

Guha. A. (2019). Green Bonds: key findings to Climate Change. ORF Issue Brief.

IEA. (2019). The Future of Rail, Opportunities for energy and the environment International Energy Agency. Retrieved from https://www.iea.org/reports/the-future-of-rail

IMD. (2020). Communicatioin received on Upgradation of Forecast System, Upgradation of Atmospheric Observation Network, Weather and Climate Services, Gramin Krishi Mausam Seva dated 6 March 2020.

IRENA. (2020). Retrieved from https://www.irena.org/Statistics/View-Data-by-Topic/Capacity-and-Generation/Country-Rankings

Isolaralliance. (2020). First World Solar Technology Summit. Retrieved from https://isolaralliance.org/wsts/

Jhala, Y., Banerjee, K., Chakrabarti, S., Basu, P., Singh, K., Dave, C., & Gogoi, K. (2019). Asiatic Lion: Ecology, Economics, and Politics of Conservation. Frontiers in Ecology and Evolution, 7.

Kanagaraj, R et al. (2019). Predicting range shifts of Asian elephants under global change. Diversity and Distributions, DOI: 10.1111/ddi.12898

Kumari, A & Bandyopadhyay, R. (2018). Corporate India Social Responsibility and Sustainability Practices: An Insight to the Agro-based Industry; Review. International Journal of Research in Social Sciences, 8(7), 847-869.

MCA. (2020). A Snapshot of CSR spent for 7334 Companies in FY 2014-15. Ministry of Corporate Affairs, Government of India. Retrieved from http://www.mca.gov.in/Ministry/pdf/CSRPRESENTATION15092016.pptx

MNRE. (2019a). Lok Sabha Unstarred Question No. 3164. Solar Industry. Ministry of New and Renewable Energy - Government of India. Retrieved from http://164.100.24.220/loksabhaquestions/annex/171/AU3164.pdf

MNRE. (2019b). Lok Sabha Unstarred Question No. 4127. Opportunities to Small Companies in the field of Renewable Energy Sector. Ministry of New and Renewable Energy - Government of India. Retrieved from http://164.100.24.220/loksabhaquestions/annex/171/AU4127.pdf

MNRE. (2019c). Communication from the Ministry of New and Renewable Energy - Government of India on Electricity form plastic waste, email dated 12 October 2020.

MNRE. (2020). Lok Sabha Unstarred Question No. 4338. Incentives for Renewable Energy Technology. Ministry of New and Renewable Energy - Government of India. Retrieved from: http://164.100.24.220/loksabhaquestions/annex/173/AU4338.pdf

MNRE. (2020a). Communication received from the Ministry of New and Renewable Energy Government of India on initiatives on solar energy, email dated 20 December 2020.

MoC. (2020). Communication received from Ministry of Coal, email dated 20 November 2020.

MoCA. (2019). Lok Sabha, Unstarred Question No. 3035. Use of Green Energy by Airports. Retrieved from http://164.100.24.220/loksabhaquestions/annex/171/AU3035.pdf

MoCA. (2020). Communication received from the Ministry of Civil Aviation, Government of India on Delhi-Dehradun flights using biofuels.

MoEFCC. (2020). Rajya Sabha Unstarred Question. No. 3224. Answered on 23.03.2020. Ministry of Environment, Forest and Climate Change, Government of India. Retrieved from https://rajyasabha.nic.in/rsnew/Questions/QResult.aspx

MoES. (2019). Communication received from Ministry of Earth Sciences, Government of India.

MoES. (2020). Communication received on Initiatives in weather and climate services and other matters from Ministry of Earth Sciences, Government of India, dated 30 July 2020.

MoHI&PE. (2019). Lok Sabha, Unstarred Question No. 3613. Promotion of Electric Vehicles. Retrieved from http://164.100.24.220/loksabhaquestions/annex/172/AU3613.pdf

MoJS. (2019a). Operational Guidelines for the Implementation of Jal Jeevan Mission – Har Ghar Jal, Ministry of Jal Shakti, Government of India.

MoJS. (2019b). Lok Sabha, Unstarred question No 845. (2019). Depletion in Groundwater Level, Ministry of Jal Shakti, Government of India. Retrieved from http://164.100.24.220/loksabhaquestions/annex/172/AU845.pdf

MoJS. (2020). One year of Jal Shakti, Ministry of Jal Shakti, Government of India. Retrieved from http://jalshakti-dowr.gov.in/sites/default/files/eBook/eBook-JalShakti-1year/eng/mobile/index.html

MoR. (2019). Lok Sabha, Starred Question No. 447. Environment friendly technology. Retrieved from http://164.100.24.220/loksabhaquestions/annex/171/AS447.pdf

MoR. (2020). Rajya Sabha. Unstarred Question No. 2363. Complete electrification of railway network. Retrieved from https://rajyasabha.nic.in/rsnew/Questions/QResult.aspx

MoR. (2020a). Communication received on Green Indian Railways from Ministry of Railway, Government of India, email dated 27 December, 2020.

Mukul, J. (2020). Business leaders come together, set up body for climate change action, Business Standard.

Nag. D. (2020). Financial Express. PM Modi inaugurates Asia's largest solar power project – Rewa Solar in Madhya Pradesh.

National CSR Data Portal. (2020). Ministry of Corporate Affairs, Government of India.

NCRMP. (2019). National Cyclone Risk Management Project. Retrieved from https://ncrmp.gov.in/ncmp-phase-ii/

NDMP. (2019). National Disaster Management Plan. Ministry of Home Affairs, Government of India. November 2019.

NDMA. (2020). National Disaster Management Authority, GoI. Retrieved from https://www.ndma.gov.in/en/ongoing-programmes/aapda-mitra.html

NISE. (2020). Communication from NISE on Solar Dryer cum Space Heating System (SoLDry) for Ladakh Region Implemented by National Institute of Solar Energy

NITI Aayog. (2020). Methanol Economy. Retrieved from https://niti.gov.in/methanol-economy

Panda, R. M., Behera, M. D., & Roy, P. S. (2017). Assessing distributions of two invasive species of contrasting habits in future climate. Journal of Environment Management, DOI: 10.1016/j.jenvman.2017.12.053

PIB. (2017). Ministry of Railways. Minister for Railways inaugurates key freight sector initiatives of Indian Railways. Retrieved from https://pib.gov.in/newsite/PrintRelease.aspx?relid=158793

PIB. (2019a). Prime Minister's Office. Pledges to more than double India's renewable energy capacity target to 450 GW. Retrieved from https://pib.gov.in/PressReleasePage.aspx?PRID=1585979

PIB. (2019b). Ocean Energy. Ministry of New and Renewable Energy, Government of India. Retrieved from https://pib.gov.in/PressReleseDetailm.aspx?PRID=1582638

PIB. (2019c). PM's remarks at Climate Action Summit 2019 during 74th session of UNGA. Retrieved from https://pib.gov.in/PressReleseDetailm.aspx?PRID=1585948

PIB. (2019d). Ministry of Home Affairs. Prime Minister announces Coalition for Disaster Resilient Infrastructure at UN Climate Action Summit 2019. Retrieved from https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1586051

PIB. (2019e). Ratification of the amended Framework Agreement of the ISA for opening up the ISA membership to all countries that are members of the United Nations. Retrieved from https://pib.gov.in/PressReleasePage.aspx?PRID=1581387

PIB. (2019f). Year End Review 2019: Ministry of Earth Sciences. Ministry of Earth Sciences, Government of India. Retrieved from https://pib.gov.in/PressReleasePage.aspx?PRID=1598130

PIB. (2019g). India Cooling Action Plan Launched. Ministry of Environment, Forest and Climate Change, Goverment of India. Retrieved from https://pib.gov.in/PressReleseDetailm.aspx?PRID=1585227

PIB. (2019h). NITI Aayog. NITI Aayog pitches for transition to Resource Efficiency and Circular Economy as an Economic Paradigm for New India. Retrieved from https://pib.gov.in/Pressreleaseshare.aspx?PRID=1561008

PIB. (2019i). Ministry of Overseas Indian Affairs. Power Minister Shri RK Singh launches SARAL. Retrieved from https://pib.gov.in/newsite/PrintRelease.aspx?relid=192752

PIB. (2020a). Ministry of New and Renewable Energy, Government of India. IREDA to Create a Green Window for Green Energy Finance. Retrieved from https://pib.gov.in/PressReleseDetailm.aspx?PRID=1595888

PIB. (2020b). Ministry of New and Renewable Energy. Government of India launches scheme for 100 % solarisation of Konark sun temple and Konark town. Retrieved from https://pib.gov.in/PressReleasePage.aspx?PRID=1625340

PIB. (2020c). Ministry of New and Renewable Energy, Government of India. Retrieved from https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1608548

PIB. (2020d). Ministry of Railways. Indian Railways to source about 1000 MW Solar Power by 2021-22. Retrieved from https://pib.gov.in/newsite/PrintRelease.aspx?relid=196213

PIB. (2020e). Ministry of Power. NTPC launches Hydrogen Fuel bus and car project for Leh and New Delhi – Invites Global EOI. Retrieved from https://pib.gov.in/PressReleasePage.aspx?PRID=1618378

PIB. (2020f). Ministry of Environment, Forest and Climate Change, Government of India. India CEO Forum on Climate Change forges long standing and sustainable partnership between the Government and private sector. Retrieved from https://www.pib.nic.in/PressReleasePage.aspx?PRID=1670351

PIB. (2020g). PM Van Dhan Yojana. Ministry of Tribal Affairs, Government of India. Retrieved from https://pib.gov.in/PressReleasePage.aspx?PRID=1631790

PIB. (2020h). Prime Minister's Office. PM to dedicate to the nation the 750 MW Rewa Solar Project. Retrieved from https://pib.gov.in/Pressreleaseshare.aspx?PRID=1637693

PIB. (2020i). Prime Minister's Office. PM to dedicate to the nation the 750 MW Rewa Solar Project. Retrieved from https://pib.gov.in/PressReleasePage.aspx?PRID=1637549

Plugboats. (2020). Excellence in Electric Boats Designed for Paying Passengers, Retrieved from https://plugboats.com/winners-of-the-1st-gussies-electric-boat-awards/

PTI. (2018). Infrastructure Investment for USD 4.5 trillion a challenge: Finance Minister Piyush Goyal, New Indian Express.

Raghavan, K., Sanjay, J., Gnanaseelan, C., Mujumdar, M., Kulkarni, A. & Chakraborty, S. (2020). Assessment of Climate Change over the Indian Region. A Report of the Ministry of Earth Sciences (MoES), Government of India: A Report of the Ministry of Earth Sciences (MoES), Government of India. 10.1007/978-981-15-4327-2.

Ramaswami, G. & Sukumar, R. (2013). Long-term environmental correlates of invasion by Lantana camara (Verbenaceae) in a seasonally dry tropical forest. PLoS ONE 8(10): e76995. doi:10.1371/journal.pone.0076995.

Saberwal, V. K. et al. (1994). Lion-human Conflict in the Gir Forest, India, Conservation Biology, 8(2), pp. 501–507. doi: 10.1046/j.1523-1739.1994.08020501.x.

Sikkim Climate Inventory and Monitoring System. (2019). IORA Ecological Solutions Private Limited.

SLOCAT. (2016). Delhi Airport becomes first airport in Asia-Pacific to achieve carbon neutral status. Retrieved from https://slocat.net/1760-2/

Sukumar, R. (2003). The living elephants: evolutionary ecology, behaviour and conservation. New York: Oxford University Press, ISBN 0-19-510778-0

Tata Power. (2020). World's largest solar rooftop installation on a cricket stadium. Retrieved from https://www.tatapower.com/plants-projects/solar-rooftop-projects/cci.aspx

Thapa, S., Chitale, V., Rijal, S. J., Bisht, N., & Shrestha B. B. (2018). Understanding the dynamics in distribution of invasive alien plant species under predicted climate change in Western Himalaya. PLOS ONE 13:e0195752.

The Hindu. (2018a). Brabourne gets world's largest rooftop solar plant. Retrieved from https://www.thehindu.com/news/cities/mumbai/brabourne-gets-worlds-largest-rooftop-solar-plant/article24795400.ece

The Hindu. (2018b). IAF plane takes to the air on blended bio-fuel. Retrieved from https://www.thehindu.com/news/national/iaf-aircraft-flies-on-blended-bio-fuel/article25765552.ece

The Hindu. (2020). INR 180 per day as energy cost compared to over INR 8,000 required for a diesel ferry. Retrieved from https://www.thehindu.com/news/national/kerala/indias-first-solar-ferry-sails-into-global-contest/article31769302.ece

The New Indian Express. (2020). 'Time for nature': Education and the environment. Retrieved from https://www.newindianexpress.com/opinions/2020/jun/06/time-for-nature-education-and-the-environment-2152899.html

The Times of India. (2020). CSE honours 172 schools with Climate Change Awards for 2019. Retrieved from https://timesofindia.indiatimes.com/articleshow/73983030.cms

The Tribune. (2019). Geothermal project to come up in Ladakh.

Toyota Bharat. (2020). Retrieved from https://www.toyotabharat.com/toyota-in-india/environment/

UNFCCC. (2019). Infosys' Journey to Carbon Neutrality, India. Retrieved from https://unfccc.int/climate-action/momentum-for-change/climate-neutral-now/infosys

United News of India. (2020). Youth Climate Conclave. Retrieved from http://www.uniindia.com/~/youth-climate-conclave-launched/States/news/1749662.html

World Bank. (2019). 60% of Delhi Metro now powered by solar energy from Madhya Pradesh.

*****

Annexure I- Abbreviations

Acronym	Expansion
AAI	Airports Authority of India
ADB	Asian Development Bank
ADCPs	Acoustic Doppler Current Profilers
AIBP	Accelerated Irrigation Benefit Programme
AICRP	All India Coordinated Research Project
AJAY	Atal Jyoti Yojana
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
AR4	Fourth Assessment Report
ARGs	Automatic Rain Gauges
AS	Arabian Sea
ASI	Annual Survey of Industries
ATF	Aviation Turbine Fuel
AUST	Advanced Ultra Supercritical Technology
AWS	Automated Weather Stations
BEE	Bureau of Energy Efficiency
BEEP	Buildings Energy Efficiency Programme
BEVs	Battery Electric Vehicles
BHAVINI	Bharatiya Nabhikiya Vidyut Nigam Limited
BHEL	Bharat Heavy Electricals Limited
BNVSAP	Bharat New Vehicle Safety Assessment Programme
BoB	Bay of Bengal
BPKP	Bharatiya Prakritik Krishi Paddhati Programme
BR	Biological richness
BRTS	Bus Rapid Transit System
BS	Bharat Stage
BUR	Biennial Update Report
C_2F_6	Hexafluoroethane
CADWM	Command Area Development and Water Management
CAFÉ	Corporate Average Fuel Efficiency
CAGR	Compounded Annual Growth Rate
CAMPA	Compensatory Afforestation Fund Management and Planning Authority
CAT	Climate Action Tracker
CBDR-RC	Common but Differentiated Responsibilities and Respective Capabilities
CBM	Coal Bed Methane
CC	Canopy Cover
CCA	Culturable Command Area
CCAP	Climate Change Action Programme
CCU	Carbon Capture Unit
CCUS	Carbon Capture Utilisation & Storage
CDM	Clean Development Mechanism
CDRI	Coalition for Disaster Resilient Infrastructure
CDs	Cyclonic Disturbances
CEA	Central Electricity Authority
CERC	Central Electricity Regulatory Commission
CF4	Carbon tetrafluoride

CGD	City Gas Distribution
CGWB	Central Ground Water Board
CH_4	Methane
CII	Confederation of Indian Industry
CIMFR	Central Institute of Mining and Fuel Research
CMFRI	Central Marine Fisheries Research Institute
CMIS	Coastal Management Information System
CNG	Compressed Natural Gas
CO_2	Carbon dioxide
COP	Conference of Parties
CORDEX	Coordinated Regional Climate Downscaling Experiment
COVID-19	Corona Virus Disease of 2019
CPCB	Central Pollution Control Board
CRCPMP	Climate Resilient Coastal Protection and Management Project
CRRI	Central Road Research Institute
CRZ	Coastal Regulation Zone
CSIR	Council of Scientific and Industrial Research
CSR	Corporate social responsibility
CSS	Centrally Sponsored Scheme
CVI	Coastal Vulnerability Index
CWC	Central Water Commission
CWMI	Composite Water Management Index
CZMAs	Coastal Zone Management Authorities
CZMP	Coastal Zone Management Plan
DAY	Deendayal Antodaya Yojana
DAY-NULM	Deendayal Antodaya Yojana-National Urban Livelihoods Mission
DCs	Designated Consumers
DDUGJY	Deen Dayal Upadhyaya Gram Jyoti Yojana
DFCC	Dedicated Freight Corridor Corporation of India Limited
DI	Disturbance Index
DIAL	Delhi International Airport Limited
DISCOMs	Power Distribution Companies
DoDW&S	Department of Drinking Water and Sanitation
DoWR	Department of Water Resources
DoWR, RD&GR	Department of Water Resources, River Development & Ganga Rejuvenation
DRR	Disaster Risk Reduction
DSM	Demand Side Management
DSR	Direct Seeded Rice
DSS	Decision Support System
DST	Department of Science and Technology
DVC	Damodar Valley Corporation
DWRs	Doppler Weather Radars
EBP	Ethanol Blended Petrol Programme
ECBC	Energy Conservation Building Code
EEFP	Energy Efficiency Financing Platform
EESL	Energy Efficiency Services Limited
EEZ	Exclusive Economic Zone
EIT	Economies in Transition
EM-DAT	Emergency Events Database

ENS	Eco Niwas Samhita
EPA	Environment (Protection) Act
ESCerts	Energy Saving Certificates
ESCOs	Energy Service Companies
ESCS	Extremely Severe Cyclonic Storm
ESIP	Ecosystems Service Improvement Project
EV	Electric Vehicle
EVI	Electric Vehicles Initiative
FAME	Faster Adoption and Manufacturing of (Hybrid %) Electric Vehicles
FAO	Food and Agriculture Organization
FEEED	Framework for Energy Efficient Economic Development
FHTC	Functional Household Tap Connections
FICCI	Federation of Indian Chambers of Commerce and Industry
FMBAP	Flood Management and Border Areas Programme
FMD	Foot & Mouth Disease
FMOs	Flood Meteorological Offices
FMP	Flood Management Programme
FRA	Forest Resources Assessment
FSI	Forest Survey of India
GCF	Green Climate Fund
GDP	Gross Domestic Product
GEC	Green Energy Corridor
GEF	Global Environment Facility
GHG	Greenhouse Gas
GII	Global Innovation Index
GIM	Green India Mission
GIS	Geographic Information System
GLOFs	Glacial Lake Outburst Floods
GMBM	Global Market Based Measure
GoI	Government of India
GRIHA	Green Rating for Integrated Habitat Assessment
GST	Goods and Services Tax
GVA	Gross Value Added
GVW	Gross Vehicle Weight
GWP	Global Warming Potential
HDI	Human Development Index
HFCs	Hydrofluorocarbons
HPC	High Performance Computing
HW	Heatwave
HWRF	Hurricane Weather Research & Forecast
ICA	International Consultation and Analysis
ICAP	India Cooling Action Plan
ICAR	Indian Council of Agricultural Research
ICAT	Initiative of Climate Action Transparency
ICC	India Climate Collaborative
ICFRE	Indian Council of Forestry Research and Education
ICMR	Indian Council of Medical Research
ICT	Information and Communication Technology
ICZMP	Integrated Coastal Zone Management Project
IEA	International Energy Agency

IFS	Integrated Farming System
IGO	Inter-governmental Organization
IHR	International Heath Regulations
IITM	Indian Institute of Technology Madras
IMD	India Meteorological Department
IMR	Infant Mortality Rate
INC	Initial National Communication
INCOIS	Indian National Centre for Ocean Information Services
INDC	Intended Nationally Determined Contributions
INR	Indian Rupee
IODE	International Oceanographic Data Exchange
IOTWMS	Indian Ocean Tsunami Warning and Mitigation System
IPCC	Inter-governmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
IR	Indian Railways
IRC	Indian Road Congress
IREDA	Indian Renewable Energy Development Agency
IROAF	Indian Railways Organisation for Alternate Fuels
ISA	International Solar Alliance
ISFR	India State of Forest Report
ISRO	Indian Space Research Organization
ITEC	Indian Technical and Economic Cooperation
ITEWC	Indian Tsunami Early Warning Centre
IWH	Indian Western Himalayan
IWMI	International Water Management Institute
IWMP	Integrated Watershed Management Programme
JFM	Joint Forest Management
JJM	Jal Jeevan Mission
JSA	Jal Shakti Abhiyan
KTR	Kanha Tiger Reserve
KVKs	Krishi Vigayan Kendras
LAI	Leaf-area Index
LCO	Locust Circle Offices
LED	Light Emitting Diode
LNG	Liquefied Natural Gas
LPA	Long Period Average
LPG	Liquefied Petroleum Gas
LULUCF	Land Use, Land-use Change and Forestry
MAP	Mean Annual Precipitation
MDF	Moderately Dense Forest
MDGs	Millennium Development Goals
MHVM	Multi-Hazard Vulnerability Maps
MIDH	Mission for Integrated Development of Horticulture
MMR	Maternal Mortality Ratio
MNRE	Ministry of New and Renewable Energy
MGNREGA	Mahatma Gandhi National Rural Employment Guarantee Act
MGNREGS	Mahatma Gandhi National Rural Employment Guarantee Scheme
MoAFW	Ministry of Agriculture and Farmers Welfare
MoC	Ministry of Coal
MoEA	Ministry of External Affairs

MoEFCC	Ministry of Environment, Forest and Climate Change
MoES	Ministry of Earth Sciences
MoFAH&D	Ministry of Fisheries, Animal Husbandry and Dairying
MoHFW	Ministry of Health and Family Welfare
MoHUA	Ministry of Housing and Urban Affairs
MoJS	Ministry of Jal Shakti
MoP	Ministry of Power
MoR	Ministry of Railways
MoSPI	Ministry of Statistics and Programme Implementation
MoU	Memorandum of Understanding
MOVCDNER	Mission for Organic Value Chain Development for North Eastern Region
MPAs	Marine Protected Areas
MRTS	Metro Rail Transport System
MRV	Measurement, Reporting and Verification
MSME	Micro, Small and Medium Enterprises
MSW	Municipal Solid Waste
MuDSM	Municipal Demand Side Management
N	Nitrogen
N_2O	Nitrous Oxide
NADCP	National Animal Disease Control Programme
NAFCC	National Adaptation Fund on Climate Change
NAPCC	National Action Plan on Climate Change
NATCOM	National Communication
NBARD	National Bank for Agriculture and Rural Development
NCCR	National Centre for Coastal Research
NCDC	National Centre for Disease Control
NCEP	National Centers for Environmental Prediction
NCIWRD	National Commission for Integrated Water Resources Development
NCR	National Capital Region
NCSCM	National Centre for Sustainable Coastal Management
NCZMA	National Coastal Zone Management Authority
NDC	Nationally Determined Contribution
NDMA	National Disaster Management Authority
NDRF	National Disaster Response Fund
NEEFP	National Energy Efficient Fan Programme
NEMMP	National Electric Mobility Mission Plan
NEPZ	North Eastern Plains Zone
NER	North-Eastern Region
NFSM	National Food Security Mission
NGO	Non Governmental Organization
NIC	National Informatics Centre
NICRA	National Innovations in Climate Resilient Agriculture
NIH	National Institute of Hydrology
NIMS	National Inventory Management System
NIO	North Indian Ocean
NISE	National Institute of Solar Energy
NITI	National Institution for Transforming India
NLAs	National Level Agencies
NMEEE	National Mission on Enhanced Energy Efficiency
NMSA	National Mission for Sustainable Agriculture

NMSKCC	National Mission on Strategic Knowledge for Climate Change
NMVOC	Non Methane Volatile Organic Compound
NOAA	National Oceanic and Atmospheric Administration
NODC	National Oceanographic Data Centre
NO_x	Nitrogen Oxides
NPCIL	Nuclear Power Corporation India Limited
NPD	National Project Director
NPEE	National Programme on Energy Efficiency
NPL	National Physical Laboratory
NPMCR	National Policy for Management of Crop Residues
NPP	Net Primary Production
NRRI	National Rice Research Institute
NRSC	National Remote Sensing Centre
NSC	National Steering Committee
NSO	National Statistical Office
NSS	National Sample Survey
NSSO	National Sample Survey Office
NTFP	Non-Timber Forest Product
NWP	Numerical Weather Prediction
OC	Organic Carbon
ODF	Open Defecation Free
OF	Open Forest
OGD	Open Government Data
ONGC	Oil and Natural Gas Corporation
PAT	Perform, Achieve and Trade
PBCMs	Plastic Bottle Crushing Machines
PC	Planning Commission
PDDU-GKY	Pandit Deen Dayal Upadhyaya Grameen Kaushalya Yojana
PDMC	Per Drop More Crop
PFC	Perfluorocarbon
PFZ	Potential Fishing Zone
PGS	Participatory Guarantee System
PHEIC	Public Health Emergency of International Concern
PKVY	Paramparagat Krishi Vikas Yojana
PMAY	Pradhan Mantri Awas Yojana
PMAY(U)	Pradhan Mantri Awas Yojana Urban
PMEGP	Prime Minister’s Employment Generation Programme
PMFBY	Pradhan Mantri Fasal Bima Yojana
PMKSY	Pradhan Mantri Krishi Sinchayee Yojana
PMU	Project Management Unit
PSU	Public Sector Undertaking
PV	Photovoltaic
QA	Quality Assurance
QC	Quality Control
QPF	Quantitative Precipitation Forecast
R&D	Research and Development
R&M	Renovation and Modernization
RAD	Rainfed Area Development
RCP	Representative Concentration Pathway
RD&GR	River Development & Ganga Rejuvenation

RE	Renewable Energy
REC	Renewable Energy Certificate
REDD	Reduced Emission from Deforestation and Degradation
REMCs	Renewable Energy Management Centres
RES	Renewable Energy Sources
RET	Renewable Energy Technology
RFA	Recorded Forest Area
RGI	Randolph Glacier Inventory
RPO	Renewable Purchase Obligation
S&L	Standards and Labelling
S&T	Scientific and Technological
SAC	Space Application Centre
SAPCC	State Action Plans for Climate Change
SARAT	Search and Rescue Aid Tool
SBM	Swachh Bharat Mission
SBTi	Science Based Targets initiative
SBTs	Science Based Targets
SCA	Snow Cover Area
SCM	Smart Cities Mission
SDGs	Sustainable Development Goals
SDRF	State Disaster Response Fund
SEB	State Electricity Board
SEC	Specific Energy Consumption
SECI	Solar Energy Corporation of India
SERC	State Electricity Regulatory Commission
SF_6	Sulphur Hexa-fluouride
SHC	Soil Health Card
SHOC	Strategic Health Operations Centre
SHW	Severe Heatwave
SIDHIEE	Simplified Digital Hands-on Information on Energy Efficiency
SLNP	Street Lighting National Programme
SNC	Second National Communication
SO_2	Sulfur Dioxide
SOC	Soil Organic Carbon
SOP	Standard Operating Procedure
SPCBs	State Pollution Control Boards
SPV	Special Purpose Vehicle
SPV	Solar Photo Voltaic
SSAP	State Specific Action Plan
STR	Satpura Tiger Reserve
T&D	Transmission and Distribution
TAC	Technical Advisory Committee
TARANG	Transmission App for Real-time Monitoring & Growth
TPES	Total Primary Energy Supply
TTE	Team of Technical Experts
UBGO	Upper Ganga Basin Organization
UDAY.	Ujwal DISCOM Assurance Yojana
UJALA	Unnat Jyoti by Affordable LEDs for All
ULB	Urban Local Body
UN	United Nations

UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNGC	UN Global Compact
UNIDO	United Nations Industrial Development Organization
UNISDR	United Nations International Strategy for Disaster Reduction
URJA	Urban Jyoti Abhiyaan
USD	United States Dollar
UTs	Union Territories
VDF	Very Dense Forest
VOC	Volatile Organic Compound
VSCS	Very Severe Cyclonic Storms
WHO	World Health Organization
WIM	Warsaw International Mechanism
WIPO	World Intellectual Property Organisation
WMO	World Meteorological Organisation
WRB	Wave Rider Buoy
WRI	World Resources Institute
WtE	Waste to Energy
ZED	Zero Defect Zero Effect

Units and Quantities

BCM	Billion Cubic Meter (equals 1 km^3)
C	Celsius
Gg	Giga gram
GW	Gigawatt
GWh	Giga Watt hour
ha	Hectare
km	kilometre
km^2	Square kilometre
km^3	Cubic kilometre
ktoe	kilo tonne of oil equivalent
kW	kilowatt
kWh	kilowatt hour
kWp	kilowatts peak
m	Million
m^3	Cubic meter
Ma^{-1}	Water equivalent per unit area per year
Mha	Million hectare
MJ	Mega Joule
Mt	Million tonne
$MtCO_2$	Million tonne of Carbon dioxide
$MtCO_2e$	Million tonne of Carbon dioxide equivalent
$MtCO_2eq$	Million tonne of Carbon dioxide equivalent
MW	Megawatt
$m.w.e.a^{-1}$	Mean water equivalent per annum
t	tonne
Tg	Teragram
TJ	Terajoule

toe	tonne of oil equivalent

Conversion Table

1 Gigagram (Gg)	= 1000 tonne
	= 10^9 g
1 Teragram (Tg)	= 1 Million tonne
	= 1000 Gg
	= 10^6 tonne = 10^{12} g
1 Terajoule (TJ)	= 10^3 GJ
	= 10^{12} Joules
1 Calorie	= 4.18 J
1 Lakh	= 100,000 = 10^5
1 Crore	= 10,000,000 = 10^7
1 Million	= 1,000,000 = 10^6
1 Billion	= 1,000,000,000 = 10^9
1 Trillion	= 1,000,000,000,000 = 10^{12}

ANNEXURE II- Institutional Arrangements

Composition of the National Steering Committee (NSC) for India's Third National Communication (TNC) and Biennial Update Reports (BUR) to the United Nations Framework Convention on Climate Change (UNFCCC)

Chairman

(i) Secretary, MoEFCC

Members

(ii) Special/ Additional Secretary (In-charge: Climate Change matters), MoEFCC
(iii) CEO, NITI Aayog or his representative
(iv) Secretary, Department of Agricultural Research and Education, Ministry of Agriculture and Farmers Welfare or his representative
(v) Secretary, Department of Agriculture Co-operation and Farmers Welfare, Ministry of Agriculture and Farmers Welfare or his representative
(vi) Secretary, Department of Economic Affairs, Ministry of Finance or his representative
(vii) Secretary, Ministry of New and Renewable Energy or his representative
(viii) Secretary, Department of Science & Technology or his representative
(ix) Secretary, Ministry of Coal or his representative
(x) Secretary, Ministry of Power or his representative
(xi) Chairman, Railway Board or his representative
(xii) Secretary, Ministry of Road Transport & Highways or his representative
(xiii) Secretary, Ministry of Shipping or his representative
(xiv) Secretary, Ministry of Petroleum & Natural Gas or his representative
(xv) Secretary, Department of Water Resources, River Development and Ganga Rejuvenation or his representative
(xvi) Secretary, Ministry of Health & Family Welfare or his representative
(xvii) Secretary, Ministry of Earth Sciences or his representative
(xviii) Secretary, Department of Rural Development or his representative
(xix) Secretary, Ministry of Housing and Urban Affairs or his representative
(xx) Secretary, Department of Industrial Policy & Promotion, Ministry of Commerce and Industry or his representative
(xxi) Secretary, Ministry of Steel or his representative
(xxii) Secretary, Ministry of Civil Aviation or his representative
(xxiii) Secretary, Ministry of Statistics and Programme Implementation or his representative
(xxiv) Director General, India Meteorological Department or his representative
(xxv) Joint Secretary (UNES), Ministry of External Affairs
(xxvi) Representative, United Nations Development Programme, India-Office, New Delhi
(xxvii) Joint Secretary (Climate Change), MoEFCC

Member Secretary

(xxviii) Advisor (Climate Change), MoEFCC

Composition of the Technical Advisory Committee for India's Third National Communication and Biennial Update Reports to the United Nations Framework Convention on Climate Change

Chairman

(i) Additional Secretary / Special Secretary (In-charge: Climate Change matters), MoEFCC

Members

(ii) Representative, Indian Space Research Organization
(iii) Advisor (Energy), NITI Aayog
(iv) Director General or representative, Indian Council of Agricultural Research
(v) Director General or representative, Forest Survey of India
(vi) Dr. Ajay Mathur, Director General, TERI
(vii) Prof. J. Srinivasan, Divecha Centre for Climate Change, IISc, Bengaluru
(viii) Prof. Chandra Venkatraman, IIT Bombay
(ix) Dr. K. Kavi Kumar, Madras School of Economics
(x) Dr. L.S. Rathore, Former Director General, India Meteorological Department
(xi) Dr. Kirit Parikh, Chairman, IRADe, New Delhi
(xii) Prof. T. Jayaraman, MS Swaminathan Research Foundation, Chennai
(xiii) Prof. Amit Garg, Indian Institute of Management, Ahmedabad
(xiv) Prof. Raman Sukumar, Indian Institute of Science, Bengaluru
(xv) Dr. Subodh Sharma, Former Adviser, MoEFCC
(xvi) Dr. Navroz Dubash, Centre for Policy Research, New Delhi
(xvii) Dr. Arvind Kumar, Chair, India Water Foundation, New Delhi
(xviii) Joint Secretary (Climate Change), MoEFCC

Member Secretary

(xix) Advisor (Climate Change), MoEFCC

Contributors to India's Third Biennial Update Report

Project Management Unit

National Project Director

Dr. J. R. Bhatt
Scientist 'G'/ Adviser
National Project Director, NATCOM
Ministry of Environment, Forest and Climate Change
Government of India,
Room number 326, 'Jal' Wing, Indira Paryavaran Bhavan
Jor Bagh Road, New Delhi
Telefax No.+91-11-24695293
E-mail: jrbhatt@nic.in

Programme Officers

Lokesh Chandra Dube
lokesh.dube@gov.in

Abhijit Basu
abhijit.basu31@govcontractor.in

Biba Jasmine Kaur
biba.kaur@nic.in

Sruthi Vinod
sruthi.vinod92@gov.in

Jaypalsinh Chauhan
chauhan.jaypalsinh@gmail.com

NATCOM Cell, 115, Pandit Deendayal Antyoday Bhawan, CGO Complex, New Delhi-110 003

Participating Institutions and Experts

Laboratories of the Council for Scientific and Industrial Research (CSIR)

Central Institute of Mining and Fuel Research (CIMFR)
Barwa Road, Dhanbad – 826001,
Phone: 91-326-2296023

Dr. Pinaki Sarkar
Dr. D Mohanty
Dr. Santi Gopal Sahu
Dr. Ashok K. Singh
Dr. Ashis Mukherjee
Dr. Manish Kumar
Dr. Pradeep K Singh

Indian Institute of Petroleum (IIP)
Mohkampur, Rajpur Road,
Dehradun- 248001
Phone: 91-135-2660203

Dr. Sunil Pathak
Dr. Iranna Gogeri
Dr. Pranab Das
Mr. Yograj Singh
Mr. Vineet Sood

National Environmental Engineering Research Institute (NEERI)
Nehru Marg, Nagpur - 440 020
Tel: 91-712-2249755

Dr. Atul Vaidya
Dr. Karthik M
Ms. K. V. V. K. Sravvya
Mr. Harish Barewar

Institutes of Indian Council of Agricultural Research (ICAR)

Central Research Institute of Dryland Agriculture (CRIDA)
Santoshnagar, Hyderabad - 500 059
Ph: 91-40-24530177

Dr. J.V.N.S. Prasad
Dr. K.V. Rao
Dr. DBV Ramana
Dr. C.A. Rama Rao
Dr. BMK Raju
Dr. G Venkatesh
Dr. V Girija Veni
Dr. Sumanta Kundu
Dr. B Ramakrishna

Indian Agricultural Research Institute (IARI)
Pusa Road, New Delhi 110 012
Tele: 91-11-25841490

Dr. Arti Bhatia
Dr. Niveta Jain
Dr Himanshu Pathak

National Dairy Research Institute (NDRI)
Karnal-132001
Ph.: 91-184-2259088

Dr. Madhu Mohini

Dr. S. S. Thakur
Dr. Goutam Mondal

Institutions of Ministry of Environment, Forest and Climate Change

Forest Survey of India (FSI)
Kaulagarh Road, PO-IPE, Deharadun-248194
Tel.: 91-135-2756139

Dr. Subhash Ashutosh
Mr. Prakash Lakhchaura

Indian Council of Forestry Research and Education (ICFRE)
PO- New Forest, Dehradun-248006
Phone: +91-135-2750296 (O)

Dr. R. S. Rawat
Dr. Gurveen Arora

Other Institutions

Confederation of Indian Industry (CII)
Thapar House, 2nd Floor, 124 Janpath,
New Delhi 110001 India
Phone: +91 11 41502307

Dr. Seema Arora
Mr. Kamal Sharma
Ms. Priyanka Yadav
Ms. Tanya Sinha
Mr. Varun Agarwal

National Remote Sensing Centre (NRSC)
CRF Colony, Balanagar, Hyderabad, Telangana
91-40-23884000

Dr. T R Kiran Chand
Dr. K Sreenivas
Dr. P V N Rao
Dr. C. S. Jha

Technology Information Forecasting and Assessment Council
'A' Wing, Vishwakarma Bhavan, Shaheed Jeet Singh Marg, New Delhi, Delhi 110016

Prof. Pradeep Srivastava
Dr. Gautam Goswami

Universities/ Educational institutions

Indian Institute of Management Ahmedabad (IIM A)
Vastrapur, Ahmedabad - 380015, India
Ph: 91 79 6632 4952

Prof. Amit Garg
Mr. Jaypalsinh Chauhan
Dr. Vidhee Avashia
Ms. Jyoti Maheshwari

Indian Institute of Science (IISc)
CV Raman Road,
Bangalore - 560 012
Phone: 91 - 80 - 2334 1838

Prof. N. H. Ravindranath
Dr. Indu K Murthy
Prof. G. Bala

Non-governmental research organizations

Council on Energy, Environment and Water (CEEW)
Sanskrit Bhawan, A-10,
Qutab Institutional Area, Aruna Asaf Ali Marg,
New Delhi - 110067, India
Tel: +91 11 40733300

Dr. Arunabha Ghosh
Dr. Vaibhav Chaturvedi
Mr. Sumit Prasad
Ms. Shanal Pradhan
Ms. Shikha Bhasin

The Energy and Resources Institute (TERI)
Habitat Place, Lodhi Road
New Delhi -110003
Tel: 91 11 24682100

Dr. Ritu Mathur
Ms. Monica Dutta

Iora Ecological Solutions
225 B, FF, Indraprastha Gyan Mandir Complex, Lado Sarai Village Complex, New Delhi 110030, Tel: +91-11-41077547

Dr. Sumana Bhattacharya
Ms. Shweta Pandey

MS Swaminathan Research Foundation
3rd Cross Street, Institutional Area, Taramani
Chennai 600 113, India

Prof. T. Jayaraman
Dr. Sreeja Jaiswal
Mr. Gaurav Gharde
Mr. Goutham Radhakrishnan

National Institute of Advanced Studies
Indian Institute of Science Campus
Bangalore 560 012, India

Dr. Tejal Kanitkar
Miss. Juhi Chatterjee

Individual expert contributors

Dr. Hardik Shah, Formerly PS to MoEFCC

Dr. Raman Sukumar, Professor, IISc, Begaluru

Dr. L S Rathod, Formerly DG, IMD

Dr. K J Ramesh, Formerly DG, IMD

Dr. P C Maithani, Adviser, MNRE

Dr. Anjan Ray, Diretor, CSIR-IIP, Dehranun

Dr. S D Attri, DDG, IMD

Shri Shivendra Mohan, ED, Railway Board

Shri Abhay Bakre, DG, BEE

Shri Ashok Kumar, Director, BEE

Ms. P. Bhanumati, DDG, MoSPI

Shri Krishna Kumar Tiwari, Deputy Director, MoSPI

Dr. Himangana Gupta, Formerly Programme Officer, NATCOM Cell

Dr. Nayanika Singh, Formerly Programme Officer, NATCOM Cell

Dr. Simi Thambi, Formerly Programme Officer, NATCOM Cell

Ms. Abha Tewary, Formerly Programme Officer, NATCOM Cell

Comments/ Inputs

Ministry of Environment, Forest and Climate Change, Government of India

Mr. Ravi Shankar Prasad, Additional Secretary, MoEFCC

Mr. Sanjay Kumar, DGF & SS, MoEFCC

Ms. Richa Sharma, Joint Secretary, MoEFCC

Ms. Anshu Singh, Statistical Adviser

Dr. Subrata Bose, Scientist F

Mr. Raghu Kumar Kodali, Scientist F

Dr. Amit Love, Scientist E

Mr. Shard Sapra, Scientist E

Mr. Ajay Raghava, Scientist D

External Reviewers

Ms. Aishwarya KS, SSEF

Dr. Ajay Mathur, TERI

Dr. Ajay Kumar Singh, CIMFR

Dr. Amit Kanaudia

Dr. Anshu Bharadwaj, SSEF

Ms. Apurba Mitra, WRI

Prof. Arshid Jehangir, UoK

Dr. Arvind Kumar, IWF

Prof. Ashok Bhatnagar, formerly University of Delhi

Dr. Ashwini Kulkarni, IITM

Dr. Asif Qureshi, IITH

Dr. Baerbel Sinha, IISER Mohali

Dr. Balakrishnan Nair T.M., INCOIS

Dr. Binoy Saikia, CSIR-NEIST

Prof. Bhaskar Sinha, IIFM

Mr. Chirag Gajjar, WRI

Dr. Damandeep Singh, CDP

Dr. Divya Shah, DAC&FW

Prof. G. S. Rawat, WII

Shri Gopal Iyengar, MoES

Dr. Himanshu Pathak, IARI

Dr. K. R. Shanmugam, MSE

Dr. M. Maheswari, CRIDA
Dr. M. Mohapatra, IMD
Dr. Manda Verma, DAC&FW
Dr. Naresh Kumar, BIT Mesra
Dr. Navroz Dubash, CPR
Dr. O. P. Sreejith, IMD
Dr. Pulak Guhathakurta, IMD
Dr. Purnamita Dasgupta, IEG
Mr. Pustav Joshi, SSEF
Shri Rabindra Kumar Jena, MoP
Shri Rajendra Kumar Jain, CWC
Dr. R. Krishnan, IITM
Dr. R. S. Maheshkumar, MoES
Dr. R. S. Rawal, GBPNIHE
Mr. Raghav Anand, SSEF
Prof. Rajiv Chaturvedi, BITS Goa
Prof. Ramya Sunder Raman, IISER Bhopal
Mr. Raman Mehta, Vasudha Foundation
Mr. Ruchir Shukla, SSEF
Dr. S. Naresh Kumar, IARI
Prof. Satish Chandra, CRRI
Ms. Saumya Chaturvedula, ICLEI
Mr. Shantanu Goel, Independent Consultant
Mr. Shubhashis Dey, SSEF
Prof. Sudhir Chella Rajan, IITM
Mrs. Sunitha Devi S., IMD
Prof. Tarun Gupta, IITK
Ms. Ulka Kelkar, WRI
Dr. Umamaheswaran, ISRO
Prof. Vimal Mishra, IITGN
Dr. V. K. Soni, IMD
Ms. Vaishali Sharma, SSEF
Mr. Vivek Chandran, SSEF
Mr. Vivek Sen, SSEF

Annexure-III
List of events /consultative meetings

- National Brainstorming Meeting on GHG Inventory at Godavari Conference Hall, Indira Paryavaran Bhawan, Jor Bagh Road, New Delhi on 21 February 2019.
- Meeting of the Technical Advisory Committee of National Communications at on 03 April 2019 at Indira Paryavaran Bhawan, New Delhi.
- Symposium on environmental and climate initiatives of Indian Railways at MoEFCC on 28 January 2020.
- Expert Group Meeting of LULUCF Sector Inventory at Satluj Hall, MoEFCC, Indira Paryavaran Bhawan, Jor Bagh Road, New Delhi on 07 February 2020.
- Meeting of the Inventory Experts on BUR-3 on 9 March 2020 at MoEFCC, Indira Paryavaran Bhawan, New Delhi.
- Virtual Meeting of the Technical Advisory Committee to India’s Third National Communication and BURs to the UNFCCC on 15 October 2020 at Indira Paryavaran Bhawan, New Delhi.
- A virtual meeting to review national GHG inventory for BUR-3 on 7 November 2020.
- Virtual meeting to the National Steering Committee to India’s Third National Communication and BURs to the UNFCCC on 11 November 2020.


INDIA