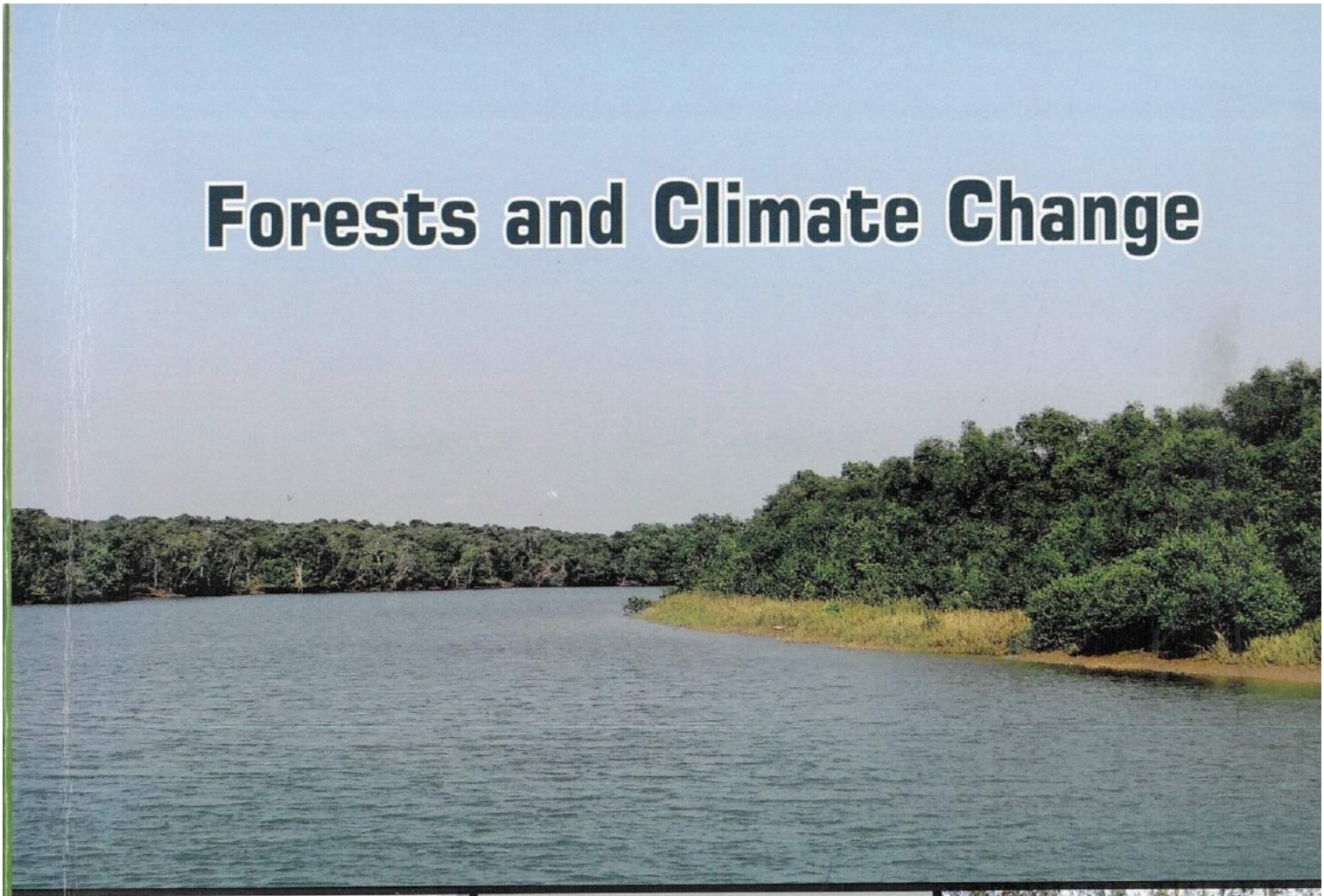
Forests and Climate Change



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Forests and Climate Change

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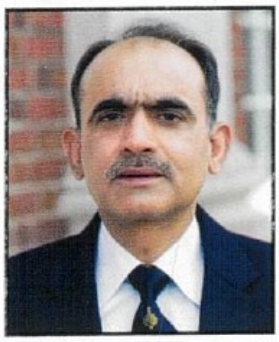
Foreword

Climate Change is one of the most serious global environmental challenges with implications on primary sectors such as agriculture, horticulture, fisheries, freshwater supply, health and natural ecosystems including forests. The fifth assessment report of the Intergovernmental Panel on Climate Change, released in 2013, states that "It is extremely likely that human activities caused more than half of the observed increase in global average surface temperature from 1951-2010". Historically, the responsibility for green house gas emissions' increase lies largely with the industrialized world, though the developing countries are likely to be the source of an increasing proportion of future emissions.

The second national communication submitted by India in 2012 indicates that 45.9% of forests of the country are likely to be adversely impacted by the changing climate. The adverse impacts could be increased incidence of fire and drought, further spread of invasive species and low natural regeneration. This is in addition to the well known fact that the forest ecosystems in India are already subjected to extreme socio-economic pressures such as diversion of forest land for development purposes, unsustainable removal of small timber, fuel wood, NTFP, and unregulated grazing resulting in forest degradation. Hence, projected impacts of Climate Change would be an additional pressure that can substantially affect the future availability of goods and services from forests which in turn, would have a profound impact on forest-dependent communities and their livelihoods.

In view of the seriousness of these issues, it is important for all forestry professionals to have an in-depth knowledge of Climate Change and its implications on forest sector. It is expected that the booklet on **"Forests and Climate Change"** covering the important aspects will go a long way in providing the requisite information to the field foresters. Realizing the need for capacity building of forestry officials in this new emerging field, the Academy has already initiated organizing of training modules for IFS (P) and in-service officers. I congratulate Dr. Mohit Gera, IFS, and his team for bringing out this booklet to be utilized in training programmes organized by the Academy to increase awareness on this new emerging field.

Shashi Kumar
Director, IGNFA



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Preface

Climate change is a huge challenge for a developing country like India that face large climate variability and is vulnerable to its profound impact on key sectors like agriculture, health, water and forestry. This is likely to significantly impact the economic growth and social development of the country, where eradication of poverty is the first and overriding priority.

From the perspective of climate change, forest ecosystems are unique, as they are the source as well as the sink for CO_2, which is the most abundant greenhouse gas in the atmosphere. According to one estimate, greenhouse gas emissions from the forestry sector constitute around 17% of the global greenhouse gas emissions. Deforestation, forest degradation, fragmentation and diversion of forestland for non-forest purposes are the main sources of CO_2 emissions and constitute the key issues in developing countries like India. On the other hand, forestry sector also provides significant opportunities to not only reduce emissions, but also to remove accumulated CO_2 from the atmosphere, and sequester it in vegetation and soil. Even after harvest, durable wood products continue to lock carbon for varying periods extending upto 70-100 years or beyond. Studies have indicated that forestry sector in the developing countries provides large and relatively low cost climate change mitigation opportunities. Besides, forestry mitigation projects implemented under mandatory and voluntary carbon markets incorporating technical, institutional and financial interventions could lead to large positive impact on sustainable management of country's forests.

Forestry officials and forest depending communities will have to play a key role in implementation of strategies on almost all aspects of forests and climate change interactions, which include mitigation and adaptation to the climate change. This necessitates capacity building of the forest officers and other stakeholders on the complex issues of likely impacts of climate change on forest ecosystems, appropriate adaptation strategies and formulation of mitigation projects acceptable in global carbon markets. As a step in this direction, an introductory reading material in the form of a booklet on **"Forests and Climate Change"** has been prepared with the latest information on almost all aspects of interface between forest ecosystems and changing climate. The Academy is organizing specific training programmes on forests and climate change issues and it is expected that this booklet would be instrumental in

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Acknowledgements

A "National Workshop cum Training Programme of National Stakeholders for creating awareness on Non-Legally Binding Instrument (Forest Instrument) on all types of forests" was organized by IGNFA with the financial support of Food and Agriculture Organization, Rome during 12-14 Dec, 2012. The main objective of the workshop was to create awareness and build capacity among the wide range of stakeholders within the country for effective reporting on progress in implementation of Non-legally binding instruments, which focus on Sustainable Management of Forests. As a step further to this objective, the second booklet on **"Forests and Climate Change"** is being brought out. The publishing of this booklet would not have been possible without active support and guidance of Dr. Shashi Kumar, Director, IGNFA. The encouragement provided by Sh. Vinod Kumar, former Director, IGNFA is also gratefully acknowledged. The authors also acknowledge the guidance received from Dr. Jagdish Kishwan, Chairman *'Apex Academic Committee on REDD-plus in relation to global warming and Climate Change'* during the various meetings of REDD-plus Cell of IGNFA.

Sh. Jiju J. S. and Ms. Sadhana Yadav, Academic Associates, REDD-plus Cell deserve a very special appreciation for their contribution on literature search, formatting and providing regular assistance in writing of the manuscript. Last but not the least, the assistance provided by Dr. Miru Srivastava and Sh. Sandeep Aswal in developing this booklet is thankfully acknowledged.

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Content

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Abbreviations

A&R	Afforestation and Reforestation
ANR	Assisted Natural Regeneration
AR5	Fifth Assessment Report
BAU	Business-as-Usual
C- stock	Carbon Stock
CAMPA	Compensatory Afforestation Fund Management and Planning Authority
CDM	Clean Development Mechanism
CERs	Certified Emission Reductions
CH_4	Methane
CMP	Meeting of the Parties
CO_2	Carbon Dioxide
COP	Conference of the Parties
DD	Deforestation and Degradation
DNA	Designated National Authority
DOE	Designated Operational Entity
EB	Executive Board of CDM
ET	Emission Trading
FAO	Food & Agriculture Organization
FCPF	Forest Carbon Partnership Facility
FCS	Forest Carbon Stocks
FSI	Forest Survey of India
FTC	Forest and Tree Cover
GHGs	Greenhouse Gases
GIM	Green India Mission
GIS	Geographic Information System
GoI	Government of India
H_2O	Water Vapour
HFCs	Hydrofluoro Carbons
ICFRE	Indian Council of Forestry Research and Education
IIRS	Indian Institute of Remote Sensing
IISc	Indian Institute of Science
INCCA	Indian Network for Climate Change Assessment
INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change

JFM	Joint Forest Management
JFMCs	Joint Forest Management Committees
JI	Joint Implementation
KP	Kyoto Protocol
lCER	Long Term Certified Emission Reductions
LDCs	Least Developed Countries
LULUCF	Land Use, Land-Use Change and Forestry
MAI	Mean Annual Increment
MODIS	Moderate-Resolution Imaging Spectroradiometer
MoEF&CC	Ministry of Environment, Forest and Climate Change
MRV	Measuring, Reporting and Verification
N_2O	Nitrous Oxide
NABARD	National Bank for Agriculture and Rural Development
NAP	National Afforestation Programme
NAPCC	National Action Plan on Climate Change
NATCOM	National Communication
NDC	Nationally Determined Contribution
NF_3	Nitrogen Triflouride
NFRL	National Forest Reference Level
NIE	National Implementation Entity
NPP	Net Primary Productivity
NRSC	National Remote Sensing Center
NTFPs	Non-Timber Forest Products
O_3	Ozone
OECD	Organization for Economic Co-operation and Development
PDD	Project Design Document
PFCs	Per Fluorocarbons
PPs	Project Participants
RCPs	Representative Concentration Pathways
REDD	Reducing Emissions from Deforestation and Forest Degradation
SAVI	Soil Adjusted Vegetation Index
SBI	Subsidiary Body for Implementation
SBSTA	Subsidiary Body for Scientific and Technological Advice
SF_6	Sulphur Hexafluoride
SFDs	State Forest Departments
SIS	Safeguard Information System
SMF	Sustainable Management of Forests
SOC	Soil Organic Carbon
tCER	Temporary Certified Emission Reductions
UNFCCC	United Nations Framework Convention on Climate Change
UN-REDD	United Nations-REDD
VCS	Voluntary Carbon Standards
WII	Wildlife Institute of India

Introduction

1.1 Global Warming and Climate Change

The climate of earth is determined by the incoming energy from the Sun, the outgoing energy radiated from Earth, and exchange of energy among the atmosphere, land, oceans, ice and living things. The Earth's atmosphere is divided into four layers i.e. Troposphere, Stratosphere, Mesosphere and Ionosphere. The entire climatic phenomenon takes place in these layers with most of it being regulated in the Troposphere. Earth is powered by solar radiation. Roughly one-third of this solar energy reaching the top of Earth's atmosphere is reflected back into space. The remaining two-thirds are absorbed by the surface and, to a lesser extent, by the atmosphere. To balance the absorbed incoming energy, the Earth radiates the same amount of energy back to space. Much of this thermal radiation emitted by land and ocean is absorbed by the atmosphere, including clouds and radiated back to earth by Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), Water Vapour (H_2O) and Ozone (O_3) collectively called 'Greenhouse Gases' (GHGs) and the phenomenon is called the 'Greenhouse Effect'. In the absence of this naturally occurring greenhouse effect, the average temperature at the Earth's surface would be 15°C colder and would not support life. Thus the natural greenhouse effect makes the life possible on earth.

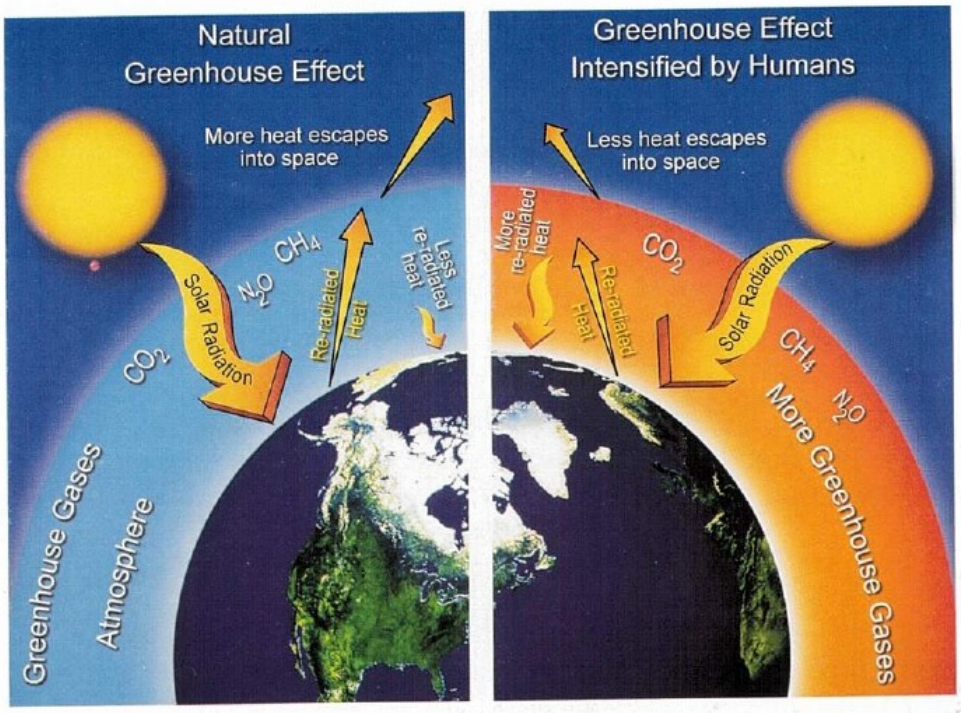

Figure: 1 Greenhouse Effect (Source: https://www.google.co.in)

After the industrial revolution which started in the middle of the eighteenth century, human activities, primarily the burning of fossil fuels and clearing of forests have greatly intensified the greenhouse effect. The concentration of most common GHGs, i.e., CO_2 has been increased since the beginning of the industrial revolution from 290 ppm to more than 400 ppm now, which is leading to unequivocal and continuous rise in global average temperatures. This continuous rise in the Earth's temperature is called 'Global Warming'. Available scientific studies have demonstrated that global warming has resulted in change of climate of the Earth.

Inter-governmental Panel on Climate Change (IPCC), defines Climate Change as *'any change in climate over time, whether due to natural variability or as a result of human activity'*. This definition differs from that of the United Nations Framework Convention on Climate Change (UNFCCC), which defines Climate Change as: *'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods'*. The fifth assessment report (AR5) of IPCC has confirmed that warming of the climate system is unequivocal, and since 1950s, many of the observed changes are unprecedented over decades to millennia. It is extremely likely that more than half of the observed increase in global average surface temperature from 1951 to 2010 was caused by anthropogenic factors leading to higher greenhouse gas concentrations. Each of the last three decades has been successively warmer at the Earth's surface than any preceding decade since 1850. In the Northern Hemisphere, 1983-2012 was likely the warmest 30-year period of the last 1400 years.

According to AR5 of IPCC, the global surface temperature has risen by almost 0.89°C over the period 1901-2012. The global mean sea level has risen by 0.19 m, over the same period.

Global surface temperature by the end of the 21st century is likely to be in the range of 1.5°C to 4.5°C, relative to the average of 1986-2005.

1.2 Projected Climate Change at Global Level

As per fifth assessment report of IPCC, the global surface temperatures have risen by almost 0.89°C over the period 1901-2012 and about 0.72°C over the period 1951-2012. The report has predicted that relative to the reference period of 1986-2005, the rise in global surface temperature by the end of the 21st century is likely to be in the range of 1.5°C to 4.5°C and in the range of 0.3°C to 0.7°C for the period 2016-2035. This would cause further warming and induce many changes in the global climate systems during this century and will very likely to be more severe than those observed during the last century (IPCC, 2013).

It is extremely likely (95-100% probability) that human activities have caused more than half of the observed increase in global average surface temperature from 1951 to 2010 **(AR5, IPCC, 2013)**.

The scenarios developed for assessment of future climate are called "Representative Concentration Pathways" (RCPs). AR5 describe four different 21st century pathways of GHG emissions and atmospheric concentrations, air pollutant emissions and land use. The RCPs have been developed using Integrated Assessment Models as input to a wide range of climate model simulations to project their consequences for the climate system. The RCPs represent the range of GHG emissions, which include a stringent mitigation scenario (RCP2.6), two intermediate

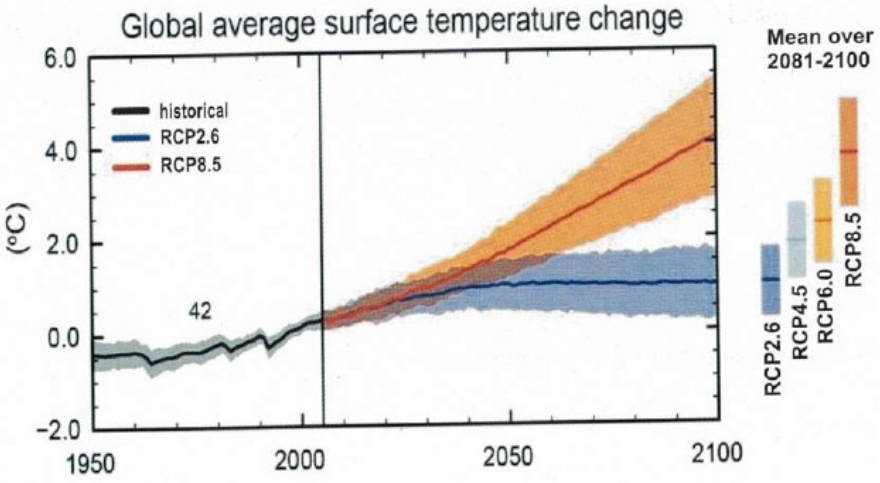

Figure: 2 Projected global average surface temperature change (Source: AR5, IPCC, 2013)

scenarios (RCP4.5 and RCP6.0), and one scenario with very high GHG emissions (RCP8.5). RCP2.6 is representative of a scenario that aims to keep global warming likely below 2°C above pre-industrial temperatures. Scenarios without additional efforts to constrain emissions ('baseline scenarios') lead to pathways ranging between RCP6.0 and RCP8.5 (AR5, IPCC, 2013).

The assessment report further states that the global mean sea level has risen by 0.19 m, over the period 1901-2010, based on tide gauge records and additionally on satellite data since 1993. The mean rate of sea level rise has been 1.7 mm per year between 1901 and 2010. Between 1993 and 2010, the rate has been higher at 3.2 mm per year. Further global mean sea level rise for 2081-2100 (relative to 1986-2005) is likely to be in the range of 0.26-0.97 m depending upon the extent of rise of GHGs (IPCC, 2013). The report further reveals that, it is very likely that there will be further shrinking and thinning of Arctic sea ice cover and decrease of northern high-latitude spring time snow cover as global mean surface temperature rises.

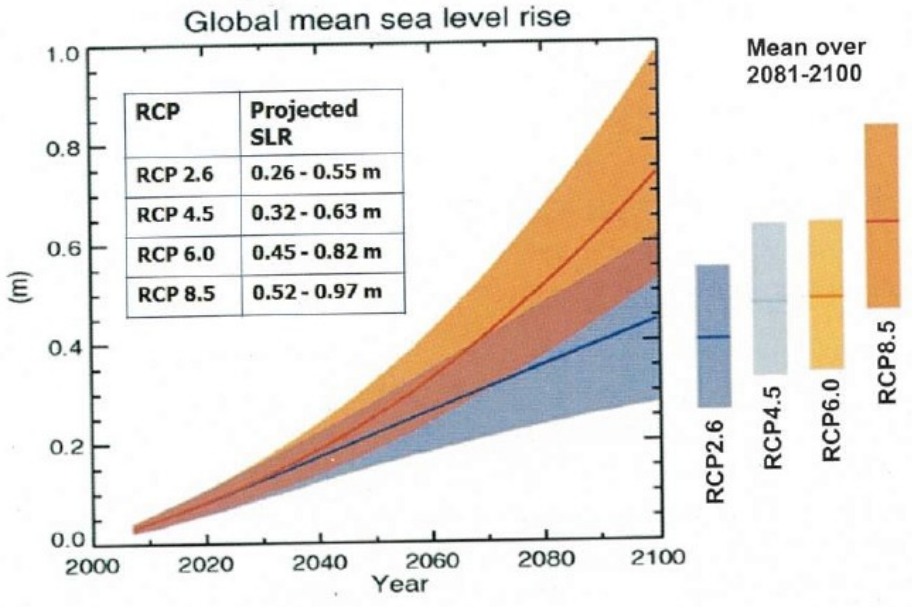

Figure: 3 Projected global mean sea level rise (Source: AR5, IPCC, 2013)

1.3 Likely Impacts of Climate Change at Global Level

Though all countries are affected by Climate Change, they are affected in different ways and to different extents in important sectors like water resources, agriculture, health, marine and terrestrial ecosystems.

1.3.1 Likely impact on water resources

According to fifth assessment report of IPCC, the fractions of the global population that will experience water scarcity and will be affected by major river floods are projected to increase with the level of warming in the 21st century. Climate Change is projected to reduce renewable surface water and groundwater resources in most dry subtropical regions. The frequency of droughts is likely to increase by the end of the 21st century in dry regions while water resources are projected to increase at high latitudes. The interaction of increased temperature; increased sediment, nutrient and pollutant loadings from heavy rainfall; increased concentrations of pollutants during droughts and disruption of treatment facilities during floods will reduce raw water quality and pose risks to drinking water quality.

According to fourth assessment report of IPCC, Climate Change is expected to intensify current stresses on water resources. On a regional scale, mountain snow packs, glaciers and small ice caps play a crucial role in freshwater availability. Widespread mass losses from glaciers and reductions in snow cover over recent decades are projected to accelerate throughout the 21st century resulting in decreasing water availability, hydropower potential, and changing seasonality of flows from major mountain ranges of the Hindu-Kush, the Himalayas and the Andes where more than one-sixth of the world's population currently lives. Changes in precipitation and temperature are projected to lead to changes in runoff and water availability. Runoff is projected with high confidence to increase by 10 to 40% by mid-century at higher latitudes and in some wet tropical areas, including populous areas in East and South-East Asia, and decrease by 10 to 30% over some dry regions at mid-latitudes and dry tropics, due to decrease in rainfall and higher rates of evapo-transpiration. Many semi-arid areas (e.g. the Mediterranean Basin, Western United States, Southern Africa and North-Eastern Brazil) are projected to suffer a decrease in water resources due to Climate Change. The impacts of Climate Change and climate variability on water resources are likely to cause severe droughts and flood problems in both urban and rural areas.

1.3.2 Likely impact on agriculture

According to fifth assessment report of IPCC, the annual GHG emissions from agricultural production in 2000-2010 were estimated at 5.0-5.8 $GtCO_2$ eq / yr. Greenhouse gas emissions from agriculture comprised about 10-12% of man-made GHG emissions in 2010. The sector is the largest contributor of non-carbon dioxide (non-CO_2) GHGs such as methane.

The fourth assessment report has also indicated that crop productivity is projected to increase slightly at mid- to high latitudes due to local mean temperature increases of up to 1 to 3°C depending on the crop, and then decrease with further rise of temperature beyond 3°C. At lower latitudes, especially in seasonally dry and tropical regions, crop productivity is projected to decrease for even small local temperature increases (1 to 2°C), which would increase the shortage of food and risk of hunger. Globally, the potential for food production is projected to increase with increase in local average temperature over a range of 1 to 3°C, but above this rise in temperature, it is projected to decrease.

In India, studies have shown that an increase of temperature from 1 to 4°C is likely to result in reduced grain yield of rice (0 to 49%), green gram (13 to 30%) and soybean (11 to 36%). The linear decrease of grain yield per °C of temperature increase was 14%, 8.8%, 7.3%, and 7.2% in rice, soybean, wheat, and green gram, respectively. The country also loses 1.8 million tonnes of milk production at present due to climatic stresses in different parts of the country. Global warming is projected to further adversely impact milk production by 1.6 million tonnes by 2020 and more than 15 million tonnes by 2050, as per studies conducted by scientific institutions. The studies have also highlighted that the higher milk producing crossbred cows and buffaloes will be more adversely affected than indigenous varieties (NATCOM II, 2012).

1.3.3 Likely impact on human health

According to IPCC fifth assessment report, the projected Climate Change will impact human health and is expected to lead to increase in ill-health in many regions and especially in developing countries with low income. Due to rise in temperature the risks of malnutrition in poor regions will increase, risks from vector-borne diseases are projected to generally increase with warming, due to the extension of the infection area and season, despite reductions in some areas that become too hot for disease vectors.

While assessing the impact of Climate Change on human health, the IPCC fourth assessment report shows that millions of people are projected to be affected by way of increase in malnutrition; diseases and injury due to extreme weather events; increased burden of diarrheal diseases; increased frequency of cardio-respiratory diseases due to higher concentrations of ground-level ozone in urban areas related to Climate Change; and the altered spatial distribution of some infectious diseases. However, Climate Change is projected to bring some benefits in temperate areas, such as fewer deaths from cold exposure, and some mixed effects such as changes in range and transmission potential of malaria in Africa. Overall, it is expected that benefits will be outweighed by the negative health effects of rising temperatures, especially in developing countries.

1.3.4 Likely impact on marine and terrestrial ecosystems

According to fifth assessment report of IPCC, a large fraction of terrestrial, freshwater and marine species faces increased extinction risk due to Climate Change. The extinction risk is increased relative to pre-industrial and present periods, under all RCP scenarios, as a result of both the magnitude and rate of Climate Change. Extinctions will be driven by several climate associated drivers like warming, sea-ice loss, variations in precipitation, reduced river flows, ocean acidification and lowered ocean oxygen levels and their interaction with simultaneous habitat modification, over-exploitation of stocks, pollution, eutrophication and invasive species.

Marine ecosystems, especially coral reefs and polar ecosystems are at risk due to ocean acidification, which has its impacts on physiology, behavior and population dynamics of organisms. Highly calcified molluscs, echinoderms and reef-building corals are some examples those which are vulnerable to increasing ocean temperatures. The AR5 also indicates that the progressive expansion of Oxygen Minimum Zones and anoxic 'dead zones' in the oceans is projected to further constrain the fish habitats.

It is expected that due to rise in temperature, the net carbon uptake by terrestrial ecosystems is likely to peak before mid-21st century and then weaken or even reverse if the current pace of land use, land use changes remains. Approximately 20 to 30% of plant and animal

species assessed so far are likely to be at increased risk of extinction if increases in global average temperature exceed 1.5 to 2.5°C (IPCC, 2007). For increases in global average temperature exceeding 1.5 to 2.5°C and in concomitant atmospheric CO_2 concentrations, major changes are projected in ecosystem structure and function, species' ecological interactions and shifts in species' geographical ranges. This is likely to result in predominantly negative consequences for biodiversity and flow of ecosystem goods and services.

1.4 Projected Climate Change at National Level

According to India's Second National Communication to UNFCCC, the likely rise in annual mean surface air temperature by the end of the century for the country is in the range of 3.5°C to 4.3°C. The prediction also depicts that there may not be significant decrease in the monsoon rainfall in the future except in some parts of the southern peninsula; instead of that it may rise and vary from 9% to 16% towards the end of the 21st century. Further, impact assessment of future climate on water recourses indicate that majority of river systems show an increase in precipitation at the basin level, except the Brahmaputra, Cauvery and Pennar, which show marginal decrease in precipitation. In a majority of river systems, the evapo-transpiration is expected to increase by more than 40%. Due to increased CO_2 fertilization, the Net Primary Productivity (NPP) tends to increase by an average of 30.3% by 2035 and by 56.2% by 2085; it is higher in the Northeastern part of the country due to warmer and wetter climate predicted there. A trend similar to NPP distribution is simulated for Soil Organic Carbon (SOC). In terms of agricultural crops, the productivity may rise but there will be a small reduction (2% to 10%) in protein content (NATCOM II, 2012).

Global Response to Climate Change

2.1 Introduction to UNFCCC

Expression of public concern over Climate Change issues began with the first world climate conference held in 1979. This led to the establishment of Intergovernmental Panel on Climate Change (IPCC) in 1988, which issued its first assessment report in 1990 and confirmed that threat of Climate Change was real. This gave rise to adoption of the United Nations Framework Convention on Climate Change (UNFCCC) on 9th May, 1992, which opened for signatures (ratification) during the Earth submit. The Convention came into force on 21st March, 1994 and with almost all countries as parties to the Convention till date, it has now become the most universally adopted Convention.

Evolution of UNFCCC (In chronological order)

First world Climate Conference	- 1979
Establishment of IPCC	- 1988
2nd Climate Conference and 1st assessment report of IPCC	- 1990
Adoption of UNFCCC	- 1992
UNFCCC enters into force	- 1994
COP begins	- 1995
Kyoto Protocol adopted	- 1997
KP ratified, CMP begins	- 2005
COP 21& CMP 11 meeting in Paris	- 2015
COP 22, CMP 12 and CMA1 meeting in Marrakech	- 2016

The ultimate decision-making body of the Convention is its Conference of the Parties (COP). It meets every year and reviews the implementation of the Convention, adopts decisions to further develop the Convention's rules, and negotiates substantive new commitments. There are two subsidiary bodies, which meet at least twice a year to carry out preparatory work for the COP: The Subsidiary Body for Scientific and Technological Advice (SBSTA) provides advice to the COP on matters of science, technology and methodology, including guidelines for improving standards of national communications and emission inventories and the Subsidiary Body for Implementation (SBI) helps to assess and review the Convention's implementation, for instance by analyzing national communications submitted by Parties. It also deals with financial and administrative matters (Fig. 4).

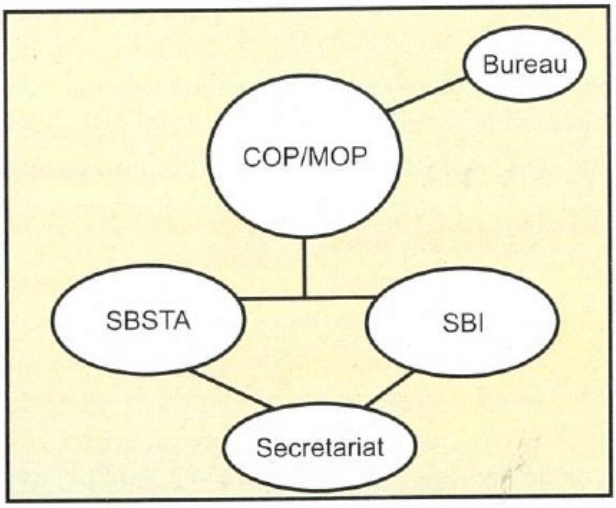

Figure: 4 Convention and support institutions (Source: IPCC, 2003)

A secretariat staffed by international civil servants supports all institutions involved in the Climate Change process and negotiation, particularly the Conference of the Parties (COP), the Conference of the Parties serving as the meeting of the Parties (CMP), the subsidiary bodies (which advise the

COP/CMP), and the COP/CMP Bureau, which deals mainly with procedural and organizational issues arising from the COP/CMP and also has technical functions.

2.1.1 The framework for action

The Convention sets an overall framework for intergovernmental efforts to tackle Climate Change. It establishes objectives and principles and spells out commitments for different groups of countries according to their circumstances and needs. It also provides a set of institutions to enable governments to monitor efforts to implement the Convention and to share insights on how best to pursue the Convention's aims.

2.1.2 Commitments

The Convention divides countries into three main groups according to differing commitments i.e. Annex-I, Annex-II and Non-Annex-I. The industrialized countries that were members of the OECD (Organization for Economic Co-operation and Development) in 1992 and the countries with economies in transition including the Russian Federation, the Baltic States, and several Central and Eastern European States are known as Annex-I Parties. Within the Annex-I Parties, the countries that were member of OECD are required to provide financial resources to enable developing countries to undertake emission reduction activities under the Convention and to help them adapt to adverse effects of Climate Change. These countries are known as Annex-II Parties. In addition, they have to "take all practicable steps" to promote the development and transfer of environmentally friendly technologies to developing countries.

The developing countries which are not part of Annex-I countries are known as Non-Annex-I Parties. Certain groups of developing countries are recognized by the Convention as being especially vulnerable to the adverse impacts of Climate Change, including countries with low-lying coastal areas and those prone to desertification and drought. Others, such as countries that rely heavily on income from fossil fuel production and commerce, feel more vulnerable to the potential economic impacts of Climate Change response measures. The Convention emphasizes activities that promise to answer the special needs and concerns of these vulnerable countries, such as investment, insurance and technology transfer. Among these Non-Annex-I countries, 48 countries classified as least developed countries (LDCs) are given special consideration under the Convention on account of their limited capacity to respond to Climate Change and adapt to its adverse effects.

All Parties to the Convention i.e., the countries that have ratified, accepted, approved, or acceded to it are subject to general commitments to respond to Climate Change. These countries agree to compile an inventory of their greenhouse gas emissions, and submit reports, known as national communications, on actions they are taking to implement the Convention.

2.1.3 Objectives and principles of UNFCCC

The main objective of the Convention is: *"To achieve stabilization of atmospheric concentrations of greenhouse gases at levels that would prevent dangerous anthropogenic interference with the climate system."* Defining what is meant by 'dangerous' involves social and economic considerations as well as scientific judgment. The Convention does, however, states that the level of concentrations should be reached in a time frame that allows

Principles of UNFCCC

i) Equity and Common but Differentiated Responsibilities
ii) A precautionary approach
iii) Development and Climate Change are interlinked

ecosystems to adapt naturally, food security to be preserved and economic development to proceed in a sustainable manner.

The Convention has laid down the following principles:

i) Equity and common but differentiated responsibilities

This principle which reflects the reality that, although Climate Change is a global issue and must be tackled as such, industrialized countries have historically contributed most to the problem and have more resources with which to remedy it. Developing countries, for their part, are more vulnerable to adverse effects and their capacity to respond is likely to be lower. This principle is the basis for division of countries as Annex-I and Non-Annex-I Parties. The principle of equity underlines the equal right of all human beings on global commons, i.e., the atmosphere.

ii) A precautionary approach

This principle provides recognition that though many uncertainties surround Climate Change, waiting for certainty before taking action, or precautionary measures, runs the risk of being too late to avert the worst impacts. The Convention notes that *"where there are threats of serious or irreversible damage; lack of full scientific certainty should not be taken as a reason for postponing such measures."*

iii) Development and Climate Change are interlinked

This principle recognizes that patterns of energy consumption, land use and demographic growth are key drivers of development and Climate Change. The Convention sees sustainable economic growth and development as essential ingredients of successful policies to tackle Climate Change. It also calls for policies and measures dealing with Climate Change to be cost effective and delivering global benefits at the lowest possible cost.

Greenhouse Gases recognized under UNFCCC

CO_2 -	Carbon dioxide
CH_4 -	Methane
N_2O -	Nitrous oxide
PFCs -	Perfluorocarbons
HFCs -	Hydrofluorocarbons
SF_6 -	Sulphur hexafluoride
NF_3 -	Nitrogen trifluoride (added in 2011)

2.2 Kyoto Protocol and CDM

After about three years of hectic negotiations, a substantial extension to the Convention that outlined legally binding commitments was adopted at the third meeting of Conference of the Parties (COP 3) held in December, 1997, known as the *Kyoto Protocol* (KP). As per KP, Annex-I Parties were assigned legally binding emission reduction targets that amount to an aggregate reduction shared among all such countries of at least 5.2% from 1990 levels by the years 2008-12, known as first commitment period. The individual emissions reduction targets for each country (Annex-I Party) are listed in Annex-B to the protocol. The KP was to enter into force, provided it was ratified by at least 55 parties to the Convention, including enough developed countries to encompass 55% of Annex-I CO_2 emissions of 1990 level. These conditions ensured that no single party to the Convention may block the entry into force of KP. The protocol was ratified with the signing of Russian Federation and came into force on 16th Feb, 2005.

Total CDM Projects - 7732
(Globally as on 31st July 2016)

China	- 3,764 (48.7%)
India	- 1,628 (21.1%)

The Kyoto Protocol supplements and strengthens the Convention. Only countries, which

acceded to the Convention, can become parties to the Protocol. The Protocol is founded on the same principles as the Convention and shares its ultimate objective, as well as the way it groups countries into Annex-I, Annex-II and Non-Annex-I Parties. It also shares the Convention's institutions, including its two Subsidiary Bodies and the Secretariat. The Conference of the Parties serves as the **'Meeting of the Parties'** to the Protocol (CMP). The IPCC supports the Protocol on scientific, technical and methodological matters as it does the Convention.

2.2.1 Clean development mechanism (CDM)

The Kyoto Protocol also provided three innovative mechanisms designed to boost the cost-effectiveness of Climate Change mitigation at global level by opening ways for the countries to cut emissions, or enhance carbon sinks, more cheaply abroad than at home. These mechanisms are Joint Implementation (JI), Emission Trading (ET) and Clean Development Mechanism (CDM). Out of the three mechanisms, only CDM is relevant to developing countries like India. The aim of CDM is that the industrialized countries would invest in 'clean' projects in developing countries and emission reduced or removals increased through such CDM projects would be credited to them. CDM has been able to generate significant investment in developing countries, especially from private sector to contribute towards objectives of UNFCCC, enhance the transfer of environment friendly technologies and promote sustainable development in general.

> Three innovative mechanisms of KP designed to deal with emission reduction targets:
> i) Joint Implementation (JI)
> ii) Emission Trading (ET)
> iii) Clean Development Mechanism (CDM)

i) CDM project activity cycle

Participants to the CDM project activity (PP) must prepare a project design document (PDD), including a description of the baseline and monitoring methodology to be used, an analysis of environmental impacts, comments received from local stakeholders and a description of new and additional environmental benefits that the project is intended to generate (Fig.5). An independent operational entity, also called 'designated operational entity' (DOE), will then review this document to ascertain the correctness of methodologies and procedures and, after providing an opportunity for public comments, decide whether or not to validate it. The DOE also requires a letter of approval from host country, which is given by country's Designated National Authority (DNA). In case of India there is National Clean Development Mechanism Authority chaired by the Secretary, Ministry of Environment, Forest and Climate Change. The process of approval takes around 2-3 months and there is no fee for seeking an approval. More information on the 'Host Country Approval' can be had from www.envfor.nic.in.

When a project is duly validated, the operational entity will forward it to the Executive Board of CDM for formal registration. Unless a participating party or three Executive Board members request a review of the project, its registration becomes final after eight weeks. Once a project is running, it will be monitored by the project participants. They will prepare a monitoring report, including an estimate of CERs generated by the project, and will submit it for verification by the DOE. To avoid conflict of interest, this will usually be a different DOE to that which validated the project. Validation and verification can be carried out by same DOE only in case of small scale CDM Projects. Following a detailed review of the project, which may include an onsite inspection, the DOE will produce a verification report and, if all is well, will then certify the emission reductions as real. Unless a participating party or three Executive Board

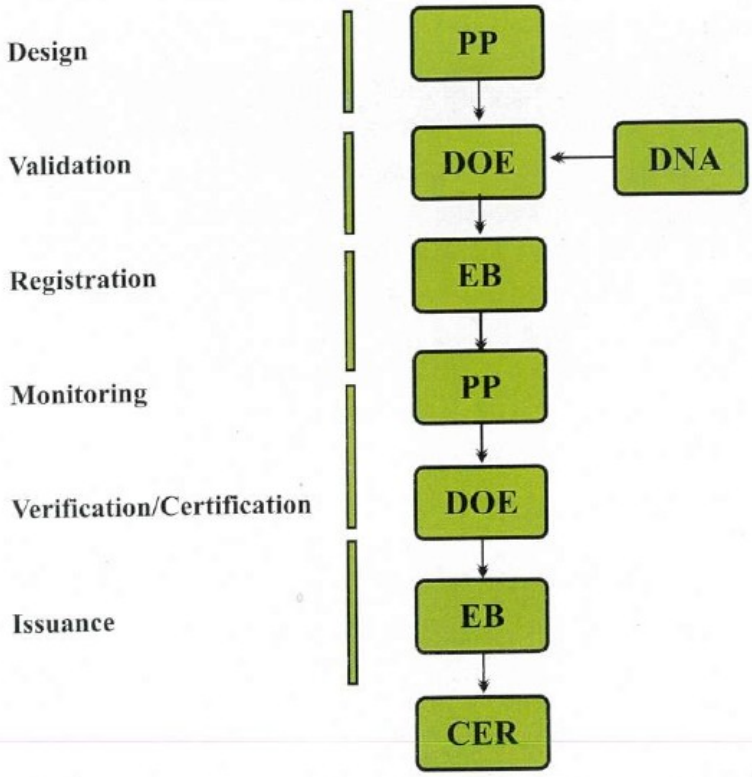

Figure: 5: CDM Project

members request a review within 15 days, the Board will issue the CERs and distribute them to project participants as requested (UNFCCC, 2003).

As on 31st July 2016 there are 7,732 projects registered under CDM at global level out of which 1,628 (21.1%) are from India. China has contributed maximum projects (3,764) which are 48.7% of CDM projects registered globally. However, only 66 projects have been registered so far from forest sector at global level which constitutes 0.85% of the total projects (UNFCCC, 2016). This includes 19 forestry projects from India, which is 28.8% of forestry projects registered so far. In the overall CDM basket, the number of projects from forest sector is quite low due to several challenges being faced by the sector.

2.3 Second Commitment period of Kyoto Protocol (2013-2020)

During the first commitment period, 42 developed countries (Annex-I countries) were assigned legally binding GHG emission reduction to an average of 5.2 % of 1990 levels. During the second commitment period, developed country parties are committed to reduce GHG emissions by at least 18% below 1990 levels in the eight-year period from 2013 to 2020. In this period, Annex-I countries may also choose to account for GHG removals by sinks resulting from 'forest management' besides afforestation and reforestation. However, forest management project activities undertaken under CDM projects shall not exceed 3.5% of the base year GHG emissions excluding LULUCF. While accounting for forest management, Annex-I countries shall demonstrate methodological consistency between the reference level and reporting including in the area accounted for, in the treatment of harvested wood products (Doha Amendment, 2012).

2.4 Paris Climate Agreement

The process of negotiation for post-2020 Climate Change regime was initiated during Cancun Agreement (COP 16) in December 2010, which led to the formation of Ad Hoc Working Group on Long-term Cooperative Action under the Convention. In COP 16 the Green Climate Fund, Technology Mechanism and Cancun Adaptation Framework were also established. In the Climate Change talks in Durban (COP 17), governments committed to a new universal Climate Change agreement by 2015 for the period beyond 2020, leading to the launch of a new subsidiary body called Ad Hoc Working Group on the Durban Platform for Enhanced Action (ADP). The COP 17 also launched a work plan on enhancing mitigation ambition to identify and to explore options for a range of actions that can close the ambition gap with a view to ensuring the highest possible mitigation efforts by all Parties.

During COP 18, 2012 in Doha, governments agreed to speedily work towards a universal Climate Change agreement by 2015 and to find ways to scale up efforts before 2020 beyond existing pledges to curb emissions. They also adopt the 'Doha Amendment', launching a second commitment period of the Kyoto Protocol. The 19th COP held in Warsaw 2013, came out with a rulebook on REDD-plus and a mechanism to address loss and damage caused by long-term Climate Change impacts.

The 20th COP held in Lima, in December 2014 concluded the talks with 'Lima Call for Climate Action' that laid the foundation for a new global climate deal. All the countries agreed to submit their Intended Nationally Determined Contributions (INDCs) by March 2015 and a significant progress on adaptation was made with newly launched Green Climate Fund (GCF) crossing an initial $10 billion target.

The 21st COP held in Paris, in December 2015 reaffirmed the goal of limiting global temperature increase well below 2°C, while urging efforts to limit the increase to 1.5°C. It called for all parties to establish binding commitments to make 'Nationally Determined Contributions' (NDCs), and to pursue domestic measures aimed at achieving them. Further, it was decided that each country shall prepare, communicate and maintain successive NDCs every five years with the clear expectation that they will represent a progression beyond the previous ones.

Paris agreement also recognized the implementation of policy approaches and positive incentives for reducing emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks. It further recognized joint mitigation and adaptation approaches for sustainable management of forests while reaffirming the importance of non-carbon benefits. It also recognized adequate and predictable financial resources from public, private, bilateral and multilateral sources such as GCF.

2.5 Ratification of Paris Agreement

As mentioned above, the Parties to the UNFCCC adopted the Paris Agreement at the twenty-first session of the Conference of the Parties held in Paris, in December 2015. The Paris Agreement shall enter into force when at least 55 Parties to the Convention accounting in total for at least an estimated 55% of the total global greenhouse gas emissions have deposited their instruments of ratification, acceptance, approval or accession with the depositary. The Paris Agreement was opened for signature on 22nd April 2016 at a high-level signature ceremony

convened by the Secretary General in New York. At that ceremony, 174 Parties to the Convention signed the agreement and 15 Parties also deposited their instruments of ratification.

Currently, there are 191 signatories to the Paris Agreement. Of these, as on 7th October 2016, 74 Parties to the Convention including India have deposited their instruments of ratification, acceptance or approval accounting in for 58.82% of the total global greenhouse gas emissions, hence fulfilling the requirement for ratification. The agreement will now enter into force on 4th November, 2016. Consequently, the first session of the Conference of the Parties serving as the Meeting of the Parties to the Paris Agreement (CMA1) will take place in Marrakech in conjunction with COP 22 and CMP 12.

2.6 UN Climate Conference of 2016

COP 22 of UNFCCC held in Marrakech, Morocco accelerated global climate action across a broad range of areas as it fast-tracked the political and practical aims of the historic Paris Climate Change Agreement. The Conference outcomes included multi-billion and multi-million dollar packages of support for clean technologies; building capacity to report on climate action plans, and initiatives for boosting water and food security in developing countries. Another important outcome had been the setting of a deadline of 2018 to complete the rule book for operationalizing the Paris Agreement to ensure confidence, cooperation and its success over the years and decades to come.

This has been a COP of action that has accelerated progress under the Paris Agreement across finance, new initiatives, ambition and solidarity between nations and across continents which is evident from **Marrakech Action Proclamation for our Climate and Sustainable Development.** Nations reaffirmed that the Paris agreement is in their national interests and a key catalyst to a better, more prosperous future for their citizens. The conference ended with announcement of Fiji as the incoming President of the 2017 UN climate conference (COP 23) which will be hosted by the UNFCCC in Bonn.

Forests and Climate Change

3.1 Forest Sector and Climate Change

At global level, forest sector is one of the important sources of CO_2 emissions which accounts for 1.6 ± 0.8 GtC annually. This constitutes around 20% of the global CO_2 emissions (Ravindranath and Murthy, 2003). During 2000-2010, around 13 million ha of forest land has been deforested annually, which has contributed highly in addition of CO_2 to the atmosphere (FAO, 2010). Deforestation, forest degradation, fragmentation and diversion of forest land for non forest purposes are the main sources of CO_2 emissions and also the key issues in developing countries. In forest ecosystems, CO_2 is retained in live biomass and in decomposing organic matter and soil too plays an important role in the global carbon cycle. Carbon is exchanged naturally between these systems and the atmosphere through photosynthesis, respiration, decomposition, and combustion. Human activities such as land-use change, deforestation and burning of wood lead to release of CO_2 in atmosphere.

Forestry sector also offers large CO_2 mitigation opportunities for removal of accumulated CO_2 in the atmosphere and sequester it in vegetation and soil (Sharma *et al.*, 2003). Durable wood products also continue to lock carbon for varying periods extending upto 70-100 years or beyond. During photosynthesis, trees and vegetation absorb CO_2 from the air and emit oxygen. Humans can also add to this carbon sink through efforts such as afforestation and reforestation. The removal of CO_2 from the atmosphere can be achieved at comparatively lower costs in the forestry sector when compared with other sectors such as energy, chemical industry, transport, agriculture and waste management. Moreover, the costs are likely to be still lower when sequestration activities take place in developing countries like India.

3.2 Ecological Services from Forests Ecosystems

Forest cover is one of the most prominent features of the global landscapes covering about 30 per cent of its geographical area. These forests, spread over different physiographic zones, are integral to environment, economy, culture and history of the different countries. In addition to well-known tangible benefits such as timber, fuelwood, fodder, fibre, grasses and other NTFPs, forests also provide intangible services such as hydrological services, preventing land degradation, ecotourism, biodiversity conservation and carbon sequestration, to name a few.

These benefits can be divided into three types *viz.*, direct use, indirect use, and non-use benefits. Direct use benefits include consumptive benefits such as timber and non-timber forest products production and non-consumptive benefits such as forest recreation, education, research, and habitat for floral and faunal species. Indirect use benefits which are considered intangible in nature include ecological functions of forests such as watershed benefits leading to enhancement of agricultural productivity; soil conservation and recharging of ground water; ecosystem services such as nitrogen fixing, carbon storage and sequestration, waste assimilation

and certain micro-climatic functions; and evolutionary processes, i.e., forests provide global life support and are storehouses of biodiversity. Forests, including tree plantations, provide an important ecosystem service which is as a carbon sink when forests are preserved even if they may not be having a higher incremental growth. Likewise, tree plantations sequester carbon in the form of higher incremental growth. Thus, forest sector provides these ecosystem services of carbon sink and sequestration which play a very important role in Climate Change mitigation.

Finally, the non-use benefits which are purely intangible in nature occur from mere existence of forests are the existence and bequest values. The existence values are the ones that people attach to the continued existence of certain species of wildlife such as tiger or a biodiversity hot-spot and wish to see such species or forests preserved in their own right. The bequest values arise from the willingness of the people leading to the conservation of forestry resources for posterity. The total economic benefit of a forest ecosystem, thus, refers to the sum of direct, indirect and non-use benefits.

3.3 Likely Impacts of Climate Change on Forests of India

Only a few studies are available, which address the likely impact of climate change on forests of India. The study by Ravindranath *et al.* 2006 on analysis of the 35,190 forested grids at national level reports that more than two third forested grids are likely to undergo vegetation change by the year 2100. Almost all major forest types of India, *viz.,* Deodar, Fir-Spruce, Sal, Chir-pine, Fir, Blue pine, Mixed Conifers, Western Ghat semi-evergreen forests, Western Ghat evergreen forests, Mangroves, Khair-Sissoo forests, scrubs, miscellaneous forests, Up-land Hardwoods, Teak, Bamboo forests, Khasi pine and Dipterocarps species are likely to be impacted by the projected Climate Change. The study further states that the actual impacts may be more as different species respond differently to the changing climate. A few endemic species may show a steep decline in population and may even get extinct. These impacts are expected to have adverse socio-economic implications for the forest-dependent communities and the economy of the country. Moreover the impacts of Climate Change on forest ecosystems are likely to be long-term and irreversible. The study further reports that the average net primary productivity (NPP) is projected to increase by 1.5 times for tropical evergreen forests but the rate of increase is expected to be lower for temperate deciduous, cool conifer and cold mixed forests.

The climate modeling for likely impacts of Climate Change on natural ecosystems and biodiversity in Himalayan region by Indian Network for Climate Change Assessment has shown that out of the 98 vegetation grids covering the Himalayan region, 56% of the grids are projected to undergo change in vegetation by 2030s indicating that more than half of the vegetation and biodiversity is vulnerable to the impacts of changing climate. The Net Primary Productivity is, however, projected to increase in the region by about 57% on an average by the 2030s, as compared to the baseline (INCCA, 2010).

Another recent study has also reported that a significant part of the Himalayan biodiversity hotpots that stretches along the north-western part of India along the States of Jammu & Kashmir and Himachal Pradesh are highly vulnerable to the likely impacts of changing climate (Gopalkrishnan *et al.* 2011). The study has shown that low tree density and biodiversity status as well as higher levels of fragmentation contribute to the vulnerability of forests. The mountainous forests of north-western Himalayan region are susceptible to the adverse impacts of Climate Change as likely Climate Change is predicted to be larger for regions with greater elevations.

According to India's Second National Communication to UNFCC, the climate modeling for likely impacts of Climate Change on natural ecosystems and biodiversity in India has shown that out of 1064 vegetation grids, 326 (30.6%) grids are projected to be vulnerable as per A1B SRES IPCC scenario by the year 2035 and 489 (45.9%) grids are projected to be vulnerable by the year 2085. This is in line with other studies and demonstrates the vulnerability of India's forests to the changing climate. The Net Primary Productivity as reported by other studies as well, is to increase in India by an average of 30.3% by 2035 and by 56.2% by 2085 under A1B scenario (MoEF, 2012).

According to the IPCC, roughly 20-30% of vascular plants on the planet are estimated to be at an increasingly high risk of extinction as temperatures increase by 2-3°C above pre-industrial levels (Fischlin *et al.*, 2009). Even small changes in climate could affect phenological events such as flowering and fruiting that may escalate into major impacts on forest biodiversity. This is because co-evolution has produced highly specialized interactions among specific plant and animal species in natural forests. Overall, it is very likely that even modest losses in biodiversity would cause consequential changes in the ecosystem services that forests provide. Climate Change affects forest ecosystems in their structure and morphology, thus causing an impact on their functionality. Vulnerability analysis of forest ecosystems in the national communications demonstrates that Climate Change can significantly affect the availability of forest goods and services in terms of quality and quantity (MoEF, 2012).

3.4 Mitigation Potential of Forest Sector under CDM

The types of forestry activities *viz.*, afforestation and reforestation eligible under CDM include planting of wastelands, agroforestry, farm forestry, planting of orchards and other plantation activities. There is enough evidence to show that individuals and communities can use tree plantations sustainably to support livelihoods besides carrying out agricultural and horticultural production. The carbon benefits associated with such plantations could be additional returns to the growers. The available reports on the amount of carbon stored and likely carbon benefits for different plantation models is given in Table 1 (Gera *et al.*, 2006; Gera *et al.*, 2011a; 2011b). It is evident that the tree plantation models, *viz.*, tree species of commercial importance; horticulture tree species; tree species of medicinal importance, and tree species of long rotation show a wide range of sequestration potential, which varies from 0.19 tC/ha/yr in case of Plum block plantation to 4.81 tC/ha/yr for Pine block plantation. The sequestration potential depends on the mean annual increment (MAI) of wood growth, i.e., above and below ground, in terms of t/ha/yr. Though, woody litter and soil organic carbon also have been taken into account for these calculations, their contributions have been observed to be small and rather negligible in certain cases as compared to wood growth. In general, the higher the MAI, higher will be the sequestration potential, provided there is no harvest during the mitigation project period. In case of harvest during the project period, the carbon pools get adversely impacted due to IPCC default approach (IPCC, 2003), which says that the moment trees are harvested, the equivalent CO_2 is deemed to have been emitted in to the atmosphere.

The sequestration potential as reported for fast growing tree species, varies from 1.42 tC/ha/yr in case of Poplar bund plantation to 2.54 tC/ha/yr for Poplar block, whereas, Eucalyptus bund plantation is reported to have recorded a sequestration potential of 1.62 tC/ha/yr. The reason for comparatively lower sequestration potential recorded for these seemingly fast growing tree species is attributed to their shorter rotations leading to loss of carbon on every

harvest carried out during the period of analysis. For example, Poplar is grown with a rotation of six years, which is supposed to be harvested five times during the CDM project period of analysis, which was taken as 30 years. The sequestration potential reported for horticulture species is quite small except for Mango, which is 1.15 tC/ha/yr. The development of carbon sequestration projects squarely involving these species may not be feasible because of low productivity of these plantations resulting in lower rates of carbon sequestration.

The sequestration potential reported for tree species of medicinal importance varied in the range of 0.90 tC/ha/yr for Amla block plantation to 2.93 tC/ha/yr for Bahera bund plantation, whereas, Harar and Reetha showed a sequestration potential of 2.30 and 2.60 tC/ha/yr, respectively. The reason for significantly higher potential from seemingly slow growing NTFP species may be attributed to comparatively longer rotations (30-50 yrs) and no harvest during the project period.

Interestingly, the block plantation interventions dedicated for long rotation crops on forest lands, *viz.*, Oak-Pine-mix, Mixed species and Pine, recorded higher sequestration potential in the range of 3.69 tC/ha/yr for Oak-Pine-Mix block to 4.81 tC/ha/yr for Pine block plantation, whereas, the Mixed species plantation showed a sequestration potential of 3.99 tC/ha/yr. The higher sequestration potential is attributed to long rotation of the selected interventions coupled with no wood harvest, during the project period. Ravindranath *et al.* (2007) gave a sequestration potential for long rotation crops under Indian scenario in the range of 5.0- 5.97 tC/ha/yr, which is comparable with the estimations as shown in Table 1. Similarly, Makundi and Sathaye (2004) reported a sequestration potential of 3.27 and 4.8 tC/ha/yr, respectively for long rotation plantations and temperate forest management under a scenario where crops are not harvested during the analysis period.

As already stated, the carbon benefits on account of sequestration directly depend on the sequestration rate per unit area per unit time. These benefits have been calculated at the carbon price of $\$5/tCO_2$. The carbon benefits as estimated for plantation interventions involving horticulture species have been observed to be small and vary from Rs. 204/ha/yr for Plum to Rs. 1263/ha/yr for Mango block plantation. This is obviously due to very slow woody growth of the horticulture crops coupled with regular hedging of plants for new branches. Among the interventions involving long rotation crops, Pine block showed the maximum carbon benefits of Rs.5295/ha/yr on account of its moderate growth but long rotation and no harvest during the analysis period. Other similar interventions, *viz.*, Mixed species and Oak-Pine block also recorded comparable higher benefits of Rs.4395/ha/yr and Rs.4059/ha/yr, respectively. The likely carbon benefits for the plantation interventions involving tree species of medicinal importance, *viz.*, Bahera (*Terminalia bellerica*) Harar (*Terminalia chebula*) and Reetha (*Sapindus mukorossi*) are also significant and range between Rs. 990/ha/yr for Amla (*Emblica officinalis*) block to Rs 3225/ha/yr for Bahera (*Terminalia bellerica*) bund.

The fast growing tree species in the present study, however, have registered higher sequestration potential when the harvested wood products are also included in the sequestered carbon pools. The species, which are harvested earlier, like Poplar, start giving wood products immediately after harvest and the carbon pool, because of wood products, starts growing with every harvest and adds to the total carbon sequestered pool. Therefore, Poplar has recorded maximum increase with wood products as compared to the sequestration levels without wood products. Accordingly, the carbon benefits are significantly higher for Poplar block plantation if wood products are also included in estimation of sequestration levels. These studies have

demonstrated that tree plantations, particularly for long rotation, have substantial potential to remove the accumulated CO_2 from atmosphere and sequester it in vegetation, soil and also keep it locked in durable wood products. The monetary benefit on account of this ecosystem service has the potential to supplement the income of growers.

3.5 Managing Forests for Mitigation of Climate Change

Forests and trees are important carbon sinks. They absorb carbon dioxide from the atmosphere and store it as carbon. Carbon sequestration by forests has attracted much interest as a mitigation approach, as it has been considered a relatively inexpensive means of addressing Climate Change immediately. Increasing forest area and density through afforestation, reforestation and forest restoration results in increased absorption of carbon dioxide from the atmosphere. Once the trees are harvested, new trees can grow in their place and continue to sequester carbon. Planted forests today cover around 264 million hectares and absorb an estimated 1.5 gigatonnes of carbon from the atmosphere each year (FAO, 2010).

Trees outside forests include agro-forestry systems on farm lands, trees in the rural landscape, along roads, rivers, canal banks, railway lines and trees in and around cities. While contributing to environmental sustainability, they also provide income and a range of goods and ecosystem services for rural households, thus contributing to food security and poverty eradication. Throughout the world, trees outside forests help mitigate climate change by storing carbon, halting land degradation, providing fuel to substitute fossil fuels and fixing nitrogen to reduce the use of fertilizers. Trees in agricultural landscapes represent a globally important carbon stock, almost half of the world's agricultural land has at least 10 percent tree cover. The contribution of trees outside forests to climate change mitigation can be increased by promoting agro-forestry systems and urban forestry.

Forest management activities that conserve carbon stocks in forests include sustainable management of forests, prevention and control of forest fires, prevention and control of invasive species, management of forest health and vitality, management and extension of Protected Areas, especially the wildlife corridors, and conservation of biodiversity.

Forestry CDM Project Experience

4.1 CDM Forestry Projects

Under the CDM, forestry projects come under LULUCF, i.e., land use, land use change and forestry. The terms like forest, afforestation and reforestation are defined in the CDM text as: *"Forest is a minimum area of land of 0.05-1.0 ha with tree crown cover (or equivalent stocking level) of more than 10-30% with trees with the potential to reach a minimum height of 2- 5 meters at maturity in-situ".*

Thresholds for definition of 'Forest' for CDM projects

i) Minimum area of land: 0.05-1.0 ha
ii) Tree crown cover: 10-30%
iii) Minimum height on maturity: 2- 5 m

Each developing country was supposed to submit its own definition giving a value for minimum area, tree crown cover and minimum tree height within the range provided in the definition. India has defined forest as an area of minimum 0.05 ha with a crown cover of more than 15% and minimum height of 2 metre. Therefore, the definition of forest accepted by India is *"Forest is a minimum area of land of 0.05 ha with tree crown cover (or equivalent stocking level) of more than 15% with trees with the potential to reach a minimum height of 2 metre at maturity in-situ".* This definition accepted and communicated by India requires that any land devoid of adequate tree cover, say agriculture, wasteland or forest will have to be either afforested or reforested on a minimum area of 500 m^2 with such trees which have a potential to reach a minimum height of 2 meter at maturity and so densely planted that the crown cover reaches from less than 15% before planting to more than 15% during the CDM project activity.

India's definition of 'Forest' for CDM forestry projects

i) Minimum area of land: 0.05ha
ii) Tree crown cover: more than 15%
iii) Minimum tree height: 2 meter

The CDM text defines *afforestation* as *'The direct human-induced conversion of land that has not been forested for a period of at least 50 years to forested land through planting, seeding and/or the human-induced promotion of natural seed sources'.* Afforestation is relevant to agriculture, wastelands and other fallow lands which can be taken up for CDM A&R projects. On the other hand reforestation *is 'The direct human-induced conversion of non-forested land through planting, seeding and/or the human-induced promotion of natural seed sources, on land that was forested but that has been converted to non-forested land'.* For the first commitment period, reforestation activities were limited to reforestation occurring on those lands that were not classified as forests as per CDM definition as on 31.12.1989 and continue to be not a forest since that until the CDM project activity.

4.2 Small Scale CDM Forestry Projects

In order to facilitate the involvement of poor communities living around forests and encourage CDM forestry projects, there is a provision for small scale forestry projects which are

required to meet simpler modalities and procedures and can be developed and processed with much lower costs. Small scale project activities under CDM are those activities that are expected to result in net anthropogenic GHG removals by sinks of less than 16 kilo tonnes of CO_2 annually and are developed or implemented by low-income communities and individuals. These small scale projects have been provided with some relaxations such as reduced requirements of PDD; simplified baseline methodologies are in place; bundling of projects allowed for PDD; same DOE may undertake validation, verification and certification; and monitoring plans are simpler. Leakage assessment is also simplified for these projects.

4.3 Important Issues in CDM Forestry Project Development

There are a number of issues which must be addressed while formulating a forestry CDM project. The important among these are Development of baseline, Non-permanence, Additionality and Leakage assessment.

4.3.1 Development of baseline

The baseline is the scenario that reasonably represents the anthropogenic emissions by sources of GHGs that would occur in absence of proposed CDM project activity. A clear and verifiable baseline scenario giving C-stock changes in 'without project' situation needs to be presented using approved methodologies. The baseline is a status of carbon pools in the absence of project, which could be static or dynamic depending upon the situation. To date 11 approved methodologies exist for large scale and 7 for small scale forestry projects.

4.3.2 Non-permanence

This is concerned with the durability of C-stocks in forestry CDM projects. Non-permanence is a serious issue due to a possibility of reversibility in C-stocks due to anthropogenic or environmental changes. The issue of non-permanence is addressed for LULUCF project activities by accounting for emission reductions as temporary CER (tCER) or long term CER (lCER). A tCER expires at the end of the commitment period following the one during which it is issued which can be taken as five years, while an lCER expires at the end of the crediting period (20 or 30) for which it was issued (UNFCCC, 2004). Both tCERs and lCERs are likely to command lower prices compared to the permanent CERs because on expiry of non-permanent CERs, the buyer will have to arrange for the replacement of these CERs with permanent CERs.

4.3.3 Additionality

This requires that C-stocks accrued to a C-sequestration project are "additional" to those that would occur in the absence of the project. One may argue that agroforestry plantations with good financial returns are a well recognized "business as usual" practice and cannot be treated as additional. However, enabling conditions for a successful agroforestry project may not exist in most of the areas and a project that facilitates such conditions can qualify as a CDM project. Tools for demonstration and assessment of additionality in A&R CDM projects are available on website of UNFCCC. As per these tools, the proposed A&R project activity should not have taken place except for CDM benefits. The project activity should not be financially most attractive and if so, proper barrier analysis will have to be carried out to justify that the project activity is additional.

4.3.4 Leakage assessment

Leakage is the increase in GHG emissions by sources which occur outside the boundary of the project activity but are measurable and attributable to the project activity. The project should also demonstrate how leakage issue will be addressed to ensure sustained carbon benefits. The project areas dedicated to common lands may have substantial leakage compared to agroforestry plantations as these lands may not be yielding woody biomass prior to their use as agriculture lands. The possibility of leakage is very high on lands such as degraded forests which were being used for biomass removal before the CDM project activity.

4.4 India's Forestry CDM Experience

As per earlier estimates, the annual global demand for certified emission reductions during 2008-2012 was estimated to be around 250 million tonnes of CO_2 (Haites, 2004). Out of this demand, a significant portion could have originated from forestry projects and it was expected that the country would earn significant revenues from forestry CDM projects during 2008-12. However, the real experience had been quite dismal wherein real demand never really increased for CERs from forest sector and carbon price remained subdued and later declined to even less than a dollar per tonne of CO_2. This has dampened the enthusiasm to develop forestry CDM projects in the country and elsewhere. The challenge has been further compounded by the fact that the likely demand for CERs from forestry projects is expected to be much lower during second commitment period due to very few countries deciding to continue with the KP. Despite these challenges, our country has registered 19 forestry projects under CDM which is 28.8% of total 66 forestry projects registered at global level till date. Brief details of registered projects from India are given in Table 2.

Performance of Forest sector under CDM

66 CDM forestry projects have been registered so far at global level and out of which 19 (28.8%) are from India.

4.5 Challenges Faced by Forestry CDM Projects

Apart from complex modalities and procedures for developing and processing of CDM forestry projects, there have been several other challenges associated with the projects from forest sector. First and the foremost is binding the growers for a pre-decided raising of a tree crop requiring a waiting period ranging from 6-20 yrs or even longer, for which they may not be prepared unless there are assured recurring benefits. It is therefore necessary to create enabling conditions that ensure a flow of project induced benefits. For example the farmers may prefer raising horticulture crops such as Mango or Litchi in hope of getting continuous flow of recurring benefits rather than going for a long rotation timber yielding tree species associated with lower or no recurring returns and long rotation.

Another major hindrance to the development of forestry CDM projects involving small farmers is the transaction costs, which include cost of project development, validation, implementation, monitoring, verification and certification along with the payment for CER issuance fee. In addition, costs may be incurred on development of baseline, consultation and involvement of different stakeholders, socio-economic and environment impact assessment, time and effort spent in search, negotiation and for finalizing the deal. Transaction costs in forestry CDM projects are higher in case the plantations are spread over a large number of

patches. Even one project involving plantation on 1000 ha of land may involve 500 to 1000 small patches of plantations, which are required to be monitored and later verified for issuance of CERs. This requires larger statistical sample for monitoring, resulting in even higher transaction costs.

The major hindrance to forestry CDM projects has been the limited market demand for non-permanent CERs issued under these projects. Moreover, being non-permanent they are traded at a heavy discount compared to a normal CER. This has resulted in a situation where virtually no market exists for CERs generated from forestry projects and buying of these credits had been limited to by the agencies like 'Biocarbon Fund' or by way of investment by private entities.

REDD-plus

5.1 Evolution of REDD-plus

Forest sector is uniquely placed in Climate Change scenario. On one hand deforestation and forest degradation contributes significantly to the warming of global climate systems, and on other hand forests have the potential to arrest the fast pace of changing climate by removing accumulated carbon dioxide from atmosphere and sequester it into vegetation and soil. In durable wood products also, the carbon continues to be locked for long time. Hence, when global forest resources are saved from further deforestation and degradation, and enhanced simultaneously, they deliver large reductions in GHG emissions and bring removal of carbon dioxide from the atmosphere. Reducing emissions from deforestation and forest degradation (REDD) offers an opportunity to mitigate significant sources of emissions at relatively low costs. It also has the potential to generate substantial co-benefits of biodiversity conservation, opportunities for livelihood and sustainable development. However, reducing these large emissions has not been the part of mitigation effort of the global community as these were earlier not included in United Nations Framework Convention on Climate Change (UNFCCC) or its Kyoto Protocol.

Any serious effort of combating global Climate Change without addressing emissions from forestry sector may not help in limiting the rise in global temperature to the desired levels. In this backdrop, REDD, a forest based Climate Change mitigation measure, was introduced during COP 11 (Eleventh Conference of Parties to UNFCCC) in 2005 through a proposal by a group of countries led by Papua New Guinea calling themselves 'The Coalition for Rainforest Nations'. Two years later, the proposal was taken up at COP 13 in Bali and the concept evolved into REDD-plus by also incorporating different measures of enhancing forest cover and carbon stocks, i.e., conservation, sustainable management of forests and enhancement of forest carbon stocks.

REDD-plus became part of the Cancun Agreement (COP 16) in December 2010, as it was reflected in the outcome of the Ad Hoc Working Group on Long-term Cooperative Action under the Convention. The Climate Change talks in Durban (COP 17) on REDD-plus, centered around four key areas of finance, safeguards, reference levels, and measuring, reporting & verification (MRV) of carbon emissions from forest activities. Some progress was made on issues of finance and parties were allowed to choose from number of financing options including markets. During COP 18 held in 2012 in Doha, it was decided to undertake a work programme on result based finance for REDD-plus comprising two co-chairs, one each from developing and developed countries, which included ways and means to transfer payments for result based actions and ways to incentivize non-carbon benefits.

REDD-plus made a significant progress during the COP 19 held in Warsaw, which was dubbed by many experts as REDD-plus COP. The major decision was on result based finance for

developing countries implementing REDD-plus activities which would allow them to receive funds. The **'Warsaw Framework'** for REDD-plus emphasized that developing countries must measure, report and verify anthropogenic forest related emissions as part of National Forest Monitoring System and address social and environmental safeguards.

The 20th COP held in Lima, in December 2014 deliberated on the guidance with respect to type of information, transparency, consistency and comprehensiveness on Safeguard Information System (SIS) to be kept in place by the developing countries. The 21st COP held in Paris in December 2015 also recognized the implementation of policy approaches and positive incentives for reducing emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks. It further recognized joint mitigation and adaptation approaches for sustainable management of forests while reaffirming the importance of non-carbon benefits. It also recognized adequate and predictable financial resources from public, private, bilateral and multilateral sources such as GCF.

5.2 Issues and Challenges for REDD-plus

REDD-plus is based on a core principle of financially incentivizing the individuals, communities, and countries to reduce GHG emissions from forest sector. It is more than a decade when REDD came into existence, yet several elements of it are still to be finalized. The issues of reference levels, MRV of carbon emissions from forest activities, finance and safeguards are some key challenges, which have been centering among most of the Climate Change negotiations pertaining to REDD-plus. One also needs to find ways to measure reductions in emissions when data are poor or non-existent to put a REDD-plus mechanism into action. It is further required to ensure that reductions in deforestation and degradation are real and it should create mechanism that stops destruction of forest in non-project areas or other countries. The fact that trees store carbon temporarily and the stored carbon is released back in to the atmosphere on harvest, i.e., non-permanence, is another important methodological challenge that needs to be addressed. The co-benefits of REDD-plus performance like biodiversity conservation, watershed benefits and several other ecosystem services pose enormous challenges on their measurements.

5.3 REDD-plus in India

To implement REDD-plus, India has enabling policies and legal framework like Indian Forest Act, 1927; Wildlife Protection Act, 1972; Forest Conservation Act, 1980; National Forest Policy, 1988; Biological Diversity Act, 2002 and Forest Rights Act, 2006 in place for the sustainable management of its forests. The country has demonstrated its commitment to address Climate Change by launching an ambitious 'Green India Mission' (GIM) programme under its National Action Plan on Climate Change for further improving the quality and extent of forest and tree cover. Participation of local communities in forest management, and centrally sponsored scheme on 'Intensification of Forest Management', for creation of infrastructure for the development, protection, and conservation of forest resources in the country further strengthen its commitments for mitigation of Climate Change. MoEF&CC has also initiated the review of Indian Forest Policy which is likely to further strengthen the REDD- plus performance.

It is well recognized that significant scaling up of finance is required for the successful and

sustainable implementation of REDD-plus in developing countries. However in all the past COP meetings, finance has been a contentious issue. In a significant improvement during COP 21 it has been decided that, GCF will provide support for the least developed countries and developing countries for the formulation of national Climate Change adaptation and mitigation plans and for the implementation of REDD-plus policies and projects. In 2015, GCF has recognized National Bank for Agriculture and Rural Development (NABARD) as the National Implementation Entity (NIE) in India in the area of Climate Change adaptation and mitigation.

5.4 India's stand on REDD-plus

As per 'National REDD-plus Policy and Strategy' of MoEF&CC, REDD-plus aims to guide forest conservation and management in the country while safeguarding the rights of local communities. The policy also strives to manage forests for a bouquet of ecosystem services with an appropriate mechanism for REDD-plus funding and transforming the financial benefits to the communities in a fair, equitable and transparent manner based on their performance. The REDD-plus Policy is supposed to be operationalized and implemented through National REDD-plus strategy designed to address critical gaps in the capacity and institutional framework towards creating REDD-plus readiness in the country. This would help to incentivize the removals in the form of enhancement of forest carbon stocks opting for sub-national level approach to construct Reference Level which may eventually be integrated to construct single National Forest Reference Level (NFRL). The policy on REDD-plus also emphasizes on achieving various thematic elements of sustainable management of forests by addressing the drivers of deforestation and forest degradation, afforestation of degraded areas and protection measures. The safeguards to protect the rights of forest dependent communities are already in place in the form of policy and legal instruments like Joint Forest Management (JFM) programmes, Forest Rights Act and the Biological Diversity Act. India's existing institutional set-up with some additional responsibilities could be used for implementation and management of REDD-plus in the country.

5.5 Operationalization of REDD-plus in India

The 'National REDD-plus Policy and Strategy', further states that the National REDD-plus framework is expected to be designed and implemented by establishing 'National REDD-plus Authority' in MoEF&CC under a National Steering Committee with other supporting Institutions, i.e. Government, Semi-Government and Non-Government, Technical and Scientific, in coordination with State Forest Departments (SFDs) and other stakeholders. The National REDD-plus Authority with support from REDD-plus Cell of MoEF&CC and assistance from SFDs and other institutions are well suited for undertaking the pilot REDD-plus projects for generating valuable experiences and technical capability. This will also help in field testing of proposed methodologies in coordination with Forest Survey of India as a nodal agency for MRV. This framework calls for adoption of simple and systematic approach to build capacity of all the stakeholders on various issues ranging from general awareness about REDD-plus strategy to their roles and responsibilities. The capacity needs to be developed also on MRV mechanism, social and environmental safeguards, benefit-sharing and other related issues.

National REDD-plus policy and strategy envisages that REDD-plus programme could result in capturing of around one billion tonnes of additional CO_2 over the next three decades. The policy also aims at developing National Forest Monitoring System for establishment of

robust and transparent national, sub-national MRV and National REDD-plus information system for analysis of available data amongst various institutions. At present India is in the readiness phase of REDD-plus which includes development of national strategy, construction of NFRL, MRV, SIS and capacity building.

5.6 REDD-plus Performance of SFDs: Need for Documentation

India is among the first country in the world which started managing its forests scientifically and sustainably. India's current forest and tree cover is estimated to be 79.42 million ha, constituting 24.16 % of the geographical area of the country. However, the quality of forests is not of the desired level as evident from absence of natural regeneration on one third of the forest area; moderate to heavy incidences of fire over half the forest area and only around 11% of forests are free from injuries such as illicit felling, girdling and lopping. The heavy biotic pressure is also due to grazing, and other anthropogenic influences. The situation is so challenging that more than one-third of forests are devoid of humus and half of the forests are characterized by shallow to medium soil depth.

In order to deal with these challenges, the SFDs carry out numerous forest management, plantations and other forestry activities which add to the REDD-plus performance. These actions, if documented systematically would demonstrate REDD-plus achievements at the national level. SFDs under different schemes and projects take definite steps towards reducing forest degradation, which includes protection, soil and moisture conservation measures and gap plantations. In order to reduce pressure on forests, SFDs carry out high density fuelwood plantations outside forests, promote agro-forestry, farm forestry and distribute seedlings for planting on homesteads and other privately owned blank areas. Measures on providing alternatives to fuelwood such as providing LPG connections, solar cookers, improved cook stoves, pressure cookers etc., are also taken which helps in reducing degradation of forests. Some of the steps, which could add to the performance towards reducing deforestation, would be alternatives to land diversion such as construction of underground roads and tunnels for road and rail transport, construction of flyovers with underpass for wildlife in forest areas, and other alternatives such as cable transportation in hilly areas.

The SFDs carry out management of all government owned forests as per the prescriptions of the approved working plans which adds to the REDD-plus performance towards Sustainable Management of Forests. About a quarter of these forests are managed with the partnership of local communities on the principle of 'care and share', which are potential areas to be taken up under REDD-plus. All the protected areas, i.e., National Parks, Wild Life Sanctuaries, Conservation Reserves, Community Reserves, Biosphere Reserves managed by the State Wildlife Departments can be included under 'Conservation' component of REDD-plus. Under the component on 'Enhancement of Forest Carbon Stocks', the SFDs may include afforestation, reforestation, ANR, gap plantations, canal bank, railway and roadside plantations and other similar afforestation interventions under various schemes including GIM.

5.7 REDD-plus Pilot Projects in India

India's first REDD-plus pilot project by Plan Vivo is located in the East Khasi Hills district (Mawphlang) in Meghalaya, which has been initiated in 2010 with the support from Ecometrica. There are some other pilot projects which have been concluded or under implementation with

the help of institutions such as TERI which carried out pilot studies in Uttarakhand, U.P., M.P., Orissa, West Bengal, Nagaland, Gujarat, and Rajasthan. ICFRE is involved in 'REDD-plus pilot project in Van Panchayats of Uttarakhand' and IGNFA is also carrying out a 'Pilot study on REDD-plus' in the same state. Another project on 'Partnership for Land Use Science (Forest-PLUS)' funded by USAID under bilateral agreement with MoEF&CC has been implemented in four locations in H.P., Karnataka, M.P. and Sikkim with the aim to explore methods and approaches to REDD-plus implementation.

5.8 REDD-plus Initiative of IGNFA

A **"Cell for REDD-plus in relation to global warming and Climate Change"** has been set up in Indira Gandhi National Forest Academy, Dehradun to equip itself to impart latest knowledge and skills on 'Forest and Climate Change' in general and 'REDD-plus' in particular, to entry level and in-service IFS officers as well as officers of other services who visit IGNFA for different courses. The mandate of the Cell is to deliberate upon and opinion building on issues relating to international REDD-plus framework; modalities, procedures and on-going negotiations; National REDD-plus framework; Construction of National Forest Reference level; MRV and Capacity building of stakeholders in REDD-plus implementation.

The REDD-plus Cell has made significant progress towards meeting its objectives, which include finalization of four modules for capacity building of entry level and in-service officers and other stakeholders. These modules are three day module on "Forest and Climate Change" for entry level IFS officers; two day module on "Climate Change and REDD-plus" for in-service IFS officers; one week module on "Forest and Climate Change with special reference to REDD-plus" for in-service IFS officers and two day module on "Forest and Climate Change with special reference to Ecological Functions" for officers from other services. The Cell has also finalized the structure of reading materials for these modules. The Cell has also brought out few publications which include brochures on 'REDD-plus' and booklet on "Forest and Climate Change: A Primer". A reading material on "Forests and Climate Change" has also been compiled for entry level IFS officers. The Cell has also conducted two modules for IFS (P) of 2013-15 and 2014-16 Courses during 27-28 May 2015 and 10-11 December 2015, respectively. Both the modules were received very well by the IFS (P). **The module conducted for 2014-16 Course has received National Level award in "Excellence in Andragogy and Methodology" by the DoPT for the year 2016.**

In order to strengthen the capacity building initiatives of Academy on REDD-plus, a pilot study on REDD-plus is being carried out in Timli Forest Range, Kalsi Soil Conservation Forest Division, Shiwalik Circle of Uttarakhand with the objectives to estimate the potential of emissions reduction due to avoidance of forest degradation; study of the drivers of forest degradation and ways to address them for emission reductions and to develop a practical module on REDD-plus to be utilized for capacity building of IFS officers. The pilot is being implemented on 9907 ha of forest of Timli Range. The Landsat satellite data of study area has been downloaded from USGS earthexplorer website and classified for the three time frames *viz.*, 1998, 2008 and 2014 by using ERDAS imagine 2014 software. The area has been classified in four different forest density classes *viz.*, very dense forest, moderately dense forest, open forest and non forest and compartment wise area statistics has been generated for three time lines.

As per IPCC Good Practice Guidelines, 2006 all the four carbon pools *viz.*, (i) Above ground woody biomass, (ii) Below ground biomass (iii) Dead organic matter (iv) Soil organic

carbon, have been analyzed for the carbon stock of the study area. Stratified random sampling technique has been applied as per FSI Methodology and 25 random sample points each were generated in the 2014 classified image in the four density stratum with the help of ERDAS Imagine software. One sample plot of 0.1 ha has been laid out on each of the stratified point in a manner that plot location could be accessible. The total carbon stock has been estimated for the study area for the year 2014 using FSI methodology. SAVI (Soil Adjusted Vegetation Index) image has been generated for the three time line of the study area for the estimation of biomass of earlier years and for biomass change detection. Logarithmic regression equation has been developed by correlating biomass value acquired from the field survey and SAVI values of the same coordinates in 2014 satellite image for each plot. Using this regression equation, biomass of entire project site was calculated for 2014 and also of the year 2008 and 1998 to estimate extent of degradation. The Socio-economic study has also been carried out to assess the dependence of the local people on the forests of Timli range, i.e. drivers of degradation, and to work out strategies to address these drivers. The pilot study is likely to be completed soon and the outcome will be utilized in capacity building of entry level and in-service IFS officers.

Vulnerability of India's Forests and Adaptation Strategies

6.1 Status of Forests in India

The recorded forest area of India is 764,566 km^2, which constitutes 23.26% of its total geographical area. By legal status, Reserved Forests constitutes 12.93%, Protected Forests 6.37% and Un-classed Forests 3.96% (ISFR, 2015). The major forest types are the Tropical Wet Evergreen Forest, Tropical Semi-evergreen Forest, Tropical Moist Deciduous Forest, Littoral and Swamp Forest, Tropical Dry Deciduous Forest, Tropical Thorn Forest, Tropical Dry Evergreen Forest, Sub-tropical Broad-leaved Hill Forest, Sub-tropical Pine Forest, Sub-tropical Dry Evergreen Forest, Montane Wet Temperate Forest, Himalayan Moist Temperate Forest, Himalayan Dry Temperate Forest, Sub-alpine Forest, Moist Alpine and Dry Alpine Scrub.

The total forest cover in the country is 701,673 km^2, which represents 21.34% of its total geographical area (ISFR, 2015). The country is endowed with very rich flora and fauna. The forests are unique with spectacular plant groups such as Conifers, Sal, Teak, Bamboos, Casuarina, Dipterocarps and many other species. Forests of the country support a wide range of biodiversity. The country has 103 national parks, 536 wildlife sanctuaries, 18 biosphere reserves, 26 conservation reserves and 67 community reserves (WII, 2016).

Beside timber, fuelwood, fodder and other NTFP, the forests of the country provide various ecosystem services, which flow beyond their natural confines and contribute to the welfare of the entire country. Some of the important services are climate regulation, water regulation and recharge, biodiversity conservation and carbon storage, which are relevant at regional and global level. One of the most critical functions of the forests of the country is protecting the upper catchments of various river systems. These rivers provide water to millions of people, used for drinking, irrigation, and industrial purposes. Forests are also ecologically important as they are home to a number of endemic plant and animal species. Forests also play a complimentary role to agriculture including animal husbandry, which is the major occupation and supports livelihood of two third of the population.

Despite their utility and ecological importance, forests in India are degrading due to a number of pressures like diversion of forest lands for developmental purposes, unsustainable harvests of forest products, encroachments, forest fires, invasive species and various other biotic interferences.

6.2 Evidences of Likely Impacts of Climate Change

A study by Funk *et. al.*, 2014 shows the latest evidence on how Climate Change is disrupting the forests of the Rocky Mountain region. According to the study carried out from 2000 to 2012, bark beetles killed trees on 46 million acres and the U.S. Forest Service estimates that as many as 100,000 beetle-killed trees now fall to the ground every day in Southern

Wyoming and Northern Colorado alone. The changing climate played a key role in these outbreaks like winter warming which increases the survival and multiplication of bark beetles. Due to winter warming other ecological changes are also observed like earlier end of hibernation, migration and breeding in some species. It is expected that winter warming may also cause changes in species distribution, expansion of range of some butterfly species etc., (USDA, 2014).

Recent studies on likely impacts of Climate Change on forests of India demonstrate several evidences on how ecosystems are responding to the changing climate. A study conducted by Singh *et. al.*, 2012 on the alpines of Uttarakhand reveals the shift of treeline, i.e., *Betula utilis* from the year 1970 to 2006 due the impact of ongoing warming under the background influence of increasing levels of GHGs. Another study carried out by Acharya *et. al.*, 2012 in Sikkim provides some evidences of Climate Change impact on birds, reptiles, amphibians and butterflies. The study observed that due to increasing temperature many species shifted their ranges upwards along the elevation gradients. Late breeding or breeding failure among birds, earlier breeding of amphibians, biased sex-ratio in female snakes and disappearance of turtle due to long dry weathers are some of the evidences of Climate Change documented by the authors. A study in Arunachal Pradesh in 2011 by Bharali & Khan reported the phenological changes in some floral species, (i.e., *Rhododendron* species and Orchids). Another study by Upgupta *et. al.*, 2015 on forests of Himachal Pradesh shows that the districts of Chamba, Kullu, Shimla, Mandi and Kangra are most vulnerable to the changing climate by 2030s.

6.3 Pressures on Forest Resources of India

Approximately 275 million people in India are known to live in the forest fringes and earn bulk of their livelihood from forests (World Bank, 2006). It is also known that and more than 40 per cent of the forests in country are degraded and under-stocked (Aggarwal *et al.*, 2009 ; Bahuguna *et al.*, 2004). There are a number of geographical, demographic and socio-economic factors responsible for this degradation. In addition to the fragile ecosystems, increasing population with low agricultural production, large and unproductive bovine population, degraded community forests and restricted means of livelihood constitute a vicious cycle of poverty resulting in tremendous pressure on forests in the country. Some of the major pressures on forests that have resulted in deforestation and forest degradation in our country are discussed below.

6.3.1 Unregulated removal of wood

The Forest Survey of India (FSI) estimated that 853.88 million persons in our country use fuelwood as a source of energy for cooking or heating, out of which 199.63 million (23.38%) use fuelwood from forests. The total fuelwood consumption in the country is 216.42 million tonnes per year whereas forests can produce only 58.75 million tonnes annually on sustainable basis. The total annual consumption of round wood other than fuelwood i.e., wood for construction, household furniture, and industrial furniture is 48.0 million m^3 which has been estimated by assuming different life spans of wood used for construction, household furniture, industrial furniture and agricultural implements (SFR, 2011). This demand along with informal removal of wood puts tremendous pressure on forests of the country. Likewise, fuelwood constitutes 71% of the source of domestic energy and is especially important to forest dwellers and rural people.

6.3.2 Diversion of forestland for non-forestry purposes

Due to ever increasing developmental activities, the forests are increasingly being diverted for purposes such as hydel power projects, industry, road building and mining. Between 2009 and 2011, a total of 36,700 ha of forest land has been diverted for various developmental activities in the country as per the State of Forest Report of 2011 (FSI, 2012), of which a major part has been diverted for hydel power and mining projects. This is understood to have resulted in problems such as increased soil erosion and landslides.

6.3.3 Unregulated grazing

Grazing and trampling of regenerated seedlings by livestock is the biggest threat to the regeneration of vegetation in all forest areas of the country. The National Biodiversity Strategy and Action Plan (GoI, 2002) has estimated that the requirement for green fodder in the country is 1061 million tonnes per annum whereas for dry fodder of 589 million tones is required annually. However, pastures over the common lands including forests, are a source of about 280 million tonnes of fodder annually (Planning Commission, 2011). Most of this gap is filled by unregulated grazing, illegal removal such as heavy lopping of trees and cutting of saplings. The decreasing area of pastures and diverting of some pastures for tree plantation has resulted in even greater pressure on the remaining areas, especially along the forest fringes.

6.3.4 Forest fires

Uncontrolled fires have caused tremendous damage to the forest biodiversity of the country. It occurs under conditions of high temperature, extreme dryness, strong winds and low moisture in the forest floor. Since the year 2005, FSI has been monitoring forest fires across the country using inputs received from Moderate-resolution Imaging Spectrometer (MODIS) satellite system. While carrying out National Forest Inventory (NFI), FSI also observes the incidence of fire ocularly and classify it as 'heavy' if the area is affected by fire more than 50%, 'moderate' if the area is affected 10-50%, and 'mild' if the area is affected less than 10%. A total of 2, 41,892 forest fires have been reported from 2004-2005 to 2015-2016 in the country. From this survey it is observed that the Tropical thorn forests, Tropical dry deciduous forests and Sub tropical broad leave forests are most prone to the forest fire. The study also reveals that 2.4% of the country's forests are reported to have heavy fire incidence, 7.5% forests have moderate fire incidence, 54.4% forests have mild fire incidence and 35.71% forests recorded no fire incidence (ISFR, 2015).

6.3.5 Presence of weeds

Weed is an undesirable plant species growing on a particular site. The study by FSI (ISFR, 2013) indicates that weeds are absent in only 4.29% of the forest area. About 20.32% area has 'very dense' to 'dense' weeds whereas 59.67% area has 'moderate to scanty' presence of weeds. Weeds are considered to be resilient to the changing climate owing to their longer seed viability and high adaptability to different ecological conditions. It is believed that the extent of weed infestation would increase with increasing temperatures.

6.3.6 Biotic influence

The living organism influences the forest ecosystems in many ways which is termed as Biotic influence. They not only influence by their interaction with the surrounding vegetation but also by their effect on soil, thus determining the nature of vegetation accruing on a particular

location (ISFR, 2013). As per FSI report of 2013, India's forests to the extent of 11.05% are facing heavy biotic influence, whereas moderate to mild biotic influence is being faced by 63.53% of forest area. Only 13.28% of country's forest area is free from biotic influence, which highlights the pressure on our forests.

6.4 Suggested Adaptation Measures

Adaptation measures are planned responses aimed at reducing the vulnerability of a system. It is an adjustment in human and natural systems in response to actual or expected climate stimuli or their impacts that moderate harm or exploit beneficial opportunities (IPCC, 2007). The need to include adaptation into forest management and policies is becoming increasingly recognized, especially in tropical and temperate areas. In particular, forest stakeholders face challenges related to understanding vulnerability, identifying adaptation options and implementing adaptation strategies.

Forest ecosystems in India are already under heavy socio-economic pressures leading to forest degradation. Adverse impacts of Climate Change will be an additional pressure on the already vulnerable vegetation. This can significantly affect the availability of forest goods and services in terms of quality and quantity. Many non-timber forest products are likely to be more vulnerable to changes in climate system than timber and fuelwood production (Robledo and Forner, 2005), and hence would have a more profound impact on the forest-dependent communities deriving their livelihood needs from collection, handling, value addition and selling of these NTFPs.

Though the climate modeling studies demonstrate the adverse impact of changing climate on forest ecosystems of our country, yet there is no certainty on the projected impacts. Nevertheless, it is imperative to begin developing adaptation measures, based on the scientific literature for similar ecological conditions. Some of the adaptation measures for the country could be:

i) Identification of critical forest ecosystems and species and initiating measures that would reduce pressure on such ecosystems and species and ensure their conservation either through in-situ or ex-situ means.

ii) Maintaining of proper health and hygiene of the forest ecosystems to reduce vulnerability to pests and diseases.

iii) The State Forest Departments needs to strengthen the existing fire detection and management systems and work towards reducing the response time. It would also be important to ensure proper sanitation and watch and ward measures to prevent incidences of fire.

iv) The country needs to enforce strict grazing management, which should ensure no grazing in the plantation and natural regeneration areas. Grazing should be regulated and communities need to be encouraged to keep only productive livestock, which could be stall-fed or kept confined to dedicated grasslands and pastures.

v) Incorporating Climate Change concerns in the working plans/management plans prescriptions to ensure that the management interventions are in line with adaptation

measures. The new National Working Plan Code, 2014 recognize these concerns but more needs to be done at state level by the State Forest Departments for its operationalization.

vi) To build the capacity of the forest departments to understand the vulnerability of the forest ecosystems to the changing climate. In this context, country should come up with state level capacity building programmes focusing on vulnerability of forest ecosystems and their future management to address mitigation of Climate Change and enhance the adaptive capacity of forests.

Apart from these specific adaptation measures, country should adopt good practices of sustainable forest management, which would help in reducing vulnerability and increasing adaptive capacity of the forests and communities to cope with the likely impacts of Climate Change. Some of the strategies could be arresting forest degradation, rehabilitating degraded forests and wastelands to increase the forest cover and improving productivity of forests and plantations to meet the ever-increasing demand for forest products. Such strategies have to necessarily adopt a well-balanced approach incorporating all aspects of the forest sector. For instance, supply-side mechanisms must be augmented by demand-side management to ensure sustainable use of the State's forest resources. This will involve enhanced investment and capacity building of the forest department and the communities to facilitate informed decision-making.

6.5 Green India Mission (GIM)

The National Mission for a Green India is one of the eight missions under the National Action Plan on Climate Change (NAPCC) announced by India in June, 2008. This mission recognizes the adverse impact of Climate Change on forest and biodiversity of the country, the communities and people associated with it. The mission aims at responding to Climate Change by a combination of adaptation and mitigation measures, which would help in enhancing carbon sinks in sustainably managed forests and other ecosystems, adaptation of vulnerable species/ecosystem to the changing climate and adaptation of forest-dependent communities. GIM puts "greening" in the context of Climate Change adaptation and mitigation. Greening is meant to enhance ecosystem services such as carbon sequestration and storage in forests and other ecosystems; provisioning of hydrological services and biodiversity conservation; as well as other provisioning services such as fuel, fodder, small timber and non-timber forest products.

The main objectives of the mission are to increase forest/tree cover on 5 m ha of forest/non-forest lands and improve the quality of forest cover on another 5 m ha. GIM also envisage improvement of ecosystem services including biodiversity, hydrological services and carbon sequestration as a result of treatment of 10 m ha. This is also projected to increase forest-based livelihood income of about 3 million households living in and around forests and enhance annual CO_2 sequestration by 50 to 60 million tonnes by the year 2020.The target to increase 10 m ha forest/ non-forest land includes qualitative improvement of forest cover in moderately dense forest (1.5 m ha), open degraded forest (3.0 m ha), degraded grassland (0.4 m ha) and wetlands (0.1m) while for new forest cover the mission plans the afforestation/eco-restoration of scrub land, mangroves, ravines, cold deserts, shifting cultivation areas and abandoned mining areas (2 m ha), Urban/peri urban areas (0.2 m ha) and Agro-forestry/social forestry and non cultivable lands (3.0 m ha).

The mission also plans to adopt landscape approach with comprehensive interventations at the scale of 5000-6000 ha at a time, wherein all forest and non-forest areas could be taken up for treatment and addressing of drivers of degradation. GIM also envisages involving Gram Sabha to facilitate the mission activities and creation of new cadre of young community foresters from Scheduled Tribes and other forest dwelling communities. The government has initiated this mission with a budget of Rs 46,000 crores for a period of 10 years coinciding with twelfth and thirteenth five year plans.

6.6 Managing Forests for Adaptation to Climate Change

In addition to mitigation and adaptation measures envisaged under GIM, the budgetary programs of MoEF&CC and State Forest Departments can also be geared up for enhancing the adaptation capability of our forests. The following forest management measures are suggested by the authors.

6.6.1 Rehabilitation of degraded forests and afforestation of wastelands

42.83 % of the total forest cover of the country is covered by open forests (ISFR, 2015), along with significant area under scrub-lands. The regeneration of scrub-lands will require intensive plantation and afforestation activities and open forests could be regenerated through a combination of plantation and assisted natural regeneration. The biggest hurdle to such an initiative is availability of the required financial resources, which mostly come from budgetary support of the government. Such areas can be also taken up under on-going Green India Mission. Likewise, alternative sources such as funding under REDD-plus can be tapped for afforestation, reforestation and conservation projects. REDD-plus framework is now in place and there is likelihood of flow of funds in near future for forest conservation, sustainable management of forests and enhancement of carbon stocks, beside other REDD-plus activities.

6.6.2 Improving productivity of forests and plantations

Improving the productivity of existing plantations and forest areas is another option to meet the ever-increasing demand from forests. The adoption of silvicultural practices and improved planting materials can increase the productivity of forests in the country. As per MoEF's estimates, productivity can be enhanced to 1.35 m^3 per ha per year in drier regions, 7.66 m^3 per ha per year in moist/wet regions, and 4-5 m^3 per ha per year in other parts of the country (MoEF, 1999).

In case of plantations, productivity can potentially be increased manifold by planting of superior planting stock raised through tree improvement programmes as well as through clonal technology. For instance, the annual productivity of a seed raised Eucalyptus plantation is only 4-5 m^3 per ha, which can increase to 20-40 m^3 per ha with the introduction of genetically improved clonal plants. However, tree improvement programmes have not received enough attention and funding. In this context, the State Forest Departments needs to strengthen their research facilities and also may collaborate with the central forestry research institutions, agricultural universities, to intensify research activities on raising of superior planting materials and on silvicultural practices.

6.6.3 Strengthening community forest management

Strengthening of community forest management could be another strategy for sustainable

management of forests. There are around 100,000 JFM committees in the country, which are managing around 220 lac ha of the forest area (FSI, 2008). Various studies across the country indicate that community forest management has had a positive impact on vegetation and income, and on the relationship between local communities and the forest department. Green Indian Mission also envisages empowerment of forest based communities which would be critical for the success of such interventions.

Women and marginalized sections of the communities also need to be empowered through self-help groups (SHGs) so that they can actively participate in such interventions. Further, possibility of introducing a mechanism on payment for environmental services also needs to be explored where the communities could be paid directly for protection and management of forests by the beneficiaries of these services.

6.6.4 Diverting pressures away from forests

Yet another opportunity to reduce the pressure on forests is agro-forestry and farm forestry wherein trees may be planted on and along farm boundaries and homesteads in a manner that does not affect crop productivity. Strategies for promoting farm forestry should focus on educating and motivating farmers, rationalizing legal barriers on felling and transport of produce, bringing about market reforms and fostering farmer-industry linkages.

6.6.5 Demand-side management

The demand side management requires promoting use of wood as a 'carbon neutral material' in place of energy intensive metallic structural materials and development of technologies for efficient utilization of wood into long-term carbon traps. In case of fuelwood, augmenting the use of alternatives to fuelwood such as LPG, biogas and solar energy, as also efficiency improvements in use of fuelwood are some measures that can reduce the demand for fuelwood. For example, it has been estimated that an improved 'chulha' (cook stove) reduces fuel wood demand by 400 kg per household per annum. Likewise other efficient technology options such as use of non-conventional energy sources like solar energy also would help in reducing the burden on forests significantly (TERI, 2008).

6.6.6 Improving livelihoods of forest dependent communities

Ensuring better livelihood opportunities for forest-dependent people can reduce the over-exploitation of forest resources. Forest based interventions alone cannot fulfill the livelihood needs of the communities in question. Hence, initiatives to enhance their livelihood options need to be dovetailed with interventions in the agricultural sector and other income-generation activities. In the forestry sector, livelihoods can be improved significantly through NTFP and medicinal plant parts oriented forest management and creating the enabling conditions such as value addition and marketing. Growing of fast growing tree species on farm lands even by small and marginal farmers also offer substantial livelihood opportunities.

6.6.7 Strengthening of Protected Area network

The country has 16.5 million ha dedicated to Protected Areas in the form of national parks, wildlife sanctuaries, conservation reserves, community reserves and biosphere reserves. However the fragmentation of wildlife habitats that have occurred over the years need to be reversed. Strengthening of wildlife corridors is also suggested as a measure to overcome the adverse effects of fragmentation. This would address the issues of large mammals like elephants

and tigers and the human-wildlife conflicts arising as a result of shrinking and degraded animal habitats. Increasing the forest cover in areas that lead to enhancement of the potential role of designated protected areas would also be a step towards sustainable development.

6.6.8 Integrated watershed development approach

Watershed based development is a good example of ecosystem approach. Watershed development programmes have been implemented in Hill states and elsewhere for long and have helped in treating catchments of major rivers of the region conserving biodiversity and improving livelihoods of local people. Such projects have also been able to achieve multiple objectives of improving vegetation cover, water availability, increasing incomes of local communities and enhancing administrative capacity of the Gram Panchayats and Gram Sabhas. Various interventions related to agriculture, livestock improvement, horticulture, forestry, irrigation, soil and water conservation, development of market linkages, enterprise development, and income generation have been implemented through projects in an integrated manner through local institutions. Such projects seem to have effectively addressed a number of ecological, economic and social issues but the challenge would be to ensure sustainability of these interventions. Watershed programmes could be further strengthened and promoted for sustainable management of forest ecosystems in the country by mobilization of funding from bilateral and other sources.

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Table 1: Carbon sequestration potential and likely Carbon benefits for different tree plantation models

Tree plantation model	Annual incremental carbon sequestered (tC/ha/yr)	Annual incremental carbon sequestered (tCO_2/ha/yr)	Likely carbon benefits (Rs/ha/yr)
Trees Species of Commercial importance			
Poplar block	2.54 (4.42)*	9.3 (16.22)	2790/- (4866/-)
Poplar bund	1.42 (2.46)	5.21 (9.03)	1563/- (2709/-)
Eucalyptus bund	1.62 (2.15)	5.95 (7.89)	1785/- (2367/-)
Horticulture Tree Species			
Apple block	0.75	2.77	831/-
Pear block	0.73	2.67	801/-
Plum block	0.19	0.68	204/-
Mango block	1.15	4.21	1263/-
Tree species of Medicinal importance			
Amla (*Emblica officinalis*) block	0.90	3.30	990/-
Bahera (*Terminalia bellerica*) bund	2.93	10.75	3225/-
Harar (*Terminalia chebula*) bund	2.30	8.44	2532/-
Reetha (*Sapindus mukorossi*) bund	2.60	9.54	2862/-
Long Rotation Tree Species (block plantation)			
Pine	4.81	17.65	5295/-
Pine-Oak Mixed	3.69	13.53	4059/-
Mixed species	3.99	14.65	4395/-

* With wood products; Carbon price = \$5/tCO_2; \$1=Rs 60/-

Table: 2 CDM Forestry Projects Registered from India up to 31st July, 2016. (Total: 66, India: 19)

S. No	Title of Project	Project location	Date of registration	Host party	Other parties	Reduction per annum	Project area (ha)	No. of land parcels	Species selected	Choice of CERs	Crediting period	C-Pools chosen
1	Small Scale cooperative afforestation CDM Pilot Project activity on private lands affected by shifting sand dunes in Sirsa Haryana	Sirsa, Haryana	23.03.2009	India	-	11, 596 (s.s.project)	369.5	239	*Ailanthus excelsa*, *Acacia tortilis*, *Eucalyptus* hybrid, *Acacia nilotica*, *Dalbergia sissoo*, *Zizyphus mauritiana*, *Prosopis cineraria*	tCER	20 years	AGB & BGB
2	Reforestation of severely degraded lands in AP under ITC SF project	14 Mandals in Khammam, A.P.	05.06.2009	India	-	57,792	3070.19	3398 (No. of farmers)	*Eucalyptus tereticornis* *Eucalyptus camaldulensis*	ICER	30 years	AGB & BGB
3	The International Small Group and Tree Planting Program (TIST), Tamil Nadu	3 Distt. of T.N i.e. Kancheepuram, Truvannamalai & Thiruvallur	15.01.2010	India	UK & N.Ireland	3,594 (s.s.project)	106	175	*Casuarina equisetifolia* *Eucalyptus* species, *Tectona grandis*	tCER	30 years	AGB & BGB
4	Improving rural livelihoods through C-sequestration by adopting Environment Friendly Technology based on Agroforestry Practices	3 Distt. in Orissa, i.e., Koraput, Kalahandi & Rayagada and 3 in A.P. i.e., Visakhapatnam, Vizianagram & Srikakulam.	28.02.2011	India	Canada Italy Luxembourg France Japan Spain	4,896 (s.s.project)	1607.7	1590 (no. of farmers)	*Eucalyptus species*, *Casuarina equisetifolia* & Clonal *Eucalyptus*	tCER	30 years	AGB & BGB

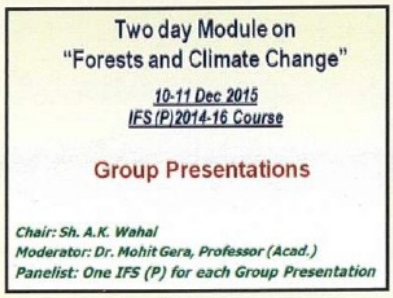
S. No	Title of Project	Project location	Date of registration	Host party	Other parties	Reduction per annum	Project area (ha)	No. of land parcels	Species selected	Choice of CERs	Crediting period	C-Pools chosen
5	H.P Reforestation Project-Improving &Livelihoods and Watersheds	Project located in 177 GPs in 11 watershed divisions of Mid-Himalayan Watershed Development Projects (MHWDP) of H.P.	04.03.2011	India	Switzer-land Ireland Spain	41,400	4003.07	420	45 tree species mainly local species	tCER	20 years	AGB, BGB & SOC
6	Begepalli CDM reforestation program	5 taluks of Chick-Ballapur distt. of Karnataka	27.05.2011	India	-	92,103	8933.34	12347	*Tamarindus indica*, *Mangifera indica*, *Ziziphus mauritiana* and *Anacardium occidentale*	lCER	20 years	AGB & BGB
7	Reforestation of degraded land in MTPL in India	Districts of Nabarangpur, Koraput & Malkangiri in Orissa; Vijayanagaram & Srikakulam in A.P; and Bastar in Chhattisgarh	01.08.2011	India	-	146,998	14,969	12,437	*Eucalyptus tereticornis*	tCER	30 Years	AGB, BGB & SOC
8.	Agro-forestry Interventions in Koraput district of Orissa	Jeypore , Kundra, Kotpad, Boipariguda and Boriguma blocks of Koraput district	19.11.2012	India	-	1130 (s.s.project)	380.2	622	*Eucalyptus clones (Eucalyptus camaldulensis* and *Eucalyptus tereticornis)*	tCER	30 yrs	AGB, BGB & SOC

S. No	Title of Project	Project location	Date of registration	Host party	Other parties	Reduction per annum	Project area (ha)	No. of land parcels	Species selected	Choice of CERs	Crediting period	C-Pools chosen
9.	Rehabilitation of Degraded Wastelands at Deramandi in Southern District of National Capital Territory of Delhi through Reforestation	Dera Mandi/South Delhi/Delhi	30.01.2013	India	-	12,138 (s.s.project)	358.5	-	*Acacia leucopholea, Acacia nilotica, Prosopis juliflora* and other local species.	tCER	30 yrs	AGB & BGB
10.	Small scale Allahabad JFM A/R CDM Project on degraded lands in Division, Uttar Pradesh, India.	Northern region of India State - Uttar Pradesh Allahabad Forest Allahabad	03.08.2015	India	-	3794 (s.s.project)	506.63	25	*Azadirachta indica, Embilica officinalis Aegle marmelos Madhuca indica* and other native species.	tCER	20 yrs	AGB & BGB
11.	Small scale Chitrakoot JFM A&R CDM Project on degraded lands in Chitrakoot Forest Division, Uttar Pradesh, India.	Northern Region of India State - Uttar Pradesh District - Chitrakoot	14.10.2015	India	-	3743 (s.s.project)	287.32	24	*Emblica officinalis, Tectona grandis, Acacia auriculiformis* and other local species.	tCER	20 yrs	AGB & BGB
12.	Small scale Obra JFM A&R CDM Project on degraded lands in Obra Forest Division,	Northern Region of India State - Uttar Pradesh District - Sonbhadra	26.11.2015	India	-	5571 (s.s.project)	326.72	22	*Emblica officinalis, Acacia auriculiformis, Tamarindus*	tCER	20 yrs	AGB & BGB

S. No	Title of Project	Project location	Date of registration	Host party	Other parties	Reduction per annum	Project area (ha)	No. of land parcels	Species selected	Choice of CERs	Crediting period	C-Pools chosen
	Uttar Pradesh, India								*indica* and other species of local importance.			
13.	Small scale Renukoot JFM A&R CDM Project on degraded lands in Renukoot Forest Division, Uttar Pradesh, India	Northern Region of India State - Uttar Pradesh District - Sonbhadra	26.11.2015	India	-	7670 (s.s.project)	284.04	28	*Azadirachta indica, Bauhinia variegata, Tectona grandis, Emblica officinalis* and other species of local importance.	tCER	20 yrs	AGB & BGB
14.	Small scale Sonbhadra JFM A&R CDM Project on degraded lands in Sonbhadra Forest Division, Uttar Pradesh, India	Northern Region of India State - Uttar Pradesh District - Sonbhadra	26.11.2015	India	-	8721 (s.s.project)	337.45	-	*Mangifera indica, Cassia fistula, Embilica officinalis* and other species of local importance.	tCER	20 yrs	AGB & BGB
15.	Small scale Jhansi JFM A&R CDM Project on degraded lands in Jhansi Forest Division, Uttar Pradesh, India Pradesh, India	Northern Region of India State - Uttar Pradesh District - Jhansi	26.11.2015	India	-	3376 (s.s.project)	268.87	14	*Acacia auriculiformis, Acacia catechu, Acacia nilotica, Aegle marmelos* and other species of local importance.	tCER	20 yrs	AGB & BGB
16.	Small scale Lalitpur JFM A&R CDM Project on degraded	Northern Region of India State - Uttar Pradesh	26.11.2015	India	-	5375 (s.s.project)	416.09	25	*Acacia auriculiformis, Acacia catechu,*	tCER	20 yrs	AGB & BGB

S. No	Title of Project	Project location	Date of registration	Host party	Other parties	Reduction per annum	Project area (ha)	No. of land parcels	Species selected	Choice of CERs	Crediting period	C-Pools chosen
	lands in Lalitpur Forest Division, Uttar Pradesh, India	District - Lalitpur							*Acacia nilotica, Albizia lebbeck* and other species of local importance.			
17.	Small scale Mirzapur JFM A&R CDM Project on degraded lands in Mirzapur Forest Division, Uttar Pradesh, India	Northern Region of India State - Uttar Pradesh District - Mirzapur	26.11.2015	India	-	10,667 (s.s.project)	763.79	-	*Acacia auriculiformis, Psidium guajava, Emblica officinalis, Mangifera indica* and other species of local importance.	tCER	20 yrs	AGB & BGB
18.	Small scale Kashi JFM A&R CDM Project on degraded lands in Kashi Forest Division, Uttar Pradesh, India	Northern Region of India State - Uttar Pradesh Districts– Chandauli and Varanasi	26.11.2015	India	-	4694 (s.s.project)	320.51	21	*Azadirachta indica, Tectona grandis, Haplophragma adenophyllum* and other species of local importance.	tCER	20 yrs	AGB & BGB
19.	Small scale Mahoba JFM A&R CDM Project on degraded lands in Mahoba Forest Division, Uttar Pradesh, India	Northern Region of India State - Uttar Pradesh District - Mahoba	26.11.2015	India	-	4356 (s.s.project)	265.46	34	*Azadirachta indica, Butea monosperma, Dalbergia sissoo, Tectona grandis, Emblica officinalis* and other species of local	tCER	20 yrs	AGB & BGB

Module on Forests and Climate Change conducted for capacity building of IFS (P) 2014-16 Course 10-11 December, 2015 in IGNFA by REDD-plus Cell



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