Forests and Climate Change:
A Primer

Indira Gandhi National Forest Academy
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REDD-plus Cell 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 REDD-plus and related issues to various stakeholders especially Indian Forest Service Probationers, In-service Indian Forest Service Officers, and officers belonging to other services like IAS, IPS, IRS, IRTS and members of Higher Judiciary. The mandate of the Cell is to deliberate upon and opinion building on issues relating to:

a) International REDD-plus framework;
b) Modalities, procedures and current debate on negotiations;
c) National REDD-plus framework;
d) Construction of National Forest Reference level;
e) Forest Governance and Implementation of REDD-plus in India;
f) Assessment of carbon stocks and MRV issues;
g) Capacity building of stakeholders in REDD-plus implementation;
h) REDD-plus financing possibilities; and similar other issues related to REDD-plus.

Two Committees have been constituted for functioning of the REDD-plus Cell:

I) The **"Apex Academic Committee on REDD-plus in relation to global warming and climate change",** which involves the stakeholders, viz., MoEFCC, FSI, ICFRE, WII, IIRS and other experts in the field of Forests and Climate Change. The Apex Committee plays an advisory role to the Cell.

ii) The **"Core Academic Committee on REDD-plus in relation to global warming and climate change"** consists of experts drawn from forestry institutions located in Dehradun and MoEFCC, New Delhi. The Core Academic Committee looks after day to day working of the Cell.

Till date, the Cell has finalized capacity building modules and structure of reading materials for IFS (Probationers), In-service IFS officers and officers belonging to other services. A pilot project on REDD-plus is also being carried out in "Timli Forest Range" of Kalsi Soil Conservation Forest Division of Uttarakhand Forest Department.

Third Apex Academic Committee Meeting of REDD-plus Cell of IGNFA

Forests and Climate Change:
A Primer

Dr. Mohit Gera
Professor & Member Secretary, REDD-plus Cell

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Note:

i) This booklet is for internal circulation only for training purposes.

ii) Based on author's contribution to a chapter on "Climate Change and Indian Forests: Vulnerability, Mitigation and Adaptation Strategies" published in FRI publication "Sustainable Forest Management for Multiple Values: A Paradigm Shift" (Vol. 1) in 2014.

R. K. Goel
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Message

While the Climate Change is understood to be one of the most serious global environmental challenges confronting the humanity 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".

The study conducted by Indian Network on Climate Change Assessment on likely impacts of Climate Change on forest ecosystems has shown that 45.9% of the country's forests are vulnerable. 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: A Primer"** covering all important aspects will go a long way in providing the requisite information and knowledge to the field foresters. Realizing the need for capacity building of forestry officials in this new emerging field, the Academy dedicates itself to the cause and plan to begin with organizing 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 during the course of training programmes to be organized by the Academy on the subject in coming years to increase awareness among forest officials so as to address the issue in all its seriousness.

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Foreword

Climate change is a huge challenge for developing countries like India that face large climate variability and are 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. India, therefore has a huge stake in the global climate change negotiations that are taking place under the purview of United Nations Framework Convention on Climate Change.

Forests play a significant role in climate change mitigation by acting not only as sinks, but also removing the accumulated carbon dioxide from the atmosphere and storing it in biomass and soils. On harvest, the durable wood products also contribute significantly in locking the carbon into these products for periods which may vary upto several decades. On the other hand forests are also significant sources of greenhouse gas emissions due to large scale deforestation and forest degradation in several countries. Without direct management interventions, climate change is likely to jeopardize forest ecosystem health, resilience, productivity, biodiversity and carbon storage capability. The strong relationship between forests and climate implies that a dramatic change in one will influence the other. Sustainable forest management can help reduce the adverse impacts of climate change on forests and forest-dependent communities, and ensure that forests play their role in mitigating climate change. Thus, it is important for forest managers to understand the interface between climate change and forests. The booklet on **"Forests and Climate Change: A Primer"** is being published with the aim to equip the foresters to understand the likely impacts of climate change on forests, strategies for adapting to the changing climate and mitigation role of forests so that these considerations can be incorporated into forest management plans and practices.

I congratulate Dr. Mohit Gera, Professor & Member Secretary of REDD-plus and his team for bringing out this booklet which will be a key reading material for capacity building of not only Indian Forest Service Probationers and in-service IFS officers but also other stakeholders on issues of Forests & Climate Change.

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Preface

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 adaption 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: A Primer"** has been prepared with the latest information on almost all aspects of interface between forest ecosystems and changing climate. The Academy is looking forward to organize specific training programmes on forests and climate change issues and it is expected that the booklet would be instrumental in filling up the information gap on this important subject.

Dr. Mohit Gera
Professor & Member Secretary,
REDD-plus Cell

Acknowledgements

The financial support of Food and Agriculture Organization, Rome in organizing "National Workshop cum Training Programme of National Stakeholders for creating Awareness on Non-Legally Binding Instrument (Forest Instrument) on all types of forests" during 12-14 Dec, 2012 is hereby acknowledged. The main objective of the workshop was to create awareness and build capacity among the wide range of stakeholders with in 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 booklet on **"Forests and Climate Change: A Primer"** is being brought out. The publishing of this booklet would not have been possible without active support and guidance of Sh. R.K. Goel, Director, IGNFA. The guidance received from Dr. Alok Saxena, Additional Director in overall structure and sequencing of the chapters is gratefully acknowledged.

Sh. Ajay Kumar Gupta, Academic Associate, REDD-plus Cell deserve a very special appreciation for his contribution on literature search, formatting and providing regular assistance in writing of the manuscript. Last but not the least, the assistance provided by supporting staff Dr. Miru Srivastava and Sh. Sandeep Aswal in developing this booklet is thankfully acknowledged.

Dr. Mohit Gera
Professor & Member Secretary,
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Abbreviations

A&R	Afforestation and Reforestation
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 Systems
GoI	Government of India
H_2O	Water Vapour
HFCs	Hydrofluorocarbons
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
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 Spectrometer
MoEFCC	Ministry of Environment, Forests and Climate Change
MRV	Measuring, Reporting and Verification
N_2O	Nitrous Oxide
NAP	National Afforestation Programme
NAPCC	National Action Plan on Climate Change
NATCOM	National Communication
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	Perfluorocarbons
PPs	Project Participants
REDD	Reducing Emissions from Deforestation and Forest Degradation
SBI	Subsidiary Body for Implementation
SBSTA	Subsidiary Body for Scientific and Technological Advice
Sf_6	Sulphur hexafluoride
SFDs	State Forest Departments
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 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 Earth's natural greenhouse effect makes life as we know it possible. However, 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 (Fig.1). The concentration of most common GHGs, i.e., CO_2 has increased since the beginning of the industrial revolution from 290 ppm to 396 ppm now, which is leading to unequivocal and continuing 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.

Fig : 1 Greenhouse Effect

Source: http://www.nps.gov/goga/naturescience/climate-change-causes.htm

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 the 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 (IPCC, 2013).

- According to AR5 of IPCC, the global surface temperatures have 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. It is extremely likely that human activities have caused more than half of the observed increase in temperature during 1951-2012 (IPCC, 2013). 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.

The assessment report further states that the global mean sea level has raised 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 and near surface permafrost as global mean surface temperature rises.

- It is extremely likely (95-100% probability) that human activities caused more than half of the observed increase in global average surface temperature from 1951 to 2010. (AR5, IPCC, 2014)

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 and Forests.

1.3.1 Likely impact on water resources

According to fourth assessment report of IPCC, Climate Change is expected to intensify current stresses on water resources (IPCC, 2007a). 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

The fourth assessment report has also mentioned 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 increases 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 reduced grain yield of rice (0 to 49%), potato (5 to 40%), green gram (13 to 30%) and soybean (11 to 36%). The linear decrease of grain yield per °C of temperature increase was 14%, 9.5%, 8.8%, 7.3%, and 7.2% in rice, potato, 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 (MoEF, 2012).

1.3.3 Likely impact on human health

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 terrestrial ecosystems

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, 2007a). For increase 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

A scientific study from Indian Network for Climate Change Assessment (INCCA, 2010) on prediction of future climate for India has indicated an all round warming over the Indian subcontinent associated with increasing GHGs concentrations. The study has projected a likely rise in annual mean surface air temperature by the end of the century 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 has increased 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 (MoEF, 2012).

Global Response to Climate Change

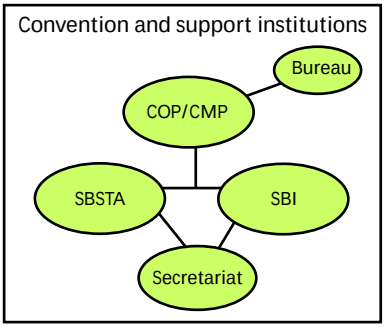
2.1 Background to UNFCCC

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 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 Summit. 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.

Background to UNFCCC (In chronological order)

First world Climate Conference	– 1979
Establishment of IPCC	– 1988
2nd Climate Conference and Ist 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
19 COP meeting in Warsaw	– 2013

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 .



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.

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.

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.

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, state that the level of concentrations should be reached in a time frame that allows ecosystems to adapt naturally, food security to be preserved and economic development to proceed in a sustainable manner.

Principles of UNFCCC

- Equity and Common but Differentiated Responsibilities
- A precautionary approach
- Development and Climate Change are interlinked

The Convention has laid down the following principle:

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

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 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.

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 support 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) and
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.2). 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 a National Clean Development Mechanism Authority chaired by the Secretary, Ministry of Environment, Forests 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/.

Total CDM Projects - 7530
(Globally as on 2nd July 2014)

China - 3,759 (49.9%)
India - 1,511 (20%)

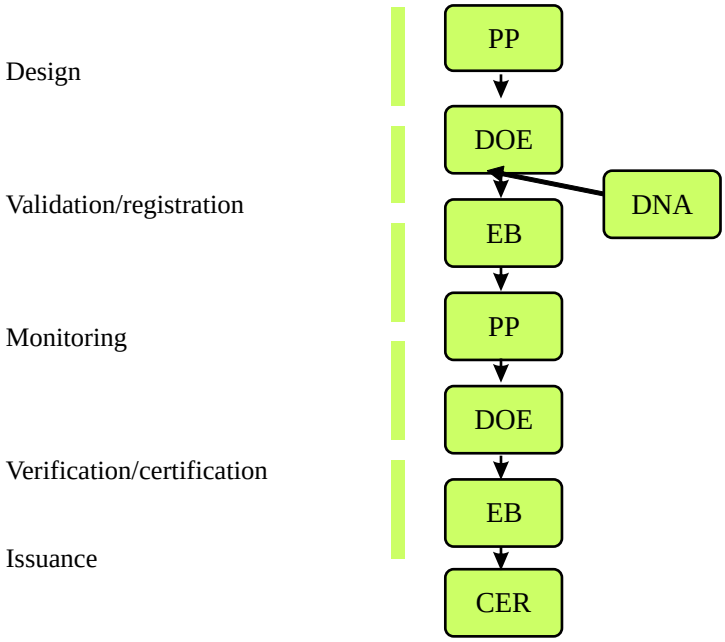


Fig: 2 CDM project cycle

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 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 2nd July 2014, a total of 7,530 projects have been registered under CDM at global level out of which 1,511 (20%) are from India. China has contributed maximum projects (3,759) which are 49.9% of CDM Projects registered globally. However, only 55 projects have been registered so far from forest sector at global level which constitutes 0.73% of the total projects (UNFCCC, 2014). This includes 9 forestry projects from India. 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).

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; 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.

On the other hand the forestry sector 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 such efforts 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 disposal. 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 watershed benefits, 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 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 on 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 occur from mere existence of forests and could be existence and bequest benefits. 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 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 Impact of Climate Change on Forests in India

A study by Indian Institute of Science, Bangalore (Ravindranath et al., 2006) covering the forests of the entire country, based on analysis of the 35,190 forested grids, reported that more than two third of forested grids are likely to undergo vegetation change by the year 2100. The study indicated that all major forest types are likely to be impacted by the projected Climate Change; however, the actual impacts may be more as different species respond differently to changing climate. A few endemic species may show a steep decline in population and may even become 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. On the positive side, the study reports that the average net primary productivity 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.

Later, another study using more sophisticated Climate Change assessment models assessed the likely impacts of Climate Change on forests of India for two future time-frames i.e., 2021-50, labeled as '2035' during which atmospheric CO_2 concentration is excepted to reach 490 ppm, and 2071-2100, labeled as '2085' during which atmospheric CO_2 concentration is expected to reach 680 ppm (Gopalkrishnan et al., 2011). It has projected that about 30.6% of the forested grids are likely to undergo change in vegetation by 2035 and similar change is expected to the extent of 45.9% by 2085 (MoEF, 2012). Vulnerability assessment carried out in the study showed that the vulnerable forested grids are spread across India. However, their concentration is likely to be higher in the upper Himalayan stretches, parts of Central India, Northern Western Ghats, and Eastern Ghats. In contrast, Northeastern forests, Southern Western Ghats, and the forested regions of Eastern India are projected to be least vulnerable to the changing climate. The study has also shown that low tree density and biodiversity status as well as higher levels of fragmentation contribute to the vulnerability of forests (Gopalkrishnan et al., 2011).

3.3.1 Pressures on Forest Resources

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; Bhuguna 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 discussed below.

i) 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 of annual sustainable yield. The total annual consumption of wood other than fuelwood i.e., wood for construction, household furniture, and industrial furniture is 48.0

million m^3 which also comes from the forests (FSI, 2012a). 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.

ii) Diversion of forest land 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-2011 (FSI, 2012a), of which a major part has been diverted for hydel power and mining projects. This is believed to have resulted in problems such as increased soil erosion and landslides.

iii) Unregulated grazing

Grazing and trampling of regenerated seedlings by livestock is the biggest threat to the regeneration of vegetation in all forested areas of the country. The National Biodiversity Strategy and Action Plan (GoI, 2002) has estimated that the requirement for green fodder is 1061 million tonnes per annum and for dry fodder is 589 million tonnes per annum. 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 reduction in the size of pastures and closing of some pastures for tree plantation has resulted in even greater pressure on the remaining area, especially along the forest fringes.

iv) Unregulated collection of NTFP including medicinal plant parts

The other major pressure on forest resources comes from the unsustainable harvesting of NTFPs which also includes medicinal plants parts. A serious consequence of the low productivity of agriculture and livestock is the over-exploitation of NTFPs including medicinal plant parts to supplement low incomes. For example, extraction of medicinal plant parts in alpine meadows for sale has resulted in over-exploitation of several herb species. Pressure is particularly high on high value medicinal plant parts such as Salampanja (*Orchis latifolia*), Kutki (*Picrorhiza kurroa*), Dhup (*Jurinea macrocephala*) and Atis (*Aconitum heterophyllum*) in NW Himalayas.

v) Forest fires

Uncontrolled fires have caused tremendous damage to the forest biodiversity of the country. Forest fires generally spread in two phases. The first phase occurs during late March and early April when fresh leaf litter, especially in Chir pine and dry deciduous forests, gets accumulated and burnt. The second phase of fire, which occurs in May-June, is more serious. 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. A total of 134,225 forest fires have been reported from 2004-2005 to 2010-2011 in the country, out of which 43% fires covering an area of 208,348 sq. km have been observed in moderately dense forests, 40% fires covering an area of 161,856 sq. km in open forests and the remaining over an area of 49,867 sq. km in very dense forests, (FSI, 2012b). Though, reliable data is not available on loss of carbon, but this must be substantial.

3.3.2 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, 2007b). 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.

As discussed above, the forest ecosystems in India are already subjected to heavy socio-economic pressures leading to forest degradation, and Climate Change will be an additional pressure on these ecosystems. Climate Change can significantly affect the availability of goods and services from forests 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 relying upon NTFPs for their livelihoods. Despite availability of projections on future climate, there is no certainty about the likely impacts of the Climate Change on the forests in India, yet it is imperative to begin developing adaptation strategies, based on the scientific studies carried out under similar ecological conditions. Some of the adaptation measures for the country's forests 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 the landscape integrity and avoid forest defragmentation.

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

iv) The State Forest Departments needs to strengthen the existing fire detection and management systems and work towards reducing the response time. Ensuring proper sanitation measures to prevent incidence of fire will also be very important.

v) Grazing being a State subject, the States need to come out with a policy on grazing, 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.

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

vii) Realizing the fact that wood is climate friendly unlike steel or cement concrete, there is a need to promote more wood production, use, and substitute it with steel and cement concrete. There is a huge scope of increasing the wood production by promoting age old practice of agro and farm forestry in the country. This however will require reforms in regulatory regime for growing, harvesting and utilization of wood production from farm lands.

viii) To build the capacity of the forest department to understand the vulnerability of the forest ecosystems to the changing climate. In this context capacity building programmes focusing on forest ecosystems and their future management would be important.

3.4 Mitigation Role and Sequestration Potential of Forest Sector

The types of forestry activities viz., afforestation and reforestations 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 Long

rotation tree species 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 by the authors. 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 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 mixed 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 bellirica*) 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/ya for Bahera (*Terminalia bellirica*) 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.

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 meter at maturity in-situ"*.

Thresholds for definition of 'Forest' for CDM projects

1. Minimum area of land: 0.05-1.0 ha
2. Tree crown cover: 10-30%
3. 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.

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; 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.

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

1. Minimum area of land: 0.05 ha
2. Tree crown cover: more than 15%
3. Minimum tree height: 2 meter

4.2.1 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.

i) 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.

ii) 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 years) 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.

iii) 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.

iv) 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.

4.3 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 9 forestry projects under CDM which is 16.3% of total 55 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

55 CDM projects from Forestry sector have been registered so far at global level and out of which 9 (16.3%) are from India

4.3.1 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 would be 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 & 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 Emergence and Development of REDD-plus

Deforestation and forest degradation are not only contributing to Climate Change but also have severe adverse impacts on a wide range of important products such as timber, fuelwood, paper, food and fodder as well as various ecosystem services like protection of soil and water resources, conservation of biological diversity, carbon sequestration and several other services provided by forests. Most of this deforestation and forest degradation is taking place in developing countries where millions of households depend on goods and services provided by forests and constitute an important source of livelihood and a safety net for the rural poor. In view of the highly significant environmental, social and economic potential of forests, the sector can make significant contribution to a low-cost global Climate Change mitigation portfolio that provides synergies with adaptation to Climate Change and sustainable development. To address these issues, a forest-based Climate Change mitigation option named as 'REDD' (Reducing emissions from deforestation and forest degradation), was initiated in 2005 in Montreal during the 11th Conference of the Parties (COP) negotiations for a post-Kyoto Climate Change regime, through a submission from Costa Rica and Papua New Guinea on behalf of the Coalition of Rainforest Nations. Subsequently during COP-12 in Nairobi, India's proposal of including the compensation for conservation of forest under the umbrella of forest-based mitigation measures was accepted and became the part of further negotiations.

The 'Bali Action Plan' agreed during 13th session of COP held in Bali, laid the foundation of subsequent negotiations on scope of this forest-based mitigation mechanism by consideration of policy approaches and positive incentives on issues relating to REDD. The nations affirmed the urgent need to take further meaningful action and decided on a two-year time frame to discuss the REDD framework. As a result, the 'Copenhagen Accord' agreed during COP-15 not only recognized the crucial role of reducing emission from deforestation and forest degradation but also acknowledged the role of conservation, sustainable management of forests and enhancements of forest carbon stocks in developing countries, which is referred as 'REDD-plus'.

A substantial improvement on REDD-plus was made in Cancun at COP-16, which set out the broad scope of REDD-plus in line with the 'Bali Action Plan'. The developing country parties were encouraged to contribute to mitigation actions in the forest sector by undertaking REDD-plus activities, viz., (a) Reducing emissions from deforestation (b) Reducing emissions from forest degradation (c) Conservation of forest carbon stocks (d) Sustainable management of forests and (e) Enhancement of forest carbon stocks, as deemed appropriate by each party and in accordance with their respective capabilities and national circumstances.

The countries aiming to undertake these activities were to develop a national strategy or action plan, a national forest reference emission level and/or national forest reference level, and a robust and a transparent national forest monitoring system. The agreement specified the implementation of REDD-plus in three phases; outlined the financing of REDD-plus through voluntary funds; and the promotion and support of social and environmental safeguards. The safeguards included prevention of negative impact activities such

Components of REDD-plus

i) Reducing emissions from deforestation;
ii) Reducing emissions from forest degradation;
iii) Conservation of forest carbon stocks;
iv) Sustainable management of forests; and
v) Enhancement of forest carbon stocks

as the conversion of natural forests to other land uses and to promote protection of biodiversity and ecosystem functions. It also ensures full participation of local communities and sustainable livelihoods, the addressing of gender issues, and respect for the knowledge and rights of indigenous peoples, as enshrined in the United Nations declaration.

The Climate Change talks in Durban (COP-17) centered around four key areas of REDD-plus, i.e., finance, safeguards, reference levels, and measuring, reporting and verification (MRV) of carbon emissions from forest activities. Significant progress on reference levels, and MRV was achieved with decisions on how to set reference emissions levels, and defining how to measure emission reductions stemming from forestry initiatives. However, the achievements on safeguards and REDD-plus financing, despite many deliberations, have been below expectations due to the weak decisions on social and environmental safeguards for the programme, and no advances on sources of long-term funding except setting up of 'Green Climate Fund', which had no real or promised money.

During COP-18 at Doha, it was decided to undertake a work programme to scale up and improve the effectiveness of REDD-plus finance by (a) transfer payments for results-based actions (b) incentivize non-carbon benefits and (c) improve the coordination of results-based finance. In COP-19 held last year at Warsaw, Governments have shown their firm commitment to reduce emissions from deforestation and forest degradation by delivering a set of seven decisions collectively termed as the 'Warsaw Framework' for REDD-plus. The significant set of decisions comprises decisions on results-based finance to give an impetus to the full implementation of activities; guidelines and procedures for the technical assessment of submissions from country parties on proposed forest reference emission levels and/or forest reference levels; modalities for measuring, reporting and verification (MRV); dissemination of information on safeguards; modalities of forest monitoring systems; institutional arrangements; and addressing drivers of deforestation. These decisions provide guidance for ensuring environmental integrity and pave the way towards the full implementation of REDD-plus activities on the ground. The 'Warsaw Framework' was also backed by pledges of US $280 million financing from the US, Norway and the UK to support developing nation actions to progress the full implementation of the activities under REDD-plus.

5.2 REDD-plus Architecture

REDD-plus framework is confronted with important issues centered on the design, scope and financing needs; its cost effectiveness; measuring, reporting, and verification (MRV) of carbon emissions from forests and social and environmental safeguards. Some of the other important issues such as ensuring several co-benefits of reducing emissions from forests and the definitions of important elements of proposed REDD-plus mechanism have not been addressed so far. These issues are still being debated, and the actual design and framework of REDD-plus has yet to take a final shape. Some of these important issues and challenges being faced by REDD-plus are discussed below.

i) Design and framework for REDD-plus

It is not yet decided whether REDD-plus will be a part of the existing UNFCCC mitigation architecture or it will be the part of a new universal climate agreement to be finalized by 2015 for post-2020 period. Another key issue is whether Afforestation and Reforestation, currently part of the CDM under the Kyoto Protocol, would be merged with REDD-plus in a comprehensive forest sector accounting framework.

ii) Financing REDD-plus

The financing mechanisms for REDD-plus have to be flexible and innovative, so that they can adapt to countries' changing needs and experiences. REDD-plus funding is required in three areas, viz, (i) up front investments in REDD-plus readiness activities like infrastructure, forest monitoring systems,

capacity building and demonstration activities (ii) ongoing costs of implementing national policies and measures and (iii) compensation payments to forest owners for forgone profits (Dutschke et al., 2008). The desired funding to exploit the REDD-plus potential can be arranged through Official Development Assistance and other forms of public funding for countries with restricted access to REDD-plus global mechanisms. The other option could be a market-based mechanism that would trade CERs similar to the CDM in an "offsets" market in which industrialized nations can purchase emission credits to offset their emissions and thus meet their respective emissions reduction commitments.

iii) Setting the reference level for REDD-plus payments

There are three types of the 'baselines' emerging in the current debate. These are: (i) the historical baseline, which is the rate of deforestation and degradation (DD) and the resulting GHG emissions over the past x years (ii) the projected business-as-usual (BAU) scenario, that is, how would emissions from DD evolve without the REDD-plus activity, and (iii) the crediting baseline, that is, the level at which REDD-plus payments should start (Angelsen, 2008). A BAU baseline is the benchmark for assessing the impact of REDD-plus measures that were implemented (and ensuring additionality), whereas the crediting baseline is the benchmark for rewarding the country or the project if emissions are below that level. Almost all submissions from different countries use historical deforestation as the point of departure, and most also recommend that 'national circumstances' and 'rewarding early action' be taken into account. These principles however still have to be put into practice.

A key dilemma facing negotiating country parties is that, on the one hand, generous baselines, based on 'country-by-country' assessments that take national circumstances into account, may create 'tropical hot air', which undermines overall real emissions reductions and the credibility of REDD-plus. On the other hand, too-tight crediting baselines may make an agreement unacceptable. In short, some kind of balancing is required between the risk of 'tropical hot air' and the participation and political acceptance of REDD-plus by the country parties for the success of negotiations and this is likely to be the key to success.

iv) Measuring, Reporting, and Verification (MRV) of carbon emissions from forests

It is concerned with different forest monitoring technologies and the trade-offs between the different methods. There are two main methods for measuring the C-stocks: (i) the stock-difference approach, which measures forest carbon stocks at different points in time, and (ii) the gain-loss approach, which estimates the net balance of additions and removals from the carbon pool. There is a trade-off between the cost and the accuracy of the methods. In some countries, the need for a high level of precision requires the use of fine-resolution remotely sensed data to detect forest degradation or small-scale deforestation, which comes at a cost. Similarly, ground measurements, crucial to verify and measure carbon stocks, are time consuming and relatively expensive at a large scale, such as a national inventory.

As the capacity of countries to carry out MRV is highly variable, a global REDD-plus scheme must be flexible enough to avoid discrimination against countries with poor MRV capacity. A phased approach is recommended to allow for capacity building, to let countries gain experience, and to eventually integrate them into a performance-based payment mechanism in a future climate regime. Incentives should be put in place that encourage more accuracy and efficiency, and provide support for capacity building. To overcome national capacity and cost constraints, the option of centralized monitoring by an international institution can also be explored (Wertz-Kanounnikoff et al., 2008).

v) Achieving REDD-plus co-benefits

REDD-plus co-benefits are one of the reasons why it has claimed substantial attention in international climate negotiations. It has the potential to alleviate poverty, protect human rights, improve governance, conserve biodiversity, and provide other environmental services, i.e., co-benefits, as well as reduce GHG emissions. Each co-benefit is required to be linked with specific design features of REDD-

plus at the global and national levels so that the co-benefits can be achieved without undesirable consequences. Integrating REDD-plus into mainstream economic development strategies is important to benefit the poor and lead to performance-based payments, data transparency and financial accountability. Further, international scrutiny could exert a positive influence on human rights and governance. In addition, biodiversity benefits can be enhanced by geographically targeting vulnerable areas (Brown et al., 2008).

5.3 India's stand on REDD-plus

The submission from Ministry of Environment, Forests and Climate Change, Govt. of India on REDD-plus provides a framework of approach to develop and implement a national REDD-plus strategy and actions pursuant to relevant COP decisions for assessment and monitoring of forest carbon stocks (MoEF, 2011a; MoEF, 2011b). India's national strategy aims at increasing and improving the forest and tree cover of the country for enhancement of forest ecosystem services that flow to the local communities. The services include fuelwood, timber, fodder, NTFP and also the carbon sequestration. The country recognizes that carbon service from forest and plantations is one of the co-benefits and not the main or the sole benefit. Initiatives like Green India Mission (GIM) and National Afforestation Programme (NAP), together with programmes in sectors like agriculture and rural development are expected to add or improve 2 million ha of forest and tree cover annually in the country. With a conservative sequestration level of 1t C per ha, this would annually sequester 2 million tonnes of carbon incrementally, and post 2020, the forest and tree cover will be adding at least 20 million tonnes of carbon every year. This would require an annual investment of Rs. 90 billion for 10 years. The country expects a substantial part of this investment to be met under REDD-plus financing from different sources including UNFCCC (MoEF, 2012). The Government of India may also initiate a process under various schemes such as NAP, CAMPA and GIM to reward the conservation efforts of communities with the parameters of enhancing carbon and associated ecosystem services.

i) Institutional mechanism for REDD-plus at national level

The Government of India has established a 'REDD-plus Cell' in the Ministry of Environment, Forests and Climate Change (MoEFCC) having the task of coordinating and guiding REDD-plus related actions at the national level, and to discharge the role collaborating with and of guiding the State Forest Departments (SFDs) to collect, process and manage all relevant information and data relating to forest carbon accounting. National REDD-plus Cell is to also guide formulation, development, funding, implementation, monitoring and evaluation of REDD-plus activities in the States. The Cell is also expected to assist the MoEF and its appropriate agencies in developing and implementing appropriate policies relating to REDD-plus implementation in the country.

ii) National level forest carbon stocks accounting

Forest carbon stock accounting at national level has been institutionalized by making FSI the lead Institution for the country, which will have a networking approach involving other national level institutions, viz., Indian Council of Forestry Research and Education (ICFRE), Indian Institute of Remote Sensing (IIRS), Indian Institute of Science (IISc), Wildlife Institute of India (WII), and any other organization that FSI deems fit to co-opt. The country intends to further work on i) technological and methodological issues, and ii) policy and definitional issues to be able to contribute proactively in the future deliberations of the UNFCCC on REDD-plus.

The forest carbon stocks of the entire country will be compiled at the national level, and will comprise such stocks corresponding to the forest cover and trees outside forest in the country. These stocks once accounted for in the first accounting period shall continue to be accounted for in the subsequent accounting periods also. The country also advocates that the reference emission level/reference level shall

be fixed in an open and transparent manner following the procedure agreed for the purpose, which will include independent expert review by UNFCCC.

iii) Methodological issues

India's future strategy in this regard is to devolve more and more responsibility on the SFDs to carry out the assessment and estimation of forest carbon stocks (FCS) in conjunction with the biennial exercise of assessment of forest and tree cover (FTC). This is considered essential to improve the precision level for estimation of FCS as the State Governments can cover more number of sample points, than that being covered by the FSI at present due to constraints of time, finances and inadequate number of technical experts. In future, the SFDs can take the responsibility of carrying out the inventories for FCS and FTC by more effectively utilizing the services of their Remote Sensing Application Centres. FSI at that time can act as the source for providing remotely sensed data required by the States for the purpose of carbon accounting.

iv) Definitional and policy issues

Government of India has proposed that the terms which are being used in REDD-plus text, like deforestation, forest degradation, conservation, sustainable management of forests, enhancement of forest carbon stocks, national forest reference level/national forest reference emission level, and others should be clearly defined. More insight into understanding the definition of sustainable management of forest (SMF) is required to steer its proper application in forestry-based mitigation actions in different parts of the country. In ensuring the safeguards for the rights of the local communities including tribals, and above all, of women folk of the local communities, India intends to involve civil society and SFDs in working out provisions and modalities for the same under the extant Forest Rights Act, and approaches of Joint Forest Management.

v) National forest reference level

The country gives highest priority to fixing of the reference level for carbon stocks in its forest and tree cover for measurements, reporting and verification of baseline and incremental forest carbon stocks. The country considers that the reference level in essence will be a baseline forest carbon stocks position corresponding to a specific year, which may be called the 'zero year' and needs to be fixed with consensus amongst intra-country stakeholders that would include the Central Government, State Governments, forest experts, scientists, local communities and the civil society. It is presumed that the starting point for fixing a forest reference level will be an agreement on the 'zero year' backed by sound logic, time series of scientific historical data, and milestones of relevant legislation and policy prescriptions.

vi) Social and environmental safeguards

Developing countries are expected to follow safeguards, with a view to ensure full participation of indigenous peoples including tribals, local communities, women and other stakeholders, and conservation of natural forests and biodiversity in implementing the REDD-plus activities. India intends to ensure that all REDD-plus incentives available from international sources will flow fully and adequately to the local communities which participate in management of forest resources or are dependent on them for sustenance of their livelihood. A part of the incentives is also expected to be invested in conservation and improvement of the ecosystem services like biodiversity conservation and non-timber forest produce.

vii) Financing mechanism for REDD-plus

As per provisions of REDD-plus mechanism, the countries need to explore financing options for full implementation of the results-based actions. India has reiterated its position of favouring a flexible combination of market-based and non-market based financing approaches. The country is likely to propose

a market-based approach for fluxes with respect to a reference level for actions viz., (a) Reducing emissions from deforestation (b) Reducing emissions from forest degradation (c) Sustainable management of forest and (d) Enhancement of forest carbon stocks; and a non-market based approach for stocks with reference to actions viz., (e) Conservation of forests carbon stocks and (f) Sustainable management of forests.

5.4 REDD-plus Readiness in India

5.4.1 Measuring, Reporting and Verification of Carbon for REDD-plus

A robust yet simple monitoring mechanism is essential for successful implementation of REDD-plus in India. FSI has been assigned the job for the measuring, reporting and verification of carbon assessment for the relevant REDD-plus components. It has also been suggested that the year 2000 which marked the beginning of digital recording of data may be taken as 'zero year' and the carbon may be assessed by adding above ground and below ground carbon estimated using IPCC guideline. However, there is a need to build the capacity of SFDs with respect to MRV and carbon assessment. The expertise available with FSI and other institutions like the National Remote Sensing Centre (NRSC) and Indian Council of Forestry Research and Education (ICFRE) could also be effectively utilized. Additional elements to capture information relevant for REDD-plus initiatives could be built into their existing monitoring systems along with application of emerging technologies in Remote Sensing and GIS.

5.4.2 Safeguards measures, co-benefits and local community involvement

REDD-plus mechanism provides adequate safeguards to the rights of the local forest dependent community and biodiversity. It is to be ensured that there should be an equitable benefit-sharing mechanism for the success of the REDD-plus programme among the forest dependent communities. As the communities in forest fringe villages are actively protecting and managing forests, they can be crucial for implementing REDD-plus by involving them more directly to the management and conservation framework of forests. REDD-plus is a low-cost mitigation option with multiple co-benefits for forest dependent communities and biodiversity conservation. It has to be ensured that forest biodiversity is not sacrificed for carbon and there should be adequate safeguards to it while implementing the REDD-plus progress. All key stakeholders and community based organizations at the grassroots level need to be involved in designing, implementing, and monitoring of REDD-plus activities. There are more than 100,000 JFM Committees in the country managing around 22 million ha of degraded forests. There is a tremendous potential for rejuvenating these degraded forests by tailoring community-based conservation strategies aligned with the implementation of REDD-plus. Therefore, the country is in an advantageous position to take the lead in REDD-plus implementation if it is able to utilize the existing network of JFM Committees, which encompass around 30% of its forest areas.

5.4.3 Capacity building

REDD-plus activities need to be mobilized at the local level by engaging local communities in drawing a working plan and a budget. There is a need to build capacity of forest dependent communities for carbon assessment and project formulation under REDD-plus which should be a simple, easy and step-by-step approach at various levels, so that they can benefit from finances generated from the selling of enhanced carbon. There is need for identification and creation of a Centre of Excellence for REDD-plus from which State Governments could take technical assistance for capacity building of these key stakeholders. There is a need for greater thrust on research in relevant areas of REDD-plus and transferring the knowledge to field in simple language for benefit at field level.

To significantly strengthen REDD-plus action, MoEF and SFDs need to organize regular capacity building workshops for stakeholders at national, state and regional level. These workshops could create

awareness and later provide training to forest officials and JFM Committees on REDD-plus concept, assessment and monitoring of carbon and related issues. There is need to build capacity of forest dependent communities for carbon assessment and monitoring under REDD-plus which should be simple, easy to understand and a step-by-step approach so that quality standards as required under MRV may be fulfilled.

5.4.4 Institutional Framework, Policy & Governance for REDD-plus

The Government of India needs to put in place a suitable institutional mechanism at national, sub-national and local levels for the implementation of REDD-plus, besides defining linkages with emerging international mechanism for REDD-plus. There is an urgent need of developing a national level strategy for implementation of REDD-plus which should also necessarily take into account the issues of regional variability. The role of other concerned Ministries, Departments, Institutions, and the private sector also needs to be worked out to supplement and support REDD-plus implementation. There is a great scope of convergence of developmental programmes in areas within forest and fringe forest areas from Rural Development, Tribal and Social Welfare, Health, Education, and Power Development Departments.

The State Governments need to evolve a Gram Sabha-based forest governance model and bring appropriate reforms to empower Gram Sabhas to play a key role for implementation of REDD-plus. The Gram Sabha should be the core body to constitute the committee on REDD-plus and Joint Forest Management Committee while the State Forest Department can provide the technical guidance for monitoring the implementation of management plan. The corporate sector, being an emitter of GHGs, must play a role in carbon sequestration through sustainable development of forests.

5.4.5 Financing of REDD-plus Pilots

The Government of India should make efforts to overcome the inadequacy of financial resources for the implementation of sustainable management of forests for enhancing carbon stocks. Though international policies with respect to REDD-plus are still at the negotiation stage, the country has to prepare itself for implementation of REDD-plus projects and make use of the funds available through carbon financing. Therefore, the GoI should fund at least one pilot study on REDD-plus in each State of the country. Since there is no regulatory market operational for REDD-plus, Government of India should avail the funding from voluntary markets for preparedness activities including undertaking research and pilot projects. A few voluntary mechanisms like Plan Vivo, VCS, and Forest Carbon Partnership Facility (FCPF) of World Bank and UN-REDD are the windows available for carbon finance and preparedness for REDD-plus but the country has not joined these facilities as yet.

For operationalization of REDD-plus, there is need to take up pilot projects also for identification of gaps in technological and implementation aspects. The Government of India may establish linkage with FCPF and UN-REDD so that grants may be obtained for the capacity building of communities and forest officials for the implementation of REDD-plus. Community Forest Resource Committees in the Gram Sabha, Van Panchayats and JFMCs, are the appropriate institutions to start with REDD-plus pilot projects in India jointly with the support of State Forest Departments.

5.5 Green India Mission

The national mission for a Green India is one of the eight missions under the National Action Plan on Climate Change (NAPCC). The Green India Mission (GIM) recognizes that Climate Change phenomena will seriously affect and alter the distribution, type and quality of natural forests of the country and the associated livelihoods of the people.

Aims of GIM

- Enhancing carbon sinks in sustainably managed forests and other ecosystems;
- Adaptation of vulnerable species/ecosystems to the changing climate; and
- Adaptation of forest-dependent communities.

GIM has been tailored as a comprehensive strategy for Climate Change adaptation and mitigation, which also aims to enhance ecosystem services from forests such as carbon sequestration and storage, hydrological services, biodiversity conservation; as well as other provisioning services such as fuelwood, fodder, small timber and non-timber forest products.

The Mission aims at addressing Climate Change by enhancing carbon sinks in sustainably managed forests and other ecosystems; enhancing the resilience and ability of vulnerable species/ecosystems to adapt to the changing climate; and enabling adaptation of forest-dependant local communities in the face of climatic variability. These aims are envisaged to be accomplished through four major objectives which have to be achieved by 2020 (NMGI, 2011). These are: increased forest/tree cover on 5 million ha of forest/non-forest lands; improved quality of forest cover on another 5 million ha; improved ecosystem services including biodiversity, hydrological services and carbon sequestration as a result of treatment of 10 million ha.; increased forest-based livelihood income of about 3 million households living in and around the forests; and enhanced annual CO_2 sequestration by 50 to 60 million tonnes by the year 2020 and onwards. The total budget approved for the mission is Rs 46,000 crores over 10 years covering both Centre and the States.

Within the overall objective of treating 10 million ha of forest and non-forest area, the Mission has specific targets for different forest types and ecosystems which will enable achievement of its overall objectives. The Mission targets: (a) qualitative improvement of forest cover/ecosystem in moderately dense forests (1.5 million ha), open degraded forests (3 million ha), degraded grasslands (0.4 million ha) and wetlands (0.1 million ha) (b) eco-restoration/afforestation of scrub, shifting cultivation areas, cold deserts, mangroves, ravines and abandoned mining areas (1.8 million ha) (c) bringing urban/peri-urban lands under forest and tree cover (0.20 million ha) and (d) agro-forestry/social forestry (3 million ha).

5.6 The Way Forward

During the conference of parties (COP) held in Durban in 2011, the Ad-hoc Working Group on the Durban Platform for Enhanced Action (ADP) was established to develop a protocol, another legal instrument or an agreed outcome with legal force under the Convention, applicable to all Parties for post 2020 implementation. The ADP is to complete its work as early as possible, but no later than 2015, in order to adopt this protocol, legal instrument or agreed outcome with legal force. As the negotiations become increasingly complex, fundamental differences continue to grow and separate various coalitions of nations. Groups have yet to resolve central issues such as the magnitude of national emissions commitments; the means of implementation-particularly finance, technology transfer and capacity building; agreement on basic principles-common but differentiated responsibilities, equity, and historical responsibility; and whether the ultimate agreement will be legally binding.

The post-2020 agreement faces daunting, substantive and procedural challenges. Indeed, limiting global temperature rise to 2°C would require major emitting nations to reduce emissions by 50-80% by 2050. Many, including rapidly growing developing countries, are unwilling to accept such stringent targets. In addition, estimates of the financial aid required to assist developing countries are expected to rise from hundreds of billions of dollars per year in the near future to trillions of dollars per year by 2050. In such a complex situation, it seems that the ultimate climate agreement is more likely to reflect bottom-up pledges based on national priorities and circumstances than a forced, top-down reconciliation designed to meet non-binding, aspirational global goals to cut down emissions. The forest sector, however, has gained importance during the last several years because of 'REDD-plus' framework which is likely to remain at centre stage and form an important component of post-2020 Climate Change mitigation regime.

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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			
Pine block	4.81	17.65	5295/-
Oak-Pine Mixed block	3.69	13.53	4059/-
Mixed species**	3.99	14.65	4395/-

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

** *Alnus nepalensis, Pyrus pashia, Aesculus indica, Fraxinus spp.,* Oak, *Cupressus* etc.

Table: 2 CDM Forestry Projects Registered from India up to 2nd July, 2014. (Total: 55, India: 9)

S. No	Title of Project	Project location	Date of registration	Host party	Other parties	Reduction per annum (tCO_2)	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 and 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 and 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	*Casurina 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, *Casurina equisetifolia* & Clonal *Eucalyptus*	tCER	30 years	AGB, BGB
5	H.P Reforestation Project-Improving Livelihoods and Watersheds	Project located in 177 GPs in 11 watershed divisions of Mid-Himalayan Watershed Development Project (MHWDP) of H.P.	04.03.2011	India	Switzerland Ireland Spain	41,400	4003.07	420	45 tree species, mainly local species	tCER	20 years	AGB, BGB & SOC

S. No	Title of Project	Project location	Date of registration	Host party	Other parties	Reduction per annum (tCO_2)	Project area (ha)	No. of land parcels	Species selected	Choice of CERs	Crediting period	C-Pools chosen
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 & Anacardium occidentale* etc.,	ICER	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
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, Prosopis cineraria, Acacia tortilis, Albizzia lebbek, Tamarindus indica, Syzygium cumini, Ficus* spp., *Ailanthus excelsa, Butea monosperma, Dalbergia sissoo, Azadirachta indica, Zizyphus muaritiana*	tCER	30 yrs	AGB, BGB

*S.S. Project - Small scale project

About IGNFA

Indira Gandhi National Forest Academy functions as a staff college for Indian Forest Service officers with a mandate to prepare a cadre of professionally trained forest officers to manage India's precious forest resources and to serve as an apex institution for capacity building of IFS officers. The cardinal principle of the Academy is to develop knowledge, skill and a professional attitude towards forestry by way of capacity building through trainings. During the professional training and various in-service courses, the forest officers are exposed to a wide variety of forestry management aspects in the country, latest developments and emerging trends in forestry as well as ingredients of participatory approach enabling them to manage forest resource base of the country on principle of sustainable development and to meet aspirations of people for goods & services from forestry sector besides ensuring ecological security of the country.

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