India’s proposed Modified

Submission on Forest Reference Levels for REDD+ Result based Payments under UNFCCC

Content

Acronyms and Abbreviations

AFOLU	Agriculture, Forestry and Other Land Use
AGB	Above Ground Biomass
BGB	Below-ground Biomass
COP	Conference of the Parties
DOM	Dead Organic Matter
FREL	Forest Reference Emission Level
FRL	Forest Reference Level
FSI	Forest Survey of India
FTM	Forest Type Mapping
GIM	Green India Mission
GIS	Geographic Information System
GPG	Global Greenhouse Gas
GPG	Good Practices Guidance
GPS	Global Positioning System
IPCC	Intergovernmental Panel on Climate Change
IRS	Indian Remote Sensing (Satellite)
ISFR	India State of Forest Report
JFM	Joint Forest Management
LISS	Linear Imaging and Self-scanning Sensor
LULUCF	Land Use, Land-use change and Forestry
MDF	Moderately Dense Forest
MoEF&CC	Ministry of Environment, Forest & Climate Change
MRV	Monitoring Reporting and Verification
NAPCC	National Action Plan on Climate Change
NDVI	Normalised Difference Vegetation Index
NFI	National Forest Inventory
NFMS	National Forest Monitoring Systems
NFP	National Forest Policy
NTFP	Non Timber Forest Products
NWPC	National Working Plan Code
OF	Open Forest
PAs	Protected Areas
PESA	Panchayat (Extension to Scheduled Areas)
REDD+	Reducing Emissions from Deforestation and Forest Degradation
SFR	State of Forest Report
SMF	Sustainable Management of Forest
SOC	Soil organic Carbon
SOI	Survey of India
TOF	Trees Outside Forest
UNFCCC	United Nations Framework Convention on Climate Change
VDF	Very Dense Forest
WII	Wildlife Institute of India

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Forest Reference Level for REDD+ in India

Summary: India has used the historic period of 2000-2008 for the construction of Forest Reference Level (FRL). The activity chosen for the FRL is Sustainable Management of Forest. All the five pools have been considered and only CO2 gas has been taken into account for the construction of FRL. FSI has used IPCC; GPG 2003 guidelines for construction of FRL. As per the suggestions of Assessment Team (AT), following changes have been made in the Initial submission:

1. All the editorial changes suggested by AT has been incorporated at the relevant places.
2. All new additions have been highlighted with red colour and word/sentences to be deleted are strike off.
3. List of acronyms has been added in the beginning.
4. Content table has been revised.
5. At section 2.2, Existing Legal and Policy Framework in India has been added by replacing the old section 2.2 Governance.
6. Additional clarifications have been added wherever required based on AT questions
7. Change matrix for 2000-2004 has been added in annexure 6. Depiction of satellite image (FCC) and corresponding classified image has been added at annexure-7

1. Introduction

REDD+ as it is reflected in paragraph 70 of Decision 16/CP.1,referred to 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 suggested by AT). Abatement of forest-based CO_2 emission is critical to limiting global warming. As per the latest Assessment Report 5 (AR 5) of IPCC, the AFOLU sector contributes about 20-24 % of total emission. These emissions are mainly taking place in tropical developing countries.

The Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC) adopted at its sixteenth session (COP-16) a milestone decision on Reducing Emissions from Deforestation and Forest Degradation (REDD+). This decision encourages developing countries to develop a "National Forest Reference Emission Level (FREL) and/or National Forest Reference Level (FRL) or, if appropriate, as an interim measure, sub-national FREL and/or FRL, in accordance with the national circumstances". FREL and FRL serve as benchmark for assessing performance of implementation of REDD+ in a country. A country that undertakes the activities reducing emissions from deforestation and/or reducing emissions from forest degradation will use the FREL as the benchmark to assess progress of its performance (as suggested by AT). On the other hand, FRL is relevant benchmark when a country undertakes to implement the activities for

enhancement of forest carbon stocks; conservation of forest carbon stocks; and sustainable management of forests (as suggested by AT).

This decision necessitates the development of a National Forest Reference Emission Level (FREL)/ Forest Reference Level (FRL), adjusting for national circumstances, if required. The Ministry of Environment, Forest and Climate Change has given a project to Forest Survey of India, entitled Development of Forest Reference Level for REDD+ in India in January 2015.

2. National Circumstances

2.1 Forest Resources and Pressure on forest

India is a vast country with a rich biological diversity. It is one of the 12 mega diversity countries having a vast variety of flora and fauna, commanding 7% of world's biodiversity and supporting a variety of forest types, varying from the alpine forests in the Himalayas thorn forests in the hot deserts, from dry deciduous forests to wet evergreen forests and mangroves. There are 16 forest type groups and 221 forest types in India. With about 2.5% of the world's geographic area and about 2% of forest area, India at present is supporting 16% of the world population and 18% of the cattle population. The total forest area of the country is 7,67,419 sq km. Forest is the second-largest land use in India after agriculture. Roughly, 275 million rural people in India depend on forests for at least part of their subsistence and livelihood (World Bank, 2006). As per the India State of Forest Report (FSI, 2017), the forest cover of the country stood at 708,273 km^2, while it was 701,495km^2 in 2015 updated assessment (FSI, 2017), recording an increase of 6778 km^2 within two years. The National Forest Policy of India envisages 33% of its geographical area under forest and tree cover. The total forest and tree cover of the country is 24.4% of its geographical area. The country has very low per capita forest cover of 0.06 ha. The forest cover in the country is not uniform and varies in different States and regions. Mainly it is concentrated in Himalayas, north eastern states, central India and Western Ghats.

The energy from wood resources is an important parameter to define the social functions performed by the forests. This social function of the forests has been given due consideration, while judging the sustainability of forest resources and preparing management plans. The human population using the fuelwood as main source of cooking is 854 million (Annexure-4). Similarly, grazing and collection of fodder for livestock in forest not only help them to feed but provide a ground for breeding as well. Certain tribal communities keep herds of cattle & sheep. The number of such cattle & sheep are considered as status symbol in their communities. Such communities though do not have their own grazing ground for the cattle, they depend largely on forest. Hence, the dependence of human & cattle population on forests speaks about the social function of forests. As per ISFR 2011, the dependence of biomass consuming livestock on forest is about 37 percent (Annexure-5).

2.2 Existing Legal and Policy Framework in India

The policy and legal framework that has evolved in tune with the Constitutional provisions are effectively attuned to safeguarding the natural resources of the country including forests, wildlife and biodiversity in general. This framework guides and directs the sustainable management of forests ensuring the conservation of biodiversity and also respecting and upholding the rights of the local communities on lands and forest products.

Various acts and legislations in India are a strong testimony of country's commitment to the philosophy of forest conservation. Provisions of the Policies and Acts described hereafter are in tune with the constituents of REDD+. Further, the people centric approach adopted in the management of forests for almost over three decades supports the important precept of REDD+ that natural resources are to be conserved and protected for enhancement of ecosystem services for the benefit of local community dependent thereon. The other safeguards inherent in the concept of REDD+, i.e., conservation and preservation of biodiversity, enhancement of ecosystem services, respect for knowledge, traditions and rights of local communities, and open and transparent forest governance, etc. are fully covered under various legislations mentioned below. A brief mention of the relevant legislations in the following paragraphs brings out clearly the synergy and support of the legislations for implementation of REDD+ in India.

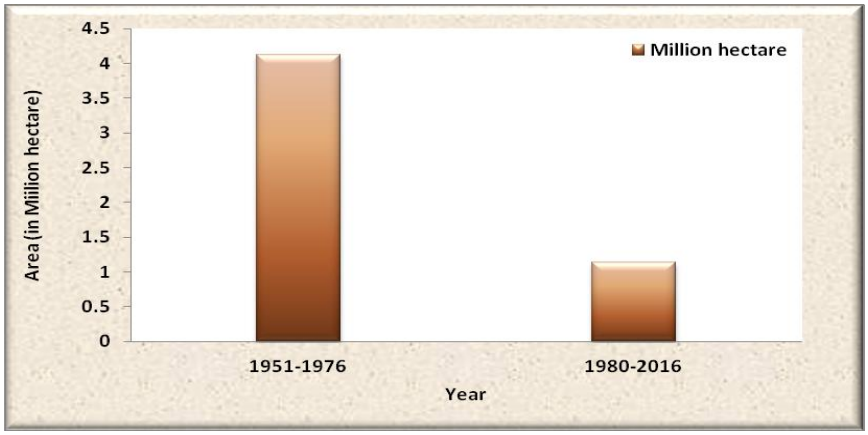
2.2.1 Indian Forest Act, 1927: This is the country-wide Act to consolidate the law relating to forests, the transit of forest-produce and the duty leviable on timber and other forest-produce. Proper implementation of the provisions of this Act is capable of ensuring conservation of biodiversity of the natural forests as also enhancing the quality and extent of the forest and tree cover in the country, which, in turn, contribute to enhance REDD+ performance.

2.2.2 Wild Life (Protection) Act, 1972: As this Act provides for the protection of wild animals, birds and plants and for matters connected therewith or ancillary or incidental thereto, it perfectly synergises with the adherence to safeguards of REDD+ relating to conservation of biodiversity and non-conversion of natural forests into plantations.

2.2.3 Water (Prevention and Control of Pollution) Act, 1974: This is the Act to provide for the prevention and control of water pollution and maintaining or restoring wholesomeness of water. REDD+ implementation will need to ensure soil and water conservation, and to avoid activities that would adversely impact the quality of natural or stored water.

2.2.4 Forest (Conservation) Act, 1980: The Forest Conservation Act, 1980 is one of the most effective legislations contributing to reduction in deforestation. This was enacted to reduce indiscriminate diversion of forest lands for non-forestry purposes, and to help regulate and control the land use changes in forests. The Act empowers only the Union Government to allow the diversion of forest for non-forestry use. With the enactment of this act, the deforestation and conversion of forest lands to non-

forest use has been drastically reduced. The pace of diversion of forest land for non-forest purposes was around 1,60,000 hectares per annum from 1951 to 1976. It come down drastically to 32,000 ha annually (MoEFCC, 2016) during 1980-2011 after the implementation this Act (Figure 2.1). Being an Act for regulating diversion of forest land for non-forestry purposes, and to strike a balance between conservation and development, it helps to enhance performance of REDD+ implementation in the country by supporting conservation and improvement of natural forests.



(Source: MoEFCC, 2016)

Figure 2.1: Impact of Forest (Conservation) Act, 1980 on pace of forest diversion for non forest purpose

2.2.5 Air (Prevention and Control of Pollution) Act, 1981: This Act provides for the prevention, control and abetment of air pollution making it obligatory on REDD+ activities not to give rise to or abet air pollution.

2.2.6 Environment (Protection) Act, 1986: An act to provide for protection and improvement of environment and for matters connected therewith, it empowers the Central Government to establish authorities to prevent pollution in all its form and to tackle specific environmental problems that are peculiar to different parts of the country. REDD+ activities need to ensure that their implementation does not result in any abetment of pollution of air, water, land or any other natural resource.

2.2.7 National Forest Policy, 1988: The principal aim of National Forest Policy (NFP), 1988 is to ensure environmental stability and maintenance of ecological balance. The policy aims for maintaining one-third of the country's geographical area under forest and tree cover and calls for massive afforestation and social forestry programmes with people's participation for increasing the forest and tree cover in the country. The core aim of NFP perfectly synergises with REDD+ objective of climate change mitigation in forestry sector. More the area under forest, more the mitigation service it will provide.

The National Forest Policy (1988) is presently under revision. The overall objective and goal of the draft National Forest Policy (2018) is to safeguard the ecological and

livelihood security of people, of the present and future generations, based on sustainable management of the forests for the flow of ecosystem services. In order to achieve the national goal for eco-security, the country should have a minimum of one-third of the total land area under forest and tree cover.

The draft National Forest Policy (2018) also lays emphasis on Integrating climate change mitigation and adaptation measures in forest management through the mechanism of REDD+ so that the impacts of the climate change are minimised. Under the draft policy strategic actions especially sustainable forest management will be taken to strengthen forest-based climate change mitigation and adaptation.

2.2.8 Panchayat (Extension to Scheduled Areas) Act, 1996: The Panchayat (Extension to Scheduled Areas), 1996 also known as PESA, was enacted to enable Tribal Self Rule in these areas. The Act extended the provisions of Panchayats to the tribal areas of nine states that have Fifth Schedule Areas. Most of the North eastern states under Sixth Schedule Areas (Assam, Meghalaya, Tripura and Mizoram where autonomous councils exist) are not covered by PESA, as these states have their own Autonomous Councils for governance. PESA gives special powers to the *Gram Sabhas* in scheduled areas especially for the management of natural resources.

2.2.9 Biological Diversity Act, 2002: The Act provides for conservation of biological diversity, sustainable use of its components and fair and equitable sharing of the benefits arising out of the use of biological resources knowledge and for matters connected therewith or incidental thereto. Essence of this Act is manifest in the core concept of REDD+ implementation, which provides for uncompromising safeguards for conservation of biological diversity of natural forests, and also for upholding the rights of the local communities who are privy to the knowledge about different uses of forest biodiversity.

2.2.10 National Environment Policy, 2006: This policy which builds on the existing policies related to preservation of natural resources is intended to guide action in developing regulatory reforms, and programmes and projects for environmental conservation by the Central and State Governments. The dominant theme of the policy is that the people dependent on natural resources for their livelihood obtain better livelihood from conservation than from degradation of resource. The policy emphasises partnership of different stakeholders. If local communities are motivated to enhance and conserve the forest and wooded areas, they get the benefit of enhanced goods and services generated from the forest ecosystems. Mitigation is one of the services provided by a forest ecosystem, and thus add quantum to REDD+ performance.

2.2.11 The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006: This is the important Act to recognise and vest the forest rights and occupations in forest land in forest dwelling scheduled tribes and other traditional forest dwellers who have been residing in such forests for

generations but whose rights could not be recorded; and to provide for a framework for recording the forest rights so vested and the nature of evidence required for such recognition and vesting in respect of forest land. Implementation of this Act contributes towards adherence to the safeguards related to rights of the local communities with respect to their proprietorship of land and non-timber forest products.

2.2.12 The National Green Tribunal Act, 2010: This Act enables creation of a special tribunal to handle the expeditious disposal of the cases pertaining to environmental issues. The stated objective is to provide a specialized forum for effective and speedy disposal of cases pertaining to environment protection, conservation of forests and for seeking compensation for damages caused to people or property due to violation of environmental laws or conditions specified while granting permissions.

2.2.13 National Water Policy, 2012: The objective of the National Water Policy is to take cognizance of the existing situation, to propose a framework for creation of a system of laws and institutions and for a plan of action with a unified national perspective. The policy also stated that conservation of rivers, river corridors, water bodies and infrastructure should be undertaken in a scientifically planned manner through community participation.

2.2.14 National Agroforestry Policy, 2014: The policy underlines the environmental contribution of agroforestry by preventing deforestation, and promoting carbon storage, biodiversity conservation, and soil and water conservation. Agroforestry provides employment to rural as well as urban people through production, industrial processing and value addition of the tree products. The policy perfectly synergises with objectives of REDD+ implementation in the country by explicitly supporting the coverage of trees outside forest (TOF), and by preventing decimation of natural forests.

2.2.15 National Working Plan Code-2014: According to National Working Plan Code-2014 (for Sustainable Management of Forests and Biodiversity in India) the forest management planning must provide for sustainable management of forests and its biodiversity as enshrined in the National Forest Policy, encompassing the ecological (environmental), economic (production) and social (including cultural) dimensions. The objectives for attaining this goal include conservation of forests and reducing forest degradation, maintenance and enhancement of ecosystem services including ecotourism, enhancement of forest productivity together with establishment of regeneration to improve forest health and vitality as per ecological and silvicultural requirements of the species, progressively increasing the growing stock and carbon sequestration potential, maintenance of biological diversity, sustainable yield of forest produce, prevention of soil erosion and stabilization of the terrain; improvement and regulation of hydrological regime; people's involvement in planning

and management of forests fulfilling socio-economic and livelihood needs of the people.

Chapter 2 of the National Working Plan Code-2014, refers to REDD+ at paragraph 17 of National Working Plan Objectives and other Management Planning. Paragraph 17 states, "…..*Implementation of REDD+, therefore requires efforts/mechanisms to measure forest carbon, interventions and payments to local people in addition to alternative activities such as fodder development to avoid lopping of tree branches, and efficient cooking energy devices, etc."* The linkage of REDD+ with forest measurements in the Code is mentioned at para 26, which, *inter alia,* reads, *"……A robust and dynamic national carbon MRV based on forest resource assessment of working plan can also be realized for REDD+ provided sufficient resources are made available to the Stares for estimating carbon from different pools of forest carbon".*

National Action Plan on Climate Change: Eight National Missions

1. National Solar Mission
2. National Mission for Enhance Energy Efficiency
3. National Mission on Sustainable Habitat
4. National Water Mission
5. National Mission for Sustaining the Himalayan Ecosystems
6. National Mission for a Green India
7. National Mission for Sustainable Agriculture

2.2.16 National Action Plan on Climate Change: India has launched National Action Plan on Climate Change (NAPCC) in 2008 and identifies a number of measures that simultaneously advance the country's development and climate change related objectives of adaptation and mitigation. The implementation of the NAPCC is designed to take place through eight National Missions, which form the core of the National Action Plan and incorporate multi-pronged, long-term and integrated strategies for achieving India's key goals in the context of climate change. National Mission for a Green India also called Green India Mission (GIM) is one of the key missions under NAPCC dealing with mitigation and adaptation of climate change in the forestry sector (MoEFCC, 2014).

2.2.17 National Mission for Empowerment of Women, 2010: The Government of India has undertaken various initiatives over the years including policy reforms, programmes and action plans at various levels for empowering women and facilitates their active participation in the social, economic and political life of the country. Some of major policy measures of Government of India include *inter alia*, reservation of one third to 50% of seats for women in the local Governments for ensuring equal representation of women and to bring gender parity. National Environment Policy (2006) seeks inter alia, elimination of gender disparities. National Policy on Education (1986) provides for universal access and enrolment. National Mission for Empowerment of Women (2010) aims to strengthen processes that promote all round Development of women. The New National Policy for Women (Draft 2016) is more focused on 'from being recipients of welfare benefits to the need to engage them in the development process'. The mission of this policy is to create

an effective framework to enable the process of developing policies, programmes and practices, which will ensure equal rights and opportunity for women in the family, community, workplace and in governance. From aforesaid, it can be concluded that the present legal and policy framework is quite consistent and supportive of women's participation in the REDD+.

Thus, the entire policy and legal framework as detailed heretofore, supports the conceptualization and implementation of REDD+ in India. However, constant review and monitoring of REDD+ implementation as also amendments in present legislative framework in future will be required to ensure continuation of synergy between the general legal framework and the REDD+ execution.

2.3 Forest Management

The scientific forest management in India dates back to mid 19th century. The first planned working of forest in the country started way back in 1837 in Travancore. Uniform countrywide approach towards the preparation of Working Plans for scientific management of forests was started in 1884. After independence in 1947, a huge thrust on scientific management was given for conservation and development of forests. Basically, Indian forests are managed on the principle of sustainability and conservation. Therefore, the production from recorded forest area is very meagre around 2.0 to 3.0 million tonnes per year (Annexure-2). All management activities are carried as prescribed in concerned working plans. The working plans are written for Recorded Forest Area which has legal connotation of forest (Annexure-3).

Since late seventies, after realizing the importance of conservation of natural forest, India has started tree plantation outside the forest to meet the fuel, fodder and timber demands of people. Community participation was encouraged and many village level committees came into being. Private sector also started tree plantation to produce raw material for wood based industries. Individuals started growing trees in their agricultural field or homesteads. Governmental initiative led to tree plantations along roads, railways, canals and on governmental lands. In urban areas, trees came up in parks, gardens, institutional areas etc. for providing aesthetic and environmental services. Recently India has come out with National Agroforestry Policy 2014 to provide impetus for planting trees. As a result of all above efforts the country is producing 42.8 million m^3 per year industrial wood (Annxeure-2) meeting more than eighty percent of demand from industries. Recognizing its importance, National Working Plan Code 2014 (NWPC 2014) recommends conducting of Trees Outside Inventory (TOF) in each forest division so that policy intervention for the same can also be prepared.

The working plans are being prepared as per the new NWPC 2014 administered by the Ministry of Environment, Forests and Climate Change (MoEF&CC), Government of India, and are usually valid for a 10 year period. The Working Plan Officer prepares the draft working plan which after approval of the State Government is sent to the Regional Office of the MoEF&CC for obtaining approval of the Central Government.

The day to day management of forests is the responsibility of the State Forest Departments of respective State/UT Governments, who are also responsible for the protection, conservation, administration and development of forests.

India has developed a strong network of Protected Areas (PAs) covering 16.12 m ha (as on September, 2011; Forest Sector Report India 2010) of the country's geographical area including National Parks (102), Wildlife Sanctuaries (515), Conservation Reserves (47) and Community Reserves (4), these are the repository of rich flora and fauna of the country. The Wildlife Institute of India (WII) imparts training to the forest officers and scientists in protected area management. Each National Park and Wildlife Sanctuary is managed as per approved management plan.

There are more than 300 million forest dependent people including around 87 million tribals, deriving their livelihood and substantial part of their income from forests. India started Joint Forest Management (JFM), a partnership between local communities and the Forest Department in the nineteen eighties following the "Care and Share" principle. More than 100 thousand JFM Committees involving around 20 million people are managing approximately 22 mha of forest area. JFM has contributed significantly in stabilizing forest and tree cover of the country. There is a great scope for improvement of forest cover by addressing drivers of forest degradation with people's participation and cross-sectoral support.

3 Information on Forest Reference Level

The process of developing FRL draws strength from data and information from Forest Survey of India (FSI) National Forest Monitoring Systems (NFMS) which provide information for Monitoring Reporting and Verification (MRV). The NFMS provides forest-related emissions reduction estimates by sources and removals by sinks. At the same time it will provide results from implemented REDD+ activities and their emissions/removals in national Green House Gas (GHG) inventories. As pointed out above, FRL(s) are benchmarks used to assess the performance of REDD+ implementation. The comparison of MRV emission estimates resulting from REDD+ implementation with the FRL(s) will indicate the performance of REDD+ activity. Therefore, the definitions, methodologies, scope etc followed in MRV and FRL are kept same for consistency and comparability (Decision 14/CP.19). The available data and information about forest area, change in area and GHG inventories was analysed and necessary calculations and changes were carried out in order to construct relevant FRL.

3.1 Scope: Activity, Pool and Gases

Annex (c) to Decision 12/CP.17 (Guidance on systems for providing information on how safeguards are addressed and respected and modalities relating to forest reference emission levels and forest reference levels as referred to in decision 1/CP.16) which says "Pools and gases, and activities listed in decision 1/CP.16, paragraph 70, which have been included in forest reference emission levels and/or forest reference levels and the reasons for omitting a pool and/or activity from the construction of forest reference emission levels and/or forest reference levels, noting that significant pools and/or activities should not be excluded;"

For construction of FRL, the activity taken by India is "Sustainable Management of Forest (SMF). By analysing the forest cover assessment between 2000 to 2004 and 2004 to 2008, it has been observed that, activities such as deforestation, forest degradation, enhancement of canopy densities and afforestration (leading to enhancement of carbon stocks) have been observed in significant forest area (change matrix for 2000-2004 and 2004-2008 has been given in Annexure-6 to illustrate the change in area under different category). The new area, which is annually brought under forest as per definition, is slightly more than the area which is harvested (shifted from forest to non-forest) and as per definition goes out of forest activity. Similarly, the extent of forest which is experiencing enhancement in canopy densities is slightly more than the extent of forest which is experiencing degradation. It is primarily, output of practicing of sustainable management of forests which is followed all over the country. Moreover in India "All forests are to be managed under the prescriptions of a working plan/scheme which are prepared on the basis of principles of sustainable management of forests; conservation and development of biodiversity; maintenance and enhancement of ecosystem services including carbon sequestration; and the participation of local people in planning and management of forest resources"–(National Working Plan Code, 2014). Due to this reason, the activity Sustainable Management of Forest has been taken as activity for construction of FRL.

Regarding pools to be selected, all the five pools namely Above Ground Biomass, Below Ground Biomass, Dead Wood, Litter and Soil Organic Carbon have been selected for construction of FRL because, India has a time series good quality data through regular National Forest Inventory programme for all the pools. Only CO_2 gas has been taken into account for construction of FRL.

3.2 Definition of forest

As per 13/CP.19, Annex, paragraph 2 (g), the forest definition used for the construction of the FRL should be consistent with definition used for GHG inventory India has used the same definition as was used for GHG inventory, which is given as follows:

"All lands, more than one hectare in area, with a tree canopy density of more than 10 percent irrespective of ownership and legal status. Such lands may not necessarily be a recorded forest area. It also includes orchards, bamboo and palm."

(The definition of forest has been taken exactly as was used for GHG inventory and FRA 2015. The only difference in above definition is that it has been explained further. The separate area under orchards, bamboo and palm are not available as it is not possible to delineate these areas from satellite. However, the area under TOF/plantation given under forest types includes these areas partly based on the ancillary information from State Forest Departments, toposheet etc. Scrubs and shrubs are not the part of the forest cover.)

3.3 Data Used

The activity data and emission factors have been derived from National Forest Monitoring System (NFMS). India is assessing its forest cover since 1987 using remote sensing satellite data. Over the years, many technological advancement have been taken place in the field of remote sensing and mapping. FSI kept pace with rapidly changing technology and improved its assessment over the years. The results are published in successive India State of Forest Report, a biennial publication of FSI, MoEF & CC. The activity data taken for construction of FRL is forest cover assessment for the years 2000, 2004 and 2008. In addition, inventory of forest resources of the country on a regular basis under its National Inventory Programme (NFI) is another important activity of FSI. It collected data on different parameters from about 17000 sample plots in both forest and TOF every cycle. For estimating the emission factors, the inventory data of three cycle i.e. 2002 to 2008 was combined.

3.4 Scale

The FRL has been constructed at the National Level as the activity data used for construction of FRL is based on wall-to-wall mapping using satellite data and emission factors derived from national forest inventory spread over entire country.

3.5 Methodology of construction of FRL

Country has to submit information and rationale on the development of their FRL (Decision 12/CP. 17, II, paragraph 9; Decision 13/CP.19, Annex, paragraph 2 (c)). The **historical method to calculate FRL has been considered**. FSI has been monitoring and reporting forest area and has also estimated forest carbon stocks. FSI has adopted the stock difference method for calculating forest carbon stocks, which is appropriate keeping in view the expertise, availability of historical data and regularity of assessments. Details of methodology has been ~~is~~ narrated in following paragraphs.

The calculation of GHG inventories require information on extent of an emission/removal category termed as 'Activity data' and emission or removal of GHG per unit of area (emission/removal of CO_2 per ha of forest area) termed as 'Emission factors' as per the 'Good Practices Guidance' (GPG), 2003 developed by Intergovernmental Panel on Climate Change (IPCC). The methodology used by FSI for activity data and emission factors has been described in the following paragraphs.

3.5.1 Activity data

Forest Survey of India (FSI) has a long experience of forest cover mapping using wall to wall satellite data. This activity was started by FSI in 1987 using Landsat (MSS) imagery with 80 m resolution. The technique of interpretation was visual and scale of mapping was 1:1 million. The on screen interpretation was followed by extensive ground truthing. The forests were classified into two canopy classes

namely dense forest (crown cover of more than 40%) and open forests (crown cover between 10-40%). Mangroves were delineated as a separate class considering its importance. Though mangroves are presented separately, it is a part of overall forest cover. Degraded forests having crown cover of less than 10% were classified as scrub (a non-forest category). During the successive assessment, many improvements took place because of availability of better satellite data and higher mapping scale. However, there was a major methodological improvement since 2001. FSI switched over to digital interpretation of the satellite data with spatial resolution of 23.5 meters and scale of mapping at 1:50,000. As a result, the minimum mappable unit has been reduced from 25 ha to 1.0 ha and it was possible to report forest cover figures in three density classes namely Very Dense Forest (with canopy density of more than 70 %), Moderately Dense Forest (with canopy density between 40 % and 70 %) and Open Forest (with canopy density between 10 % and 40 %). Thus the data after the year 2000 is comparable. Table 1 shows the technological advancement in forest cover assessment taken over the years.

Table -1: History of Forest Cover Mapping in India

<table>
<tr><th>Data Period (publication)</th><th>Sensor</th><th>Resolution</th><th>Scale</th><th>MMU (ha)</th><th>Mode of interpretation</th></tr>
<tr><td>1981-83 (SFR’87)</td><td>LANDSAT-MSS</td><td>80 m</td><td>1:1 million</td><td>400 ha</td><td rowspan="4">Visual</td></tr>
<tr><td>1985-87 (SFR’89)</td><td>LANDSAT-TM</td><td rowspan="3">30 m</td><td rowspan="6">1:250,000</td><td rowspan="6">25 ha</td></tr>
<tr><td>1987-89 (SFR’91)</td><td>LANDSAT-TM</td></tr>
<tr><td>1989-91 (SFR’93)</td><td>LANDSAT-TM</td></tr>
<tr><td>1991-93 (SFR’95)</td><td>IRS-1B LISS II</td><td rowspan="2">36.25 m</td><td rowspan="3">Visual/ Digital</td></tr>
<tr><td>1993-95 (SFR’97)</td><td>IRS-1B LISS II</td></tr>
<tr><td>1996-98 (SFR’99)</td><td>IRS-1C,1D LISS III</td><td rowspan="6">23.5 m</td></tr>
<tr><td>2000-01 (SFR’01)</td><td>IRS-1C,1D LISS III</td><td rowspan="5">1:50,000</td><td rowspan="5">1 ha</td><td rowspan="5">Digital</td></tr>
<tr><td>2002-03 (SFR’03)</td><td>IRS-1D LISS III</td></tr>
<tr><td>2004-05 (SFR’05)</td><td>IRS-1D LISS III</td></tr>
<tr><td>2006-07 (ISFR’09)</td><td>IRS-P6-LISS III</td></tr>
<tr><td>2008-09(ISFR’11)</td><td>IRS-P6-LISS III</td></tr>
</table>

2010-12 (ISFR'13)	**IRS-P6 & Resourcesat2 LISS III**				

The methodology being followed now uses Digital Image Processing software and involves the number of steps (Rawat *et al.* 2003): Acquisition of satellite data; Geometric Rectification of raw data; Mosaicing of rectified scenes; Classification of forest cover using Normalised Difference Vegetation Index (NDVI); Interactive method of display is used for assigning threshold values for each class (very dense, moderately dense, open and scrub); Density class of forest cover and colour is accordingly allocated.

Flow chart of methodology of dynamic forest cover mapping using remote sensing is shown in the Fig.1.

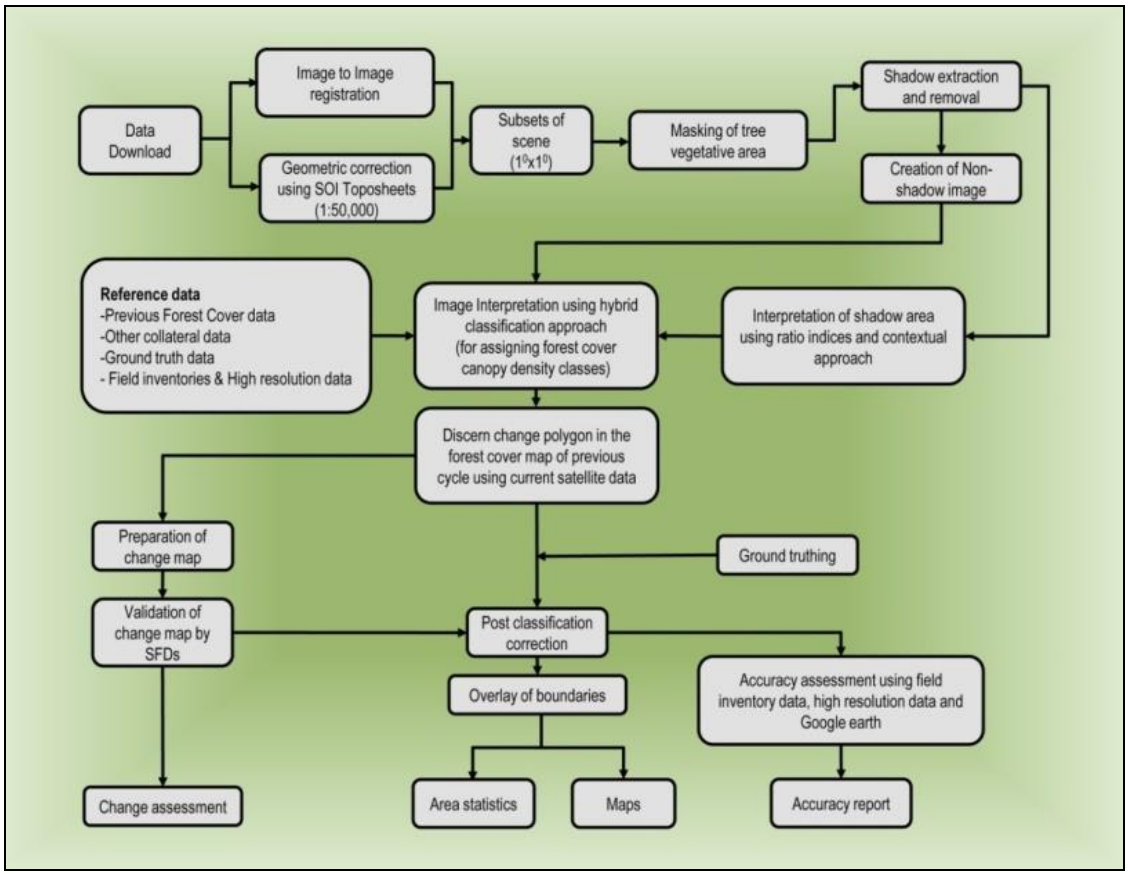


Figure 1: Schematic Diagram of the methodology followed in Forest Cover Mapping

The output includes forest cover maps on 1:50,000 scale. These maps show forest cover in four classes- (i) Very Dense forest, having canopy density of more than 70%; (ii) Moderately dense Forests with canopy density 40%-70%; (iii) Open Forests with canopy density between 10 %-40% and (iv) Scrub which are forest areas having less than 10% canopy density. The information of forest cover is published in India State of Forest Report (ISFR) for the entire country, state and districts. Change matrix is also given at the country and state level.

A classification is not complete unless its accuracy is assessed. FSI carry out accuracy assessment of classification in the form of error matrix. Classified and ground truth data is compared on about 4000 sample plots to prepare the error matrix. For ground truth, the information of forest inventory and high resolutions satellite data is used. The classification accuracy for various report is above 90 %, which is well within the acceptable limit. For illustration, the error matrix prepared for ISFR 2013 is shown in table 2.

Table 2: Error matrix

Classification Classes	Ground truth (based on field inventory data)						User's Accuracy (Per cent)
	VDF	MDF	OF	Scrub	NF	Total	
VDF	210	22	3	1	1	237	**88.81**
MDF	17	1,221	60	4	8	1,310	**93.21**
OF	7	80	1,137	9	16	1,249	**91.03**
Scrub	1	9	12	192	7	221	**86.88**
NF	3	37	39	17	1,019	1,115	**91.39**
Total	238	1,369	1,251	223	1,051	4,132	
Producer's Accuracy (%)	88.24	89.19	90.89	86.10	96.96		
Overall Accuracy	**91.46**						
Overall Kappa Statistics	**0.88**						

Source: ISFR 2013

3.5.2 Improvement in Classification of previous cycles

As pointed out earlier, FSI switched over to digital interpretation of the satellite data (LISS III, multispectral, 23.5m spatial resolution) commencing from the year 2001. It used digital interpretation of satellite data on 1:50,000 scale for mapping and monitoring of forest cove of the country. This has resulted in providing more realistic information on forest cover as areas having forest cover down to 1 ha could be delineated while in earlier assessments, forest cover down to 25 ha could only be delineated. Similarly blanks down to 1 ha within forested areas can be separated. The entire exercise has resulted in new base-line information on forest cover. As perennial woody vegetation (including bamboos, palms, coconut, apple, mango etc.) has been treated as tree and thus all lands with tree crops, such as agro-forestry plantations, fruit orchards, tea and coffee estates with trees etc., have been considered in forest cover provided such patches of trees/forests qualifies the definition of forest.

This has been viewed as great advantage over earlier methodology but threw a number of challenges for interpretation of satellite data as canvas suddenly opened up for number of potential small patches between 1.0 ha to 25 ha.

It is pertinent to mention here that while carrying out digital classification at 1:50,000 scale in 2001, FSI decided to adopt conservative approach and included those areas in forest cover which satisfied the definition of forest cover and there were, seemingly, very less or no possibility of misclassification.

Remote sensing data has certain inherent limitations that affect the accuracy of the Forest Cover Mapping, some of which are mentioned below:

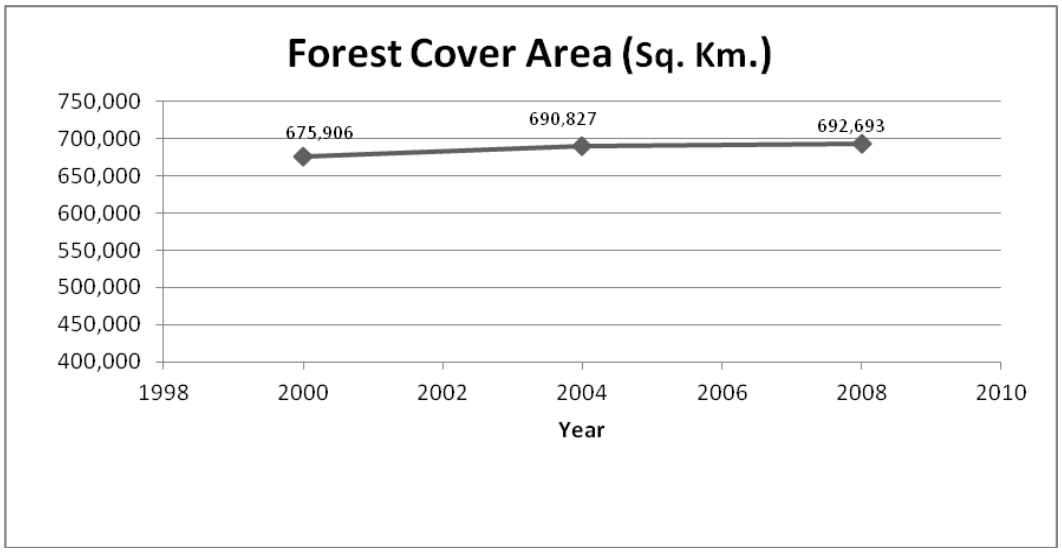
- Since the resolution of the LISS-III sensor data is 23.5 m, land cover having a geometric dimension on the ground less than 23.5 m is not discernible.
- Considerable ground details may sometimes be obscured due to clouds and shadows. Such areas can be classified to a certain extent with the help of collateral data.
- Non-availability of appropriate season data sometimes leads to misinterpretation of the features owing to poor reflectance of data.
- Occurrence of weeds like lantana in forest areas and agricultural crops like sugarcane, cotton, *etc*. adjacent to forest area causes mixing of the spectral signatures and often make precise forest cover delineation difficult.
- Young plantations and tree species with less chlorophyll or poor foliage are many times not discernable on satellite images due to low leaf area index and transmittance.
- Where heterogeneity in tree species composition is high, generalized classification may affect the accuracy level.

Due to above limitations, there are certain interpretational changes in the forest cover assessment of a particular year. Thus the change in the forest cover between two consecutive cycle may contains the actual changes happened during the two years and also contains interpretational changes which pertain to other previous period as well. The historic data taken for construction of FRL is 2000-2008.

The forest cover assessment based on interpretation of 2000, 2004 and 2008 satellite data (sensor LISS III, resolution: 23.5m) had already been carried out as part of FSI's mandated activity and has appeared in the various 'State of Forest reports' (SFRs). In each SFR, the figures of that year is given with a change with respect to previous cycle. As mentioned above, the change comprises of both actual and interpretational changes. For the purpose of constructing FRL, FCMs corresponding to year 2000 (SFR 2001), 2004 (SFR 2005) and 2008 (ISFR 2011) got revised by incorporating the interpretational changes observed in the subsequent assessments to the year they belong. In this process, the maps and figures of forest cover were revised for the year 2000, 2004 and 2008. The details of FCM for different cycles along with improved forest cover for the year 2000, 2004 and 2008 is given in table 3.

Table 3: Forest Cover with Improved area

Cycle of Assessment	Publication	Data Period	Forest Cover (km^2)	Improved Forest Cover (km^2)
I	SFR 1987	1981-83	640819	-
II	SFR 1989	1985-87	612717	-
III	SFR 1991	1987-89	639323	-
IV	SFR 1993	1989-91	638857	-
V	SFR 1995	1991-93	638675	-
VI	SFR 1997	1993-95	633307	-
VII	SFR 1999	1996-98	637288	-
VIII	SFR 2001	2000	653898	675906
IX	SFR 2003	2002	677816	-
X	SFR 2005	2004	690171	690827
XI	ISFR 2009	2006	692394	-
XII	ISFR 2011	2008-09	692027	692693
XIII	ISFR 2013	2010-12	697898	-



3.5.3 Forest Type Mapping (FTM)

Forest type wise extent of forest cover is useful information which provides a basis for characterizing forests in terms of floristic composition and ecological value. In the year 2011, FSI has published “Atlas of forest types of India” mapping forest types as per revised classification of Champion & Seth (1968) on 1:50,000 scale down up to 200 types described in the classification. In the first ever such attempt at the national level, extensive study in GIS framework using the relevant layers like, soil, rainfall, temperature along with the remote sensing data, details from the working plans, thematic maps of FSI, inventory information etc was carried out. The exercise involved extensive and widespread ground truthing covering every part of the country.

The FTM was one time exercise using the satellite data of the 2004 year. This information was not available for data of other years. The methodology for assigning

forest types groups to other years' data was developed. As per the methodology, the forest area of 2004, which remained forest area in 2000 and 2008, were assumed same forest types. The additional forest area in 2000 and 2008, if not plantation (based on ancillary information), was assigned the forest type based on the nearness to available forest type confirming to soil and rainfall. The forest type group has been assigned to the data corresponding to the forest cover of the year 2000, 2004 (interpretational changed area) and 2008.

3.5.4 Stratification of Activity Data

Stratification is required for any heterogeneous population to gain precision of estimates by dividing it into relatively homogeneous sub-population based on some stratification variable. Since, in this case, carbon stored in the vegetation is principal variable which definitely depends upon canopy density and forest type; these two has been considered as stratification variables. Canopy density wise spatial information is available from the 'forest cover mapping'. This was supplemented with the forest type wise information generated under the national forest type mapping project carried out by FSI. This gave three canopy density classes and fifteen type group classes – thus resulting forty-five classes in all.

Using this type/density classification, the area statistics (**Activity data**) were generated by a series of steps of intersection and differencing of maps using GIS techniques.

Table 4: Forest type and Forest density wise area (sq km) for the year 2008

Forest Type Class	VDF	MDF	OF	Total
Tropical Wet Evergreen-North East	997	2815	1132	4944
Tropical Wet Evergreen-Western Ghats	4884	8566	2943	16393
Tropical Semi Evergreen-North East	16090	34072	30960	81122
Tropical Semi Evergreen-Eastern Deccan	36	122	201	359
Tropical Semi Evergreen-Western Ghats	1983	10808	5949	18740
Tropical Moist Deciduous Forests	20459	77033	49056	146548
Littoral & Swamp Forests	1703	2533	2223	6459
Tropical Dry Deciduous Forests	18846	126920	130859	276625
Tropical Thorn Forest	150	2901	8529	11580
Tropical & Subtropical Dry Evergreen Forests	151	582	561	1294
Subtropical Pine/Broadleaved Hill Forests	4098	18942	15905	38945
Montane & Moist Temperate Forest	10237	15828	8977	35042
Sub Alpine & Dry Temperate Forest	3937	8130	6027	18094
Alpine Scrub	426	1024	1280	2730
Plantation/TOF	258	11191	22369	33818
Total	84255	321467	286971	692693

Regarding the plantation/TOF category, it is mentioned that it is not possible to delineate the area under plantations and orchards by the satellite data used for the forest cover mapping. The information of this category as given under forest types is

derived on the basis of ancillary information such as records of State Forest Departments, toposheets etc. Thus, the area under this category is not complete.

3.5.5 Methodology for Estimating Emission Factors

FSI has been conducting the National Forest Inventory since 2002, following a robust sampling design. Under NFI, data is being collected regularly from sample plots in forest lands distributed across the country in different physiographic and climatic zones. As per the design, the cycle of the NFI is 2 years. Thus, the first NFI pertains to the period 2002-2004, second NFI to 2004-2006 and third NFI to 2006-2008. For the purpose of construction of FRL, the data of three cycle was combined to generate the emission factors. The reason of combining the three cycles data is to get the more stable estimates of emission factors. During 2002-2008, out of total 21000 sample plots, the data was collected from about 17000 sample plots.

To measure exchange of GHGs between forest eco-system and the atmosphere which is eventually the change in carbon stocks over time, FSI has used Stock-Difference method (inventory based approach or periodic accounting) for estimating various emissions factors as suggested by GPG. Under NFI, data is being collected regularly from sample plots in forest lands distributed across the country in different physiographic and climatic zones. The emission factors have been estimated partly by using the NFI data collected during 2002-2008 and partly by conducting a special study during 2008-10. The methodology used has been described as follows:

3.5.6 Above Ground Biomass (AGB) of trees having dbh ≥ 10 cm and bamboo

This information has been derived from National Forest Inventory (NFI). Under the National Forest Inventory (NFI) programme, FSI has been conducting forest inventory since 2002. The sampling design adopted for national forest inventory is two stages. In the first stage the country is divided into homogeneous strata, based on physiography, climate and vegetation called as physiographic zones and the civil districts form the sampling unit. There are 14 physiographic zones; Western Himalayas, Eastern Himalayas, North East, Northern Plains, Eastern Plains, Western Plains, Central Highlands, North Deccan, East Deccan, South Deccan, Western Ghats, East Ghats, West Coast and East Coast.

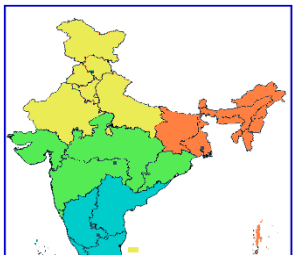


Fig 2: Physiographic zone

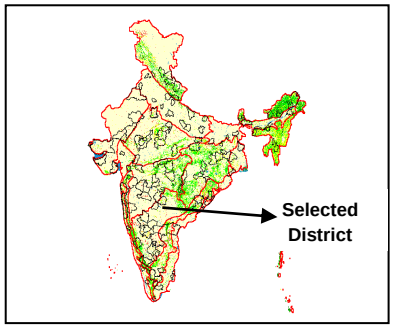


Fig 3: Selected districts of a cycle

A sample of 10 percent districts (approximately 60 districts in the country) distributed over all the physiographic zones in proportion to their size are selected randomly for detailed inventory of forest. In the second stage selected districts are divided into grids of latitude and longitudes which form the second stage sampling unit.

For forest inventory in selected districts, plots are systematically laid out in forest area which is indicated on topographic sheets by double dotted line, printed as RF,

PF, thick jungle, thick forest etc, shown in green wash and any other area reported as forest area (generally un-classed forest) by the local Divisional Forest Officer.

For each selected district, Survey of India (SOI) toposheets of 1:50,000 scale (size 15′×15′ i.e 15 minutes latitudes and 15 minutes longitudes) is divided into 36 grids of 2½′×2½′ which is further divided into sub-grids of 1¼′×1¼′ forming the basic sampling frame. Two of these sub-grids are then randomly selected to lay out the sample plots. Other forested sub-grids in the districts are selected systematically taking first two sub-grids as random start. The intersection of diagonals of such sub-grids are marked as the centre of the plot at which a square sample plot of 0.1 ha area is laid out to record the measurements. Within sample plot, sub plots of 1m x 1m are laid out at NE and SW corner for collecting data on soil and forest humus. The data on herbs and shrubs including regeneration are collected from four square plots of 1m x 1m and 3m x 3m respectively. These plots are laid out at a distance of 30 meters from the centre of 0.1 ha sample plot in all four directions along diagonals in non-hilly area and along trails in hilly areas. In case of hilly areas the plot are taken randomly 3-10 meters away either side of the trail.

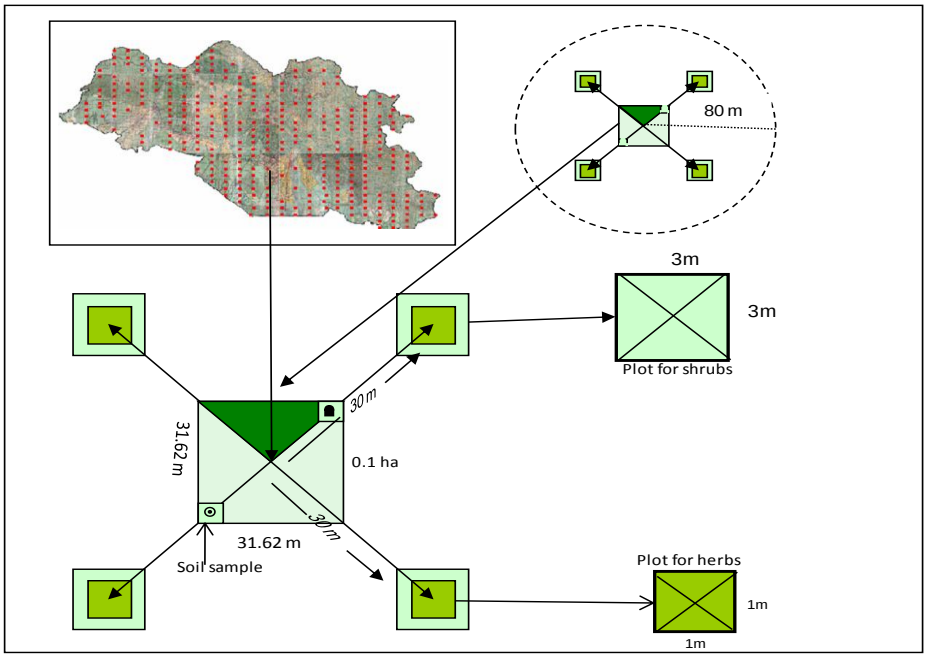


Fig 4: Layout of the sample plot in plain

At each sample plot all trees of diameter 10 cm and above were measured. The woody volume of trees for each sample plot was calculated using volume equations developed by FSI for various species. The volume equation provides above ground woody volume i.e. above ground volume, which includes volume of main stem measured upto 10 cm diameter and volume of all branches having diameter 5 cm or more. As per the design, data from about 21,000 sample plots (size 0.1 ha) had been collected between years 2002-2008. Data of specific gravity and percentage carbon content of most of the tree species have been obtained from different published

literature. For few species, percentage carbon content was ascertained by experimentation and for remaining an average of all other species was used. Standard formulae were used to calculate biomass and carbon content of each tree.

The estimates of bamboo biomass and carbon stocked in this resource are also calculated from NFI data. For estimating volume of the bark, the double bark thickness of trees measured during forest inventory and volume equation of trees have been used. Using species-wise, dbh and bark thickness, bark volume equations were developed and were adjusted for 'bark void factor' which were utilized to estimate bark volume. With the help of the specific gravity of bark, the volume was converted into biomass. Using carbon content percent of wood, carbon stored in bark was estimated and included in the above ground biomass.

3.5.7 Above Ground Biomass of branches, foliage of trees having dbh ≥ 10 cm

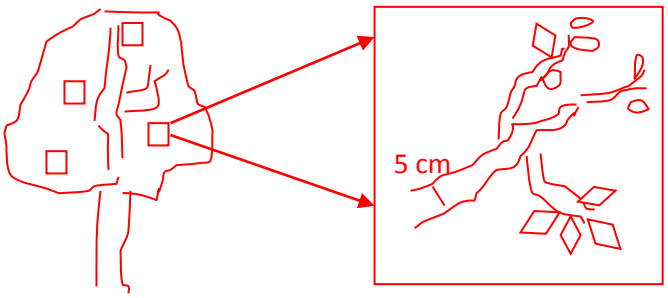
This information is not available from NFI. It is collected through a special study conducted by FSI during 2008-10 for Second National Communication to UNFCCC. The trees measured under national forest inventory (NFI) give the volume of main stem measured upto 10 cm diameter and volume of all branches having diameter 5 cm or more. It does not give the volume of main stem less than 10 cm in diameter, small branches, foliage, fruits and twigs. Since these components also stock carbon in them, their contribution in carbon stock should be accounted. This can be done by developing biomass equations taking dbh as independent variable and biomass of these components as dependent variable. Once these equations are developed, biomass of each enumerated tree can be estimated for small wood and foliage.

To develop biomass equations of small wood and foliage for each such species other than palm like trees, FSI undertook a special study during 2008-10. The classical approach of developing biomass equation demands for destructive sampling involving felling of trees. In addition, the process is very tedious and therefore a new method, which required lopping off, at the most few branches of few trees, was developed. With the analysis of NFI data collected during 2002-08, 20 important species were identified in each physiographic zone and thereafter dbh range was ascertained for each of the species. Dbh of most of the species were ranging from 10 cm to 90 cm. Therefore, it was decided to make dbh classes of 10 cm interval starting from 10-20, 20-30,……,80-90 and 90+.

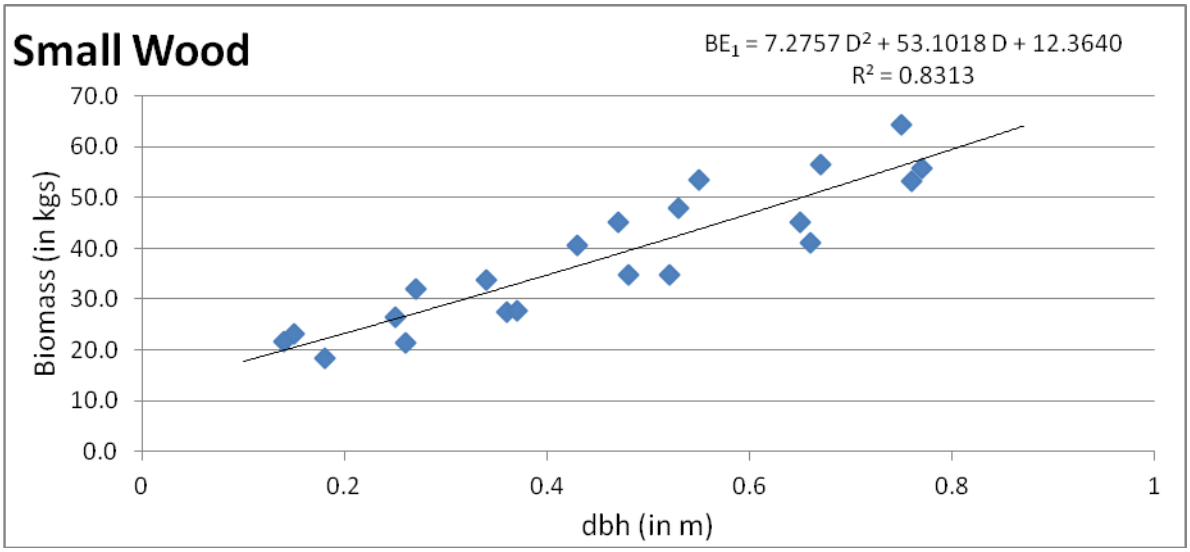
To collect data for this purpose separate format were devised. In each of the diameter class, three normal trees were selected. The normality was defined with respect to that forest. The tree chosen for data collection represent the general condition of that species in that forest. Its dbh, height, crown length, crown width in two direction and shape of the crown was recorded. In addition, canopy blank in that tree was also recorded.

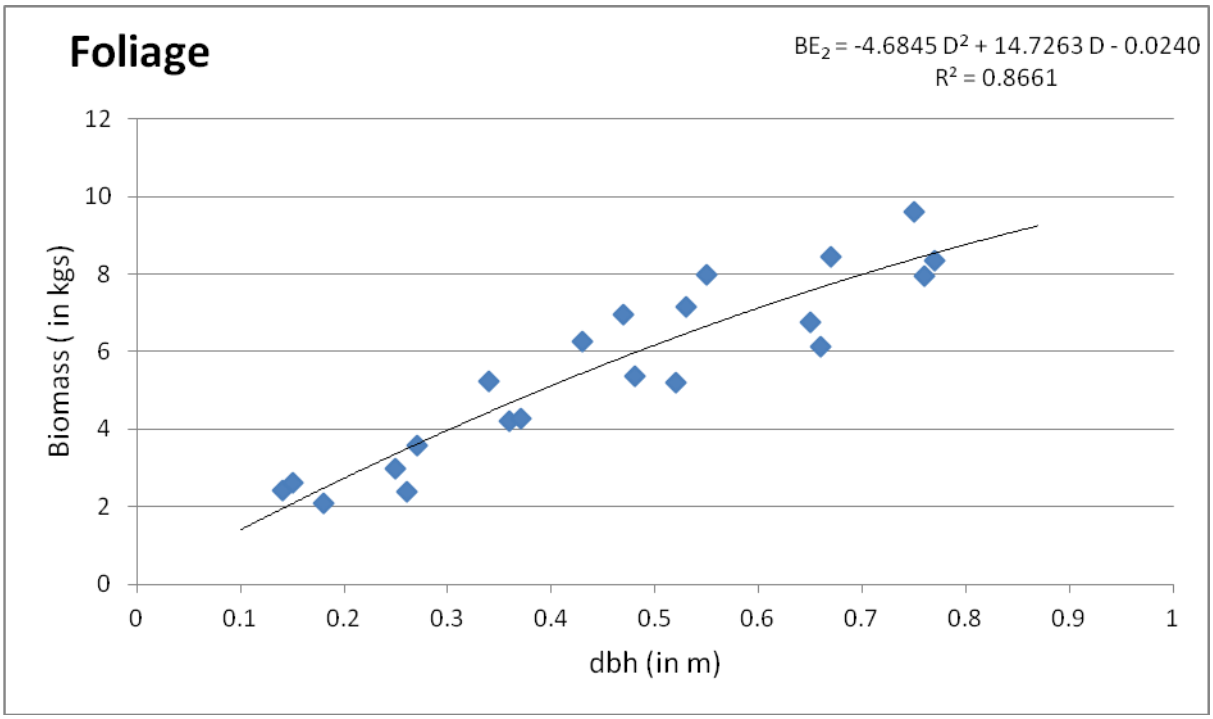
For the purpose of biomass calculation, one normal tree of each diameter class of each species was selected. In the selected tree one square meter window in all the four directions was opened in the crown until woody branches of 5 cm. dia is

reached. All such material from window was felled i.e. woody branches up to 5 cm dia, twigs, leaves, fruits and flowers. Biomass of all these parameters was separately recorded in the prescribed formats. For palm like species two leaves were felled from each tree in each diameter class and their weight and total number of leaves in those trees was counted and recorded for biomass calculation.



Taking the dry biomass of small wood/foliage as dependent variable and dbh as independent variable biomass equations were developed for each species. For example equations developed for Dalbergia sissoo giving weight in kilograms and dbh in meters is given as follows:

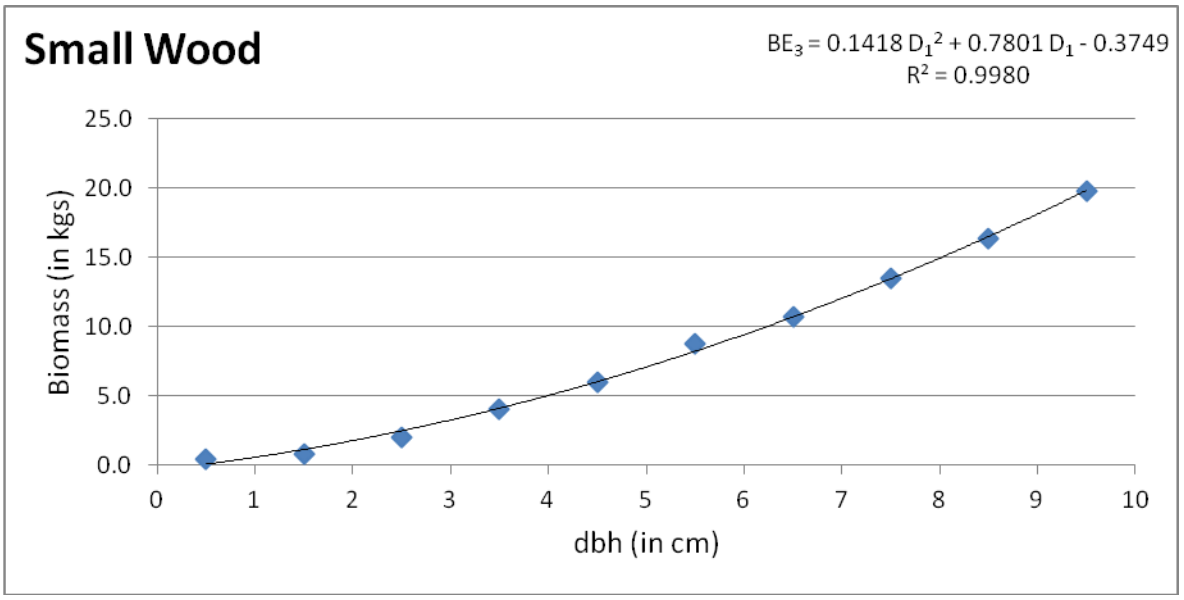


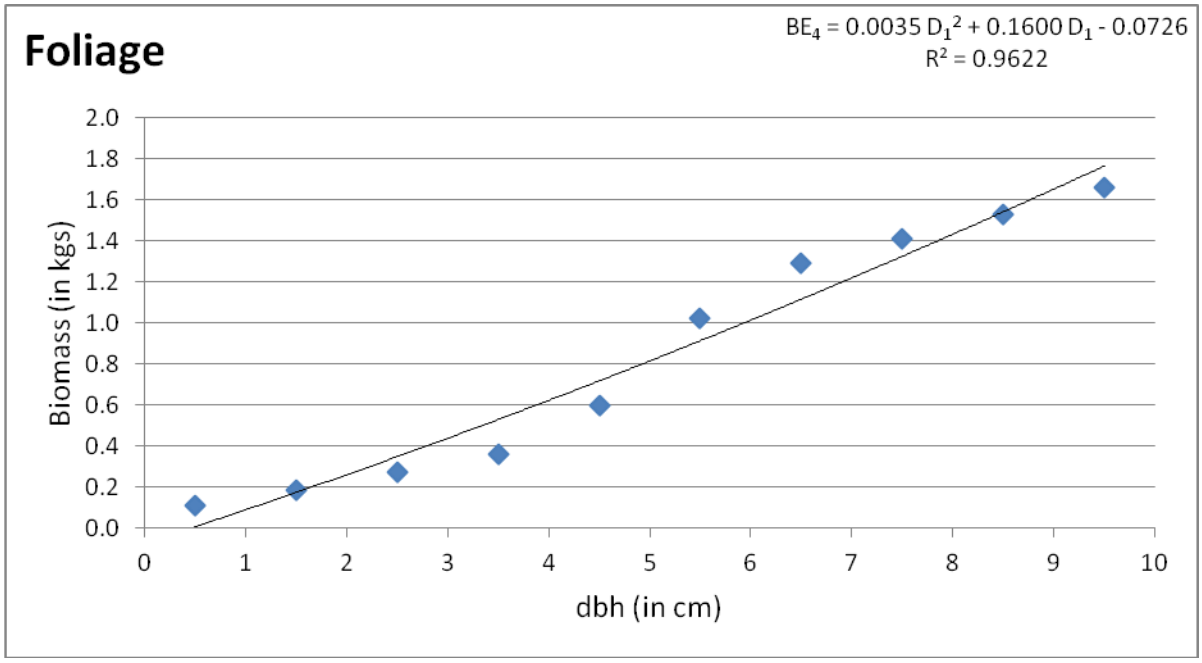


Similarly biomass equations for other species were developed. Using the plot level data of NFI, species wise carbon content, the total biomass and carbon content at plot level was calculated.

3.5.8 Above ground biomass of trees having dbh < 10 cm

This information is also not available from NFI. It is collected through a special study conducted by FSI during 2008-10 for Second National Communication to UNFCCC During the NFI, all trees having diameter 10 cm and above are taken into account. The trees less than 10 cm in dia are not measured. Since from carbon accounting view, these trees are to be measured, a special study was conducted by FSI to develop biomass equations for such trees. For this purpose, as described above, 20 important tree species were identified for each of 14 strata on the basis of NFI data collected between 2002-08. For each of such species, 3 trees of diameters 1- 9 cm (at 1.37 m. height) were felled. From the felled trees, separate biomass was calculated and recorded for wood, twigs and leaves in the prescribed format. Taking the dry biomass of wood/foliage as dependent variable and dbh as independent variable biomass equations were developed for each species. For example equations developed for Dalbergia sissoo giving weight in kilograms and dbh in cms is given as follows:





Similarly, biomass equations have been developed for other species. Using the plot level regeneration data from NFI i.e. recruits, un-established, established and all trees having dbh between 5 to 10 cm, biomass and carbon content at plot level is calculated.

3.5.9 Above Ground Biomass of Shrubs, Herbs, Climbers, and Biomass of Dead Organic Matter (DOM: Dead Wood and Litter)

This information is not available from NFI. It is collected through a special study conducted by FSI during 2008-10 for Second National Communication to UNFCCC For this purpose, the data of forest inventory conducted during 2002-08 was analysed to ascertain the optimum number of plots required for each combination of forest type and forest density. It revealed that about 15 clusters of 2 sample plots for

each combination, would suffice for estimating the biomass/carbon factors for these components if 30% permissible error is considered. This survey was conducted in the districts on randomly selected points which were already inventoried during 2002-2008 and for which forest type and density were known.

For the desired combinations of forest type and forest density, the exact geographical locations (latitude and longitude) of the optimum number of randomly selected sample plots were visited. Using this information, centre of sample point, three concentric plots of size 5mx5m, 3mx3m and 1mx1m were laid out at a distance of 30m away from the centre of sample point in North and South direction. In 5mx5m plot, all dead wood above 5 cm diameter were collected, weighed and recorded. In 3mx3m plot, all woody litter i.e. all branches below 5 cm diameter were collected, weighed and recorded. All shrubs & climbers in 3mx3m plots were uprooted, weighed and recorded in the prescribed format. In 1m x 1m plot, all herbs were uprooted, weighed and recorded. Dry biomass was converted to carbon stock. Thus on the basis of data collected carbon factors were developed for each forest type and density.

3.5.10 Organic matter in soil and forest floor

During forest inventory, the data on forest floor (non-woody litter and humus) and soil carbon was also collected from each sample plot. For collecting data on humus and soil carbon, two sub-plots of size 1mx1m are laid out within the main plot. The forest floor from both the plots was first swept and material so collected was weighed and a portion of same was kept for carbon analysis. Further, at the center of these two sub-plots, a pit of 30cmx30cmx30cm was dug and a composite sample of soil of 200gm was kept for organic carbon analysis. Samples of soil and humus were got analysed from the standard soil labs using Walkley-Black method and were used for the calculation (A detailed notes on estimation of carbon stock has already shared with AT).

3.5.11 Below Ground Biomass

This is the most difficult pool to measure and generally not measured in forest inventory. It is being included using a relationship (usually a root-to-shoot ratio) to aboveground biomass which have been established by various researchers. IPCC, GPG, 2003 also provide default ratios for six major global forest types. FSI has selectively used these defaults to arrive at the carbon number.

3.5.12 Synthesizing Data for National Carbon Estimation

GIS techniques were used to intersect forest type map and forest cover map with three density classes which has resulted in creation of 45 strata (forest type and canopy density intersections) one corresponding to each year. Further the geographical location of each sample plot of NFI was duly recorded with GPS during field inventory. These locations helped in creating a GIS compatible point layer of the forest inventory plots. This NFI point layer map was overlaid on the above map

having 45 forest type - canopy density strata. The NFI points falling in each stratum were identified. For each stratum, the plot wise information on all the parameters of each carbon pool, were aggregated to have generalized factor for that stratum. Biomass and carbon factors were specifically developed for each stratum like, shrubs, herbs, climbers, dead wood and woody litter. Multiplying activity data with these factors, different parameter wise total carbon for all the 45 strata were arrived at. This information was arranged into five carbon pools. Adding pool wise carbon contents, national carbon estimates were arrived at two point of time. The difference between pool wise carbon estimates gave the net removal of carbon.

4. Proposed Reference Level

Historical emission estimates are developed based on method narrated above using the modified time series activity data of the year 1994, 2000, 2004 and 2008. Since the classification based on digital satellite data of 1994 was reconstructed without ground truthing the accuracy of classification could not be assessed. Moreover, the NFI in India started from 2002 and the field data for emission factors pertains to 2002-08 which may be considered unrealistic for 1994.

Further, during late 1990's and early 2000's number of new Acts and policies were introduce to safeguard ecological security and interest of common man viz Biological Biodiversity Act, 2002, Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006, National Environment Policy, 2006, Agro-forestry policy etc. Many of these have significant bearing on the management of forest. Considering all above facts it was decided that the historic period of 2000 to 2008 should be considered for construction of forest reference level. The methodology of activity data and emission factors have already been described above. For the activity data forest cover of 2000, 2004 and 2008 as published in ISFRs were improved and forest cover maps were revised accordingly. Emission factors were derived using NFI data of 2002 to 2008. The activity data and carbon stock in different pools used for construction of FRL has been given in table 5.

Table: 5: Activity data and pool wise carbon stock used for FRL

Data Year	Forest Cover Area (sq.km)	AGB (m.tonnes)	BGB (m.tonnes)	DOM (wood) (m. tonnes)	DOM(Litter) (m.tonnes)	SOC (m. tonnes)	Total Carbon (m. tonnes)
2000	675906	2168.2	670.0	26.1	124.7	3847.5	6836.4
2004	690827	2309.7	760.3	25.2	119.0	3706.0	6920.3
2008	692693	2216.2	687.5	28.5	128.4	3884.3	6944.9

From table 5, the annual carbon stock has been worked out for the year 2000, 2004 and 2008. Based on annual carbon stock, historical average of annual carbon stock has been calculated. The same has been given in table 6.

Table: 6 Annual Increment Carbon Stock between 2000-08

Year	Annual Increment in Carbon stock	Hist-Av (2000-2008)
2000	19.8	13.6
2004	21.0	13.6
2008	6.2	13.6

From table, annual CO_2 equivalent has been worked out for the year 2000, 2004 and 2008. The historical CO_2 equivalent for the period 2000 to 2008 has been calculated and given in table 7.

Table: 7 Annual CO_2 equivalent between 2000-08

Year	Annual CO_2 equivalent	Hist-Av (2000-2008)
2000	72.7	49.7
2004	76.8	49.7
2008	22.6	49.7

Based upon above data, India's proposed Forest Reference Level
-49.70 million tonnes CO_2 Equivalent/ year OR -49700000 t CO_2 Equivalent/ year

5. Transparent, Complete, Consistent and Accurate Information

As per the good practice guidance for LULUCF sector 2003 for carbon accounting, the data used for constructing of FRL should be transparent, complete, consistent and accurate. India has followed these principles while constructing the FRL which are described as follows:

5.1 Transparent

This requires sufficient and clear documentation of the accounting process to be available so that credibility and reliability of estimates can be assessed. For activity data, FSI has used the satellite based remote sensing data. FSI has been carrying out forest cover mapping since 1987 using the satellite data. The data used for the purpose of FRL is LISS-III data of Resourcesat-I. All the classified maps of forest cover for different period are available with FSI. For emission factors, NFI data was used. The data of National Forest Inventory is available in the database. The methodology and results are published in the 'State of Forest Report (SFR)' biennially. All these report are available on FSI's website (www.fsi.nic.in).

5.2 Complete

By complete information, means the provision of information that allows for the reconstruction of the FRL. The information used by India for activity data and emission factors are readily available. The methodology, data sets etc are available in published document of FSI. All the relevant documents/data used for construction of FRL is available and can be made available to anyone.

5.3 Consistent

Accounting estimates for different years, gases and categories should reflect real differences in carbon rather than differences in methods. Since the technology, methodology and data is changing over the period, for the consistency purposes the old information is revised and brought out upto the level of latest level. The data used by India for construction of FRL is consistent. This fact has been already mentioned in subsequent SFRs based on which revised activity data has been constructed. For FRL construction, the same methodologies and data sets have been used as was used for reporting the GHG inventory under the National communications. Moreover, the same experts and same institutions are enrusted the task of construction of FRL who were involved in reporting GHG for National Communication. Thus, there is a consistency between the FRL and GHG inventory.

5.4 Comparable

FSI has been following the same satellite data and same methodology since 2000 for assessment of forest cover. Similarly, the NFI data used for construction of FRL is same for the entire historic period. As such, the results given for different year during 2000 to 2008 are comparable.

5.5 Accurate

Accuracy is how close estimates are to the true value; accurate measurements lack bias and systematic error. Precision is the level of agreement between repeated measurements; precise measurements have lower random error. To give confidence in the estimate, both accuracy and precision are desirable. For activity data FSI assesses accuracy of forest cover classification is each SFR. Similarly, the standard error percent is estimated for growing stock estimates and given in the report. The accuracy of forest cover classification in different SFRs is abobe 90% and standard error percent for growing stock is less than 3 % at national level. For this purpose FSI has Quality control and quality assurance schemes at different levels. For estimating the carbon stock, FSI has used most of the data/ estimates and information generated by FSI itself, which have high and known reliability level. Similarly, litter and soil organic carbon have estimated with high precision. For missing components of biomass, a separate study was undertaken and results of the study are highly precise.

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Annexure – 1

Table 1: Timber Production from Recorded Forest Area in India during 2005-10

(000' m^3)

States/UTs	2005-06	2006-07	2007-08	2008-09	2009-10	Total	Average
Andhra Pradesh	111.38	293.11	191.85	88.64	116.05	801.03	160.21
Arunachal Pradesh	40.66	40.50	30.78	35.05	31.37	178.35	35.67
Assam	11.97	27.49	13.63	13.93	7.33	74.35	14.87
Bihar	15.62	7.23	7.23	6.87	5.99	42.94	8.59
Chhattisgarh	113.61	176.45	209.32	173.49	199.32	872.20	174.44
Gujarat	25.05	29.10	48.81	42.51	32.44	177.90	35.58
Goa	0.45	0.42	0.51	0.17	0.18	1.73	0.35
Haryana	151.16	165.73	140.76	166.66	164.12	788.42	157.68
Himachal Pradesh	356.91	220.82	246.97	227.98	272.00	1324.68	264.94
Jammu & Kashmir	86.40	80.85	68.49	71.55	61.32	368.61	73.72
Jharkhand	3.38	0.56	10.76	11.62	4.67	30.99	6.20
Karnataka	77.53	65.69	44.84	44.91	45.28	278.24	55.65
Kerala	43.41	26.79	48.65	50.60	50.60	220.05	44.01
Madhya Pradesh	345.45	313.42	372.06	336.95	143.74	1511.62	302.32
Maharashtra	88.05	119.12	132.61	141.00	125.47	606.26	121.25
Manipur	9.07	9.11	8.58	2.67	6.41	35.85	7.17
Meghalaya	0.08	0.98	1.02	0.88	0.52	3.49	0.70
Mizoram	2.32	4.41	11.62	11.71	3.13	33.19	6.64
Nagaland	25.00	25.00	25.00	25.00	25.00	125.00	25.00
Odisha	19.03	22.61	21.84	27.80	20.79	112.07	22.41
Punjab	134.63	129.06	72.33	69.76	79.58	485.36	97.07
Rajasthan	37.90	35.40	38.50	36.30	36.30	184.40	36.88
Sikkim	0.09	0.05	0.03	0.07	0.05	0.30	0.06
Tamil Nadu	4.90	5.50	4.78	4.01	4.12	23.31	4.66
Tripura	2.10	2.10	2.10	2.10	2.10	10.50	2.10
Uttar Pradesh	218.73	200.58	310.67	300.08	313.13	1343.20	268.64
Uttarakhand	331.32	283.08	310.58	271.62	242.62	1439.22	287.84
West Bengal	85.99	114.59	231.58	151.12	183.40	766.68	153.34
							Union Territories
A & N Islands	6.91	5.29	9.28	8.97	8.06	38.50	7.70
Total	**2349.10**	**2405.04**	**2615.18**	**2324.02**	**2185.09**	**11878.44**	**2375.69**

Source: Forest Sector Report India 2010, ICFRE, MoEF&CC, Government of India.

Annexure – 2

Table 2: State/UT wise Potential Production of timber from TOF

(Million m^3)

S.No.	States	Growing Stock of tree spps. used as timber	Annual potential production of timber
1	Andhra Pradesh	115.683	1.939
2	Arunachal Pradesh	74.516	0.762
3	Assam	41.336	1.355
4	Bihar	47.195	1.209
5	Chhattisgarh	70.069	1.826
6	Delhi	1.040	Negligible*
7	Goa	3.895	0.019
8	Gujarat	117.993	3.099
9	Haryana	15.268	1.975
10	Himachal Pradesh	21.146	0.939
11	Jammu & Kashmir	147.745	0.830
12	Jharkhand	51.308	1.327
13	Karnataka	101.773	2.023
14	Kerala	49.059	1.628
15	Madhya Pradesh	85.106	3.168
16	Maharashtra	147.029	3.519
17	Manipur	10.691	0.220
18	Nagaland	9.392	0.289
19	Meghalaya	20.964	0.421
20	Mizoram	12.681	0.342
21	Orissa	73.624	1.418
22	Punjab	19.305	2.650
23	Rajasthan	81.560	3.463
24	Sikkim	2.017	0.025
25	Tamil Nadu	70.328	0.834
26	Tripura	7.391	0.256
27	Uttar Pradesh	81.683	5.082
28	Uttarakhand	20.917	0.697
29	West Bengal	45.693	1.436
30	Andaman & Nicobar	0.666	0.007
31	Chandigarh	0.084	Negligible
32	Dadar Nagar Haveli	0.833	0.014
33	Daman & Diu	0.108	Negligible
34	Lakshadweep	0.049	Negligible
35	Pondicherry	0.320	0.010
	Total	**1548.427**	**42.774**

*- Less than 0.005 million cum has been considered as ‘negligible’.

Source: ISFR 2011, FSI Dehradun

Annexure – 3

Recorded Forest Area

In India, however, legal connotation of forest is, mainly employed. An area of land recorded as forest in revenue records or proclaimed to be forest under a forest law or Act is described as forest. Thus, “forest area” is an area recorded as forest in the government records. Often this term is also written as “recorded forest area”. This should, however, not be confused with forest cover which is based on the capability of remote sensing satellite sensor and has nothing to do with the legality of land use or land ownership.

The recorded forest area is categorized into “Reserved Forest”, “Protected Forest” and “Unclassed Forest”. These are defined below:

Reserved Forest: An area notified under the provisions of India Forest Act or the State Forest Acts having full degree of protection. In Reserved Forests all activities are prohibited unless permitted.

Protected Forest: An area notified under the provisions of India Forest Act or the State Forest Acts having limited degree of protection. In Protected Forests all activities are permitted unless prohibited.

Unclassed Forest: An area recorded as forest but not included in reserved or protected forest category. Ownership status of such forests varies from state to state.

Table 3:: **Recorded Forest Area since 1987**

Sl No	**Year**	**Area (sq.km)**	**Percentage of geographic area (sq.km)**
1	1987	751,846	22.87
2	1989	751,346	22.85
3	1991	770,078	23.43
4	1993	770,078	23.43
5	1995	765,210	23.28
6	1997	765,210	23.28
7	1999	765,253	23.28
8	2001	768,436	23.38
9	2003	774,740	23.57
10	2005	769,626	23.41
11	2009	**769,512**	**23.41**
12	2011	769,538	23.41
13	2013	771,821	23.48

Annexure – 4

Table 4: Annual Fuelwood Consumption

Sl.No.	State	No of Persons using Fuel Wood (millions)	No of Persons using Fuel Wood from Forest (million)	Quantity of Fuel Wood used (million tonnes)	Quantity of Fuel Wood used from Forest (million tonnes)	Percentage of column (6) to column (5)
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
1	Andhra Pradesh	64.992	7.573	24.293	2.966	12.21
2	Arunachal Pradesh	0.882	0.698	0.402	0.325	80.93
3	Assam	23.373	5.812	11.421	2.494	21.83
4	Bihar	65.816	3.115	11.475	0.465	4.05
5	Chhattisgarh	20.078	7.818	4.366	1.378	31.56
6	Gujarat	40.092	7.497	9.731	2.225	22.87
7	Haryana	8.092	0.012	1.494	0.003	0.17
8	Himachal Pradesh	5.912	5.646	1.214	1.163	95.80
9	J & K	8.375	4.540	1.394	1.015	72.80
10	Jharkhand	21.733	9.984	4.844	2.849	58.81
11	Karnataka	44.681	9.584	20.967	5.776	27.55
12	Kerala	29.504	4.429	14.543	2.183	15.01
13	Madhya Pradesh	51.007	24.839	13.665	7.191	52.63
14	Maharashtra	68.904	31.845	9.508	4.527	47.61
15	Orissa	33.029	11.110	8.894	2.971	33.40
16	Punjab	13.628	0.136	3.348	0.029	0.87
17	Rajasthan	57.992	11.414	18.782	3.698	19.69
18	Tamil Nadu	42.405	7.429	12.387	2.601	21.00
19	Uttar Pradesh	175.096	10.495	19.063	1.294	6.79
20	Uttarakhand	7.289	6.060	2.566	2.139	83.38
21	West Bengal	51.202	18.574	14.158	6.361	44.92
22	North Eastern States	9.383	6.588	5.274	3.822	72.48
23	UTs	10.412	4.432	2.633	1.272	48.32
	Grand Total	**853.879**	**199.631**	**216.421**	**58.747**	**27.14**

Source: ISFR 2011

Annexure – 5

Table 5: Adult Cattle Unit Dependent on Forests

S.No	States	Total Adult Cattle Unit	Total Adult Cattle Unit dependent on forests	Total Adult Cattle Unit completely dependent on forests	% of column (5) to column (3)
(1)	(2)	(3)	(4)	(5)	(6)
1	Andhra Pradesh	34.84	14.58	7.57	21.73
2	Arunachal Pradesh	0.89	0.85	0.73	82.57
3	Assam	11.96	4.89	3.56	29.81
4	Bihar	23.57	0.90	0.66	2.78
5	Chhattisgarh	12.60	9.24	5.98	47.48
6	Gujarat	21.02	4.17	3.28	15.60
7	Haryana	9.58	0.0005	0.002	0.02
8	Himachal Pradesh	3.79	3.73	2.73	72.18
9	J & K	6.10	1.25	0.60	9.90
10	Jharkhand	12.50	2.13	1.17	8.85
11	Karnataka	18.97	8.63	2.99	15.77
12	Kerala	2.08	0.74	0.15	7.01
13	Madhya Pradesh	36.94	18.79	13.18	35.68
14	Maharashtra	27.53	23.95	16.56	60.15
15	Orissa	15.96	6.40	5.60	35.09
16	Punjab	8.61	0	0	NA
17	Rajasthan	32.32	12.23	7.19	22.24
18	Tamil Nadu	16.48	2.94	2.07	12.55
19	Uttar Pradesh	54.20	9.73	3.02	5.58
20	Uttarakhand	4.28	4.17	2.66	62.16
21	West Bengal	23.30	8.35	5.12	21.96
22	Other NE States	3.36	2.07	1.26	37.42
23	UTs	0.90	0.75	0.37	40.47
	Total	**381.78**	**140.48**	**86.39**	**22.63**

Source: ISFR 2011

Anexure-6

Change Matrix

The change matrix is generally prepared to analyse the dynamics of changes from one land class to other classes observed across the country between two epoch of time. The change matrixes indicating the change in the extent of forest cover classes between 2000 and 2004 and 2004-2008 is given below in Table 6 and 7

Table 6: Forest cover change matrix between 2000 and 2004.

INDIA						
CLASS	2004					Land Cover in 2000(km^2)
	VDF	MDF	OF	Scrub	Non Forest	
VDF	48244	32	9	2	60	48347
MDF	31151	314638	16773	55	17506	380123
OF	3633	3008	240299	89	406	247435
Scrub	79	1358	5155	40845	55	47492
Non Forest	681	945	24822	232	2537186	2563866
Land Cover 2004(km^2)	83788	319981	287058	41223	2555213	3287263
Net change	35441	-60142	39623	-6269	-8653	
Degradation	Deforestation		Enhancement		Afforestation	

Table 7: Forest cover change matrix between 2004 and 2008.

INDIA						
CLASS	Forest cover in 2008 (km^2)					Land Cover in 2004(km^2)
	VDF	MDF	OF	Scrub	Non Forest	
VDF	78211	4077	694	9	797	83788
MDF	4219	289397	16965	352	9048	319981
OF	616	19615	244826	1721	20280	287058
Scrub	3	741	2270	33205	5004	41223
Non Forest	690	8509	21859	6971	2517184	2555213
Land Cover in 2008 (km^2)	83739	322339	286614	42258	2552313	3287263
Net change	-49	2358	-444	1035	-2900	
Degradation	Deforestation		Enhancement		Afforestation	

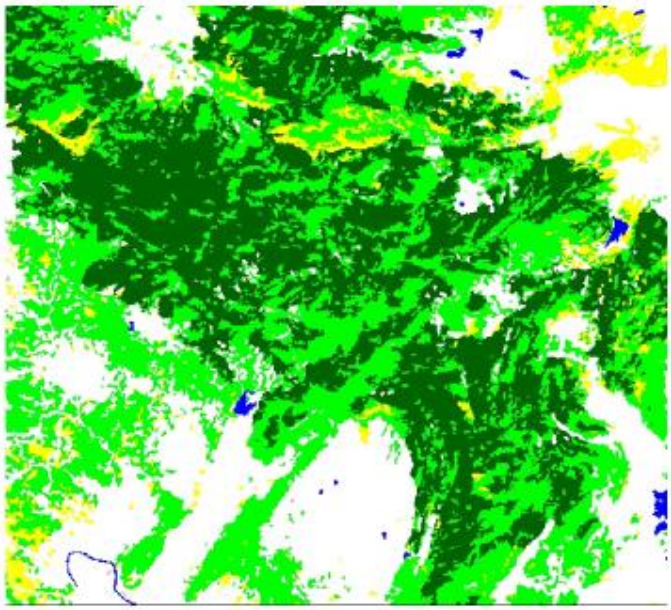
The above matrices gives the extant (activity data) of deforestation, forest degradation, enhancement in canopy density and new area under forest land cover. At the same time, diagonal elements of forest category relates to particular activity of 'conservation of forest carbon stock' of REDD+. It also provides the annual changes in area of these categories which relates to three activities of REDD+ as given in the following Table 5.

Annexure-7

Depiction of FCC and classified sample map of part of Telangana State

FCC TELANGANA (KHAMMAM)

CLASSIFIED TELANGANA (KHAMMAM)



Annexure-8

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