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## Chapter

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### Introduction

#### 1.1 INTRODUCTION

Forest Survey of India (FSI) presents findings of its mapping and forest resource assessment activities at the national level, biennially, by publishing India State of Forest Report (ISFR). The ISFR 2019 is the 16<sup>th</sup> report in the series, the first being the report of 1987. Based on the regular nationwide mapping of forest cover, sample plots based national forest inventory and the specific studies conducted at the national level, the information presented in the ISFR 2019 is **primary information on different parameters of the forest resources of the country**. Since it is a time series of biennial reports, monitoring of forest resource by comparing **different parameters with the previous assessment as change**, is a natural outcome.

ISFR meets the vital information needs of the forestry sector of the country and is widely used for policy formulation, planning and management of forests at the national level as well as by the States & UTs. Data presented in the ISFR are also used for various internationally mandated communications to the organisations such as FAO, UNFCCC, CBD etc.

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For the sake of easy readability and presentation of large content, which has further grown in this report, in the manageable size of the document, for the first time, ISFR 2019 is being presented in two volumes. The Volume I presents chapters giving national level assessments, whereas, Volume II gives information of each State and UT of the country as separate sub-chapters. Chapters in Volume I include Forest Cover, Mangrove Cover, Forest Types & Biodiversity, Forest Fires, Tree Cover, Growing Stock, Bamboo Stock, Forest Carbon and Forest & People. In Volume II there are sub chapters, each devoted to a particular State or UT wherein district level information on forest cover is also presented.

## 1.2 TECHNOLOGICAL ADVANCEMENT IN THE ASSESSMENT OF FOREST COVER

Forest Survey of India has always strived to use latest satellite data, technological tools and techniques for its different mapping and forest assessment activities. The latest available satellite data suitable for nation-wide wall-to-wall forest cover mapping are procured from the National Remote Sensing Centre (NRSC) under the Indian Space Research Organisation (ISRO). Over the last three decades, FSI has regularly improved methodology for forest cover mapping. Up to the year 1999, the forest cover mapping used to be done largely by visual interpretation method. In the year 2001, a complete switch-over to the digital interpretation based approach was adopted. In the current cycle, significant improvements in methodology of satellite data interpretation for forest cover mapping have been undertaken and a Manual of Forest Cover Mapping has been published. Methodology in detail has been described in the Chapter 2.

The following table gives an overview of different satellite data, scale of mapping and minimum mappable area used in different assessments in the last 32 years of forest cover mapping.

**TABLE 1.1** Satellite Data Used for Forest Cover Mapping over the Years

Cycle of Assessment	Year	Data Period	Sensor	Spatial Resolution	Scale	Minimum Mappable Unit (ha)	Mode of Interpretation
I	1987	1981-83	LANDSAT-MSS	80 m	1:1 million	400	Visual
II	1989	1985-87	LANDSAT-TM	30 m	1:250,000	25	Visual
III	1991	1987-89	LANDSAT-TM	30 m	1:250,000	25	Visual
IV	1993	1989-91	LANDSAT-TM	30 m	1:250,000	25	Visual
V	1995	1991-93	IRS-1B LISS II	36.25 m	1:250,000	25	Visual & Digital
VI	1997	1993-95	IRS-1B LISS II	36.25 m	1:250,000	25	Visual & Digital
VII	1999	1996-98	IRS-1C/1D LISS III	23.5 m	1:250,000	25	Visual & Digital
VIII	2001	2000	IRS-1C/1D LISS III	23.5 m	1:50,000	1	Digital
IX	2003	2002	IRS-1D LISS III	23.5 m	1:50,000	1	Digital
X	2005	2004	IRS-1D LISS III	23.5 m	1:50,000	1	Digital
XI	2009	2006	IRS-P6-LISS III	23.5 m	1:50,000	1	Digital
XII	2011	2008-09	IRS-P6-LISS III	23.5 m	1:50,000	1	Digital
XIII	2013	2010-11	IRS P6-LISS III	23.5 m	1:50,000	1	Digital
			IRS-Resourcesat-2				
			LISS III				
XIV	2015	2013-14	IRS P6-LISS III	23.5 m	1:50,000	1	Digital
			IRS-Resourcesat-2				
			LISS III				

Cycle of Assessment	Year	Data Period	Sensor	Spatial Resolution	Scale	Minimum Mappable Unit (ha)	Mode of Interpretation
XV	2017	2015-16	IRS P6-LISS III	23.5 m	1:50,000	1	Digital
			IRS-Resourcesat-2				
			LISS III				
XVI	2019	2017-18	IRS-Resourcesat-2	23.5 m	1:50,000	1	Digital
			LISS III				

### 1.3 FOREST COVER AND RECORDED FOREST AREA

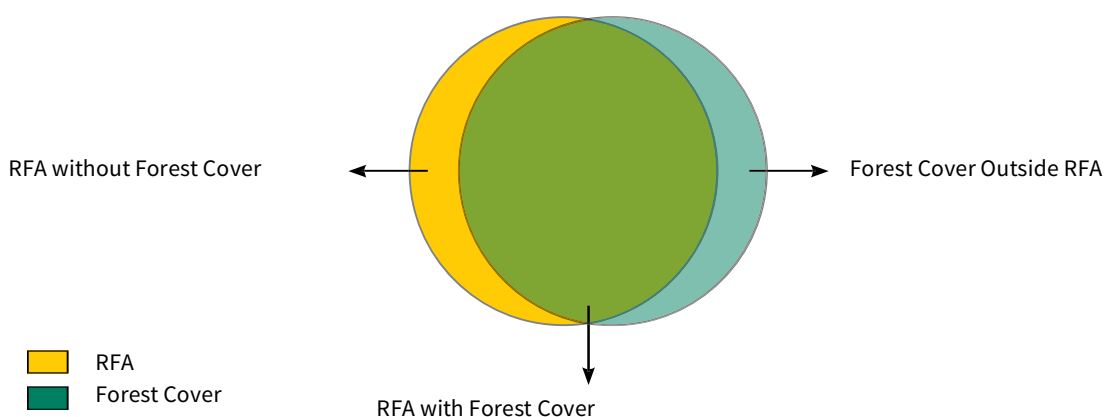
Forest Cover and Recorded Forest Area (RFA) are the two most commonly used terms to describe extent of forest. Though apparently similar terms, forest cover and RFA denote extent of forests with **different meanings**. Forest cover on one hand gives information about the forest canopy area covered on the ground irrespective of the legal status of land, whereas RFA gives extent of forest in terms of legal status or definition of land as ‘forest’ irrespective of actual forest canopy cover on the ground.

‘Forest cover’ term used by FSI includes all tree patches which have canopy density more than 10% and area of 1 ha or more in size, irrespective of their legal status and species composition. On the contrary, the term ‘Recorded Forest Area’ is used for all such lands which have been notified as forest under any Government Act or Rules or recorded as ‘forest’ in the Government records. Recorded forest area may or may not have forest cover. Thus forest cover & recorded forest area overlap with each other but they are not coterminous with each other. The diagram given in Fig 1.1 depicts the relationship between the two.

FSI obtains boundaries of recorded forest areas from the State Forest Departments (SFD) as the SFDs are the custodians of the RFAs. The boundaries of RFAs from all the States have not been made available to FSI.

The following table gives extent of RFA under different categories for each State, as received from the respective States/UTs.

**FIGURE 1.1** Forest Cover and Recorded Forest Area



**TABLE 1.2** Recorded Forest Areas (RFAs) in States and UTs

(area in sq km)

S.No.	State/ UT	Geographical Area (GA)	RFA (in different categories)			Total RFA (2019)	% of GA
			RF	PF	Unclassed Forests		
1.	Andhra Pradesh	162,968	31,959	5,069	230	37,258	22.86
2.	Arunachal Pradesh	83,743	10,589	9,779	31,039	51,407	61.39
3.	Assam	78,438	17,864	0	8,968	26,832	34.21
4.	Bihar	94,163	693	6,183	1	6,877	7.30
5.	Chhattisgarh	135,192	25,782	24,036	9,954	59,772	44.21
6.	Delhi	1,483	78	24	0	102	6.88
7.	Goa	3,702	253	0	972	1,225	33.09
8.	Gujarat	196,244	14,373	2,886	4,388	21,647	11.03
9.	Haryana	44,212	249	1,158	152	1,559	3.53
10.	Himachal Pradesh	55,673	1,898	33,130	2,005	37,033	66.52
11.	Jammu & Kashmir <sup>#</sup>	222,236	17,643	2,551	36	20,230	9.10
12.	Jharkhand	79,716	4,387	19,185	33	23,605	29.61
13.	Karnataka	191,791	28,690	3,931	5,663	38,284	19.96
14.	Kerala	38,852	11,309	0	0	11,309	29.11
15.	Madhya Pradesh	308,252	61,886	31,098	1,705	94,689	30.72
16.	Maharashtra	307,713	49,546	6,733	5,300	61,579	20.01
17.	Manipur	22,327	1,467	4,171	11,780	17,418	78.01
18.	Meghalaya	22,429	1,113	12	8,371	9,496	42.34
19.	Mizoram	21,081	4,483	0	1,158	5,641	26.76
20.	Nagaland	16,579	234	0	8,389	8,623	52.01
21.	Odisha	155,707	36,049	25,133	22	61,204	39.31
22.	Punjab	50,362	44	1,137	1,903	3,084	6.12
23.	Rajasthan	342,239	12,475	18,217	2,045	32,737	9.57
24.	Sikkim	7,096	5,452	389	0	5,841	82.31
25.	Tamil Nadu	130,060	20,293	1,782	802	22,877	17.59
26.	Telangana	112,077	20,353	5,939	612	26,904	24.00
27.	Tripura	10,486	4,175	2	2,117	6,294	60.02
28.	Uttar Pradesh	240,928	12,071	1,157	3,354	16,582	6.88
29.	Uttarakhand	53,483	26,547	9,885	1,568	38,000	71.05
30.	West Bengal	88,752	7,054	3,772	1,053	11,879	13.38
31.	A & N Islands	8,249	5,613	1,558	0	7,171	86.93
32.	Chandigarh	114	32	0	3	35	30.70
33.	Dadra & Nagar Haveli	491	199	5	0	204	41.55
34.	Daman & Diu	111	0	0	8	8	7.21
35.	Lakshadweep	30	0	0	0	0	0.00
36.	Puducherry	490	0	2	11	13	2.65
<b>Total</b>		<b>3,287,469</b>	<b>434,853</b>	<b>218,924</b>	<b>113,642</b>	<b>767,419</b>	<b>23.34</b>

Source: State Forest Departments

<sup>#</sup> Includes Jammu & Kashmir area outside LoC that is under illegal occupation of Pakistan and China.

## 1.4 NATIONAL FOREST INVENTORY (NFI)

National Forest Inventory is another major forest resource assessment activity carried out by FSI. The primary objective of the forest inventory is to assess growing stock of trees, number of trees, bamboo, soil carbon, occurrence of NTFP and invasive species and several other parameters depicting growth & health of forest. Forest inventory is done following a standardized sampling design by which sample plots for field observations are laid across the country. FSI has adopted a new grid based NFI design since the year 2016 in which approximately 6,000 sample plots are laid in forest areas and about 10,000 plots are laid in trees outside forests including urban areas every year. The design & methodology of the National Forest Inventory has been described in the Chapter 6.

Another important information which is assessed from the data of TOF inventory is the estimate of tree cover. Tree cover includes all patches of trees occurring outside RFA which are of size less than 1 ha including the scattered trees. Tree cover forms an important part of the trees outside forests (TOF). Forest cover and tree cover put together is called Forest & Tree Cover which is the parameter for monitoring progress against the national forest policy<sup>1</sup> goal of 33% of the country's geographical area under it.

## 1.5 SPECIAL FEATURES IN ISFR 2019

### 1.5.1 *Quantified estimation of dependence of people living in the forest fringe villages on forests for fuelwood, fodder, small timber and bamboo.*

More than 1,70,000 villages are located in the proximity of forests<sup>2</sup> (FSI, 2000). People living in these villages are dependent on the forests for their needs such as fuelwood, fodder, small timber, NTFPs and Bamboo to a great extent. Their removals from forests in a gradual manner go generally unrecorded and are not accounted for in any valuation process of productivity or flow of benefits. There are no reliable estimates available which provide quantification of removal of these produce in the above manner for the States & UTs or country as a whole. To bridge this information gap, FSI has carried out a study during 2018-19 to estimate the above dependence, by carrying out a country wide survey in the sampled villages. The details of the study are presented in the Chapter 10.

### 1.5.2 *Extent of Trees outside Forest in the country*

Trees outside forests (TOF) form significant part of the forest and tree cover of the country and have emerged as major source of timber in India. TOF by definition are trees found outside the recorded forest areas. As mentioned earlier, boundaries of recorded forest areas are not available for all the States & UTs. For assessment of growing stock of TOF under NFI and Tree Cover in such States & UTs, boundaries of green wash given on the Survey of India (SOI) topo sheets have been used as an alternative to the RFA boundaries. Similarly, for forest cover outside the RFA for the States where RFA boundaries are not available, green wash boundaries are used as proxy to RFA. Using the information of forest cover outside RFA/GW and tree cover, extent of TOF has been derived for the first time in the ISFR 2019 and the results are presented in the Chapter 6.

### 1.5.3 *Assessment of plant biodiversity in forests*

Forests are considered store houses of biodiversity. There are different drivers which tend to cause degradation of forests leading to loss of biodiversity & reduced ecosystem services from the forests. Biotic pressure, climate change & forest fires are known as important causes of loss of biodiversity. In this scenario, it is important to assess and monitor biodiversity in forests so that timely interventions

<sup>1</sup> National Forest Policy (1988), Ministry of Environment and Forests, Government of India

<sup>2</sup> State of Forest Report 1999 (2000), Forest Survey of India, Ministry of Environment and Forests, Government of India

can be taken if the loss of biodiversity is seen in any forest area. Forest Survey of India, in a first ever attempt has carried out a rapid assessment of biodiversity for all the States and UTs (except two) and for all the sixteen Forest Type Groups as per Champion & Seth Classification (1968). Apart from the number of tree, shrub and herb species as observed in the survey, Shanon Wiener Index which gives species richness along with the relative abundance, has also been calculated for each forest type groups in each State & UT. The results are presented in the Chapter 4.

#### **1.5.4 Refined Forest Type Map of India**

FSI has done mapping of forest types of India as per the Champion & Seth Classification (1968), for the first time in the year 2011 based on the base line forest cover data of 2005. A new exercise for refining and updating the forest types as per the latest baseline forest cover was initiated in the year 2016 and has been completed in 2019. Though new forest type atlas is under preparation, the latest forest type map of India along with the area figures of the forest type groups have been presented in the Chapter 4.

#### **1.5.5 Mapping of Fire Prone Forest Areas**

FSI sends forest fire alerts to the users who have registered themselves on FSI's website through sms, emails and web map service based on the detected forest fires using MODIS and SNPP VIIRS satellite data in near real time. FSI has been providing this service since 2004, which has improved over a period of time with the evolving technology and better availability of satellite data for this purpose. Using the accumulated data of forest fire detections of the last 14 years, a study has been undertaken by FSI for **analyzing forest fire prone areas in the country. Fire prone forest areas of different severity classes** were mapped in the grids of 5km x 5km based on the frequency of forest fires in the last 14 years. The results of the study are presented in the Chapter 5 and also for each State & UT in the respective sub chapter in Vol II.

#### **1.5.6 Wetlands in Forest Areas**

Large numbers of wetlands are found in forest areas. These wetlands are very important from the biodiversity point of view and play important role in forest-water regime and forest hydrology. Information about their spatial spread, extent and numbers within the forest areas was not available so far. FSI has undertaken a new exercise of overlaying spatial layer of wet lands obtained from Space Application Center (SAC) Ahmedabad over the boundaries of RFA or green wash where RFA boundaries were not available, to derive information about the wetlands within the forest areas. The wetland spatial layer used in the study is the same as presented in the Wetlands Atlas of India published by SAC in 2011<sup>3</sup>. Findings of the study are presented in the Chapter 2 and also for each State and UT in the respective sub chapter in Volume II.

#### **1.5.7 Forest Cover on Slopes**

**In addition to the forest cover in different altitude zones, an additional exercise has been undertaken to assess forest cover on different slope classes for each State & UT of the country. High forest cover on steep slopes may be a good indicator of stability of mountains and this information may also be useful in catchment area treatment plans.** Findings of the study are presented in the Chapter 2 and also for each State & UT in the respective sub chapter in Volume II.

#### **1.5.8 Major Invasive Species**

Invasive species pose serious threat to the sustainable management of forests. Information on important invasive species of each State & UT is collected on each sample plot in forest under NFI. Analysis of NFI data has been done for determining five major invasive species in each State & UT and

<sup>3</sup> National Wetland Atlas (2011), SAC, ISRO; sponsored by Ministry of Environment and Forests, Government of India



also an estimate of area affected by them. This information has been presented in the respective sub chapter of each State & UT of the country in Vol II.

#### **1.5.9 Important NTFP Species**

NTFPs are important source of livelihood for many tribal communities and villagers living in the proximity of forests. A new information has been generated from the forest inventory data about the top five NTFP species in each State & UT in terms of their availability in forests i.e. relative occurrence. The information has been presented in the respective sub chapter of each State & UT of the country in Vol II.

#### **1.5.10 Diameter-class wise distribution of major tree species in forests**

Using NFI data, dia-class distribution of five predominant species in each State & UT of the country has been determined. This information may provide an important input for the sustainable management of forests. The information has been presented in the respective sub chapter of each State & UT of the country in Vol II.

#### **1.5.11 Major species in Trees Outside Forests (TOF)**

Five predominant species found in TOF in each State & UT have been analysed from the TOF (Rural) and TOF (Urban) inventory data and the information along with their relative abundance has been presented for each State & UTs in the respective sub chapter in Vol II.

## **1.6 RECENT INITIATIVES OF FSI**

With the objectives of addressing the emerging information needs of the forestry sector of the country and to adopt latest tools and techniques in the field of forest monitoring and assessment, FSI always endeavours to improve the systems & processes used in its activities and new studies are also undertaken. A brief overview of some of the important initiatives is presented in this section.

#### **1.6.1 Submission of Forest Reference Level (FRL) to UNFCCC**

FSI has prepared Forest Reference Level (FRL) for the country following the internationally approved methodology given in IPCC Good Practices Guidance (2003)<sup>4</sup>. FRL is the base line emission level from the forests and is also one of the four requirements for a country to be REDD+ ready. It is used for determining performance of the country towards REDD+ implementation and performance based financing. **FRL of India was submitted by FSI to MoEF&CC in the year 2018, which after approval, has been submitted to UNFCCC. India's FRL has been uploaded on the website of UNFCCC.**

#### **1.6.2 Submission of Country Report on Global Forest Resource Assessment (FRA) 2020**

FAO, at the request of its member countries, regularly monitors the world's forests and their management and uses through the GFRA. The FRA process is coordinated by Forestry Department of **FAO through nodal agencies in different countries. FSI has been designated as nodal agency for India.** The country report for FRA 2020 has been recently submitted by FSI to FAO. GFRA 2020 is expected to be released by March, 2020 by FAO.

#### **1.6.3 Upgradation of Decision Support System (DSS)**

FSI established a web GIS based decision support system (DSS) in 2014 for facilitating MoEF&CC in objective decision making in connection with clearances under Forest (Conservation) Act, 1980. The DSS works with inputs from 12 spatial layers in GIS framework. There are two tiers of decision rules viz

<sup>4</sup> Good Practice Guidance for Land Use, Land-Use Change and Forestry (2003), Intergovernmental Panel on Climate Change, Japan

Rule 1 and Rule 2. The polygons of area of interest which pass Rule 1 are subjected to Rule 2 in which scores are assigned based on grids' overlap with the spatial layers. After four years of its operation, upgradation of DSS is under process to incorporate technological advances, add more layers and features to make it more enriched, flexible and robust.

#### **1.6.4 Modernisation of National Forest Inventory**

FSI has adopted a new improved NFI design since 2016. The new inventory design is based on grids of size 5km x 5km. The new design has led to several improvements like sampling intensity has increased leading to higher precision, the sample plots are uniformly spread across the country, the cycle of inventory has reduced, several new parameters have been added and State level estimates are possible with better precision.

FSI has taken initiatives to modernise and add further value to NFI by introducing state of the art web GIS based PDA devices with specialized applications for collection of inventory data and its transfer to central data server on real time basis. Another application has been developed for automated data processing and integration of the sample plot data with the geo-spatial layers. A command centre has been established at the FSI headquarters for day to day monitoring of NFI and analysis of data. Field crews have been equipped with gears to increase their efficiency and safety while working in the forests.

#### **1.6.5 Permanent Observation Plots**

With an objective of long term ecological monitoring of forests in the country, FSI has undertaken a new activity of establishing a network of permanent observation plots (POP) spread across the country. A design for spreading the POPs in a manner that all the forest types are represented in each State has been finalized. A draft manual has been prepared and after establishing a few POPs, on pilot basis, the first phase of laying out POPs is expected to commence from December 2019.

#### **1.6.6 Establishing a Centre for Methodology Research & Development**

FSI uses tools, techniques and methodologies for different monitoring and assessment activities. The methodologies employed by FSI are based on science of the subjects such as remote sensing, statistics, forest biometry, geodesy, forest fire, forest carbon assessment etc. To meet the requirement of regular refinement in methodologies, develop new methodologies for studies and keep pace with the advancements in science and technologies, a need for establishing a centre for research was long felt in FSI. Recently, a Centre for Methodology Research & Development has been established in FSI, Dehradun.

#### **1.6.7 Introduction of Drones in FSI**

Drones are emerging technology with several potential applications in monitoring and assessment of forests. FSI has introduced drones in its activities on pilot basis and methodology for application of drones in forest boundary demarcation is being standardized. For building capacity of SFDs in drone applications, FSI has initiated regular training programmes also.

#### **1.6.8 Collaboration with the ISRO Institutions for Forest Biomass Mapping of the Country**

FSI has recently entered into collaboration with the ISRO institutions viz Space Application Centre (SAC), Ahmedabad, National Remote Sensing Centre (NRSC), Hyderabad, North Eastern Space Application Centre (NESAC), Shillong for forest biomass mapping at the national level using Synthetic Aperture Radar Data. Under the project, forest biomass mapping of Assam and Odisha States has already been completed.



## 1.7 INDIA'S FORESTS VIS-À-VIS FOREST RESOURCES IN THE WORLD

Global Forest Resource Assessment (FRA) done by FAO once in five years provides information about the forest resources of almost all the countries in the world. The latest report of GFRA has been released by FAO in the year 2015. Status of the top ten to twelve countries in respect of forest area, change in forest area, growing stock and forest carbon as per the GFRA 2015 are presented in the Tables 1.3 (a) to (d).

**TABLE 1.3(a)** Forest area for top ten countries in 2015

S.No.	Country	Forest area (000 ha)	% of country area	% global forest area
1.	Russian Federation	8,14,931	48	20
2.	Brazil	4,93,538	58	12
3.	Canada	3,47,069	35	9
4.	USA	3,10,095	32	8
5.	China	2,08,321	22	5
6.	Democratic Republic of the Congo	1,52,578	65	4
7.	Australia	1,24,751	16	3
8.	Indonesia	91,010	50	2
9.	Peru	73,973	58	2
10.	India	70,682	22	2
<b>Total</b>		<b>26,86,948</b>		<b>67</b>

**TABLE 1.3(b)** Countries reporting the greatest annual forest area gain (2010-15)

S.No.	Country	Annual Forest area gain	
		Area (000 ha)	% of 2010 forest area
1.	China	1,542	0.8
2.	Australia	308	0.2
3.	Chile	301	1.9
4.	United State of America	275	0.1
5.	Philippines	240	3.5
6.	Gabon	200	0.9
7.	Lao People's Democratic Republic	189	1.1
8.	India	178	0.3
9.	Viet Nam	129	0.9
10.	France	113	0.7

**TABLE 1.3 (c)** Growing Stock in Forests of the top twelve Countries

S.No.	Country	Growing Stock (m. cum)
1.	Brazil	96,745
2.	Russian Federation	81,488
3.	USA	40,699
4.	Democratic republic of Congo	35,115
5.	China	16,002
6.	Indonesia	10,227
7.	Peru	8,891
8.	Cameron	5,802
9.	Gabon	5,405
10.	Papua New Guinea	5,195
11.	India	5,167
12.	Malaysia	5,034

**TABLE 1.3 (d)** Forest Carbon Stocks in the top ten Countries

S.No.	Country	Carbon Stock (m. cum)
1.	Russian Federation	1,27,900
2.	Brazil	82,229
3.	USA	41,227
4.	Democratic Republic of Congo	29,683
5.	Indonesia	12,489
6.	Colombia	8,866
7.	China	7,827
8.	India	6,754
9.	Guyana	6,715
10.	Angola	6,485



**BOX 1**

**Sustainable Development Goals**

The Sustainable Development Goals (SDGs), were adopted by all the member States of United Nations in 2015 as a universal call of action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity by 2030. It consists of 17 goals and 169 targets (UNDP, 2016).

Government of India is committed to achieve the SDGs which is reflected in the integrated approach of development plans and thrust on conservation. The Country's Development paradigm of inclusive growth converges with SDG objectives of 'leaving no one behind'.



A National Indicator framework (NIF) comprising 306 statistical indicators responding to national priorities and needs has been prepared by Ministry of Statistics and Programme Implementation (MOSPI), Government of India. The indicators directly respond to the goals and targets. Most of the goals and targets in the SDGs have environmental dimension and 25 specific targets are identified for priority implementation by the Ministry of Environment, Forest and Climate Change. FSI is reporting on the following National Indicators pertaining to forestry sector.



14.2.1: Percentage change in area under mangroves (2 years)

14.5.2: Percentage change in area under Mangroves (Annual)



15.1.1: Forest area as a proportion of total land area

15.1.2: Percentage of Tree Outside Forest (TOF) in total forest cover

15.2.1: Percentage change in Forest area coverage

15.2.3: Total tree cover achieved outside forest area

15.3.2: Increasing Tree/Forest cover in degraded area

15.4.1: Increase in forest/vegetative cover in mountain areas



