Chapter

1. Introduction

With the mandate to assess India's forest resources periodically, the Forest Survey of India (FSI) makes assessment of the country's forest and tree resources on a regular basis and publishes the results in its biennial report 'India State of Forest Report' (ISFR). The forest cover assessment is carried out using remote sensing technology on wall to wall basis whereas the tree cover estimates are derived from a sample based methodology using both field inventory data of Trees Outside Forests (TOF) and high resolution remote sensing data. The report also contains information about growing stock, carbon stock in country's forests and other important information which are based on National Forest inventory (NFI) data using sampling based methodology. This information is very useful for planners and policy makers for strategic planning and decision making in forestry sector. So far twelve such reports have been published by FSI. The last report i.e. ISFR 2011 was published by FSI in February 2012. The present report i.e. ISFR 2013 is 13th assessment in this series.

1.1 Technological Advancement

Forest Survey of India started forest cover assessment in 1987 using LANDSAT-MSS satellite data with a spatial resolution of 80m. The scale of mapping was 1:1 million and mode of interpretation was visual. In 1989, LANDSAT-MSS satellite was replaced by LANDSAT-TM with a spatial resolution of 30m. The mapping was carried out at 1:250,000 scale. This resulted in reducing Minimum Mapping Unit (MMU) from 400 ha to 25 ha. Since 1995, FSI using indigenous remote sensing satellite data and mode of interpretation partly shifted from visual to digital. Since 2001, there was major technological and methodological advancement in the techniques of forest cover mapping in terms of satellite data, scale of mapping and interpretation. Since then, the forest cover mapping has been carried out at a scale of 1:50,000 with mode of interpretation completely shifting from visual to digital using LISS-III data having spatial resolution of 23.5m. As a result of this advancement, the MMU was further reduced to one hectare from 25 ha.

Another advantage was to add one more canopy density class in the mapping of forest cover. It was now possible for FSI to classify forest cover in three canopy density classes viz. Very Dense Forest (VDF, having canopy density of 70% and above), Moderately Dense Forest (MDF, having canopy density of 40% and more but less than 70%.) and Open Forest (OF, having canopy density of 10% and more but less than 40%) against earlier two density classes i.e. Dense Forest (having canopy density over 40 per cent) and Open Forest (having canopy density between 10 and 40 per cent) used till SFR 2001. With improvement in

technology, necessary expansions in hardware and software infrastructure were also made to make it compatible with better data. Thus over last 25 years, there is a significant advancement in the remote sensing technology and FSI has kept pace with it. Table 1.1 shows the technological advancement in forest cover assessment since 1987.

1.2 Forest Cover and Recorded Forest Area

The term 'Forest Cover' as used in ISFR refers to all lands more than one hectare in area with a tree canopy of more than 10% irrespective of ownership and legal status including orchards, bamboo and palm. On the other hand, the term 'Recorded Forest Area' (or forest area) refers to all the geographic areas recorded as 'Forests' in government records. Recorded forest areas largely consist of Reserved Forests (RF) and Protected Forests (PF), which have been constituted under the provisions of Indian Forest Act 1927. Besides RFs and PFs, the recorded forest area may also include all such areas which have been recorded as forests in the revenue records or have been constituted so under any State Act or local law. Thus, 'Forest Cover' indicates presence of trees on any land irrespective of their ownership and the 'Forest Area' denotes the legal status of the land.

Although majority of the recorded forest areas have vegetation cover, yet there are blanks and areas with tree density less than 10% or even areas without any trees. These may include wetlands, rivers, riverbeds, creeks in the mangroves, snow-covered areas, glaciers, alpine pastures, cold deserts,

Table 1.1: Forest Cover Mapping over the Years

Cycle of Assessment	Year	Data Period	Sensor	Spatial Resolution	Scale	Minimum mapping unit (ha)	Mode of interpre-tation
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 LISSII	36.25 m	1:250,000	25	Visual & Digital
VI	1997	1993-95	IRS-1B LISSII	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 & IRS-P6 AWiFS	23.5 m 56 m	1:50,000	1	Digital
XIII	2013	2010-12	IRS P6-LISS-III IRS-Resourcesat 2-LISS III	23.5 m	1:50,000	1	Digital

grasslands of sholas etc. On the other hand, there are areas outside the recorded forests with tree patches of one hectare and more with canopy density above 10%. Examples include plantations on the community lands, road side, railways and canals, *Eucalyptus,* rubber, tea, and coffee plantations, etc. Such areas also constitute forest cover and are included in the forest cover assessment of FSI.

The RFA figures of various states and UTs of the country are given in Table 1.2 for reference.

Table 1.2: Recorded Forest Areas (RFAs) in States and UTs (Area in km^2)

States/UTs	Geo. Area (GA)	RFA as reported in ISFR 2011	RFA (as revised by SFDs)			Total RFA	% of GA
			Reserved Forests	Protected Forests	Unclassed Forests		
Andhra Pradesh	275,069	63,814	50,479	12,365	970	63,814	23.20
Arunachal Pradesh	83,743	51,540	10,723	9,779	31,039	51,541	61.55
Assam	78,438	26,832	17,864	0	8,968	26,832	34.21
Bihar	94,163	6,473	693	5,779	1	6,473	6.87
Chhattisgarh	135,191	59,772	25,782	24,036	9,954	59,772	44.21
Delhi	1,483	85	78	7	0	85	5.73
Goa	3,702	1,224	253	0	972	1,225	33.09
Gujarat	196,022	18,927	14,373	2,886	4,388	21,647	11.04
Haryana	44,212	1,559	249	1,158	152	1,559	3.53
Himachal Pradesh	55,673	37,033	1,898	33,130	2,005	37,033	66.52
Jammu & Kashmir	222,236	20,230	17,643	2,551	36	20,230	9.10
Jharkhand	79,714	23,605	4,387	19,185	33	23,605	29.61
Karnataka	191,791	38,284	28,690	3,931	5,663	38,284	19.96
Kerala	38,863	11,265	11,309*	0	0	11,309	29.10
Madhya Pradesh	308,245	94,689	61,886	31,098	1,705	94,689	30.72
Maharashtra	307,713	61,939	51,548	6,727	3,082	61,357	19.94
Manipur	22,327	17,418	1,467	4,171	11,780	17,418	78.01
Meghalaya	22,429	9,496	1,113	12	8,371	9,496	42.34
Mizoram	21,081	16,717	7,909	3,568	5,240	16,717	79.30
Nagaland	16,579	9,222	86	508	8,628	9,222	55.62
Odisha	155,707	58,136	26,329	15,525	16,282	58,136	37.34
Punjab	50,362	3,084	44	1,137	1,903	3,084	6.12
Rajasthan	342,239	32,639	12,475	18,217	2,045	32,737	9.57
Sikkim	7,096	5,841	5,452	389	0	5,841	82.31
Tamil Nadu	130,058	22,877	19,388	2,183	1,306	22,877	17.59
Tripura	10,486	6,294	4,175	2	2,117	6,294	60.02
Uttar Pradesh	240,928	16,583	11,660	1,420	3,503	16,583	6.88
Uttarakhand	53,483	34,651	24,643	9,885	123	34,651	64.79
West Bengal	88,752	11,879	7,054	3,772	1,053	11,879	13.38

States/UTs	Geo. Area (GA)	RFA as reported in ISFR 2011	RFA (as revised by SFDs)			Total RFA	% of GA
			Reserved Forests	Protected Forests	Unclassed Forests		
A & N Islands	8,249	7,171	5,613	1,558	0	7,171	86.93
Chandigarh	114	34	32	0	3	35	30.70
Dadra & Nagar Haveli	491	204	199	5	0	204	41.55
Daman & Diu	112	8	0.24	0	8.03	8	7.38
Lakshadweep	32	0	0	0	0	0	0.00
Puducherry	480	13	0	2	11	13	2.71
Total	**3,287,263**	**769,538**	**425,494**	**214,986**	**131,341**	**771,821**	**23.48**

Source: State Forest Departments

* The figure includes 295 sq km of proposed RF and 1,838 sq km of deemed RF (Vested Forest and Ecologically Fragile Land).

1.3 National Forest Inventory (NFI)

The estimation of wood volume of forests, generally termed as Growing Stock (GS), has always been a part of the Working Plan exercise of any forest division to estimate the annual yield. However, on a much larger scale, this exercise was started by Pre-Investment Survey of Forest Resources (PISFR), the precursor organisation of FSI, in 1965 based on sampling methodology using aerial photographs. Initially the inventory was confined to rich forest areas. Subsequently, the inventory exercise was extended to non-forest areas. New National Forest Inventory (NFI) was designed and initiated in 2002. The modified sampling design of NFI aimed at generating estimates of GS and other parameters for areas within forests as well as for TOF on a two-year cycle. The first GS estimates for forests and TOF were published in the State of Forest Report 2003.

For this exercise, the country was stratified into 14 physiographic zones constituting such areas that exhibit broad similarity in the factors (altitude, geographic location, soil and soil moisture content, precipitation, temperature, etc.) that characterise the tree growth and thus bear somewhat homogenous tree vegetation. The 14 physiographic zones are: Western Himalayas, Eastern Himalayas, North East, Northern Plains, Eastern Plains, Western Plains, Central Highlands, North Deccan, East Deccan, South Deccan, Western Ghats, Eastern Ghats, West Coast and East Coast. The NFI is taken up in 60 randomly selected districts of the country in a cycle of two years, and the information collected during previous cycles is also used to make estimates more precise. The Growing Stock information is significant as it is basic input for estimation of biomass as well as the carbon stock, which is an important component of international negotiations

under REDD+. The detailed methodology has been given in the chapter dealing with growing stock.

1.4 New Features in ISFR 2013

1.4.1 Assessment of Forest Cover within and outside Greenwash area

The changes taking place in the country's/ States' forest cover are not entirely changes within the recorded forest area alone, but also includes the changes occurring outside the recorded forest areas. The digitized forest boundaries would be useful to assess the actual changes occurring within the forest areas. This information is essentially required for policy/programme making and management of forest areas. However, due to non availability of digitized forest boundaries (only few states have attempted this), it has not been possible to assess and monitor changes within the recorded forest areas (RFA) that are under the control of State Forest Departments. However, considering the importance of this information, FSI has attempted to give forest cover within and outside the greenwash area in the present ISFR. The green wash area in Survey of India topographic sheets represents the forest areas at the time of survey carried out to prepare such topographic sheets. This green wash area by and large corresponds to recorded forest area of the country. Thus in the absence of digitized boundaries of the RFA, green wash areas have been taken as proxy to RFA. In the present assessment, the forest cover within and outside greenwash areas has been given separately to analyse the changes within and outside the forest areas.

1.4.2 Important Characteristics of India's Forests

Forest Survey of India has been conducting National Forest Inventory (NFI) since 2002. Under the NFI, as detailed in para 1.4, the country has been stratified into 14 physiographic zones and 60 districts are selected randomly for detailed inventory of forests and Trees Outside Forests (TOF) in a cycle of two years. During the field inventory, FSI collects both quantitative and qualitative data on many parameters from each plot. On analysis of quantitative data, estimation of growing stock in forests and TOF in physiographic zones and at state level are made. In addition, the carbon stock and tree cover are also estimated. These results have been published in different SFRs. However, qualitative information on various other important parameters such as forest area under different land use, intensity of regeneration, incidence of fire, injuries to crops, grazing, presence of weeds and grass, soil information, humus, rockiness, bamboo information, plantation potential, biotic influence, etc. collected during the field inventory which were not given in the previous reports have been in corporated in present report. The information on these parameters helps in describing the important characteristics of India's forest. Considering the importance of these parameters, the detailed analysis of these parameters is included in **Chapter 6: 'Important Characteristics of India's Forests'.**

1.4.3 Trees of Agroforestry in India

Agroforestry is being practiced in almost all the countries of tropics and temperate

regions since time immemorial. Agroforestry systems directly affect the life of millions of rural people as these are related to most of the agricultural lands. The supply of fuelwood, timber, fruit, fodder etc. from these tree resources has contributed significantly to the rural economy. They also play important role in combating climate change. In addition, it has the potential to provide ecosystem services, such as carbon storage, biodiversity conservation, checking soil erosion and water recharge and conservation. Apart from this, agroforestry has the potential for conserving soil by adding nutrients and organic matter which not only maintain soil fertility but also help in soil formation and conservation.

The information available about area under agroforestry, tree resources, their volume, and choice of species etc. is inadequate. FSI has been estimating the number of stems along with wood volume of TOF at state and national level under its regular TOF inventory programme and results are reported in successive reports since 2003. The information on available tree resources in agroforestry system has not been scientifically analyzed and reported earlier separately. Considering the importance of agroforestry, it was appropriate to include one additional chapter on tree resources in agroforestry systems in India. The chapter contains information about Tree green cover under agroforestry, growing stock, carbon stock under different physiographic zones and States/UTs. In addition, information on species wise number of stems and their volume under agrosystem in India has been given in **Chapter 7: 'Trees in Agroforestry Systems in India'.**

1.4.4 Urban Tree Resources

As per the population reference bureau, India is second most populous country of the world in 2013 and by 2050, the projected population of India will be the highest in the world. As per the census 2011, the level of urbanisation in India has increased from 27.81 percent to 31.16 percent. During 2001-2011, there is an increase of 2,774 towns, 242 statutory towns and 2,352 census towns. The rapid economic growth and urbanisation coupled with lopsided and faulty urban planning has led to many environmental problems in the urban area. Under this background urban tree resources are playing an important role in mitigating some of the problems arising due to urbanisation.

Urban trees and forests are contributing immensely to the quality of life in towns and cities, meeting basic needs of poor people such as food, fuel, fodder and timber. Social benefits of urban trees and forests relate to health, employment, education, recreation, aesthetic, landscape benefits, and community strengthening. Environmental services of urban forests are improvement in climate and air quality, energy savings, reduction of global warming and carbon dioxide, noise abatement, water & soil conservation, solid waste and land reclamation, and nature conservation including wildlife habitat and biodiversity. FSI has been assessing the urban tree resources continuously under TOF inventory since 2002. However, separate chapter on urban tree resources was not given in the earlier reports. Now a separate chapter on urban tree resources has been included in the present report. The information on urban area, number of stems and volume according

to species and diameter class at national and state level has been detailed in **Chapter 8: ' Urban Trees Resources'.**

1.5 New Initiatives of FSI

1.5.1 e-Green Watch

The Hon'ble Supreme Court of India issued orders in 2009 that there will be a Compensatory Afforestation Fund Management and Planning Authority (CAMPA) as National Advisory Council for monitoring, technical assistance and evaluation of compensatory afforestation activities. In view of this, it was felt mandatory by the MoEF to develop a work based application on Web GIS and MIS platform.

With a complete policy framework in place, e-Green Watch has been developed as an integrated online system that is completely transparent, reliable and accountable. It will allow for monitoring and evaluation of different activities carried out under CAMPA. The 'e-Green Watch' has mainly been developed with a view to empower all administrators to monitor the progress made under various projects that are being carried out using the CAMPA funds. It will also facilitate the change detection for proper monitoring and evaluation of plantation activities. Further it will provide a platform for social and ecological audits by independent organisations, researchers and the public.

It is designed and developed as a web-based, role-based workflow application and integrated information system which shall enable automating of various functions and activities related to monitoring and transparency in the use of CAMPA funds and various works sanctioned in the Annual Plan of Operations (State CAMPA) approved by the State Authorities.

On the pilot basis project was initiated in the five states Andhra Pradesh, Karnataka, Madhya Pradesh, Sikkim and Tripura. Subsequently, the states of Rajasthan, Uttarakhand, Uttar Pradesh, Chhattisgarh, Odisha and Maharashtra also joined. Under the e-Green watch, polygons, line data of plantations sites and point data of immovable assets, are uploaded by the State Forest Departments on the portal developed by the National Informatic Centre (NIC), thereafter FSI monitors the uploaded data and correspondingly give its comments to State Forest Departments.[Website: www.egreenwatch.nic.in].

1.5.2 Decision Support System

In pursuance of the orders of the Supreme Court of India and as mandated by the MoEF, FSI has instituted web based Decision Support System (DSS). It is an application using the remote sensing technology and GIS data for creating a database containing the district wise details of the location and boundary of:

1. Each plot of land that may be defined as forest for the purpose of diversion under the Forest (Conservation) Act, 1980.
2. Core, buffer and eco-sensitive zones of the protected areas constituted as per the provisions of the Wildlife (Protection) Act, 1972.
3. Important migratory corridors for wildlife.

4. Forest land diverted for non forest purposes in the country.

Under DSS, development of a web based application have been developed is in progress, which on completion will allow the users to extract the information from the six layers viz ; Forest Cover map, Forest type map, Biodiversity richness, Landscape integrity, Wildlife areas & Corridors, NPV layer and Hydrological layer for the area of interest. This will support the user to take appropriate decisions primarily on the FC Act cases.

1.5.3 National Forestry Information System (NFIS)

In order to evolve a uniform monitoring system for monitoring of the activities implemented in various states under centrally sponsored schemes like Green India Mission, CAMPA, NAP, a comprehensive monitoring mechanism has been devised. After studying the monitoring procedures followed by the SFDs and deriving strength from the expertise that FSI has in remote sensing and GIS based forest resource survey and experience in ground surveys, this mechanism has been formed. The 'National Forestry Information System' scheme with FSI as nodal agency has been initiated recently.

This approach for a systematic monitoring is prudent as adequate success of the plantation schemes on the ground is obligatory for the sake of financial accountability and more so for the purpose of applying mid-course corrections. The success of plantation activities result into enhanced forest cover and carbon content, thus mitigating the adverse impacts of climate change. This has potential for reaping the benefits under REDD+ mechanism also.

Under NFIS, around 20,000 plantation patches under different CSS will be monitored every year. The monitoring will involve both ground based survey and use of high resolution satellite data. In the initial year say up to 3 years, the component of ground survey will be more whereas after 4th year the component of remote sensing will be more and once the canopy of the trees is developed fully and discernable through satellite, the monitoring of plantation will be done fully using remote sensing data.

The process requires strengthening of the existing infrastructure as well as streamlining the overall FSI administrative structure. This requires creation of R&D unit at FSI headquarters and strengthening of Geomatics cells in all the zones. It ought to include some expansion at administrative as well as technical levels. The present practice of covering the country for field inventory in a cycle of 20 years is also planned to be reduced to 10 or 12 years, so that the reliable information is available for shorter spans to make it useful in calculation of carbon stored in India's forests.

1.6 Forest Resources of the World

The world's forest resources were monitored by FAO at an interval of 5 to 10 years since 1946. The Global Forest Resources Assessments (FRA) are brought out by FAO every five years now and provide a

consistent approach to describe the changes in the world's forest resources. The assessments are based on the country reports and remote sensing conducted by FAO. These assessments make an history of global forest interests, both in terms of their substantive content, but also in their changing scope.

The recent report, Global Forest Resources Assessment 2010 (FRA 2010), is comprehensive and contains latest assessment of forest resources. It examines the current status and recent trends for about 90 variables covering the extent, condition, uses and values of forests and other wooded land, with the aim of assessing all benefits from forest resources. Working closely with countries and specialists in the design and implementation of FRA 2010, FAO placed the final result with better data, a transparent reporting process and enhanced national capacity in developing countries for data analysis and reporting. This report is an essential reference in the status of the world's forests and will support policies, decisions and negotiations in all matters where forests and forestry play a role.

An indicative comparison of different regions/sub-regions vis-à-vis the world's forest resources may be made with respect to the parameter of Growing Stock (GS). The GS estimates form the basis for the estimation of biomass and carbon stocks for most countries. For FRA 2010 information was collected on the proportion of broadleaved and coniferous tree species, and on the growing stock of commercial species. In 2010, the estimated total growing stock in the world's forest amounted to 527 billion cubic meter. A comparative picture of various regions of the world is depicted in Table 1.3.

The world's total GS in forests is 527 billion cum or 131 cum per ha. The total GS shows a slightly decreasing trend caused by a global decrease in forest area. About 61 per cent of the world's total growing stock is made up of commercial species. While countries in North

Table 1.3: Growing Stock by Region and Sub-region, 2010

Region/ Sub-region	Total GS (m cum)	GS (cum per ha)
Eastern and Southern Africa	13,679	51
Northern Africa	1,346	17
Western and Central Africa	61,908	189
East Asia	21,337	84
South and Southeast Asia	29,031	99
Western and Central Asia	3,316	76
Europe excl. Russian Federation	30,529	156
Total Europe	112,052	111
Caribbean	584	84
Central America	2,891	148
North America	82,941	122
Total Oceania	20,885	109
Total South America	177,215	205
World	**527,203**	**131**

[cum: cubic meter]

America and Europe consider most of the growing stock to be commercial, less than half of the growing stock is considered to comprise commercial species in Africa, Asia and South America.

Forest Fire Vulnerability Study

FSI, using Moderate Resolution Imaging Spectro-radiometer (MODIS) Sensor data, has been carrying out the near real time monitoring of forest fires since 2004. Based on this data, an attempt has been made to map the vulnerable areas across the country using various parameters. Apart from the forest density and the forest types, population density, rainfall and the poverty have been the other factors in identification of vulnerable areas. The present study classifies the districts into different vulnerability classes. Vulnerability analysis primarily entails information on regimes and forest strata that face frequent occurrence of forest fire due to various reasons. In the recent study carried out by FSI on forest fire vulnerability analysis, data for forest fire outbreaks over a period of seven years has been taken into consideration along with the other parameters.

Based on the analysis, it has been observed that 348 districts across the country are vulnerable to forest fires with vulnerability index varying from state to state. Of the 348 districts, 168 are highly vulnerable, 69 moderately vulnerable and 111 low vulnerable. The forest cover in the highly vulnerable districts is 420,071 sq km, 105,226 sq km in the moderately vulnerable districts and 90,819 in the low vulnerable districts. At the national level, Madhya Pradesh has the highest number of vulnerable districts(24), followed by Maharashtra(18) and Andhra Pradesh(15). An analysis of the data revealed that third week of February to first week of May has been the crucial period of forest fire across the country. The information related to fire vulnerability as presented in the report (Vulnerability of India's Forests to Fire) supported with ground data from SFD's on rainfall, poverty and temperature, would act as a base information for managers at state level in preparation of their management plans for measures such as forest protection, identification of vulnerable species, creation of protected zones etc. The outcome of the study using suitable criteria building methods, and local conditions, can be used to prepare appropiate strategies for managing fires on scientific basis.