CHAPTER 1

INTRODUCTION

1.01 Background

Increasing realization of the fact that forests not only provide multiple benefits to mankind but also help in conserving the environment has created global concern for their protection and preservation. Destruction and degradation of forest resources may have detrimental effect on soil, water and climate and, hence, on human and animal life on the earth. This realization has motivated mankind to formulate appropriate policies and plans at various levels (from global to local) for forest conservation and sustainable forest management. However, for formulating appropriate policies, drawing effective management plans and for monitoring changes in the status of forests, it is essential to make accurate and periodic assessments of forest resources.

Forest Survey of India (FSI) is an organization under the Ministry of Environment & Forests, Government of India that has been carrying out assessment of forest resources in the country since its inception as Pre-Investment Survey of Forest Resources (PISFR) in 1965. Initially FSI assessed the forest resources in different parts of the country through ground inventory and interpretation of aerial photographs. However, since the early eighties, it started using satellite data to assess the forest cover of the country. As per its revised mandate of 1986, FSI has to assess forest cover of the country on a two-year cycle and to publish the information in the form of "State of Forest Report" (SFR). Its first assessment was published as SFR 1987 and the latest was the seventh assessment, published as SFR 1999. The present report i.e., the SFR 2001 is the eighth assessment in the series. Steady improvements have been made in the forest cover assessments for preparation of each report by employing latest data with higher resolution and scale, with more intensive coverage under ground verification and by using superior techniques of interpretation. While in the first assessment, resolution of data used was 80m x 80m and scale of interpretation was 1:1 million the same in the eighth assessment was 23.5m x 23.5m and 1:50,000, respectively. A summary of important features of satellite data, sensors and their properties used for various assessments carried out so far are given in Table 1.01.

Table 1.01: Satellite Data for Forest Cover Assessments from 1987 to 2001

Assessment and Year	Data Period	Sensor	Data Form	Spatial Resolution	Spectral Resolution	Scale of Interpretation
I 1987	1981-83	Landsat - MSS	Hard Copy FCC	80 m	4 Bands	1:1million
II 1989	1985-87	Landsat - TM	Hard Copy FCC	30 m	7 Bands	1:250,000
III 1991	1987-89	Landsat - TM	Hard Copy FCC	30 m	7 Bands	1:250,000
IV 1993	1989-91	Landsat - TM	Hard Copy FCC	30 m	7 Bands	1:250,000
V 1995	1991-93	IRS-1B LISS II	Hard Copy FCC & Digital*	36.25 m	4 Bands	1:250,000
VI 1997	1993-	IRS-1B LISS II	Hard Copy FCC &	36.25 m	4 Bands	1:250,000

	95		Digital*			
VII 1999	1996-98	IRS-1C/1D LISS III	Hard Copy FCC & Digital**	23.5 m	4 Bands	1:250,000
VIII 2001	2000	IRS-1C/1D LISS III	Digital	23.5 m	4 Bands	1:50,000

* Digital data used for two states only
** Digital data used for 14 states only

1.02   Forest Cover in the Previous Assessments

The forest cover in all the States and Union Territories (UT) as estimated (including corrections and revision made in SFR 1997) in the seven earlier assessments can be seen at a glance in Table 1.02.

Table 1.02   **Forest Cover in Different Assessments (1987 to 1999)**

(km^2)

State/UT	1987 Assessment	1989 Assessment	1991 Assessment	1993 Assessment	1995 Assessment	1997 Assessment	1999 Assessment
Andhra Pradesh	49,573	47,290	47,290	47,256	47,112	43,290	44,229
Arunachal Pradesh	64,132	69,002	68,757	68,661	68,621	68,602	68,847
Assam	25,160	24,832	24,751	24,508	24,061	23,824	23,688
Bihar	28,482	26,668	26,668	26,587	26,561	4,832	4,830
Jharkhand						21,692	21,644
Delhi	15	22	22	22	26	26	88
Goa	1,240	1,255	1,255	1,250	1,250	1,252	1,251
Gujarat	11,991	11,921	11,907	12,044	12,320	12,578	12,965
Haryana	513	513	513	513	603	604	964
Himachal Pradesh	12,480	12,480	12,480	12,502	12,501	12,521	13,082
Jammu & Kashmir	20,905	20,449	20,449	20,443	20,433	20,440	20,441
Karnataka	32,268	32,104	32,199	32,343	32,382	32,403	32,467
Kerala	10,292	10,292	10,292	10,336	10,336	10,334	10,323
Madhya Pradesh	130,099	135,541	135,541	135,396	135,164	74,760	75,137
Chhattisgarh						56,435	56,693
Maharashtra	45,616	44,044	44,044	43,859	43,843	46,143	46,672
Manipur	17,475	17,685	17,685	17,621	17,558	17,418	17,384
Meghalaya	16,466	15,645	15,875	15,769	15,714	15,657	15,633
Mizoram	19,084	18,170	18,853	18,697	18576	18,775	18,338
Nagaland	14,394	14,399	14,321	14,348	14,291	14,221	14,164
Orissa	53,253	47,227	47,205	47,145	47,107	46,941	47,033
Punjab	943	1,338	1,343	1,343	1,342	1,387	1,412
Rajasthan	12,758	12,884	12,889	13,099	13,280	13,353	13,871
Sikkim	2,756	3,041	3,041	3,119	3,127	3,129	3,118
Tamil Nadu	17,472	16,992	16,992	17,005	17,045	17,064	17,078
Tripura	5,953	5,535	5,535	5,538	5,538	5,546	5,745
Uttar Pradesh	31,226	33,627	33,609	33,961	33,986	10,751	10,756
Uttaranchal						23,243	23,260
West Bengal	8,432	8,015	8,015	8,186	8,276	8,349	8,362
A & N Islands	7,601	7,622	7,622	7,624	7,615	7,613	7,606
Chandigarh	2	5	5	5	7	7	7
Dadra & N. Haveli	238	206	206	206	204	204	202
Daman & Diu	0	0	0	0	0	0	0

Lakshdweep	0	0	0	0	0	0	0
Pondicherry	0	0	0	0	0	0	0
Grand Total	**640,819**	**638,804**	**639,364**	**639,386**	**638,879**	**633,397**	**637,293**
Percent	**19.49**	**19.43**	**19.45**	**19.45**	**19.43**	**19.27**	**19.39**

1.03 About this Report

This report contains six chapters and a number of annexure providing a wealth of statistics and spatial information about forest and tree cover in the country. The statistics have also been provided for each state, union territory and district. This introductory chapter gives historical information, highlights important features of the report, describes various concepts and defines several important terms used in this report. A reader should clearly understand what these terms imply if he or she wishes to fully appreciate the information provided in this report. A "Glossary of Important Terms" appended as Annexure-I may also be referred to. Chapter 2 on "Forest Cover" describes methodology and results of forest cover assessment. Chapter 3 gives estimates of "Changes in Forest Cover" with respect to 1999 Assessment. Chapter 4 on "Tree Cover" describes the methodology and quantitative estimates of tree cover. Chapter 5 is devoted to "Mangrove Cover". The last chapter on "Forest and Tree Cover" provides forest cover maps, forest and tree cover data and other important statistical information for the country, states and union territories. It also gives district wise data on forest cover for each State and UT.

1.04 New Features in SFR 2001

Taking advantage of advancements in remote sensing technology and wealth of data accumulated by Forest Survey of India, the SFR 2001 provides much more comprehensive status of forest and tree cover in the country than the previous seven reports. FSI has taken several initiatives to accomplish this. These new features, introduced for the first time in SFR 2001, are highlighted below:

- *Assessment of forest cover for the entire country using digital method;*

    Forest cover of the entire country has been assessed by interpreting satellite data using digital image processing (DIP) technique. This is in contrast with the previous assessments where visual interpretation of satellite data had been the main mode of interpretation for most of the states. Although, in 1999 assessment, forest cover of 14 states were interpreted digitally at 1:50,000 scale, the information was reprocessed at 1:250,000 scale to compare it with the 1997 assessment. The forest cover data given in SFR 1999 was based on visual interpretation at 1:250,000 scale. Digital interpretation at 1:50,000 scale has several advantages over visual interpretation done at 1:250,000 scale. It minimises subjectivity prevalent in visual interpretation. It also enables

delineation of small areas, which cannot usually be delineated by visual methods due to cartographic limitations. As a result, all the areas down to 1 ha in extent and having forest cover have been included - irrespective of whether they are within or outside the recorded forest areas. Similarly, blanks in excess of 1 ha in the forest areas can be identified and excluded, thereby giving more accurate information on forest cover. (See Chapter 2)

- *Assessment of tree cover at the national level using field inventory data*;

  Field inventory data have been used to assess tree cover in the country. Substantial tree resources exist in the country in the form of linear plantations along roads, canals, etc., scattered trees on farmlands, homesteads and urban areas and blocks of plantations and woodlots smaller than 1 ha that could not be captured by remote sensing data used in the present assessment. For assessment of such tree cover, data collected from field inventory, based on appropriate stratification and sampling techniques, have been used. (See Chapter 4)

- *Estimation of accuracy of forest cover classification*;

  A classification is not complete until its accuracy is assessed. For the first time, an independent and systematic assessment of accuracy of satellite data interpretation by FSI has been made and the results have been presented in this report. Results based on interpretation of satellite data may contain mistakes due to wrong classification. These may be due to technical or human errors. An "error matrix" is usually generated by comparing classified forest cover with the actual forest cover on the ground. An unconventional technique was employed by FSI for preparation of error matrix whereby high resolution PAN data has been used as proxy for ground verification. Comparisons were made at 3,608 locations spread throughout the country to arrive at the accuracy of the output statistics. In order to maintain objectivity in this exercise, the personnel conducting interpretation and classification of forest cover were not associated with the development of error matrix. (See Annexure-II)

- *Mangrove cover classified into dense and open mangrove and merged with forest cover*;

  India has several pockets of Mangroves, which are salt tolerant forest ecosystem, found along coast and in the estuaries. In all the previous assessments, mangroves were treated as a separate class as these could be delineated easily due to their characteristic tone, texture and location on the imageries. However, mangroves also constitute forest cover like any other tree vegetation. Therefore, it

is felt that instead of keeping mangroves as a separate class, it should also be classified into dense and open forest cover. Consequently, in the present assessment, mangrove cover has been included within forest cover. However, since mangroves constitute an important ecosystem, a separate chapter has been devoted to mangrove cover in this SFR. (See Chapter 5)

- *Revised definition of forest cover;*

  In earlier assessments, forest cover was largely confined to assessment of large continuous wooded lands. Areas, identified during ground truthing, having other land uses (e.g., coffee and tea plantations or fruit orchards or coconut crops, etc.) or under private ownership, even though having sufficient tree cover to give reflectance similar to that of forest cover, were deliberately excluded from forest cover. Thus, a complete and true status of forest cover could not be given. This has been overcome in the present assessment by clearly defining forest cover as all lands more than 1 ha in area having tree canopy density above 10 percent irrespective of the tree species and its legal status or ownership or land use.

- *New baseline information on forest and tree cover*;

  The present report provides forest cover data with high precision having cartographic limit of 1 ha. Several "new" patches of forest cover (and several blanks inside forested areas) could be interpreted since better technique (digital, in place of visual) and higher scale (1:50,000 in place of 1:250,000) of interpretation have been used for the present assessment of forest cover. In addition, due to clear-cut definition of forest cover used, all tree crops have been included. Also, countrywide information on tree cover has been given. District wise information on forest cover is provided as per the latest administrative maps of states and union territories containing several new districts for the first time. As per the latest census report (2001), the country has 593 districts whereas SOI maps are available for the years when there were only 453 districts. SOI is the authentic source of geographic area but editions of SOI toposheets showing boundaries of newly created districts may become available only after a long gap of time. Due to this constraint, derivation of forest cover area for new districts becomes a problem. However, in this report, FSI has been able to provide district wise information of forest cover for as many existing districts as possible. FSI made its own effort to update spatial layer (geo-referenced) of district boundaries. A limited help was taken from the administrative maps or drawings of different states supplied by the Census of India (not geo-referenced and at very small scale) on their website. An in-house exercise was undertaken

at FSI to digitise new district boundaries by means of *taluka* boundaries and natural features from SOI toposheets (1:250,000). In this report, information on forest cover for 589 districts (out of a total of 593 districts in the country) has been given (See Chapter 6). Thus, SFR 2001 provides new baseline information on forest and tree cover for the country. Changes in forest cover in future can be directly assessed using the present assessment.

1.05 Forest and Forest Area

A forest is generally defined as a plant community predominantly of trees and other woody vegetation. Food and Agriculture Organisation of United Nations (FAO) defines forest as land with a tree canopy cover of more than 10 percent and area of more than 0.5 ha. Forest is determined not only by presence of trees but also by absence of other predominant land uses. Thus, according to FAO, forest and rubber wood plantations are classified as forests but fruit orchards and trees planted under agroforestry system are categorised as other lands with trees outside forests. Forest also has legal connotation. An area of land recorded as forest in revenue records or proclaimed to be forest under a forest law or Act is also 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". 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.

Distribution of Recorded Forest Area

Total Forest Area = 23.38 %

☐ Reserved Forest ■ Protected Forest ☐ Unclassed Forest ☐ Non Forest Area

Figure 1.01:   Recorded Forest Area

Recorded Forest Area

(in '000 sq.km.)

■ Unclassed Forest

■ Protected Forest

■ Reserved Forest

Figure 1.02:   Recorded Forest Area in States and UTs

The recorded forest area in the country is 768,436 km^2 (or 23.38 percent of the country's geographic area) comprising of 423,311 km^2 of Reserved Forest (55.1 percent of total forest area), 217,245 km^2 of Protected Forest (28.3 percent)

and 127,882 km^2 of Unclassed Forest (16.6 percent). This distribution is depicted in Figure 1.01. The State/UT wise distribution of recorded forest area in the country is given in Table 1.03. It is also shown diagrammatically in Figure 1.02.

Table 1.03   Recorded Forest Area in States and UTs

(Area in km^2)

State/UT	Geographic Area	Reserved Forest	Protected Forest	Unclassed Forest	Recorded Forest Area	(percent)
Andhra Pradesh	275,069	50,479	12,365	970	63,814	23.20
Arunachal Pradesh	83,743	19,880	0	31,660	51,540	61.55
Assam	78,438	18,060	0	8,958	27,018	34.45
Bihar	94,163	693	5,384	1	6,078	6.45
Chhattisgarh	135,191	23,966	31,107	4,212	59,285	43.85
Delhi	1,483	78	7	0	85	5.73
Goa	3,702	236	0	988	1,224	33.07
Gujarat	196,022	13,904	396	4,699	18,999	9.69
Haryana	44,212	249	1,155	147	1,551	3.51
Himachal Pradesh	55,673	1,896	33,043	2,094	37,033	66.52
Jammu & Kashmir	222,236	20,230	0	0	20,230	9.10
Jharkhand	79,714	4,387	19,185	33	23,605	29.61
Karnataka	191,791	28,611	3,932	6,181	38,724	20.19
Kerala	38,863	11,038	183	0	11,221	28.87
Madhya Pradesh	308,245	58,734	35,587	900	95,221	30.89
Maharashtra	307,713	49,217	8,196	4,526	61,939	20.13
Manipur	22,327	1,467	4,171	11,780	17,418	78.01
Meghalaya	22,429	1,112	12	8,372	9,496	42.34
Mizoram	21,081	7,127	3,568	5,240	15,935	75.59
Nagaland	16,579	308	508	7,813	8,629	52.05
Orissa	155,707	26,329	15,524	16,282	58,135	37.34
Punjab	50,362	44	1,112	1,903	3,059	6.07
Rajasthan	342,239	11,860	17,658	2,976	32,494	9.49
Sikkim	7,096	5,376	285	104	5,765	81.24
Tamil Nadu	130,058	19,325	2,240	1,306	22,871	17.59
Tripura	10,486	3,588	509	2,196	6,293	60.01
Uttar Pradesh	240,928	11,078	2,425	3,323	16,826	6.98
Uttaranchal	53,483	23,827	10,673	162	34,662	64.81
West Bengal	88,752	7,054	3,772	1,053	11,879	13.38
A&N Islands	8,249	2,929	4,242	0	7,171	86.93
Chandigarh	114	31	0	2	32	28.45
Dadra & Nagar Haveli	491	198	5	0	203	41.34
Daman & Diu	112	0	1	1	1	1.25
Lakshdweep	32	0	0	0	0	0.00
Pondicherry	480	0	0	0	0	0.00
Total	**3,287,263**	**423,311**	**217,245**	**127,882**	**768,436**	**23.38**

Source: Forest Departments of States and Union Territories

1.06   Forest Cover

In this report, as mentioned earlier, a clear and unambiguous definition of forest cover has been used. Since, forest cover in this assessment has been interpreted from digital data obtained from remote sensing satellites IRS 1C/1D, their technological capability and limitations would have an important bearing on the definition of forest cover. Taking into account the spatial resolution of the data from sensor LISS III, technical limitations inherent in data processing and countrywide extent of assessment, forest cover down to 1 ha only could be included. With the present capability, the different tree species cannot be identified and delineated. Thus, forest cover has been taken to comprise of all woody and perennial tree species, including bamboo, palms, coconut, apples, rubber wood, etc. While interpreting satellite data, one can distinguish between reflectance of tree vegetation from other land cover, but it is not possible to know from the image what kind of land use is being practised under the tree cover or who owns the land. Thus land use or ownership cannot be taken into consideration while classifying forest cover (e.g., delineating tree lands as orchards, coffee/tea plantations, public parks, agroforestry plantations, etc.). Such an exercise at the national level would require mammoth ground verification and may take years to complete. Moreover, since National Forest Policy has set a goal for having 33 percent of country's geographical area under forest and tree cover, irrespective of land use and land ownership, there is no reason to exclude these areas from forest cover. At a later date when data processing techniques and interpretation capability improves, additional classes of forest cover can be introduced to take into account certain tree species and land use. Thus, for SFR 2001, "forest cover" implies all lands more than 1 ha area with tree canopy density above 10 percent irrespective of the tree species and its legal status or ownership or land use. On this premise, the forest cover of the entire country has been assessed. (See Chapter 2)

1.07   Land Cover Classification

The whole of geographical area of the country has been classified into two broad categories of land cover, i.e., "Forest Cover" and "Non-forest". The forest cover is further classified into only two classes that have been used in SFR 2001, viz. dense forest and open forest. These are defined below:

Dense forest: Includes all lands with a forest cover of trees with a canopy density over 40 percent.

Open Forest: All lands with a forest cover of trees with a canopy density between 10 to 40 percent.

The category "non-forest" includes all lands without forest cover, such as agricultural croplands, grasslands, wastelands, scrub, water bodies, riverbeds, snow-covered mountains and built up areas. Only "scrub" has been classified as a separate class within "non-forest". Scrub denotes lands having bushes and/or poor tree growth with canopy density less than 10 percent. Such lands are delineated largely within or around continuous forest areas.

1.08   Change in Forest Cover

By "change" in forest cover we imply determining increase/improvement or decrease/deterioration in the forest cover on the ground that has taken place during the time elapsed between the periods of data used in the two assessments. In the State of Forest Reports, the latest forest cover is compared with that in the previous assessment and the "change" is analysed. However, in the present case, any direct comparison of 2001 assessment with 1999 assessment would be invalid since technique (digital, in place of visual) and scale (1:50,000 in place of 1:250,000) of interpretation were different and the definition of forest cover was modified. The difference between forest cover as assessed in 2001 from that assessed in 1999 is not entirely due to change on the ground during the intervening period. Substantial proportion of it may have occurred over a longer period of time but could be detected only now due to technical reasons. Also, certain forest cover might have got included due to revision in the definition of forest cover. In the art of interpretation of digital data, it is well known that use of coarser resolution overestimates forest cover in the large contiguous forested areas and underestimates it in other areas. Any variation in the forest cover noted when comparing forest cover assessed digitally at 1:50,000 scale with that done visually at 1:250,000 scale would consist of, besides actual change on the ground, difference due to technical factors mentioned above. If differences on account of these technical factors could be separated out, only then the change in forest cover on the ground during the intervening period can be estimated. The method employed for this purpose and estimated change in forest cover in all the States and UTs has been given in Chapter 3.

1.09   Tree and Tree Cover

All perennial woody vegetation including bamboos, palms, coconut, apple, mango, neem, peepal, etc. have been treated as tree in this report. It excludes non-perennial non-woody species (e.g., banana) and tall shrubs or climbers (e.g., lantana or canes). For the purpose of assessing tree cover, only trees having diameter of 10 cm or more at breast height have been considered. Substantial tree wealth exists in the country in the form of linear plantations along roads, canals, etc., scattered trees on farmlands, homesteads and urban areas and blocks of plantations and woodlots smaller that 1 ha. These cannot be captured by the remote sensing satellites (IRS 1C/1D) and sensor (LISS-III) whose data have been used by FSI. All such trees and plantations constitute tree cover and it was assessed on the basis of field inventory. A well thought of stratification and sampling design was developed for assessing tree cover at the national level. A physiographic zone was considered an appropriate category to divide the country into different strata. A physiographic zone is composed of such geographic areas that exhibit broad similarity in the factors responsible for tree growth (e.g., altitude, geographic location, soil, precipitation, temperature, soil moisture, etc.) and thus support fairly homogenous tree vegetation. For the purpose of assessing country's tree wealth and tree cover through field inventory, the country was stratified into fourteen physiographic zones. The data obtained from inventory of trees in sampled rural and urban units was processed and aggregated to estimate

number of trees of different diameter classes and species for all physiographic zones. Using relationship between the diameter and crown area of trees, the number of trees were converted into "notional" area under tree cover. The detailed methodology used and the estimates of tree cover obtained are presented in Chapter 4.

1.10   Comprehensive Assessment of Forest Resources

FSI has been providing information on area under forest cover and now on tree cover, both in spatial and non-spatial forms. However, for sound planning and management decisions in forestry sector, information is also required on volumes of growing stock. In addition, quantitative information on certain other parameters is also required for monitoring status of biodiversity conservation, development of non-wood forest produce and stock of carbon within forest areas. These issues are quite important at national and global levels and have to be dealt by all forest managers at local level. These parameters would also serve as criteria and indicators for sustainable forest management. Thus, providing information on quantitative availability and spatial distribution of all kinds of vegetation in the forests becomes important. Regarding carbon stock in forests, the data on growing stock of wood can be used to estimate carbon stock in the forest biomass. However, stock of carbon in forest soil and forest floor contributes significantly to total carbon stock but has never been assessed directly at the national level. Measurement and compilation of all these information calls for a comprehensive assessment of country's forest resources in future at certain feasible periodicity. Ways and means must be found to address this issue so that sustainability of forest resources could be monitored.