

## **CHAPTER 2**

### **FOREST COVER**

#### **2.01 Introduction**

Assessment of forest cover using satellite data on a two-year cycle has been one of the most important activities of FSI since 1986. The present assessment is the 9<sup>th</sup> assessment in this series. Forest cover is defined as an area more than 1 ha in extent and having tree canopy density of 10 percent and above. This definition is based on the resolution of digital satellite data (pixel size 23.5m x 23.5m), scale of interpretation (1:50,000) and the technique employed for image processing. No distinction with respect to the type of tree crops (natural or man made) or tree species has been attempted since robust techniques are not available for making such distinction. Moreover, no cognizance of the type of land ownership or land use or legal status of land was taken as geo-referenced maps depicting such information was neither available nor possible to collect at country level. Thus, all species of trees (including bamboos, fruits or palms, etc.) and all types of lands (forest, private, community or institutional) satisfying the basic criteria of canopy density of more than 10 percent have been delineated as forest cover while interpreting satellite data. The minimum area of 1 ha for forest cover has been kept because this is the smallest area that can be delineated on a map at 1:50,000 scale.

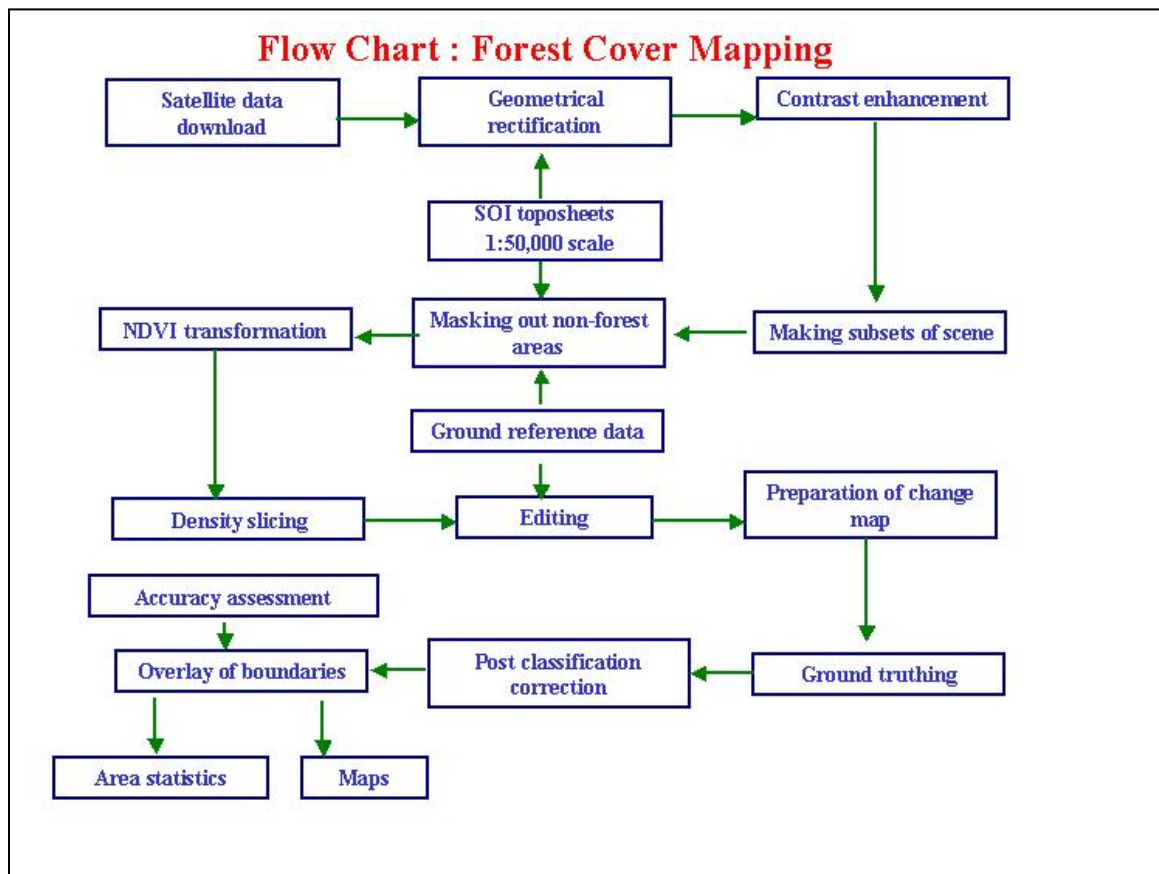
#### **2.02 Satellite Data and its Period**

The present assessment is based on digital interpretation of satellite data for the entire country. The satellite data was procured from the National Remote Sensing Agency (NRSA), Hyderabad in digital form. For the present assessment, LISS-III sensor data of IRS-1D satellite with a resolution of 23.5 m has been used. Data for nearly all the states pertained to the period from October to December 2002. These are the months when cloud cover is low and the deciduous trees still have leaves to provide satisfactory reflectance for the satellite sensors. It may be mentioned here that one scene of LISS III covers an area of about 20,000 km<sup>2</sup> (140 km x 140 km). Due to considerable overlap (15 to 20 percent) among adjacent scenes, as many as 391 scenes are required to envelope the entire country. Also, at the border of the country or for islands, the whole scene has to be procured though area of interest may be very small part of the scene. While procuring data, only those scenes were selected where cloud cover was less than 10 percent.

#### **2.03 Methodology**

Using Digital Image Processing (DIP) software, digital data from satellite available on CDs is downloaded on the Workstation. Radiometric and contrast corrections were applied for removing radiometric defects and for improving visual impact of the False Colour Composites (FCC). Geometric rectification of the data was carried out with the help of scanned SOI toposheets. Based on tone and texture the forest cover areas were delineated. Interpretation of forest cover for the whole country was done at 1:50,000 scale using polyconic projection. Normalized Difference Vegetation Index (NDVI) transformation was also used for density classification of forest cover. Areas of less than one hectare, whether classified as forest within non-forest areas or blanks within

forested areas, were excluded by clustering pixels and merged with the surrounding class. The methodology has been shown schematically in Figure 2.01.



**Figure 2.01 Flow Chart Showing Methodology of Forest Cover Mapping**

The following categories of land use were delineated based on canopy density:

<b>Forest cover</b>	<b>Crown density range</b>
Very Dense Forest (VDF)	> 70 percent
Moderately Dense Forest (MDF)	40-70 percent
Open Forest (OF)	10-40 percent
<b>Non-forest cover</b>	
Scrub	<10 percent
Non-forest	-
Water bodies	-



**Very Dense Forest**



**Moderately Dense Forest**



**Open Forest**



**Mangroves**

**Fig. 2.02 Pictorial illustration of different classes of forests**

Highly degraded forest or wastelands with stumped trees having canopy density less than 10 percent were classified as scrubs, a category of non-forest cover. Shadow areas in the scenes were treated separately. Density in shadow area was either based on ground information or was assigned according to the nearest neighbour class of density. Mangrove cover was also delineated due to their unique signature along the coastal areas. Mangroves were further classified into three density classes of forest cover described above. After delineation, mangrove cover was added up with forest cover in the respective density classes. This was then followed by extensive ground verification and all the necessary corrections were subsequently incorporated. Sheet wise mosaic of districts and States/UTs was made using SOI and Census data to compute district wise and State/UT wise forest cover.

#### **2.04 Limitations of Remote Sensing Technology**

However, there are still certain limitations with remote sensing technology when used for assessment of forest cover. Some of the major ones are listed below:

- Since resolution of data from LISS-III is 23.5 m, the linear strips of forest cover along roads, canals, bunds and rails of width less than the resolution are generally not captured.
- Young plantations and species having less chlorophyll contents in their crown do not give proper reflectance and as a result are difficult to be interpreted correctly.
- Considerable details on ground may be obscured in areas having clouds and shadows. It is difficult to interpret such areas without the help of collateral data.
- Variation in spectral reflectance during leafless period poses problem in interpretation.
- Gregarious occurrence of bushy vegetation and certain agricultural crops, such as lantana, sugarcane, cotton, etc., often pose problems in delineation of forest cover, as their reflectance is similar to that of tree canopy.

#### **2.05 Forest Cover: 2003 Assessment**

Results of present assessment (2003) of forest cover in the country are summarized in a pie chart in Figure 2.01 and Table 2.01. Forest cover is shown in three density classes viz., very dense forest (VDF) with more than 70% canopy density, moderately dense forests (MDF) with canopy density between 40% and 70% and open forests (OF) with canopy density between 10% and 40%. Scrub and water bodies are also delineated. As mentioned earlier, area under VDF, MDF and OF also includes mangrove cover of the corresponding density class. The total forest cover of the country as per 2003 assessment is 678,333 km<sup>2</sup> and this constitutes 20.64 percent of the geographic area of the country. Of this, 51,285 km<sup>2</sup> (1.56 percent) is very dense forest, 339,279 km<sup>2</sup> (10.32 percent) is moderately dense forest while 287,769 km<sup>2</sup> (8.76 percent) is open forest cover. The non-forest cover includes scrub and is estimated to cover an area of 40,269 km<sup>2</sup>.

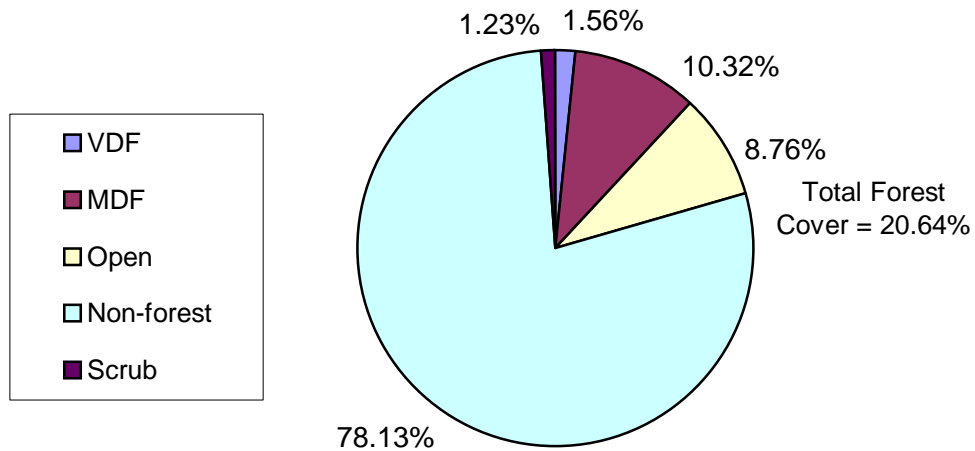
**Table 2.01 Status of Forest Cover in India**

Class	Area (km <sup>2</sup> )	Percent of Geographic Area
<b>Forest Cover</b>		
a) VDF	51,285	1.56
b) MDF	339,279	10.32
c) Open	287,769	8.76
<b>Total Forest Cover*</b>	<b>678,333</b>	<b>20.64</b>
<b>Non-forest Cover</b>		
Scrub	40,269	1.23
Non-forest**	2,568,661	78.13
<b>Total Geographic Area</b>	<b>3,287,263</b>	<b>100.00</b>

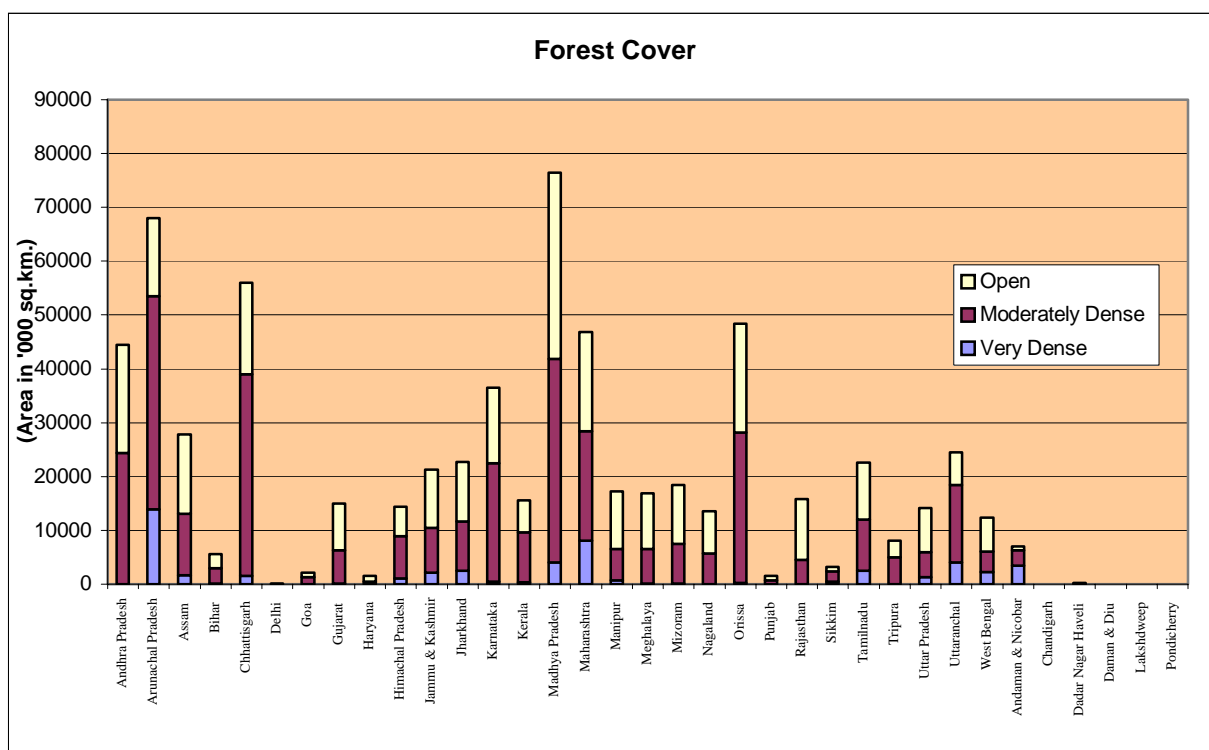
\* Including 4,461 km<sup>2</sup> under mangroves (0.14% of country's geographic area)

\*\* Excludes scrubs and includes water bodies

### Forest Cover Assessment 2003



**Figure 2.03: Forest Cover**



**Figure 2.04: Forest Cover in States and UTs**

## 2.06 State/UT wise Forest Cover

The State/UT wise forest cover in the country is shown in Table 2.02 and as bar chart in Figure 2.03. It shows that Madhya Pradesh with 76,429 km<sup>2</sup> has the maximum area under forest cover, followed by Arunachal Pradesh (68,019 km<sup>2</sup>) and Chhattisgarh (55,998 km<sup>2</sup>). Considering proportion of geographic area under forest cover, Mizoram has the maximum percentage (87.42 percent). It is followed by Andaman & Nicobar Islands (84.42 percent), Nagaland (82.09percent) and Arunachal Pradesh (81.22 percent).

**Table 2.02 Forest cover in States/UTs in India** (Area in km<sup>2</sup>)

State/UT	Geographic Area	Forest Cover				Percent	Scrub
		VDF	MDF	OF	Total		
Andhra Pradesh	275,069	23	24,356	20,040	44,419	16.15	9,748
Arunachal Pradesh	83,743	13,907	39,604	14,508	68,019	81.22	116
Assam	78,438	1,684	11,358	14,784	27,826	35.48	219
Bihar	94,163	76	2,951	2,531	5,558	5.90	150
Chhattisgarh	135,191	1,540	37,440	17,018	55,998	41.42	88
Delhi	1,483	0	52	118	170	11.47	1
Goa	3,702	0	1,255	901	2,156	58.24	0
Gujarat	196,022	114	6,231	8,601	14,946	7.62	1,743

Haryana	44,212	2	518	997	1,517	3.43	68
Himachal Pradesh	55,673	1,093	7,883	5,377	14,353	25.78	389
Jammu & Kashmir	222,236	2,102	8,395	10,770	21,267	9.57	2,947
Jharkhand	79,714	2,544	9,137	11,035	22,716	28.50	807
Karnataka	191,791	431	22,030	13,988	36,449	19.00	3,141
Kerala	38,863	334	9,294	5,949	15,577	40.08	72
Madhya Pradesh	308,245	4,000	37,843	34,586	76,429	24.79	2,378
Maharashtra	307,713	8,070	20,317	18,478	46,865	15.23	4,175
Manipur	22,327	720	5,818	10,681	17,219	77.12	74
Meghalaya	22,429	168	6,323	10,348	16,839	75.08	169
Mizoram	21,081	84	7,404	10,942	18,430	87.42	274
Nagaland	16,579	57	5,650	7,902	13,609	82.09	231
Orissa	155,707	288	27,882	20,196	48,366	31.06	5,346
Punjab	50,362	0	743	837	1,580	3.14	22
Rajasthan	342,239	14	4,482	11,330	15,826	4.62	4,564
Sikkim	7,096	458	1,904	900	3,262	45.97	360
Tamilnadu	130,058	2,440	9,567	10,636	22,643	17.41	2,040
Tripura	10,486	58	4,988	3,047	8,093	77.18	1
Uttar Pradesh	240,928	1,297	4,699	8,122	14,118	5.86	749
Uttaranchal	53,483	4,002	14,420	6,043	24,465	45.74	320
West Bengal	88,752	2,303	3,742	6,298	12,343	13.91	75
Andaman & Nicobar	8,249	3,475	2,809	680	6,964	84.42	1
Chandigarh	114	1	8	6	15	13.16	1
Dadra & Nagar Haveli	491	0	145	80	225	45.82	-
Daman & Diu	112	0	2	6	8	7.45	-
Lakshdweep	32	0	12	11	23	71.88	-
Pondicherry	480	0	17	23	40	8.33	-
<b>Total</b>	<b>3,287,263</b>	<b>51,285</b>	<b>339,279</b>	<b>287,769</b>	<b>678,333</b>	<b>20.64</b>	<b>40,269</b>

## 2.07 Forest Cover in Hill Districts

The National Forest Policy (1988), aims at having a minimum of one third of geographic area of the country under forest and tree cover and enjoins maintaining two third of the area in hills under forest cover in order to prevent erosion and land degradation and also to ensure maintenance of ecological balance and environmental stability. It is therefore felt desirable to know the extent of forest cover in the hill districts in the country. With this objective FSI started assessing forest cover in the hill districts of the country since 1997.

The classification of hill districts and *talukas* is as adopted by the Planning Commission. A hill *taluka* is one where altitude is above 500 m from the mean sea level. The Planning Commission has applied this criterion for Hill Areas and Western Ghats Development Programmes. Since forest cover assessment is done taking district as a unit, only those districts have been categorised as hill districts where the total area of hill *talukas* exceeds 50 percent of the geographic area of a district. The abstract of forest

cover in hill districts is given in Table 2.03. The hill districts have been marked “H” in the district wise forest cover tables in Chapter 7.

There are 123 districts in the country that can be classified as hill districts on the basis of the criterion explained above. The total forest cover in the hill districts of the country is 274,383 km<sup>2</sup> constituting 38.77 percent of the geographic area of these districts, against the goal of 66 percent as laid down in the National Forest Policy 1988. Out of total 123 hill districts, only 54 districts have forest cover more than 66 percent. Of the rest, 36 hill districts have forest cover less than 66 percent but more than 33 percent and the remaining 33 districts have even less than 33 percent forest cover (including 10 districts having less than 10 percent forest cover).

**Table 2.03: State/UT wise Forest Cover in Hill Districts**

(Area in km<sup>2</sup>)

State/UT	No. of Hill Dist.	Geographic area in Hill Districts	Forest Cover				Percent Forest Cover
			Very Dense Forest	Moderate Dense Forest	Open Forest	Total	
Arunachal Pradesh	13	83,743	13,907	39,604	14,508	68,019	81.22
Assam	3	19,153	943	5,678	6,537	13,158	68.70
Himachal Pradesh	12	55,673	1,093	7,883	5,377	14,353	25.78
Jammu & Kashmir	(a) 14	101,388	1,557	6,326	7,712	15,595	15.38
	(b) *	120,848	545	2,069	3,058	5,672	4.69
Karnataka	6	48,046	379	16,351	5,641	22,371	46.56
Kerala	10	29,572	315	7,428	5,057	12,800	43.28
Maharashtra	7	69,905	307	6,334	5,596	12,237	17.50
Manipur	9	22,327	720	5818	10681	17219	77.12
Meghalaya	7	22,429	168	6,323	10,348	16,839	75.08
Mizoram	8	21,081	84	7404	10942	18430	87.42
Nagaland	8	16,579	57	5,650	7,902	13,609	82.09
Sikkim	4	7,096	458	1,904	900	3,262	45.97
Tamil Nadu	5	22,789	1,121	2,710	2,209	6,040	26.50
Tripura	3	10,486	58	4,988	3,047	8,093	77.18
Uttaranchal	13	53,483	4,002	14,420	6,043	24,465	45.74
West Bengal	1	3,149	472	893	856	2,221	70.53
<b>Total</b>	<b>123</b>	<b>707,747</b>	<b>26,186</b>	<b>141,783</b>	<b>106,414</b>	<b>274,383</b>	<b>38.77</b>

\* In area under illegal occupation of Pakistan and China

## 2.08 Forest Cover in Tribal Districts

Tribals in the country are traditional forest dwellers. Forests play a significant role in the tribal economy, as these are a source of subsistence and livelihood for the tribal communities. It is commonly believed that the tribal communities live in harmony with nature and protect forests. Assessment of forest cover in tribal areas therefore acquires a



special significance. Since the 1997 assessment, FSI is regularly providing information on forest cover in districts identified as tribal districts under the Integrated Tribal Development Programme of the Government of India. In addition, all the districts of Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura, Dadra & Nagar Haveli and Lakshdweep have also been included in the list of Tribal districts owing to high tribal population. The abstract of forest cover in the tribal districts is given in Table 2.04.

Out of 593 districts in the country, 187 districts have been identified as tribal districts. The present assessment reveals that the total forest cover in these tribal districts is 407,298 km<sup>2</sup>. It constitutes 36.91 percent of the total geographic area of the tribal districts. A comparison of 2003 assessment of forest cover in tribal districts with that of 2001 assessment shows a net increase of 3,211 km<sup>2</sup> since 2001 assessment. The tribal districts are marked “T” in the district wise tables of forest cover in Chapter 7.

The forest cover in the tribal districts constitutes 60.04 percent of the total forest cover of the country whereas the geographic area of 187 tribal districts forms only 33.6 percent of the total geographic area of the country. It demonstrates that tribal districts are generally rich in forest cover, and hence forest resources. Enhanced investments in forestry activities can be used as an instrument for rapid economic development of tribal communities.

**Table 2.04: State/UT wise forest cover in Tribal Districts**

(Area in km<sup>2</sup>)

State/UT	No. of Tribal Dist.	Geographic area in Tribal Districts	Forest Cover				Percent Forest Cover
			VDF	MDF	OF	Total	
Andhra Pradesh	8	87,090	15	16,355	8,955	25,325	29.08
Arunachal Pradesh	13	83,743	13,907	39,604	14,508	68,019	81.22
Assam	16	50,137	677	4,625	6,750	12,052	24.04
Chhattisgarh	9	90,134	1,286	26,922	12,100	40,308	44.72
Gujarat	8	48,650	105	3,642	3,223	6,970	14.33
Himachal Pradesh	3	26,764	456	1,510	1,240	3,206	11.98
Jharkhand	8	44,413	1,553	5,815	6,265	13,633	30.70
Karnataka	5	26,597	244	8,415	3,653	12,312	46.29
Kerala	9	27,228	259	7,082	4,828	12,169	44.69
Madhya Pradesh	18	139,448	3,247	21,125	16,725	41,097	29.47
Maharashtra	11	138,272	6,681	11,628	10,447	28,756	20.80
Manipur	9	22,327	720	5,818	10,681	17,219	77.12
Meghalaya	7	22,429	168	6,323	10,348	16,839	75.08
Mizoram	8	21,081	84	7,407	10,942	18,430	87.42
Nagaland	8	16,579	57	5,650	7,902	13,609	82.09
Orissa	12	86,124	287	19,110	13,614	33,011	38.33
Rajasthan	5	38,218	-	2,335	3,937	6,272	16.41
Sikkim	4	7,096	458	1,904	900	3,262	45.97
Tamil Nadu	6	30,720	543	2,558	3,377	6,478	21.09

Tripura	3	10,486	58	4,988	3,047	8,093	77.18
Uttar Pradesh	1	7,680	366	502	446	1,314	17.11
West Bengal	11	69,403	2,286	3,644	5,779	11,709	16.87
Andaman & Nicobar	2	8,249	3,475	2,809	680	6,964	84.42
Dadra & Nagar Haveli	1	491	-	145	80	225	45.82
Daman & Diu	1	72	-	1	2	3	4.17
Lakshdweep	1	32	-	12	11	23	71.88
<b>Total</b>	<b>187</b>	<b>1,103,463</b>	<b>36,932</b>	<b>209,929</b>	<b>160,440</b>	<b>407,298</b>	<b>36.91</b>

## 2.09 Loss of Forest Cover due to Shifting Cultivation in N-E States

Shifting cultivation or Jhum cultivation is an agriculture landuse prevalent mainly in North-Eastern States of India where forest land use is converted to agriculture landuse temporarily and this activity is repeated after certain years. Such practice not only affects forest cover of the area adversely but also reduces its productivity and increase soil erosion.

FSI assessed forest cover affected by shifting cultivation in North-Eastern States between the period 2001-2003 and the results are shown in Table 2.05.

**Table 2.05 Loss of Forest Cover due to Shifting Cultivation in N-E States**

(Area in km<sup>2</sup>)

State	Dense Forest	Open Forest	Total
Assam	272	337	609
Arunachal Pradesh	663	262	925
Manipur	125	730	855
Meghalaya	141	543	684
Mizoram	351	336	687
Nagaland	321	1,011	1,332
Tripura	221	163	384
<b>Total</b>	<b>2,094</b>	<b>3,382</b>	<b>5,476</b>

## 2.10 Extent of water bodies inside forest cover

Food & Agriculture Organisation (FAO) has included oceans, seas, lakes, reservoirs and rivers in the definition of water body. Since forests play an important role in precipitation and conserving water, FSI has made an attempt to assess water bodies inside forest cover. These water bodies include rivers, perennial rivers and streams, lakes, ponds, wetlands, creeks, straits etc. having an area of more than 1 ha. State/UT wise extent of water bodies inside forest cover is given in Table 2.06. It is pertinent to mention here that the forest cover as assessed in this assessment and also in previous assessments, does not include water bodies.

**Table 2.06 State/UT wise Extent of Water bodies within Forest cover**(Area in km<sup>2</sup>)

S. No.	State	Water bodies	% of Forest cover
1.	Andhra Pradesh	1,496	3.37
2.	Arunachal Pradesh	396	0.58
3.	Assam	359	1.29
4.	Bihar	66	1.19
5.	Chhattisgarh	770	1.37
6.	Delhi	5	2.94
7.	Goa	25	1.16
8.	Gujarat	3,110	20.81
9.	Haryana	22	1.45
10.	Himachal Pradesh	361	2.52
11.	Jammu & Kashmir	380	1.79
12.	Jharkhand	79	0.35
13.	Karnataka	893	2.45
14.	Kerala	299	1.92
15.	Madhya Pradesh	1,324	1.73
16.	Maharashtra	769	1.63
17.	Manipur	35	0.21
18.	Meghalaya	44	0.26
19.	Mizoram	46	0.25
20.	Nagaland	45	0.33
21.	Orissa	1,541	3.19
22.	Punjab	11	0.71
23.	Rajasthan	118	0.74
24.	Sikkim	17	0.52
25.	Tamilnadu	174	0.77
26.	Tripura	43	0.53
27.	Uttar Pradesh	1,184	8.38
28.	Uttaranchal	331	1.35
29.	West Bengal	2,620	21.23
30.	Andaman & Nicobar Islands	819	11.76
31.	Chandigarh	2	10.07
32.	Dadra & Nagar Haveli	12	5.33
33.	Daman & Diu	0	0.00
34.	Lakshadweep	0	0.00
35.	Pondicherry	0	0.00
	<b>Total</b>	<b>17,396</b>	<b>2.56</b>

**2.11 Forest Cover vis-à-vis Forest Area**

A common reader may not distinguish between forest cover and forest area whereas these are two different entities. As explained earlier, a land may be recorded as

forest area and under management of forest department but may not have any discernible forest cover. On the other hand, all wooded lands or plantations, delineated as forest cover from satellite data may not be legally recorded as forest area as these could be private plantations or institutional wood lots. Although, majority of forested lands happen to be within legally recorded forest areas, all the changes taking place in the forest cover is not necessarily due to changes in the forests managed by the forest departments. Therefore, it is important from policy and planning point of view to know the extent and quality of forest cover within recorded forest areas and outside it. This information will be important and useful for the concerned forest department, civil administration and others.

With availability of GIS tools, such an exercise would be very convenient if the latest geo-referenced forest maps for the whole country showing the latest boundaries of recorded forest areas were available at 1:50,000 or 1:250,000 scales. In absence of this information and with a view to provide some estimates for the proportion of forest cover within recorded forest areas, FSI took up an in-house exercise. Boundaries of 32 groups of important Reserved Forests (RF) in 27 State/UTs were digitised from Survey of India toposheets. The RFs contiguous to each other or occurring in the same toposheets (of 1:50,000 scale) were grouped together for this exercise. These digitised boundaries were then overlaid on forest cover map of 2003 assessment and forest cover within each RF was assessed.

The selected groups of RFs together covered an area of 17,963 km<sup>2</sup>. The area of individual groups of RFs ranged from as large as 2,233.11 km<sup>2</sup> (Simlipal RF in Orissa) to as small as 9.26 km<sup>2</sup> (RFs in Delhi). The total area of selected RFs constituted about 2.2 percent of the total recorded forest area of the country (or about 4.5 percent of total Reserved Forest area of the country). The size of the sample appears reasonable, and together with the fact that the sample was drawn from nearly all forested regions of the country, this exercise can provide an insight into the status of forest cover inside the recorded forests in the country.

The data collected showed that on an average about 81.90 percent of area within RFs had forest cover. For the 32 sampled groups of RFs, the proportion of forest cover ranged from 43.14 percent (in Chamoli district of Uttarakhand where alpine grasslands and snow covered areas are also included in the RFs) to 99.09 percent (in Sikkim). Of these, 14 groups had forest cover of more than 90 percent over its area and 10 groups had between 80-90 percent forest cover. In case of 2 groups the forest cover was even less than 50 percent. It reveals that, on an average, at least 20 percent area within the reserved forests is without forest cover.

