

Chapter

2

FOREST COVER

2.1 Introduction

This chapter presents the findings of the 11th assessment of forest cover of the country, in the series of biennial assessments from 1987. The assessment of forest cover of the country is based on wall-to-wall mapping by interpretation of satellite data. The imagery of Indian Remote Sensing (IRS) satellite P6 LISS III sensor which has got spatial resolution of 23.5 m has been used (see box 2.1). The time of satellite data i.e. date of pass, largely falls in the time window of Oct 2006 to Feb 2007.

The interpretation of satellite data for forest cover mapping involves a series of steps of interpretation starting from rectification, contrast enhancement, masking, NDVI transformation, preparation of change maps and ground truthing exercise on the points spread across the country. It takes about two years time to complete the forest cover mapping of the country. Considering the special significance of forests in tribal districts, hill districts and the northeastern region of the country, the forest cover of these areas are separately analysed and changes compared to previous assessment for these areas. The results of two new studies giving forest cover distribution in different altitude zones and different forest type groups have also been presented in the chapter.

Forest cover as reported in this SFR, includes all lands having trees with canopy density 10 percent and above and with area 1 ha or more. The minimum mapped area is 1 ha of the forest cover, which corresponds to the cartographic limit (a polygon of the size 2 mm by 2 mm) on a map at 1:50,000 scale. The definition of forest cover in the SFR has been adopted considering the methodology of remote sensing

followed by FSI as it takes into account scale of interpretation (1:50,000), the optimum size of cluster of pixels, resolution of digital satellite data (pixel size 23.5m x 23.5m) and the methodology for image interpretation. According to FAO, the forest is defined as 'land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agriculture or urban land use'.

The forest cover mapping presented here does not make any distinction between type and origin of trees i.e. natural or man-made. Also, it does not recognize the type of land ownership or land use and legal status of land. Thus, all species of trees (including bamboos, fruits, coconut, palms, etc.) and all types of lands (forest, private, community or institutional) are included as forest cover provided they satisfy the

Box 2.1

Features of IRS P6 - LISS III Sensor Data

Ground Resolution: 23.5 m in all the 4 bands

Spectral Resolution: 4 bands
Green 0.52 - 0.59 μ m
Red 0.62 - 0.68 μ m
Near Infrared 0.77 - 0.86 μ m
Short wave infrared 1.5 - 1.7 μ m

Radiometric Resolution: 7 bits i.e. 128 levels

Temporal Resolution (Repetivity): 24 days

Swath (width of the strip): 141 km

Area coverage of one scene: 20,000 km² approx

criteria of minimum density and area.

2.2 Satellite Data and its Period

The satellite data for the forest cover mapping was procured from National Remote Sensing Center (NRSC), Hyderabad in the digital form. The entire country is covered by 321 scenes of IRS P6 LISS III data each of which covers the area of approximately 20,000 km² on the ground, with adjoining scenes having some overlap.

The period of satellite data is an important consideration for forest cover mapping. If the time of acquisition of data is not appropriate, then it is possible that the deciduous forests not in foliage, with inadequate tone and texture could be discerned as non forest. The scenes should also not have more than 10% ground under cloud cover so as not to obscure the ground details. With these two criteria, each scene is

selected after browsing the NRSC website. In the Indian conditions the satellite data of the period October to December is found most suitable for forest cover mapping. In the present report data for most of the States & UTs pertain to October to December 2006. Only in a few cases of North-East region and Andaman & Nicobar Islands, where availability of cloud-free data was difficult, the data period was extended up to March 2007. The period of satellite data used for each State and UT has been mentioned in the respective sections of the Chapter 7.

2.3 Methodology

The methodology of forest cover mapping involves a series of steps of processing of satellite data using digital image processing (DIP) software as shown in Fig 2.1. A hybrid approach is followed wherein advantages of the algorithms available in the software

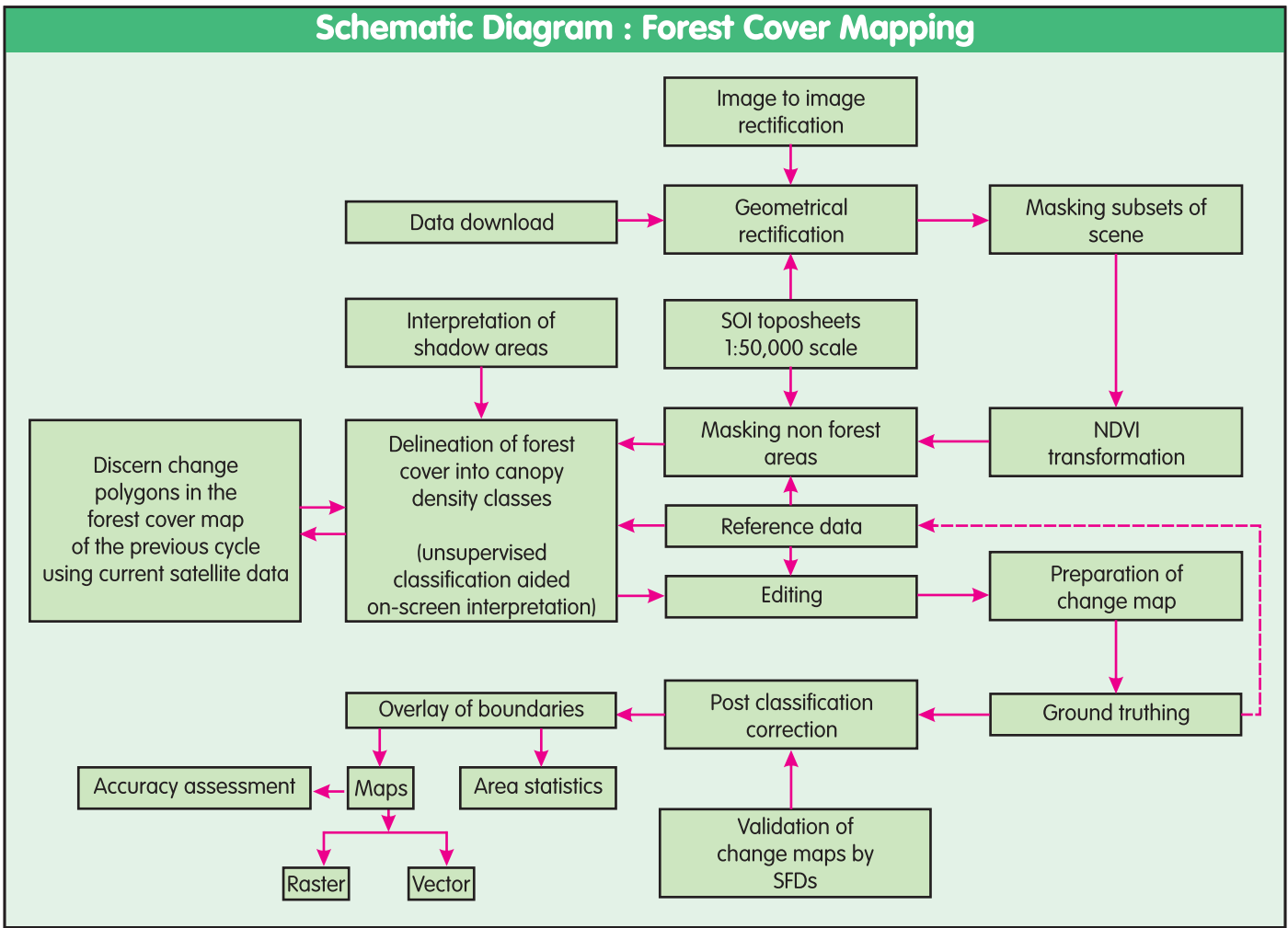


Fig. 2.1: Flow chart showing methodology of forest cover mapping

and experience and ground knowledge of the interpreter are used.

There is a significant change in the methodology followed in the current forest cover mapping, wherein vector approach has been followed in place of raster. The new approach focuses on each polygon where change in forest cover has occurred either due to improvement or degradation. Due to this change in the methodology, the subjectivity in the interpretation has been greatly reduced. The vector output of the forest cover will provide improved cartographic presentation and facilitate GIS analysis.

To begin with, geometric rectification of the satellite imagery is carried out with the help of scanned and geo-referenced Survey of India (SOI) toposheets on 1:50,000 scale. The methodology of interpretation involves a hybrid approach in which unsupervised classification (ISODATA algorithm) aided by on-screen visual interpretation of forest cover is done.

In order to make the current forest cover (2007) with the new methodology comparable with preceding one (2005), the satellite data of 2005 was re-interpreted with new methodology. Compatibility of geometric rectification was ensured with the help of a new module of the ERDAS Imagine software called Auto Sync. Normalized Difference Vegetation Index (NDVI) transformation was used for removing non-vegetated areas from the scene.

Interpretation was then followed by extensive ground verification. All the necessary corrections were subsequently incorporated. Reference data collected through ground truth and field experience of the interpreter played an important role in delineating the forest cover patches and classifying them into the three canopy density classes. The classification scheme of forest cover mapping is as follows.

Very Dense Forest	All lands with tree cover of canopy density of 70% and above
Moderately Dense Forest	All lands with tree cover of canopy density between 40% and 70%
Open Forest	All lands with tree cover of canopy density between 10% and 40%.
Scrub	Degraded forest lands with canopy density less than 10 %.
Non-forest	Any area not included in the above classes.

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.

Degraded forests with tree canopy density less than 10 percent have been classified as scrub, which does not form part of the forest cover.

Shadow areas in the scenes have been treated separately. Shadow regions on the images are highlighted using band ratio techniques. Forest cover classification of the totally obscured areas due to shadow or cloud cover has been done using the ground truth information.

Mangrove forests have characteristic tone and texture on the satellite image. Their presence on the coastal areas makes them even more conspicuous. Considering the high ecological significance, the mangrove forest cover has been separately mapped in the three canopy density classes.

2.4 Accuracy Assessment

Accuracy assessment is an essential part of remote sensing based mapping. The degree of matching of interpreted satellite data with the ground reality gives the accuracy level. Accuracy assessment for the forest cover mapping was done as an independent exercise for which randomly selected sample points were verified on the ground and tallied with interpreted data. In this assessment 4,302 points randomly distributed over the entire country were selected and the verification was done using field inventory data as well as high resolution satellite data (5.8 m). The detailed procedure of accuracy assessment has been described in Chapter 6. The error matrix presented in Table 6.3.1 reveals that out of the total 4,302 sampling points, classification of 3,962 was correct. The overall accuracy of the forest cover mapping therefore comes to be 92.10%. If the mapping is considered in two classes only i.e. forest cover and non-forest, the accuracy rises to 95.72%.

2.5 Limitations of Remote Sensing Technology in Forest Cover Mapping

There are limitations of the mapping done by interpretation of remote sensing data. The limitations are largely related to the spatial, spectral and radiometric resolutions of the satellite data used in the

mapping. Often, adverse weather conditions prevailing at the time of capturing of the satellite image lead to low quality of image, which poses problems in discerning the features to be mapped. Some of the important limitations in forest cover mapping using IRS P6 LISS III data are as follows:

- The linear strips of forest cover along roads, canals, bunds and railway lines of lesser width are generally not captured.
- Young plantations are generally not discernible.
- 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 or ground truth.
- Gregarious occurrence of bushy vegetation and

certain agricultural crops, such as sugarcane, cotton, lantana, etc., often poses problems in delineation of forest cover.

2.6 Forest Cover: 2007 Assessment

The forest cover of the country according to the current assessment is given in Table 2.6.1 and also presented in the pie chart in Fig 2.4. Forest cover is shown in three density classes, viz., very dense forest (VDF), moderately dense forests (MDF), and open forests (OF). Scrub areas have also been delineated. As mentioned earlier, area under VDF, MDF and OF also includes mangrove cover of the corresponding density class.

The forest cover of the country as per 2007 assessment is 690,899 km² which is 21.02 percent of

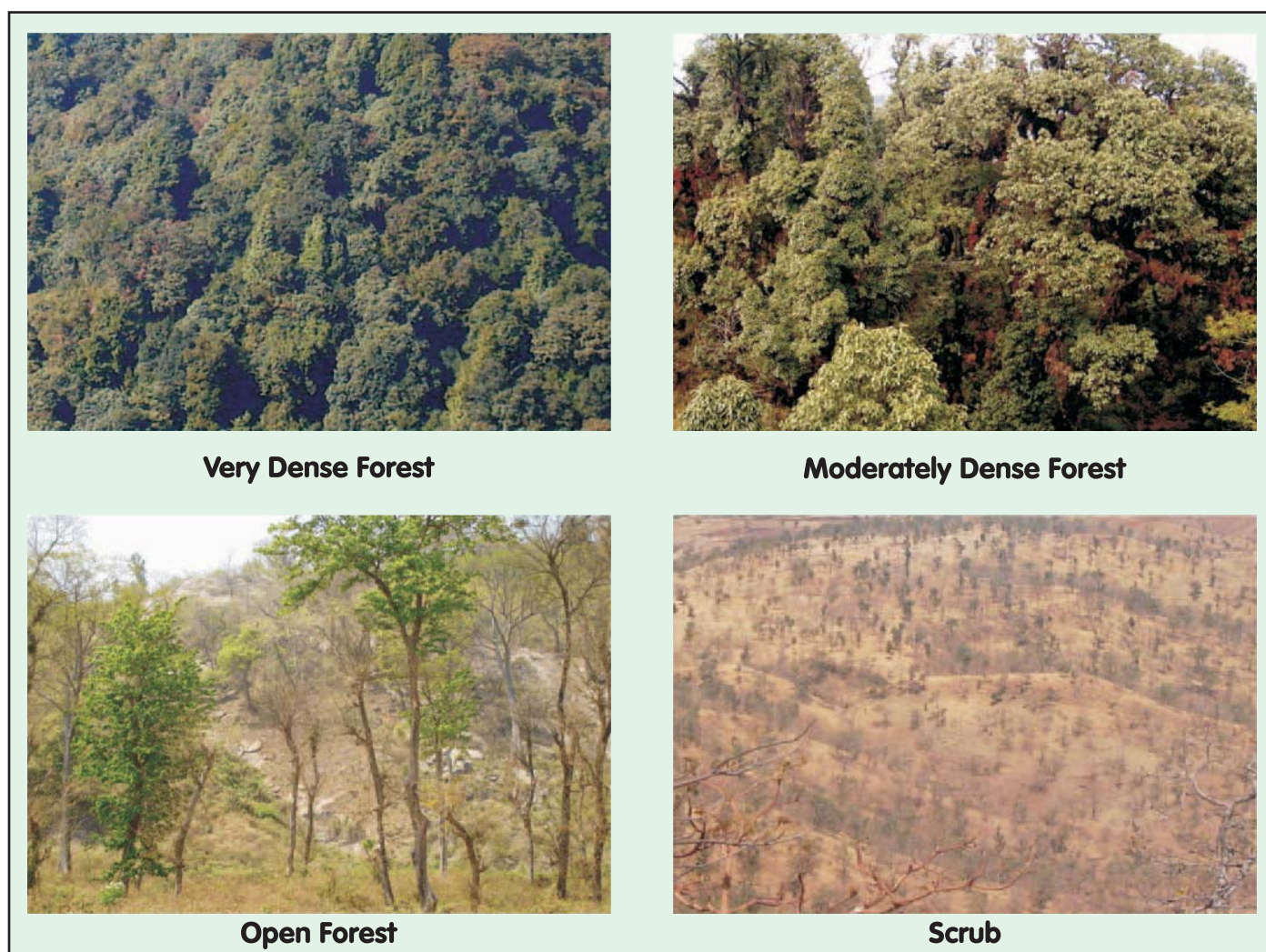


Fig. 2.2 Pictorial illustration of different classes of forest cover & scrub

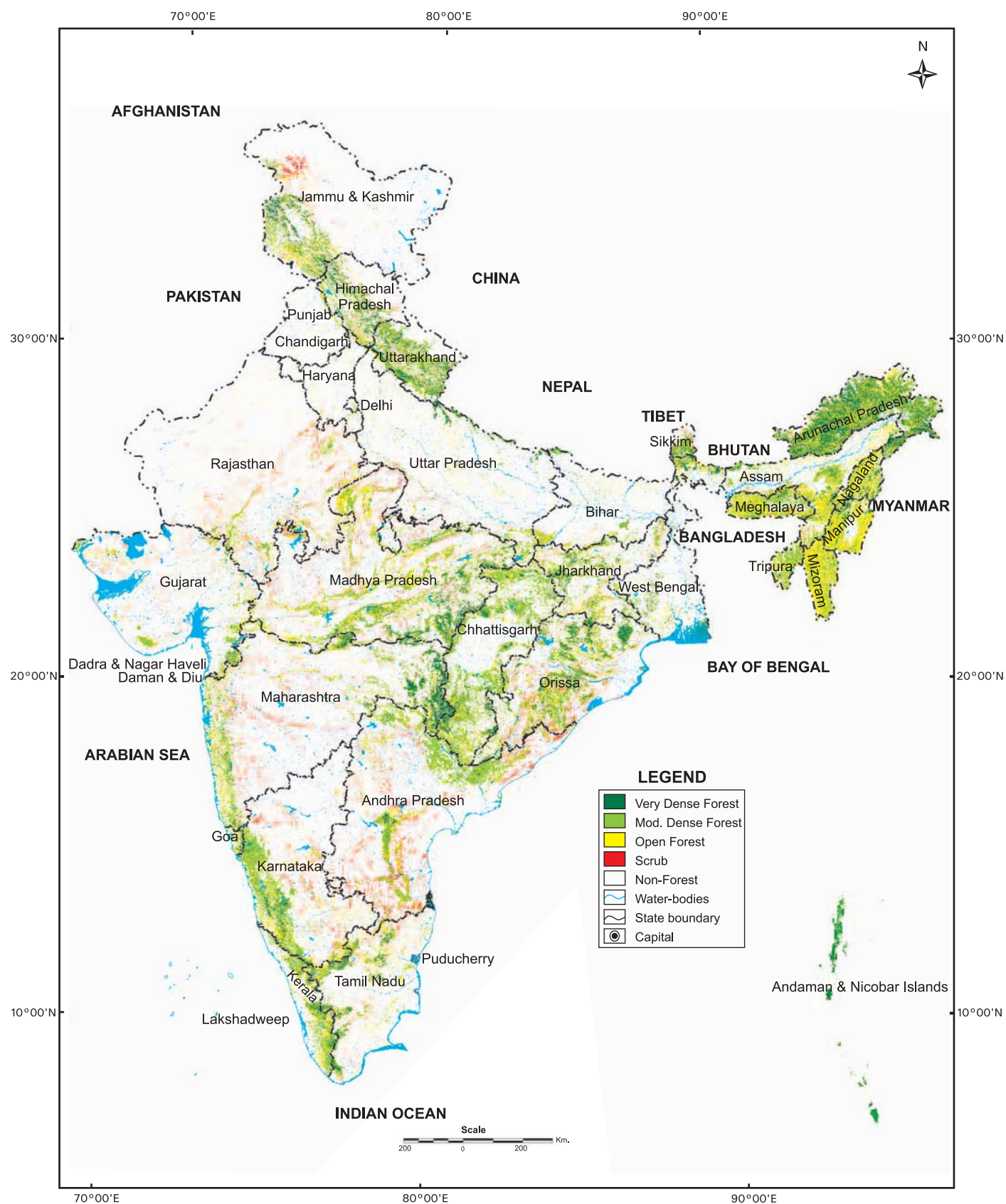


Fig. 2.3: Forest Cover Map of India of 2007

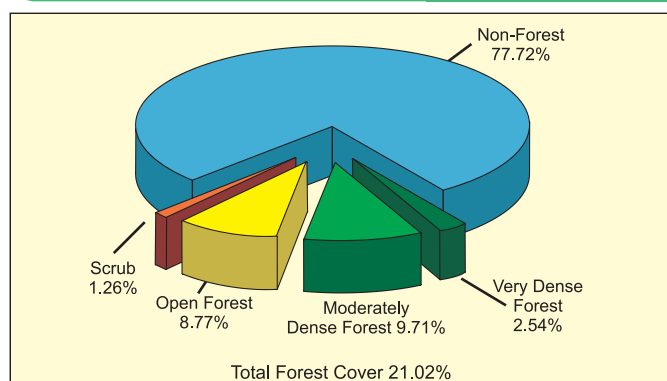


Figure 2.4: Forest Cover of India

the geographical area of the country. Very dense forest constitutes 83,510 km² (2.54%), the moderately dense forest 319,012 km² (9.71%) and open forest constitutes 288,377 km² (8.77%) of the geographical area. The scrub accounts for 41,525 km² (1.26%).

Table 2.6.1: Status of forest cover of India in 2007

Class	Area (km ²)	% of Geographical Area
Forest Cover		
Very Dense Forest	83,510	2.54
Moderately Dense Forest	319,012	9.71
Open Forest	288,377	8.77
Total Forest Cover*	690,899	21.02
Non-forest		
Scrub	41,525	1.26
Non-forest**	2,554,839	77.72
Total Geographical Area	3,287,263	100.00

* Includes 4,639 km² under mangroves

** Excludes scrubs and includes water bodies

2.7 State/UT wise Forest Cover

Forest cover of each State and UT of the country has been presented in the Table 2.7.1. Madhya Pradesh has got the largest forest cover in the country followed by Arunachal Pradesh, Chhattisgarh, Maharashtra and Orissa. In terms of percentage of forest cover with respect to total geographical area, Mizoram with 91.27% leads the table, followed by Lakshadweep (82.75%), Nagaland (81.21%), Andaman & Nicobar Islands (80.76%), Arunachal Pradesh (80.43%), Manipur (77.40%), Meghalaya (77.23%) and Tripura (76.95%). Arunachal Pradesh has got the largest area of very dense forest cover and Andhra Pradesh has got the largest area of scrub.

2.8 Forest Cover in Hill Districts

Forest cover in hilly terrain is important from the ecological considerations. Recognizing this fact, the National Forest Policy (1988) aims at maintaining two thirds of the geographical area in hills of the country under forest and tree cover.

The hill districts identified for the forest cover analysis are the ones identified by the Planning Commission for Hill Areas and Western Ghats Development Programme. As per their criterion, a hill taluka is the one which has altitude more than 500 m from the mean sea level. A hill district is one whose total area of hill talukas is more than half of the geographical area of the district.

There are 124 hill districts (marked 'H' in district-wise tables of forest cover in Chapter 7) spread over 16 States and UTs as per the above definition. Table 2.8.1 gives a State wise summary of forest cover in the hill districts of the country.

The forest cover in the hill districts of the country is 281,841 km², which is 39.82% of the total geographical area of these districts. Though the entire geographical area of these districts does not constitute the hilly terrain but the forest cover figures shown in the above table do provide a good basis to monitor the policy guidelines.

All the districts of the States of Arunachal Pradesh, Himachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura, and Uttarakhand are hill districts. The percentage of forest cover in these nine states is 66.07%.

Out of 124 hill districts, 55 have over two thirds of geographical area under forest cover; 37 have between one third and two thirds; and 32 have less than one third. Moreover, forest cover is less than 10% of geographical area in 8 hill districts.

In the hill districts of the country, comparison of forest cover of 2007 with that of 2005 (revised) shows a net gain of 663 km² of forest cover.

Table 2.7.1: Forest cover in States/UTs in India in 2007

(area in km²)

State / UT	Geographical Area	Forest Cover				% of G.A.	Change* in forest cover	Scrub
		Very Dense Forest	Mod. Dense Forest	Open Forest	Total			
Andhra Pradesh	275,069	820	24,757	19,525	45,102	16.40	-129	10,372
Arunachal Pradesh	83,743	20,858	31,556	14,939	67,353	80.43	-119	111
Assam	78,438	1,461	11,558	14,673	27,692	35.30	-66	179
Bihar	94,163	231	3,248	3,325	6,804	7.23	-3	134
Chhattisgarh	135,191	4,162	35,038	16,670	55,870	41.33	-59	107
Delhi	1,483	7	50	120	177	11.94	0	1
Goa	3,702	511	624	1,016	2,151	58.10	-5	1
Gujarat	196,022	376	5,249	8,995	14,620	7.46	16	1,463
Haryana	44,212	27	463	1,104	1,594	3.61	-10	145
Himachal Pradesh	55,673	3,224	6,383	5,061	14,668	26.35	2	327
Jammu & Kashmir	222,236	4,298	8,977	9,411	22,686	10.21	-3	2,036
Jharkhand	79,714	2,590	9,899	10,405	22,894	28.72	172	683
Karnataka	191,791	1,777	20,181	14,232	36,190	18.87	-10	3,176
Kerala	38,863	1,443	9,410	6,471	17,324	44.58	40	58
Madhya Pradesh	308,245	6,647	35,007	36,046	77,700	25.21	-39	6,401
Maharashtra	307,713	8,739	20,834	21,077	50,650	16.46	-11	4,157
Manipur	22,327	701	5,474	11,105	17,280	77.40	328	1
Meghalaya	22,429	410	9,501	7,410	17,321	77.23	116	211
Mizoram	21,081	134	6,251	12,855	19,240	91.27	640	1
Nagaland	16,579	1,274	4,897	7,293	13,464	81.21	-201	2
Orissa	155,707	7,073	21,394	20,388	48,855	31.38	100	4,852
Punjab	50,362	0	733	931	1,664	3.30	4	20
Rajasthan	342,239	72	4,450	11,514	16,036	4.69	24	4,347
Sikkim	7,096	500	2,161	696	3,357	47.31	0	356
Tamil Nadu	130,058	2,926	10,216	10,196	23,338	17.94	24	1,206
Tripura	10,486	111	4,770	3,192	8,073	76.95	-100	75
Uttar Pradesh	240,928	1,626	4,563	8,152	14,341	5.95	-5	745
Uttarakhand	53,483	4,762	14,165	5,568	24,495	45.80	2	271
West Bengal	88,752	2,987	4,644	5,363	12,994	14.64	24	29
Andaman & Nicobar	8,249	3,762	2,405	495	6,662	80.76	-1	53
Chandigarh	114	1	10	6	17	14.91	0	1
Dadra & Nagar Haveli	491	0	114	97	211	42.97	-5	1
Daman & Diu	112	0	1	5	6	5.04	0	3.0
Lakshadweep	32	0	16	10	26	82.75	0	0
Puducherry	480	0	13	31	44	9.14	2	0
Grand Total	3,287,263	83,510	319,012	288,377	690,899	21.02	728	41,525

*The change in the above table refers to change in the area with respect to revised assessment for 2005.

2.9 Forest Cover in Tribal Districts

Forests are central to the cultural and economic life of tribal people, who have lived in forests in harmony since ages. It is important to monitor and analyse the forest cover situation in the tribal areas. The

tribal districts for purpose of this section are those as identified by the Government of India under the Integrated Tribal Development Programme.

In all, there are 188 tribal districts in 26 States/UTs in the country (marked 'T' in district-wise

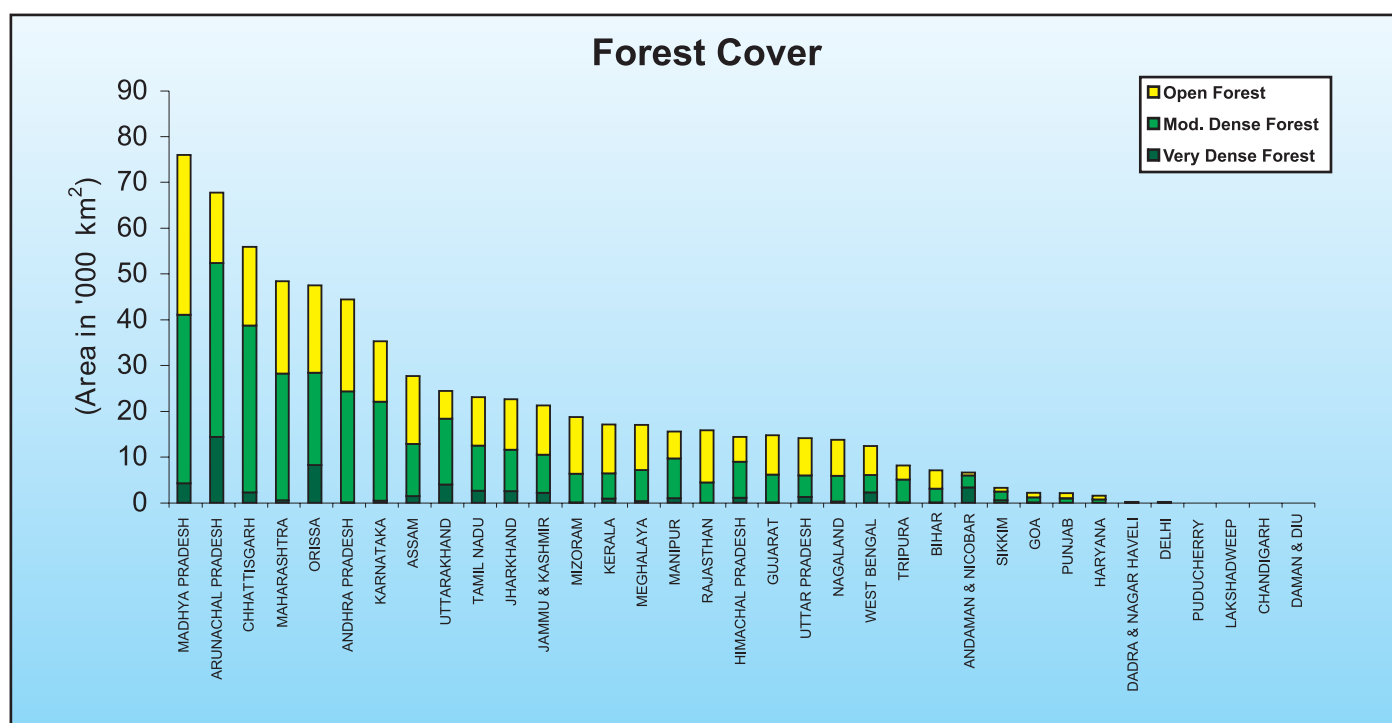


Fig. 2.5: Diagram showing class wise forest cover in different States and UTs in descending order

Table 2.8.1 : Forest cover in hill districts in 2007

(area in km²)

State / UT	No. of Hill Districts	Geographical Area in Hill Districts	Forest Cover				% of G.A.	Change* in forest cover	Scrub
			Very Dense Forest	Mod. Dense Forest	Open Forest	Total Forest			
Arunachal Pradesh	13	83,743	20,858	31,556	14,939	67,353	80.43	-119	111
Assam	3	19,153	755	5,798	6,450	13,003	67.89	-49	34
Himachal Pradesh	12	55,673	3,224	6,383	5,061	14,668	26.35	2	327
Jammu & Kashmir	(a) 14	101,388	2,958	6,507	6,844	16,309	16.09	-2	243
	(b) **	120,848	1,340	2,470	2,567	6,377	5.28	-1	1,793
Karnataka	6	48,046	1,492	14,922	6,786	23,200	48.29	0	508
Kerala	10	29,572	1,105	7,314	5,281	13,700	46.33	50	53
Maharashtra	7	69,905	319	7,246	7,943	15,508	22.18	-4	0
Manipur	9	22,327	701	5,474	11,105	17,280	77.40	328	1
Meghalaya	7	22,429	410	9,501	7,410	17,321	77.23	116	211
Mizoram	8	21,081	134	6,251	12,855	19,240	91.27	640	1
Nagaland	8	16,579	1,274	4,897	7,293	13,464	81.21	-201	2
Sikkim	4	7,096	500	2,161	696	3,357	47.31	0	356
Tamil Nadu	5	22,789	967	3,244	1,993	6,204	27.22	2	230
Tripura	4	10,486	111	4,770	3,192	8,073	76.95	-100	75
Uttarakhand	13	53,483	4,762	14,165	5,568	24,495	45.80	2	271
West Bengal	1	3,149	714	663	912	2,289	72.69	-1	0
Grand Total	124	707,747	41,624	133,322	106,895	281,841	39.82	663	4,216*

* The change in the above table refers to change in the area with respect to revised assessment for 2005.

** Refers to area outside LOC under illegal occupation of Pakistan and China.

Table 2.9.1: Forest cover in tribal districts in 2007

(area in km²)

State / UT	No. of Tribal Districts	Geographical Area in Tribal Districts	Forest Cover				% of G.A.	Change* in forest cover	Scrub
			Very Dense Forest	Mod. Dense Forest	Open Forest	Total Forest			
Andhra Pradesh	8	87,090	239	16,745	8,583	25,567	29.36	-96	2,405
Arunachal Pradesh	13	83,743	20,858	31,556	14,939	67,353	80.43	-119	111
Assam	16	50,137	651	4,666	6,691	12,008	23.95	-32	89
Chhattisgarh	9	92,656	3,611	24,573	12,026	40,210	43.40	-21	79
Gujarat	8	48,409	322	2,949	3,496	6,767	13.98	-8	382
Himachal Pradesh	3	26,764	950	1,068	1,213	3,231	12.07	0	138
Jharkhand	8	44,413	1,677	6,057	6,155	13,889	31.27	96	339
Karnataka	5	26,597	1,248	7,642	4,249	13,039	49.02	1	55
Kerala	9	27,228	1,073	7,026	5,010	13,109	48.15	53	44
Madhya Pradesh	18	139,448	5,645	20,291	16,376	42,312	30.34	-48	2,100
Maharashtra	11	138,272	7,277	11,397	10,835	29,509	21.34	-11	2,127
Manipur	9	22,327	701	5,474	11,105	17,280	77.40	328	1
Meghalaya	7	22,429	410	9,501	7,410	17,321	77.23	116	211
Mizoram	8	21,081	134	6,251	12,855	19,240	91.27	640	1
Nagaland	8	16,579	1,274	4,897	7,293	13,464	81.21	-201	2
Orissa	12	86,124	5,279	14,465	13,555	33,299	38.66	78	2,593
Rajasthan	5	38,218	0	2,444	3,904	6,348	16.61	0	940
Sikkim	4	7,096	500	2,161	696	3,357	47.31	0	356
Tamil Nadu	6	30,720	695	2,396	3,636	6,727	21.90	-3	417
Tripura	4	10,486	111	4,770	3,192	8,073	76.95	-100	75
Uttar Pradesh	1	7,680	409	475	436	1,320	17.19	-1	1
West Bengal	11	69,403	2,965	4,473	4,861	12,299	17.72	24	28
Andaman & Nicobar	2	8,249	3,762	2,405	495	6,662	80.76	-1	53
Dadra & Nagar Haveli	1	491	0	114	97	211	42.97	-5	1
Daman & Diu	1	72	0	1	3	4	5.56	0	0
Lakshadweep	1	32	0	16	10	26	82.75	0	0
Grand Total	188	1,105,744	59,791	193,813	159,121	412,625	37.32	690	12,548

*The change in the above table refers to change in the area with respect to revised assessment for 2005.

table of forest cover in Chapter 7). Table 2.9.1 presents a summary of forest cover in tribal districts of the country.

All the districts of the States of Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura; the UTs of Dadra & Nagar Haveli, and Lakshadweep are tribal districts.

The total forest cover in the tribal districts is 412,625 km², which is 37.32% of the geographical area of these districts.

The tribal districts constitute only 33.64% geographical area of the country, though the forest cover in these districts is 59.72% of the total forest cover of the country. All the North-Eastern States have over

75% geographical area under forest cover, except Assam (23.95% in 16 tribal districts). Overall, these figures indicate the richness of forest resources in the tribal districts in general, and in North-East region in particular.

The comparison of forest cover in the tribal districts with respect to 2005 assessment (revised) shows a net gain of 690 km² of forest cover.

2.10 Forest Cover in the North-Eastern States

The North-East region of the country comprising 7 States namely, Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland & Tripura is endowed with rich forest resources. The

Table 2.10.1: Forest cover in the North-Eastern States in 2007

(area in km²)

State / UT	Geographical Area	Forest Cover				% of G.A.	Change* in forest cover
		Very Dense Forest	Mod. Dense Forest	Open Forest	Total		
Arunachal Pradesh	83,743	20,858	31,556	14,939	67,353	80.43	-119
Assam	78,438	1,461	11,558	14,673	27,692	35.30	-66
Manipur	22,327	701	5,474	11,105	17,280	77.40	328
Meghalaya	22,429	410	9,501	7,410	17,321	77.23	116
Mizoram	21,081	134	6,251	12,855	19,240	91.27	640
Nagaland	16,579	1,274	4,897	7,293	13,464	81.21	-201
Tripura	10,486	111	4,770	3,192	8,073	76.95	-100
Grand Total	255,083	24,949	74,007	71,467	170,423	66.81	598

* The change in the above table refers to change in the area with respect to revised assessment for 2005.

region, which is only 7.76% of the geographical area of the country, accounts for nearly one fourth of its forest cover. This region is also rich in biodiversity and has been identified as one of the 18 biodiversity hot spots of the world. The region is inhabited by many important tribes, which constitute about 27% of the population of the region. One distinct feature of land use in this region is the prevalence of shifting cultivation, which has traditionally been the main source of livelihood of the tribal people of this region. Over the years, population of the tribals has grown and as a result of this the cycle of shifting cultivation has come down to less than 5 years in general, leading to degradation of forests.

The total forest cover in the region is 170,423 km², which is 66.81% of the geographical area as against the national average of 21.02%. Very dense, moderately dense and open forests constitute 14.64%, 43.42% and 41.94% of the total forest cover of the region respectively. As compared to 2005 assessment (revised), a gain of 598 km² of forest cover has been observed in the region. The main reasons for the gain are regeneration in shifting cultivation areas. State-wise forest cover in the region, along with the changes as compared to the previous

assessment is shown in Table 2.10.1.

2.11 Forest Cover in Different Altitude Zones

The information on the distribution of forest cover in different altitude zones is important for policy and planning in the States which have hilly terrain. Using Shuttle Radar Topography Mission (SRTM) digital elevation model of United States, an analysis in GIS was done for all the States and UTs to determine forest cover in different altitude zones. The altitude zones for the analysis were taken as 0-500m, 500-1000m, 1000-2000m, 2000-3000m and above 3000 meters. The DEM used in the analysis has a resolution of 90m, which is appropriate for national or sub national level information of this kind. The Table 2.11.1 gives altitude zone wise forest cover of the country. The State wise information has been given in the respective sections of Chapter 7.

2.12 Area above Tree Line

Beyond 4,000 meters altitude, the cold climatic

Table 2.11.1: Forest cover in different Altitude Zones

(area in km²)

Altitude Zone	VDF	MDF	OF	Total	% of G.A. of the zone
0-500m	29,600	156,702	172,101	358,403 (51.87%)	15.62
500-1000m	21,522	97,124	78,057	196,703 (28.47%)	33.58
1000-2000m	14,492	37,049	24,647	76,188 (11.03%)	72.19
2000-3000m	14,154	19,313	7,001	40,468 (5.86%)	66.04
Above 3000m	3,742	8,824	6,571	19,137 (2.77%)	7.98
Total	83,510	319,012	288,377	690,899 (100.00%)	21.02

conditions are not favourable for growth of trees. Although small patches of forest cover do exist above 4,000m in India, but these are considered as exceptions.

For all practical purposes, the area above this altitude which is also referred to as tree line, is not suitable for increasing forest cover through afforestation activities. There is a sizable area in the Himalayan region of the country which is above 4,000m. For calculating the forest & tree cover

percentage of the country, therefore, these areas need to be reduced from the geographical area. The Table 2.12.1 shows the State wise breakup of the area above 4,000m. If we remove this area above tree line i.e. 183,135 km² from the geographical area (GA) of the country, then forest cover of the country as per the current assessment of 2007 becomes 22.26% of the geographical area and if the tree cover of the country (as mentioned in Chapter 4) is also taken into consideration, the forest & tree cover of the country becomes 25.25% of the geographical area.

Table 2.12.1: Geographical area of different States above 4,000m

(area in km²)

State	Geographical Area (G.A.)	Forest & Tree Cover	Geographical Area above 4,000m*	Forest & Tree Cover (%) if the area above 4,000m is excluded from G.A.
Arunachal Pradesh	83,743	67,945	6,514	87.98
Himachal Pradesh	55,673	15,306	21,119	44.30
Jammu & Kashmir	222,236	29,450	141,313	36.39
Sikkim	7,096	3,377	3,161	85.82
Uttarakhand	53,483	25,160	11,028	59.26
Total	422,231	141,238	183,135	

* based on SRTM DEM

2.13 Forest Cover in Different Forest Types

The area of forest cover by forest types provides a basis for characterization in terms of floristic composition and ecological value. In the first ever attempt FSI has completed the exercise of mapping of forest types of India, according to Champion & Seth classification (1968) on 1:50,000 scale. The study has been carried out in GIS framework using the relevant layers like, soil, rainfall, temperature along with the remote sensing data, details from the working plans, thematic maps of FSI, inventory information etc. It also involved extensive ground truthing covering all districts of the country. The district wise forest type maps have been prepared. Using the forest type maps, the area of forest cover in different forest types has been determined and presented in this report. The Table 2.13.1 gives the distribution of country's forest cover in different type groups.

2.14 Change in Forest Cover

The change in the current assessment as compared to revised assessment of 2005 has been presented for all the States. The district wise change in

Table 2.13.1: Forest cover in different forest type groups

Forest Type Group	%
Group 1- Tropical Wet Evergreen Forest	8.75
Group 2- Tropical Semi-Evergreen Forest	3.35
Group 3- Tropical Moist Deciduous Forest	33.92
Group 4- Littoral and Swamp Forest	0.38
Group 5- Tropical Dry Deciduous Forest	30.16
Group 6- Tropical Thorn Forest	5.11
Group 7- Tropical Dry Evergreen Forest	0.29
Group 8- Subtropical Broadleaved Hill Forest	0.38
Group 9- Subtropical Pine Forest	5.99
Group 10- Subtropical Dry Evergreen Forest	0.36
Group 11- Montane Wet Temperate Forest	3.45
Group 12- Himalayan Moist Temperate Forest	3.79
Group 13- Himalayan Dry Temperate Forest	0.28
Group 14, 15, 16- Sub Alpine and Alpine Forest	3.79
Total	100.00

forest cover has been presented in the respective sections of the States and UTs in Chapter 7.

Table 2.14.1 gives the change in forest cover for each State/UT for each of the three canopy density classes. The overall change at the country level as

Table 2.14.1: Change in the forest cover of States/UTs between 2005 and 2007 assessments

(area in km²)

State / UT	2005				2007				Change*			
	Very Dense	Mod. Dense	Open	Total	Very Dense	Mod. Dense	Open	Total	Very Dense	Mod. Dense	Open	Total
Andhra Pradesh	820	24,805	19,606	45,231	820	24,757	19,525	45,102	0	-48	-81	-129
Arunachal Pradesh	20,859	31,632	14,981	67,472	20,858	31,556	14,939	67,353	-1	-76	-42	-119
Assam	1,464	11,653	14,641	27,758	1,461	11,558	14,673	27,692	-3	-95	32	-66
Bihar	232	3,253	3,322	6,807	231	3,248	3,325	6,804	-1	-5	3	-3
Chhattisgarh	4,166	35,146	16,617	55,929	4,162	35,038	16,670	55,870	-4	-108	53	-59
Delhi	7	50	120	177	7	50	120	177	0	0	0	0
Goa	511	626	1019	2156	511	624	1,016	2,151	0	-2	-3	-5
Gujarat	376	5,319	8,909	14,604	376	5,249	8,995	14,620	0	-70	86	16
Haryana	26	488	1,090	1,604	27	463	1,104	1,594	1	-25	14	-10
Himachal Pradesh	3,224	6,386	5,056	14,666	3,224	6,383	5,061	14,668	0	-3	5	2
Jammu & Kashmir	4,298	8,977	9,414	22,689	4,298	8,977	9,411	22,686	0	0	-3	-3
Jharkhand	2,595	9,892	10,235	22,722	2,590	9,899	10,405	22,894	-5	7	170	172
Karnataka	1,772	20,196	14,232	36,200	1,777	20,181	14,232	36,190	5	-15	0	-10
Kerala	1,443	9,404	6,437	17,284	1,443	9,410	6,471	17,324	0	6	34	40
Madhya Pradesh	6,648	35,035	36,056	77,739	6,647	35,007	36,046	77,700	-1	-28	-10	-39
Maharashtra	8,747	20,847	21,067	50,661	8,739	20,834	21,077	50,650	-8	-13	10	-11
Manipur	689	5,522	10,741	16,952	701	5,474	11,105	17,280	12	-48	364	328
Meghalaya	334	9,527	7,344	17,205	410	9,501	7,410	17,321	76	-26	66	116
Mizoram	134	6,384	12,082	18,600	134	6,251	12,855	19,240	0	-133	773	640
Nagaland	1,280	5,072	7,313	13,665	1,274	4,897	7,293	13,464	-6	-175	-20	-201
Orissa	7,077	21,421	20,257	48,755	7,073	21,394	20,388	48,855	-4	-27	131	100
Punjab	0	738	922	1,660	0	733	931	1,664	0	-5	9	4
Rajasthan	72	4,454	11,486	16,012	72	4,450	11,514	16,036	0	-4	28	24
Sikkim	500	2,161	696	3,357	500	2,161	696	3,357	0	0	0	0
Tamil Nadu	2,925	10,189	10,200	23,314	2,926	10,216	10,196	23,338	1	27	-4	24
Tripura	113	4,816	3,244	8,173	111	4,770	3,192	8,073	-2	-46	-52	-100
Uttar Pradesh	1,626	4,569	8,151	14,346	1,626	4,563	8,152	14,341	0	-6	1	-5
Uttarakhand	4,762	14,170	5,561	24,493	4,762	14,165	5,568	24,495	0	-5	7	2
West Bengal	2,992	4,646	5,332	12,970	2,987	4,644	5,363	12,994	-5	-2	31	24
A & N Islands	3,779	2,414	470	6,663	3,762	2,405	495	6,662	-17	-9	25	-1
Chandigarh	1	10	6	17	1	10	6	17	0	0	0	0
Dadra & Nagar Haveli	0	115	101	216	0	114	97	211	0	-1	-4	-5
Daman & Diu	0	1	5	6	0	1	5	6	0	0	0	0
Lakshadweep	0	16	10	26	0	16	10	26	0	0	0	0
Puducherry	0	14	28	42	0	13	31	44	0	-1	3	2
Total	83,472	319,948	286,751	690,171	83,510	319,012	288,377	690,899	38	-936	1,626	728

*The change in the above table refers to change in the area with respect to revised assessment for 2005.

compared to the previous assessment of 2005 (revised) is a gain of forest cover by 728 km². The States showing significant net increase in forest cover are Mizoram (640 km²), Manipur (328 km²), Jharkhand (172 km²), Meghalaya (116 km²) and Orissa (100 km²), whereas, significant net decrease in forest cover is seen in the States of Nagaland (201 km²), Andhra Pradesh (129 km²), Arunachal Pradesh (119 km²), Tripura (100 km²), Assam (66 km²) and Chhattisgarh (59 km²). While doing the ground truthing of the changes, important reasons of changes in the forest cover have also been ascertained in consultation with the officials of the State Forest Departments (SFD) which are presented in the Table 2.14.2. Subsequent to ground truthing, a detailed exercise for field validation of change locations was also undertaken in which change maps for the respective States were sent to all the SFDs by FSI. These change maps had legend for showing the type of change and each patch of change was marked with a point with latitude and longitude to facilitate field validation.

As mentioned in section 1.3 of Chapter 1, because of refinement in the methodology, forest cover maps of 2005 assessment were revisited and satellite imagery re-interpreted with new methodology. With the access to further ground truthing details (including ground truthing of the current assessment), the forest cover maps of 2005 were improved.

The net change in any class of forest cover may be the result of improvement somewhere and degradation elsewhere. A change matrix gives a quantitative account of class wise change and also the flux of changes among the classes. There could be several reasons of change components in the change matrix like (i) improvement of moderately dense to very dense forest or degradation of very dense forest to moderately dense forest, open forest, scrub and non forest, (ii) improvement of open forest to moderately dense/very dense category somewhere and its degradation to scrub or non-forest elsewhere and (iii) improvement of scrub or non-forest to open forest and sparingly to moderately dense forest.

The change matrix given in Table 2.14.3 reveals that there is an improvement of 220 km² of moderately dense and 35 km² of open forest and 36 km² of non forest to very dense forests. On the other hand, there has been degradation of 127 km² of very dense forest to moderately dense, 45 km² to open forest, 5 km² to scrub and 76 km² to non-forest, resulting in a net increase of 38 km² of very dense forest. Similarly, there is an improvement of 1,821 km² of open forests, 15 km² of scrub and 1,441 km² of non-forest to moderately dense forest but there has also been degradation of 1,948 km² of moderately dense forest to open forests, 42 km² to scrub and 2,130 km² to non-forest resulting in a net loss of 936 km² of moderately dense forest. There is an

Table 2.14.2: Reasons of change in forest cover

Andhra Pradesh	Decrease in forest cover is mainly due to departmental felling in the Eucalyptus plantation areas.
Arunachal Pradesh	Decrease in forest cover in the State is because of shifting cultivation.
Assam	Loss of forest cover is mainly attributed to encroachment in insurgency affected areas of Sonitpur, Karbi Anglong, and Darrang districts. Forest cover in the hill districts of North Cachar Hills and Karbi Anglong has decreased on account of shifting cultivation.
Chhattisgarh	The decrease in forest cover is mainly due to mining activity and encroachment in insurgency affected areas.
Jharkhand	Increase in forest cover is mainly on account of effective protection by the village forest protection committees. Plantation of miscellaneous species in Deoghar and Dumka districts has also shown an increase in forest cover.
Manipur	Increase in forest cover is mainly on account of regeneration in abandoned shifting cultivation areas.
Meghalaya	Main reason for the increase in forest cover is the afforestation activity undertaken by the forest department and regeneration in the abandoned shifting cultivation areas.
Mizoram	Increase of forest cover is mainly due to re-growth in the abandoned shifting cultivation areas and regeneration of bamboo in bamboo flowering areas.
Nagaland	Decrease in forest cover is mainly due to shifting cultivation.
Orissa	Main reason for the increase in forest cover is effective protection by the JFM committees and regeneration in shifting cultivation areas.
Tripura	Decrease of forest cover is mainly due to shifting cultivation.

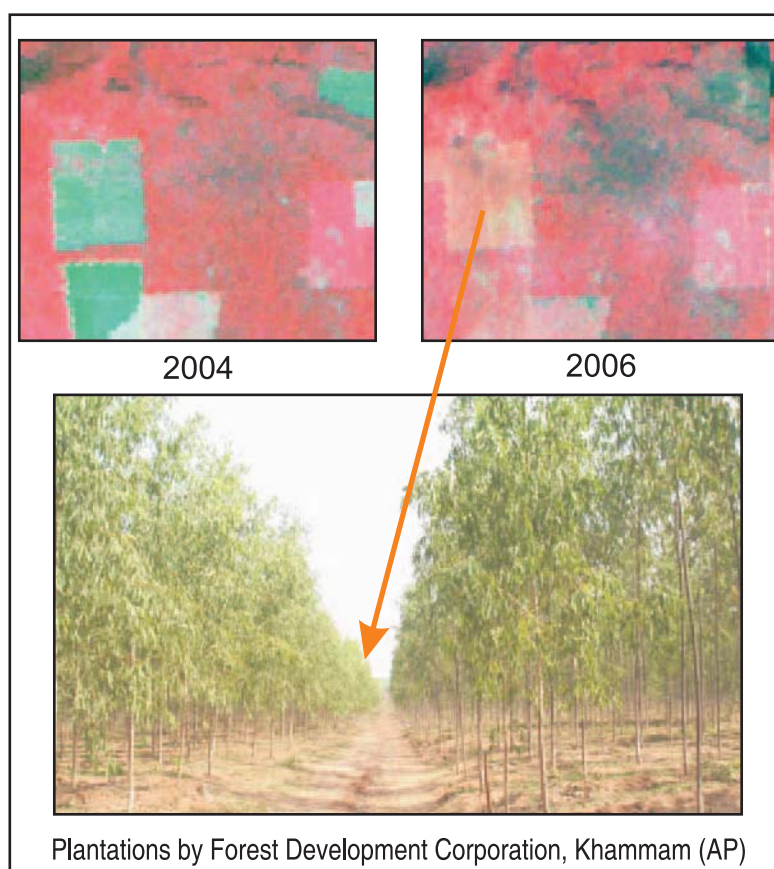
Table 2.14.3: Forest cover change matrix for India between 2005 (revised) and 2007

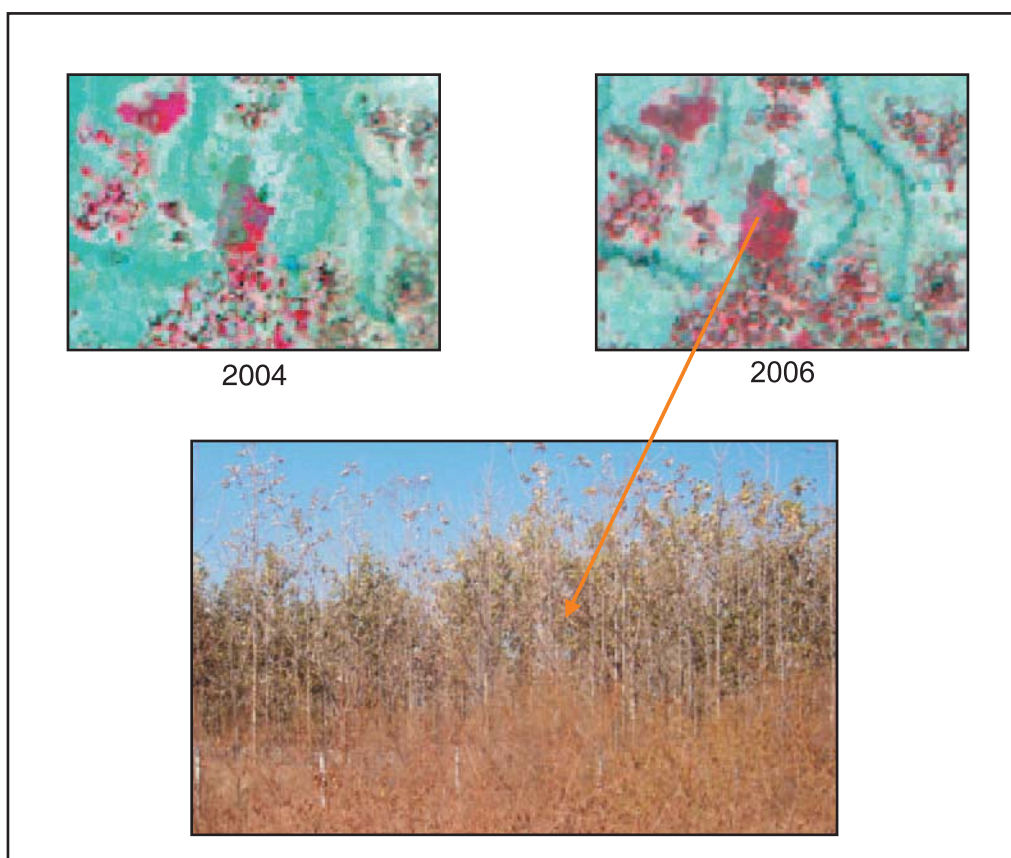
(area in km²)

Class	VDF	MDF	OF	Scrub	NF	Total of 2005
Very Dense Forest	83,219	127	45	5	76	83,472
Mod. Dense Forest	220	315,608	1,948	42	2,130	319,948
Open Forest	35	1,821	280,560	186	4,149	286,751
Scrub	0	15	161	40,828	282	41,286
Non Forest	36	1,441	5,663	464	2,548,202	2,555,806
Total of 2007	83,510	319,012	288,377	41,525	2,554,839	3,287,263
Net Change	38	-936	1,626	239	-967	

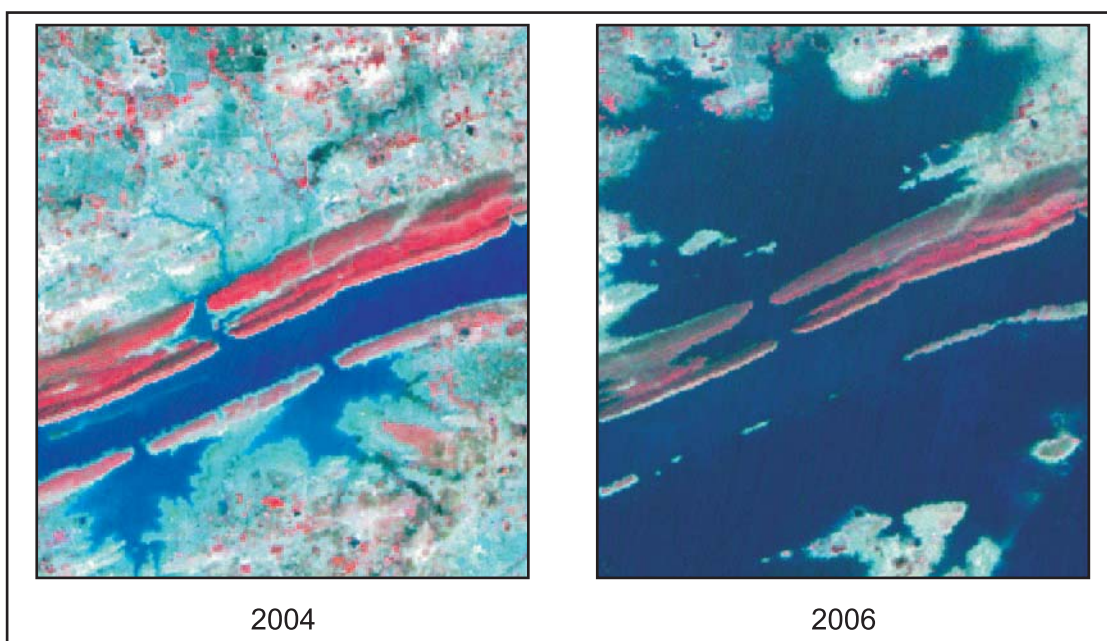
improvement of 161 km² of scrub and 5,663 km² of non forest to open forest while there is degradation of 186 km²

from open forest to scrub and 4,149 km² to non forest.

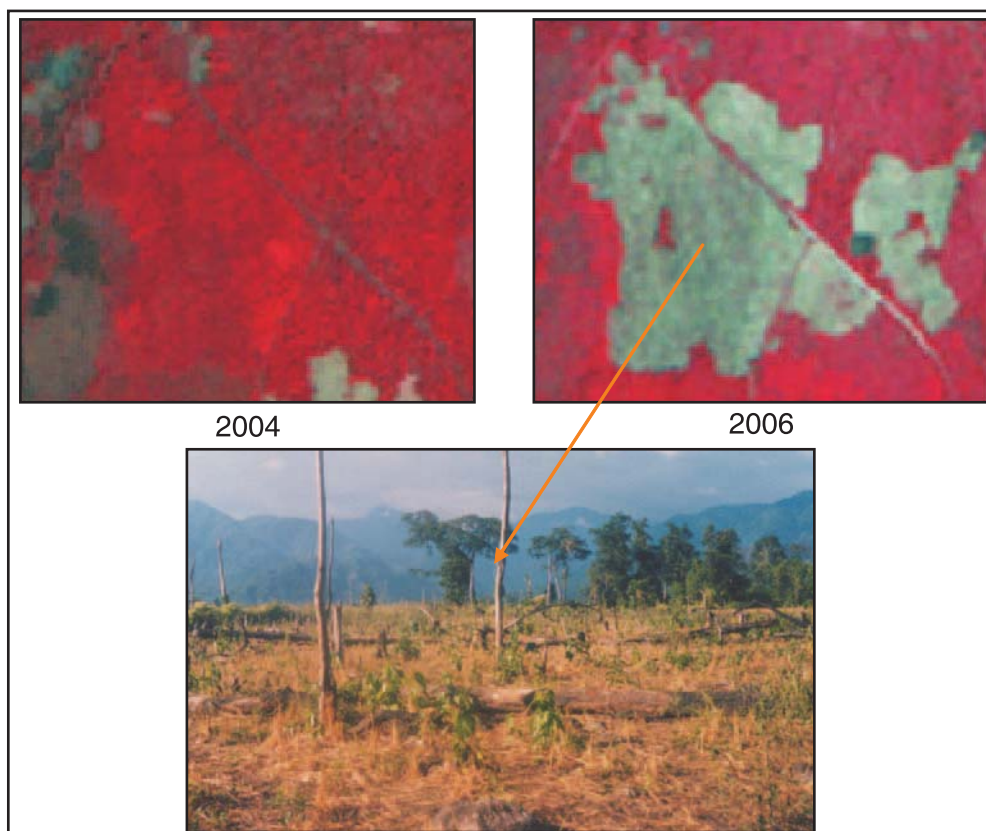




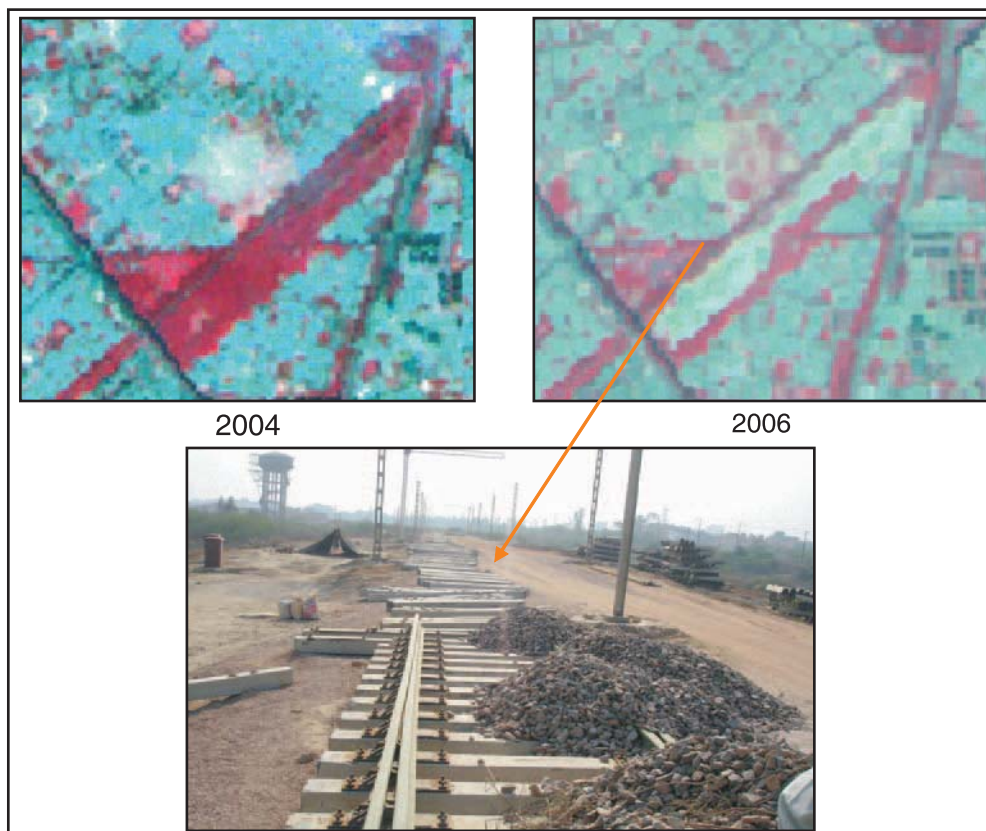
Improvement in forest cover due to plantation, Bastar (Chhattisgarh)



Submergence of forest, Bandhsagar dam, Shahdol (MP)



Loss of forest cover due to shifting cultivation, Siang East (Arunachal Pradesh)



Construction of railway track, Anand Vihar (Delhi)