

### 4.1 Introduction

India's National Forest Policy 1988 aims at maintaining 33 per cent of country's geographical area under forest and tree cover. The assessment of forest cover of the country using satellite imagery is being carried out by FSI since 1988 and results are published in successive State of Forest Reports. However, the information on tree cover was given for the first time in SFR 2001. The information on forest cover and tree cover are obtained from two different sources. The information on forest cover is obtained from wall to wall mapping of the country using satellite data, whereas the information on tree cover is obtained by partly using high resolution data and partly from field inventory data of Trees Outside Forests (TOF). The detailed methodology of forest cover assessment has been described in Chapter 2.

The LISS-III satellite sensor (spatial resolution 23.5 meter) and the scale of mapping 1:50,000 presently being used for forest cover assessment can only capture tree patches of minimum 1 ha. and more. Small patches of trees below one ha in extent are generally found in village woodlots, homestead, urban areas, compact blocks, trees along linear features such as along canal, railway line, road etc. These patches of trees, though small, play a significant role in socio-economic and ecological status of the



Trees in village woodlots in Pauri district of Uttarakhand

country. Their contributions are captured in the form of tree cover with the help of high resolution remote sensing data and supplemented by field inventory data of TOF. This information on tree cover when added to the forest cover of the country gives a complete picture of tree resources of the country.

### 4.2 Trees Outside Forests (TOF) and Tree Cover

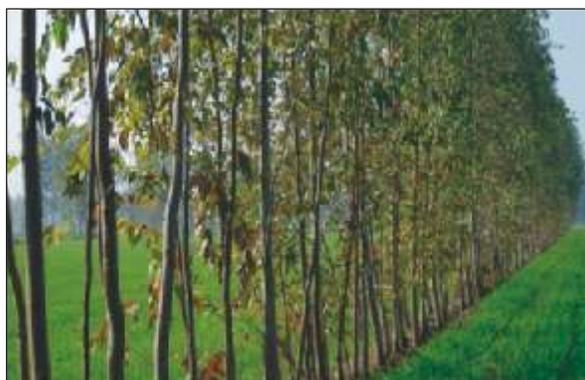
TOF and Tree Cover are two distinct but closely related entities. TOF refers to all trees growing outside recorded forest areas irrespective of patch size. The sample points under TOF inventory are spread over the entire TOF area. For the purpose of estimating growing stock from TOF, entire TOF area is taken into account. As mentioned earlier, all TOF patches of one ha and more are included in the forest cover.

However, the TOF patches which are less than one ha in extent are taken for the purpose of tree cover estimation. Thus trees included in the tree cover constitute only a part of TOF and, therefore, tree cover becomes a subset of TOF.

### 4.3 Methodology for Estimation of Tree Cover

The estimates of tree cover at national level are generated using the data collected during the inventory of TOF. The design used for inventory of TOF is two stage stratified sampling. In the first stage, the country is stratified into 14 physiographic zones based on physiography, climate, vegetation etc. A sample of 60 districts is then selected in proportion to the areas of physiographic zones from the entire country for carrying out a detailed inventory in a two-year cycle. In the second stage, separate methodology is used for rural and urban inventory. The detailed methodology has been explained in Chapter 5 dealing with the growing stock.

The estimation of tree cover of selected districts is carried out using high resolution (LISS-IV Mx) remote sensing data having a spatial resolution of 5.8 meter and field inventory data of TOF. Thus the tree cover of a district has two components. The first component consists of block and linear tree patches in rural areas between 0.1 ha and one ha identified through high resolution satellite data. The actual areas of such patches are computed from classified TOF maps of the districts after eliminating the patches which are equal to or larger than one



Trees on agriculture bunds in Nainital district of Uttarakhand

ha. The second component is the area computed from scattered trees growing in rural areas and trees in urban areas which are not precisely mapped even with high resolution satellite data (5.8 m resolution). To compute the area under these two strata, the information on crown diameter according to species as recorded in the field inventory is used. The methodology is explained in the following paragraphs.

To estimate the area of tree cover under scattered stratum, optimum numbers of sample plots as determined in the pilot study are laid out and crown diameter of each tree is recorded from all such plots. With the help of crown diameter, tree cover of each sample plot is computed, which is then converted into equivalent notional area corresponding to 70 per cent canopy density. Using tree cover area of selected plots and corresponding culturable non forest (CNF) cover area of a district, estimate at district level is generated under scattered stratum.

In the urban areas, the sampling units are Urban Frame Survey (UFS) blocks which are of varying sizes. The areas of selected UFS

blocks are computed with the help of GPS. For estimating tree cover, the crown diameter of each tree falling in the selected UFS block is recorded. With the help of crown diameter, the tree cover of each UFS block is computed following the same approach as in case of scattered stratum.

The total tree cover for a selected district is obtained by aggregating the area of tree cover under block, linear and estimated area under scattered and urban strata. On the basis of tree cover of sampled districts, the tree cover in each physiographic zone is estimated. Aggregation of tree cover of all the physiographic zones leads to tree cover estimate of the country. The present estimate is based on 28,116 sample plots falling in 179 sampled districts across the country which were inventoried during the period spanning from 2006 to 2012.

The state level estimates of tree cover are generated using small area estimation technique. Generally, sample surveys are designed to provide reliable estimates for larger areas or domains. But if sample size is small, direct estimators are not available with adequate precision. In such circumstances, small area technique is used to generate synthetic estimator with better precision. Synthetic estimation has its strength in borrowing information from larger groups for use in small area or domain under the assumption that the relation of the study character as well as for the auxiliary character between larger and smaller areas remains the same. To prepare the state level estimates of tree cover, synthetic estimators were generated using

physiographic zone level estimate of tree cover.

#### **4.4 Precision of Tree Cover Estimates**

As the tree cover estimates are based on a standard sampling design, its precision is determined by the standard error at national and physiographic zone level. The tree cover at national level has been estimated with the standard error percent of 3.10 percent. At physiographic zones levels, the standard error percent varies from 5.54 percent to 24.05 percent.

#### **4.5 Physiographic Zone-wise Tree Cover**

The total tree cover of the country has been estimated to be 91,266 sq km, which constitutes 2.78 percent of the country's geographical area. The estimates of tree cover for each physiographic zone are given in Table 4.1. It is observed that the tree cover is maximum in West Coast (10,391 sq km) followed by Central Highlands (10,127 sq km) and East Deccan (9,644 sq km). Eastern Himalayas have the lowest tree cover of 448 sq km, as this zone is predominantly under natural forests. West Coast has maximum percentage of Tree Cover (8.57 percent) with respect to its geographical area followed by Western Ghats (5.79 percent) and East Coast (3.58 percent).

#### **4.6 Tree Cover in the States and Union Territories**

Tree cover data of the physiographic zones has been processed further using small area

Physiographic Zone	Geographical Area	Tree Cover	
		Area	Per cent of G A
Western Himalayas	329,255	9,035	2.74
Eastern Himalayas	74,618	448	0.60
North East	133,990	2,655	1.98
Northern Plains	295,780	8,609	2.91
Eastern Plains	223,339	4,722	2.11
Western Plains	319,098	6,245	1.96
Central Highlands	373,675	10,127	2.71
North Deccan	355,988	6,762	1.90
East Deccan	336,289	9,644	2.87
South Deccan	292,416	8,244	2.82
Western Ghats	72,381	4,189	5.79
Eastern Ghats	191,698	4,194	2.19
West Coast	121,242	10,391	8.57
East Coast	167,494	6,001	3.58
<b>TOTAL</b>	<b>3,287,263</b>	<b>91,266</b>	<b>2.78</b>

estimation technique, viz. synthetic estimator to estimate tree cover of each state and union territory. One state may fall in one or more physiographic zones. To estimate the tree cover of the state, culturable non-forest cover area falling in different physiographic zones of different states/UTs was calculated. The estimates of tree cover of block, linear, scattered and urban strata of sampled districts have been used to estimate the total tree cover of that physiographic zone using CNF cover area. To estimate tree cover of the state, the un-inventoried districts of the state falling in a particular zone are estimated using average value of that physiographic zone. The same exercise was repeated for different physiographic zones falling in that state. Adding tree cover of different physiographic zones, tree cover for the respective states

has been estimated. However, it may be noted that in some of the States/UTs, estimates for tree cover are only indicative in nature and may have lower levels of precision since the sample size in such States/UTs were small. The estimates of tree cover in the States and UTs are given in Table 4.2 and in Figure 4.1.

The state having maximum tree cover area is Maharashtra (9,142 sq km) followed by Gujarat (8,358 sq km), Rajasthan (7,860 sq km) and J&K (7,664 sq km). Considering the percentage of geographical area of State/UTs, the Union Territory of Lakshadweep shows highest percentage of tree cover (16.69 percent) followed by Goa (9.03 percent), Chandigarh (8.51 percent) and Daman & Diu (8.46 percent).

**Table 4.2: States/ UTs-wise Tree Cover Estimate** (Area in Km<sup>2</sup>)

States/UTs	Geographical Area	Tree Cover	
		Area	Per cent of G A
Andhra Pradesh	275,069	7,187	2.61
Arunachal Pradesh	83,743	660	0.79
Assam	78,438	1,582	2.02
Bihar	94,163	2,164	2.30
Chhattisgarh	135,191	3,463	2.56
Delhi	1,483	118	7.94
Goa	3,702	334	9.03
Gujarat	196,022	8,358	4.26
Haryana	44,212	1,282	2.90
Himachal Pradesh	55,673	697	1.25
Jammu & Kashmir	222,236	7,664	3.45
Jharkhand	79,714	2,629	3.30
Karnataka	191,791	5,920	3.09
Kerala	38,863	3,146	8.09
Madhya Pradesh	308,245	7,087	2.30
Maharashtra	307,713	9,142	2.97
Manipur	22,327	224	1.00
Meghalaya	22,429	668	2.98
Mizoram	21,081	223	1.06
Nagaland	16,579	372	2.24
Odisha	155,707	4,013	2.58
Punjab	50,362	1,499	2.98
Rajasthan	342,239	7,860	2.30
Sikkim	7,096	31	0.44
Tamil Nadu	130,058	4,866	3.74
Tripura	10,486	213	2.03
Uttar Pradesh	240,928	6,895	2.86
Uttarakhand	53,483	703	1.32
West Bengal	88,752	2,144	2.42
A & N Islands	8,249	41	0.50
Chandigarh	114	10	8.51
Dadra & Nagar Haveli	491	29	5.95
Daman & Diu	112	9	8.46
Lakshadweep	32	5	16.69
Puducherry	480	29	6.07
<b>TOTAL</b>	<b>3,287,263</b>	<b>91,266</b>	<b>2.78</b>

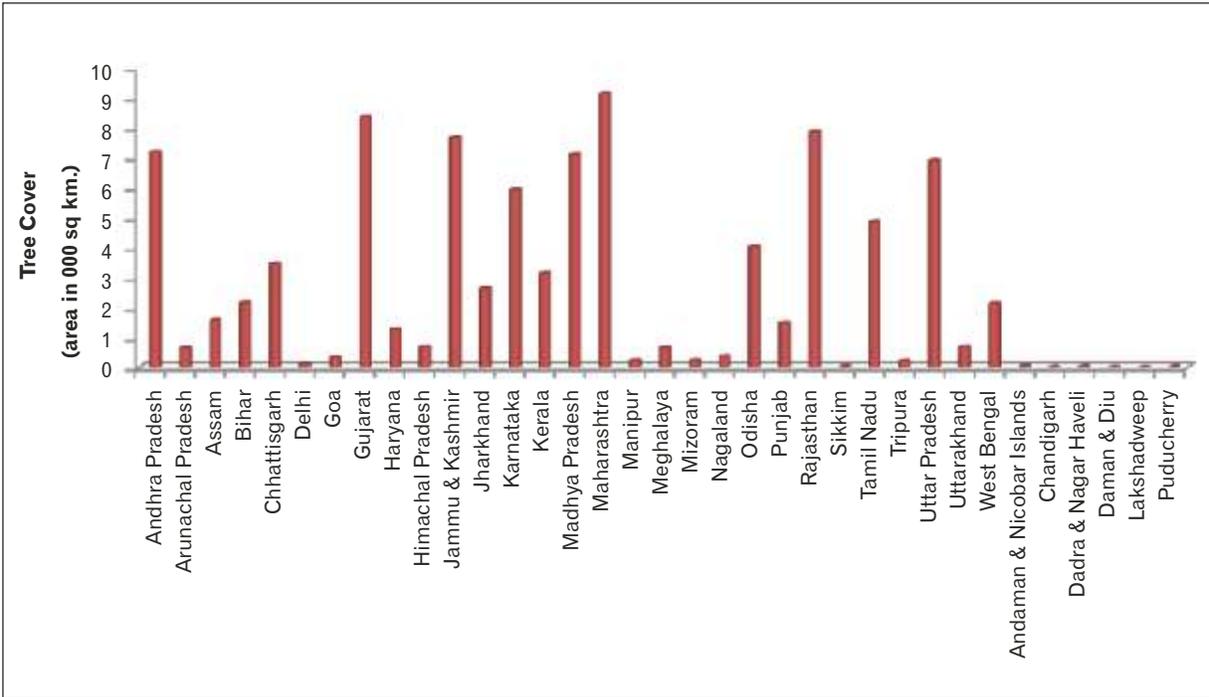


Fig. 4.1: Tree Cover in States and UTs