Chapter 4 | Tree Cover

4.1 Introduction

The forest cover assessment carried out by FSI using satellite data includes all lands comprising area of one hectare and more, with a tree canopy density of more than 10%, irrespective of their land use and ownership. However, there are many small patches of trees which are less than 1.0 ha in extent, such as trees in village woodlots, homestead, urban areas, scattered trees, trees along roads, canals, railway lines and trees in block

and linear formation with area less than 1.0 ha, that are excluded from the forest cover due to technological limitations. The contribution of such trees/patches to overall cover is estimated statistically using a sampling based methodology and is termed as tree cover.

Thus, tree cover comprises tree patches outside the recorded forest area which are not captured by remote sensing satellite during forest cover assessment having area less than the minimum mappable area of one hectare. They comprise block and linear patches having area between 0.1 ha and 1.0 ha as also the scattered trees. FSI has been estimating tree cover of the country since 2001 to have a complete picture of forest and tree cover of the country to compare with the national goal of 33% area under forest and tree cover.

4.2 Trees Outside Forests and Tree Cover

TOF and Tree Cover are two different entities but closely related to each other. TOF refers to all trees growing outside recorded forest area irrespective of patch size. For the purpose of estimating growing stock from TOF, entire TOF area is taken into account. For the purpose of forest cover assessment, all TOF patches of 1.0 ha and more are included in the forest cover. However, for the purpose of tree cover estimation, the TOF patches which are less than 1.0 ha in extent and the scattered trees in rural and urban areas are taken into consideration. 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 gathered 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 area of physiographic zone from

the entire country for carrying out a detailed inventory in a two year cycle. Separate methodology is used for rural and urban inventory. The detailed methodology has been explained in Chapter 5 dealing with the assessment of growing stock.

The estimation of tree cover of selected districts is carried out using high resolution remote sensing data as well as field inventory data. 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 1.0 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 1.0 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, adequate number of sample plots 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% 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 similar approach as in case of scattered stratum.

The total tree cover for the selected district is obtained by aggregating the area of tree cover under block, linear, 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 **30,709 sample plots** falling in **178 sampled districts** across the country which were inventoried during the period from 2004 to 2010.

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 area remains the same. To prepare the state level estimates of tree cover, synthetic estimators were generated using physiographic zone level estimates 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 S.E. percentage of 2.45 %. At physiographic zone levels, the S.E. varies from 3.18% to 17.80%.

4.5 Tree Cover in the Country: Physiographic Zone-wise

The total tree cover of the country has been estimated to be 90,844 km^2, which constitutes 2.76% of the country's geographical area. The estimates of tree cover for each physiographic zone is given in Table 4.5.1. It is observed that the tree cover is maximum in East Deccan (10,718 km^2), followed by Central Highlands (9,886 km^2) and Northern Plains (9,366 km^2). Eastern Himalayas have the lowest tree cover of 356 km^2, as this zone is predominantly forested. West Coast has maximum percentage of Tree cover (7.31%) with respect to its geographical area followed by Western Ghats (5.64%) and East Coast (3.46%). The tree cover estimates of Western Plains given in ISFR 2009 was an over estimation due to inclusion of entire desert area of Rajasthan at par with rest of the area of Western Plain. In the current assessment, a separate sub-strata has been created for desert area resulting in more precise estimate for Western Plains.

Table 4.5.1: Physiographic Zone-wise Tree Cover Estimate

Sl. No.	Physiographic Zone	Geographical Area (km^2)	Tree Cover	
			Area (km^2)	% of Geo. Area
1.	Western Himalayas	329,255	7,859	2.39
2.	Eastern Himalayas	74,618	356	0.48
3.	North East	133,990	2,275	1.70
4.	Northern Plains	295,780	9,366	3.17
5.	Eastern Plains	223,339	5,168	2.31
6.	Western Plains	319,098	7,038	2.21
7.	Central Highlands	373,675	9,886	2.65
8.	North Deccan	355,988	7,007	1.97
9.	East Deccan	336,289	10,718	3.19
10.	South Deccan	292,416	8,012	2.74
11.	Western Ghats	72,381	4,083	5.64
12.	Eastern Ghats	191,698	4,420	2.31
13.	West Coast	121,242	8,863	7.31
14.	East Coast	167,494	5,791	3.46
	TOTAL	**3,287,263**	**90,844**	**2.76**

4.6 Tree Cover in the States and Union Territories

Tree cover data of the physiographic zones has been processed further using small area estimation technique, *viz.* synthetic estimates 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 has 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 was small. The estimates of tree cover in the states and UTs are given in Table 4.6.1 and depicted in Fig 4.6.1.

Table 4.6.1: State/ UT-wise Tree Cover Estimates

Sl. No.	State/U.T.	Geographical Area (km^2)	Tree Cover	
			Area (km^2)	% of Geo. Area
1	Andhra Pradesh	275,069	7,152	2.60
2	Arunachal Pradesh	83,743	549	0.66
3	Assam	78,438	1,564	1.99
4	Bihar	94,163	2,369	2.52
5	Chhattisgarh	135,191	3,866	2.86
6	Delhi	1,483	120	8.07
7	Goa	3,702	286	7.73
8	Gujarat	196,022	7,837	4.00
9	Haryana	44,212	1,395	3.15
10	Himachal Pradesh	55,673	623	1.12
11	Jammu & Kashmir	222,236	6,550	2.95
12	Jharkhand	79,714	2,914	3.66
13	Karnataka	191,791	5,733	2.99
14	Kerala	38,863	2,755	7.09
15	Madhya Pradesh	308,245	7,090	2.30
16	Maharashtra	307,713	9,079	2.95
17	Manipur	22,327	193	0.86
18	Meghalaya	22,429	578	2.58
19	Mizoram	21,081	190	0.90
20	Nagaland	16,579	322	1.94
21	Orissa	155,707	4,301	2.76
22	Punjab	50,362	1,699	3.37
23	Rajasthan	342,239	8,272	2.42
24	Sikkim	7,096	25	0.35
25	Tamil Nadu	130,058	4,718	3.63

Sl. No.	State/U.T.	Geographical Area (km^2)	Tree Cover	
			Area (km^2)	% of Geo. Area
26	Tripura	10,486	184	1.75
27	Uttar Pradesh	240,928	7,382	3.06
28	Uttarakhand	53,483	642	1.20
29	West Bengal	88,752	2,335	2.63
30	Andaman & Nicobar Islands	8,249	39	0.47
31	Chandigarh	114	10	8.93
32	Dadra & Nagar Haveli	491	29	5.91
33	Daman & Diu	112	9	7.65
34	Lakshadweep	32	5	14.23
35	Puducherry	480	31	6.44
	TOTAL	**3,287,263**	**90,844**	**2.76**

The state having maximum tree cover area is Maharashtra (9,079 km^2) followed by Rajasthan (8,272 km^2) and Gujarat (7,837 km^2). Considering the tree cover percentage to geographical area of state/UT, the Union Territory of Lakshadweep shows highest percentage of tree cover (14.23 %) followed by Chandigarh (8.93 %) and Delhi (8.09 %).

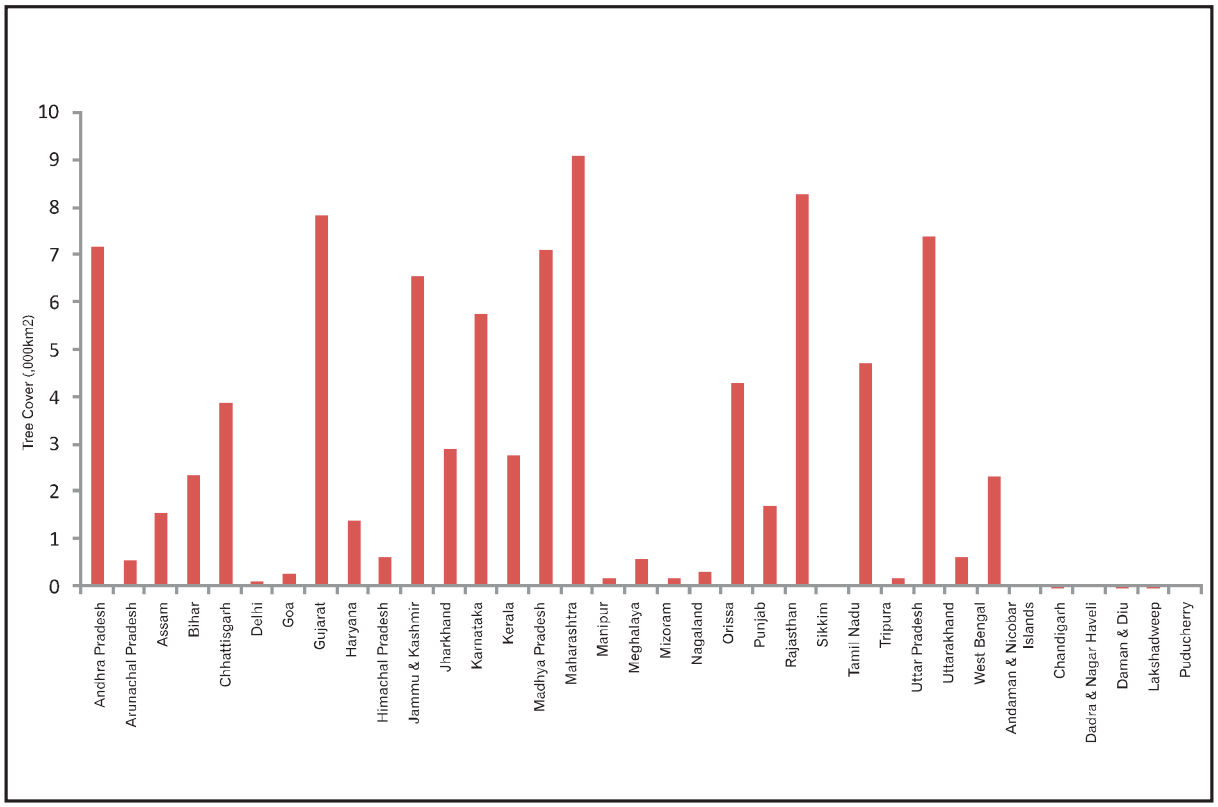

Fig 4.6.1: Tree cover in States and UTs