6

Chapter

Tree cover

The National Forest Policy 1988 aims at bringing 33% of the geographical area of the country under forest and tree cover. FSI assesses forest and tree cover of the country in biennial cycle. The forest cover assessment, which includes all areas more than 1 hectare in extent and having tree canopy density of 10% and more irrespective of land use, legal status and ownership, is done using satellite data. However, there are many small patches of trees which are less than 1 ha in extent, such as trees in village woodlots, homesteads, trees along linear features such as roads, canals, bunds, trees in urban areas, scattered trees etc. These smaller patches of trees are not included in the forest cover due to technological limitations of spatial resolution of satellite data used for the forest cover mapping. These widely spread patches of trees in the rural and urban landscapes play significant socio-economic, cultural and ecological roles. The extent of such tree formations is assessed as tree cover using a methodology based on stratified random sampling. The methodology

involves use of high-resolution remote sensing data and field measurements on sample plots. Thus, information on tree cover along with forest cover gives a complete extent of tree resources of the country which is often termed as 'Forest & Tree Cover'.

6.2   TREE COVER AND TREES OUTSIDE FOREST (TOF)

Tree cover is defined as all tree patches of size less than 1 ha occurring outside the recorded forest area. Tree cover includes trees in all formations including scattered trees. Though TOF and tree cover appear as similar terms but they are two different entities as defined in the FSI's assessment, though closely related to each other. TOF refers to all trees growing outside RFA irrespective of patch size which could also be larger than 1 ha. Thus tree cover becomes a subset of TOF. Tree cover is estimated using a sampling based methodology wherein high resolution satellite imagery is used for stratification. Thus, trees included in the tree cover constitute only a part of TOF Fig. 6.3 gives a diagrammatic relationship between the TOF and Tree Cover.
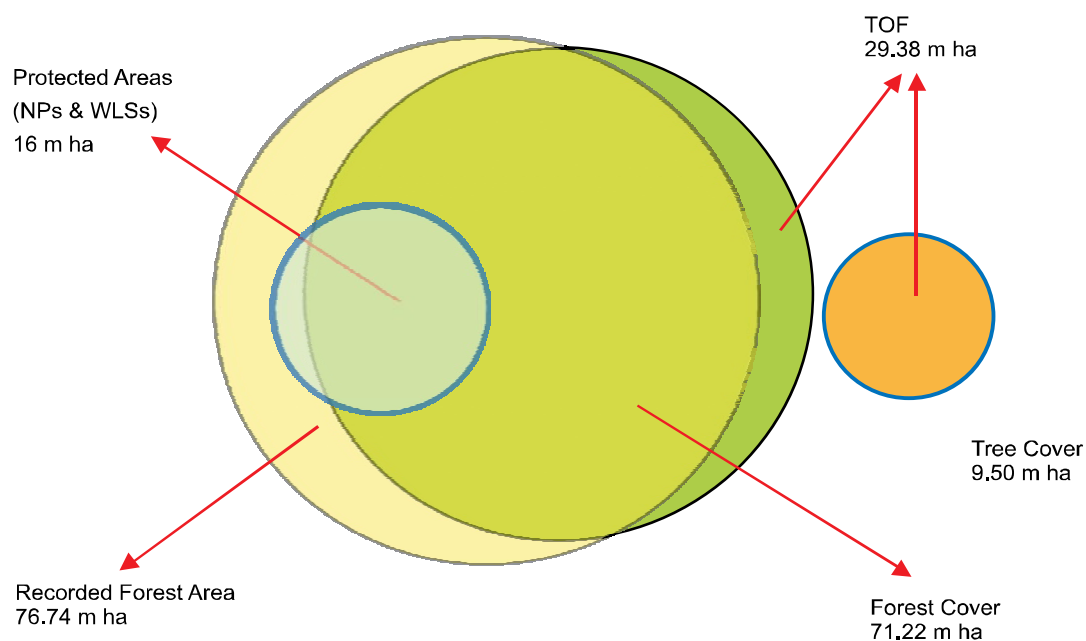
FIGURE 6.1   Linear plantation along Canal

FIGURE 6.2   Block plantation

FIGURE 6.3   Showing relationship between Tree Cover and TOF

6.3   METHODOLOGY FOR TREE COVER ESTIMATION

Tree cover of the country has been estimated State wise from the data collected during inventory of TOF in rural and urban areas following the grid based inventory design. The TOF inventories of rural and urban areas are carried out in the grids selected for a particular year. Though primary objective of TOF inventory is estimation of growing stock, the data collected during the inventory is used for estimation of tree cover also. Separate methodologies are followed for inventory of TOF (rural) and TOF (urban).

6.3.1   Estimation of Tree cover in Rural Areas

The tree cover of the rural area has been estimated by sampling approach using high-resolution satellite data in conjunction with the inventory data of TOF (rural). For inventory of rural areas, high-resolution satellite data is used for stratification of TOF into three strata namely block, linear and scattered. The methodology has been described briefly as follows:

The Multispectral data of Sentinel-2 with spatial resolution of 10 m and swath of 290 km has been used for classification of the selected grids. The Sentinel satellite data is downloaded and geo-rectified with the help of Survey of India (SOI) open series map topo sheets on 1: 50,000 scale. The image is then classified into settlement, water bodies, tree patches, agriculture and other land cover classes. This classification enables the interpreter to distinguish between tree patches and other classes. The classified image is visually analysed for editing and refinement. Since the minimum mappable area is 0.1 ha, pixels are clumped and cluster of pixels having area less than 0.1 ha are eliminated. After editing of the classified image, the final classified map is generated having three classes in TOF areas, namely Block, Linear and Scattered. From the classified TOF map, area under each category (stratum) is calculated. In addition, areas which do not support tree vegetation, like rivers and water bodies, riverbeds, snow covered mountains etc which are termed as Un-Culturable Non Forest Area are also calculated. The schematic chart of the methodology of TOF using remote sensing is depicted in the Fig 6.6.

The plot size for Block and Linear strata is 0.1 ha square plot and 10 m ×125 m strip, respectively. In case of scattered stratum, the plots of size 3.0 ha square in non-hilly areas and 0.5 ha square in hilly areas are laid out.
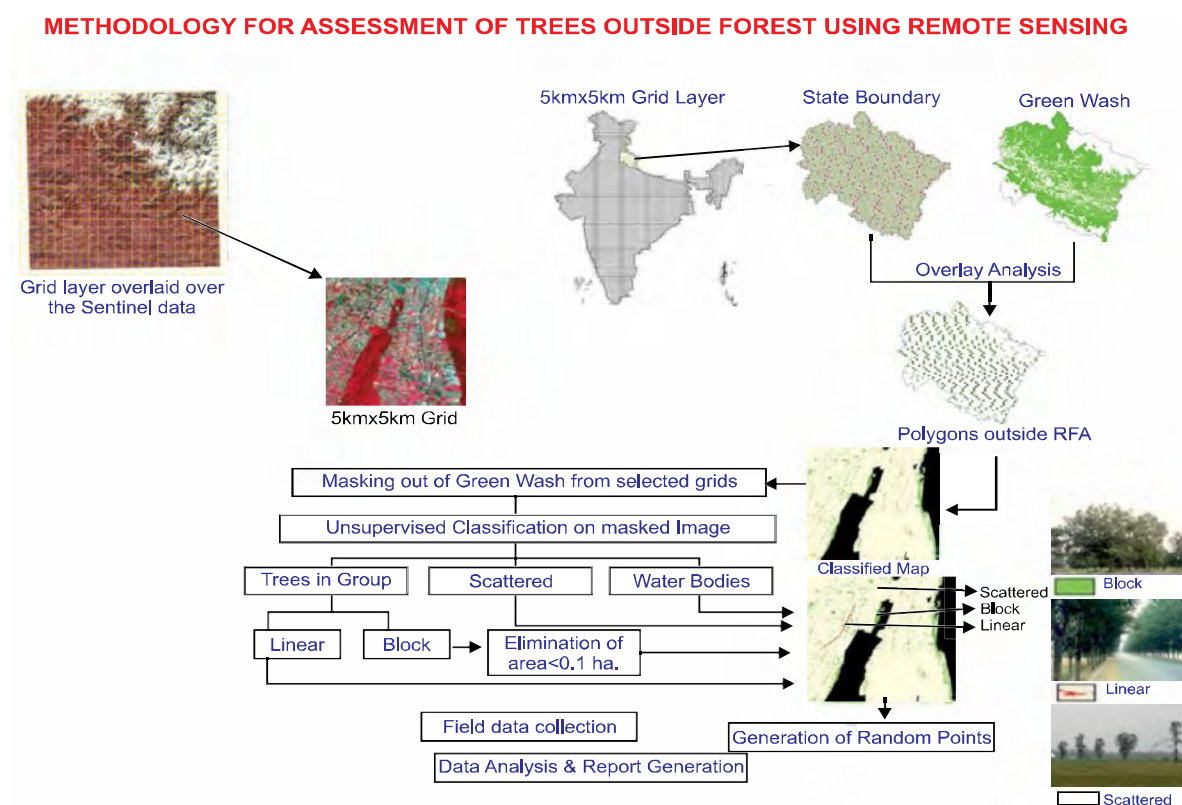
Sample points are randomly generated within selected grids for each stratum in area proportion to size and the data on pre-decided variables like dbh, crown diameter, species and category of

FIGURE 6.4   Trees in village woodlots

FIGURE 6.5   Trees on Farm Bunds

FIGURE 6.6   Schematic diagram of the methodology of TOF

plantation etc are collected on pre-designed formats. The complete enumeration of all the trees of 5 cm and above dbh is carried out.

The tree cover of the rural area comprises area of block and linear patches between 0.1 ha to 1.0 ha. For estimation of tree cover, the area of block and linear patches is computed from the classified map of the TOF for the selected grids. The blocks and linear patches having area more than 1.0 ha are clumped and eliminated as the same has been included in the forest cover. The blocks and linear patches with less than 1.0 ha area are taken for the estimation of tree cover. The computed area of block and linear are estimated at the State level with rural CNFA. For estimation of tree cover under the scattered stratum, the crown area of each tree species recorded during the field inventory is used to calculate the crown cover of each plot in scattered stratum. The enumerated crown cover is then estimated at the State level with the help of CNFA of the scattered stratum of the entire state. The area so obtained from the scattered stratum is converted into equivalent notional area corresponding to 70 percent canopy density. The total tree cover of the State is obtained by adding the estimated area of block, linear and scattered tree formations.

6.3.2   *Estimation of Tree Cover in Urban Areas*
The tree cover of the urban area is estimated from the inventory of TOF (Urban). For urban TOF inventory, urban centers defined by the office of Registrar General of India are considered as study area. For the inventory of urban areas, high-resolution satellite data is not used due to non-availability of digital boundaries of the urban areas. Moreover, configuration of urban setting does not permit to

FIGURE 6.7   Trees along road

FIGURE 6.8   Trees in urban setting

follow the same design as used for the rural inventory. Therefore for urban areas, the sampling frame is taken from the National Sample Survey Organisation (NSSO) which has stratified the urban areas into Urban Frame Survey (UFS) Blocks. UFS blocks have well defined boundaries and they generally comprise 600 to 800 population size or 120-160 households. All the UFS blocks put together cover the whole area within the geographical boundary of a town including vacant lands.

The list of all urban towns and cities as per the census of 2011[1] has been used to identify the urban grids. For the selected urban grids, optimum numbers of UFS blocks are selected for the urban inventory. The data on pre-decided variables like dbh, crown diameter, species name and category of plantation, etc are collected on pre-designed formats. The complete enumeration of all the trees of 5 cm and above dbh is carried out in the prescribed forms. The area of each surveyed UFS block is also measured with the help of GPS.

To compute the tree cover of the urban area, the block plantation of trees with area more than one hectare are eliminated, as the same has been included in the forest cover. For the remaining trees in the urban areas, the tree cover is computed from crown diameter of trees recorded during the urban inventory. Using enumerated crown cover from the selected grids and the urban CNFA, the tree cover is estimated for the urban areas. The area of tree cover so obtained is converted into equivalent notional area corresponding to 70 percent canopy density.

The total tree cover of the State is obtained by adding the estimated tree cover of rural and urban areas.

6.4   STATE-WISE ESTIMATES OF TREE COVER

The total tree cover of the country has been estimated 95,027 sq km. There is an increase of 1,212 sq km in the extent of tree cover as compared to the 2017 assessment. The standard error of the tree cover estimate at the national level has been assessed at 6.06%. The standard error at the State level varies from 3.41% to 16.86%, which is given at annexure IV. The State wise estimates of tree cover is given in Table 6.1 which shows that the State having maximum tree cover is Maharashtra (10,806 sq km) followed by Madhya Pradesh (8,339 sq km), Rajasthan (8,112 sq km) and Jammu & Kashmir (7,944 sq km). Considering the percentage of geographical area of State/UTs, the Union Territory of Chandigarh shows highest percentage of tree cover (22.34%) followed by Delhi (8.73%), Kerala (7.56%), and Goa (7.34%).

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[1]   Census of India (2011). Office of Registrar General & Census Commissioner of India, Ministry of Home Affairs, Govt. of India

TABLE 6.1   State/ UT wise Tree Cover estimates

(in sq km)

S. No	State/UTs	Geographical Area (GA)	Tree Cover	Percent of GA
1.	Andhra Pradesh	162,968	3,914	2.40
2.	Arunachal Pradesh	83,743	848	1.01
3.	Assam	78,438	1,408	1.80
4.	Bihar	94,163	2,003	2.13
5.	Chhattisgarh	135,192	4,248	3.14
6.	Delhi	1,483	129	8.73
7.	Goa	3,702	272	7.34
8.	Gujarat	196,244	6,912	3.52
9.	Haryana	44,212	1,565	3.54
10.	Himachal Pradesh	55,673	829	1.49
11.	Jammu & Kashmir*	222,236	7,944	3.57
12.	Jharkhand	79,716	2,657	3.33
13.	Karnataka	191,791	6,257	3.26
14.	Kerala	38,852	2,936	7.56
15.	Madhya Pradesh	308,252	8,339	2.71
16.	Maharashtra	307,713	10,806	3.51
17.	Manipur	22,327	173	0.77
18.	Meghalaya	22,429	710	3.17
19.	Mizoram	21,081	441	2.09
20.	Nagaland	16,579	362	2.19
21.	Odisha	155,707	4,648	2.98
22.	Punjab	50,362	1,592	3.16
23.	Rajasthan	342,239	8,112	2.37
24.	Sikkim	7,096	36	0.51
25.	Tamil Nadu	130,060	4,830	3.71
26.	Telangana	112,077	2,514	2.24
27.	Tripura	10,486	231	2.20
28.	Uttar Pradesh	240,928	7,342	3.05
29.	Uttarakhand	53,483	841	1.57
30.	West Bengal	88,752	2,006	2.26
31.	A & N Islands	8,249	41	0.50
32.	Chandigarh	114	25	22.34
33.	Dadra & Nagar Haveli	491	28	5.75
34.	Daman & Diu	111	5	4.87
35.	Lakshadweep	30	0.29	0.97
36.	Puducherry	490	23	4.66
Total		**3,287,469**	**95,027**	**2.89**

* includes Jammu & Kashmir area outside LOC that is under illegal occupation of Pakistan and China.

6.5   EXTENT OF TREES OUTSIDE FORESTS

In India, requirement of wood and wood based products to a large extent is met from Trees Outside Forests. They are also important for their ecological, socio- economic and cultural significance. TOF are also seen as an important carbon sink. Extent of TOF and its dynamics is important information for policies, planning and programme formulation for its management and enhancement.

TOF refer to tree resources found outside the recorded forest areas. FSI maps forest cover using satellite data and assesses tree cover outside forests using sampling based method. Forest Cover outside the recorded forest area is derived using boundaries of RFA. There are States where RFA boundaries are not available in digital format, in such states Green Wash shown on SOI toposheets have been used as a substitute to the RFA boundaries. Extent of TOF therefore may be estimated as the sum of extent of forest cover outside the RFA / Green Wash as given in the section 2.12 of chapter 2 and tree cover as given in the section 6.3 of this chapter.

In the current assessment, the extent of TOF has been derived for the first time and is assessed 29.38 million hectares which is 36.40 % of the total forest and tree cover in the country. The following table gives extent of TOF in the States and UTs of the country.

TABLE 6.2   State/UT wise extent of TOF

(in sq km)

S.No	State/UTs	Geo. Area	Tree cover 2019	Forest cover outside RFA	Extent of TOF**	% of Forest & Tree Cover of the State/UTs	% of Geographical Area of the State/UTs
1.	Andhra Pradesh	1,62,968	3,914	5,018	8,932	27.03	5.48
2.	Arunachal Pradesh	83,743	848	7,967	8,815	13.05	10.53
3.	Assam	78,438	1,408	8,183	9,591	32.25	12.23
4.	Bihar	94,163	2,003	2,537	4,540	48.77	4.82
5.	Chhattisgarh	1,35,192	4,248	13,195	17,443	29.14	12.90
6.	Delhi	1,483	129	136.37	265	81.68	17.92
7.	Goa	3,702	272	1,063	1,335	53.21	36.05
8.	Gujarat	1,96,244	6,912	5,072	11,984	55.05	6.11
9.	Haryana	44,212	1,565	1,229	2,794	88.22	6.32
10.	Himachal Pradesh	55,673	829	4,796	5,625	34.58	10.10
11.	Jammu & Kashmir*	2,22,236	7,944	11,390	19,334	61.27	8.70
12.	Jharkhand	79,716	2,657	11,402	14,059	53.52	17.64
13.	Karnataka	1,91,791	6,257	16,104	22,361	49.88	11.66
14.	Kerala	38,852	2,936	11,507	14,443	59.98	37.17
15.	Madhya Pradesh	3,08,252	8,339	12,730	21,069	24.55	6.83
16.	Maharashtra	3,07,713	10,806	16,139	26,945	43.75	8.76
17.	Manipur	22,327	173	1,829	2,002	27.03	8.96
18.	Meghalaya	22429	710	2,275	2,985	13.05	13.31
19.	Mizoram	21,081	441	270	711	32.25	3.37
20.	Nagaland	16,579	362	3,759	4,121	48.77	24.86
21.	Odisha	1,55,707	4,648	18,810	23,458	29.14	15.06
22.	Punjab	50,362	1,592	1,065	2,657	81.68	5.28
23.	Rajasthan	3,42,239	8,112	4,348	12,460	53.21	3.64

S.No	State/UTs	Geo. Area	Tree cover 2019	Forest cover outside RFA	Extent of TOF**	% of Forest & Tree Cover of the State/ UTs	% of Geographical Area of the State/UTs
24.	Sikkim	7,096	36	996	1,032	55.05	14.54
25.	Tamil Nadu	1,30,060	4,830	8,775	13,605	88.22	10.46
26.	Telangana	1,12,077	2,514	2,313	4,827	34.58	4.31
27.	Tripura	10,486	231	2,275	2,506	38.35	23.90
28.	Uttar Pradesh	2,40,928	7,342	5,611	12,953	27.03	5.38
29.	Uttarakhand	53,483	841	7,513	8,354	13.05	15.62
30.	West Bengal	88,752	2,006	9,825	11,831	32.25	13.33
31.	A & N Islands	8,249	41	521	562	48.77	6.81
32.	Chandigarh	114	25	13.76	39	29.14	34.41
33.	Dadra & Nagar Haveli	491	28	47	75	81.68	15.32
34.	Daman & Diu	111	5	20.49	25	53.21	22.52
35.	Lakshadweep	30	0.29	27.10	27	55.05	91.30
36.	Puducherry	490	23	51.41	74	88.22	15.15
Total		**32,87,469**	**95,027**	**1,98,813**	**2,93,840**	**36.40**	**8.94**

* includes Jammu & Kashmir area outside LOC that is under illegal occupation of Pakistan and China.

** extent of TOF given in the above table are approximate figures due to limitations of boundaries of RFAs and Green Wash areas

It is seen from the above table that the State of Maharashtra is having largest extent of TOF in the country, followed by Odisha and Karnataka. In terms of percentage of geographical area, the State of Kerala has highest percentage of TOF, followed by Goa and Nagaland.

Tree cover