Growing Stock

Chapter 6

GROWING STOCK

Growing stock (volume of wood) constitutes the most important parameter of the forest resource. Growing stock is an indicator of forest productivity. Historically and to a great extent even now forests have been managed to produce wood (timber) as a major product. Forest inventories primarily aimed at assessing the growing stock and the traditional Working Plan prescription focused on obtaining sustained yield of timber from forests. Growing stock assessment has gained further importance in the present scenario because of the role forests play in climate change and in global carbon cycle. It is estimated that the world's forests store 283 Gigatonnes (Gt) of carbon in their biomass alone, and 638 Gigatonnes (Gt) of carbon in the ecosystem as a whole including dead wood, litter and soil up to 30 cm depth. Thus forests contain more carbon than entire atmosphere ('Global Forest Resource Assessment 2005'). Growing stock provides biomass of the forest ecosystem and carbon pool. Periodic assessment of the growing stock through inventories both within and outside forest areas to know the changes taking place in total carbon pool over time is an urgent need of the hour.

Forest Survey of India generated first estimate on growing stock of forest and TOF at national level and published in 'State of Forest Report 2003'. This exercise has been continued in the present assessment as well. In addition to growing stock, data on other parameters such as regeneration status, soil carbon, biodiversity are also collected during forest inventory.

6.1 Methodology

For the assessment of growing stock of forest and TOF, the country was divided into 14 physiographic zones in 2001 (see Fig.6.1). The same zones with minor modification have been used in the present assessment. The minor modifications carried out were relocating Sikkim State and Darjeeling district of West Bengal from the Western Himalayas to Eastern Himalayas. This was done on the analysis of species because flora of Sikkim and major part (70%) of Darjeeling district was found similar to the flora of Eastern Himalayas.

The list of districts falling within each physiographic zone, completely or partially, has been given in Annexure-I for information.

The fourteen physiographic zones are listed below:

1. Western Himalayas (WH)
2. Eastern Himalayas (EH)
3. North East (NE)
4. Northern Plains (NP)
5. Eastern Plains (EP)
6. Western Plains (WP)
7. Central Highlands (CH)
8. North Deccan (ND)
9. East Deccan (ED)
10. South Deccan (SD)
11. Western Ghats (WG)
12. Eastern Ghats (EG)
13. West Coast (WC)
14. East Coast (EC)

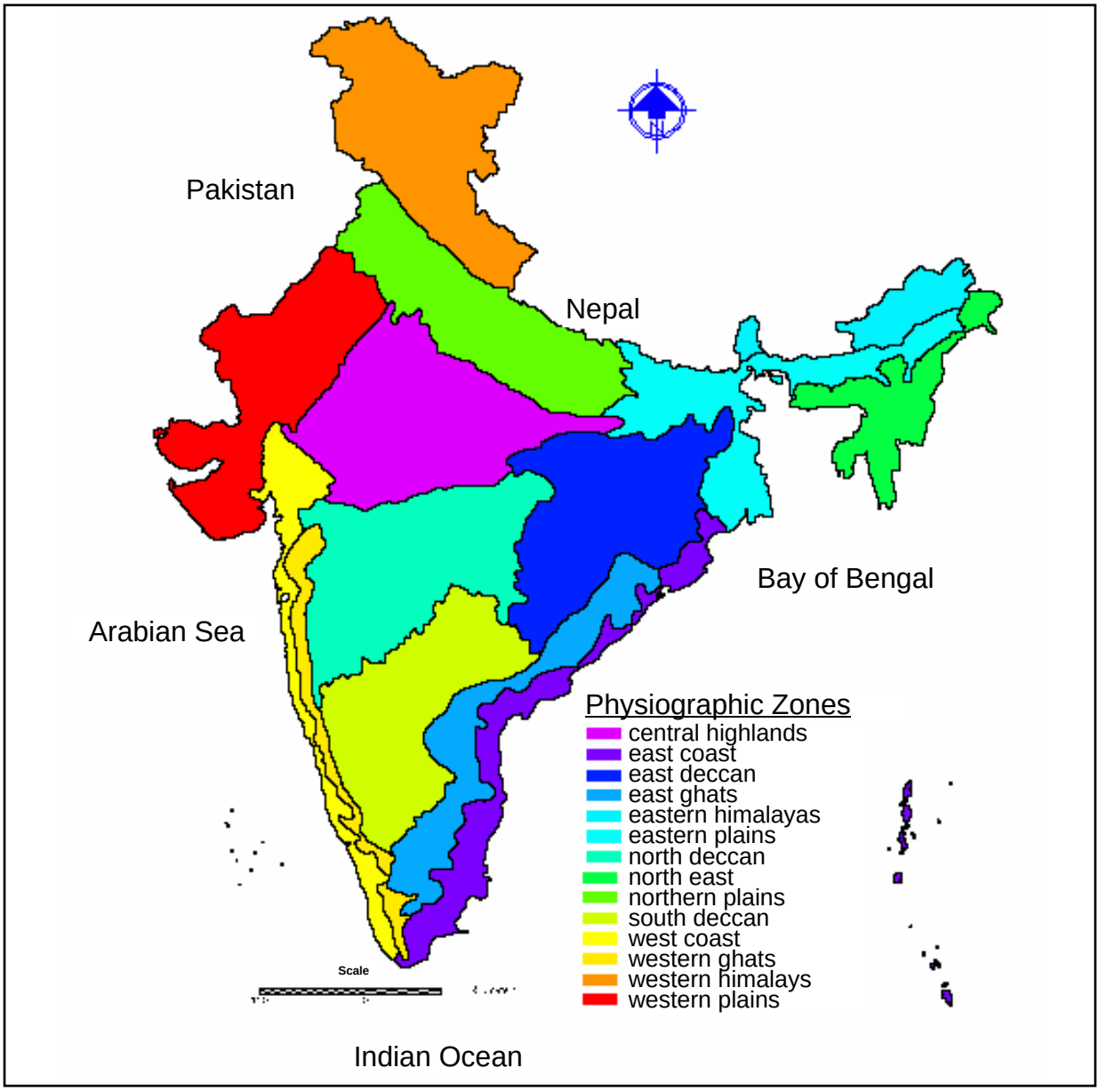

Fig. 6.1: Physiographic Zones of India

A sample of 10 percent districts (or 60 districts in the country) randomly selected and distributed over all the physiographic zones is taken for detailed inventory of forests and TOF to estimate the growing stock at zonal and national level during a cycle of two years. These estimates are to be further improved in the second and subsequent cycles as the data of first cycle will be combined with second and subsequent cycles. The random selection is without replacement; hence each time new districts are selected.

6.2 Forest Inventory

In the selected districts all those areas indicated on toposheets by double dotted line, printed as RF, PF, thick jungle, thick forest etc., shown in greenwash and any other area reported to be a forest area by the local Divisional Forest Officers (generally unclassed forests) are treated as forest.

For each selected district, SOI toposheets of 1:50,000 (size 15'x15') scale was divided into 36 grids of 2½ ' x 2½ '. Further, each grid is divided into 4 sub-grids of 1¼ 'x1¼ ' forming the basic sampling frame. Two of these sub-grids are then randomly selected to lay the sample plots. The intersection of diagonals of such sub-grids are marked as the centre of the plot at which a square sample plot of 0.1 ha area is laid out to conduct field inventory.(Fig. 6.2)

Besides measurement of tree diameter (dbh) and height of selected trees data on legal status, land use, forest stratum, topography, crop composition, bamboo,

regeneration, biotic pressure, species name falling in forest area only are also recorded.

6.3 Trees Outside Forests (Rural)

Satellite data of IRS 1C/1D PAN (5.8m) and LISS III (23.5m) for the period between Oct. 2004-Jan.2005 were acquired from National Remote Sensing Agency, Hyderabad for the selected districts. Thereafter, the PAN image was geometrically rectified with the help of Survey of India toposheets on 1:50,000 scale. The LISS III image was then co registered with the rectified PAN images. PAN and LISS III images were fused using appropriate algorithm to get a multispectral image with 5.8m spatial resolution. Since mapping of TOF areas is the objective, the boundary of forest area was digitized and masked out. The image was then classified into settlement, water bodies, tree cover, agriculture and other land covers. This classification enables the interpreter to distinguish between tree cover 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 were 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 is termed as Un-Culturable Non Forest Area were also calculated.

With the help of pilot studies conducted earlier by FSI, the optimum plot size and number of samples required for each stratum has been determined. The optimum plot size for Block and Linear strata are 0.1 ha and 10m x 125m strip, respectively. In case of Scattered stratum, the optimum size of sample plot has been fixed as 3.0 ha for non-hilly district and 0.5 ha for hilly district. The sample sizes for Block, Linear and Scattered strata have been determined as 35, 50 and 50 respectively for non-hilly districts and 35, 50 and 95 respectively for hilly district.

Desired number of sample points were randomly generated for each stratum and the data on pre-decided variables like dbh, crown diameter, species name and category of plantation, etc., were collected on designed formats. Data processing was carried out using data processing module developed for this purpose by FSI.

The schematic chart of methodology of TOF using remote sensing is depicted in Figure 6.3.

6.4 Trees Outside Forests (Urban)

National Sample Survey Organisation (NSSO), has prepared sampling frames for each urban area of this country. This organization conducts surveys by dividing all the urban centers of a district in blocks called Urban Frame Survey (UFS) blocks. These blocks have well defined natural boundaries and are formed on the basis of population or households and cover the whole area within the geographical boundary of towns including vacant lands. The description of urban areas is obtained from District Census Book for conducting the TOF inventory.

For the purpose of survey the towns have been

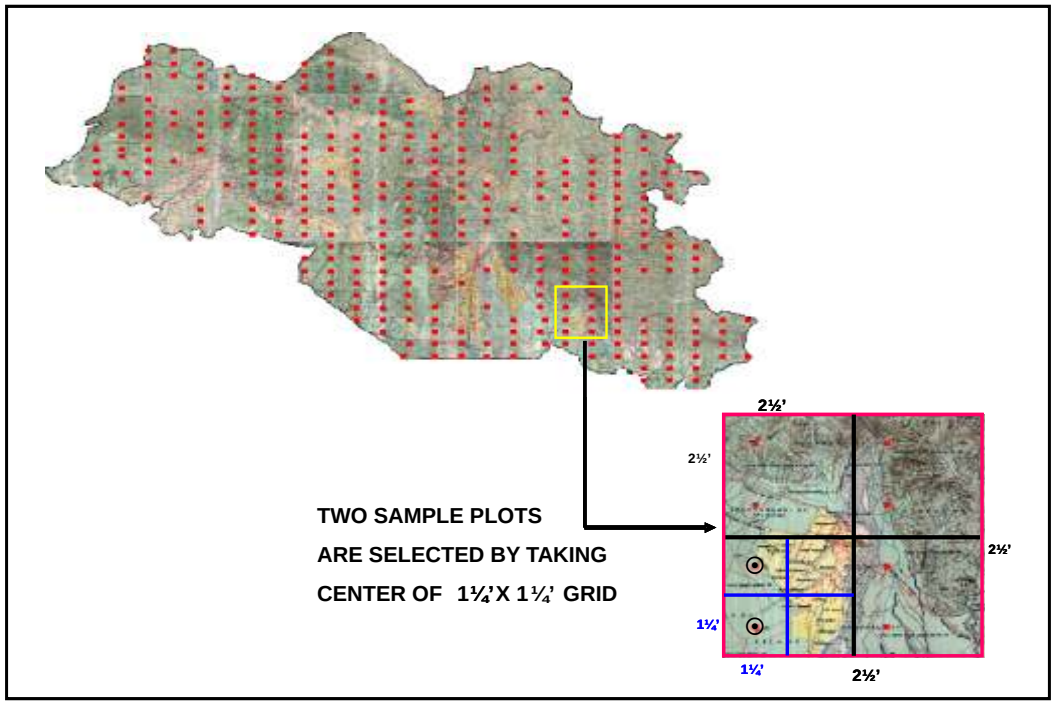

Fig. 6.2: Laying of Forest Inventory Points in a district

classified on the basis of population as given below:

Class I: Population of 100 000 and above
Class II: Population between 50 000 and 99 999
Class III: Population between 20 000 and 49 999
Class IV: Population between 10 000 and 19 999
Class V: Population between 5 000 and 9999

UFS blocks are used as sampling units(Fig. 6.4). The sample blocks in each class of town were randomly selected based on its size. Complete enumeration of all the trees of dbh 10 cm and above was carried out in the prescribed formats having similar parameters as for rural inventory.

6.5 Data Processing

The data pertaining to 120 districts (two cycles) have been analysed for estimation of growing stock within and outside forest areas.

The data collected in the field was checked manually to detect any inconsistency or recording error before entering into the computer. The data was entered in the computer using data entry module which was designed and developed separately for forest, TOF (Rural) and TOF (Urban) inventories by FSI.

For processing of forest inventory data, the inventoried plots in selected districts were classified according to legal status, i.e., recorded forest and private forest. Then per plot area (area factor) was calculated on the basis of plots in recorded forest area. These plots were further classified into different density classes and other land uses. They were then grouped into two broad classes; vegetated (very dense, moderately dense, open & plantations) and less vegetated (scrub, shifting cultivation areas etc.). The area under these classes were calculated using area factor. The plots corresponding to vegetated area were classified according to forest stratum based on dominant species appearing in a particular physiographic zone. On this basis, growing stock (species wise volume and number of trees) of the sample plot was calculated for a particular forest stratum of the selected district. Volume equations developed for each tree species were used. These volume equations have been listed in Annexure II.

To estimate the growing stock of a Physiographic Zone, area under each stratum was first estimated using the ratio method. Thereafter, per hectare figure of growing stock for each stratum was used to estimate the growing stock of the physiographic zone. This process was repeated for all physiographic zones. Summing up of growing stocks of all the physiographic zones yielded the growing stock of forests for the whole country.

In case of TOF inventory, the data processing was carried out separately for rural and urban areas. In rural areas, the estimation of growing stock was carried out separately for Block, Linear and Scattered strata. The area figure for block and linear stratum was obtained by digital

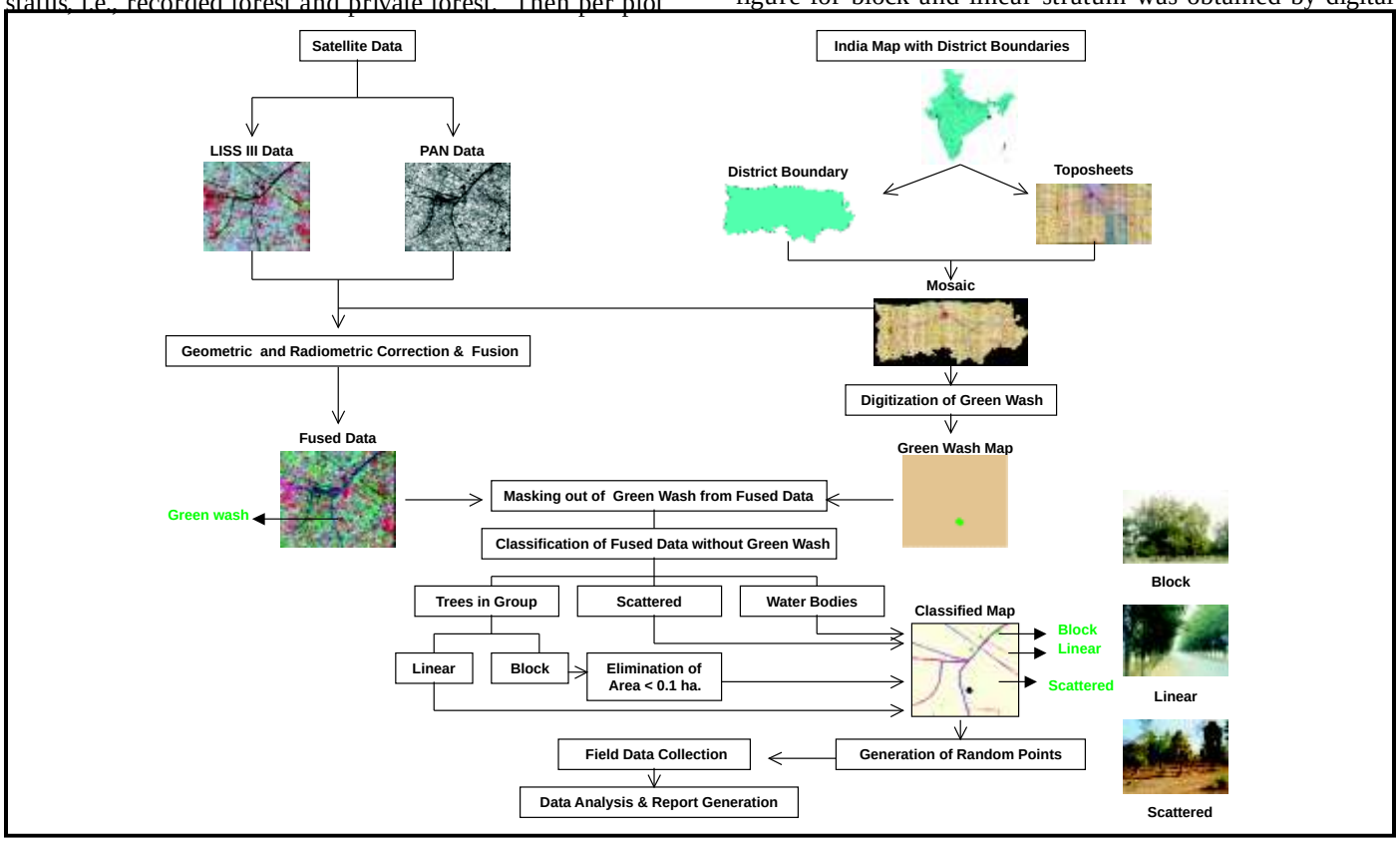

Fig. 6.3: Schematic Chart of Methodology of TOF

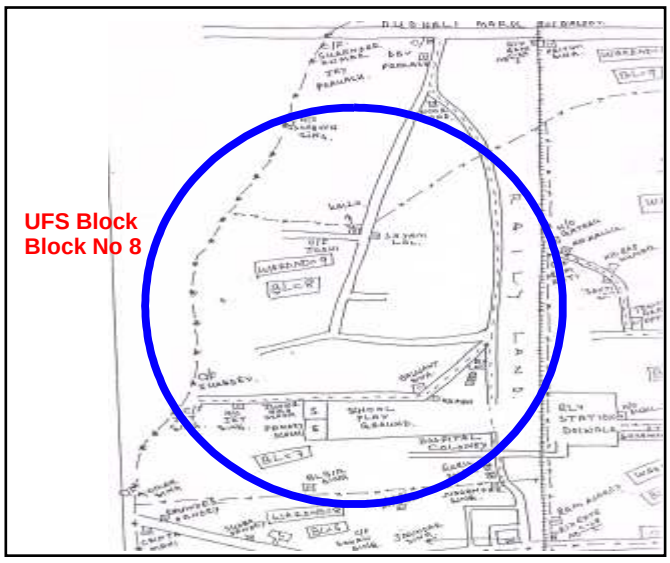

Fig. 6.4: UFS Block Map

interpretation of remote sensing data, whereas the area of scattered stratum was obtained by subtracting the area of block and linear patches from rural CNF area. In case of urban stratum, the area was taken from Census data. Species and diameter class wise number of stems enumerated in sample plots were used for calculating stems per hectare under each stratum. The corresponding volume per hectare was also calculated using volume equations available with FSI. To obtain the growing stock in TOF of the district per ha figures of stems & volume and area factor of each stratum was used and then growing stock of the physiographic zone was estimated. The country wide growing stock estimates of TOF were generated by adding the estimates of physiographic zones.

6.6 Results

The growing stock estimates of forests and trees outside forests at physiographic zone and national level have been generated. The present estimates of growing stock inside forest is based on 14729 sample plots whereas
estimates outside forest is based on 20228 sample plots spread over the 120 districts and is therefore more robust and accurate compared to estimates givan in SFR 2003 where results were estimated on the basis of 7262 sample plots inside forest and 10145 sample plots outside forest spread over 60 districts.

The physiographic zone wise growing stock (stems & volume) within forest and in TOF along with the total growing stock is presented in Table 6.1.

The total growing stock of wood in the country is estimated to be 6,218 million cubic metre comprising 4,602 million cubic metre inside forest area and 1616 million cubic meter outside recorded forest area (TOF). The average growing stock in the forest per hectare of forest area works out to be 59.79 cubic metre. Maximum growing stock in forest area is found in Western Himalayas followed by East Deccan and Western Ghats.

National level growing stock of major species by diameter class of forest and TOF has been presented in Annexure III. The percentage distribution in growing stock of top 10 species of forest has been presented in Table 6.2 and of TOF in Table 6.3

It is observed that Shorea robusta has the maximum contribution both in stems (8.42%) and volume (8.04%) in forest followed by Tectona grandis, Terminalia crenulata, Pinus roxburghii and Anogeissus latifolia having a contribution of 4.33, 2.82, 2.71 & 2.44% respectively.

In TOF, Magnifera indica contributes maximum volume of 11.18% of total volume followed by Cocos nucifera, Syzygium cuminii, Azadirachta indica and Madhuca latifolia having a contribution of 4.94, 4.2, 3.91 and 3.72 percent respectively.

Table 6.1: Physiographic zone wise growing stock (stems & volume)

Physiographic Zone	Area of Phy. Zone (km^2)	Recorded Forest Area (km^2)	Growing Stock					
			In Forest		In TOF		Total	
			Stems (million)	Volume (m. cum)	Stems (million)	Volume (m. cum)	Stems (million)	Volume (m. cum)
West. Himalayas	329,255	91,073	1,355	976.214	539	194.230	1,894	1,170.444
Eastern Himalayas	74,618	47,965	1,010	500.364	162	67.470	1,172	567.834
North East	133,990	79,431	1,287	404.116	521	99.390	1,808	503.506
Northern Plains	295,780	14,230	329	169.448	520	113.803	849	283.251
Eastern Plains	223,339	31,709	581	295.808	341	91.437	922	387.245
Western Plains	319,098	13,666	58	6.314	340	82.215	398	88.529
Central Highlands	373,675	80,665	721	96.078	317	106.806	1,038	202.884
North Deccan	355,988	87,260	1,391	267.964	291	71.157	1,682	339.121
East Deccan	336,289	128,757	2,405	588.329	355	175.255	2,759	763.584
South Deccan	292,416	49,459	616	252.540	423	147.608	1,039	400.148
Western Ghats	72,381	32,399	660	463.315	267	109.273	927	572.588
Eastern Ghats	191,698	74,418	1,109	412.605	213	89.839	1,322	502.444
West Coast	121,242	20,765	397	84.829	513	158.329	910	243.158
East Coast	167,494	17,826	334	84.113	359	109.439	692	193.552
Total	3,287,263	769,621	12,252	4,602.038	5160	1,616.244	17,412	6,218.282

Table 6.2: Growing Stock in Forest for top ten species

Sl.No.	Species Name	Total volume (Percentage)	Total stems (Percentage)
1.	Shorea robusta	8.04	8.42
2.	Tectona grandis	4.33	6.31
3.	Terminalia crenulata	2.82	3.41
4.	Pinus roxburghii	2.71	1.52
5.	Anogeissus latifolia	2.44	3.31
6.	Abies smithiana	2.43	0.24
7.	Quercus semecarpifolia	2.08	0.83
8.	Abies pindrow	1.94	0.34
9.	Castanopsis species	1.76	1.60
10.	Schima wallichii	1.68	0.98

Table 6.3: Growing stock in TOF for top ten species

Sl.No.	Species Name	Total volume (Percentage)	Total stems (Percentage)
1.	Mangifera indica	11.18	8.91
2.	Cocos nucifera	4.94	4.29
3.	Syzygium cumini	4.20	1.23
4.	Azadirachta indica	3.91	4.36
5.	Madhuca latifolia	3.72	1.09
6.	Borassus flabelliformis	3.64	1.79
7.	Ficus species	2.72	0.66
8.	Prosopis cineraria	2.65	3.26
9.	Tamarindus indica	2.57	0.62
10.	Acacia arabica	2.31	3.87