Gist of Indian State of Forest Report

December, 2018
Target PT 2019

Complete Revision through 4000+ MCQs

- 45 Days Concept cum Revision Classes with Daily Test
- 15 Days Prelims Current Affairs Classes + Tests
- Special Classes on Economic Survey & Budget
- Special Classes on India Year Book & Mapping
- Prelims Mock Test Series
- Prelims Study Material

60 DAYS Classroom & Online Programme

- This programme covers the complete syllabus including History, Geography, Polity, Economy, Science, Environment and Current Affairs with the correct mix of Fundamental and Advance level of study to cover micro detailing of sub-topics & current developments.
- 45 Days Concept cum Revision Classes for covering basic concepts. In each session there will be a test of 50 questions (based on the topics given in schedule) followed by Class to cover basic aspects of each topic and approach to handle questions.
- The idea behind taking test before classes is that, first students should brainstorm on the given topics through the test to find their strong and weak areas. Then a class on same topics will provide a conceptual clarity that helps to revise the topics twice on the same day.
- 15 days Current Affairs classes covering last 2 years current topics/issues, updates on Indian Year Book (IYB), PIB, Budget and Economic Survey supplemeted by notes.
- Current Affairs Classes will also include updates on Indian Year Book (IYB), PIB, Budget and Economic Survey.
- Special Classes on Mapping (World & Indian Geography).
- Prelims Test Series including 15 Mock Test and 8 Current Affairs Tests.
- Complete Prelims Study Material & Prelims Current Affairs Material will also be provided (It will cover Current Affairs of past 2 years).

Batch Starts 10 JANUARY 2019

Test Timings : 9:00 AM to 10:00 AM
Class Timings: 10:00 AM onwards

Fee ₹ 17,000 /- (+GST)

Off. No. 6, 1st Floor, Apsara Arcade, Karol Bagh, New Delhi-110005 (Karol Bagh Metro Gate No. 5)

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Contents

1. Methods of determination of forest cover ............................................................... 04
   (a) Introduction
   (b) Technical Advancement in Forest area assessment
   (c) Differentiation between Forest Cover and Recorded Forest Area
   (d) National Forest Inventory (NFI)
   (e) Recent Initiatives of FSI

2. Forest Cover ........................................................................................................... 06
   (a) Introduction
   (b) Classification of forest cover in terms of canopy density
   (c) Forest Cover (2017 Assessment)
   (d) State/UT wise Forest Cover
   (e) States/UTs having forest cover more than 33 per cent
   (f) Changes in the forest cover
   (g) Forest Cover in Hill district
   (h) Forest Cover in Tribal Districts
   (i) Forest Cover in the North-Eastern States
   (j) Relationship between Forests and Water
   (k) Mangrove Cover

3. Forest Fire ............................................................................................................... 09
   (a) Introduction
   (b) Forest Fire Alert System 2.0
   (c) Forest Fire Pre warning alerts
   (d) Regional Variations in Forest Fires

4. Tree Cover .............................................................................................................. 11
   (a) Introduction
   (b) Difference between Trees outside Forest (TOF) and Tree cover
   (c) Physiographic Zone-wise Tree Cover

5. Growing Stock ...................................................................................................... 12

6. Bamboo Resources of the Country ...................................................................... 14

7. Carbon Stock In India’s Forests ............................................................................ 15
Methods of determination of forest cover

Introduction

- The State Of Forest Report (ISFR) is a biennial publication of forest survey of India (FSI), an organization under Ministry of Environment, Forest & Climate change, Government of India, engaged in assessment of country’s forest resources. The first state report was brought out in 1987.

- Assessment of forest resources is necessary because it is essential to recognize carbon stock and natural capital of the country.

- The forest cover estimation is a wall to wall mapping which is done through assessment using advanced technology in following ways:
  - Through high resolution satellite image
  - Through field inventory data of trees outside forest.

Technical Advancement in Forest area assessment

- New Technologies in field of satellite imaging and GIS (Geographic information system) has yielded positively in forest area assessment. Wall to wall mapping is done through satellite imagery through various satellites, such as:
  - LANDSAT-MSS
  - LANDSAT-TM
  - IRS-1B LISSII
  - IRS-1C/1D LISS III
  - Resourcesat-II

Differentiation between Forest Cover and Recorded Forest Area

- **Forest Cover**: The term ‘Forest Cover’ as used in ISFR refers to all lands more than one hectare in area with a tree canopy of more than 10 %, irrespective of land use, ownership and legal status. It may include even orchards, bamboo, palm etc and is assessed through remote sensing.

- **Recorded Forest Area**: The term ‘Recorded Forest Area’ or ‘Forest Area’ refers to all the geographic areas recorded as ‘Forests’ in government records. Recorded forest area mainly consists of Reserved Forests (RF) and Protected Forests (PF), which have been notified under the provisions of Indian Forest Act, 1927 or its counterpart State Acts. Besides RFs and PFs, the recorded forest area may also include all such areas, which have been recorded as forests in the revenue records or have been constituted so under any state Act or local laws.

- Recorded forests may have blank areas with tree density less than 10 % such as degraded lands, wetlands, rivers, riverbeds, creeks in mangroves, snow-covered areas, glaciers and other snow covered areas, alpine pastures, cold deserts, grasslands etc. As per the definition of forest cover, such areas are excluded from the assessment of forest cover.

- On the other hand, there are areas outside the recorded forests with tree patches of one hectare and more with canopy density above 10%. For example plantations on the private/community lands, road, rail and canal sides, rubber, tea, and coffee plantations etc. Such areas also constitute forest cover and are included in the forest cover assessment.

National Forest Inventory (NFI)

- National Forest Inventory contains all data which has been collected by Forest Survey of India (FSI) since 1965. It contains data on different types of forest cover and forested area.
Recent Initiatives of FSI

- **E-Green Watch**
  The e-Green Watch is a web-based user-friendly application developed by NIC that is transparent, reliable and accountable. It enables the temporal change detection for the effective monitoring and evaluation. The application hosted on FSI portal is capable of depicting the Compensatory Afforestation, Diverted Land, Plantations, and other Asset categories on the Google earth imagery.

- **Decision Support System (DSS)**
  Decision Support System (DSS) is Web-GIS based application developed by FSI, to provide qualitative and quantitative information with respect to Forests. The DSS enables forest managers to arrive at a well informed decision. This system is highly useful for taking decisions with respect to proposals under Forest Conservation Act, 1980.

- **New Sampling design for NFI**
  The new sampling design is a grid based instead of district based as used to be earlier. Under the new design, nationwide grids of 5 km x 5 km have been created. Each year, selected grids are selected for forest and TOF inventory. The cycle for forest inventory is kept at 5 years and cycle for TOF has been kept at 10 years.

- **Technical Cooperation Programme for National Forest Monitoring System (NFMS)**
  FSI has initiated a Technical Cooperation Programme (TCP) for Strengthening National Forest Inventory and Monitoring Protocols and Capacities in India with the technical assistance of FAO. The main objectives of the project are to develop and set up a new integrated National Forest Monitoring System (NFMS), build national capacities on forest monitoring and pilot test implementation in selected states.

**Global changes in forest area**

FAO regularly monitors the world’s forests and their management under Global Forest Resources Assessments (GFRA) through country reporting system by member countries. The forest area for top ten countries in 2015 is given in Table below. These countries account for some 67 percent of global forest area. India is placed as 10th in the top ten countries.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Country</th>
<th>Forest area (000 ha)</th>
<th>% of country area</th>
<th>% global forest area</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Russian Federation</td>
<td>814931</td>
<td>48</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>Brazil</td>
<td>493538</td>
<td>58</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>Canada</td>
<td>347069</td>
<td>35</td>
<td>9</td>
</tr>
<tr>
<td>4</td>
<td>Unites State of America</td>
<td>310095</td>
<td>32</td>
<td>8</td>
</tr>
<tr>
<td>5</td>
<td>China</td>
<td>208321</td>
<td>22</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>Democratic Republic of the Congo</td>
<td>152578</td>
<td>65</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>Australia</td>
<td>124751</td>
<td>16</td>
<td>3</td>
</tr>
<tr>
<td>8</td>
<td>Indonesia</td>
<td>91010</td>
<td>50</td>
<td>2</td>
</tr>
<tr>
<td>9</td>
<td>Peru</td>
<td>73973</td>
<td>58</td>
<td>2</td>
</tr>
<tr>
<td>10</td>
<td>India</td>
<td>70682</td>
<td>22</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>26869</strong></td>
<td><strong>48</strong></td>
<td><strong>67</strong></td>
</tr>
</tbody>
</table>
Introduction

The Minimum Mappable Unit in respect of forest cover assessment is an area of 1 ha in extent and having tree canopy density of 10 percent and above.

Classification of forest cover in terms of canopy density

<table>
<thead>
<tr>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Dense Forest</td>
<td>All lands with tree canopy density of 70 percent and above.</td>
</tr>
<tr>
<td>Moderately Dense Forest</td>
<td>All lands with tree canopy density of 40 percent and more but less</td>
</tr>
<tr>
<td>than 70 percent</td>
<td></td>
</tr>
<tr>
<td>Open Forest</td>
<td>All lands with tree canopy density of 10 percent and more but less</td>
</tr>
<tr>
<td>than 40 percent</td>
<td></td>
</tr>
<tr>
<td>Scrub</td>
<td>Degraded forest lands with canopy density less than 10 percent.</td>
</tr>
<tr>
<td>Non-forest</td>
<td>Lands not included in any of the above classes. (includes water)</td>
</tr>
</tbody>
</table>

Forest Cover (2017 Assessment)

The total forest cover of the country, as per current assessment is 7,08,273 sq km which is 21.54% of the geographic area of the country. In terms of density classes, area covered by VDF (Very Dense Forest) is 98,158 sq km, that with MDF (Moderately Dense Forest) is 3,08,318 sq km and OF is 3,01,797 sq km corresponding to 2.99, 9.38 and 9.18 percent respectively of the total geographical area of the country.

State/UT wise Forest Cover

Forest cover of States and UTs of the country has been depicted in table. Area wise, Madhya Pradesh has the largest forest cover (77,414 sq km) in the country followed by Arunachal Pradesh (66,964 sq km), Chhattisgarh (55,547 sq km), Odisha (51,345 sq km) and Maharashtra (50,682 sq km). In terms of percentage of forest cover with respect to total geographical area, Lakshadweep leads at 90.33%, followed by Mizoram (86.27 %), Andaman & Nicobar Islands (81.73%), Arunachal Pradesh (79.96%), Manipur (77.69%), Meghalaya (76.45%), Nagaland (75.33%) and Tripura (73.68%).

States/UTs having forest cover more than 33 per cent

The present assessment shows that 15 states/UTs have above 33 per cent of the geographical area under forest cover. Out of these states and UTs, seven states have more than 75 per cent forest cover while eight states have forest cover between 33 per cent and 75 per cent. Highest forest cover is in Lakshadweep with 90.33 % of total area is covered with forest. Other states having more than 33% forest cover are Mizoram, Andaman & Nicobar Islands, Arunachal Pradesh, Manipur, Meghalaya, Nagaland, Tripura, Goa, Kerala, Sikkim, Uttarakhand Dadra & Nagar Haveli, Chhattisgarh and Assam.
Changes in the forest cover

After taking into account the changes observed during the two assessments periods i.e. ISFR 2015 (Updated) and ISFR 2017, there has been an increase of 6,778 sq km forest cover at the national level. Three states namely Andhra Pradesh, Karnataka and Kerala have contributed to an increase of 2,141 sq km, 1,101 sq km and 1,043 sq km respectively, much of which can be attributed to plantation and conservation activities both within and outside the Recorded Forest areas as well as improvement in interpretation due to better radiometric resolution of the recent satellite data from Resourcesat-2. Other states where significant increase has been observed are Odisha (885 sq km), Assam (567 sq km), Telangana (565 sq km), Rajasthan (466 sq km), Himachal Pradesh (393 sq km), Uttar Pradesh (278 sq km), Jammu & Kashmir (253 sq km) and Manipur (263 sq km).  The States which show reduction in forest cover primarily include Mizoram (531 sq km), Nagaland (450 sq km) and Arunachal Pradesh (190 sq km).

Forest Cover in Hill district

Forest cover plays a crucial role in the maintenance of mountain ecology and economy with particular reference to soil, water and environmental conservation. In the present assessment, the forest cover of the hill districts has been given separately. The hill districts as identified by the erstwhile Planning Commission for Hill Areas and Western Ghats Development Programme have been taken into consideration for forest cover analysis. There are 127 hill districts. As per the present assessment, the forest cover in the hill districts of the country is 283,462 sq km, which is 40.22 per cent of the total geographic area of these districts. All districts of the States of Arunachal Pradesh, Himachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura and Uttarakhand are hill districts. The current assessment shows an increase of 754 sq km of forest cover in all hill districts of the country.

Forest Cover in Tribal Districts

Tribals and forest have a traditional inter linkage and dependence for fulfilling the social, economic, cultural, religious, and medical needs. Thus it is highly imperative to monitor and analyze the forest cover situation in the tribal areas. The total forest cover in the tribal districts is 4,21,170 sq km which is 37.43% of the geographical area of these districts. The current assessment shows an actual increase of 86.89 sq km in all the tribal districts of the country.

Forest Cover in the North-Eastern States

- North-Eastern region of the country comprising eight States namely, Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura is endowed with rich forest resources and is one of the 18 biodiversity hotspots of the world. The region, with just 7.98 per cent of the geographical area of the country, accounts for nearly one fourth of its forest cover. One distinct feature of land use is the prevalence of shifting cultivation in hilly parts of almost all the States of this region. Shifting cultivation has traditionally been intricately linked to socio-cultural life of tribal people.

- As per the present assessment the total forest cover in the region is 1,71,306 sq km, which is 65.34% of its geographical area in comparison to the national forest cover of 21.54%. The current assessment shows an actual decrease of forest cover to the extent of 630 sq km in the North-Eastern region. The main reason for this decrease is attributed to shifting cultivation and other biotic pressures prevalent in the region.

Relationship between Forests and Water

The increase in water bodies within the forested areas of the country dearly brings out the positive effects of forests in augmenting water resources. Various hydrological functions such as recharge of aquifers, reducing run-off, increasing availability of water for irrigation etc enhanced due to conservation of forests. Adequate emphasis on protection and conservation of forests is necessary for improving water resources which can positively influence various sectors such as Agriculture, Animal Husbandry, Industry etc besides improving health and wellbeing of the people. There is an increase of 2,647 sq km in the extent of water bodies over the decade (2005-2015). In general, all the States and UTs show an increase except Arunachal Pradesh, Uttar Pradesh, Haryana and Bihar. The States of Maharashtra, Gujarat, Madhya Pradesh, Telangana, Andhra Pradesh, Tamil Nadu and Karnataka show an increase of more than 100 sq km over the decade.
Mangrove Cover

- Intertidal tropical and subtropical regions between latitudes 24°N - 38°S bear halophytic vegetation called 'Mangroves. These diverse group of plants, exhibit varied morphological and physiological adaptations in order to survive the harsh physical environment in spite of these regions receiving 1000-3000 mm of annual rainfall and a temperature regime between 26-35°C. The limiting factors include lack of oxygen, high salinity and diurnal tidal inundation. The adaptations include succulent leaves, sunken stomata, aerial breathing roots called ‘pneumatophores; higher cellular salt concentration, vivoparity, support structures like stilt roots and buttresses etc.

- Mangroves are therefore considered as most productive wetlands, but they are increasingly threatened by biotic pressure, changing land use patterns and natural calamities. It is therefore imperative to regularly assess and monitor the mangroves for designing appropriate conservation strategies.

### Status of Mangrove Cover Worldwide

- Mangroves are mostly distributed over 123 countries and territories in the tropical and sub-tropical region of the world. Asia has the largest amount of the world’s mangrove. The total Mangrove cover in the world is 150,000 sq.km (Source: World Atlas of Mangroves, 2010). The most extensive area of mangrove is found in South East Asia followed by South America, North Central America, and West and Central Africa. South Asia comprises 10,344 sq km which is 6.8 % of the world’s mangrove cover. India’s contribution is 45.8% of the total Mangrove cover in South Asia.

### Mangrove Cover (2017 Assessment)

- The current assessment shows that mangrove area in the country is 4921 sq km, which is 0.15 per cent of the country’s total geographical area. The Very Dense mangrove comprises 1481 sq km (30.10%) of the mangrove cover, Moderately Dense mangrove is 1480 sq km (30.07%) while Open mangroves constitute an area of 1960 sq km (39.83%). There has been a net increase of 181 sq km in the mangrove cover of the country as compared to 2015 assessment.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>State/UT</th>
<th>Very Dense Mangrove</th>
<th>Moderately Dense</th>
<th>Open Mangrove</th>
<th>Total</th>
<th>Change with respect to 15FR 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Andhra Pradesh</td>
<td>0</td>
<td>213</td>
<td>191</td>
<td>404</td>
<td>37</td>
</tr>
<tr>
<td>2.</td>
<td>Goa</td>
<td>0</td>
<td>20</td>
<td>6</td>
<td>26</td>
<td>0</td>
</tr>
<tr>
<td>3.</td>
<td>Gujarat</td>
<td>0</td>
<td>172</td>
<td>968</td>
<td>1,140</td>
<td>33</td>
</tr>
<tr>
<td>4.</td>
<td>Karnataka</td>
<td>0</td>
<td>2</td>
<td>8</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>5.</td>
<td>Kerala</td>
<td>0</td>
<td>5</td>
<td>4</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>6.</td>
<td>Maharashtra</td>
<td>0</td>
<td>88</td>
<td>216</td>
<td>304</td>
<td>82</td>
</tr>
<tr>
<td>7.</td>
<td>Odisha</td>
<td>82</td>
<td>94</td>
<td>67</td>
<td>243</td>
<td>12</td>
</tr>
<tr>
<td>8.</td>
<td>Tamil Nadu</td>
<td>1</td>
<td>25</td>
<td>23</td>
<td>49</td>
<td>2</td>
</tr>
<tr>
<td>9.</td>
<td>West Bengal</td>
<td>999</td>
<td>692</td>
<td>423</td>
<td>2,114</td>
<td>8</td>
</tr>
<tr>
<td>10.</td>
<td>WI Islands</td>
<td>399</td>
<td>169</td>
<td>49</td>
<td>617</td>
<td>0</td>
</tr>
<tr>
<td>11.</td>
<td>Daman &amp; Diu</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>12.</td>
<td>Puducherry</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>1,481</td>
<td>1,480</td>
<td>1,960</td>
<td>4,921</td>
<td>181</td>
</tr>
</tbody>
</table>
Introduction

Fires have always played a very important role in shaping forests since ancient times. Foresters use it as a tool in scientific forest management as certain species regenerate and establish well under light fire conditions. However, uncontrolled fires is one of the major causes of degradation of forests. Precious forest resources including carbon locked in the biomass is lost due to forest fires every year, which adversely impact the flow of goods and services from forests. Often forest fires are caused intentionally by communities to promote grass growth, clear areas for shifting cultivation, clear forest floor for NTFP collection e.t.c and sometimes due to arson especially for hunting wildlife or encroaching forest land. Unintentional fires from cigarette/bidi butts sometimes cause havoc if not noticed at an early stage.

Forest Fire Alert System 2.0

During the current year (2017), the system of forest fire alerts underwent a complete revamp in order to serve the interests of the users in a better way. Automation of the whole process including night-time fire alerts were carried out which has led to significant reduction in the time taken for processing. In order to improve the spatial and temporal resolution of the alerts, data from SNPP-VIIRS (Visible Infrared Imaging Radiometer Suite) was also included. The revamped fire alert system which was launched on 23rd January 2017 has been christened as “Forest Fire Alert System 2.0”. The main features and advantages of this system are given below.

- **Improved Resolution of Alerts:** Inclusion of Forest Fire Alerts from SNPP-VIIRS Sensor with higher resolution of 375m x 375m along with MODIS sensor which has a resolution of 1km x 1km has further improved identification of smaller fires. Further, the SNPP-VIIRS sensor has better capabilities over MODIS for detection of fire boundary of large fires and fires under thick canopy. The SNPP-VIIRS alerts pertaining to 1.30 am and 1.30 pm also improve the temporal frequency of fire alerts when combined with MODIS.

- **Customized Alerts:** SMS and email alerts are provided as per requirement of users up to beat level, wherever, the administrative boundary layer has been made available by the State Forest Departments

- **Improved users experience:** Users now have the option of registering their details, modifying as well as deleting their profiles from the Forest Survey of India Website (www.fsinicin). An OTP based system has been put in place for user authentication. A link is also included in all alerts to enable users to provide feedback on aspects such as whether fire has actually occurred or not extent of area burnt(in Hectare) and also any other observations they may want to make.

- **Control Panel for State Nodal Officers:** Every State Nodal Officer is provided with an administrative panel for the respective state which allows bulk registration of their departmental users. The admin page also enables the states to generate reports of fire alerts, feedback etc as per their template needs.

Forest Fire Pre warning alerts

Forest Survey of India, with years of experience with the repository of fire related data, developed in 2016, an indigenous “Pre Warning Alert System”. The alerts to State Forest departments are based on parameters like Forest Cover, Forest Type, Climatic Variables (Temperature and Rainfall), and recent fire incidences over the area. The GIS layers of these parameters are overlaid and intersect areas above threshold values are chosen and communicated as pre warning forest fire alerts in the form of KML files through email to the nodal officer of the State Forest Departments.
Regional Variations in Forest Fires

It may be seen from below two charts that the drought conditions that prevailed over the country during 2004, 2009, 2012, and 2016 correspond well with the total number of fire detections pertaining to these years. It may be seen that the fire detections in Western States do not correspond to the peaks observed in the national trend with the exception of 2016. The number of fire detections is usually below 500 per year indicating their comparatively lower vulnerability. In addition, the influence of drought on forest fires is less pronounced in the region as the inter-annual variations in number of fire detections is comparatively lower. This is true for Southern States as well, where although the peaks correspond well with the drought years, the inter-annual variation is less pronounced. An alternating trend of low peaks, close to 5000 detections annually which is followed by a trough indicates specific forest management practices and resource use.
Introduction

Forest cover includes all areas more than 1 ha in extent and having tree canopy density of 10% and above irrespective of land use and legal status. However, there are small patches of trees less than 1.0 ha in extent such as trees in small scale plantations, compact blocks, woodlots, or trees along linear features, such as roads, canals, bunds etc and scattered trees which are not being captured by satellite sensors used for forest cover mapping due to technological limitations. These patches of trees, though small, play a significant role in socio-economic and ecological status of the country. The contribution of such trees 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. Thus information on tree cover along with forest cover of the country gives a complete picture of tree resources of the country.

Difference between Trees outside Forest (TOF) and Tree cover

It is essential to differentiate between “TOF” and “Tree Cover” as two entities looks very similar but have different meaning. Trees existing outside the recorded forest area mainly in the form of block, linear & scattered size of patches are called TOF. During the inventory of TOF, sample points are spread over the entire CNFA. On the basis of field inventory, the growing stock is estimated for TOF. Tree cover, on the other hand, is an estimated area comprising of tree patches, which are less than one hectare and isolated trees outside the recorded forest. Thus, trees included in the tree cover constitute only a part of the TOF.

Physiographic Zone-wise Tree Cover

It is observed that the tree cover is maximum in Central Highlands (11,534 sq km) followed by East Deccan (10,663 sq km) and West Coast (9,445 sq km). Eastern Himalayas have the lowest tree cover of 610 sq km, as this zone is predominantly under natural forests. West Coast has maximum percentage of Tree Cover (8.31%) with respect to its geographical area followed by Western Ghats (5.58 %) and East Deccan (3.19%).

Tree Cover in the States and Union Territories

The state having maximum tree cover area is Maharashtra (9,831 sq km) followed by Rajasthan (8,266 sq km), Madhya Pradesh (8,073 sq km) and Gujarat (8,024 Sq km). Considering the percentage of geographical area of State/UTs, the Union Territory of Daman & Diu shows highest percentage of tree cover (9.01%) followed by Chandigarh (8.77%) and Goa (8.73%).
The calculation of growing stock has assumed greater importance as it provides a key input for deriving the amount of carbon sequestered in the forests. Food and Agricultural Organization (FAO) and United Nations Framework Convention on Climate Change (UNFCCC) guidelines for implementation of REDD+ strategy require every country to have a National Forest Monitoring System (NFMS) consisting of satellite based land monitoring system, National Forest Inventory and Green House Gas (GHG) inventory. India’s long experience and expertise in measuring its growing stock at regular intervals places it in a pre-eminent position among nations equipped to respond to REDD+ requirements. Forest Survey of India has been in the vanguard of this national endeavor.

- The growing stock estimates of forests and trees outside forests have been generated at physiographic zone, national and State level. The present estimates are based on 20,912 sample plots laid out inside forest and 33,054 sample plots outside forest areas in 180 districts.

<table>
<thead>
<tr>
<th>Physiographic Zone</th>
<th>Areas of Phy. Zone (sq km)</th>
<th>Growing Stock (million cum)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Forest</td>
</tr>
<tr>
<td>Western Himalayas</td>
<td>328,952</td>
<td>959.980</td>
</tr>
<tr>
<td>Eastern Himalayas</td>
<td>81,752</td>
<td>391.600</td>
</tr>
<tr>
<td>North East Ranges</td>
<td>127,857</td>
<td>287.240</td>
</tr>
<tr>
<td>Northern Plains</td>
<td>295,909</td>
<td>141.070</td>
</tr>
<tr>
<td>Eastern Plains</td>
<td>222,365</td>
<td>178.310</td>
</tr>
<tr>
<td>Western Plains</td>
<td>320,507</td>
<td>11.260</td>
</tr>
<tr>
<td>Central Highlands</td>
<td>371,281</td>
<td>135.880</td>
</tr>
<tr>
<td>North Deccan</td>
<td>365,711</td>
<td>293.740</td>
</tr>
<tr>
<td>East Deccan</td>
<td>333,824</td>
<td>671.540</td>
</tr>
<tr>
<td>South Deccan</td>
<td>291,317</td>
<td>219.270</td>
</tr>
<tr>
<td>Western Ghats</td>
<td>73,681</td>
<td>423.120</td>
</tr>
<tr>
<td>Eastern Ghats</td>
<td>192,068</td>
<td>272.220</td>
</tr>
<tr>
<td>West Coast</td>
<td>113,611</td>
<td>150.200</td>
</tr>
<tr>
<td>East Coast</td>
<td>168,634</td>
<td>82.950</td>
</tr>
<tr>
<td>Total</td>
<td>3,287,469</td>
<td>4218.380</td>
</tr>
<tr>
<td>Growing stock (ISFR 2015)</td>
<td>4195.047</td>
<td>1573.340</td>
</tr>
<tr>
<td>Change</td>
<td></td>
<td>23.333</td>
</tr>
</tbody>
</table>
The physiographic zone-wise growing stock (volume) within forest and in TOF area along with the total growing stock is presented in Table.

It is observed that Shorea robusta has the maximum contribution in total volume (11.36%) followed by Tectona grandis, Pinus roxburghii, Terminalia crenulata, and Anogeissus latifolia having a contribution of 5.57, 3.97, 3.62 and 2.96% respectively.

In TOF, Mangifera indica contributes maximum volume of 13.01% of total volume followed by Cocos nucifera, Azadirachta indica and Bombax ceiba with a contribution of 6.71, 6.50 and 3.45% respectively.

To estimate the annual production of timber from TOE, inventory data of TOF for last three cycles pertaining to period 2010-2016 has been used. Estimates were generated state-wise. For each state, the estimates of growing stock were arranged according to species which were further arranged according to timber and other species. For calculation of production, only timber species were considered. The rotation period of different timber species is available with FSI from State Forest Departments and other sources. Using estimates of growing stocks and rotation period of the species, annual potential production has been calculated for each state by applying Von Mentel formula. Adding the estimates of state, total annual production of timber for the country has been arrived at. The estimates of annual production of timber given in ISFR 2011 has been updated due to availability of revised rotation period for different timber species. Accordingly, the estimates of annual potential production of timber given in ISFR 2011 has been updated to 69.04 million cum from 42.77 million cum as reported in ISFR 2011. The main reason of this increase is due to revised rotation period for each species. Earlier only three rotation periods i.e. short medium and long rotation were used for estimation of production.
Bamboo Resources of the Country

- Bamboo is one of the fastest growing plants with ability to survive in a wide variety of climatic and edaphic conditions. It is capable of growing under soil conditions varying from organically poor to mineral rich soil and moisture to drought to flooding which makes it effective for reclaiming degraded lands. Bamboo also plays an important role in carbon sequestration and bio-diversity conservation. Their diversity in terms of size, being light yet strong, hard and straight, fast growth, and abundance make bamboos amenable to versatility of use which is often species specific.

- 125 indigenous and 11 exotic species of bamboo belonging to 23 genera are reportedly found in India. The principal bamboo genera occurring in India are Arundinaria, Bambusa, Chimonobambusa, Dendrocalamus, Dinochola, Gigantochloa etc. More than 50 % of the bamboo species occur in Eastern India- Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura, and West Bengal. Other areas rich in bamboo are the A & N Islands, Chhattisgarh, Madhya Pradesh, and the Western Ghats.

- The total estimated green weight of bamboo culms at national level is 189 million tonnes of which green sound bamboos contribute 70% and dry sound bamboos contribute remaining 30%. As compared to the estimate of ISFR 2011, there is an increase of about 19 million tonnes equivalent green weight of bamboo observed in the present assessment. There is an increase in Equivalent Green Weight (EGW) for higher culm size classes i.e. 5-8 cm and 8+ cm diameter classes suggesting an improvement in culm sizes.

- The total bamboo bearing area of the country is estimated to be 15.69 million hectare. Madhya Pradesh has maximum bamboo bearing area of 1.8 m ha followed by Maharashtra (1.6 m ha), Arunachal Pradesh (1.5 m. ha) and Odisha (1.2 m ha).

- As compared to the estimates of ISFR 2011, the total bamboo bearing area in the country has increased by 1.73 m. ha. Comparing state wise area of present assessment with ISFR 2011, it has been observed that bamboo bearing area in Madhya Pradesh has shown highest increase of 5108 sq km followed by Maharashtra (4462 sq km). Similarly, Mizoram has shown highest decrease of 5978 sq km in the bamboo bearing area followed by Arunachal Pradesh (958 sq km). Overall, total bamboo bearing area has increased.

- Maximum occurrence of pure bamboo was observed in Arunachal Pradesh (137 sq km) followed by Manipur (95 sq km) and Nagaland (57 sq km). Dense bamboo was found maximum in Arunachal Pradesh (5358 sq km) followed by Madhya Pradesh (4581 sq km) and Maharashtra (3911 sq km). The area with hacked bamboo clumps was found maximum in Madhya Pradesh (1714 sq km) followed by Maharashtra (1389 sq km) and Chhattisgarh (933 sq km). Bamboo regeneration was found maximum in Karnataka (2943 sq km) followed by Maharashtra (2625 sq km) and Madhya Pradesh (2560 sq km).
Climate change has emerged as the leading environmental issue in the recent past. The resulting variability of climate change poses serious threat to the environment and the quality of human life all over the world. It is for this reason, the parties to the United Nations Framework Convention on Climate Change (UNFCCC) have undertaken a comprehensive exercise to address the issues of climate change adaptation and mitigation. Forests play an important role in mitigation and adaptation of climate change. Forests sequester and store more carbon than any other terrestrial ecosystem and are an important natural ‘brake’ on climate change. Carbon sequestration by forests has attracted much interest as a mitigation approach, as it has been considered a relatively inexpensive means of addressing climate change immediately. In India, varied climate regimes and topography, large geographical area, long coastline and the existence of oceanic islands have endowed it with a diversity of natural biomes—from deserts to alpine meadows, tropical rain forests to temperate pine forests, mangroves to coral reefs and from marshland to high altitude lakes.

Forests and climate change are intimately intertwined. Forests regulate the climate, rain, groundwater and soil of the Earth. Forests are both sources and sinks of carbon. A growing forest captures carbon from the atmosphere and a mature forest is a store house of carbon. The world’s forests and forest soils currently store more than one trillion tons of carbon - twice the amount found floating free in the atmosphere.

According to Global Forest Resource Assessment Report 2010 of FAO (FAO, 2010), the total forest carbon stock of the world is 652 Giga tonnes (161.8 t/ha). Out of this the forest biomass contains 289 Giga tonnes (71.6 t/ha); the ‘dead organic matter’ contains 72 Giga tonnes (71.6 t/ha); and forest soil organic carbon contains 293 Giga tonnes (72.3 t/ha) of carbon.

The carbon stock of 2017 has been estimated to be 7083 million tonnes. There is an increase of 39 million tonnes of carbon stock as compared to 2015.

<table>
<thead>
<tr>
<th>Component</th>
<th>Carbon Stock in forest as per ISFR 2015</th>
<th>Carbon stock in forest in 2017</th>
<th>Net change in Carbon stock</th>
<th>Annual increase in Carbon stock</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above Ground Biomass</td>
<td>2220</td>
<td>2238</td>
<td>18</td>
<td>9.00</td>
</tr>
<tr>
<td>Below Ground Biomass</td>
<td>695</td>
<td>699</td>
<td>4</td>
<td>2.00</td>
</tr>
<tr>
<td>Dead wood</td>
<td>29</td>
<td>30</td>
<td>1</td>
<td>0.50</td>
</tr>
<tr>
<td>Litter</td>
<td>131</td>
<td>136</td>
<td>5</td>
<td>2.50</td>
</tr>
<tr>
<td>Soil Organic Carbon</td>
<td>3969</td>
<td>3979</td>
<td>10</td>
<td>5.00</td>
</tr>
<tr>
<td>Total</td>
<td>7044</td>
<td>7082</td>
<td>38</td>
<td>19.00</td>
</tr>
</tbody>
</table>

In forest ecosystem, enormous carbon is stored which is classified in five pools by GPG. The living portion of biomass carbon is classified in two pools: the ‘above ground biomass’ (AGB) and ‘below ground biomass’ which are stores of significant amount of carbon. The ‘dead organic matter’ (DOM) is also classified into two pools: ‘dead wood’ and ‘litter’. The fifth pool is ‘Soil Organic Matter’ (SOM) which contains substantial amount of organic carbon.

The carbon stock of 2017 has been estimated to be 7083 million tonnes. There is an increase of 39 million tonnes of carbon stock as compared to
the estimates of previous assessment. The annual increase of carbon stock is worked out to be 19.50 million tonnes which is 71.5 millions tonnes of carbon-di-oxide equivalent. Soil organic carbon is the largest pool of carbon followed by AGB, BGB, Litter and dead wood. On comparing the changes between present and previous assessment, maximum changes has been observed in AGB followed by soil organic carbon, litter and dead wood.

- Arunachal Pradesh has maximum carbon stock of 994.5 million tonnes followed by Madhya Pradesh(695.5 million tonnes, Chhatisgarh (560.9 million tonnes) and Maharashtra (493.0 million tonnes).

- The per hectare carbon stock among different states /UTs indicates that Andaman Nicobar is contributing maximum per hectare carbon stock of 170.68 tonnes followed by Arunachal Pradesh, Sikkim and Karnataka.