Chapter 1

INTRODUCTION

1.1 About Forest Survey of India

Forest Survey of India (FSI), was established in the year 1981 with the objective to carry out assessment of forest and forest resources to aid scientific planning and decision making in the forestry sector. The origin of the institution could be traced back to the year 1965, when the "Pre-investment Survey of Forest Resources" (PISFR) project was initiated by Government of India with the sponsorship of FAO and UNDP. The mandate of the organisation was revised in 1986, wherein it was envisaged to carry out a biennial assessment of forest cover and forest resources based on remote sensing and inventory.

The mandate of the organisation has further expanded in recent times to include Decision Support System for forest diversion, e- Green watch a platform to monitor afforestation efforts funded through CAMPA, Forest fire alert dissemination and related studies, use of high resolution and very high resolution data for monitoring, etc. However, forest cover assessments published as India State of Forest Report (ISFR) remains the most important work of the organisation and is used countrywide for monitoring and planning purposes.

1.2 Forest Cover Mapping: An Overview

Forest Cover assessment using mid-resolution satellite data is a useful strategy for periodic assessments as it is both time and cost effective when compared to field inventory. The first country wide forest cover assessment was carried out in the year 1987 and since then, Forest Survey of India has been carrying out this exercise once in every two years. The fifteenth forest cover assessment was published as India State of Forest Report- 2017. The whole process of forest cover assessment takes two full years due to the vast size of the country as well as the scientific rigour of the exercise to achieve high levels of accuracy.

Forest Policy of India 1988 envisages a goal of achieving 33% of geographical area of the country under forest cover. Nation-wide forest cover mapping (FCM) done by FSI serves as a monitoring mechanism towards this policy goal.

1.2.1 Objectives of Forest Cover Assessment

The Forest Cover assessment published in ISFRs are a very important source of primary information regarding forests which are widely used across Central Government, State Governments, forestry professionals of State Forest Departments, academia and other stakeholders.

The basic objectives of the exercise are as below.

1. Biennial assessment of forest cover of the country to monitor forest cover and forest cover changes at various levels (District, State and National) to provide inputs for policy and planning.

2. To generate data and statistics on forest cover, density classes, forest cover changes for planning and scientific management of forests of the country.
3. To provide base data for forest carbon assessment in the country.
4. To provide inputs for international reporting and tracking progress on forestry related parameters.

The forest cover assessments provide, in general, the state of affairs of the forestry sector of the country and a broad evaluation of the forest related policies, legislations, programmes and activities across various levels in the country.

1.2.2 User's Perspective

A. Country Level

1. The forest cover estimate and net change in forest cover provides an overall picture of the forestry sector in the country.
2. Helps identify states and regions where forest cover is decreasing or degrading so that appropriate interventions (Policy, programmes etc,) can be targeted.
3. Used for planning purposes to identify suitable areas for national, international projects, afforestation programs, planning of greening of highways, wastelands etc.
4. Identification of valuable forest areas for special efforts in conservation and protection.
5. Provides inputs in diversion of forest land for non-forestry purposes through Decision Support System.
6. Help in planning of various projects such as infrastructure projects like road, rail and industrial projects like mining, hydro-energy etc. for suitable site and alignment purposes.
7. Forest cover data is used as an input for various national level inventories and reports such as GHG, Growing Stock, Carbon stock inventory, estimation of FRL under REDD+ etc. These are also to be used in international reporting to UNFCCC, Aichi targets under CBD, GFRA (FAO) etc.
8. Numerous national, international studies use forest cover and other related information reported in ISFRs for scientific and policy research.
9. Forest cover and its changes in thematic contexts such as tribal areas, hilly areas, north eastern region provide valuable policy inputs .

B. State Level

1. The forest cover estimate and net change in forest cover provides an overall picture of the forestry sector in the state.
2. Provides a broad reflection of the various efforts for afforestation of the state government as well as the drivers of degradation/ deforestation in the state.
3. Provides inputs to design or modify policies, plans and programmes of the Government.
4. Various research institutions, projects and organisations make use of forest cover data for numerous aspects which includes watershed planning, biodiversity assessments, hydrological studies, town and country planning etc.

C. Division/ District level

1. Thematic data of forest cover and density classes provide a good understanding of the forest area and its quality in the Division, which can be used for various planning purposes such as
   - Identification of areas for afforestation (open or moderately dense forests)

- Identification of areas, which are degraded / deforested when, compared to previous assessment. Specific interventions could be targeted in such areas based on ground conditions.
- Assess potential areas for improvement in tree cover outside forest areas such as agro-forestry lands, common lands, Government lands etc.
- Provide a sampling framework for Working Plan preparation including stratification and in preparation of other scientific management plans

1.2.3 Keeping pace with Technology

Over the years, several technological and methodological advances have taken place in the mapping of forest cover in terms of availability of better satellite data, higher scale maps and improved mode of interpretation. FSI has always kept pace with technological advancement and improved its assessment over the years.

The first remote sensing based nation-wide forest cover assessment of 1987 was carried out using LANDSAT-MSS satellite data with a spatial resolution of 80 meters. The scale of mapping was 1:1,000,000 and mode of interpretation was visual with a Minimum Mappable Unit (MMU) of 400 ha. In1989, LANDSAT-MSS satellite was replaced by LANDSAT-TM with a spatial resolution of 30 meters. The mapping was carried out at 1:250,000 scale thereby reducing the Minimum Mappable Unit (MMU) from 400 hectare to 25 hectare.

Since 1995, FSI started using indigenous remote

Table 1.1: Forest Cover Mapping over the Years

Cycle of Assess-ment	Year	Data Period	Sensor	Spatial Resolution	Scale	Minimum Mappable Unit (ha)	Mode of Interpretation
I	1987	1981-83	LANDSAT-MSS	80 m	1:1 million	400	Visual
II	1989	1985-87	LANDSAT-TM	30 m	1:250,000	25	Visual
III	1991	1987-89	LANDSAT-TM	30 m	1:250,000	25	Visual
IV	1993	1989-91	LANDSAT-TM	30 m	1:250,000	25	Visual
V	1995	1991-93	IRS-1B LISSII	36.25 m	1:250,000	25	Visual & Digital
VI	1997	1993-95	IRS-1B LISSII	36.25 m	1:250,000	25	Visual & Digital
VII	1999	1996-98	IRS-1C/1D LISS III	23.5 m	1:250,000	25	Visual & Digital
VIII	2001	2000	IRS-1C/1D LISS III	23.5 m	1:50,000	1	Digital
IX	2003	2002	IRS-1D LISS III	23.5 m	1:50,000	1	Digital
X	2005	2004	IRS-1D LISS III	23.5 m	1:50,000	1	Digital
XI	2009	2006	IRS-P6-LISS III	23.5 m	1:50,000	1	Digital
XII	2011	2008-09	IRS-P6-LISS III	23.5 m	1:50,000	1	Digital
XIII	2013	2010-11	IRS P6-LISS-III IRS-Resourcesat-2 LISS III	23.5 m	1:50,000	1	Digital
XIV	2015	2013-14	IRS P6-LISS-III IRS-Resourcesat-2 LISS-III	23.5 m	1:50,000	1	Digital
XV	2017	2015-16	IRS-Resourcesat-2 LISS-III	23.5 m	1:50,000	1	Digital

sensing satellite data and mode of interpretation was partly shifted from visual to digital. The satellite data used for forest cover assessment since 2001 is LISS-III with a spatial resolution of 23.5 meters and a scale of interpretation of 1: 50,000. The mode of interpretation was shifted from visual to digital and the MMU has been further reduced from 25 ha to one ha.

The Table 1.1 shows a snap shot of technological advancement that took place in the assessment of forest cover over the last three decades.

1.3 Forest Cover

Forest Cover for the purpose of Forest Cover Mapping done by FSI is defined as,

"All Lands more than one hectare in area, with a tree canopy density of more than 10 percent irrespective of ownership and legal status. Such lands may not necessarily be a recorded forest area. It also includes orchards, bamboo and palm"

As may be seen from the above definition, forest cover is not dependent on land use and therefore an area which satisfies the above definition irrespective of land use is included in the forest cover assessment. This is a very important factor to consider for the end users so that the data and statistics are used in the correct sense and not mis-interpreted.

Besides reporting forest cover at various levels, the India State of Forest reports also provide useful insights into the forest cover within the Recorded Forest areas (RFA) which are those that have been legally notified as forest under Central/ State legislations. This provides useful information to SFDs on Forest cover changes within RFA and in the recent ISFR 2017, Forest Survey of India has compared Forest Cover changes within and outside RFA of 16 states in ISFR 2017. The information is prepared by making use of the digital boundaries provided by the SFDs to FSI. It is also very important to note that most of the 16 states listed in the table, have not been able to provide 100% of the digitized boundary information, as these are in various stages of preparation or updation at their level. However, it still provides useful information on the performance of SFDs in protection and conservation of forests within the RFAs.

For states where, digitised RFA data are not available, useful comparisons of forest cover within and outside Green wash Areas are provided. These Greenwash areas are obtained by digitising the green shaded areas from Survey of India toposheets which indicates presence of forests.

Besides these, various kinds of analysis such as change matrix showing inter density class movement of forests, forest cover across various altitude levels, Forest cover in tribal districts, mangrove cover information, average patch size information of forest cover etc. are provided in the ISFRs.

1.4 Approach

The forest cover is mapped using a hybrid classification approach using satellite imagery from LISS-III sensor along with other data. The methodology adopted is explained in detail in Chapter-3.

The broad approach adopted by FSI is depicted pictorially below.

It is necessary to highlight once again that the approach relies a lot on the skill of the analysts. The analysts have good understanding about the topography, forests and land use related aspects of

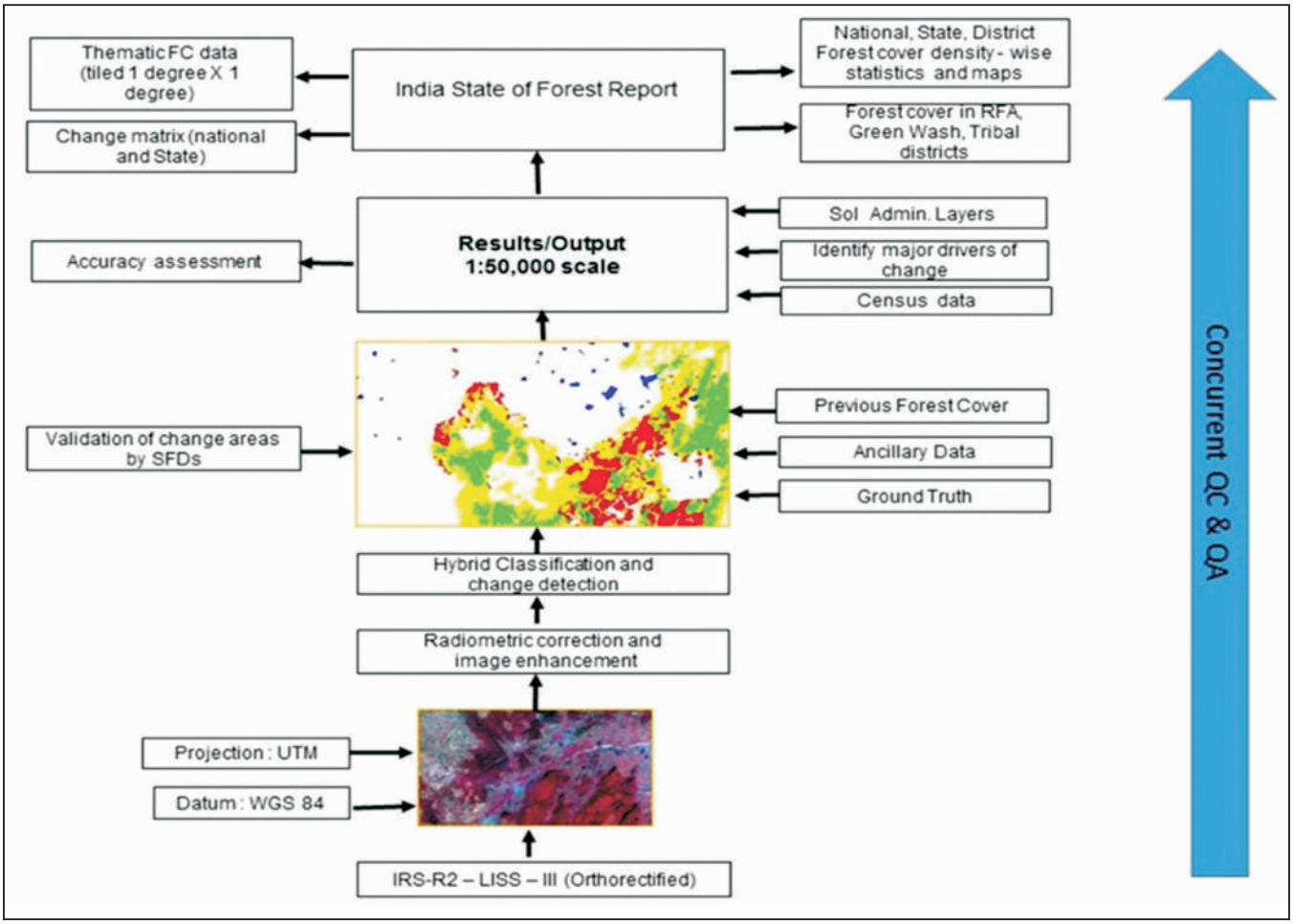

Fig.1.1: FSI's approach for Forest Cover Assessment

the Districts/ State, which is allotted to them. This human input is an essential component of the forest cover mapping exercise.

1.5 Limitations of the Forest Cover Assessment Exercise

Remote sensing data has certain inherent limitations that affect the accuracy of the Forest Cover Mapping, some of which are mentioned below:

- Since the resolution of the LISS-III sensor data is 23.5 m, land cover having a geometric dimension on the ground less than 23.5 m is not discernible.
- Considerable ground details may sometimes be obscured due to clouds and shadows. Such areas can be classified to a certain extent with the help of collateral data and image processing techniques
- Non-availability of appropriate season data sometimes leads to misinterpretation of the features owing to poor reflectance of data.
- Occurrence of weeds like lantana in forest areas and agricultural crops like sugarcane, cotton, etc. adjacent to forest area causes mixing of the spectral signatures and often make precise forest cover delineation difficult.
- Young plantations and tree species with

less chlorophyll or poor foliage, many a times are not discernable on satellite images due to low leaf area index and transmittance.

- Where heterogeneity in tree species composition is high, generalized classification may affect the accuracy level.

1.6 About the Manual

The manual has been prepared with the foremost objective of having a uniform approach for mapping of forest cover with an overall aim to improve consistency and accuracy of the exercise. Various past internal circulars and manuals have been referred and updated in preparation of this manual. A manual of this nature is especially relevant for the vast exercise of Forest Cover mapping at the national level, which besides various other scientific inputs also relies heavily on analyst's knowledge and therefore to minimise bias, which often creeps in, it was felt necessary to have a document that all analyst would follow uniformly. It is pertinent to mention here that a team of over 50 technical personnel including the officials in four zonal offices are involved in the wall-to-wall forest cover mapping of the country. The manual therefore becomes a guiding document to ensure uniformity amongst the team of analysts and also continuity of the methodology over a period of time.

The manual is organised into 4 chapters. The next chapter on "Implementation Plan" describes the internal processes, timelines and various Quality Control and Quality Assurance steps, which are crucial to the Forest cover mapping exercise. The Chapter 3 describes the methodology in detail with scenarios, case studies etc. The final Chapter is a Step-wise Procedure for digital interpretation of satellite data for Forest Cover mapping describing the steps involved in the exercise using ERDAS IMAGINE software, which is used for Digital Image Processing of raster data, and Arc GIS, which is used for, vector related analysis.