Chapter 2

FOREST COVER MAPPING IMPLEMENTATION PLAN

2.1 Introduction

India is one of the few countries that carry out monitoring of Forest Cover at a short interval of two years. The exercise is huge considering the geographical area of the country and the diverse physiography, which gives rise to various challenges in mapping. It is sometimes difficult to carry out forest cover mapping in many areas in the North East, Andaman and Nicobar Islands due to the constant cloud cover. The knowledge of the analyst is an important input in Forest Cover Mapping (FCM). Due to diversity in the landscapes, it is necessary that the analyst is properly oriented towards the allotted area, its terrain, forest composition etc. in order to minimize misinterpretation. This is important as there is significant mixing of reflectance on the satellite data from Agriculture, undergrowth, phenological changes etc. As the biennial forest cover mapping is a time bound exercise, it is imperative to have a sound Implementation Plan to not only monitor the progress of work but also its quality in order to achieve the desired accuracy levels. This chapter on Implementation Planning helps to capture various internal processes that are aimed at achieving the objectives of the exercise. These practices and institutional mechanisms are a result of accumulated experiences from various Forest Cover Mapping cycles of the past and this Chapter is aimed at consolidating various internal circulars issued from time to time in this regard.

2.2 Implementation Plan

2.2.1 Volume of work and its Distribution

The work progress of the exercise is monitored on 1 degree x 1 degree units as denoted by Survey of India (SoI) map sheets at 1:250000 scale. Although the country is covered in 394 one degree (SoI) sheets (approx), the number of effective sheets work out to be around 270 (approx). The volume of mapping work in an area covered by a degree sheet, depends upon various factors such as forest cover, dynamicity of the change in land use in the area, Trees outside Forests (ToF) workload etc.

The FCM work is largely done at the Head Quarter (HQ), though Zonal offices are also allotted States within their respective jurisdiction which helps logistically. The knowledge from field work of forest inventory which is solely carried out by zones will also be helpful in interpretation work. Almost half of the volume of work is carried out in the zonal offices. The regional offices are also equipped with adequate, well trained manpower to carry out this exercise pertaining to the states allocated to them. Overall responsibility of methodology, compilation, quality control, systems and other technical matters rests with the Headquarters.

The distribution of work and allotment of States and UTs across the Zones and HQ for the current cycle is shown in the figure below.

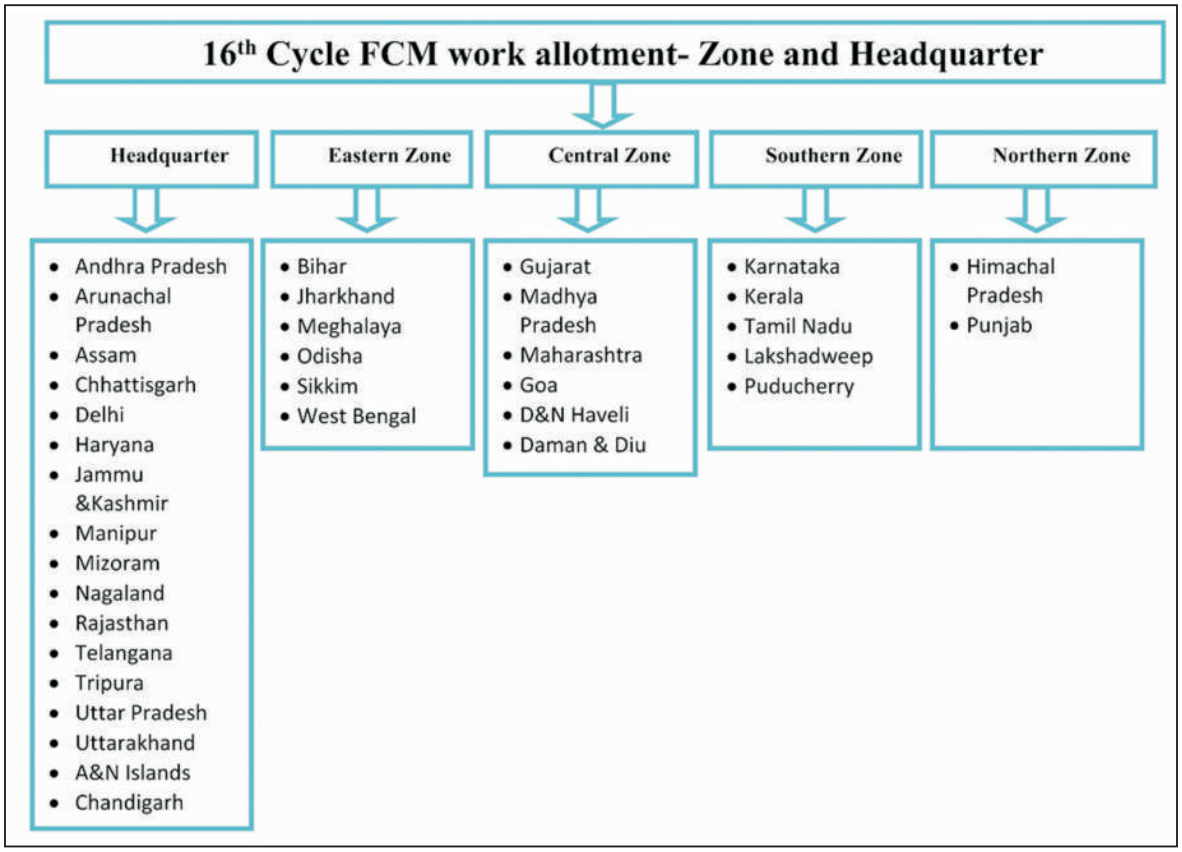

Fig. 2.1 : Indicative work allotment distribution chart

Period	Ist year assessment									IInd year assessment								
Activity	Jan to April	May	June	July	August	September	October	November	December	January	February	March	April	May	June	July	August	September to December
Satellite Data procurement and distribution																		
Rectification and workshop on FCM methodology																		
Classification of data																		
Ground truthing																		
Incorporation of post field corrections,Change Map generation and validation																		
Quality Check and Quality Assurance																		
Statistics generation																		
Accuracy assessment																		
Report Writing																		

Fig. 2.2: Time Line Chart

2.2.2 Schedule of Activities

Time is a major factor to consider while preparing the schedule of activities for such a complex activity like the Forest Cover Mapping. Based on experiences from previous cycles, the activity schedule indicating the major activities and time allocated for these activities has been standardised, which is given in the Figure 2.2.

2.2.3 Preparatory Workshops

As may be seen from the figure above, the preparatory works for the following cycle begin even before the completion of the current FCM cycle. The cycle begins with browsing for available and the suitable satellite imagery. As a preparatory activity, workshops are held at Dehradun to build capacity of the analyst on the methodology. These workshops aim at bringing the analysts approach for mapping of forest cover classes at the same level besides highlighting the various steps followed in the methodology and also bring about any innovations or recent updates in the methodology. Technical personnel from zones involved in FCM also compulsorily attend these workshops and trainings.

For example in the current cycle, use of ortho-rectified satellite imagery required certain minor modifications to the methodology which was included in these preparatory workshops. It is also aimed to distribute the available satellite data during these workshops itself so that the actual work on these could start immediately.

2.3 Data Procurement

a) Satellite Data

The appropriate time of satellite data used for FCM is post monsoon period at the peak of the growing season. This season also excludes cloud cover from most of the regions in the country. The following standards are important to consider pertaining to data procurement.

- **Optimum season of acquisition**: Corresponds to that in which forest classes can be distinguished from other land cover classes. October to December is considered most suitable. However, in some areas of the North Eastern States and Andaman and Nicobar Islands, this period could be extended to January- March of the following year.
- **Minimum cloud cover and good radiometric quality:** In general, maximum 10 to 15 percent cloud cover is permissible in data selection. However, in extreme cases this may be relaxed and in such instances, additional data within the allowed period, with different pattern of cloud may be used.
- **Distribution of Data:** The satellite data procured from NRSC is browsed by a central team at HQ. The Deputy Director (System Management) is the nodal officer who maintains

Fig. 2.3: Panoramic photograph of ground location

an account with National Remote Sensing Centre (NRSC), Hyderabad. The data before distribution is verified by the central team at HQ and is distributed to Zonal offices through File transfer Protocol (FTP) transfer/ by post.

- **Use of other satellite data:** In extreme cases, when quality image from LISS-III is not available, Joint Director, Forest Geo-informatics Division may allow to use cloud free data from other satellites/sensors like LANDSAT TM, Sentinel etc. which have comparable resolution.

b) Administrative Boundaries

- The boundary layers of various administrative units up to district level along with the authenticated area are procured from Survey of India for the purpose of area calculation and generation of maps. For previous assessment, the boundary vector upto District level was procured from Survey of India. However, the area was not provided by SoI and the area published in Census 2011 was used as per the advice of Survey of India. However, ideally, we should aim at procuring these two from Survey of India to avoid mismatch.
- Digital open series toposheets (1:50,000 scale) was procured during the previous assessment and was used as an input to correct/update the administrative boundary information wherever required as the data procured from Survey of India had digitisation issues.

c) Recorded Forest Area (RFA) boundary

Recorded forest area boundary for the states is supplied by the respective SFDs. However, most of the states have not been able to complete digitisation of the RFA. Many states have digitised these areas from SoI toposheets and some states have also carried out a combination of High resolution satellite imagery and Ground truth for survey of RFA. Before using the RFA boundary information, this needs to be evaluated for its utility value. The RFA vector is overlaid on satellite imagery to ascertain shifts and errors due to digitisation and only in cases where this shift is not very high (<100m), the RFA data is used for analysis. Another factor to consider, is the completeness of the RFA data and to ascertain this, the reported RFA area is compared with the area from the vector file. RFA information is used only in cases where atleast 80% of the RFA is digitised.

It is also important to note that, RFA boundary may be replaced by the States as and when better data is available due to change in methodology. Therefore, while making comparisons of forests within RFA, both within and across ISFRs, it is important to note if any changes have been made on the RFA boundary used for the purpose.

d) Collateral Data

Various important collateral data such as National Forest Inventory (NFI) data, e-Green Watch plantations database, burnt area database, previous ground truth database, forest cover layers of previous year, feedback from the SFDs etc., are widely used as collateral inputs to aid interpreters to improve their classification. While using various collateral sources, it is important to look at the period of the collateral data and not use the inputs as such. For example, the NFI data can be of various years while the satellite imagery may be from a recent date and therefore, collateral data sources may not exactly represent ground

Parameter	Accepted RMS error for Hilly terrain	Accepted RMS error for Plains
Root Mean Square error for image registration	<1.5 pixel	<1 pixel

situation. However, except in areas where abrupt negative change in canopy cover are observed, the collateral data sources are very useful to the analysts for classification in difficult areas such as hill shadows.

2.4 Image Rectification and Image Improvement

Ortho- rectified satellite data has been adopted for FCM exercise from the current assessment onwards and this has better positional accuracy compared to the previous cycle satellite data rectified using SoI toposheets. Due to this, satellite data from the current cycle is used to rectify the satellite image as well as the thematic data of the previous cycle. This is carried out using the Autosync feature of the software.

While carrying out the image registration, the following standards are to be followed.

2.5 Interpretation

Image interpretation is an art and science of transforming remotely sensed data into information, using logical process in detecting, identifying, classifying, measuring, and evaluation of the satellite data. General steps involved to extract information from digital remote sensing data for forest cover mapping are mentioned below sequentially-

- Previous classification layer of FCM is used as a base layer for current cycle assessment.
- The forest cover is classified into three density

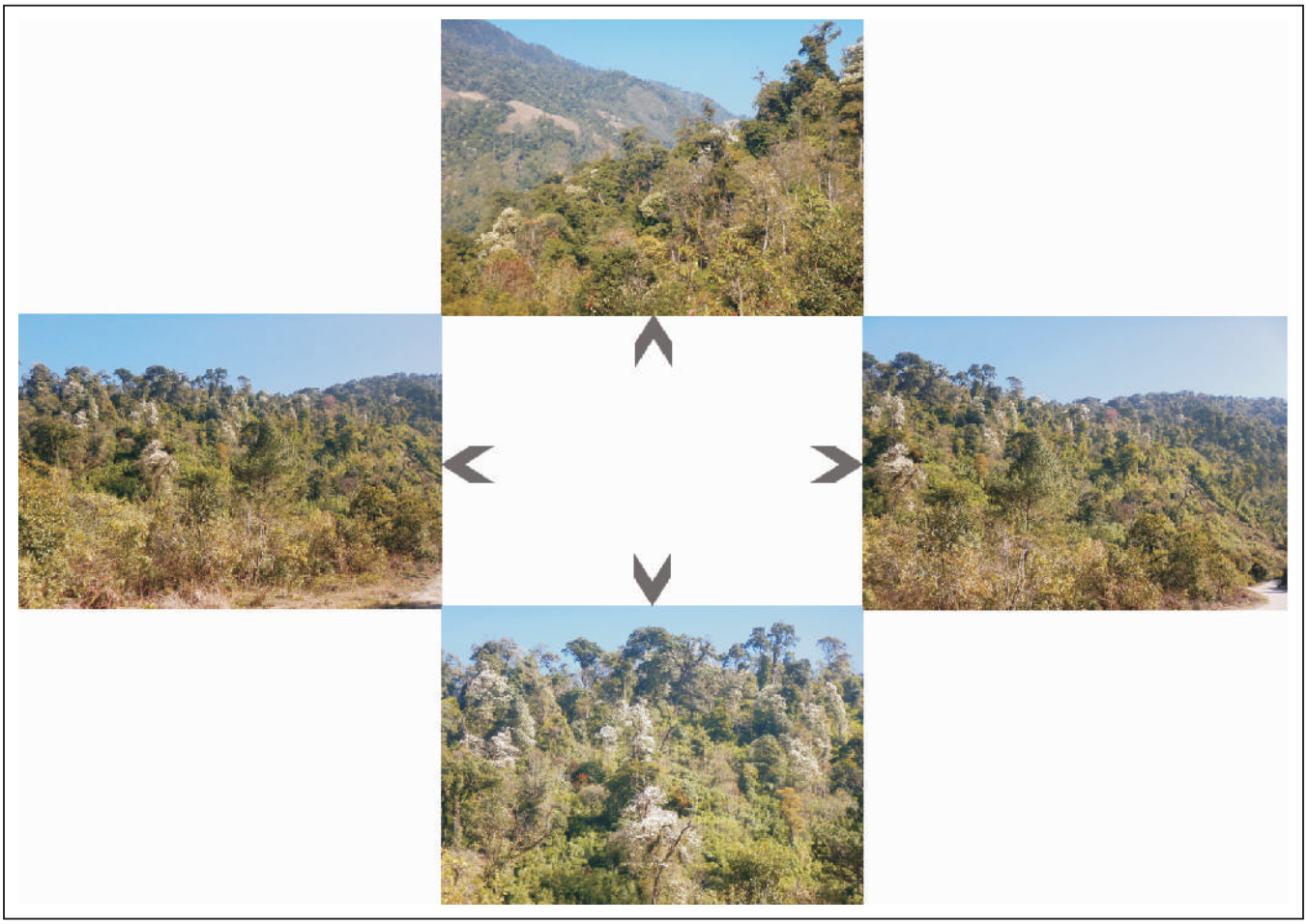

Fig. 2.4 : Four directional photograph of change points on ground

classes- Very Dense Forest (VDF), Moderately Dense Forest (MDF) and Open Forest (OF). The classification is based on the scheme as per Fig. 3.3 in chapter 3.

- Once the forest areas and non-forested areas according to present satellite images area extracted, the hybrid classification approach for image interpretation is followed.
- On screen visual analysis in discerning forest cover patches is central to the methodology, while algorithm based digital classification aid the visual analysis in interpretation.
- The base layer i.e. the previous cycle forest cover map is updated with the latest satellite data by incorporating change polygons.
- Scene-wise classification is followed restricted to allotted State boundary.

State-wise mosaic of the classified layer is prepared for further area statistic generation.This is the most important step in the FCM exercise and takes the longest time to complete. This step needs to be monitored closely as errors during this step would adversely affect the results of the FCM exercise. Some of the major aspects to consider while monitoring this step are

- Quality of assessment of non-forests within the forest mask and vice versa.
- Changes within density classes using contextual and ratio indices approach.
- Interpretation of shadow mask and cloud mask area.
- Extraction of surface water using NDWI, region grow or other suitable techniques.
- Use of collateral data for interpretation.
- Generation of doubt points for Ground Truth.
- Classification of real and interpretational change.

2.6 GroundTruthing (GT) and Photo Library

Ground truth is an integral part of the FCM exercise which helps to improve accuracy of the classification by providing important field inputs for classification of doubt areas as well as to identify the drivers of change (both degradation and improvement). The most important points to consider for monitoring are as below.

- The doubt points should be generated in a manner that aids the interpretation. The doubt points should not include those areas where deforestation as well as the reason for change can be clearly ascertained from satellite imagery or Google Earth.
- Doubt points with significant change, signature mixing, radiometric distortion- haze, poor reflectance are taken into consideration for validation. The generated doubt points should consider both real as well as interpretational change.
- Whenever, major interpretational changes are identified on the image, they should be thoroughly verified on the ground through Ground Truth.
- The doubt areas should not just be confined to one region or area of the image. It should be well distributed across the area.
- All the points for ground truth which are to be visited in the field for GT should be prior approved by the supervisors
- Prior to ground truthing, a tentative area figure has to be generated for the increase/decrease in forest cover.
- Geo-tagged field photos (usually panoramic view, close and in between) are taken. The photos should be well numbered and referred to in the field form.
- After completing ground truthing exercise all the field forms, field photographs are to be maintained in a photo library.

- All Ground Truth should be carried out jointly with the State Forest Departments and the signature of the forest officer is mandatory on the GT forms.
- Ground truthing also helps in gathering signature of forest cover.

2.7 Post Field Corrections

After Ground Truth, the inputs from field visit are incorporated into the interpretation and the change maps are prepared for validation by the State Forest Departments. The issues to consider for monitoring here are timely generation of maps, ensuring delivery of maps to the States on time, pursuing with them for validation along with reasons for change (both positive and negative) and proper interpretation of their comments and incorporation in the final interpretation.

It has been observed in the past that many times the maps shared in CD form get damaged in transit. Therefore, additionally they may be hosted at FTP for download by the State Forest Departments.

2.8 Edge Matching and Generation of Provisional Statistics

Edge matching is an important exercise which not only increases the visual impact of the maps but also improves the overall accuracy by removing the bias of analysts in the boundary areas.

Both Scene to Scene and State to State edge matching are important. The first one is carried out at the stage of incorporation of post field correction. The interpreters who are working on the same state thus under the supervision of the same supervisor, will match the scene edges under the guidance of the supervisor. The availability of GT points in the edges and other collateral data are to be used for correction exercise. It is important to ensure that cosmetic corrections are just not carried out and that too in a hurry.

The State to State edge matching is to be carried out at a later stage when the teams from both HQ and Zones come together for cross checking exercise.

2.9 Concurrent Quality Checking & Quality Assurance Approach

The Implementation Plan mainly focuses on the Quality Checking & Quality Assurance (QC & QA) standards and steps to be followed to ensure the same. At every step of the methodology, quality standards are to be ensured and the standards available have been outlined in the Chapter. It is expected that the concurrent monitoring of the processes will ensure that the data output is of the desired quality and accuracy.

The most important QC & QA procedures are to be captured using the Scene QC & QA form which is provided in the annexure I&II.
Some of the major monitoring activities which ensures concurrent QC & QA are outlined below.

2.9.1 Monthly Review

Work progress as well as work quality is monitored at HQ level as well as the zonal level every month. The progress of work is collected on the last week of the month by the HQ and is reviewed during the monthly FCM review meeting headed by the Joint Director who is the divisional head. Similar reviews are also held at the end of the month by the Regional Directors and the compiled information is sent to HQ by the last working day of the month which is included in the monthly review held on first Monday of the month. The physical progress of the work along with the quality parameters are discussed during the monthly review meetings headed by the Joint Director, Forest Geo-Informatics Division, HQ.

A degree sheet is the basic unit for monitoring the work output. The scene wise work progress pertaining to various steps are converted into the corresponding degree sheet and compiled at the HQ. The information from the monthly review is also reported to the Survey and Utilisation Division of Ministry of Environment, Forest and Climate Change on a monthly basis.

2.9.2 Periodic Review

Besides the monthly review of FCM exercise at both Zone and HQ level, Director General conducts detailed periodic review of the exercise. The decisions taken in such reviews are recorded and directions are issued to all concerned for compliance. Work Progress review of FCM exercise is also an important agenda in all the periodic review meetings of the Zonal offices which are conducted at HQ time to time.

2.9.3 QC &QA Team

In order to strengthen the QC & QA processes, a team of officers and technical personnel have been identified for monitoring purposes for the current assessment. This team is responsible to design suitable formats to capture various monitorable parameters and compile and highlight areas of concern to the Joint Director in a periodic manner.

The most important milestones where this exercise needs to be carried out are as below.

- Rectification of previous cycle data and thematic layer
- Geometric/ToA Correction
- Interpretation
- Pre Ground Truth change points generation and provisional change estimates
- Post -field corrections
- Edge Matching (scene to scene)
- Edge Matching (State to State)
- Final area calculation and report generation

The QC & QA team has a nodal member designated by the Regional Directors of the respective zone. These nodal members from the four zones are key to compile the QC & QA related information and relay it to HQ. Capacity building of the QC & QA team also needs to be conducted once in six months.

2.9.4 Quarterly Review of Zones by Assistant Directors

In order to ensure adherence to the common methodology and also to concurrently monitor the work progress both in terms of quality and quantity, Assistant Directors are allotted a Zone for monitoring purposes. The Assistant Directors visit the Zones once in three months and submit a report to the HQ. During the visit, the issues observed by the Assistant Directors are clearly documented and shared with the Regional Directors for their follow-up.

2.9.5 Final Cross-Checking Exercise

The final cross checking exercise is carried out just before finalisation of the data and preparation of the provisional FCM statistics. The sample sheets are drawn based on two parameters,

i. Random selection across the two strata i.e States (management regime) and analyst (Skill).
ii. Sheets with high net change over threshold.

During the previous assessment, all analysts were divided into fifteen teams for cross checking of these selected sheets. The observations of these teams were conveyed to the analysts and in cases where discrepancy in classification was observed in a particular scene, the adjoining scenes by the same analysts were compulsorily checked. All errors that are noticed during this exercise are to be reconciled before finalisation.