Application of GIS & RS in Survey and Mapping of Joint Forest Management (JFM) Areas in Orissa Forestry Sector Development Project- A Scientific Approach

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Abstract:
The overall objective of the project is to restore degraded forests and improve the income level of villagers by promoting sustainable forest management including Joint Forest Management (JFM) plantation and community/tribal development, with larger goals of improving environment and alleviating poverty. Current vegetation and land use map has been prepared with GIS technology using satellite imagery (LISS-III), at a scale of 1:50, 000 showing degraded forest area in the divisions. DGPS device has been used for boundary survey of JFM sites. Base maps of the JFM areas are prepared in 1: 5000 scale with adequate control network established through DGPS survey. High resolution satellite imagery (2.5 m resolution cartosat b/w data and 6.5m resolution LISS IV multi-spectral data) are being used for extraction of ground features including vegetation status. The satellite imageries were provisionally rectified (geo-referenced) based on control points identified on Survey of India topographic maps. Satellite Imageries were interpreted within the AOI for visible features such as roads, tracks, railway lines, vegetations, river, streams, water bodies, settlements, etc. Pre-field maps were certified by the DMUs to proceed further with the field survey work. Ground truth maps (rectified image prints) with certain interpreted features were provided to the survey team for conducting the field survey. Details of vegetation in the JFM sites were collected during the field survey. Information on forest class, forest type, crop composition, age class, regeneration status, root stock and soil type and condition were recorded during the vegetation survey. Based on the above standard, thematic mapping was carried out in Arc GIS and layers were organized with their corresponding attributes. Final maps (base map, forest map, land use map) of each treatment were prepared and verified. The maps are being used in forest based micro planning for future monitoring and evaluation of the project component.

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1. Introduction:

There has been a paradigm shift in natural resource management in the late 1980s all over the world and India in particular, by refocusing of management decisions to more decentralized level of governance and public involvement in these management decisions. Such moves towards a participatory and community-based approach have to be viewed as against the traditional top-down models of policymaking that historically have been prevalent since the introduction of scientific forest management in the country.

The first report on forest cover o the country was published in 1987 by the Forest Survey of India, using LANDSAT data of US satellite through visual interpretation technique on 1:1 Million scales. The resolution of the sensor was 76M. From the second assessment the resolution improved to 30meters and scale of forest mapping adopted was 1: 250,000. The Indian Remote Sensing satellite (IRS) data having resolution of 36.25 meter have been used since the fifth assessment. In the seventh assessment (1999) refinement have been brought in the methodology and the digital method of interpretation have been used in 13 states of India. Presently the scale of the resolution in IRS has come to ~ 5.8meter and for IKONOS data it has a resolution of 1meter. As such much more accurate GIS based forest mapping and assessment is now possible.

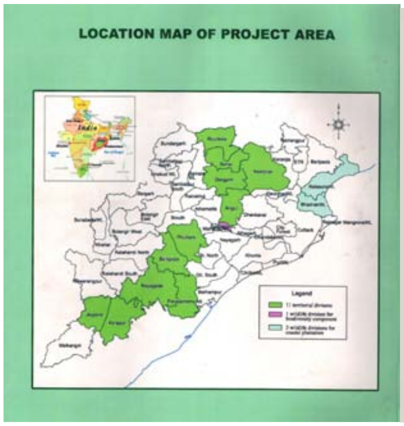
Joint Forest Management could be described as management of the state forestlands jointly by the state and community with joint sharing of benefits. JFM is a collaborative arrangement between the Forest Department and the people living on the forest fringe, whereby the people protect and manage degraded forests and help in their regeneration and the state, in return, gives rights to people for collection of Non-timber-forest-products (NTFP), fuel wood and a share of the final produce. Forest degradation has not only created socio-economic problems but is also contributing to environmental problems. Consequently it is the duty of all the stakeholders to work for sustainable development/management of forests for achieving long term goal of healthy forests and healthy communities.

Using a compass for forest mapping is a common method so far we have, which is a very traditional one having low work efficiency and making mapping task much more tedious and much more time consuming. To eliminate such demerits and bring efficiency and ease while carrying out a forest survey, a new, and more advanced and more sophisticated technique called Geographic Information System (GIS), Remote Sensing (RS) and Differential Global Positioning System (DGPS) has been used in this project for better monitoring and management of the project.

2. Study Area and JFM site Selection:

The Government of Orissa has launched the Orissa Forestry Sector Development Project (OFSDP) with the assistance from Japan International Cooperation Agency (JICA), envisages Restoration of 1.96 lakh ha of degraded forest through 2275 VSS in 14 Forest Divisions of Orissa. The Project covers 14 Forest and Wildlife Divisions of the state, namely Angul, Balliguda, Bonai, Deogarh, Jeypore, Keonjhar, Koraput, Paralakhemundi, Phulbani, Rayagada, Rourkela, Satkosia WL, Balasore WL, and Bhadrak WL. Survey and Mapping activity covers in 11 divisions (Angul, Balliguda, Bonai, Deogarh, Jeypore, Keonjhar,Koraput, Paralakhemundi, Phulbani, Rayagada, & Rourkela) out of 14 divisions(see fig-1) of the project division.

GIS tool being used satellite imagery(LISS-III) a base map at a scale of 1: 50, 000 (topographic maps produced by the Survey of India). The map developed by ORSAC used a basis for the selection of JFM sites where project activities will be extended. As per the project mandate, the total number of target villages is 2,275 and 196,650 ha in 11 divisions and VSS shall be formed in three phases by implementing one third of the total target each year. Out 2275 sites, 54 are biodiversity sites, and 2221 are JFM villages. Total number of villages selected in three batches is 2026.



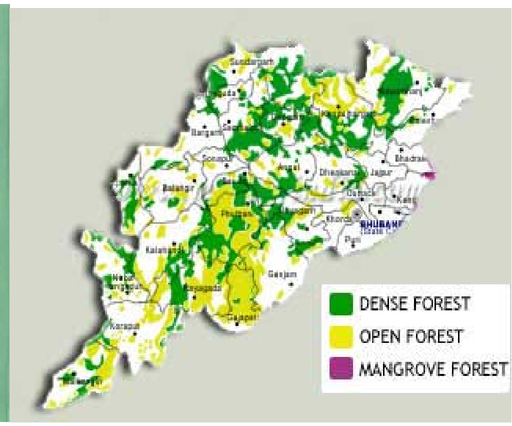
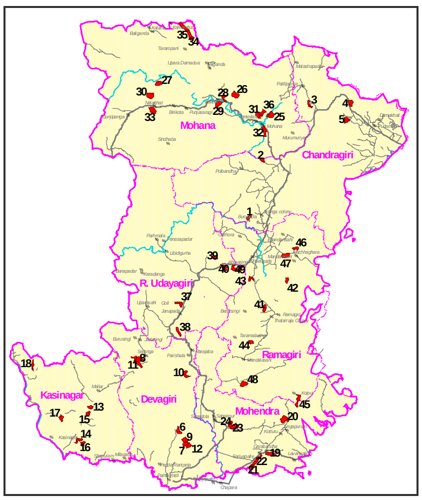


Fig- 1 Location Map of Project division.   Fig-2 Forest Coverage



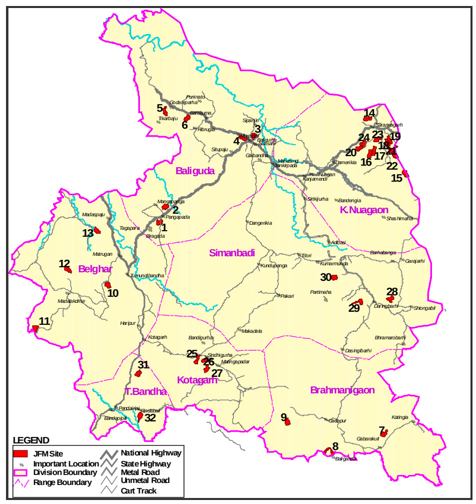


Fig- 3 Paralakhimundi site selection area, Phulbani Site Selection area

3. Objectives:

The broad objective of the project is to ground survey and mapping activities including preparation of 1: 5000 scale GIS compatible digital maps of selected degraded forest areas as inputs for micro planning for intervention in JFM mode. The overall objective of the project is to restore degraded forests and improve the income level of villagers by promoting sustainable forest management including Joint Forest Management (JFM) plantation and community/tribal development, with larger goals of improving environment and alleviating poverty. The Specific Objectives are as follows.

1. Selection of degraded village by using LISS III satellite image and weight age method
2. DGPS survey of JFM area demarcated by the villagers in consultation with the DMU and FMU staff.

3. Indent Satellite imagery and pre field mapping of the study area, including control Work, Image Processing and Rectification of Satellite Imagery
4. Ground Truthing and Collection of Field data for GIS mapping of each site
5. Preparation of base, land use, and forest map of the all the project sites
6. Post GIS verification and Training to the project staffs for using the Map(1: 5000) in forest micro planning process.

4. Data Collection Process:

Selection and procurement of Satellite imageries, i.e 2.5m resolution Cartosat data along with 5.8m resolution LISS IV multi-spectral data was used for survey and mapping of JFM areas. Satellite imageries were indented so as to cover the entire project area. The indent was placed with National Remote Sensing Agency, Hyderabad (NRSA) National Data Centre with authorization of OFSDP for procurement of cloud free Satellite imageries covering the project divisions.

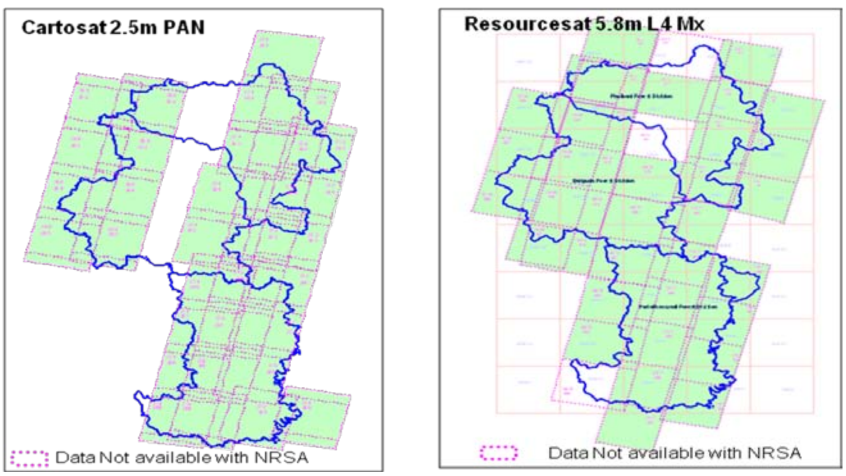


Fig-4 Division wise Cartosat and Resourcesat area covering area

Control Survey was done to correctly geo-reference the satellite imageries as per ground co-ordinates. DGPS readings were observed on clearly visible point feature on imageries (inner bend of a Road Intersection, Bridge railing, permanent Building, etc.) by 30-45 minutes Satellite tracking. Care was taken to select 4 to 6 controls on periphery of JFM sites/JFM site cluster and at least 4 controls per image. The readings were post processed with corresponding base station readings for arriving at co-ordinate readings. All the satellite imageries were finally rectified based on the control point co-ordinate reading collected in DGPS mode.

PERFORMANCE SPECIFICATIONS

Measurements

- Advanced Trimble Maxwell technology
- High-precision multiple correlator L1 and L2 pseudorange measurements
- Unfiltered, unsmoothed pseudorange measurement data for low noise, low multipath error, low time domain correlation, and high dynamic response
- Very low noise L1 and L2 carrier phase measurements with <1 mm precision in a 1 Hz bandwidth
- L1 and L2 Signal-to-Noise ratios reported in dB-Hz
- Proven Trimble low-elevation tracking technology
- 24 Channels L1 C/A Code, L1/L2 Full Cycle Carrier, WAAS/EGNOS

Code differential GPS positioning[1]

Horizontal. . . . . ±(0.25 m + 1 ppm) RMS
Vertical . . . . ±(0.5 m + 1 ppm) RMS
WAAS differential positioning accuracy typically <5 m 3DRMS[2]

Static and FastStatic GPS surveying[1]

Horizontal. . . . . ±5 mm + 0.5 ppm RMS
Vertical . . . . ±5 mm + 1 ppm (× baseline length) RMS

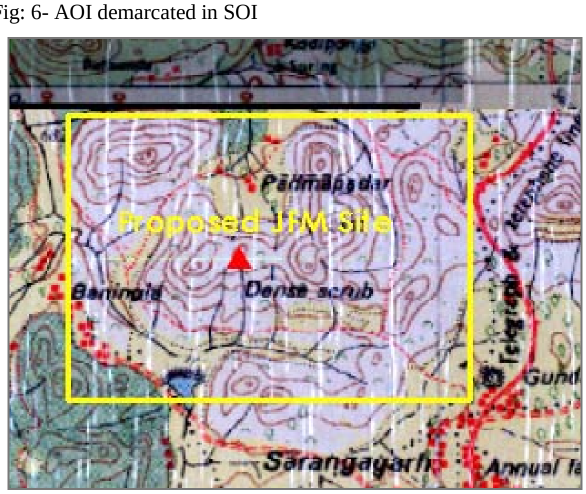
Kinematic surveying[1]

Real-time and postprocessed kinematic surveys
Horizontal. . . . . ±(10 mm + 1 ppm) (× baseline length) RMS
Vertical . . . . ±(20 mm + 1 ppm) RMS
Initialization time. . . . . Single/Multi-base minimum
10 sec + 0.5 times baseline length in km, up to 30 km
Scalable GPS infrastructure initialization time . . . . <30 seconds
typical anywhere within coverage area
Initialization reliability[3]. . . . . Typically >99.9%

Fig – 5 Trimble DGPS model and its specification.

A joint visit to each JFM site was made for demarcation of Area of interest. Sites were marked on topo sheets for identifying the site correctly on satellite imageries. The tentative boundary information collected during the joint reconnaissance survey was superimposed on the provisionally rectified satellite imageries with appropriate buffer on all sides so as to define a site specific Area of Interest (AOI). Satellite imageries were interpreted within the AOI for visible feature such as roads, tracks, railway lines, vegetations, river, streams, water bodies, settlements, etc. A Sample pre field map is depicted below. Pre-field maps were certified by the DMUs to proceed further with the field survey work.

Fig: 6- AOI demarcated in SOI



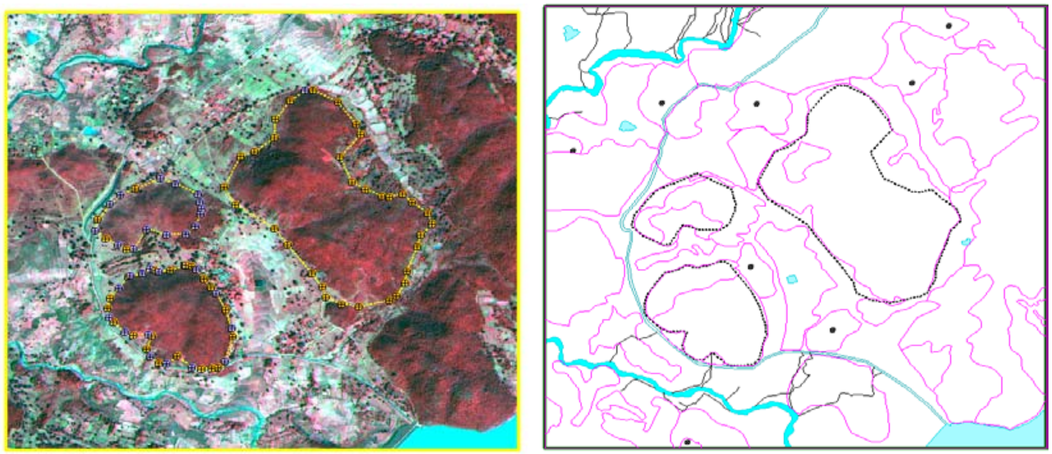


Fig- 7 AOI marking & feature extraction from imagery

Based on the terrain conditions (sub-mountainous regions with moderate to dense canopy) reference station based DGPS survey was adopted for survey of the JFM treatment areas.

Boundary survey was undertaken using DGPS devices for each treatment area. First pillar reading was observed for 10 minutes and all other JFM/RF pillars were observed for 5-10 mins. The readings were post processed for effecting the differential corrections and were used for mapping.

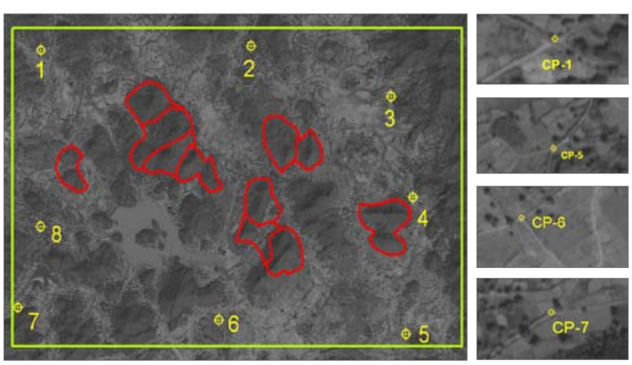


Fig- 8 Planning of Control points in imagery

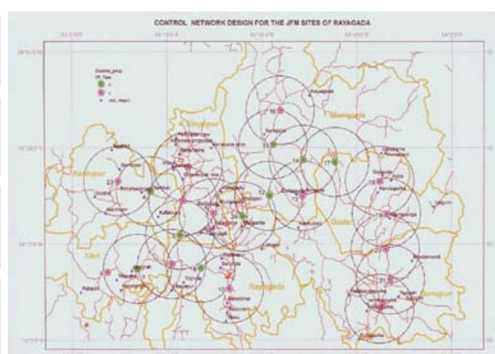


Fig-9 Control design of network sites

Ground truth maps (rectified image prints) with certain interpreted features were provided to the survey team for conducting the field survey (refer figure below). Field information on land use, transport, drainage, etc. were marked on the ground truth map and corresponding data was recorded in tabular format.

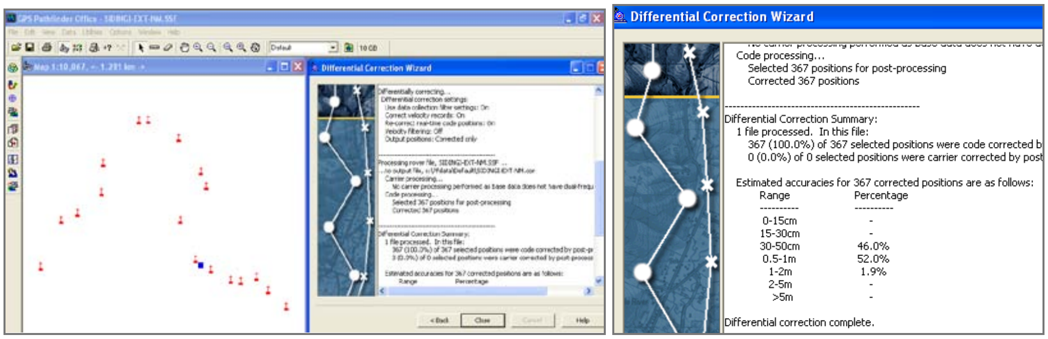


Fig- 10- Post Processing differential correction and its results

Details of vegetation in the JFM sites were collected during the field survey. The JFM areas were divided into several blocks based on relative canopy density. Information on forest class, forest type, crop composition, age class, generation status, rootstock and soil type and condition were recorded during the vegetation survey. Periodic reviews and internal consultations were made amongst survey teams of various divisions to adopt the best practices.

5. **Methodology :**

The following broad schematic has been adopted during the project period.

Fig –11 Study design

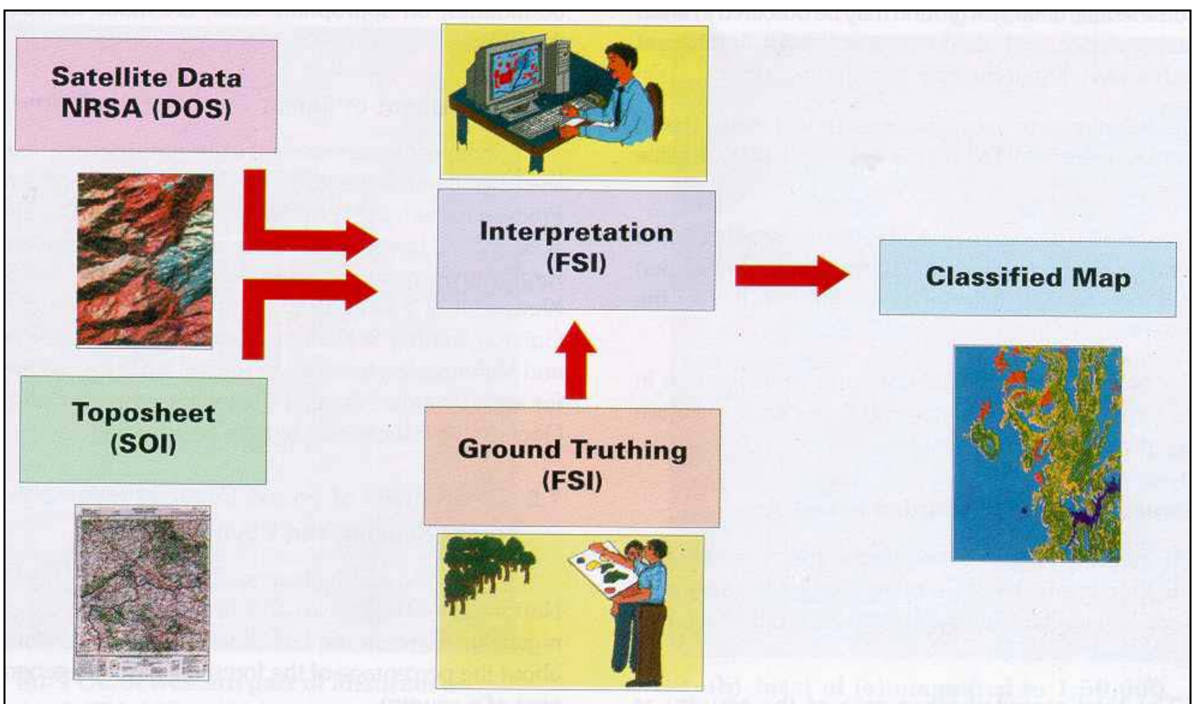


Fig. 1.1 Schematic presentation of the methodology of forest cover mapping

The specific methodology has been adopted during the project implementation period.

Fig- 12 Work Design:

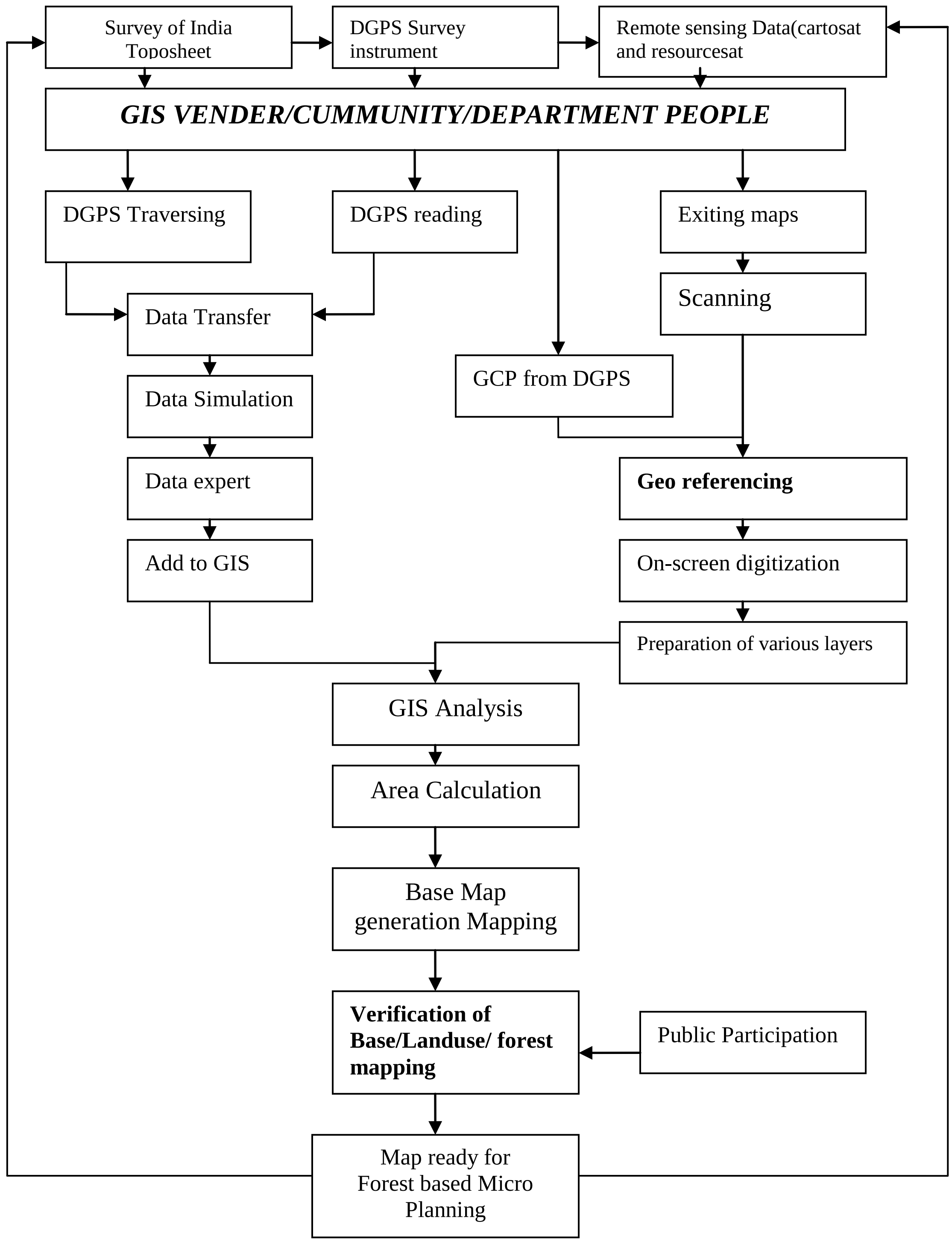
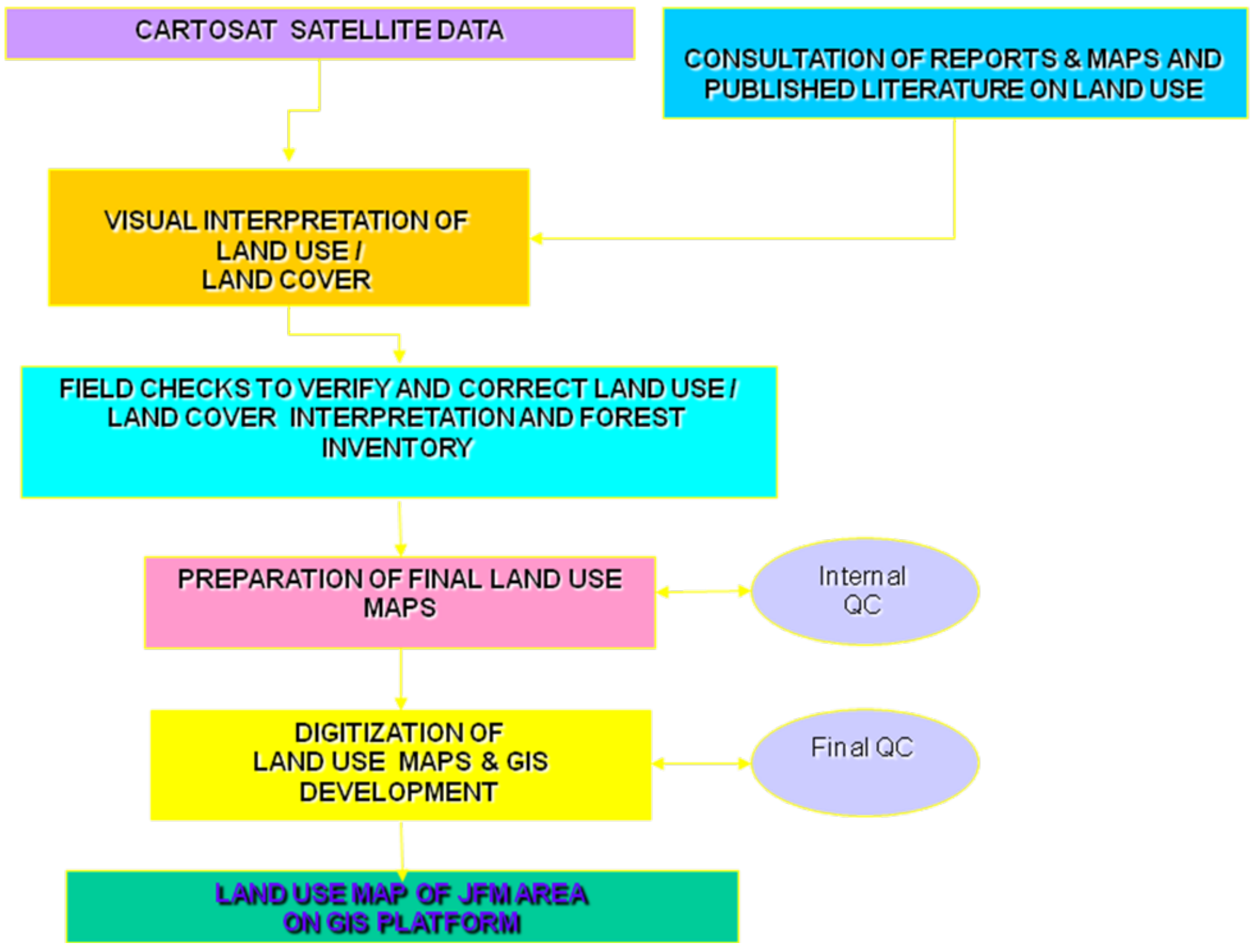


Fig- 13- LAND USE / LAND COVER MAPPING



6. Data Analysis process and interpretation:

It is to be noted that Survey of India maps on scale 1:50,000 do not cater for topographical features of 1:5,000 scale accuracy and shall be used for reference and initial planning, and not for preparation of GIS data. For elevation contours on topographical maps are very informative, thus, must be referred. Cartosat b/w data 2.5m resolution and Resourcesat LISS IV Mx data 6m resolution from NRSA, Hyderabad has procured for analysis and interpretation of base, landuse and vegetation mapping. Sufficient ground control points has taken to Geo-reference the Satellite imagery to achieve the accuracy required for mapping at 1:5,000 scales. Ground control points are being identified on the Imagery and relevant field records were prepared and well documented. UTM system of coordinates / WGS84 Geodetic Datum and ellipsoid / Zone

44 (for Southern and Central cluster) or 45 (for Northern cluster) has been used for the project. RMS values of control point observations have been recorded to assess the quality of control work. Raw data (downloaded from DGPS), and also the adjusted coordinates with RMS values were collected. List of control points were submitted in the excel format along with sketch of all control points with the description and digital photographs. The reference station (at least two stations) has been observed for upto about 8 hours depending on the distance between them. The GCPs from the 1st phase and 2nd phase and 3rd phase of OFSDP project has been connected with the network for consistency. JFM boundary pillars were surveyed with DGPS in differential mode using a base or beacon station. Treatment area boundary pillars (Forest boundary and JFM boundary pillars) were coordinated with the GCPs. Geo referenced Satellite Imagery and pre field maps were used to collect the field data i.e topographical features, forest boundary, forest pillars, fire lines, forest type crop composition, vegetation type, regeneration status, degradation land, soil type, slop, etc. The classification of all above mentioned features are accurate with respect to ground reality. Above data has been collected and verified on ground before processing GIS data base. The information relating to vegetation (major species, tree age class, stock density, regeneration status, root stock), soil, slope & elevation has been recorded in a form of Grid based map and supporting report for each site with appropriate sketches (keeping the surveyed boundary intact), coordinates from hand-held GPS, and photographs for micro planning and for validation of satellite image interpretation results. Each grid in Grid based map represents 4 hectare area, i.e. 200 x 200 meters on ground. This way an area of roughly 80 hectares can be represented in approximately 20 grids (Considering Grids representing more than 50% JFM/Project area). The special attention has been given and properly record existing and identifiable forest plantation, non-forest species plantation in side the demarcated area. All the above mentioned data's are collected and verified on ground before processing GIS data base. Based on the above standard, thematic mapping was carried out in Arc GIS and layers were organized with their corresponding attributes. Final maps (base map, forest map, land use map) of each treatment were prepared and verified. The maps are being used in forest based micro planning for future monitoring and evaluation of the project component.

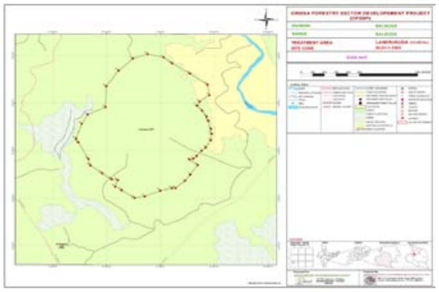


Fig- 14- Base Map

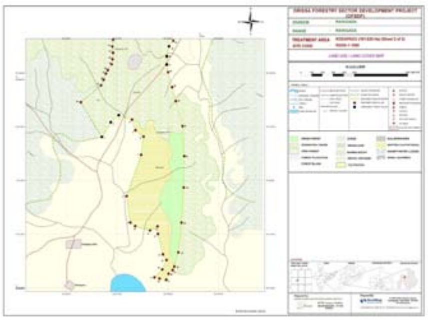


Fig- 15-Landuse Map

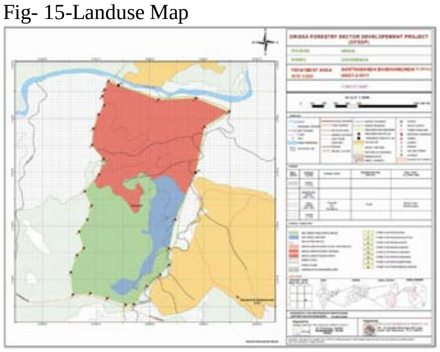


Fig-16-Vegetation Map

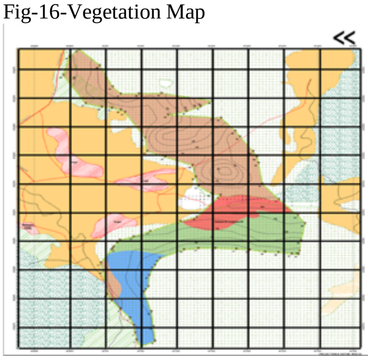


Fig- 17-Grid based Forest Map

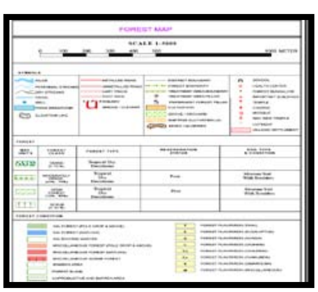


Fig- 18- Index Map

7. Conclusion

While new policies and programs represent a historic opportunity to shift from management practices of the 19th century to newly adapted systems that may better respond to the social and environmental needs of the 21st century, many challenges remain. India's social cultural and ecological diversity requires that emerging local forest management be tailored to respond to prevailing problems and opportunities. This requires an understanding of vegetative conditions, local leadership and institutions and the importance of forest to the local and regional economy. Viable management partnerships need to be based on a solid understanding of forest use dependencies, balancing economic and ecological objectives to benefit participating village communities, the state and the nation.

Participatory forest management (also referred to as JFM), offers new hope for communities most directly dependent upon forest for their multiple purpose needs. Exciting beginnings have been made in a number of states in India through JICA. Local forest protection committees are proliferating; some spontaneously others with the encouragement and assistance of forest department field staff and NGOs. GIS based tools and techniques have been used of contemporary/scientific methods of forestry data acquisition and management. GIS and RS tool is a Quick and accurate method of survey and mapping for better resource planning (Micro plans/management plan preparation, monitoring (Temporal features of satellite imageries facilities future monitoring), development of in-house expertise through trained staff, Safe storage, ease of updating and quick retrieval of data. GIS helps in organizing dataset and visual representations facilitate for Government officials, Planners, Managers, students for better decision making

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