Preparation of landuse/landcover map using RS and GIS technique

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3.1 Introduction

Land is the most important natural resource which embodies soil, water and associated flora and fauna involving total ecosystem. The knowledge of land use and land cover is important for many planning and management activities as it is considered as an essential element for modelling and understanding the earth feature system. The term land use relates to the human activity or economic function associated with a specific piece of land, while the term land cover relates to the type of feature present on the surface of the earth (Lillesand and Kiefer, 2000). Land use or land cover inventories are assessed in increasing importance in various sectors like agricultural planning, settlement and cadastral surveys, environmental studies and operational planning based on agro-climatic zones. Information on land use or land cover allows a better understanding of the land utilization aspects like cropping patterns, fallow lands, forests, pasture lands, wastelands and surface water-bodies which are vital for development planning. Land cover maps are presently being developed from local to national to global scales.

Land use is constrained by environmental factors such as soil characteristics, climate, topography and vegetation. It also reflects the importance of land as a key and finite resource for most human activities including agriculture, industry, forestry, energy production, settlement, recreation, and water catchment and storage. Land is a fundamental factor of production, and through much of the course of human history, it has been tightly coupled with economic growth. Often improper land use causes various forms of environmental degradation. For sustainable utilization of the land ecosystems, it is essential to know the natural characteristics, extent and location, its quality, productivity, suitability and limitations of various land uses. Land use is a product of interactions between a society's cultural background, state, and its physical needs on the one hand, and the natural potential of land on the other. In order to improve the economic condition of the area without further deteriorating the bio environment, every bit of the available land has to be used in the most rational way.

The importance of Land use and Land cover (LULC) dynamics in general and forest cover dynamics in particular is duly recognized by the International Geosphere Biosphere Programme (IGBP), the International Human Dimension Programme (IHDP) on Global Environmental Change (GEC), the United Nations Framework Convention on
Climate Change (UNFCC), the United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (UN-REDD Programme) and many other national and international organizations. In order to understand the dynamics of LULC, it is essential to identify the causes of land degradation across landscapes which are often the product of diverse natural processes and human interventions within a landscape mosaic (Lee et al., 1999; Apan et al., 2000; Nagendra et al., 2004).

Satellite remote sensing technology has found its acceptance worldwide for rapid resource assessment and monitoring, particularly in the developing world. Satellite images have been utilized for land use and land cover mapping. National Aeronautical and Space Administration (NASA) of USA has made most significant contributions with satellite based remote sensing techniques. Since 1972, after the Landsat-1 was launched, remote sensing technology and its application has undergone a tremendous change in terms of sensing development, aerial flights with improved sensors, satellite design development and operations including data reception, processing, interpretation, and utilization of satellite images. All these advancements have widened the applicability of remotely sensed data in various areas like forest cover, vegetation type mapping, and their changes on a regional scale. If satellite data is judiciously used along with the sufficient ground data, it is possible to carry out detailed forest inventories, monitoring of land use, and vegetation cover at various scales. To date, the most successful attempt in developing a general purpose classification scheme compatible with remote sensing data has been by Anderson et al. 1976, which is also referred to as USGS classification scheme. Other classification schemes available for use with remotely sensed data are basically modification of the above classification scheme.

3.2 Review of Literature

A general overview of vegetation of India obtained through the forest type map prepared initially by Champion, (1936) and subsequently revised by Champion and Seth, (1968) based on bioclimatic attributes. But mapping of vegetation and land use/land cover is not an easy task through conventional techniques. In recent times, advancement of remote sensing and GIS technology has helped many workers to generate spatial database on
vegetation and land use/land cover and to monitor existing vegetation and land use/land cover types.

In recent years, remote sensing techniques have been developed, which have proved to be of immense value for preparing accurate land use/land cover maps and monitoring changes at regular intervals of time. The following case studies have well explained the advantages of remote sensing techniques over conventional ground survey methods.

Temporal studies of land use/land cover in Varaha river basin, Andhra Pradesh, India by Murthy and Rao, (1997) was carried out using remote sensing data of 1986 and 1992. Visual interpretation techniques were followed to delineate land use/land cover categories. The image characteristics such as size, shape, shadow, tone, color, texture, pattern, etc. were considered for interpretation. Maps depicting various land use/land cover were generated using ground truth data. The results revealed significant changes in the area of built up land, irrigated land, plantation, degraded forest and upland over a period of 6 years.

Kimothi et al., (1997) studied the horticultural plantations in Kumarsian Tehsil in Shimla District, Himachal Pradesh using remote sensing. Mapping and identification of various land use features and horticultural plantations in the Himalayan region using RS satellite data becomes more complex because of shadow casting due to rough terrain, difficulty in getting cloud free data, large diversity in vegetation composition based on altitude and co-existence of apple plantations with forest. Moreover, well demarcated horticultural plantation maps are not available and there is encroachment of horticultural plantation in the forest area. Remote sensing, in such inaccessible terrain offers a unique opportunity to map and monitor horticultural plantations in cost and time effective manner. IRS LISS-II images of March 30, April 20 and October 27, 1992 were scanned to differentiate horticultural plantations from forest and other land use/land covers. This comparison has helped in understanding the dynamics of seasonal changes in the horticultural area and selection of optimum season satellite data for mapping of horticultural plantations. It was observed that IRS LISS-II data of April 20 was found more appropriate for identification and discrimination of horticultural plantations (apple and almond). Based on ground truth information and preliminary interpretation of IRS LISS-II data at 1:50,000 scale, a final interpretation key was prepared in order to
delineate the apple and almond plantations. Different growth stages coupled with
different canopy structure has helped to categorize the apple plantations into three
categories. Horticultural plantation map on 1:50,000 scales were finalized by
incorporating necessary correction/modification using ground truth and final
interpretation key. The classes as well as their boundaries were refined. Area under
different horticultural plantations was estimated by millimeter dot grid overlay.

Prasad et al., (1998) worked on the conservation planning for the Western Ghats of
Kerala using GIS techniques for location of biodiversity hot spots. Results of the study
reveal an increase of 194 km² of evergreen forests in Periyar division, and a decrease in
deciduous forests in 10 out of 20 forest divisions. Also there has been a massive increase
in the forest plantations from 1.62% to 47.57% in certain divisions.

Karia et al., (2001), studied the forest change detection in Kalarani Round, Vadodara
Gujarat by using Remote Sensing and GIS. They studied the spatial distribution of the
different forests during 1970 to 1999 using integrated remote sensing and GIS
techniques. The study revealed that area under forest in the Kalarani Round, is
progressively reducing with the time. The base map was prepared from Survey of India
toposheets on 1:50,000 scale. The forest map was converted to 1:50,000 scale using
Optical Reflecting Projector (ORP). The interpretation of land use/land cover classes was
done with the help of image elements like tone, texture, shape, shadow, size, pattern,
location and association. The ground data was collected and the forest classes were
ascertained and verified with the signature on the imagery. The density of the forest with
respect to crown cover was recorded. Based on the field observation and image
interpretation, the interim forest map was modified and finalized to obtain a classified
forest type and land use map. The classification schemes followed had some changes as
compared to that of Survey of India classification. The maps prepared for the years 1970
to 1999 through 1989 were used for change analysis. Increase or decrease in vegetation
and land covers from temporal series was obtained by overlaying the maps. The
composite map thus obtained depicted the status of forests in the corresponding years.

Krishna et al., (2001) have studied the application of Remote Sensing and Geographical
Information System for Canopy Cover Mapping. The satellite digital data from IRS 1C
LISS III of March 1999 was geometrically corrected. Supervised maximum classification
likelihood algorithm was adopted for land cover mapping. Nineteen classes, based on spectral reflectances, were deleneated. The areas of dominant cropping pattern were digitised using the base digital data, ground truth and landforms (plain, upland, tobacco growing and forest). The two maps were overlaid and reclassified as per the cover classes. The crop calendar of the area was linked with the land cover map to estimate the month wise crop canopy cover percentage.

Chingkei, (2002) evaluated and monitored the vegetation of Barak Basin by using digital image classification and GIS techniques. The IRS-1C LISS-III data of December 1998 was used for the vegetation mapping. Four forest classes viz, thick vegetation, moderate vegetation, sparse vegetation, degraded land and three non-forest classes viz, agriculture, jhum, water bodies were classified.

Roy and Joshi, (2002) have studied the various issues and policies related to the forest cover in North East India. They stated that the classification of Champion and Seth (1968) was based on ground observations. They further mentioned that the satellite based forest mapping supplemented by extensive field survey could overcome the gaps in mapping done using field survey only.

Kushwaha and Behera, (2002) studied the biodiversity characterization in Subansiri district, Arunachal Pradesh using remote sensing and GIS. IRS 1C LISS-III digital data were used. Four scenes were mosaiced after suitable radiometric and geometric corrections. Overlaying the district boundary created a sub-set of satellite data for the district. Survey of toposheets on 1:50,000 scales were used to extract road, drainage, settlements and contour information. ERDAS Imagine and ARC/Info software were used for image processing and spatial analysis. Ground-truthing was done first to correlate image tone and texture with different vegetation types. A vegetative cover map containing 18 classes was prepared and area under each was estimated.

Manju et al., (2005), studied the mapping and characterization of inland and wetlands using remote sensing and GIS. IRS-ID LISS III data of November 2000 (Post - monsoon season) and March 2001, (Pre - monsoon season) were used. The IRS-ID LISS III images are geometrically rectified to extract the data pertaining to the study area. The digital image processing was carried out using ERDAS Imagine software and the GIS analysis is carried out using Arc/Info software. The methodology proposed by RRSSC (2000)
was adopted. In order to map and classify the different inland wetland classes, FCC of water bodies was generated from the FCC of the study area. Further, the turbidity and aquatic vegetation status of the wetlands are characterized into three levels namely low, medium and high.

Talukdar et al., (2005), developed a spatial modelling for biological richness analysis in Nokrek Biosphere Reserve North-Eastern India using LISS-III digital data and customized Unix-Arc Info based package "BIOCAP" was used for Landscape Analysis and Biodiversity Characterisation (IIRS, 2002). Land use land cover map and the biological richness analysis have been carried out using methodology adopted by Roy and Tomar (2000). The field information has been used to derive other landscape parameters viz. ecosystem uniqueness (EU), species richness (SR) and total importance value (TIV). Based on the tonal variations and their location five vegetation classes namely Sub-Tropical Evergreen Forest (30.54km$^2$, 3.37%) confined to the core zone of biosphere reserve, Tropical Evergreen Forest (137.71km$^2$, 16.79%), Tropical Semi-evergreen Forest (109.25km$^2$, 13.52%), Moist Mixed Deciduous (191.69km$^2$, 23.38%), Bamboo patches (15.66km$^2$, 1.91%) growing in areas under abandoned jhum were identified.

Joshi et al., (2005) studied the land use/land cover identification in an alpine and arid region (Nubra Valley, Ladakh) using satellite remote sensing data of LISS III October 2001. In addition, the topographic maps were used to generate the ancillary layers. The DEM was generated using contours at 200 m interval, spot heights and drainage. ERDAS Imagine 8.4 was used for the digital image processing. Arc View 3.2a and ARC/INFO 8.1 was used for the visual interpretation and map generation. The field survey was undertaken to get acquainted with the general patterns of vegetation and habitat types of the area. A vegetation cover/land cover map of Nubra valley was obtained.

Singh et al., (2005) analyzed the vegetation cover type mapping in Mouling National Park in Arunachal Pradesh, Eastern Himalayas through an integrated Geospatial approach. Primary data consisted of digital data of IRS 1C LISS-III sensor of January 1999 with spatial resolution 23.5 was used. Ancillary data consisted of survey sheets and forest cover maps (FSI, 2002). For image analysis ERDAS Imagine software and for DEM generation Arc/INFO GIS software was used. Garin 12 Channel Global
Positioning System (GPS) was used to record ground truth locations. Geometric distortions were removed by georeferencing the image-to-map registration using Survey of India sheets on 1:50,000 scale. Maximum-forested area (252.80 km$^2$) in national park was covered by sub-tropical evergreen forest followed by temperate broad-leaved forest (147.09 km$^2$). The occurrence of temperate conifer forests and Rhododendron Scrub in this region was reported here for the first time.

Kumar et al., (2006) formulated the long term management plan of Keibul Lamjao National Park (KLN) Manipur, based on GIS and remote sensing techniques supported by ancillary data. The study envisages the zonation of the park into five zones considering the protection of habitat as well as tourist attraction and eco development strategies for the livelihood of the people. The management plan can further be strengthened to integrate various socio-economic consideration of the surrounding of the park.

Puneet et al., (2006) analysed the sites suitability for Khair (Acacia catechu) in part of Doon Valley using geoinformatics. A GIS based index model was used for identification of potential sites for growing khair. A false color composite of IRS 1D LISS-III data of October 2001 on 1:50,000 scale was used to identify the khair-bearing areas for the Study. Ancillary data used included the toposheet (53 J/04), Dehradun Forest Division (DFD) map, management plan of DFD, document on rates of khair wood (from Uttaranchal Forest Corporation) and field data. Standard guidelines with respect to inventory analysis and site suitability using remote sensing and GIS were followed (Kushwaha et al., 2003; Singh et al., 2003). Both supervised and unsupervised image interpretation techniques were also used. The sites suitable map for Khair production was prepared. An area of about 317.35 ha was found suitable for khair production.

Das et al., (2007), studied and mapped forest types, land use and land cover of Singrauli Coal field area (Madhya Pradesh) using satellite remote sensing techniques. IRS-1B, LISS-II, FCC geocoded paper prints with standard band combination (2, 3, 4) on a scale 1:50,000 were used. The images were analysed visually to characterise forest vegetation with respect to type, density, species composition along with land use practices. Seven forest classes and eight non-forest classes were observed.
Sudhakar et al., (2008), analyzed the landscape of Fambong WLS East district, Sikkim, India using remote sensing and GIS techniques. The study area from the satellite data was extracted and the scene was subjected to supervised MXL classification techniques using ground truth information. Based on the intensive field observations, vegetation type map including nine spectrally separable clusters of major communities were segregated. These communities are further analyzed through phytosociological analysis of 0.1 ha plots.

Pranjit et al., (2008), studied the land-use and land-cover change and future implication analysis in Manas National Park, using multi-temporal satellite data of 1977 (LANDSAT TM), 1998 (IRS 1D LISS III) and 2006 (IRS 1D LISS III). The 1: 50,000 Survey of India topographical sheets 78J/13, 78J/14, 78N/1 and 78N/2 were utilized in the preliminary processing of satellite data. A false colour composite (FCC) was generated using the different bands of the satellite data. The satellite imagery was rectified or geometrically corrected using ground control points (GCPs) obtained from topographical sheets and the GPS points collected from the field. Using polynomial equation the scene was geometrically corrected and georeferenced into latitude/longitude coordinate system using polyconic projection system. The pixels were re-sampled using the maximum likelihood algorithm and the study area was extracted from the scene using Park boundary maps in ERDAS Imagine 9.0 software. Using GCPs, training sets were generated for different land-cover and land-use types and the image classified based on a combination of visual and digital classification schemes. Finally the three satellite imageries falling in different dates were superimposed to detect changes in land use over a period of time. Results indicate landscape level changes in the vegetation and overall habitat quality within the park. There was a substantial increase in savannah grassland (74.6%) accompanied by decline in alluvial grasslands (46.8%) from 1977-2006. A total of 20.47 km² has also been encroached and water sources in the park have declined during this period.

Kumar et al., (2008), studied the mapping of Apple Orchards using remote sensing techniques in cold desert of Himachal Pradesh, India. The IRS 1D LISS III satellite image of October 23, 2002 acquired from National Remote Sensing Centre (NRSC), Hyderabad had been used. As the minimum size of the apple orchards encountered in the study area was more than 3 hectare, LISS III image of 23.5 m spatial resolution was
found to be suitable for mapping of apple orchard. In addition, toposheets on 1:50,000 scales procured from Survey of India (SOI), Dehradun, were used for georeferencing the satellite images. The classification of apple orchards was done using digital image processing in Erdas Imagine 8.6 software. The orchards were found in 154.6 ha of the study area.

Rajitha et al., (2010), studied the land-cover change dynamics and coastal aquaculture development in the East Godavari delta, Andhra Pradesh. Multi-spectral satellite images acquired by the Indian Remote Sensing (IRS) satellite (sensors LISS II and LISS III) in 1990, 1994, 1997, 1999 and 2005 were used for the land-cover change detection. Land-cover changes were quantified based on normalized difference vegetation index (NDVI) image differencing and a post-classification comparison approach. The change detection results were examined in terms of the proportion of land-cover classes and change trajectories with particular emphasis on coastal aquaculture development within the study area.
3.3 Materials and Methods

3.3.1 Data used

Satellite data

The following satellite data has been used in the study:

Table 3. Details of satellite data used.

<table>
<thead>
<tr>
<th>Satellite</th>
<th>Sensor</th>
<th>Date of Generation</th>
<th>Path-Row</th>
<th>Wavelength width in μm/ band</th>
<th>Scale</th>
<th>Spatial Resolution</th>
<th>Swath</th>
<th>Area covered</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRS-P6</td>
<td>LISS IV</td>
<td>22 Jan. 2009</td>
<td>101-064</td>
<td>0.52-0.59 (Green) 0.62-0.68 (Red) 0.77-0.86 (NIR)</td>
<td>1:50,000</td>
<td>5.8m</td>
<td>23.5 km</td>
<td>Western part of Manipur (Jiribam Sub-Division)</td>
</tr>
<tr>
<td>IRS-P6</td>
<td>LISS IV</td>
<td>22 Jan. 2009</td>
<td>101-013</td>
<td></td>
<td>1:50,000</td>
<td>5.8m</td>
<td>23.5 km</td>
<td></td>
</tr>
</tbody>
</table>

**IRS-P6**

IRS-P6 also known as Resourcesat-1 was launched by the indigenously built polar satellite launch vehicle on October 17, 2003. The orbit parameters of IRS-P6 are same as IRS-1C. The payload system of IRS-P6 consists of three solid state cameras: a high resolution multispectral sensor –LISS-IV, a medium resolution multispectral sensor –LISS-III, an Advanced Wide Field Sensor (AWiFS).

Topographic sheets

Survey of India (SOI) topographic sheets of 1973 were used for the study. The sheet number are 83H/1 and 83H/2 at 1:50,000 scale.

3.3.2 Software and Instrument used

The following softwares and instruments were used for satellite data processing and GIS analysis.

- ERDAS Imagine 9.1 for image analysis and mapping.
- ArcGIS 9 for database creation, analysis and map composition.
- Hand held GPS (Garmin) for ground verification.
- Digital camera
3.3.3 Preliminary study

Jiribam sub-division area was studied from Google Earth and Bhuvan. Some ancillary data such as Topographic sheets, Manipur Forest map (FSI 2011), District map, Sub-divisional map etc. were collected and studied.

3.3.4 Pre-processing

Paradigm for the preparation of final map was shown in figure 7. The satellite data acquired from National Remote Sensing Centre (NRSC) was initially downloaded from CD-ROM. It was corrected for radiometric and geometric errors. Indian Remote Sensing Satellite (IRS-P6), LISS-IV (5.8 m resolution) data of January 2009, geo-registered to UTM Zone 46 N projection and WGS 84 datum were used. UTM projection was chosen due to its easy application and widespread usage throughout the world. More importantly, UTM projections are best suited for small areas that lie within a single zone. The Survey Of India (SOI) Toposheet (Topobase) 83H/1 & 83H/2 of a scale of 1:50.000 was digitally scanned and georeferenced using Ground Control Points (GCPs). The satellite data was then geometrically rectified following image-to-map registration with the aid of the georeferenced toposheets. This was done by superimposing geometrically corrected satellite data over the Topobase in the digital domain. This process ensured the creation of correctly georeferenced database. The co-registration of spatial features and GCPs with that of Topobase has been verified using the Swipe tool available with the ERDAS Imagine Viewer.

Mosaic Preparation

The geometrically corrected scenes are joined to form a mosaic using the Mosaic tool available under the Data Preparation Module of ERDAS Imagine.

Delineation and creation of FCC (False Color Composite) of the study site

The study area has been delineated from the mosaic scene using the updated Jiribam Sub-Division boundary as the mask. FCC of the study area was also generated using band 2, 3 & 4. Further classification was carried out on this extracted scene to reduce space and time consumption.
Fig. 5. Study Area view from Satellite image (FCC LISS IV).
Fig. 6. Study Area view from SOI Toposheets.
3.3.5 Classification

Visual image interpretation technique of classification was applied in the study. It is a process of identifying what we see on the images and communicates the information obtained from these images to others for evaluating their significance. The visual interpretation methodology developed by the National Remote Sensing Agency (1989) was used in the present study. This comprise of the following six major steps:-

- Selection and acquisition of data
- Prefield interpretation
- Ground data collection and verification
- Postfield interpretation and modification
- Computation of area
- Final cartographic map preparation and reproduction.

Reconnaissance of the area under study is a prerequisite for any kind of attempt in mapping natural resources of the earth. The preliminary survey of the area assists in acquainting the worker with the various kinds of classes of LULC types present in the field and subsequently help in adopting a suitable classification scheme and interpretation key for the final map generation. Hence a general reconnaissance of the study area was carried out and different classes of LULC that could be demarcated on the
LISS IV satellite imagery were identified on the ground. A classification scheme was developed for the study area following Anderson et al. (1967). A final interpretation key for the various classes was prepared using spectral characteristics of classes and field knowledge. The interpretation key for LULC classification is given in Table 4.

**Image Interpretation techniques for construction of final interpretation key**

The richness of the red in false colour composite image indicates the density of the vegetation. Dense forests appeared with dark red tone with rough texture and open forests represented lighter red tone with smooth texture. Patches of light red mottled tones represented scrub vegetation. The Pinkish red or light green patches within the forest indicated degraded forest land. Agricultural land belonged to two categories namely fields with crop (cropped land) and harvested agricultural fields (cleared or fallow land). Each had a separate spectral signature. The cropped land was easily delineated based on light or bright pinkish tone, while the cleared or fallow land showed light cyan tones. The agricultural fields could also be identified on the satellite imageries due to its association with habitation and proximity to water courses. The agricultural fields also showed smooth texture. Human settlements were sparsely distributed and only a few polygons of crowded settlements were identified on the map based on cyan tone and rough texture. Plantations were blackish red to dark red in color with rectangular or regular shape. Water bodies were appeared in dark blue or light blue tone with smooth texture.

Table 4. Image interpretation key for LULC classification on FCC of IRS-P6 LISS IV data.

<table>
<thead>
<tr>
<th>LULC Class</th>
<th>Tone</th>
<th>Texture</th>
<th>Shape</th>
<th>Spectral Signature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dense Forest</td>
<td>Dark red to light red</td>
<td>Rough</td>
<td>Irregular</td>
<td>![Image]</td>
<td>Tree cover (forest canopy density &gt;40%)</td>
</tr>
<tr>
<td>Open Forest</td>
<td>Light Red</td>
<td>Smooth</td>
<td>Irregular</td>
<td>![Image]</td>
<td>Tree cover (forest canopy density 10-40%)</td>
</tr>
</tbody>
</table>
Mapping and Quantitative Assessment of Vegetation of Jiribam Sub-Division, Imphal East District, Manipur, India using Remote Sensing and GIS

<table>
<thead>
<tr>
<th>Class</th>
<th>Color Description</th>
<th>Texture</th>
<th>Shape</th>
<th>Attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scrub</td>
<td>Light red or pinkish red</td>
<td>Coarse</td>
<td>Varying</td>
<td>Bushy vegetation with shrubs or scattered trees (forest canopy density &lt;10%)</td>
</tr>
<tr>
<td>Degraded Forest</td>
<td>Pinkish red to light green</td>
<td>Medium</td>
<td>Smooth</td>
<td>Scattered trees/shrubs with exposed ground surface; canopy density &lt;10%</td>
</tr>
<tr>
<td>Agriculture</td>
<td>Pinkish or light green or light blue or light cyan</td>
<td>Medium</td>
<td>Smooth</td>
<td>Crops/ current fallow Lands, surrounded by small to medium size settlements.</td>
</tr>
<tr>
<td>Settlement</td>
<td>Cyan</td>
<td>Rough</td>
<td>Irregular/regular</td>
<td>Urban as well rural (Maximum rural)</td>
</tr>
<tr>
<td>Wasteland</td>
<td>Pinkish red or light cyan or whitish</td>
<td>Smooth</td>
<td>Irregular/regular</td>
<td>Exposed soil, grassfield, playground etc.</td>
</tr>
<tr>
<td>Water Bodies</td>
<td>Dark blue or light blue</td>
<td>Smooth</td>
<td>Irregular/Linear</td>
<td>River, stream and pond</td>
</tr>
<tr>
<td>Rubber Plantation</td>
<td>Blackish red to dark red</td>
<td>Medium Smooth/ Medium Coarse</td>
<td>Irregular/Regular/ Rectangular</td>
<td>Rubber plants (Mature as well as Young)</td>
</tr>
</tbody>
</table>

On screen digitization was done in ArcMap 9.2 software. A polygon map was generated where each polygon represented a distinct class. The classes were then assigned their respective attributes. Ground truth verification was done by using a handheld GPS during field visit. GPS readings which included river bank, road crossing, rubber, teak and litchi growing sites, tea garden etc and other important and identifiable landuse/landcover
types were recorded and brought into GIS platform. It was found that points were very accurate in the satellite image. Finally, the area statistics of different categories of LULC and colour coded classified map of Jiribam Sub-Division was generated.

3.4 Results

The visual interpretation of the satellite data with the ground truth was used to map different categories of land use/land cover (LULC). Fig. 8 shows the LULC map of Jiribam Sub-Division. Area statistics of different categories of land use/land cover is also given in table 5. Eleven categories of LULC were classified which include three forest classes (open forest, dense forest and degraded forest), four plantation types (teak, rubber, cashew and tea) and four other land use (agriculture, settlement, water bodies and wasteland). Brief descriptions of different categories of land use/land cover are as follows:

Forest

Forests constitute the major proportion (62%) of Jiribam Sub-Division. The forest type of this region belongs to 2B/C2 Cachar Tropical Semi-evergreen Forest (Champion and Seth, 1968). In the present study, the forest was divided into 3 classes namely degraded, dense and open forest.

The dense forests are characterised by their multi-storeyed nature and exhibits diverse species composition. Many important tree species were found. Some of them were *Terminalia citrina*, *Messua ferrea*, *Neolamarckia cadamba*, *Artocarpus chamaea*, *Tetrameles nudiflora*, *Michelia sp.*, *Kayea sp.*, *Duabanga sonneratioides* etc. Numerous climbers and lianas too were noticed. Species of *Bauhinia*, *Acacia*, *Derris* and *Entada* were very common. Patches of several species of Cane and gregarious growth of *Caryota urens*, *Licuala peltata* etc. were also very common. Among the shrubby species *Clerodendrum viscosum*, *Saurauia roxburghii*, *Croton caudatus*, *Melastoma malabathricum*, *Cyathea spinulosa* and various species of wild *Musa* were very common. The epiphytic flora was found to be very rich and diverse. Number of beautiful orchids mainly species of *Cymbidium* and *Dendrobium*, besides fern and fern-allies were very common. It was observed that the northern and southern portion of the study area had this type of forest.
Open forests were greatly disturbed. The native forest stands were frequently interspersed with Teak plantations. The most common tree species in this category were *Adina cordifolia*, *Albizia procera*, *A. lebbeck*, *Bischofia javanica*, *Toona ciliata*, *Dillenia indica*, *Bombax ceiba*, *Cassia* sp., *Bauhinia variegata*, *Gmelina arborea*, *Sapium baccatum*, *Emblica officinalis*, several species of *Ficus*, *Sterculia villosa*, *Kydia calycina*, *Oroxylum indicum* etc. Bamboos also occurred in these forests gregariously as secondary formations. Extensive thickets of invasive species such as *Lantana camara* and *Eupatorium odoratum* intermixed with *Gleichenia* and *Dicranopteris* sp. were very common. Thick clumps of *Saccharum spontaneum*, *Phragmites karka* and *Thysanolaena maxima* were also found. The herbaceous flora was found to be very rich.

Degraded forests occupied over 21% of the total geographic area. Canopy cover found in this forest was less than 10%. Common species found in these forests were *Bauhinia* spp., *Acacia* spp., *Erythrina* spp., *Melastoma malabathricum*, *Croton caudatus*, *Licuala peltata*, *Phragmites karka* etc. This is an indicator of high biotic pressure in the area. During field work it was observed that the main factors leading to this pressure were anthropogenic fire, lopping and grazing. This type of forest class was mostly observed in the vicinity of human habitation.

**Plantations**

Four types of plantations namely, rubber plantation, teak plantation, cashew plantation and tea plantation were found. Major type of plantation found were rubber (1.07%) followed by teak (0.98%). Pure patches of rubber (189 ha.) and teak plantation (172 ha.) were observed. In 1977-78 the Jiribam Forest Division had taken up rubber plantation in Jiribam. Rubber plantations were scattered around the villages of Uchathol, Harinagar, Champanagar, Ningthembam, Ningshingkhul, Khasia, Jarolpokpi, Aglapur, Sonapur, Sabughat and Boroikhal. Teak was the most commercially important timber tree especially for furniture making. Teak plantations have been raised for industrial purposes since long and scattered around the villages of Jirimukh, Makhabasti, Laingangpokpi and Chhotabekra. The floor of teak growing areas remains full of fallen leaves during winter. Tea estate in Jiribam which is the only one in Manipur occupies 42 ha. i.e. 0.23% of the total area. It is located at Mongbung. Shade trees such as *Albizia lebbeck*, *Albizia stipulata*, *Bombax ceiba*, *Cassia fistula* and *Indigofera zolingeriana* were found in the
Jiribam tea estate. This tea plantation farm was set up in Jiribam in the year 1982 under the Manipur Plantation Crops Corporation (MPCC) Ltd. A relatively small patch of horticultural plantations of litchi and cashew were also encountered at Bidyanagar near Kadamtala.

**Other land use**

Other land use categories included agriculture, settlement, water bodies and wasteland. Agriculture covers 12.28% of the total area and the main agricultural crop is paddy. Agriculture is the major source of livelihood economy. Human settlements occupy 17.43% of the total area and are sparsely distributed. There are 66 Revenue Villages and 13 Hill Pocket Villages. Villagers have planted many plants in their home garden to meet small timbers, fuel wood, fruits, vegetables and of course for their daily requirement and minor income.

Water bodies occupy 2.59% and the main water bodies are Barak and Jiri river which flows on the western border of the Jiribam Sub-Division. Few ponds were also found scattered in and around the villages. Barak and Jiri river are the main waterway for transport of timber and other forest produces like bamboo, canes, brooms etc. and assumes great significance on account of its forming a part of the interstate boundary. People too commute mainly in the river. There is regular Motor launch service from Fulartal in Assam to Sibapurikhal and beyond along the Barak river. Wasteland covers 2.77% of the total area and includes exposed soil, grassed field, playground etc. Table 5 shows the areal distribution of the major landuse/landcover categories of the study area.
Table 5. Areas under the different categories of land use/land cover of Jiribam Sub-Division.

<table>
<thead>
<tr>
<th>Land use/land cover</th>
<th>Area (ha)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dense Forest</td>
<td>3699</td>
<td>21.11</td>
</tr>
<tr>
<td>Open Forest</td>
<td>3544</td>
<td>20.22</td>
</tr>
<tr>
<td>Degraded Forest</td>
<td>3719</td>
<td>21.22</td>
</tr>
<tr>
<td>Subtotal</td>
<td>10962</td>
<td>62.55</td>
</tr>
<tr>
<td>Plantations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teak plantation</td>
<td>172</td>
<td>0.98</td>
</tr>
<tr>
<td>Rubber plantation</td>
<td>189</td>
<td>1.07</td>
</tr>
<tr>
<td>Cashew plantation</td>
<td>5</td>
<td>0.02</td>
</tr>
<tr>
<td>Tea Garden</td>
<td>42</td>
<td>0.23</td>
</tr>
<tr>
<td>Subtotal</td>
<td>408</td>
<td>2.30</td>
</tr>
<tr>
<td>Other land use</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agriculture</td>
<td>2153</td>
<td>12.28</td>
</tr>
<tr>
<td>Settlement</td>
<td>3034</td>
<td>17.43</td>
</tr>
<tr>
<td>Water Bodies</td>
<td>435</td>
<td>2.59</td>
</tr>
<tr>
<td>Wasteland</td>
<td>487</td>
<td>2.77</td>
</tr>
<tr>
<td>Subtotal</td>
<td>6149</td>
<td>35.07</td>
</tr>
<tr>
<td>Total</td>
<td>17519</td>
<td>100</td>
</tr>
</tbody>
</table>
Fig. 8. LULC map of Jiribam Sub-Division.
Plate 1. Field photos of some land use/land cover categories.
Accuracy assessment

The classified land use/land cover types were validated with the help of an extensive GPS aided field survey. The ground reference data were compared with the classified map and the accuracy was quantitatively assessed. The overall accuracy of the classified map was calculated using the following formula (Rashid et al., 2013):

\[ \rho = \left( \frac{n}{N} \right) \times 100 \]

where \( \rho \) is classification accuracy; \( n \) is number of points correctly classified on image and \( N \) is number of points checked in the field. The overall accuracy of the classified land use/land cover map was 96.47%. Moreover class-wise accuracy of different land use/land cover types is mentioned in table 6.

Table 6. Accuracy of the classified land use/land cover types.

<table>
<thead>
<tr>
<th>Land use/land cover Types</th>
<th>Ground control points taken</th>
<th>Points correctly classified</th>
<th>Accuracy (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open Forest</td>
<td>40</td>
<td>40</td>
<td>100.00</td>
</tr>
<tr>
<td>Dense Forest</td>
<td>24</td>
<td>24</td>
<td>100.00</td>
</tr>
<tr>
<td>Degraded Forest</td>
<td>21</td>
<td>19</td>
<td>90.47</td>
</tr>
<tr>
<td>Agriculture</td>
<td>12</td>
<td>12</td>
<td>100.00</td>
</tr>
<tr>
<td>Settlement</td>
<td>17</td>
<td>15</td>
<td>88.23</td>
</tr>
<tr>
<td>Water Bodies</td>
<td>6</td>
<td>5</td>
<td>83.33</td>
</tr>
<tr>
<td>Wasteland</td>
<td>5</td>
<td>4</td>
<td>80.00</td>
</tr>
<tr>
<td>Teak plantation</td>
<td>11</td>
<td>11</td>
<td>100.00</td>
</tr>
<tr>
<td>Rubber plantation</td>
<td>30</td>
<td>30</td>
<td>100.00</td>
</tr>
<tr>
<td>Cashew plantation</td>
<td>2</td>
<td>2</td>
<td>100.00</td>
</tr>
<tr>
<td>Tea Garden</td>
<td>2</td>
<td>2</td>
<td>100.00</td>
</tr>
<tr>
<td>Total</td>
<td>170</td>
<td>164</td>
<td>96.47</td>
</tr>
</tbody>
</table>
3.5 Discussion

In the present day world, land use and land cover mapping is of great significance in scientific scholarly research, management and planning. Regional land use pattern reflects the character of interaction between man and environment. Area developmental planning with integrated approach has been accepted world over for optimal management and better utilization of natural resources towards improving living conditions of the people and to meet the growing demands of an increasing population. Land use planning involves the inventory of the land resources and taking stock of the present scenario. This is the first task to be taken by the planners towards attaining the goal. Remotely sensed satellite images provide a synoptic overview of the whole area. This leads to quick and truthful representation of the real world in the best possible manner. Remote sensing and GIS are highly capable in studies of land use and land cover.

The present study was based on visual image interpretation (VII) technique supported by ground verification. Visual interpretation was shown to have more quality compared to digital classification for analyzing high resolution satellite data. Land use and land cover features have been precisely captured through on-screen visual interpretation. VII method of classification of remotely sensed data is an effective method of classifying land use and land cover especially when the analyst is familiar with the area being classified. It relies on the interpreter to employ visual cues such as tone, texture, shape, pattern and relationship to other objects to identify the different land cover classes. The primary advantage of visual interpretation is the utilization of the human brain to identify features in the image and relate them to features on the ground. In the present study the VII method was employed due to the following reasons. Firstly the area was familiar to me as I had explored the area thoroughly and had a good knowledge of the existing land use and land cover categories. Also there was a lot of heterogeneity in the landscape. Many classes were very small in size. The classes were not being effectively delineated as there was mixing of spectral signatures using the digital classification technique. Hence it was decided to use the VII technique for optimum separation of the LULC categories.
Data collected from the field was geo-referenced so that the points where the data were collected can be located on the imagery. GPS was commonly used to record this location information. The type of information collected can range from detailed notes describing a site to a photograph of the site. Based on the screen digitization of the FCC of LISS IV data, eleven categories of LULC were classified which include three forest classes (open forest, dense forest and degraded forest), four plantation types (teak, rubber, cashew and tea) and four other land use (agriculture, settlement, water bodies and wasteland) (Fig. 9). The overall accuracy of the classified land use/land cover map was 96.47 %. No LULC classification would be complete without an accuracy assessment. The map was fairly accurate (96.47%) and estimation was comparable with other accuracy assessment done elsewhere 91.3 % (Kumar et al. 2008), 85.82 % (Rashid et al. 2013), 80% (Jayakumar et al. 2002).

Out of the total area forest occupies 62% and the rest 38 % was under non-forest categories. During field work it was evident that natural forests are shrinking and degrading due to many reasons. People living in the vicinity of forest were clearing the forests for jhum cultivation, fuel wood and Non-Timber Forest Products (NTFPs).
collection and for hunting. Encroachment of forest land was also responsible of causing extensive damage of forest vegetation. This also led to extensive degradation of land and would hamper the essential ecosystem services beyond repair in the future if the current trend continued.

Agriculture land occupied 12% of the total area. Agriculture and horticulture are the main economic activities of the general populace. The agricultural customs of the villages can be broadly classified into two categories- jhum cultivation and settled cultivation. Jhum cultivation or shifting cultivation is widely practised in the hilly region of the sub-division while settled cultivation is restricted in the flat plains or gentle slopes and the flood plains of Jiri and Barak river. Agricultural field remains vacant during winter. It is recommended to plant suitable Rabi crops. Betel leaf cultivation which is locally termed as “pan-jhum” was found to be solely practiced in parts of open forest by villagers. Plantation covered 2.3% of the total area. The plantation areas are anticipated to expand owing to its economic importance.

Human settlements occupied 17.43% of the total area and were mostly rural type. Urban type of settlements was only found in and around Jiribam town. Rural settlements were mostly observed in and around open and degraded forest. Most of the people of Jiribam sub-division are rural poor. They settle in small hamlets or villages which most often are isolated, generally underdeveloped and lack most of basic amenities. They form an intricate relationship with nature and their surroundings.

Barak and Jiri river are the main water bodies and occupied 2.59% of the total area. They are the main waterway for transport of forest produces, agriculture and horticulture produces. People of river bank villages like Somapunji, Bhubandhar, Chhtobekra, Jatrapur, Borobekra, Jakuradhar etc. use Barak river as their lifeline waterway. Fishing activities were also carried out in these rivers by the villagers.

3.6 Conclusion

For many planning activities accurate and current information on land use and land cover is required. The scope of image-interpretation as a tool for analysis and data collection is widening with the advance of remote sensing techniques. Space images have already found their use in interpretation for the various aspects of earth and environmental
sciences. Because of the flexibility of its techniques and substantial gains in accuracy, speed and economy over conventional ground methods, the future of image-interpretation is assured. Many types of image interpretation keys are available or may be constructed depending on the abilities of the interpreter and the purpose to be served by the interpretation. Visual interpretation method allows the most detailed differentiation of structures and objects. The visual interpretation technique is advantageous in detecting spatial patterns and in drafting precise boundaries around relatively homogenous area. The perfection of LULC mapping from the satellite imageries depends upon the combination of in-depth knowledge about the geography of study area as well as the science of imageries. Ground truth verification is compulsory to confirm the resultant map prepared using satellite imageries.

The role of bioresources in meeting a region's requirement of fuel, food, fodder and timber has increased the interest for quantifying the amount of biomass available in a region. The issue of land use is of paramount importance to environmental issues on all spatial scales. Changes in land cover and land use have affected bioresource availability and biodiversity at species, genetic and ecosystem levels. Biodiversity and biological resources are vital to the very foundation of sustainable development of a region. Recent land use changes have led to species loss, and the loss of ecosystem has affected essential ecological functions. Biodiversity has direct (medicines, food, fuel, fiber, etc.), indirect (regulating air and water quality, soil fertility, economic values) as well as ethical, aesthetic and cultural values. Natural forests are shrinking at an alarming rate due to high anthropogenic pressure. The need of hour is to conserve the fragmented repositories of natural forests by implementing stringent conservation measures such as scientific management, participatory forest management and proper method of collection and harvesting of Non-Timber Forest Products (NTFPs).
3.7 References


Mapping and Quantitative Assessment of Vegetation of Jiribam Sub-Division, Imphal East District, Manipur, India using Remote Sensing and GIS


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