Technical Manual

National Land Use Land Cover Mapping using Multi-temporal Satellite Data

(2nd Cycle)

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15.	Abstract: Manual describes the process of carrying out the LULC 50K 2nd cycle mapping and change analysis. The classification of cycle-2 has been simplified from 79 classes to 54 classes based on the experience gained in cycle-1 mapping. Onscreen visual interpretation technique will used for mapping and to modify the changed polygon areas, overlaying 1st cycle vectors on terrain corrected Resourcesat-2 LISS-III imagery of 2011-12 for LU/LC changes. LULC codes designed for Level – III will be used for codification of polygons and ground verification will be carried out for the areas where changes are observed. Database will be subject to quality assessment both at Internal and external levels. **Keywords:** Land Use / Land Cover, LULC, Resourcesat – 1/2. LISS-III, Remote Sensing, GIS, ISRO, Land Use, Land Cover, Land Cover Change, Natural Resource Census				

Amendments

Sl. No.	Section Number	Page No.	Brief Description of the Change	Revision Number	Date	Approved by

Acknowledgements

The primary objective of preparing this manual is to have uniformity amongst the scientific community, which will form a basic reference while executing the project work.

These land use / cover classification concepts were discussed and endorsed at the meeting Held at National Remote Sensing Centre on 2 November 2011. The classification for second phase was developed through an interactive feedback approach involving all State Remote Sensing centre University and government officials, as well as from the experience gained through the first cycle LULC study undertaken.

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Technical Manual Team

Contributors

The manual has been finalized in regional Land Use Land Cover Project (2nd cycle) workshops held at different locations throughout the country. Following members of "Manual Drafting Task Team" have contributed in the preparation of manual:

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The classification system adopted in the manual was finalized during "National Workshop on results of 1st cycle of LULC50K Mapping and Classification Scheme Finalisation for 2nd Cycle" held at NRSC during 02nd and 03rd November 2011. Complete list of participants are given under Annexure – VII.

Contents

Chapter - 1

PRODUCT REALISATION PLAN

1. Introduction

In India, remote sensing during the last four decades has contributed significantly towards its development by providing reliable timely information on natural resources for planning and development. Indian Remote Sensing Satellite (IRS) series - Resourcesat, Cartosat, Oceansat etc which provide required data for carrying out many earth resources development projects. Some of the important projects carried out in the country include Land Use/Cover mapping, Groundwater Prospects Mapping under Drinking Water Mission, Forecasting Agricultural output using Space, Agro meteorology and Land based observations (FASAL), Forest Cover/Type Mapping, Grassland Mapping, Biodiversity Characterization, Snow & Glacier Studies, Coastal Studies, Coral and Mangroves Studies, Wasteland Mapping etc. The information generated by large number of projects have been used by various departments, industries and others for different purposes like development planning, monitoring, conservation etc.

Change detection through repetitive satellite remote sensing in temporal and spatial domain, offers the most economical means of assessing environmental impact of the developmental processes, monitoring of bio-species diversity of an ecosystem and generation of suitable action plans for sustainable development. Availability of data at different spatial resolutions (1 km, 56 m, 24 m, 5 m or better in multi-spectral mode) provides a means for observing the earth simultaneously at macro and micro levels.

1.1 Background and scope of the project

Natural resources mapping using satellite remote sensing have been an ongoing activity under the NNRMS framework in ISRO / DOS for more than three decades. With a large amount of spatial information generated under NNRMS, one of the important requirements is to archive, retrieve and serve this information for various applications. Establishing and maintaining a national Natural Resources Repository (NRR) through a NNRMS gateway Portal thus became critical. The main aim of the NNRMS-NRR is to create and maintain a systematic archive of all the digital spatial data holdings of thematic and base maps generated using remote sensing images and promote / encourage its use for government, business and societal needs.

Natural Resources Repository (NRR) has three major elements viz., data generation, database organization and spatial data services. All the three elements of NRR programme are being addressed through a set of projects with ISRO/DOS centers taking a lead role. Data generation is addressed through Natural Resources Census (NRC) project (addresses periodic inventory of 7 different thematic layers on 1:50K), Large Scale Mapping (LSM at 1:10K scale) using the high-resolution satellite remote sensing data and SIS-DP study for selected areas.

The second element of systematic database organization, maintenance and networking of database servers is being addressed by Natural Resources Data Base (NRDB) project. NNRMS Portal serves as the front-end for the NRR, enabling the users to interact and obtain the needed data for their applications.

In the light of the above background, the project on Natural Resources Census was launched by the Department of Space during 11th five year plan. The Natural Resources Census (NRC) project aims at generation of a set of thematic maps through systematic inventory & mapping using Resourcesat data and creation of GIS database of the same for the whole country. The project uses IRS images (56 m, 24 m & 5.8 m) to prepare natural resources information layers viz., land use/land cover, soil, land degradation, wetlands, vegetation, snow & glaciers, geomorphology at 1:50,000 scale and land use/land cover at 1:250,000 scale, periodically for monitoring the natural resources.

The 1st cycle of the nation-wide land use/ land cover mapping at 1:50,000 scale using IRS data is completed for the country. Spatial database organization and generation of seamless database for entire country is accomplished. Atlas has been prepared and distributed to various user departments. The LULC information is also put in Web for wider public usage with limited number of classes.

Land Use Land Cover (LULC) is dynamic in nature and requires regular monitoring to understand areas of rapid change and to ascertain the reasons/ drivers for the change. The change in land use / land cover is the resultant of many interacting processes operating on the natural resources. This will enable planners and administrators to initiate the appropriate measure for preventing / arresting the degradation of natural resources.

1.2 User Request / User Communications

This is an ISRO-DOS project under NR Census project primarily to meet the requirements of various user communities in the country.

1.2.1 End Benefit to Users

The potential users of LULC database include the Planning Commission, State Planning departments, Ministry of Rural Development, Environment and Forests, Earth Sciences, Central Water Commissions, Urban Development, Science and Technology, Agriculture, ICAR Institutions, Pollution Control Boards, State Land Use Boards etc. Besides this it is also useful for various scientific research programmes like climate change studies, weather forecasting, carbon sequestering, growth trend analysis etc.

1.3 Relevance to the larger goal

The main aim of the NNRMS-NRR is to create and maintain a systematic archive of all the digital spatial data holdings of thematic and base maps generated using remote sensing images and promote / encourage its use for government, business and societal needs. Inventory and monitoring of land cover is one of the major objectives. In continuation to first cycle of mapping, 2nd cycle of mapping is initiated.

1.4 Objectives

The objective of the project is to generate land use/cover map of 2011-12 for the entire country using three season data.

Specific objectives include:

- To generate spatial database on land use/land cover for 2011-12;
- To generate land use/land cover change database along with change matrix with respect to 2005-06; and
- To identify areas of major change.

1.5 Classification system for 2nd cycle LULC mapping

The schema for classification to be followed in the 2nd cycle of LULC Mapping was finalized after elaborate discussions within the DOS set-up as well as with other Central / State government departments. This was reviewed and discussed at length during the brainstorming session in the National Workshop held on 02 and 03rd November 2011.
Around 78 participants representing many national (SLUSI, CRIDA, CAZRI, FSI, C-DAC etc.), academic (Osmania University, Anna University, BIT Mesra etc.), NGOs (MSSRF, CLUMA etc.), state level (representing 14 states) organizations along with the representatives from ISRO Headquarters, SAC and NRSC (Annexure –II) deliberated on the classification for cycle - 2.

Based upon the suggestions received during workshop, the classification system was finalized and recommended for use in 2nd cycle of NRC LULC mapping. The classification system considered is having three level hierarchical systems, wherein level-III is with 54 classes; level - I is with 31 classes and level-I is having 8 classes. The details of classification schema and its definitions are elaborated in Chapter – 2.

1.6 Details of Study Area

All the States (29) and Union Territories (6) of the country.

1.7 Methodology

Onscreen visual interpretation technique will be used while carrying out 2nd cycle of LULC mapping. The GIS vector layer created during 1st cycle of LULC mapping will be overlaid onto Terrain corrected Resourcesat-2 LISS-III satellite imagery of year 2011-12. Satellite imagery will be enhanced to improve the basic visual interpretation characteristics. The methodology essentially is based on editing of the previous cycle of LULC vector data layer created using 2005-06 IRS LISS-III data. Vector polygons for the change areas will only be edited wherever interpretation conflicts/ changes are observed.

Advantages for visual interpretation approaches are as following:

- Context / Texture / Pattern based classes can be delineated
- Various enhancement options are possible to exploit the capability of multiband / multi season data.
- Minimizes the issues of sensor radiometry and date of pass
- Temporal assessment is time effective
- Adoptability and operational feasibility is high
- Domain knowledge and site adaptation is used to ascertain land use units.

Following steps, broadly describe the process of LULC 2nd Cycle of mapping:

- Overlay of vector data from 1st cycle of LULC mapping onto terrain corrected Resourcesat-2 LISS-III imagery of 2011-12 (preferably of Rabi season);
- Interpret to capture the LU/LC change by modifying the polygons with appropriate change codes;
- Resultant vector will be overlaid on to kharif

season satellite imagery to incorporate the changes which are better delineable in Kharif data;

- Areas where summer season crops are being cultivated, summer season data will be used to delineate the crop areas;
- Stratification for forest and other classes will be used for the areas whenever necessary to generate season wise classified outputs;
- Water bodies to be modified using Kharif season (post monsoon data) data;
- LULC codes designed for Level – III will be used for codification of polygons;
- Ground verification will be carried out for the areas of major changes and some of the sample doubtful locations can also be included;
- Internal quality assessment of resultant vector will be carried out and certified for 100 % of the study area;
- Sample areas (20%) will be subjected to external QAS;
- Final quality checked data will be used to generate the area statistics and final map generation;

1.8 Quality Assurance Mechanism and Accuracy Standards

The project envisages mapping of land use / land cover under three-fold classification system using visual analysis technique at 1:50,000 scale. Since the project is being carried out at national level, the output plays an important role for effective utilization. Further, the output generated under this project will go into the Natural Resources Information System (NRIS) as an input, which can be used for various applications. Hence, the geographic integrity of output is very important. To accomplish this task, quality of the output is ensured by carrying out the quality checks at various stages of the product generation.

1.9 Geodatabase

The databases of LULC 50K project consists of raster data (satellite image), thematic data (LULC data, base layers etc) and ground truth data. The database will be organized in a central storage system (NAS or SAN) at NRSC and also in Geo-RDBMS environment for web hosting and further sharing and dissemination. It is also proposed to prepare a centralized repository of ground truth data namely field photographs, field observation data and metadata etc.

The satellite data will be organized scene wise and also as a state mosaic. The LULC layer will be organized map sheet wise, district mosaic and finally as a state mosaic in shape file format. The final vector layers will be stored and organized in geo-RDBMS environment at NRSC as a central repository. The spatial framework, administrative, base layer and available land use map of previous cycle with the partner mapping organizations has to be used with same spatial framework for creation of new LULC layer.

1.10 Deliverables

At the end of 2nd cycle of LULC mapping following deliverables are planned:

- State wise seamless land use /land cover GIS data for 2011 – 12
- State wise GIS layers for administrative boundaries and base information
- Land use/land cover atlas for 2011-12 with change matrix

Chapter - 2

LAND USE/LAND COVER CLASSIFICATION SYSTEM

2. Introduction

The rich experience gained during 1st cycle of LULC mapping forms the base for development of classification system for 2nd cycle. In any land cover mapping exercise for creating geo-database the following four elements are inextricably linked.

- Scale,
- Surface area of the smallest unit to be mapped,
- Nature of the basic information used; in this case, IRS earth observation satellite data,
- Structure of the nomenclature and the number of units it contains.

On the basis of the first three elements listed above and also the classification system used for mapping of LULC in the 1st cycle, the revised land use / land cover classification has been formulated with refinement in definition of land use class.

The primary objective of this chapter is to familiarize the scientific personnel involved in the mapping process with the definitions and classification scheme to be used for heads on interpretation and mapping so as to maintain standard operational procedures.

2.1 Classification Scheme followed in 1st cycle of NRC - LULC mapping

During the first cycle of NR Census land use / land cover mapping a threefold classification system, having 8 classes in level-I, 35 classes in level-II and 79 classes in level-III was used (NRSA, 2007). This hierarchical classification is primarily based upon the USGS Land Use and Land Cover Classification using remote sensor data (Anderson, 1971). The classes used in this were primarily having land cover categories for level-I and mix of land use and land cover for level-II and level-III (Annexure – I). These classifications were arrived after carrying out NR Census Pilot studies spread over different parts of the country.

2.2 Major international LULC classification system

Before arriving at Classification Schema for NRC - LULC 2nd cycle, a review of major internationally used Land Use / Land Cover classification using remote sensing data were carried out to find its applicability to the requirement of our country along with its compatibility. Major international LULC classifications which are referred are as following:

- USGS Land Use and Land Cover Classification System (Anderson et. Al. 1976)
- UN FAO Land Cover Classification System (Di Gregorio and Jansen, 2004)
- CORINE land cover (Bossard et. al. 2000 and Buttner et. al.2002)
- U.K. Land Use and Land Cover Classification. Version 4.4. (Harrison,2006)
- BALANS Land Cover and Land Use Classification (Malmberg and Metria 2001)

- IGBP DISCover Land Cover Classification (1999)
- Australian land cover (Atyeo and Thackway, 2006)
- Five Land Cover Products over the African Continent (Bai,2010)
- EOSD Land Cover Classification Legend Report, Version – 2 (Wulder and Nelson, 2003)
- USA Florida Land use, cover and forms - Classification system. 3rd ed. (1999)
- Land-cover classification of China (Liu et al. 2002)

Majority of the above classifications were used for creating the LULC database for large areas (national / continental), applied for moderate scale and are amenable for use with remote sensing data.

2.3 Classification Schema for NRC - LULC 2nd cycle

Experience gained during 1st cycle LULC mapping, a need was felt to revise the existing classification system. The criteria considered for classification revision are as follows:

- Number of LULC units and area occupied in the national database.
- Ease of delineation using remote sensing data at 1:50000 scale.
- Class definitions, compatibility with earlier classification.
- Suitability for carrying out change mapping.

In the light of the above, the classification system was reviewed and discussed at length during the brainstorming session during the National Workshop held on 02 and 03rd November 2011. Around 78 participants representing many national (SLUSI, CRIDA, CAZRI, FSI, C-DAC etc.), academic (Osmania University, Anna University, BIT Mesra etc.), NGOs (MSSRF, CLUMA etc.), state level (representing 14 states) organizations along with the representatives from ISRO Headquarters, SAC and NRSC (Annexure –I) deliberated on the classification for cycle - 2. Based upon the suggestions received during workshop, the classification system was finalized and recommended for use in 2nd cycle of NRC LULC mapping (Table–2.I).

2.4 Features of LULC Cycle-2 classification system

The classification system considered is a three level hierarchical system, wherein level-III with 54 classes can be collapsed into defined level-II 31 classes and level-II can be collapsed to level-I 8 classes. Following are the criteria considered while devising the revised classification system:

- It must be possible to map total geographical area of the country, in other words there can be no heading for 'unclassified land';
- Interpretation accuracies of 85 percent or greater can be achieved;
- Repeatable results among interpreters and from one time of sensing to another are possible;
- Suitable for use with data from different seasons;
- Effective use of subcategories to permit use of data from ground surveys and large scale imagery;
- Aggregation of categories must be possible; and
- Comparison with future land use data should be possible.

In the current cycle of mapping apart from representing the current status of LULC categories a spatial change in LULC from 1st cycle mapping are also to be depicted. In order to facilitate this a equivalent class conversion table has been prepared wherein classification

system used in 1st cycle of mapping are mapped to the revised LULC classification system which is given in Annexure –I.

Table –2.1 Land Use / Land Cover Classification for 2nd cycle of NRC LULC mapping

Sl - 1	L - I	Sl - II	L - II	Sl - III	L - III	LU11_12	LU_CODE
1	Built Up	1.1	Urban	1.1.1	Built up - Compact (Continuous)	1	010111
				1.1.2	Built up - Sparse (Discontinuous)	2	010112
				1.1.3	Vegetated / Open Area	3	010109
		1.2	Rural	1.2.1	Rural	4	010201
		1.3	Industrial	1.3.1	Industrial area	5	010301
				1.3.2	Ash / Cooling Pond / effluent and other waste	6	010304
		1.4	Mining / Quarry	1.4.1	Mining – Active	7	010401
				1.4.2	Mining - Abandoned	8	010402
				1.4.3	Quarry	9	010403
2	Agricultural land	2.1	Cropland	2.1.1	Kharif	10	020101
				2.1.2	Rabi	11	020102
				2.1.3	Zaid	12	020103
				2.1.4	Cropped in 2 seasons	13	020104
				2.1.5	Cropped in more than 2 seasons	14	020105
		2.2	Fallow land	2.2.1	Fallow land	15	020201
		2.3	Agriculture Plantation	2.3.2	Agriculture Plantation	16	020301
		2.4	Aquaculture	2.4.3	Aquaculture	17	020400
3	Forest	3.1	Evergreen / Semi evergreen	3.1.1	Dense / Closed	18	030101
				3.1.2	Open	19	030102
		3.2	Deciduous (Dry / Moist / Thorn)	3.2.1	Dense / Closed	20	030201
				3.2.2	Open	21	030202
		3.3	Forest Plantation	3.3.1	Forest Plantation	22	030300
		3.4	Scrub Forest	3.4.1	Scrub Forest	23	030400
		3.5	Swamp / Mangroves	3.5.1	Dense / Closed	24	030601
				3.5.2	Open	25	030602
		3.6	Tree Clad Area	3.6.1	Dense / Closed	26	030701
				3.6.2	Open	27	030702
4	Grass/Grazing	4.1	Alpine / Sub-Alpine	4.1.1	Alpine / Sub-Alpine	28	040100
		4.2	Temperate / Sub Tropical	4.2.1	Temperate / Sub Tropical	29	040200
			Tropical / Desertic	4.2.2	Tropical / Desertic	30	040300

Sl - 1	L - I	Sl - II	L - II	Sl - III	L - III	LU11_12	LU_CODE
5	Wastelands	5.1	Salt Affected Land	5.1.1	Salt Affected Land	31	050100
		5.2	Gullied / Ravinous land	5.2.1	Gullied	32	050201
				5.2.2	Ravinous	33	050203
		5.3	Scrub land	5.3.1	Dense / closed	34	050301
				5.3.2	Open	35	050302
		5.4	Sandy area	5.4.1	Desertic	36	050401
				5.4.2	Coastal	37	050402
				5.4.3	Riverine	38	050403
		5.5	Barren rocky	5.5.1	Barren rocky	39	050500
6	Wetlands	6.1	Inland	6.1.1	Natural (Ox-bow lake, cut-off meander, waterlogged etc.)	40	060100
				6.1.2	Manmade (Water logged, saltpans etc.)	41	060200
		6.2	Coastal	6.2.1	Lagoon, creeks, mud flats etc.	42	060300
				6.2.2	Saltpans	43	060400
7	Water bodies	7.1	River	7.1.1	Perennial	44	070101
				7.1.2	Non Perennial	45	070102
		7.2	Canal / drain	7.2.1	Canal / drain	46	070200
		7.3	Lake / Ponds	7.3.1	Permanent	47	070301
				7.3.2	Seasonal	48	070302
		7.4	Reservoir / Tank	7.4.1	Permanent	49	070401
				7.4.2	Seasonal	50	070402
8	Snow, Shifting cultivation &Rann	8.1	Snow	8.1.1	Snow	51	080100
		8.2	Shifting cultivation	8.2.1	Current	52	090101
				8.2.2	Abandoned	53	090102
		8.3	Rann	8.3.1	Rann	54	Rann

2.5 Land Use / Land Cover classes and its definitions

Land classification refers to systematic grouping of different land types based on similar characteristics. Land can be classified based on physical determinants such as soil profile, soil texture and factors connected with environmental and agro-climatic conditions, besides the purpose for which it is being used. Land Cover Classification considers biophysical characteristics, while attributes related to climate, soil, etc. is termed as Agro-Climatic and Agro-Ecological Classification. Land Use Classification considers the functional use of land connected with socio-economic activities.

According to (UN-FAO, 2005) Land cover is the observed (bio) physical cover on the earth's surface. When considering land cover in a very pure and strict sense, it should be confined to the description of vegetation and man-made features. Consequently, areas where the surface consists of bare rock or bare soil is land itself rather than land cover.

Land use is characterized by the arrangements, activities and inputs people undertake in a certain land cover type to produce, change or

maintain it. Definition of land use in this way establishes a direct link between land cover and the actions of people in their environment). Although land use is generally inferred based on the cover, yet both the terms are related and interchangeable.

2.5.1 Built-Up Land

Built-up areas are characterized by substitution of the original (semi-) natural cover or water surface with an artificial, often impervious, cover. This artificial cover is usually characterized by long cover duration. (FAO, 2005).

Basically they are the area of human habitation that has a cover of buildings, transport and communication, utilities in association with water, vegetation and vacant lands. It consists of four level - 2 classes namely - Urban built-up, Rural, Industrial and Mining/Quarry.

2.5.1.1 Built up - Urban

Urban areas are non-linear built up areas covered by impervious structures adjacent to or connected by streets. This cover is related to centers of population. This class usually occurs in combination with, vegetated areas that are connected to buildings that show a regular pattern, such as vegetated areas, gardens etc. and industrial and/or other areas. (FAO, 2005).

Hence, all places with a municipality, corporation or cantonment or which are notified town areas and all other places which satisfy the criteria of a minimum population of 5000, at least 75% of whose male working population is non-agricultural and having a density of population of at least 400 sq. km. are placed under this category.

This also includes:
Permanent residential, industrial, transportation, power, communications and isolated areas such as mills, shopping centres, parks, playgrounds, open spaces, institutions etc. It also includes temporary hutments like slums, hostels etc. It comprises of three Level-3 classes as discussed below.

2.5.1.1.1 Built up - Compact (Continuous)

Most of the land is covered by Buildings, roads and artificially surfaced area and cover almost all the ground. (CORINE 2000)

The built up - compact class is assigned when the urban structures and transport network (i.e. impermeable surfaces) occupies more than 80 % of the surface area. This coverage percentage pertains to real ground surface. Therefore, localization of this cut-off point requires close attention to avoid confusion with the apparent vegetation (i.e. Visible tree crowns) and permeable surfaces under trees. This also includes:

- Urban centre types and dense ancient suburbs where buildings form a continuous and homogeneous;
- Public services or local governments and commercial/industrial activities with their connected areas inside continuous built up when their surface is less than 2.25 ha;
- Parking lots, concrete or asphalt surfaces;
- Transport network;
- Small squares, pedestrian zones, yards;
- Urban greenery (parks and grass areas) amounting to less than 30 % of the polygon area; and
- Cemeteries with or without vegetation having less than 2.25 ha located inside compact urban areas.

2.5.1.1.2 Built up - Sparse (Discontinuous)

Most of the land is covered by the structures like buildings, roads and artificially surfaced areas associated with vegetated areas and bare soil, which occupy discontinuous but significant surfaces. (CORINE 2000). Between 30 to 80 % of the total surface should be impermeable.

The discrimination between compact and sparse built-up is set from the presence of vegetation visible in the satellite image illustrating either single houses with gardens or scattered apartment blocks with green areas between them.

The density of houses is the main criteria to attribute a land cover class to the built-up areas or to the other LULC area. In case of patch work of small agricultural class and scattered houses, the cut-off-point to be applied for sparse built-up is 30 % at least of built up are within the patchwork area.

This also includes:

- Scattered blocks of residential flats, hamlets, small villages where numerous interstitial spaces (gardens, lawns) can be distinguished;
- Large blocks of flats where green spaces, parking areas and adventure playgrounds cover significant surface area;
- Transport network, sport area, cemeteries with or without vegetation; and
- Urban residential layouts marked for the construction of residential houses.

Note: Area under vegetation and or green spaces occupying more than 2.25 ha. are to be excluded from this and will be included into category of vegetated / open area. Small sparse urban areas with less than 2.25 ha are grouped together if the distance between each of them is less than 150 m in order to reach 2.25 ha.

2.5.1.1.3 Vegetated / Open Area

These are vegetated areas within urban agglomeration (situated within or in contact with urban areas). A polygon will be included in this category if vegetation cover of trees, shrubs and herbs covers at least 5% of the total surface area.

This also includes:

- Parks, sport and leisure facilities, camping grounds, sports grounds, leisure parks, golf courses, race courses, including formal parks etc. ;
- Areas used for electricity, electric sub-stations and installations for transmitting like transmission towers; and
- Area under vegetation and or green spaces situated within or in contact with built-up and are occupying more than 2.25 ha.

This does not include:

- Forest areas, water bodies, wetlands and mangroves situated within built-up areas.

2.5.1.2.1 Built-Up Area - Rural

These are the lands used for human settlement of size comparatively less than the urban settlements of which more than 80% of the people are involved in the primary activity of agriculture. All the agricultural villages covering 5 hectares area and more are included in this category.

They are built-up areas, smaller in size, mainly associated with agriculture and allied sectors and non-commercial activities, generally lack supporting facilities that are unique to urban areas like hospitals, industries (large and medium scale), institutional etc.

Note: Many areas in different parts of our country are endowed with plantation (particularly backyard plantation), aquaculture ponds are established in continuation of built-up areas. In these cases prominent category are to be marked and secondary categories are to recorded under the field PI_LU. Such areas are prominently seen in West Bengal, Assam Valley and Kerala, wherein built-up areas with plantation or aquaculture co-exist in a homogenous manner.

2.5.1.3 Industrial

Non-linear impervious surfaces are included in this class which is related to trade, manufacturing, distribution and commerce. (FAO, 1995) and are not occurring in continuity with urban cover.

2.5.1.3.1 Industrial area

All the areas that are described above except for the areas under ash / cooling / tailing pond, which are characterized by water saturation, are classified under this category. These are artificially surfaced areas (with concrete, asphalt, tar macadam, or stabilised, e.g. beaten earth) without vegetation, which also contains buildings and/or vegetation.

These are areas where the human activity is observed in the form of manufacturing along with other supporting establishments of maintenance. Heavy metallurgical industry, thermal, cement, petrochemical, engineering plants etc., are included under this category.

This also includes:

- Research and development establishments;
- Security and law and order services (fire stations, penal establishments);
- Stud farms, agricultural facilities (co-operatives, state farm centres, livestock farms,

living and exploitation buildings);

- Nuclear power plants, military barracks, testing sites, test fields, biological waste water;

treatment plants, water houses, transformers;

- Hospitals, spas, universities, schools;
- Abandoned industrial sites and by-products of industrial activities where buildings are

still present; and

- Telecommunication networks (relay stations for T.V., telescopes, radar stations).

This does not include:

- Commercial/industrial units which are connected to urban fabric;
- Places of worship: convents, monasteries, etc. ; and
- Urban built-up areas with units equal or larger than 2.25 ha inside commercial/ industrial units.

2.5.1.3.2 Ash / Cooling / effluent pond& other waste

These are the portions of industry which is used for temporary storage of ash, contaminated soil, rubble, cooling of hot water or tailing pond associated with industry. The areas where industrial waste is permanently kept, categorized as other waste which has to be delineated under this category.

This also includes:

- Stockpile of storage dump of industrial raw material or slag/effluents or waste material or quarried/mixed debris from earth's surface ;
- Lands which have been deteriorated due to large scale industrial effluent discharge; and
- Accumulated waste debris after extraction of required minerals.

2.5.1.4 Mining / Quarry

Mining / quarry areas encompass area under surface operations. The recognizable impacts of these activities on the landscape are unmistakable giant pit mines covering vast areas. The presence of water bodies does not necessarily imply inactive or unused extractive areas; ponds or lakes are often an integral part of an extractive operation. (USGS, 1999).

This also includes:

- Industrial complexes where the extracted material is refined, packaged or further processed;
- Open-pit extraction often associated with heaps of extracted building material (gravel, sand, stone or clays) or ore and non-ore mineral material (iron, manganese ores, magnesite, lignite, brown coal, kaolin, etc.);
- Infrastructure of buildings and installations providing for extraction, or primary processing of the quoted material and minerals;
- Mine dumps and mine pits filled with water;
- Transport networks associated with areas of open-pit extraction; and
- Rock salt pits, sand extraction site inside coastal dune areas, inland Saline areas, oil fields with wells, petroleum, gas and liquid petroleum gas, shale oil extraction site.

This does not include:

- Associated land of mines where barren materials are dumped (coal tips, slag dumps); and
- Extraction sites abandoned and reconverted to leisure areas.

2.5.1.4.1 Mining - Active

These are the areas where presently large scale surface operations of removal of economically important ores are presently going on.

2.5.1.4.2 Mining - Abandoned

These are the areas where large scale surface operations of removal of economically important ores are carried out in the past, but presently kept abandoned due to various reasons like, economical, operational, viability, disturbances etc.

2.5.1.4.3 Quarry

These are manifestations of surface mining operations where in small scale excavation of land surface for sand, gravel, clay phosphate mines, limestone quarries etc. are taking place. They are mostly characterised by its nearness to urban areas.

This also includes:

- Surface rocks and stone quarries, sand and gravel pits, brick kilns, etc.

2.5.2 Agricultural Land

These are the lands primarily used for agriculture for production of food, fiber, and other commercial and horticultural crops. It includes land under crops (irrigated and unirrigated, fallow, plantations etc.).In a broad sense, agricultural lands may be defined as those lands which are cultivated to produce food crops and related activities. Native vegetation has largely been replaced by introduced species through clearing, and sowing of new species. Under this four Level-2 classes are included namely cropland, fallow land, agricultural plantation and aquaculture.

2.5.2.1 Cropland

These are the areas with standing crop as

on the date of satellite overpass. Cropped areas appear in bright red to red in color with varying shape and size in a contiguous to non- contiguous pattern. Three cropping seasons exist in India viz., kharif (June/July - September/October), rabi (November/ December - February/March) and zaid (April-May). It is a necessary pre-requisite to consult the crop calendar of an area, which is highly region specific, before acquiring the satellite data to ensure standing crop as on the date of satellite overpass.

2.5.2.1.1 Kharif Crop

These are the cultivated between June/July to September/ October coinciding with SW monsoon season. It is associated with rain-fed crops under dry land farming with limited or no irrigation and areas of rain-fed paddy and other dry crops.

2.5.2.1.2 Rabi Crop

These areas are cultivated between November / December to February / March. It is associated with areas under assured irrigation irrespective of the source of irrigation. However, rabicropped areas also occur in rain-fed regions, under residual soil moisture conditions especially in black soil areas with high rainfall during Kharif season.

2.5.2.1.3 Zaid Crop

These are the areas that are cropped April - May (summer) which are mostly associated with irrigated areas with fertile soils, confined to plains/delta areas.

Note: While classifying areas under kharif/rabi/ zaid, a apriori knowledge about the area, ground data, crop calendar of the area and interaction with local officials are to considered

2.5.2.1.4 Cropped in 2 seasons

These are the areas that are cropped during two cropping seasons that are often seen associated with irrigated areas. Three combinations are possible in this category viz., – Kharif + Rabi, Kharif + Zaid and Rabi + Zaid.

Kharif and rabi cropped areas: These are the areas mostly in command areas and have two crops grown in kharif and rabi seasons

Kharif and summer cropped areas: These are the areas where only kharif and summer crops are cultivated, located in isolated pockets.

Rabi and summer cropped areas: These are the areas where rabi and summer crops are cultivated, located in those regions where cultivation of crops is constrained during kharif season due to excessive rainfall or flooding during kharif season.

This also includes:
The area under chili crop, long duration paddy is to be included under this category.

2.5.2.1.5 Cropped in more than 2 seasons

These are the areas which are cropped in more than two cropping seasons. It includes triple cropped areas (kharif, rabi and zaid), areas under multiple cropping. Long duration crops like sugarcane, cotton, banana, pineapple etc., need to be considered classifying under this category.

2.5.2.2.1 Fallow Land

An agricultural system with an alternation between a cropping period of several years and a fallow period (Ruthenberg, 1980). In

another terms these are the lands, which are taken up for cultivation but are temporarily allowed to rest, un-cropped for one or more season, but not less than one year and for not more than five years.

Note: These are the cropland areas, which are un- cropped during the agricultural year under consideration as on the date of satellite overpass during all the cropping seasons.

2.5.2.3.1 Agricultural Plantation

These are the areas under agricultural tree crops planted adopting agricultural management techniques. These also includes the areas of land use systems and practices wherein cultivation of herbs, shrubs, and vegetable crops are deliberately integrated with agricultural crops mostly in irrigated conditions for ecological and economic reasons. These areas are separable from cropland, especially with the data acquired during rabi/ zaid season. Plantations appear in dark-red to red tone of different sizes with regular and sharp edges indicating the presence of a fence around it.

This also includes:

- Permanent commercial crops: coffee, mulberry, tea, rubber etc., which are normally grown in the hilly regions and are closely associated with forest cover;
- Plantations of berry shrubs, raspberries, gooseberries, blackberry crops etc.
- Abandoned orchards which still preserve characteristic alignments;
- Fruit, orchards of apples, pears, plums, apricots, peaches, cherries, figs and other rosaceae;
- Ligneous crops : chestnut, walnut, almond, hazel, pistachio groves;
- Permanent florist plantations of roses, marigold etc.;
- Willow plantation for wicker production;
- Tropical fruit trees: avocados, guava, mango, papaya, pomegranate, cashew nut, coconut, etc. ; and
- Citrus fruit trees : oranges, lemons, mandarins, tangerines, grapes etc.

2.5.2.2.4.1 Aquaculture

These are the areas where fish and shrimps are bred and reared for commercial purposes. Aquaculture ponds are located mostly along coast or in lakes, river and estuaries.

This also includes:

- Breeding and rearing of fresh water or marine fish in captivity.

2.5.3 Forest

The term forest is used to refer to land with a tree canopy cover of more than 10 percent and area of more than 0.5 ha. Forest are determined both by the presence of trees and the absence of other predominant land uses within the notified forest boundaries. The trees should be able to reach a minimum height of 5 m (MOEF, 2011) within the notified forest boundaries.

This also includes:

- Forest stands on agricultural lands (e.g. windbreaks and shelterbelts of trees with a width of more than 20 m).

2.5.3.1 Evergreen/Semi-Evergreen

This term as such describes the phenology of perennial plants that are never entirely without green foliage (Ford-Robertson, 1971)

This category comprises of tall trees, which predominantly remain green throughout the year. It includes both coniferous and tropical broadleaved evergreen species. Semi- evergreen is a forest type that includes

a combination of evergreen and deciduous species with the former dominating the canopy cover.

Delineation of two sub-categories is possible using satellite data under level III viz., dense/ closed and open, based on the canopy cover/ density.

2.5.3.1.1 Dense/Closed

This category includes all areas where the canopy cover/density is more than 40 %.

2.5.3.1.2 Open

This category includes all the forest areas where the canopy cover/density ranges between 10 - 40 per cent.

2.5.3.2 Deciduous (Moist/Dry/Thorn)

This applies to the phenology of perennial plants that are leafless for a certain period of the year (Ford-Robertson, 1971). The leaf shedding usually takes place simultaneously in connection with the unfavorable season (UNESCO, 1973)

This category is predominantly composed of species, which shed their leaves once a year, especially during summer. These are mostly broad leaved tropical forests with a tendency to shed their leaves annually. Delineation of two sub-categories is possible using satellite data under level III viz., dense/ closed and open, based on the canopy cover/ density.

This also includes:

- Acacia thorn forests in semi-arid areas like Gujarat, Rajasthan, western Madhya Pradesh, Delhi and to some extent in Tamilnadu and Karnataka

2.5.3.2.1 Dense/Closed

This category includes all the areas where the canopy cover/density is more than 40 %.

2.5.3.2.2 Open

This category includes all the forest areas where the canopy cover/density ranges between 10 - 40 per cent.

2.5.3.3.1 Forest Plantation

These are the areas of tree species of forestry importance, raised and managed especially in notified forest areas. Most of these are located in uplands, coastal areas within notified areas. Many of these can be identified based on the sharp boundary exhibited by them.

This also includes:

- Teak, Sal, Eucalyptus, Casuarina, Bamboo etc.

2.5.3.4.1 Scrub Forest

These are the forest areas which are generally seen at the fringes of dense forest cover and settlements, where there is biotic and abiotic interference. Most times they are located closer to habitations. Forest blanks which are the openings amidst forest areas, devoid of tree cover, observed as openings of assorted size and shapes as manifested on the imagery are also included in this category.

2.5.3.5 Swamp / mangrove

These are the areas with the plants evergreen in nature, halophytic, dense or woody in nature, occurring along tidal waters/creeks, estuaries and along the delta in coastal areas. They are densely colonized in coastal on tidal flats, estuaries salt marshes etc.

Delineation of two sub-categories is possible using satellite data under level III viz., dense/ closed and open, based on the canopy cover/ density.

2.5.3.5.1 Dense/Closed

This category includes all the areas where the canopy cover/density is more than 40%.

2.5.3.5.2 Open

This category includes all the forest areas where the canopy cover/density range between 10 - 40 per cent.

2.5.3.6 Tree Clad Area

Areas with tree cover lying outside the notified forest area with woody perennial plant with a single, well-defined stem carrying a more-or-less-defined crown and being at least 3 m tall. Plants essentially herbaceous but with a woody appearance (e.g. bamboos and ferns) are also classified as trees if the height is more than 5 m and as shrubs if the height is less than 5 m.

Delineation of two sub-categories is possible using satellite data under level III viz., dense/ closed and open, based on the canopy cover/ density.

2.5.3.6.1 Dense/Closed

This category includes all the areas where the canopy cover/density is more than 40%.

2.5.3.6.2 Open

This category includes all the forest areas where the canopy cover/density ranges between 10 - 40 per cent.

2.5.4 Grassland & Grazing Land

These areas are described as the natural potential (climax) plant cover as being composed of principally native grasses, Forbes and shrubs. This category includes grassland, shrub and brush land and mixed Rangeland (USGS). In other terms the land where the potential vegetation is predominantly grasses, grass like plants, forbs or shrubs and is capable of being grazed.

Located in plains, uplands, and hill-slopes or close to rivers/ streams, they are associated with agricultural lands, dry lands fenced from cultivation, riverbeds and forested areas in high altitudes.

This also includes:

- Grasslands which are artificially managed for various purposes including for grazing;
- Naturally growing grasslands where climate is the prime controlling factor; and
- Semi-natural grasslands occurring in normal upland situations that have been deforested by man.

This does not include:

- Lantana species which are to be classified as scrub;
- Lawns inside sport and leisure facility areas; and
- Swampy grassland, fallow land etc.

2.5.4.1.1 Alpine/Sub-Alpine

These are the lands that are exclusively used for farming grasses and are also called as alpine meadows and pastures. They are placed between coniferous forest and permanent snow covered areas. An alpine zone begins where the tree zone ends at the limit of the

"timber line". Altitude at which the alpine zone commences is variable and line between 3000 - 5600 meters. These are commonly found in the states of Jammu & Kashmir, Himachal Pradesh, Sikkim and Arunachal Pradesh

2.5.4.2.1 Temperate/Sub-Tropical

These are the grasslands that are located in the temperate zone and sub-tropical zone respectively.

2.5.4.3.1 Tropical/Desertic

These are the grasslands that have a spatial spread in tropical zones and desertic areas confined to the states of Tamilnadu, Kerala, Karnataka, Rajasthan, Gujarat and to some extent Maharashtra.

2.5.5 Wastelands

Wasteland is described as degraded land which can be brought under vegetative cover with reasonable effort and which is currently underutilized and land which is deteriorating for lack of appropriate water and soil management or on account of natural causes. Wastelands can result from inherent/imposed disabilities such as by location, environment, chemical and physical properties of the soil or financial or management constraints.

2.5.5.1 Salt-Affected Land

These are the areas / land that contain excessive concentration of salts (soluble salts or exchangeable saline or both). Salinization can result from improper management of canal irrigation water resulting in the rise of water table and consequent accumulation of salts in the root zone in arid, semi-arid and sub humid (dry) conditions and ingress of sea water in coastal regions and/or use of high-salt containing ground water. They also become saline when soils have developed on salt containing parent materials or have saline ground water. Coastal saline soils may be with or without ingress or inundation by sea water.

2.5.5.2 Gullied / Ravinous Land

Gullies and ravines are formed as a result of localized surface run-off affecting the unconsolidated material resulting in the formation of perceptible channels causing undulating terrain. Gullies develop from rills which are tiny water channels with a few centimeters deep, formed as a resultant impact of heavy rainfall and wearing action of run-off generated there from.

They are commonly found in sloping lands, and further classification of this category is possible based on the depth, width, bed slope, frequency and morphology of bed material of the ravines. They are mostly associated with stream courses and sloping grounds with good rainfall and entrenched drainage. Underlying land surface as gully and or ravine is to be recognized, irrespective of fact that most of the gully and ravinous areas in are covered under scrub vegetation.

2.5.5.2.1 Gullied land

It is a large intermittent water course with steep sides; an obstacle to agricultural machinery (SSSA). Gullies are formed as a result of localized surface run-off affecting the unconsolidated material resulting in the formation of perceptible channels causing undulating terrain. If rills are neglected and the erosion continues for a long time, it develops into gullies. They are commonly found in sloping lands, developed as a result of concentrated run-off over fairly long time.

2.5.5.2.2 Ravinous Land

The word ravine is usually associated not with an isolated gully but an intricate network of gullies formed generally in deep alluvium and entering a nearby river, flowing much lower than the surrounding. Ravines are basically extensive systems of gullies developed along the river course.

2.5.5.3 Scrub Land

This is a land, which is generally prone to deterioration due to erosion. Such lands generally occupy topographically high locations, excluding hilly/ mountainous terrain. Scrublands are associated with moderate slopes in plains and foot hills and are generally surrounded by agricultural lands

2.5.5.3.1 Dense Scrub

These areas possess shallow and skeletal soils, at times chemically degraded, extremes of slopes, severely eroded and lands subjected to excessive aridity with scrubs dominating the landscape. They have a tendency for intermixing with cropped areas

2.5.5.3.2 Open Scrub

This category has a similar description as mentioned in the earlier class excepting that they possess sparse vegetation or devoid of scrub and have a thin soil cover.

2.5.5.4 Sandy Area

These are the areas that have stabilized accumulation of sand, in coastal, riverine or inland areas, that can be either desertic or coastal. They appear as white to light yellow/ bluish depending on moisture content and at time light red when vegetation is associated with the class, vary in size, with regular to irregular shape with contiguous to linear pattern They are predominantly located in deserts, riverbeds and along the shores.

This also includes:

- River dune formation in the immediate vicinity of great rivers (Riverine Sand);
- Inland and lacustrine dunes; and
- Shifting dunes with or without vegetation and or open grasslands (Desertic Sand).

2.5.5.4.1 Desertic sand

Desertic sands are those confined to arid environment where the rainfall is scanty. These lands are characterized by accumulation of sand developed in situ or transported by Aeolian processes.

2.5.5.4.2 Coastal sand

Coastal sands are the sands that are accumulated as a strip along the sea-coast. Very high reflectance exhibited by this category especially in the NIR region of the spectrum enable their separation with the salt affected land.

2.5.5.4.3 Riverine sand

Riverine sands are those that are seen as accumulations in the flood plain as sheets which are the resultant phenomena of river flooding. The sandy areas occurring within or in continuity to river course are to be excluded from this category.

2.5.5.5.1 Barren/Rocky/Stony Waste

This class contains areas that are either dominated by a continuous rock surface or

covered by a coarse rock fragments. Rock surface is continuous with some areas may be covered by shallow layer of soil or there could be isolated pockets of soil or a mixture of both. They also include areas where rock or mineral fragments cover the surface. (FAO, 2005)

2.5.6 Wetland

All submerged or water-saturated lands, natural or man-made, inland or coastal, permanent or temporary, static or dynamic which necessarily have a land-water interface, are defined as wetlands. Hence, the portions of water body (partial or full) having emergent vegetation or observable submerged vegetation is placed in the Wetlands category. (USGS, 1999).

This also includes:

- Long abandoned marshes and waterlogged areas invaded by vegetation; and
- All submerged or water-saturated lands, natural or man-made, inland or coastal, permanent or temporary, static or dynamic and are vegetated, which necessarily have a land-water interface.

2.5.6.1 Wetland - Inland

Areas flooded or liable to flooding during the great part of the year by fresh, brackish or standing water with specific vegetation coverage made of low shrub, semi-ligneous or herbaceous species. It includes water-fringe vegetation of lakes, rivers, and brooks and of fens and eutrophic marshes etc. (CORINE 2000).

2.5.6.1.1 Wetland - Inland - Natural

These are the areas that include ox-bow lakes, cut-off meanders, playas, swamp, marsh, peat bogs etc (with vegetation).

2.5.6.1.2 Wetland - Inland - Manmade

Waterlogged areas (seasonal and perennial) created due to negative effect of human management practices and are present with vegetation.

2.5.6.2 Wetland - Coastal

These are the areas which are submerged by high tides at some stage of the annual tidal cycle. Non-wooded areas either tidally, seasonally or permanently waterlogged with brackish or saline water (CORINE 2000).

This includes:

- Estuaries, lagoons, creek, backwater, bay, tidal flat/mud flat, sand/beach, coral reef, rocky coast, mangrove, salt marsh/marsh with vegetation and other hydrophytic vegetation

2.5.6.2.1 Lagoon, creeks, mud flats etc.,

These include estuaries, lagoons, creek, backwater, bay tidal flat/mud flat, mangrove, salt marsh/marsh with vegetation and other hydrophytic vegetation

2.5.6.2.2 Saltpans

Saltpans are flat expanses of areas covered with salt usually white under the Sum. Saltpans are manmade saline ecosystem from which crude salt is extracted during summer. These are undrained, usually small and shallow, natural depression or hollow in which brackish water accumulates and evaporates leaving behind salt deposits.

2.5.7 Water Body

This category comprises areas with surface water, either impounded in the form of ponds,

lakes and reservoirs or flowing as streams, rivers, canals etc. These are seen clearly on the satellite image in blue to dark blue or cyan color depending on the depth of water.

If lake or reservoir is a part of river system then the boundary demarcation between streams and lakes / reservoirs or the ocean can be the straight line across the mouth of the stream. Straight line can be drawn at point which is more than two times of average width stream / river for 30 km proceeding to the center of reservoir or lake).

River bed with width more than 100 meters needs to be delineated from the imagery.

This also includes:

- Areas with flowing standing surface water, in the form of ponds, lakes and reservoirs;
- Areas with flowing surface water such as streams, rivers, canals etc. ; and
- Sand or gravel accumulations along streams < 2.25 ha and are connected to main water course.

This does not include:

- Water bodies with emergent vegetation (to be classified as wetland).
- Water bodies connected to watercourses; and
- Hydroelectric plant located on watercourses > 2.25 ha

2.5.7.1 River /Stream

Rivers/streams are natural course of water flowing on the land surface along a definite channel/slope regularly or intermittently towards a sea in most cases or a lake or an inland basin in desert areas or a marsh or another river.

2.5.7.1.1 Perennial

These are the rivers/streams that flow continuously throughout the year.

2.5.7.1.2 Non Perennial

The water covers the surface for less than nine months in each year (FAO, 2005). This also includes the dry part of river generally characterized by the presence of sand or exposed rocks.

2.5.7.2.1 Canal / Drain

Canals and drains are artificial water course constructed for irrigation, navigation or to drain out excess water from agricultural lands

2.5.7.3 Lakes / Ponds

These are accumulation of water in a depression of various sizes either natural or saline. Areas of tailings and abandoned pits and quarries may remain recognizable for a long time due to presence of water is to be classified under this category.

2.5.7.3.1 Permanent

Perennial lakes/ponds are those that retain water in them either for more than one season (usually more than three months of a year, FAO, 2005) or throughout the year and usually not subjected to extreme fluctuation in water level. Ponds are body of water limited in size, either natural or artificial, regular in shape, smaller in size than a lake, generally located near settlement.

2.5.7.3.2 Seasonal

This category includes the above areas except

that they remain dry either partially or totally throughout the year.

2.5.7.4 Reservoir / Tanks

Reservoir is an artificial lake created by construction of a dam across the river specifically for hydel power generation, irrigation, and water supply for domestic/ industrial needs, flood control, either singly or in combination. Tanks are small lakes of impounded water ways constructed on land surface for irrigation. They are associated with croplands, low lands and reservoirs surrounded by hills without vegetation

2.5.7.4.1 Permanent

This includes all reservoirs/tanks with water spread seen at least during one season in a year (usually more than three months of a year, FAO, 2005)

2.5.7.4.2 Seasonal

Dry reservoirs/tanks are those, which do not have water spread throughout the year

2.5.8 Snow, shifting cultivation &Rann

2.5.8.1.1 Snow Covered

These are the areas under perpetual snow cover confined to the Himalayan region. They appear in bright white to white in color depending on the moisture and thickness of the snow spread in large areas. While delineating this category satellite imagery of least snow cover are to be used.

2.5.8.2 Shifting Cultivation

Shifting cultivation is the name we use for agricultural systems that involve an alternation between cropping for a few years on selected and cleared plots and a lengthy period when the soil is rested. Cultivation consequently shifts within an area that is otherwise covered by natural vegetation. (Ruthenberg, 1980). This cover is followed by the vegetative and / or bare cover of the fallow period that can last for several years (Shaneret. Al., 1982)

It is a method of cyclical cultivation, chiefly in vogue in the tropics, where cultivators cut the tree crop, burn it, and raise field crops for one or more year before moving on to another site and repeating the process. It is also known by different names in different regions like roving agriculture, Taungyas (Myanmar), Kumri (Tamil Nadu), Punam (Malayalam), Podu (Telugu) Jhum (Assamese).

2.5.8.2.1 Current

These are the areas that are used for cultivation by the process mentioned above which are clearly perceptible on the satellite image that are in pre-burnt /post-burnt condition.

2.5.8.2.2 Abandoned

These are the areas that were under shifting cultivation, left idle for more than one year but less than 5 years thereby giving a scope for the regeneration of secondary vegetation, especially bamboo or grasses. This category has a tendency to get mixed with forested areas.

Note: The areas under Shifting cultivation, left abandoned for more than 3-4 years and regenerated with secondary growth of bamboo, need to be kept outside the class 'Shifting cultivation'. They have to be classified under appropriate forest category as described above.

2.5.8.3.1 Rann

This is an extensive salt marsh area located in western India between the Gulf of Kutch and the Indus River delta.

2.6 Mapping guidelines

Mapping methodologies to map Land Use / Land Cover categories by adopting classification Schema of NRC - LULC 2nd cycle has been described in a comprehensive way in chapter 3. Since this is cycle-2 mapping, the interpretation of cycle-1 mapping is to be followed and wherever changes are observed, the polygons need to be modified. For understanding the cycle-1 interpretation, the technical manual “Manual – National Land Use Land Cover Mapping using Multi-temporal Satellite Data, 2006 may be referred.

Chapter - 3

MATERIAL AND METHODS

3.0 Material and Methods

In this section different steps to be followed in the updation of land use land cover map of 2005 and 2006 using three seasons (kharif / rabi /zaid) satellite data of 2011-12 leading to preparation of LULC map 2011-12 and also the LULC change map generation are discussed below:

3.1 Methodology

The methodology will be on on-screen visual interpretation using visual image interpretation keys like tone, texture, size, pattern, association etc. Visual interpretation approach followed in Cycle-1 (LULC manual) forms the basis for cycle-2 also like class delineation based on context / texture / pattern, enhancement of raw satellite data to improve delineation of LULC classes, use of multiband / multi-season data for interpretation and updating LULC cycle-1 polygons of change using T2 satellite data. Resultant output from this will be vector format LULC layer. Figure 3.1 gives overview of the methodology of LULC cycle-2.

Advantages for visual interpretation approaches are as following:

- Context / Texture / Pattern based classes can be delineated
- Various enhancement options are possible to exploit the capability of multiband / multi season data.
- Minimizes the issues of sensor radiometry and date of pass
- Temporal assessment is time effective
- Adoptability and operational feasibility is high

Following steps, broadly describe the process of LULC 2nd Cycle of mapping:

- Overlay of vector data from 1st cycle of LULC mapping onto terrain corrected Resourcesat-2 LISS-III imagery of 2011-12 (preferably of Rabi season);
- Interpretation to capture the change by modifying the polygons of changed areas only;
- Resultant vector will be overlaid on to kharif season satellite imagery to incorporate the changes which are better delineable in Kharif data;
- Areas where summer season crops are being cultivated, summer season data will be used to delineate the crop areas;
- Stratification for forest and other classes will be used for the areas whenever necessary to generate season wise classified outputs;
- Water bodies will be modified using Kharif season (post monsoon data) data;
- LULC codes designed for Level – III will be used for codification of polygons;
- Ground verification will be carried out for the areas of major changes and some of the sample doubtful locations can also be included;
- Internal quality assessment of resultant vector will be carried out and certified for 100 % of the study area;
- Sample areas (20%) will be subjected to external QAS;

- Final quality checked data will be used to generate the area statistics and final map generation;

3.2. Computer

For robust handling and timely accomplishment of the steps involved in image analysis, the following minimum standard hardware configuration is required.

- Processor: Minimum of 2.0 GHz Intel I-3 make or equivalent processor
- Disk space: Minimum of 500 GB
- RAM: Minimum of 2 GB
- Display size: At least 19" monitor

Note: These are the minimum requirements and any additional capacity available in above configuration will improve the functionality.

3.3 Input Data

3.3.1 Satellite Data

The input data for this project is terrain corrected Resourcesat-2 LISS-III (24.0m) data supplied by NRSC data centre (NDC). In the absence of Resourcesat-2 data, IRS-P6 LISS-III terrain corrected data will be utilized. In case it is not terrain corrected, then geo-rectification will be done at NRSC and sent to the partner institutes. In case no cloud free data for Kharif season is available for 2011-12, previous year LISS-III data will be used in the study. Multi-temporal data from AWiFS sensor for the same corresponding years will be procured for supplementing information for Kharif season.

Data selection: Partner Institutions will select / suggest date for three seasons Satellite data by browsing. NRSC also will carry out / support this activity as and when required, due to difficulties at PI level. PI will ensure the complete data coverage for their study area are ensured.

3.3.2 Ancillary data

In the preparation of land use / land cover map the ancillary data in the form of topographic maps, district and any other published relevant material are to be used as reference data. Survey of India digital topographic maps on 1: 50,000 scale can also be used for identification of base features and for planning ground data collection. Legacy data on land use land cover data, wastelands data generated for 2008-09 are also to be used as a reference during delineation of various wasteland classes.
LULC Cycle-1 data and Wastelands Data of 2008-09 : NRSC will supply this data to PIs.

3.3.3 Ground truth Data

Ground truth/ field verification is an important component in mapping and its validation exercise. Utmost care and planning is required for collecting ground data and its verification. To facilitate a good ground truth the following steps need to be followed:

- Identify and list all the doubtful areas and change areas for the ground verification and refer all such areas with respect to the toposheet to know their geographical location and accessibility on the ground.
- Prepare field traverse plan to cover maximum doubtful areas and change areas in the field. Ensure that each traverse covers, as many doubtful and change areas, and
- Ensure 100% ground truth collection of the change areas is done and this information is required as a Point layer in GIS specifying the spot location with latitude and longitude which also needs to be linked with digital ground photos.

Steps in LULC Second Cycle Analysis

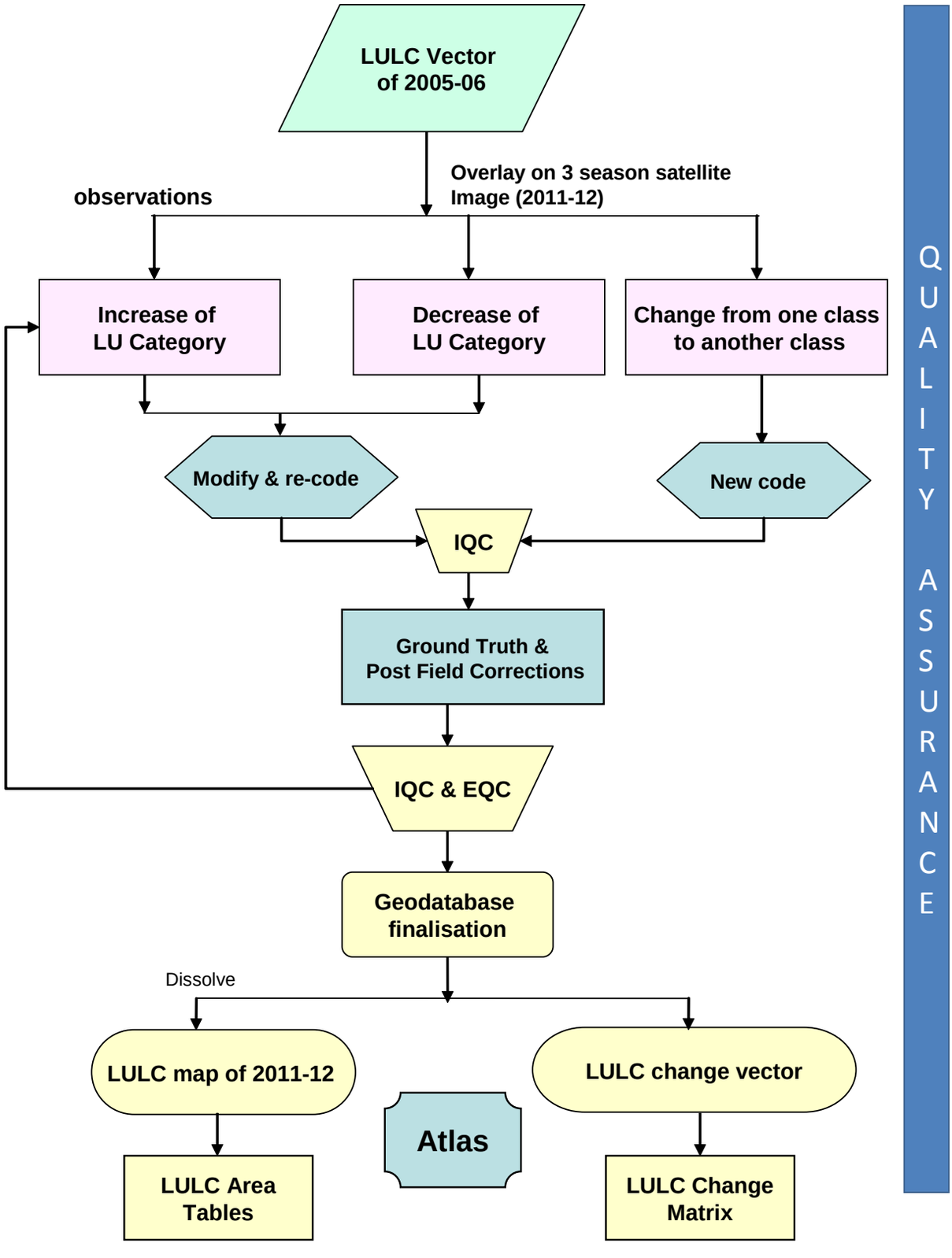


Fig 3.1. Methodology for LULC Cycle-2
Seasons of data: kharif (June-Oct.), Rabi (Dec-March) and summer (April-May).

Ground truth required for the project will be carried out using GPS, good quality camera (digital camera is preferred), hardcopies of images, and ground truth proforma developed for the project.

- Proforma based ground truth information (Annexure- III)
- Field information collected has to be later archived as softcopy information in an easily portable format (especially as comma separated text) for database compilation and for Quality Assurance.
- Geographic coordinates for the change areas visited should be recorded in Degree-Minute-Second (dd/mm/ss) format. For the purpose of recording the coordinates GPS should preferably be used In the absence of it, SOI toposheet can be used to translate the position in terms of lat. – long.
- While using GPS, each sample point locations can be marked into GPS and which can be downloaded into the computer after returning to base station. Downloaded GPS points can directly read by many GIS software packages.
- A clear picture of the landscape is to be obtained for maximum possible location so that adjacency issues are understood. In order to have better visibility of land surface feature at each ground survey point it is suggested to have photographs in the directions of sun illumination. Record the directions of photographs.
- Project field visit team should use good quality digital camera to collect geotagged photographs. An indicative specification of digital camera with inbuilt GPS and Compass in provided under Annexure – VI. A 2 minute movie clipping in AVI format is also required to be taken.

3.3.4 Satellite data preparation

- The satellite data will be supplied in 4 separate bands and a FCC image needs to be generated from these using the layer stacking tool in Image processing/ GIS software.
- Thoroughly examine the temporal data sets for the variability in signature of a particular land use / land cover type.
- An interpreter needs to identify the feature where there is a change on the Image and then modify the LULC vector.
- The vector interpreted using a particular season data can be overlaid on to other two data sets in the order of clarity in signature.
- Seasonality of a particular use and land cover type should be taken care while preparing the interpretation key.

3.3.5 Image enhancements

- Image enhancement is essential for improving the image contrast for better delineation of LULC classes. Image radiometry characteristically varies from one scene to another.
- The type of enhancement varies depending upon the scene coverage, feature type to be extracted etc. For instance major part of a scene may be covered with sea surface or snow which will have bearing on the overall contrast of the scene, which needs to be balanced.
- Color composites of different bands can yield varied levels of information due to diverse reflectance pattern in bands. Different combinations need to be considered for visual delineation of LULC classes. For detecting snow areas from clouds and irrigated / sub-surface water

logged areas, SWIR-NIR-Red (R-G-B) band combination will be of immense use.

- In general linear stretch provides optimum separation of features for normal distribution. However, based on the working experience on the study area a special enhancement (other than linear stretch) can also be used. Standardized LUT / images used for analysis have to be archived and be available for QAS.
- In order to improve the delineation of land use land cover class, specific spectral enhancement methods like Principle Component, Edge enhancement, NDVI, etc. may also be attempted. This information may be used as an add-on data set to supplement the FCC of LISS – III imagery. In such case, a noting of the additional information used has to be recorded which will be quite useful during quality check.

3.3.6 Image Interpretation

- Image interpretation is defined as 'the art of examining images for the purpose of identifying objects or surface features and judging their significance. Interpreter studies the remotely sensed data and attempts through logical processes in detecting and identifying, classifying, measuring and evaluating the significance of physical and cultural significance of spatial relationship' (Manual of Remote Sensing, Vol. 1p. 369).
- The image interpretation key provides a critical reference base for advanced interpretation. It helps the interpreter in evaluating the information in an organized and consistent manner. An image interpretation key for the study area has to be designed by Partner Institutions prior to interpretation, which can be further refined in course of interpretation. The broad image characteristics for interpreting the land use / land cover has already been discussed in the LULC 50k first cycle manual.
- Description of each land cover feature has to be provided in the key in specific reference to all interpretation elements viz., Tone, Texture, Size, Shape, Association, Pattern, etc. While delineating land use and land cover classes like waterlogged in black cotton soil area, salt-affected lands vs sands, etc. use of extra knowledge / band combinations while carrying out on screen visual interpretation is useful.
- Any land use / land cover class which is less than the minimum mapping size of 2.25 ha, may be generalized to the nearest/ surrounding class. In the example illustrated below the waterbody within a patch of Kharif crop is generalized as Kharif crop. Figure – 3.5
- Also individual smaller units of land use / land cover class which are less than 2.25 ha may be grouped into one larger class. In the example illustrated below small polygons of Built-up which are less than 2.25 ha are grouped to make a single large unit of the Built-up class. Figure -3.6.

3.3.7 LULC Data Preparation

- The LULC Vector layer of 2005-06 supplied is as per the standards required for this project. It is provided along with five fields added in its attribute table ie "LU0506", "LU_Class1", "LU11_12", "Change" and "PI_LU".
- The LULC_0506 field will be pre-coded as per the classes being followed in 2011-12 except for the Built-up Urban Class and Subclasses which needs to be re-

interpreted in the 2005-06 layer before taking up change mapping.

- All the Built-up Urban Classes (LU_Codes: 010101, 010102, 010103, 010104, 010105, 010106, 010107, 010108, 010110) needs to be merged into a single feature. This merged built up polygon then needs to be re-interpreted to classify the features as Compact, Sparse and vegetated areas (As per the classification being followed for 2011-12) based on the satellite image of 2005-06. LU_code: 010302 (mining/ quarry) needs re-interpretation to separate out Mining areas and Quarries. LU_code 040400 (Manmade grasslands) also to be appropriately recoded based on their location in altitude zone.(Alpine/ Temperate/ Tropical)
- Changed features only need to be picked up during the course of the interpretation, however if any feature is not properly classified during the earlier mapping exercise, then the feature needs to be corrected giving the correct id and to be marked as "CCIE" (Category/Class Change Interpretation Error) in the Change Field.
- As the classification system is prepared to cater the requirements of the entire country, many of the state specific classes may have been missed out. A separate item PI_LU (text) can be added into the database for recording such classes.

Table – 3.1: Classes of first cycle LULC mapping (2005-06) which needs recoding and reinterpretation

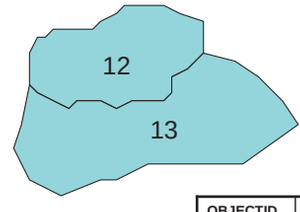
LU0506	LU_CODE	LU_Class	To be re-interpreted as
0	010101, 10102, 010103, 010104, 010105, 10106, 010107, 010108, 010110	Built Up – Urban (Subclasses)	1 (Built up – Compact (continuous), 2 (Built up - Sparse (Discontinuous), or 3 (Vegetated / Open Area)
0	010302	Built Up - Mining/ Quarry	7 (Mining – Active) 8 (Mining – Abandoned) or 9 (Quarry)
0	040400	Manmade Grasslands	28 (Alpine / Sub-Alpine) 29 (Temperate / Sub Tropical)Or 30 (Tropical / Desertic)

3.4 LULC Change

Land Use / Land Cover maps will undergo the possible changes:

- Decrease in areas (Category Change)
- Increase in areas (Category Change)
- Change from One class to another class
- No change

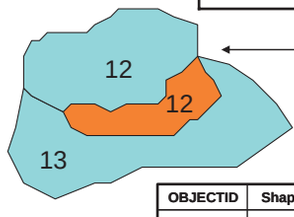
Figure - 3.2



Increase in Area (Category Change)

Attribute table

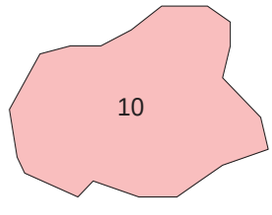
OBJECTID	Shape	LU_CODE	Description	Shape_area	LU_0506	LU_1112
1	Polygon	020103	Agricultural land- Zaid Crop	55152.85	12	Null



CUT POLYGON

OBJECTID	Shape	LU_CODE	Description	Shape_area	LU_0506	LU_1112	Change
1	Polygon	020103	Agricultural land- Zaid Crop	55152.85	12	12	NO
2	Polygon	020103	Agricultural land- Zaid Crop	23636.91	13	12	CC
3	Polygon	020104	Agricultural land- Cropped in 2 seasons	35451.12	13	13	NO

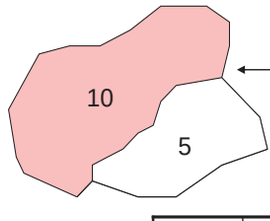
Figure - 3.3



Decrease in Area (Category Change)

Attribute table

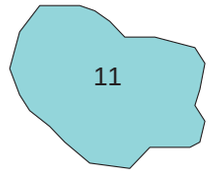
OBJECTID	Shape	LU_CODE	Description	Shape_area	LU_0506	LU_1112
1	Polygon	020101	Agricultural land- Kharif Crop	78789.76	10	Null



CUT POLYGON

OBJECTID	Shape	LU_CODE	Description	Shape_area	LU_0506	LU_1112	Change
1	Polygon	020101	Agricultural land- Kharif Crop	55152.85	10	10	NO
2	Polygon	020105	Built-up - Industrial	23636.91	10	5	CC

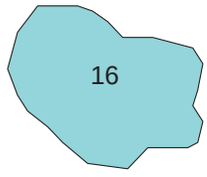
Figure - 3.4



Change from One Class to another with interpretation error

Attribute table

OBJECT ID	Shape	LU_CODE	Description	Shape_ area	LU_0506	LU_1112
1	Polygon	020102	Agricultural land- Rabi Crop	36188.55	11	Null



OBJECT ID	Shape	LU_CODE	Description	Shape_ area	LU_0506	LU_1112	Change
1	Polygon	020301	Agricultural land- Agricultural Plantation	36188.55	11	16	CCIE

3.5 Final output Generation

The land use land cover map needs to be finalized in light of the ground observations, visual interpretation keys, available ancillary and legacy data sets. Once map is finalized they need to be checked for topological and labeling errors. Edge matching of the features is to be carried out to maintain the continuity of classes between adjoining sheets. Final map will be put to accuracy evaluation by quality team. Only Quality Checked maps will be put to further processing like area estimation, mosaicing, map composition and output generation.

Paper prints will be generated for the selected areas for better visualisation. Small polygons less than 3 mm x 3 mm (2.25 ha for 1:50,000) will be filtered, after ensuring availability of crucial classes of importance. Base map features will be overlaid and then map will be generated on the layout consisting of theme map, legend, sources of data, index map, agencies involved, project name and year of publication, scale bar, north arrow. Data models will be applied to aggregate the land use land cover classes to get the maps on different scales for state / India. Transformation need to be done for land use land cover datasets to fit all district outputs in state /India framework

Map compositions in the format as prescribed under geodatabase chapter needs to be prepared for the district mosaics and state mosaics and their soft copy output and original map composition files are to be submitted.

3.5.1 LULC area statistics Generation

After finalization of LULC database district wise area statistics will be generated by applying district mask and to compute the area statistics. In addition to these district-wise area statistics generation, following are to be calculated for each district:

Net Sown Area (NSA): Net area sown represents the area sown with crops at least once in any of the crop season of the year, counting area sown more than once in the same year. So, it will be calculated as following:

NSA : Sum of area under LUCODE 020101 + 020102 + 020103 + 020104 + 020105 + 020301

Area under agriculture: NSA + area under LUCODE 020201

Gross Cropped Area (GCA): This represents the total area sown once and/or more than once in a particular year, i.e. the area is counted as many times as there are sowings in a year. This total area is also known as total cropped area or total area sown.

GCA: Sum of area under NSA + 020104 + 020105 + 020105

Cropping Intensity: Cropping intensity is defined as a ratio between net sown area (NSA) and gross cropped area (GCA). It thus indicates the additional percentage share of the area sown more than once to NSA. It may be measured by the formula-gross cropped area/ net sown area x 100. The intensity of cropping, therefore, refers to raising a number of crops from the same field during one agricultural year. The index of cropping intensity is 100 if one crop has been grown in a year and it is 200 if two crops are raised. Higher the index, greater is the efficiency of land use.

Cropping intensity = (Gross cropped area / Net sown area) x 100

As the present exercise is to capture the LULC change over 2005-06 to 2011-12 period a change matrix indicating the class wise change in LULC over the period. United Nation (2005) has defined Land Cover Matrix as " The land-cover change matrix cross-tabulates land cover at two different points in time. It shows how much of the opening stock of a land cover category is still the same in the closing stock and the gross flows between the different categories of land cover"

Output

Completed LULC database after the final quality check needs to be submitted in Geo database format for state wise mosaic.

3.6 Instructions for Cycle-2 LULC Map On 1:50K

The steps that are needed to be followed for generation of LULC map of second cycle along with the change map:

Step 1:

- Make a copy of the LULC 05-06 vector. Run a command to change the vector from a multiple part feature to a single part feature.

Under Arc Toolbox > Data Management > Features > Multipart feature to Single part feature.

- Check for the fields "LU0506", "LU_Class1" "LU11_12", "Change" and "PI_LU" and if required then add them.
- The field LU_Class1 has the LULC classes at Level I and as a drop down list. The field LU11_12 has the LULC classes at Level III as a drop down list. Appropriate class may be selected based on the feature.

Step 2:

- Check for Built-up Urban class and subclasses. It needs to be reinterpreted as Compact / Sparse and Vegetated along with Mining/Quarry class and Man made Grasslands in the 2005-06 vector layer before taking up change mapping.

- The wasteland layer of 2008-09 needs to be referred and necessary interpretation may be carried out on the LULC layer of 2011-12 before looking for change in other LULC classes.

Step 3:

- Overlay this on the 2011-12 image.
- Observe for change in the polygons (change from one class to another class). Follow this procedure grid-wise using the 15' x 15' grid provided.
- If there is an increase in polygon, then in the editor toolbar use "CUT POLYGON FEATURE" and modify the polygon.
- The new polygon thus split to be recoded in the "LU11_12" field as per Table 2.1 to an appropriate class to denote the changed class.
- In the "Change" field to enter text as 'CC' to denote Category Change. If an interpretation error is noticed, then CCIE" may be shown in Change field. Figure – 3.2

Step 4

- If there is a decrease in polygon, then in the editor toolbar use "CUT POLYGON FEATURE" and modify the polygon.
- The new polygon thus split to be recoded in the "LU11_12" field as per Table 2.1 to an appropriate class to denote the changed class.
- In the "Change" field to enter text as 'CC' to denote Category Change.
- If an interpretation error is noticed, then "CCIE" may be shown in Change field. Figure – 3.3

Step 5

- For change from one LU class to another, select the polygon and open the attribute table and recode the LU11_12 field to an appropriate class from Table 2.1.
- If the change is only to a small extent in one polygon, then to again use "CUT POLYGON" and then recode the changed area of the polygon as per Table 2.1
- In the "Change" field to enter text as 'CC' to denote Category/ Class change.
- If an interpretation error is noticed, then "CCIE" may be shown in Change field. See Figure – 3.4
- If any feature is not properly classified during the earlier mapping exercise, then the feature needs to be corrected giving the correct id and to be marked as "CCIE" (Category/Class Change Interpretation Error) in the Change Field

Step 6

- Once the recoding of the "LU11_12" field is complete for the state, then the change map between 2005-06 and 2011-12 is ready and is to be generated using the new attribute codes of "LU11_12" field.
- Ensure that all the polygons are coded at 3rd level only with the appropriate LU11_12 code (Table 2.1).
- Generate change statistics and change matrix based on the above queries.

Step 7

- Create a copy of the above vector layer and to prepare a LULC map of 2011-12,

based on the revised LU_CODE field.

- Dissolve the vector on “LU11_12” field.
- Now the map of 2011-12 is ready.
- Then generate the statistics for the Land Use / Land Cover of 2011 -12.
- Any land use / land cover class which is less than the minimum mapping size of 2.25 ha, may be generalized to the nearest/ surrounding class. (In the example illustrated below the waterbody within a patch of Kharif crop is generalized as Kharif crop. Fig. 3.5).
- Also individual smaller units of land use land cover class which are less than 2.25 ha may be grouped into one larger class. (In the example illustrated below small polygons of Built-up which are less than 2.25 ha are grouped to make a single large unit of the Built-up class. Figure – 3.6).

Table 2.1 lists the change categories of 2011-12 and their associated codes to be used in the “LU11_12” field (Short Integer). This field only needs to be recoded to depict the change seen in the year 2011-12.

NOTE: While coding/ recoding the First level LULC class from the field “LU_Class1” needs to selected and then the appropriate Third level class in the LU11_12 field should be selected from the drop down menu. Only after this the Change field gets activated.

Change” Field (Text, width = 5) should contain text ‘CC’ for Category/ Class Change, ‘CCIE’ Category Change Interpretation error and ‘NO’ for No change.

After the coding of the field LU11_12 is complete, the LU_Code and the LU_Class (for Description) field as given under Table 2.1 needs to be calculated using a common LUT .

Figure -3.5

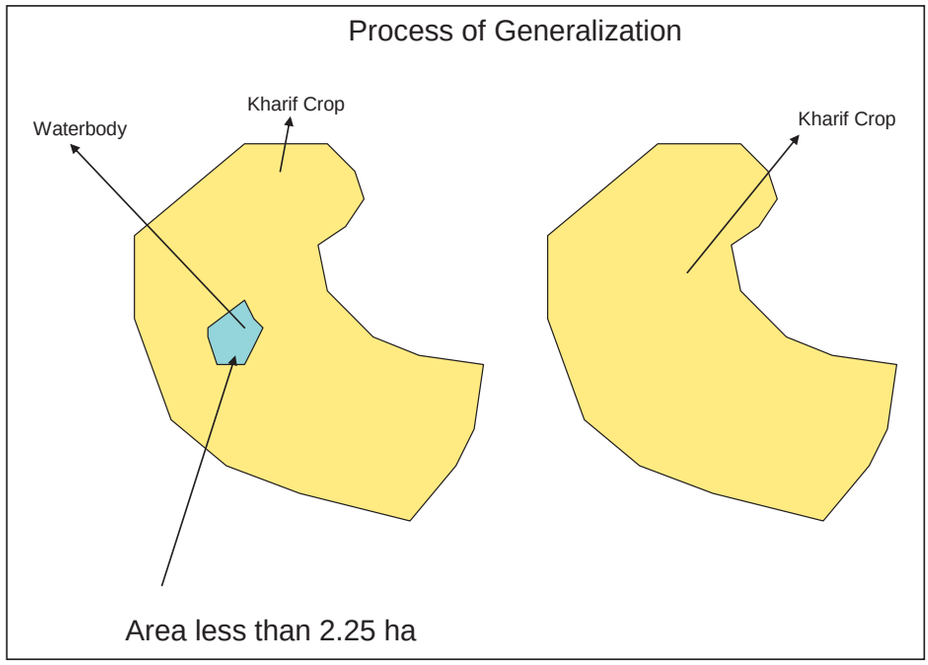
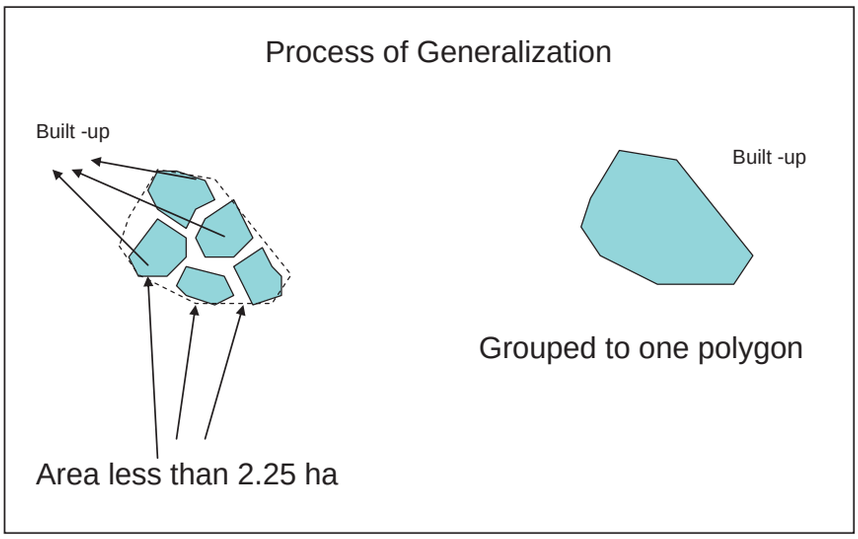
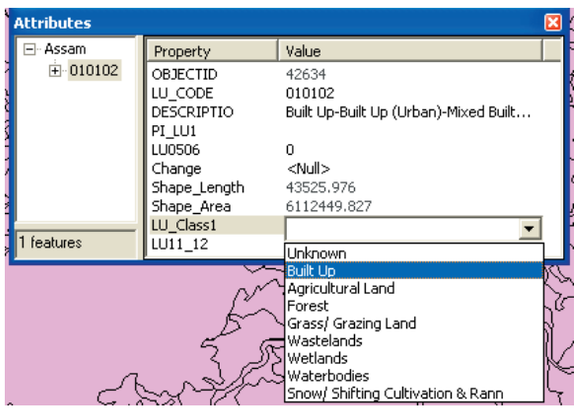


Figure -3.6





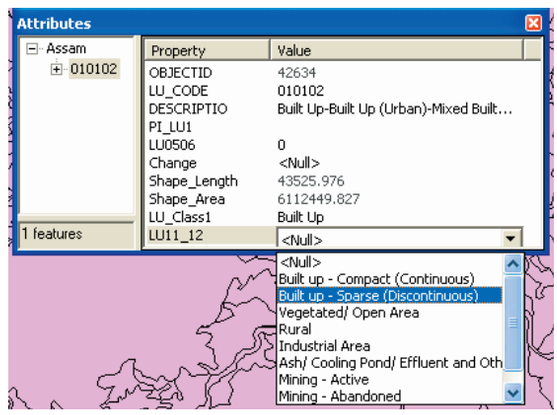


Table 3.2: Change code and corresponding Type of change

Change Code	Type of Change
CC	Category/ Class change
CCIE	Category/ Class change Interpretation Error
NO	No Change

Partner institutions need to submit the Monthly Progress reports in the prescribed format (Annexure IV) by 10th of every month.

3.7 Accuracy Assessment

A comprehensive accuracy assessment protocol will be followed for determining the quality of information derived from remotely sensed data. Accuracy assessment involves determination of thematic (classification) as well as locational accuracy. In addition GIS database(s) contents will also be evaluated for accuracy. Methodological details of accuracy assessment are given in the following sections.

3.7.1 Thematic Accuracy

Accuracy assessment will be done for each state. All the Land Use Land Cover categories will be numbered map-wise and sample chosen for field verification using the following Equation (Jensen 1986):

Sample Size

N= 4 pq' / E2

Where p is the expected percent accuracy (90 %), q' = difference between 100 and p. E is the allowable error, and N the number of points to be sampled. It is planned to ensure

10 % sample for LULC of each state and also all the LU/LC categories present in the state.

ii) Accuracy Estimation

Classification accuracy expected for various LU/LC categories is 90 percent at 90 percent confidence level. This will be tested on a sample basis assuming a binomial distribution. All the mapped LU/LC categories will be field verified and tabulated in contingency matrix in the following manner:

Total Accuracy: Number of correctly identified LU classes/total number of LU classes

Accuracy = {(60+14+8) / 100} * 100

Similarly, accuracy for each LU/LC category will be determined.

Accuracy Estimation for determining the User accuracy and Producer accuracy needs to be calculated for the second cycle mapping. For the detailed procedure please refer to the Manual on Land Use/ land Cover of the First Cycle mapping. A minimum of 135 points per each district may be selected and checked for interpretation quality and consistency of interpretation.

Table 3.3: Contingency table for assessment of Classification Accuracy

	LU/LC type determined from field/reference data				
LU/LC Type identified and mapped		Built Up	Cropland	Waterbodies	Totals
	Built Up	60	5	2	67
	Cropland	6	14	0	20
	Waterbodies	2	3	8	13
	Totals	68	22	10	100

Chapter - 4
QUALITY ASSURANCE MECHANISM AND ACCURACY STANDARDS

4.1 Quality Assurance Mechanism and Accuracy Standards

The project envisages mapping of land use / land cover under three-fold classification system using visual analysis technique at 1:50,000 scale. Since the project is being carried out at national level, the output plays an important role for effective utilization. Further, the output generated under this project will go into the Natural Resources Information System (NRIS) as an input, which can be used for various applications. Hence, the geographic integrity of output is very important. To accomplish this task, quality of the output is ensured by carrying out the quality checks at various stages of the product generation. The quality assurance at various stages is discussed:

4.2 Input data

Satellite data: The input data for this project is terrain corrected Resourcesat-2 data supplied by NRSC data centre (NDC). In the absence of R2 data geo rectification of IRS-P6 data will be done at NRSC and sent to the partner institutes.

Seasons of data: Kharif (June-Oct), Rabi (Dec-March) and Summer (April-May).

Data selection: Partner Institutions will select / suggest three seasons Satellite data by browsing.

NRSC also will carry out / support this activity as and when required, due to difficulties at PI level.

PI will ensure the complete data coverage for their study area after receiving all the three data sets.

LULC Cycle-1 data: NRSC will supply this data to Partner Institutions. after recoding and including three more columns in the attribute table.

4. Image analysis and interpretation

The executing PI should have two teams-

- one for quality check and the
- other to carryout mapping.

PIs will be informed that the persons involved in the quality should not be included in the mapping and vice versa.

4.3.1 Pre-field visual interpretation

It will be done as per the technical manual instructions following the Classification scheme and Methodology.

Preliminary visual interpretation tiles should be checked 100 % by internal quality control team at PI in the given format (Annexure-II).

4.3.2 Ground truth collection

Information collected through ground data forms enables improvements in classification accuracy, confidence level and estimates. It

should be done in tiles where changes have taken place.

The ground truth information collected in the prescribed proforma (Annexure III) should be verified.

Ground truth need to be collected in the tiles cleared by internal quality team.

Maximum change areas as suggested in the methodology need to be visited by PI.

Collected information should be shown during internal as well as external quality checks.

4.4 Geo-data base creation

The NNRMS standards finalized for Natural Resources Repository (NRR) will be adapted in this project. Quality checks should be carried out at above-mentioned stages in a systematic manner by the EOQCT. The remarks of the Quality Control Team should be recorded in the prescribed format (Annexure II) with specific recommendations.

In the current project a two-fold quality assurance mechanism is adopted namely Internal Quality Control and External Quality Control.

4.5 Internal Quality Control

4.5.1 At NRSC Level

All the satellite data products are quality checked (Data Processing, NRSC) before they are sent to Partner Institutes.

4.5.2 At Partner Institute Level

At the PI level two teams will be identified – Internal Quality Control Team (IQCT) and Mapping team. The persons involved in the quality team will not be included in the mapping and vice versa.

The input will be given to the Mapping Team (MT) who carries out the mapping work as per the guide lines provided in the technical manual. IQCT should monitor and check the quality of the work done by Mapping Team at various stages of project execution namely visual interpretation, ground truth collection, output products including Metadata and Geo-data base creation. The internal quality check (QC) will be carried out in the format (Annexure-II) provided in this manual. Once the IQCT clears the outputs and other intermediaries, the External Quality Audit Team (EQAT) will evaluate the quality assurance of the product.

4.6 External Quality Control

To accomplish the external quality checks, an External Quality Audit team (EQAT) identified by Project Director of NRC will be the principal scientist of the respective states. EQAT will select a minimum of 20% of the products at random for quality assurance. The products whose samples do not meet the quality standards were returned to PI for incorporation of necessary corrections as suggested by EQAT. It will be responsibility of the IQCT to incorporate all the suggestions made by EQAT. If the quality is not met in these randomly drawn areas, the entire lot will be rejected. When a revised quality evaluation is conducted again by EQAT, the areas again will be drawn at random. They may or may not be the same as the previously drawn lot. Only those outputs meeting the accuracy standards will be cleared for incorporation in the geo database.

4.7 Output Products Including Metadata

The output data need to be checked for the seamlessness with adjacent maps. The check will be carried out for both continuity of the mapping using and thematic accuracy. To assess the quality a 15' x 15' grid will be overlaid on the output data and approved number of random points, as defined in the methodology chapter, will be generated in each of the grid. The thematic accuracy will be visually assessed at these points and reported in the format given below:

4.8 GIS Database Standard

The quality of the repository depends on the GIS database. It is a result from the digitalization of outputs and inputting of thematic maps into the GIS database of the NNRMS repository. To maintain utmost quality of the GIS database, stringent parameter values have been considered in NNRMS standards. Both raster (Image) as well as vector data need to submitted to GIS database. The raster data should contain enhancement LUT file and file having X,Y pairs of points used for geo-rectification. Thirteen basic parameters are identified in the NNRMS GIS Data Base Standards and they are given below:

4.9 Project Execution

Timeliness is important for successful project execution. Respective team leaders at Executing Organization (EO) (PI) will conduct informal periodic reviews and the progress made will be monitored closely and recorded along with the reasons for non-compliance of time targets, if any. The progress made, along with the progress reports, will be presented in the project review meetings held at appropriate places and the minutes of the meetings will be with both the EO and NRSC.

The following table summarizes the quality check parameters of output product.

Sl No	Parameter	Standard
1	Spatial framework	National / State
2	Tie-Point Intervals for Spatial Framework	5' X 5'
3	Coordinate units for Precision	Decimal-Seconds
4	Projection for GIS database	LCC / TM
5	Datum	WGS 84
6	Position (Planimetric) Accuracy (1mm of scale)	50m
7	Sliver Polygon Tolerance (SPT) (Less than MMU)	< 2.25ha
8	Thematic accuracy of mapping	90/90
9	Grid size (for all rasters)	24.0m

Chapter - 5

Database Organization and Management

In order to realize the numerous benefits from multiple cycle archival data, judicious organization and management of the voluminous spatial database that steadily grows with each year is very crucial. Recent state-of-the-art technology solutions and emerging trends contributes a great deal in designing and implementing highly functional geo-databases. Designing, planning and implementing geospatial databases encompasses a detailed study of the process flow, interfaces to other project activities, input data sources, essential technology elements, data organization schema, GUI design for user interaction, envisaged output products, access control policies, data sharing / transfer modalities and compatibility with national- level databases like National Resource Repository (NRR). Geo-spatial database creation is more encompassing with a long-term view of the data handled under the project. This also encompasses identifying the important data sets that need to form part of the spatial database, designing the necessary hardware and software architectures, establishing the mandatory standards and procedures to be followed, and deploying the developed data services for optimal utilization through web services.

5.1 National Spatial Framework (NSF)

The definition of the National Spatial Framework (NSF) is the most critical aspect for seamlessness of the multi-scale spatial database of the repository. The NSF for LULC 50K data sets has been already designed as per NNRMS framework in phase I of the project. The same NSF will be adopted for second cycle of the project. The phase I outputs of LULC 50K project were created using LCC/TM projections system and WGS84 datum where measurements can be made in projected coordinates i.e. meters (Fig. 5.1). The spatial extent shall be the area of eastern longitudes in between 68d & 98d and the northern latitudes in between 6d & 38d (Fig. -5.2).

5.2 Database Organization

The databases of LULC 50K project consists of raster data (satellite and ground truth images), thematic data (existing LULC data, base layers etc) and ground truth data. The database will be organized in a central storage system (NAS or SAN) at NRSC and also in Geo-RDBMS environment for web hosting and further sharing and disseminations. It is also proposed to prepare a centralized repository of ground truth data namely field photographs, field observation data and metadata etc. The each mapping organization has to upload these data sets to the centralized server system through a web application or submit to NRSC at end of the mapping season. These ground truth data sets will be used during QC of the spatial data sets. List of different data category as a part of LULC 50 K repository is shown in Table 5.1.

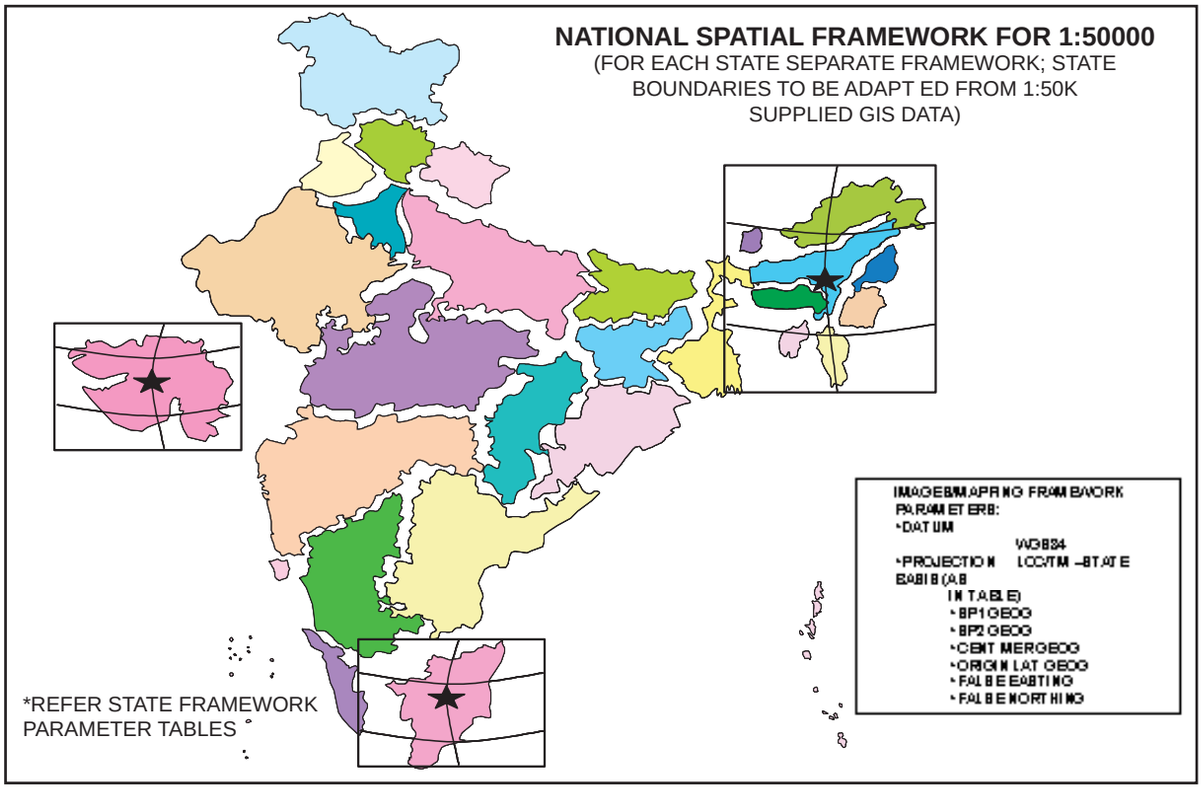


Figure – 5.1: National Spatial Framework (NSF) from NNRMS

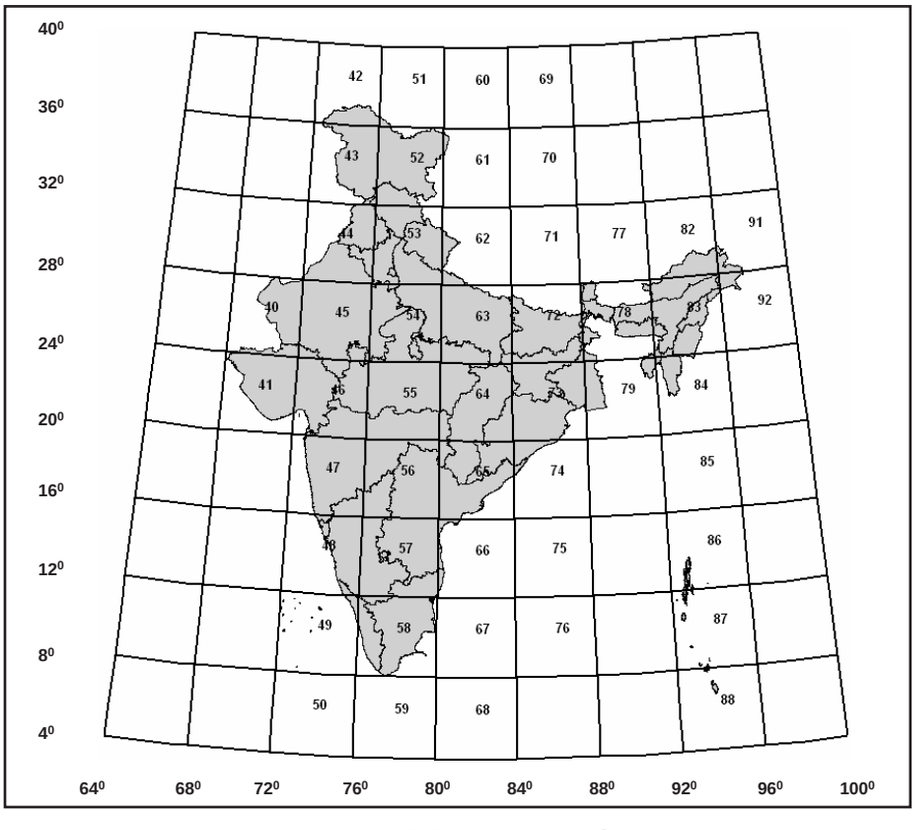


Figure – 5.2: India on NSF

The satellite data will be organized scene wise. The LULC layer will be organized as a district mosaic and finally as a state mosaic in GIS file format. The final vector layers will be stored and organized in geo-RDBMS environment at NRSC as a central repository. *The base layers (e.g.- administrative boundaries, infrastructure layers) available with the Partner Institutions along with spatial framework which were used during 1st mapping cycle (with recent updates) are to be used.*

One of the most important design considerations of a geo spatial database is the formulation of a naming scheme for uniquely identifying each dataset that is stored in the geo-database. Towards this, naming conventions are evolved for LULC 50K project. These conventions are also useful for unambiguous data transfer and sharing among the different processing activities right from geo-rectification of satellite data to final geo-database creation. Two letter state codes are used for file naming.

Table 5.1. Data categories and their mode of generation.

S. No.	Data category	Data	Category	Source
1	Rectified LISS - III scenes	format	code	NRSC
2	Land use land cover data (district mosaic)	Raster	REC	Partner Institution
3	Land use land cover data (state mosaic)	Vector	LULC	- do -
4	Field Photos (GIS point layer)	Vector	LULC	- do -
5	Ground truth forms	MS-Excel	FPS	- do -

5.2.1 Satellite Data – Raster

The satellite data of this project is rectified Resourcesat 2-LISS III data for year 2011-12. The central repository is also consists of Resourcesat 1- LISS III data for year 2005-06 by using which cycle 1 of LULC 50K mapping project has been completed.

Naming conventions
Scene wise:

Table 5.2 satellite data- scene wise organization

Information Type	Value	Example
Satellite	2 Char	Resourcesat 1 / 2 as R1 or R2
Sensor (l3)	2 char	l3
Radiometry	3 char	10B
Path	3 char	104
Row	2 char	54
Date	7 char	14oct08

Example files name- r2_l3_10B_104_54_14oct11.xxx

5.2.2 Thematic Data - Vector

The output of the project is land use/land cover map data of India in vector data format. The LULC data of previous cycle is stored in shape file format (.shp) version 5 and managed in geo-RDBMS environment as a central repository at NRSC. The LULC maps of second cycle are also planned to create and manage in similar fashion. The mapping organization has to follow the guidelines for creation of LULC data and attribute codification scheme for creation and organization of LULC data sets.

Naming conventions

District wise:

Table 5.3 Thematic data- district wise organization

Information Type	Value	Example
Category	4 char	lulc
State	2 Char	For Andhra Pradesh- ap
District	4Char	GUNT for Guntur.
Calendar Year	4 Char	1112 for 2011-2012

Example files name- lulc_ap_gunt_1112.shp

State wise:

Table 5.4Thematic data- State wise organization

Information Type	Value	Example
Category	4 char	lulc
State	2 Char	For Andhra Pradesh- ap
Calendar Year	4 Char	1112 for 2011-2012

Example files name- lulc_ap_1112.shp

Coding Convention:
The LULC map generated under this project has to follow a coding convention in the attribute of shape file. The two attributes i.e. LU_CODE and LU_CLASS are necessary required. The intermediate or unnecessary attribute must be deleted before final submission of data. The sample attributes in the state level LULC map are shown in Fig 5.4:

5.3 Base Layers - Vector

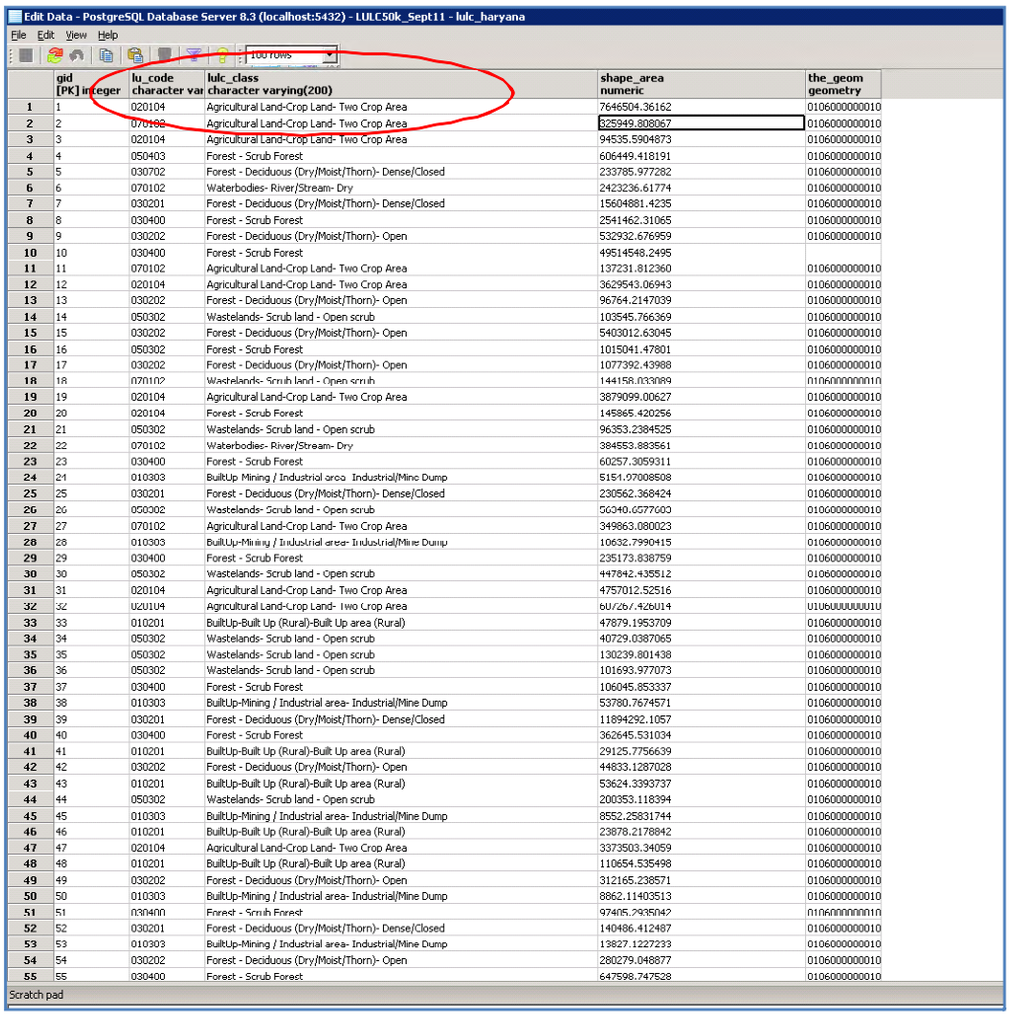
The base layers which are available with individual partner Institutions (Table – 5.5) are to be used for this project. The necessary updation with latest satellite imagery is to be carried out.

Table 5.5

S. No.	Data Category
1	Administrative boundaries
2	Road network
3	Rail network
4	Settlements

The base layers used in this project need to be submitted to NRSC in shape file format with proper naming convention.

Example files name- state_ap_bound.shp



Edit Data - PostgreSQL Database Server 8.3 (localhost:5432) - LULC50k_Sept11 - lulc_haryana

File Edit View Help

100 rows

	gid [PK] integer	lu_code character var	lulc_class character varying(200)	shape_area numeric	the_geom geometry
1	1	020104	Agricultural Land-Crop Land- Two Crop Area	7646504.36162	0106000000010
2	2	070102	Agricultural Land-Crop Land- Two Crop Area	325949.808067	0106000000010
3	3	020104	Agricultural Land-Crop Land- Two Crop Area	94535.5904873	0106000000010
4	4	050403	Forest - Scrub Forest	606449.418191	0106000000010
5	5	030702	Forest - Deciduous (Dry/Moist/Thorn)- Dense/Closed	233785.977282	0106000000010
6	6	070102	Waterbodies- River/Stream- Dry	2423236.61774	0106000000010
7	7	030201	Forest - Deciduous (Dry/Moist/Thorn)- Dense/Closed	15604881.4235	0106000000010
8	8	030400	Forest - Scrub Forest	2541462.31065	0106000000010
9	9	030202	Forest - Deciduous (Dry/Moist/Thorn)- Open	532932.676959	0106000000010
10	10	030400	Forest - Scrub Forest	49514548.2495	
11	11	070102	Agricultural Land-Crop Land- Two Crop Area	137231.812360	0106000000010
12	12	020104	Agricultural Land-Crop Land- Two Crop Area	3629543.06943	0106000000010
13	13	030202	Forest - Deciduous (Dry/Moist/Thorn)- Open	96764.2147039	0106000000010
14	14	050302	Wastelands- Scrub land - Open scrub	103545.766369	0106000000010
15	15	030202	Forest - Deciduous (Dry/Moist/Thorn)- Open	5403012.63045	0106000000010
16	16	050302	Forest - Scrub Forest	1015041.47801	0106000000010
17	17	030202	Forest - Deciduous (Dry/Moist/Thorn)- Open	1077392.43988	0106000000010
18	18	070102	Wastelands- Scrub land - Open scrub	144158.033089	0106000000010
19	19	020104	Agricultural Land-Crop Land- Two Crop Area	3879099.00627	0106000000010
20	20	020104	Forest - Scrub Forest	145865.420256	0106000000010
21	21	050302	Wastelands- Scrub land - Open scrub	96353.2384525	0106000000010
22	22	070102	Waterbodies- River/Stream- Dry	384553.883561	0106000000010
23	23	030400	Forest - Scrub Forest	60257.3059311	0106000000010
24	24	010303	BuiltUp-Mining / Industrial area- Industrial/Mine Dump	5151.97008508	0106000000010
25	25	030201	Forest - Deciduous (Dry/Moist/Thorn)- Dense/Closed	230562.368424	0106000000010
26	26	050302	Wastelands- Scrub land - Open scrub	56040.6577600	0106000000010
27	27	070102	Agricultural Land-Crop Land- Two Crop Area	349863.080023	0106000000010
28	28	010303	BuiltUp-Mining / Industrial area- Industrial/Mine Dump	10632.7990415	0106000000010
29	29	030400	Forest - Scrub Forest	235173.838759	0106000000010
30	30	050302	Wastelands- Scrub land - Open scrub	447842.435512	0106000000010
31	31	020104	Agricultural Land-Crop Land- Two Crop Area	4757012.52516	0106000000010
32	32	020104	Agricultural Land-Crop Land- Two Crop Area	607267.426014	0106000000010
33	33	010201	BuiltUp-Built Up (Rural)-Built Up area (Rural)	47879.1953709	0106000000010
34	34	050302	Wastelands- Scrub land - Open scrub	40729.0387065	0106000000010
35	35	050302	Wastelands- Scrub land - Open scrub	130239.801438	0106000000010
36	36	050302	Wastelands- Scrub land - Open scrub	101693.977073	0106000000010
37	37	030400	Forest - Scrub Forest	106045.853337	0106000000010
38	38	010303	BuiltUp-Mining / Industrial area- Industrial/Mine Dump	53780.7674571	0106000000010
39	39	030201	Forest - Deciduous (Dry/Moist/Thorn)- Dense/Closed	11894292.1057	0106000000010
40	40	030400	Forest - Scrub Forest	362645.531034	0106000000010
41	41	010201	BuiltUp-Built Up (Rural)-Built Up area (Rural)	29125.7756639	0106000000010
42	42	030202	Forest - Deciduous (Dry/Moist/Thorn)- Open	44833.1287028	0106000000010
43	43	010201	BuiltUp-Built Up (Rural)-Built Up area (Rural)	53624.3393737	0106000000010
44	44	050302	Wastelands- Scrub land - Open scrub	200353.118394	0106000000010
45	45	010303	BuiltUp-Mining / Industrial area- Industrial/Mine Dump	8552.25831744	0106000000010
46	46	010201	BuiltUp-Built Up (Rural)-Built Up area (Rural)	23878.2178842	0106000000010
47	47	020104	Agricultural Land-Crop Land- Two Crop Area	3373503.34059	0106000000010
48	48	010201	BuiltUp-Built Up (Rural)-Built Up area (Rural)	110654.535498	0106000000010
49	49	030202	Forest - Deciduous (Dry/Moist/Thorn)- Open	312165.238571	0106000000010
50	50	010303	BuiltUp-Mining / Industrial area- Industrial/Mine Dump	8862.11403513	0106000000010
51	51	030400	Forest - Scrub Forest	97405.2935042	0106000000010
52	52	030201	Forest - Deciduous (Dry/Moist/Thorn)- Dense/Closed	140486.412487	0106000000010
53	53	010303	BuiltUp-Mining / Industrial area- Industrial/Mine Dump	13827.1227233	0106000000010
54	54	030202	Forest - Deciduous (Dry/Moist/Thorn)- Open	280279.048877	0106000000010
55	55	030400	Forest - Scrub Forest	647598.747528	0106000000010

Scratch pad

Figure 5.4- Coding convention for LULC data

5.4 Statistics

The LULC statistics at districts and state level will be stored in .xls file and finally it will organize in RDBMS environment. The mapping organization has to submit district and state level statistics to NRSC.

5.5 Ground truth data

The ground truth data is one of the important output of LULC 50K project. The ground truth collection and field photographs are also stored and managed at central server system at NRSC. In the second cycle of LULC project it is proposed to prepare a centralized repository of ground truth data namely field photographs, field observation data and metadata etc. Each mapping organization has to upload or provide these data sets to the centralized server system through a web application. These ground truth data sets will be used during QC of the spatial data sets.

Naming conventions

Field Photographs File naming:

Table 5.6

Information Type	Value	Example
Category	3 char	FPS
State	2 Char	For Andhra Pradesh- ap
Season	4 Char	krif/ rabi/ zaid
Date	6 Char	4th May 2012 as- 040512
Photo number	3 Char	For photo no 1- 001

Example files name- fps_ap_krif_040512_001.jpg

Geographic information of field Photographs (Mandatory):

The field photograph taken during ground truth must be geo tagged as per guidelines given in table 5.6 & table 5.7. The geo tag information will be stored in .xls file as per defined fields in table 5.8. This excel worksheet along with jpg file must be submitted to NRSC either through a website provided for this purpose or through email/CD immediately after completion of ground truth.

Table 5.7 Description of geo tagging elements

Information Type	Value	Example value
Unique ID	UID	AP001
Unique File name	FPS_File	fps_ap_krif_040512_001.jpg
Latitude	LAT	160 37’ 40.74” N
Longitude	LONG	800 40’ 28.13“ E
Observation	Text	Descriptions or any specific observation.
Class	6 Char	020104 for Agriculture crop land Cropped in 2 seasons

The table containing the information about field photographs may look like:

Table 5.8- Sample table for geo tagging of field photographs

UID	FPS_File	LAT	LONG	Class	Recorded
AP001	fps_ap_ krif_040512_001.jpg	160 37’ 40.74” N	800 40’ 28.13“ E	030201	Forested area.
AP002	fps_ap_ krif_040512_002.jpg	160 36’ 38.35” N	800 43’ 30.39“ E	020104	Agriculture land with kharif crop.
AP003	fps_ap_ krif_040512_003.jpg	160 42’ 18.15” N	800 55’ 39.67“ E	010303	Meerjapuram Builtup area.

Geo tag table File naming:

Category (ground Truth) -	3 chars	gtr
State -	2 chars	ap
Season (krif/ rabi/ zaid)	4 chars	Krif
Calendar year -	4 chars	1112
File Number	2 chars	01

Example files name- gtr_ap_krif_1112_01.xls

5.6 Metadata creation

NRR/ NSDI activity has clearly defined a number of data structuring mechanisms for efficient management of geospatial databases by means of standardized metadata content. Since significant efforts have already gone into the NNRMS database design, it is appropriate to design the LULC – 50K database also in conformity with that of NNRMS. This not only helps in leveraging the already defined standards, but also to easily generate NRR/ NSDI compatible outputs from the project database as and when required to contribute, share or transfer data sets to NSDI nodes. The NSDI metadata standard version 2.0 is used for creation of metadata for satellite and thematic data for cycle 1 of LULC 50K project where nine essential elements are required out of 27 defined elements.

Table 5.9 Sample Metadata for LULC 50K map of Uttarakhand

Field name	Description
ABSTRACT DATA INFORMATION	
MD METADATA IDENTIFICATION	The map service is on Land Use/Land Cover map of India on 1:50,000 scale and published under BHUVAN web portal of NRSC, ISRO. The maps are generated using multi-season satellite data of IRS LISS-III sensor for the year 2011-12.
CITATION INFORMATION	
DATA PREPARED BY	National Remote Sensing Centre, ISRO Hyderabad, with the participation of TERI University, Delhi and Uttarakhand Space Application Centre, Dehra Dun
ORIGINAL SOURCE	NRC-LULC 50K Project
SOURCE SCALE AND DATE	1:50,000 and 2011-12
MAPPING YEAR	2011-2012
DIGITIZING YEAR	Not Applicable
ASSOCIATED PROJECT PREPARING DATA	NRC-LULC 50K Project
ASSOCIATED PUBLICATION	Project Reports and Land Use/Land Cover Atlas of India by Land Use and Cover Monitoring Division, LRUMG, RSA, NRSC, Hyderabad
EMAIL	ddrsa@nrsc.gov.in
AFFLIATION	Project Director and Deputy Director, RSA
CORPORATE NAME	National Remote Sensing Centre, ISRO
CORPORATE ADDRESS	Balanagar, Hyderabad, India

Field name	Description
CONTACT INFORMATION	
CONTACT PERSON	Project Director/Deputy Director, RSA
ORGANIZATION	National Remote Sensing Centre, ISRO
MAILING ADDRESS	Balanagar, Hyderabad
CITY	Hyderabad
COUNTRY	India
TELEPHONE	+914023884101
FAX	+914023884259
EMAIL	ddrsa@nrsc.gov.in
COVERAGE INFORMATION	
COVERAGE X MIN	75.575
COVERAGE X MAX	79.042
COVERAGE Y MIN	28.709
COVERAGE Y MAX	31.467
COVERAGE T LATE	Not Applicable
COVERAGE T EARLY	Not Applicable
COVERAGE PLACE NAME	India
COVERAGE PERIOD NAME	October,2011 - September,2012
COVERAGE SPATIAL RESOLUTION	24 meter
COVERAGE SPATIAL GEOREFERENCE	GCS WGS-84
COVERAGE SPATIAL AGGRAGATION	2011-2012
COVERAGE TEMPORAL PRECISION	Not Applicable
COVERAGE TEMPORAL INTERVAL	5 Years
COVERAGE TEMPORAL AGGRAGATION	Not Applicable
COVERAGE NOTE	Entire India
COVERAGE ALTERNATIVE METADATA	Not Applicable
DATA IDENTIFICATION INFO	
NAME OF DATASET	LULC Map of Uttarakhand - 2011-12
NAME OF DATA	LULC1112
THEME	Land Use/Land Cover
KEYWORDS	LULC, LISS-III, Remote Sensing, GIS, ISRO, 1:50000, Land Use, Land Cover, 2011-2012
ACCESS CONSTRAINTS	Unrestricted
USE CONSTRAINTS	As per data and web service policy published in http://www.bhuvan.nrsc.gov.in
PURPOSE OF CREATING DATA	Scientific assessment of Land Use/Land Cover and generating digital database along with change analysis using 3-season Resourcesat-2 LISS-III satellite data.
DATA TYPE	Vector

Field name	Description
DATA QUALITY	
LOGICAL CONSISTENCY REPORT	Not Available
COMPLETENESS REPORT	Available
PROCESS DESCRIPTION	The multi-temporal georeferenced IRS LISS-III satellite data having 24 meters spatial resolution was acquired for Kharif, Rabi and Zaid seasons of 2011-12. Satellite data was interpreted using the visual interpretation techniques as per the classification methodology given in the LULC Manual.
PROCESS DATE	2011-12
SOURCE ORIGINATOR	NRSC, ISRO
SOURCE PUBLICATION DATE	November,2012
SOURCE TITLE	LULC Map of India 2011-12
SOURCE ONLINE LINKAGE	http://www.bhuvan.nrsc.gov.in
SOURCE SCALE DENOMINATOR	50,000
TYPE OF SOURCE MEDIA	online
SOURCE TIME PERIOD OF CONTENT	2011-2012
SOURCE CORRENTNESS REFERENCE	Not Available
SOURCE CITATION ABBREVIATION	Not Available
SOURCE CONTRIBUTION ATTRIBUTE ACCURACY REPORT	Stratified random points generated were used to assess the accuracy of the classification. The number of sample points for each class is selected on the basis of proportion of the area of the class in the image. However, a minimum of 10% of total polygons were checked for assessment of the accuracy for each state. Ground truth data, legacy maps, and multi-temporal FCC have formed the basis for assessment and generation of Kappa co-efficient. The Kappa accuracy is found to be about 90% and each class's accuracy is about 85%.
HORIZONTAL POSITIONAL ACCURACY REPORT	For products covered in the plain terrains an accuracy of less than one pixel (24 meters) and for hilly regions 2 to 3 pixels is achieved.
VERTICAL POSITIONAL ACCURACY REPORT	Not Applicable

Field name	Description
DATASET TOPIC CATEGORY INFORMATION	
MD METADATA IDENTIFICATION	Bhuvan
MD DATAIDENTIFICATION TOPIC	Dissemination and sharing of Geo-spatial information derived from IRS data on Land Use and Land Cover of India
LANGUAGE INFORMATION	
LANGUAGE ISO0639 2BSH	English
METADATA DATE STAMP	
MD METADATA DATE STAMP	01/11/2012
ONLINE RESOURCE	
ONLINE RESOURCE	http://www.bhuvan.nrsc.gov.in
QUICKLOOK	
QUICKLOOK of Uttarankhand.jpg	

Note: All the elements in Table 5.9 are essential. The mapping organization has to fill all the fields and submit it along with final LULC map and state mosaic satellite data.

The typical file naming convention for metadata file will be as shown below:

- Meta_lulc_uk_1112. xls (for state mosaic of LULC data- Uttarkhand)
- Meta_r2_l3_uk_1112.xls (for state mosaic of satellite data- Uttarkhand)

5.7 Preparation of Data for map product generation

The LULC map products in printable form as atlas are planned at state and district level. The sample template for State and District level LULC map are shown in Figure 5.5 and Figure 5.6.

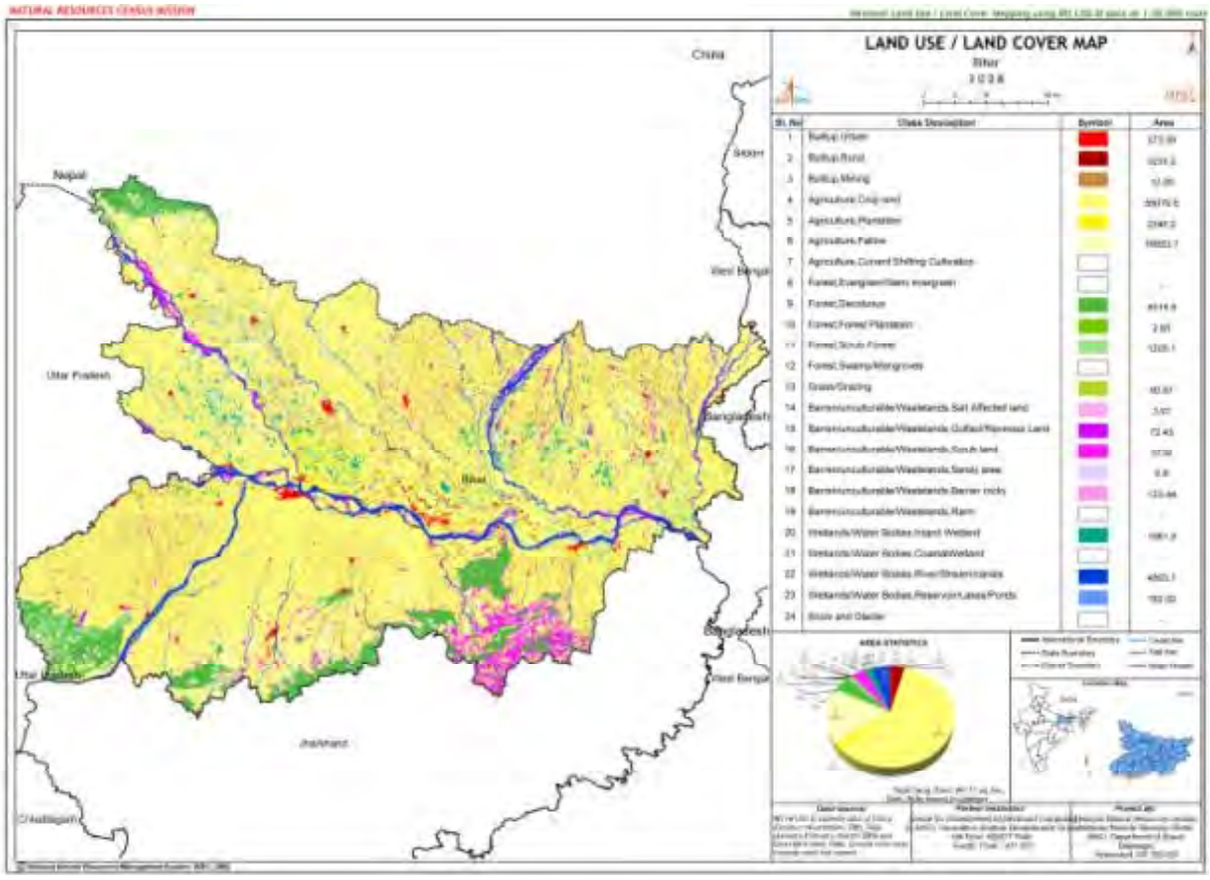


Figure 5.5 Template for state level LULC map product- Bihar state

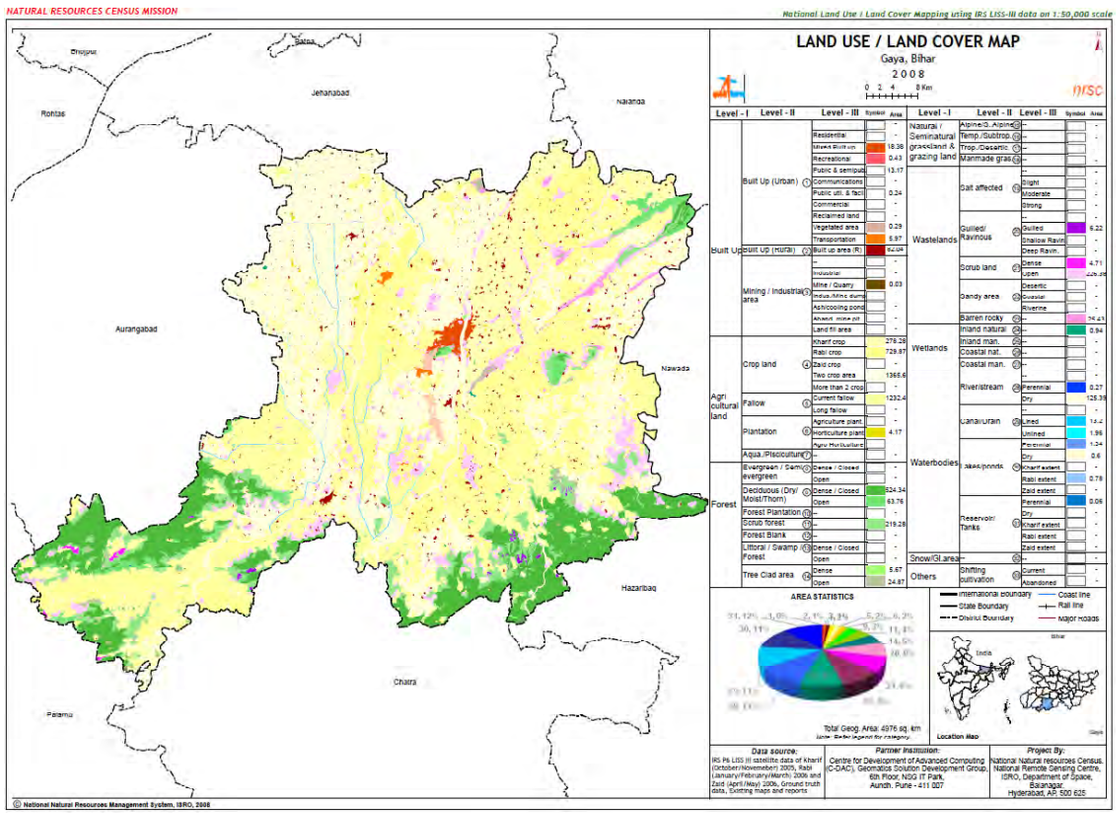


Figure 5.6 Template for District level LULC map product- Gaya district of Bihar

Chapter - 6

PROJECT ORIENTATION WORKSHOP

It is proposed to have regional workshops which will be organized to give an insight into the classification scheme, methodology and database organization. There will be hands-on training for interpretation and modifying the layer as per the current three season data acquisition.

The attendance sheet format to be completed after the conducting the workshop is given as below:

Sl. no.	Name	Organisation	Signature
1			
2			
3			
4			
5			
6			
7			
8			

After the training process, the effectiveness will be confirmed, through the feedback sheet as given in Annexure - V

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ANNEXURES

Natural Resources Census - LULC 50K Mapping (2nd Cycle) - Classification

Sl. No.	Level 1	Level 2	Level 3	Sl. No.	Level 2	Level 3	
1	Built Up	Urban	Residential	1 / 2	Urban Built-up	Built up - Compact (Continuous)	Built up - Sparse (Discontinuous)
2			Mixed builtup				
3			Recreational				
4			Public / Semi Public				
5			Communication				
6			Public utilities / facility				
7			Commercial				
8			Reclaimed				
9			Transportation				
10			Vegetated Area	3		Vegetated / Open Area	
11		Rural	Rural	4	Rural	Rural	
12		Mining / Industrial Area	Industrial	5	Industrial	Industrial area	
13			Mine / Quarry	6		Ash / Cooling pond / effluent and other waste	
14			Industrial / Mine dump				
15			Ash / Cooling pond	7	Mining / Quarry	Mining – Active	
				8		Mining - Abandoned	
16			Abandoned Mine Pit	9		Quarry	
17			Land fill area				

Sl. No.	Level 1	Level 2	Level 3	Sl. No.	Level 2	Level 3
18	Agricultural land	Crop Land	Crop Land	10	Crop Land	Crop Land
19			Rabi	11		Rabi
20			Zaid	12		Zaid
21			Two cropped	13		Cropped in 2 seasons
22			More than two cropped	14		Cropped in >2 seasons
23		Fallow Land	Current	15	Fallow Land	Fallow land
24			Long			
25		Plantation	Agricultural	16	Agriculture Plantation	Agriculture Plantation
26			Horticultural			
27			Agro Horticultural			
28		Aqua / Pisciculture	Aqua / Pisciculture	17	Aquaculture	Aquaculture
29	Forest	Evergreen / Semi evergreen	Dense / Closed	18	Evergreen / Semi evergreen	Dense / Closed
30			Open	19		Open
31		Deciduous (Dry / Moist / Thorn)	Dense / Closed	20	Deciduous (Dry / Moist / Thorn)	Dense / Closed
32			Open	21		Open
33		Forest Plantation	Forest Plantation	22	Forest Plantation	Forest Plantation
34		Scrub Forest	Scrub Forest	23	Scrub Forest	Scrub Forest
35		Forest Blank	Forest Blank			
36		Swamp / Mangroves	Dense / Closed	24	Swamp / Mangroves	Dense / Closed
37			Open	25		Open
38		Tree Clad Area	Dense / Closed	26	Tree Clad Area	Dense / Closed
39			Open	27		Open

Sl. No.	Level 1	Level 2	Level 3	Sl. No.	Level 2	Level 3
40	Grass/ Grazing land	Alpine / Sub-Alpine	Alpine / Sub-Alpine	28	Alpine / Sub-Alpine	Alpine / Sub-Alpine
41		Temperate / Sub Tropical	Temperate / Sub Tropical	29	Temperate / Sub Tropical	Temperate / Sub Tropical
42		Tropical / Desertic	Tropical / Desertic	30	Tropical / Desertic	Tropical / Desertic
43		Manmade	Manmade			
44	Wastelands	Salt Affected Land	Slight	31	Salt Affected Land	Salt Affected Land
45			Moderate			
46			Strong			
47		Gullied / Ravinous Land	Gullied	32	Gullied / Ravinous Land	Gullied
48			Shallow ravine	33		Ravinous
49			Deep ravine			
50		Scrub land	Dense / Closed	34	Scrub land	Dense / closed
51			Open	35		Open
52		Sandy area	Desertic	36	Sandy area	Desertic
53			Coastal	37		Coastal
54			Riverine	38		Riverine
55		Barren rocky	Barren rocky	39	Barren rocky	Barren rocky
56	Wetlands	Inland Natural	Inland Natural	40	Inland	Natural (Ox-bow lake, cut-off meander, water-logged etc.)
57		Inland Manmade	Inland Manmade	41		Manmade (Water logged, saltpans etc)
58		Coastal Natural	Coastal Natural	42	Coastal	Lagoon, creeks, mud flats etc.
59		Coastal Manmade	Coastal Manmade	43		Saltpans

Sl. No.	Level 1	Level 2	Level 3	Sl. No.	Level 2	Level 3
60	Waterbodies	River / Stream	Perennial	44	River	Perennial
61			Dry	45		Non Perennial
62		Canal / Drain	Lined	46	Canal / Drain	Canal / Drain
63			Unlined			
64		Lake / Ponds	Perennial	47	Lake / Ponds	Permanent
65			Dry	48		Seasonal
66			Kharif extent			
67			Rabi extent			
68			Zaid extent			
69		Reservoir / Tanks	Perennial	49	070401	Permanent
70			Dry	50	070402	Seasonal
71			Kharif extent		070403	
72			Rabi extent		070404	
73			Zaid extent		070405	
74	Snow Shifting cultivation &Rann	Snow	Seasonal	51	Snow	Snow
75			Permanent			
76		Glacial	Glacial			
77		Shifting cultivation	Current	52	Shifting cultivation	Current
78			Abandoned	53		Abandoned
79		Rann	Rann	54	Rann	Rann

Annexure - II

NATIONAL LULC 50K - Second Cycle

QC PROFORMA
(Internal / External QAS)

Centre: **District:**

Sl. No.	05-06 LU/LC code	Latitude N	Longitude E	Comment/Suggestion

Interpreted by: **Corrected on:** **Signature**
Date:

IQC done by: **Verified on :** **Signature**
Date:

EQC done by: **Verified on :** **Signature**
Date:

Annexure - III

NATIONAL LULC 50K - Second Cycle

Ground Truth Proforma

State: **District:**

Date:

Sl. no.	Lat (Deg N)- Long (Deg E)	05-06 lu/lc class	2011-2012 lu/lc class	Change/ Interpretation error	Photo No / Remarks

Notes:_____

_____

_____

_____

Name of the Scientist

Signature: **Countersigned:**

Annexure - IV

NATIONAL LULC 50K - Second Cycle

Monthly Progress Report

State: **Total No. of Districts:**

Month:

Sl. no.	District name	Total No of scenes	Interpretation Completed (No. of scenes)	IQC done	GT Done	EQC done	Remarks

Principal Investigator:

Signature:

Date:

Annexure - V

NATIONAL REMOTE SENSING CENTRE

FEEDBACK PROFORMA

Land Use/ Land Cover mapping – 2nd Cycle

Place of Workshop:

Workshop Date:

Topic: Lecture cum Hands - on experience

Rate the Following in the scale of 1 to 5 (Please Tick)
(5-Excellent, 4-Very Good, 3-Good, 2-Satisfactory, 1- poor)

	5	4	3	2	1
Clarity of Lecture Objective					
Whether Objective met					
Learning techniques in Mapping LU/LC Change					
Faculty Presentation Skills					
Usefulness of the workshop					
Overall evaluation					

Any other General comments:

Annexure – VI

SUGGESTED MINIMUM SPECIFICATION OF DIGITAL CAMERA FOR COLLECTING GEOTAGGED FIELD PHOTOGRAPHS

Pixel: 14 mega pixel
Optical Zoom: 10 x
Builtin GPS and Compass
Shooting Mode: 3D, Panorama mode etc.
Video Recording: High Definition (HD) full HD is preferred
Memory Card: Secure Digital with 8 GB memory

(Note: A number of digital camera manufacturers are making digital camera with above specifications. In order to retain the high quality of photographs manufacturers like Nikon, Canon, Sony, Panasonic to be preferred)

Annexure – VII

List of Participants and affiliation of LULC workshop on 2nd & 3rd November 2011 who have contributed in the finalisation of the manual

Sl. No.	Name (Prof./Dr/Mr./Ms)	Organisation
01	Ashok Gahlot,	SRSAC, Jodhpur
02	Mahendra Singh	SRSAC, Jodhpur
03	D.C. Loshali	PRSC, Ludhiana
04	S.N. Das	SLUSI, New Delhi
05	Vivek Kale	MRSAC, Nagpur
06	Sanjeev Verma	MRSAC, Nagpur
07	Suresh Francis	KSRSEC, Thiruvananthapuram
08	Nizamuddin	KSLUB, Thiruvananthapuram
09	S. Edison	KSLUB, Thiruvananthapuram
10	M M Kimothi	USAC, Dehradun
11	N. Shamungou Singh	MRSAC, Imphal
12	Nesatalu Hiese	NASTEC, Kohima
13	S. Sudhakar	NESAC, Umiam
14	Vinod Bothale	MRSAC, Nagpur
15	D.K. Prabhuraj	KSRSAC, Bengaluru
16	C.R. Francis	KSRSAC, Bengaluru
17	J. Krishna Murthy	ISRO HQ, Bengaluru
18	Uday Raj	RRSC (S), Bengaluru
19	A. Jeyaram	RRSC (E), Kolkata
20	A.K. Joshi	RRSC, (C) Nagpur
21	A.T. Jeyaseelan	JSAC, Ranchi
22	C. Jegannathan	BIT, Mesra
23	R. Vidhya	IRS, Chennai
24	Utpal Sarma	ARSAC, Guwahati
25	Virendra Kumar	RSAC, Lucknow
26	P.C. Moharana	CAZRI, Jodhpur
27	Rakesh Paliwal	RRSC (W), Jodhpur
28	A.S. Arya	SAC, Ahmedabad
29	Narendra Shivare	MAPCOST, Bhopal
30	S. Padmaja	Osmania University, Hyderabad
31	N.C. Gautam	CLUMA, Hyderabad
32	Kaushalya Ramachandran	CRIDA, Hyderabad
33	K.V. Rao	CRIDA, Hyderabad
34	K.M. Reddy	APSRAC, Hyderabad
35	D.V.J. Sastry	APSRAC, Hyderabad
36	G. Meher Baba	APSRAC, Hyderabad
37	K.V.V. Ramesh	APSRAC, Hyderabad

Sl. No.	Name (Prof./Dr/Mr./Ms)	Organisation
38	S.V.R. Reddy	APSRAC, Hyderabad
39	D.V.R. Murthy	APSRAC, Hyderabad
40	M. Kudrat	RRSC (N), Dehradun
41	Sushma Gairola	USAC, Dehradun
42	Swathi Uniyal	USAC, Dehradun
43	Jay Anand	MSSRF, Chennai
44	Rabindra Panigrahy	C-DAC, Pune
45	V.N. Ambade	FSI, Nagpur
46	V. K. Dadhwal	NRSC
47	G. Behera	NRSC
48	Y.V.N. Krishna Murthy	NRSC
49	Raghu Venkataraman	NRSC
50	M.V.R. Sesha Sai	NRSC
51	S.V.C. Kameswara Rao	NRSC
52	C.S. Murthy	NRSC
53	K. Sreenivas	NRSC
54	K. Vinod Kumar	NRSC
55	M.V. Ravi Kumar	NRSC
56	V. Bhanu Murthy	NRSC
57	V. Venkateswar Rao	NRSC
58	G. Srinivasa Rao	NRSC
59	C.B.S. Dutt	NRSC
60	M.M. Ali	NRSC
61	M.S.R. Murthy	NRSC
62	V. Raghavaswamy	NRSC
63	Y.V.S. Murthy	NRSC
64	K. Venugopala Rao	NRSC
65	Jonna Saindranadh	NRSC
66	A. V. Suresh Babu	NRSC
67	Satish Chandra Jayanthi	NRSC
68	S. S. Rao	NRSC
69	R. Nagaraja	NRSC
70	D. Chandrasekharan	NRSC
71	D. Vijayan	NRSC
72	Milind Wadodkar	NRSC
73	T. Ravi Sankar	NRSC
74	Manoj Raj Saxena	NRSC
75	G. Padma Rani	NRSC
76	Rajiv Kumar	NRSC
77	B. Shyam Sunder	NRSC
78	G. Ravi Shankar	NRSC

Annexure – VIII

List of Partner Organisations (LULC 2nd Cycle of Mapping)

1 Andhra Pradesh Remote Sensing Applications Centre, Hyderabad - 500 038
2 Arunachal Pradesh Remote Sensing Applications Centre, Itanagar - 791 113
3 Assam Remote Sensing Applications Centre, ASTEC, Guwahati - 781 005
4 Birla Institute of Technology, Mesra, Ranchi - 835 215
5 Chattisgarh Council on Science & Technology, Raipur - 492 007
6 Bhaskaracharya Institute of Space Applications & Geoinformatics, Gandhinagar - 382 007
7 Haryana Space Applications Centre, Hissar - 125 004
8 Remote Sensing Applications Cell, HP Council on ST & E, Shimla - 171 009
9 Environment, Ecology & Remote Sensing, Srinagar - 190 018
10 Jharkhand Space Applications Centre, Ranchi - 834 004
11 Karnataka State Remote Sensing Applications Centre, Bangalore - 560 001
12 Kerala State Remote Sensing & Environment Centre, Thiruvananthapuram - 695 033
13 Madhya Pradesh Remote Sensing Applications Centre, MAPCOST, Bhopal - 462 003
14 Maharashtra Remote Sensing Applications Centre, Nagpur - 440 011
15 Manipur Remote Sensing Centre, Imphal - 795 001
16 North Eastern Space Applications Centre, Umiam - 793 103
17 Mizoram Remote Sensing Application Centre, Aizawl - 796 012
18 Nagaland State S & T Council, Kohima - 797 001
19 Orissa Space Applications Centre, Bhubaneswar - 751 023
20 Punjab Remote Sensing Applications Centre, Ludhiana - 141 004
21 State Remote Sensing Applications Centre, Rajasthan, Jodhpur - 342 003
22 Remote Sensing Cell, DST, Gangtok - 737 101
23 Tripura Space Applications Centre, Agartala - 799 006
24 Institute of Remote Sensing, Anna University, Chennai - 600 025
25 Remote Sensing Applications Centre, Uttar Pradesh, Lucknow - 226 021
26 Uttarakhand Space Applications Centre, Dehradun - 248 001
27 Geo-informatics & RS Cell, West Bengal, Kolkata - 700 091