Land Use/Land Cover Mapping Using Remote Sensing and GIS Techniques

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Abstract

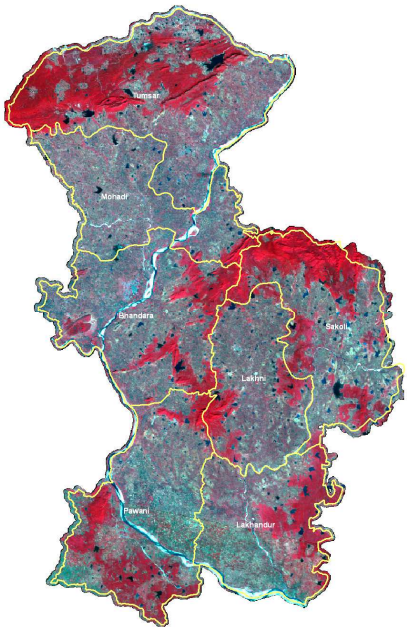
Maharashtra is a large and prosperous state with rich natural resources and extensive variability in terrain characteristics and associated ecosystem. Maharashtra has a total geographical area of 30.8 million hectares, and is currently supporting a human population of 968 million distributed over seven distinct rainfall zones. The generation of spatial information of the earth surface has become handy with the advent of satellite remote sensing which coupled with GIS technology has enhanced the data storage, retrieval and analysis. Further, creation of computerized data base adds a new dimension to the dissemination of information in the form of networking for the free flow of data and information exchange for speeding up implementation programmes. The satellite based derived information in combination with the ground support data is an excellent input, which can be updated from time to time.

KEYWORDS: LULC System, IRS-LISS-III

INTRODUCTION:

Location and Extent:

The district of Bhandara is located in the north-eastern extreme of the Nagpur Division of Maharashtra State. The district lies between 20^0 10' and 21^0 35' north latitudes and 79^0 16' and 80^0 38' east longitudes. Geographically, the district lies entirely within the Wainganga basin. Three major tributaries of the Wainganga, the Bagh, the Bawanthari and the Chulband drain the district. The district is traversed west to east in the middle by the Nagpur Calcutta (South-Eastern) broad gauge railway line and the Nagpur-Raipur National Highway.



The district covers an area of 3190 sq. km (BES Report 2003-2004).The district has 7 tahsils viz., Bhandara, Tumsar, Mohadi, Tiroda, Sakoli, Lahni, Lakhandur and Pauni. The district is bounded by the Balaghat district of Madhya Pradesh in the north, the Gondiya district in the east, Chandrapur district in the south and Nagpur district in the west.

Drainage:

The entire district falls within the Wainganga drainage, as enunciated earlier. The major rivers of the district are the Wainganga and its tributaries. viz., Bagh, Bawanthari and Chulband. The Kanhan, just before its confluence with the Wainganga and the Garhvi in its upper reaches flow through the district for short distances

Climate:

The climate of Bhandara district is on the whole dry except during the monsoon season. The cold season from December to mid February followed by the summer lasting up to the end of May, the south west monsoon season from June to September and the post monsoon or retreating monsoon season in October and November. The maximum temperature is about 47.5^{o}C and minimum temperature around 7.4^{o}C. The district lies in the assured rainfall region and has an average rainfall of 1420 mm.

Natural Vegetation:

As per the data provided by BES (2003-04), out of the total area of 3180 sq. km, 1488 sq.km area is under forest cover. Out of this 59% belongs to reserved forest and 21% to protected forest and unclassified forest comes to 19%. The forests fall in the broad type “Southern Tropical Dry Deciduous Forest” and consist of sub-types: 1) teak forests and 2) mixed forests. The proportion of teak forests is very small and teak occurs in mixture with its associates. The other commercially important associates of teak are Sag, Halda, Tinsa, Shisham, Mhowa, Rohan, Khair, Dikamali, Garari,Bamboos, Tendu leaves, Lac etc. The other commercially important associates found in the forests are: 1) Tendu leaves, useful in bidi industries, 2) Mhowa flowers and fruits 3) Palas for propagation of lac 4) Kadai of Rulha and Dhaora for gum, 5) Khair for manufacture of kath etc.

Table-1

S.NO.	COMMON NAME	BOTANICAL NAME
1	Neem	*Azaridicta Indica*
2	Babul	*Accasia Arabica*
3	Palas	*Butea Frondosa*
4	Khair	*Accasia Catechu*
5	Mango	*Mangifera Indica*
6	Amla	*Phyllanthus Emblica*
7	Jamun	*Jambolina*
8	Ghaneri	*Lantana Camera*

Grasses like Kusali *(Heteropogon)*, Marvel *(Dichanthium)* and Sheda *(Schima)* are also seen in the area.

However, these maps are outdated and the updating happens every 20-25 years. Thus, this land use information does not represent current situation of land use and also does not reflect changes. Land use Atlas from National Atlas and Thematic Mapping Organization (NATMO) which are mainly small scale land use maps

published (1.6 Million and smaller scales) also are out dated with updation happening every 10-15 years.

Land use generated by Soil Survey organizations that are based on soil mapping units from which land use information can be deciphered. Such maps are generated and available for specific project areas and are based on satellite images or aerial images. Also it has published 'Land Resource Atlas' for the country on 1:250000 scale in 1996. The foregoing discussion has highlighted the need for spatial accounting and monitoring of LULC systems like agriculture, surface water bodies, waste lands, forests etc. for the sustainable utilization of natural resources of our country. Considering this need and potential of IRS–LISS III sensor in monitoring the natural resources. The goal of the study is to map and monitor the land use/cover on 1:50,000. This mapping/monitoring will be done based on a National Standard Land Use/ Cover Classification System which will be able to meet the requirements of the various user agencies and also encapsulate the 9-fold classification needs of BES/DES. The objectives of the project are as follows:

Objectives

- Generate land use/ land cover data base for the period 2009-2010 using three seasons (Kharif, Rabi & Zaid) LISS III satellite data and repeat the exercise at every 5 years period.
- Digital data base creation based on standard codification and integration with base details and to generate seamless digital data at district/state/national level.
- Generate District-wise tables of the NR parameters and the changes over the previous Census cycle.
- Preparation of LULC Information System for easy query .
- Report the areas of major land use change with appropriate scale maps and assessment report on causative factors and remedial measures.

Users Perspective

The project outputs would be primarily useful for the following.

- Provides a spatial database on net sown area for different seasons there by facilitating to monitor and assessment of different cropping systems under rain fed and irrigated conditions.
- Facilitates monitoring of dynamic land covers like surface water, forest and waste lands etc.
- Serves as a primary database for regional EIAs, planning and developmental activities and for addressing global environmental issues like biodiversity, climate change, land cover atmosphere interactions, carbon sinks, etc.
- Works as a useful database for different Ministries and Departments like Agriculture, Rural Development, Environment and Forest, Water Resources, National Bureau of Soil Survey and Land Use Planning, All India Soil and Land Use Survey and universities etc.

Approach

The broad steps involved in the generation of LULC database are as follows .

- Use of multi temporal LISS-III data covering kharif (Aug –Nov), rabi (Jan-Mar), zaid (April- May) seasons to address spatial and temporal variability in land cover classes. In the event of non availability of cloud free and good quality of LISS-III data the use of multi-sensor data is contemplated.

- Preliminary interpretation: The land cover polygons as seen in the satellite data will be delineated on screen using standard classification system and a preliminary interpretation map will be prepared.
- Preparation for Fieldwork: The steps involve identification of statistically sound sample grids that will be verified on the ground. On the basis of the interpretative uncertainty highlighted during the preliminary interpretation a portion of map units will be selected for field checking. This first set of points will be integrated, if necessary, by an extra set of checks to assure a good statistical representation of the land cover classes.
- Fieldwork: Fieldwork is executed by the interpreters using a fully standardized methodology.
- The details of field data: The fieldwork involves establishing the relationship between image elements and the tentatively identified LULC categories during preliminary interpretation. An "intermediate" interpretation accuracy will be done using field data. This information will allow the interpreters to evaluate in a rather objective way the work done in the preliminary phase of interpretation.
- Final interpretation: The delineation of LULC categories made during the preliminary interpretation phase will be modified based on information collected during the fieldwork, existing maps such as wasteland, biodiversity, LULC data, etc. During this phase the classes with accuracies could be aggregated to the nearest LULC class.
- The Minimal Mapping Area: is a concept applied by cartographers when addressing the smallest area that can be shown on a map. Historically, the cartographers determined one particular minimum size of area to be mapped; this was applied to all classes contained in the legend. The minimum mapping polygon of 3mm x 3mm is equivalent to 2.25 ha. on 1: 50000 scale has been considered. However, for few important classes variable mapping area can be adopted to preserve the local variations.
- Digital database: This steps involves the finalization of land cover layer through editing, digitization, coding and geographic referencing of land cover polygons to facilitate their follow-up GIS processing. GIS processing and integration of land cover and basic topographic layers in a comprehensive digital land cover database. Developments of meta-database for effective dissemination of information on land cover products to the users.
- To develop Implementation Document to monitor the progress. The satellite data used for the purpose are as shown in table-2

Table-2

Sr. No.	Satellite/Sensor	Season	Path-Row	Date of Pass
1	IRS-P6, LISS-3	Kharif	100-57	Nov. 09
2	IRS-P6, LISS-3	Kharif	100-58	Nov. 09
3	IRS-P6, LISS-3	Rabi	100-57	Jan. 10
4	IRS-P6, LISS-3	Rabi	100-58	Jan. 09
5	IRS-P6, LISS-3	Zaid	100-57	Apr. 10
6	IRS-P6, LISS-3	Zaid	100-58	Apr. 10

Land Use/Land Cover Classification System:

The rich experience gained over the past two decades in the implementation of a standard national land use/land cover classification amenable for use with remote sensor data for mapping on 1 : 250,000 scale and to some extent on 1 : 50,000 scale enhanced our ability to understand and manage country's natural resources. Earlier efforts to map the theme on 1: 50,000 scale followed certain standards which required modifications in the current day's context. To this extent, an exhaustive land use/land cover classification was evolved to facilitate an in-depth assessment of all the land use/land cover categories. The benefits of implementing/adopting a classification are tending to persuade for evolving a standard classification system that is guided by practical experience and continuous observation over the past many years and above all that meet the user requirements. The following points were considered ideal in terms of most favorable conditions.

- Satellite data and season of its acquisition, collateral data and legacy data
- Classification scheme
- Ground data collection
- Classification of multi-temporal data-sets

A key strategy of the current project is use of multi-temporal data sets for classification in a pursuit to achieve improved classification accuracies. The IRS P6 LISS III data, geometrically corrected is the primary input for classification and mapping. Multi-temporal data acquired during kharif (September – November), rabi (December/January–February/March) and zaid (April-May) while taking into account the crop calendar of an area will be used for the purpose. Digital Survey of India topographic map layer on 1 : 50000 scale will form the base layer for the mapping activity.

Classification Scheme:

The classification system amenable for use with remote sensor data varies with the objectives of the classification and the type of satellite data that is being used for the purpose. The nomenclature and definition of each of the categories is variable because of the said variations. There are various organizations in the country, which have evolved classification systems depending upon their objective and functionality. The sole objective of a classification scheme is to group together a set of observational units on the basis of their common attributes. It is essential to further re-group the above observational units so as to share additional attributes that are similar in nature and interrelated. The land use / land cover classification systems for 1: 50,000 scale that will be followed in the NRC Mission are as given.

Description of Land Use/Land Cover Categories:

The land use/land cover classification has been designed with a three level hierarchic based configuration, each level containing information of increasing specificity.

Definition and Explanation

Land Use/Land Cover

Land use refers to 'man's activities and the various use which are carried on land'. Land cover refers to 'natural vegetation, water bodies, rock/soil, etc. Although land use is generally inferred based on the cover, yet both the terms are related and interchangeable. Categories that are enlisted under Level 1 contain broad land use/land cover classes that can be delineated using a coarser resolution satellite image with minimal assistance from supplemental information, at 1:10,00,000 scale. Such information is useful for general planning purposes when detailed information is not

mandatory. Built-up land, agricultural land, forest, wasteland, water bodies and others comprise the land use/land cover categories as Level I.

In Maharashtra, almost all the important land use categories are present and listed below. The land use / land cover classification systems along with feature codes for 1: 50,000 scale that will be followed in the NRC Mission are as given below

Approach

The broad steps involved in the generation of LULC database are as follows:

Use of multi temporal LISS:III

Data covering kharif (Aug –Nov), rabi (Jan- Mar), zaid (April- May) seasons to address spatial and temporal variability in land cover classes. In the event of non availability of cloud free and good quality of LISS-III data the use of multi-sensor data is contemplated. Ortho rectification of multi-temporal datasets to correct the effect of relief and georeferencing with reference framework using LCC/TM projection and WGS 84 datum.

Preliminary interpretation:

The land cover polygons as seen in the satellite data will be delineated on screen using standard classification system and a preliminary interpretation map will be prepared.

Preparation for Fieldwork:

The steps involve identification of statistically sound sample grids that will be verified on the ground. On the basis of the interpretative uncertainty highlighted during the preliminary interpretation a portion of map units will be selected for field checking. This first set of points will be integrated, if necessary, by an extra set of checks to assure a good statistical representation of the land cover classes.

Fieldwork:

Fieldwork is executed by the interpreters using a fully standardized methodology.

The details of field data:

The fieldwork involves establishing the relationship between image elements and the tentatively identified LULC categories during preliminary interpretation. An “intermediate” interpretation accuracy will be done using field data. This information will allow the interpreters to evaluate in a rather objective way the work done in the preliminary phase of interpretation.

Final interpretation:

The delineation of LULC categories made during the preliminary interpretation phase will be modified based on information collected during the fieldwork, existing maps such as wasteland, biodiversity, LULC data, etc. During this phase the classes with accuracies could be aggregated to the nearest LULC class.

The Minimal Mapping Area:

It is a concept applied by cartographers when addressing the smallest area that can be shown on a map. Historically, the cartographers determined one particular minimum size of area to be mapped; this was applied to all classes contained in the legend. The minimum mapping polygon of 3mm x 3mm is equivalent to 2.25 ha. on 1: 50000 scale has been considered. However, for few important classes variable mapping area can be adopted to preserve the local variations.

Digital Database:

This steps involves the finalization of land cover layer through editing, digitization, coding and geographic referencing of land cover polygons to facilitate their follow-up GIS processing. GIS processing and integration of land cover and basic topographic layers in a comprehensive digital land cover database.

Developments of meta-database for effective dissemination of information on land cover products to the users.

- To implement process based QAS to regulate the data flows and outputs as per the standards.
- To develop Implementation Document to monitor the progress.

Accuracy Assessment and Geodatabase Standards:

Table-3
CLASSIFICATION ACCURACY ASSESSMENT REPORT
ACCURACY TOTALS

Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy
Built Up-Built Up (Urban)-Residential	3	3	3	100.00%	100.00%
Agricultural Land-Crop Land-Kharif Crop	30	31	25	85.33%	81.65%
Agricultural Land-Crop Land-Rabi Crop	17	15	11	64.91%	73.33%
Agricultural Land-Crop Land-Two crop area	23	20	18	88.26%	90.00%
Agricultural Land-Crop Land-Zaid Crop	3	3	3	100.00%	100.00%
Agricultural Land-Crop Land-More than two crop	9	12	9	100.00%	75.00%
Agricultural Land-Fallow-Current Fallow	3	3	3	100.00%	100.00%
Forest-Deciduous (Dry/Moist/Thorn)-Dense/Closed	3	3	3	100.00%	100.00%
Forest-Deciduous (Dry/Moist/Thorn)-Open	3	3	3	100.00%	100.00%
Forest-Scrub Forest	3	3	3	100.00%	100.00%
Wastelands-Scrub land-Dense scrub	5	5	5	100.00%	100.00%
Wastelands-Scrub land-Open scrub	4	4	4	100.00%	100.00%
Wastelands-Barren Rocky/Stony waste	4	4	4	100.00%	100.00%
Wastelands-Gullied/Ravinous land-Gullied	3	3	3	100.00%	100.00%
Waterbodies-River/Stream-Perennial	3	3	3	100.00%	100.00%
Waterbodies-Canal/Drain-Lined	3	3	3	100.00%	100.00%
Built Up-Built Up (Rural)-Built Up area (Rural)	4	4	4	100.00%	100.00%
Built Up-Built Up (Urban)-Transportation	3	3	3	100.00%	100.00%
Agricultural Land-Plantation-Agriculture Plnt.	3	3	3	100.00%	100.00%
Built Up-Built Up (Urban)-Vegetated Area	3	3	3	100.00%	100.00%
Built Up-Mining / Industrial area-Mine/Quarry	3	3	3	100.00%	100.00%
Waterbodies-Lakes/ponds-Dry-Kharif extent	3	4	3	100.00%	75.00%
Waterbodies-Lakes/ponds-Dry-Rabi extent	4	4	4	100.00%	100.00%
Waterbodies-Lakes/ponds-Dry-Zaid extent	5	4	4	82.00%	100.00%
Agricultural Land-Plantation-Agriculture Plnt.	3	4	3	100.00%	75.00%
Totals	150	150	133		

Overall Classification Accuracy = 90.17%

KAPPA (STATISTICS)
Overall Kappa Statistics = 0.8821

RESULTS:

LU_CODE	DESCRIPTION	Area in Sq.Km	In %
010101	Built Up-Built Up (Urban)-Residential	6.92	0.002169
010109	Built Up-Built Up (Urban)-Vegetated Area	0.78	0.000245
010201	Built Up-Built Up (Rural)-Built Up area (Rural)	71.40	0.022382
010302	Built Up-Mining / Industrial area-Mine/Quarry	1.00	0.000313
020101	Agricultural Land-Crop Land-Kharif Crop	2843.01	0.891226
020102	Agricultural Land-Crop Land-Rabi Crop	1258.62	0.394552
020103	Agricultural Land-Crop Land-Zaid Crop	2.08	0.000652
020104	Agricultural Land-Crop Land-Two crop area	1796.92	0.563298
020105	Agricultural Land-Crop Land-More than two crop	907.80	0.284577
020201	Agricultural Land-Fallow-Current Fallow	0.64	0.000201
020300	Agricultural Land-Plantation	51.78	0.016232
020302	Agricultural Land-Plantation-Horticulture Plant	0.28	8.78E-05
030201	Forest-Deciduous (Dry/Moist/Thorn)-Dense/Closed	18.39	0.005765
030202	Forest-Deciduous (Dry/Moist/Thorn)-Open	19.38	0.006075
030400	Forest-Scrub Forest	3.65	0.001144
050201	Wastelands-Gullied/Ravinous land-Gullied	0.21	6.58E-05
050301	Wastelands-Scrub land-Dense scrub	238.15	0.074655
050302	Wastelands-Scrub land-Open scrub	104.22	0.032671
050500	Wastelands-Barren Rocky/Stony waste	73.25	0.022962
070101	Waterbodies-River/Stream-Perennial	25.82	0.008094
070201	Waterbodies-Canal/Drain-Lined	14.00	0.004389
070403	Waterbodies-Reservoir/Tanks-Dry-Kharif extent	83.49	0.026172
070404	Waterbodies-Reservoir/Tanks-Dry-Rabi extent	36.50	0.011442
070405	Waterbodies-Reservoir/Tanks-Dry-Zaid extent	99.98	0.031342

CONCLUSION:

The study area dominates in agriculture land as about 88.12% of the total geographical area. Forest lands are very negligible less than 1% of the geographical area of the districts. Continuously the land should be put to use of around 4.48% which now in waste land categories. Extent of water in perineal context is around 1.35% of the total area, which indicates good ground water potential and land can be of good agricultural capacity.

Overall results using remote sensing techniques are the indicators but actual extent can be improved using more optical and microwave technology. New research should be taken place in physics point of view of the technology. Electromagnetic energy interaction in the present scenario of Bhandara district using three season data as well as conventional information can be research for coming generation. To introduce new sensors of satellite in different humidity, pressure and temperature as well as entropy and isotropy will be new focus area towards research.

The author may evolved the atmospheric behaviour of electromagnetic energy in visible, infrared and microwave spectrum of different agriculture species of food, forest, wasteland and water bodies, mining etc.

REFERENCES:

1. Kauffman, Y. J., The atmospheric effect of remote sensing and its correction, in Theory and application of optical remote sensing (ed. G. Asrar), John Wiley and Sons, N. Y., 1989, 336.
2. Ayyangar, R. S. (1978), Experiment to evolve methods for separation and identification of agricultural crops from multispectral information. In 'Proc. 12th Internat. Symp. Remote Sensing of Environment' ERIM, Ann Arbor: Michigan.
3. Rao, U. R. (1996) Space Technology for Sustainable Development, Tata Mc Graw-Hill Publishing Company Ltd., New Delhi.
4. Roy, P. S. and Shirish, A. Ravan. (1996). Biomass Estimation using satellite remote sensing data-An investigation on possible approaches for natural forest. (ed.) R. Uma Shankar.
5. Anderson, J.; Hardy, E. E., Roach, J. T. and Witmer, R. E. (1976). A Land use and land cover classification system for use for remote sensing data. USGS Professional paper 964, US Govt. Printing Officer, Washington D. C.
6. Chaurasia, R.; Loshali D. C.; Dhaliwal, S. S; Minakshi; Sharma, P. K.; Kudrat, M. and Tiwari, A. K. (1996). Land use change analysis for agricultural management – A case study of tehsil Talwandi Sabo, Punjab. Photonirvachak, J. Indian Soci. Remote Sensing; 24 (2): 115-124.
7. Gautam, N. C. (1978). Urban land use studies through aerial photo-interpretation techniques, Pink Publishing House, Mathura.
8. National Commission Agriculture (1976). Chapter V-Resources Development Ministry of Agriculture and Irrigation, Govt. of India, New Delhi.
9. Rao, D. P. (1998). Remote sensing and GIS for sustainable development: An overview. Proc. Int. Symp. On Natural Resources and Environmental Monitoring, 1-4 September, 1998, Budapest, Hungary.
10. Lillesand, T. M. and Kiefer, R. W. Remote Sensing and Image Interpretation, 2nd ed., John Wiley and Sons, New York, 1987.
11. Richards, J. A. Remote Sensing Digital Image Analysis: An Introduction, Springer-Verlag, Berlin, 1986.
12. Radhakrishnan, K., Geetha Varadan and Diwakar, P. G. Digital Image processing techniques – An overview, Natural resources management – a new perspective, Indian Space Research Organization, 1992.