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ROLE OF GIS AND REMOTE SENSING IN LAND USE AND LAND COVER STUDIES

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Abstract

To observe, understand, and analyse data from a geographic perspective, remote sensing and GIS techniques are used. Ground truth verifications were also carried out in the field to ensure that the categorisation was accurate. For land use and land cover mapping, remote sensing gives a synoptic picture and multi-temporal data. The use of remote sensing and GIS tools to map LULC and detect changes is a cost-effective means of gaining a detailed understanding of the land cover change processes and their repercussions. To understand how LULC change affects and interact with global earth systems, information is needed on what changes occur, where and when they occur, the rate at which they occur, and the social and physical forces that drive those changes. The information needs for such a synthesis are diverse. Remote sensing has an important contribution to making and documenting the actual change in land use/land cover in regional and global scales.

***Keywords** : GIS , Remote Sensing , Land use, Land cover, Urban*

Introduction

Although the phrases land use and land cover are frequently used interchangeably, each has its own meaning. The surface cover on the ground, such as vegetation, urban infrastructure, water, bare soil, and so on, is referred to as land cover. Land cover identification provides the foundation for tasks such as thematic mapping and change detection analysis. The function of the land, for example, recreation, wildlife habitat, or agriculture, is referred to as land use.

Land use and land cover (LULC) changes have been among the most significant noticeable human modification of Earth's terrestrial surface. Land surfaces comprising the physical and biological entities including vegetative cover, water bodies, bare lands or artificial structures represent land cover (Ellis, 2007). Alternatively, land use refers to an intricate combination of socio-economic, management principles and economic purposes and its contexts for and within which lands are managed. We often designate land use and land cover together, but there is a distinct difference between the two.

When used together, the terms Land Use / Land Cover (LULC) and Land Use / Land Cover (LULC) refer to the categorization or classification of human activities and natural elements on the landscape over time using established scientific and statistical methods of analysis of appropriate source materials.

LULC change is possibly the most obvious form of global environmental change visible at spatial and temporal scales having great relevance to our daily life (CCSP, 2003). Technically, LULC change is directly related with the mean quantitative changes in spatial extent (increase or decrease) for a specified type of land cover and land use respectively. Both anthropogenic and environmental forces largely affect the behaviour of changes in land use and land cover (Liu et al, 2009)

Land cover is the physical material at the surface of the earth. Land use is the description of how people utilize the land for the socio-economic activities.

Need for estimation of land use and land cover change

Food and water security for the growing population, as well as concerns arising from climate change, must be addressed for inclusive growth and development in various fields and sectors (Ramakrishna,1998). Because India's land area accounts for only 2.3 percent of global terrestrial area yet houses 17 percent of the world's population and 11 percent of the world's livestock, the pressure on the Indian land mass is nearly 4–6 times that of the global average. The area under cultivation has been nearly constant at roughly 1402.0 Mha over the last 40 years (Roy and Murthy, 2009). The pattern of land usage and land cover has changed dramatically over the decades. LULC has a variety of effects, including reduced plant cover, biodiversity loss, climate change, carbon dynamics, pollution, and changes in hydrological regimes.

Different factors have a significant impact on land cover and land use. Several environmental factors, such as Land cover is determined by soil qualities, climate, terrain, and vegetation all at the same time. Demographic factors such as population, technology, and political considerations all influence land use. Ownership structures, economies, and systems, as well as attitudes and values.

Remote sensing as a tool for land use and land cover change

There is ample collection of data produced from remote sensing and vary from the very highspatial resolution images (such as CartoSat, IKONOS and Quickbird), to regional datasets produced at regular intervals (e.g., LISS III, TM/ETM, SPOT), to lower spatial resolution (>250 m) images now produced daily across the entire Earth (e.g., MODIS). The temporal dynamics of the synoptic view of the earth’s surface by satellite assisted data capture has given us an important tool to study the variations in land use and land cover over a period of time. The changes in the land use and land cover manifested as a function of the changes either natural or manmade, have a bearing on the reflectance patterns of incidence radiation due to the changes in the vegetative cover, soil moisture or the various modifications of the earth’s surface (Navalgund, 2001).

Since the changes in land use and land cover are more or less unidirectional, without much oscillation, it is safe to extrapolate the changes in spatial extents and also calculate the rate of changes. A very important tool in this regard is the Geographical Information System (GIS). The Geographic Information System is a powerful tool in which spatial information can be stored, organized, and retrieved in a user friendly environment. The Conjunction of satellite remote sensing data and ancillary data in a GIS environment combined with the Global positioning system (GPS) data is a potential tool to environment management.

Table 1: LULC CLASSIFICATION SYSTEMS – INTERNATIONAL SCENARIOS

Sl.	Classification System	Organ. / Country	L– I	L-II	L-III	Remarks
1	NRC-LULC50K	India	8	31	54	Meeting user requirements of various Indian user department
2	NRC-AWiFS	India	9	19	--	Emphasis on Area under agriculture
3	DES / BES	India	5/9			Statistical compilation
4	Globeland 30	China	10			Global coverage using USGS free data
5	IGBP	Global	17			Elementary LC more suited for climate modeling
6	Anderson (USGS)	USA	9	37	--	Flexibility given to user for L-III and L-IV
7	CORINE 2000	Whole Europe	5	15	44	Intended for 100,000 scale LC database and tuned for application in climate modeling
8	FAO - LCCS	10 African Country	Dichotomous – 8 Modular ~ 40K			Flexible enough to adopt various geographical regios of the world
9	LCM 2007	U.K.	23			Three cycles using SPOT imagery
10	USGS Mod.	USA (Florida)	9	41	190	Suitable for Aerial based mapping and confined for Florida

Table 2 : SCALE - METHOD - OUTPUT

Sl.	Classification System	Organ. / Country	Scale	Method	Output
1	NRC-LULC50K	India	1:50K	Knowledge based	Vector
2	NRC-AWiFS	India	1:250K	Digital, rule based	Raster
3	DES / BES	India	Statistical	Survey	Table
4	Globeland 30	China	1:50K	Mix (MLC, SVM, Dec. tree + Object + Knowledge)	Raster
5	IGBP	Global	1:1m	Digital	Raster
6	Anderson (USGS)	USA	Defined for 1:250K (L-II)	Only classification	Vector/Raster
7	CORINE 2000	Whole Europe	MMU 25 ha	On screen visual interpretation	Vector
8	FAO - LCCS	10 African Country	Dynamic scale	Visual interpretation	Vector
9	LCM 2007	U.K.	MMU 0.5ha	N.A.	Vector (MMU 0.5ha) & Raster 25m, 1km

Table 3: LAND USE MAPPING SYSTEM

LEVEL	SCALE	DATA SOURCE	FREQUENCY	METHOD
1.National	1:500,000	Medium Resolution (56 m) Satellite data	annually	Digital classification
2.State	1:250,000	Medium Resolution (24 m) Satellite data	Once in five years	Digital classification
2.District	1:50,000	Medium Resolution (24 m) Satellite data	Once in five years	On-screen interpretation
3. Village	1:10,000	High resolution satellite data (2.5 m)	Once in eight years	On-screen interpretation
4. Cadastral ??	1:5,000	Very High resolution satellite data (<1 m) / cadstre	Once in 3 years in LUZ only	On-screen interpretation

What are the benefits of LULC Maps?

The social and economic development of a society is completely dependent on its expansion. This is the primary rationale for conducting socioeconomic surveys. Both spatial and non-spatial datasets are included in this type of survey. At the local, regional, and national levels, LULC maps play a critical role in programme design, management, and monitoring. On the one hand, this type of information aids in the understanding of land use issues, and on the other, it aids in the formulation of policies and programmes necessary for development planning. It is vital to monitor the ongoing process of land use/land cover pattern throughout time in order to ensure sustainable development (Singh).

To accomplish sustainable urban development and to prevent haphazard expansion of towns and cities, authorities involved in urban development must establish planning models that allow every available piece of land to be used in the most reasonable and optimal way possible. This necessitates current and historical land use/land cover data for the area. LULC maps also aid in the investigation of changes in our ecology and surroundings. We can develop regulations and implement programmes to safeguard our environment if we have detailed information about the research unit's Land Use/Land Cover (Singh).

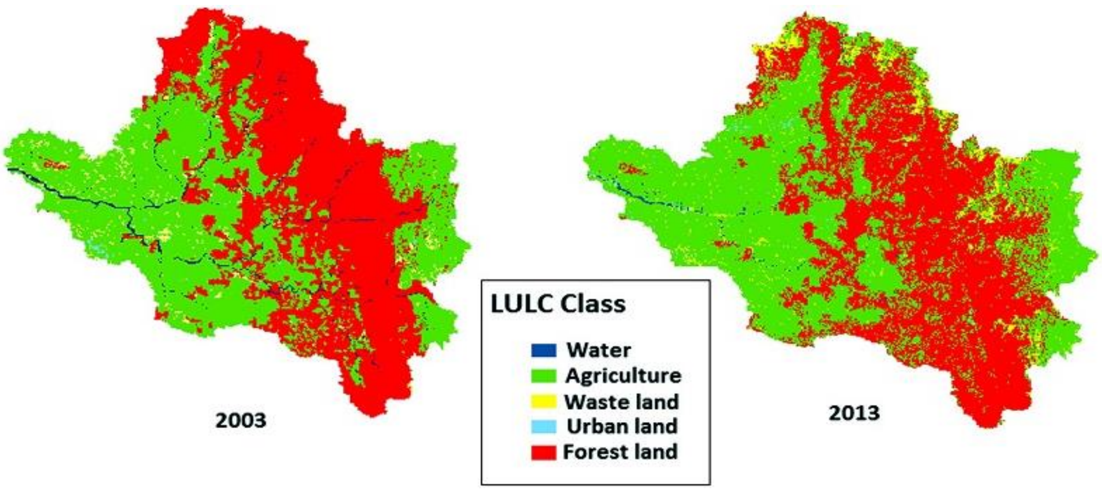


Figure 1 : Change detection is shown at the same region at two different time periods using LULC map

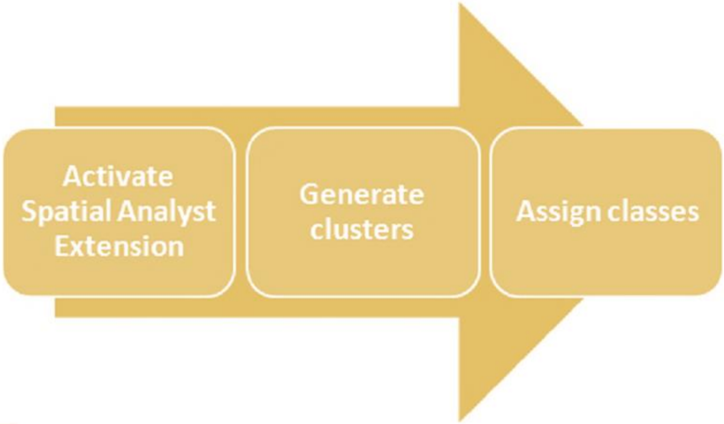
LULC classification

LULC classification is one of the most widely used applications in remote sensing. The most commonly used approaches include:

Unsupervised classification (calculated by software)

This type of classification is based on the software analysis of an image without the user provided sample classes. This involves grouping of pixels with common characteristics. The computer uses techniques to determine which pixels are related and groups them into classes. The user can specify which algorithm the software will use and the desired number of output classes but otherwise does not aid in the classification process. However, the user must have knowledge of the area being classified (such as wetlands, developed areas, coniferous forests, etc.).

Steps involved:



Supervised classification (human guided)

This is based on the idea that a user can select sample pixels in an image that are representative of specific classes and then direct the image processing software to use these training sites as references for the classification of all other pixels in the image. Training sites (also known as testing sets or input classes) are selected based on the knowledge of the user. The user also sets the bounds for how similar other pixels must be to group them together. These bounds are often set based on the spectral characteristics of the training area, plus or minus a certain increment (often based on "brightness" or strength of reflection in specific spectral bands). The user also designates the number of classes that the image is classified into.

Steps involved:

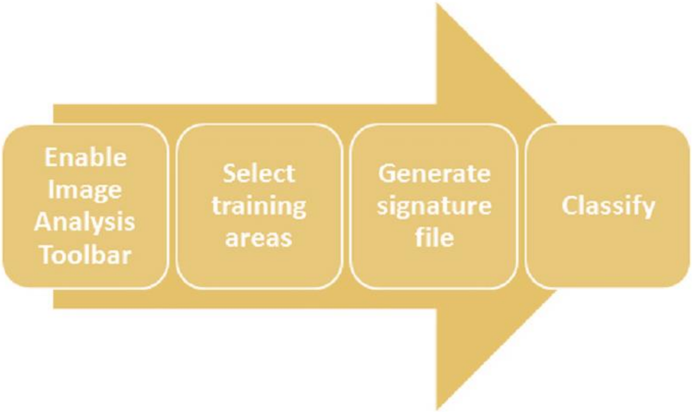


Image segmentation

Image segmentation is the partition and pick-up of the homogeneous regions of the image. In the results of segmentation, the consistency of gray the smoothing of boundary and the connectivity are fulfilled. The classical method of segmentation is the spatial cleaning based on the measurement space. Image segmentation is a crucial processing procedure for the classifications and feature extraction of high-resolution remote sensing image.

main image segmentation methods are:

Threshold based: Threshold segmentation is the simplest method of image segmentation and also one of the most common parallel segmentation methods. It is a common segmentation algorithm which directly divides the image gray scale information processing based on the gray value of different targets.

Edge Detection Segmentation: The edge of the object is in the form of discontinuous local features of the image, that is, the most significant part of the image changes in local brightness, such as the gray value of the mutation, colour mutation, texture changes and so on. The use of discontinuities is to detect the edges and to achieve the purpose of image segmentation.

Regional Growth Segmentation: The regional growth method is a typical serial region segmentation algorithm, and its basic idea is to have similar properties of the pixels together to form a region. The method requires first selecting a seed pixel and then merging the similar pixels around the seed pixel into the region where the seed pixel is located.

Geospatial data and LULC

The availability of spatial data is quickly rising thanks to advances in remote sensing, monitoring networks, and geographic information systems (GIS). Not only maps and locations of land use and land cover (LULC) are included in this geospatial data, but also many aspects of data, such as socioeconomic data from the census. The increased use of multi-temporal, satellite-derived environmental data or other thematic raster data in environmental modelling has been aided by improvements in the use and accessibility of these data. Remote sensing delivers near-real-time synoptic information on vegetation growth conditions across a vast geographic area. The normalised difference vegetation index (NDVI), which is based on visible (red) (VIS) and near-infrared (NIR) band reflectance generated from the most extensively used global NDVI data sets, is used to determine the vegetation growth pattern.

Use of Remote-Sensing Data in LULC Modeling

Remote sensing data of both historical and present time are extremely important for evaluating and monitoring changes in LULC parameters which are quite helpful in modelling LULC through scenario development, driving-force analysis, model parameterization, and model validation.

1. **Scenario Development**: Future land use scenarios are vital tool for various research interests such as land-use impacts on greenhouse gas emissions and climate, biodiversity, water resources and hydrologic change. Scenario-based approaches are used in numerous global environmental assessments and can also be used for simple projections of historical rates of LULC change. Sometimes modelling LULC change focuses on creating a single reference condition through extrapolation of historical trends, while adjusting certain LULC types for testing the hypothesis about future influences.

2. Driving-Force Analysis: It is increasingly important to note that the ultimate goal of studies on LULC change dynamics using remote sensing is to finding the primary driving forces of that change (Chowdhury, 2006). Linking remote-sensing information with ground-based social data and uses in LULC models can significantly increase our understanding of the primary drivers of LULC change. Remote sensing cannot directly observe and monitor the Governmental policy that has a foremost influence on LULC change, but can evaluate the impact of the policy on land use, letting LULC modelers to build qualitative and quantitative relationships between a policy driver and impacts on LULC change.

3. **Model Validation:** Model validation remains an under developed component of LULC modelling science due to dearth of data availability and not due to validation techniques available. Obviously, it is not possible to validate future projections of land use as no validation data are available for modelled future dates, so modelers naturally depend on historical period to accomplish model validation. Ray and Pijanowski (2010) used black-and-white aerial photography to validate model output for a backcasting application in the Muskegon River watershed in Michigan. However, LULC modelers give less importance on pixel-by-pixel accuracy assessments due to path-dependence and the inherent stochasticity of LULC-modeling processes.

Applications of LULC maps

- Natural resource management
- Wildlife habitat protection
- Baseline mapping for GIS input
- Urban expansion / encroachment
- Routing and logistics planning for seismic / exploration/resource extraction activities
- Damage delineation (tornadoes, flooding, volcanic, seismic, fire)

- Legal boundaries for tax and property evaluation
- Target detection - identification of landing strips, roads, clearings, bridges, land/water interface

Conclusion

Remote sensing is an important tool for investigating land use and land cover change analyses. Climate and socioeconomic dynamics are significantly impacted by LULC change on a global and local scale. Models of LULC change that combine remote sensing data with social data can considerably improve our knowledge of the key causes of LULC change.

Land Use/Land Cover (LULC) is a broad term that describes the categorization or classification of human activities and natural features on the landscape across time using established scientific and statistical methods of analysis of acceptable source materials. It can be classified in a variety of ways. There are many different types of LULC elements, such as urban or built-up land, agricultural land, forest land, and so on. Natural resource management, baseline mapping for GIS input, legal borders for tax and property evaluation, and many more uses are all possible using LULC maps. Without the assistance of other geospatial datasets, LULC mapping is impossible.

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