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ROLE OF REMOTE SENSING AND GIS IN LAND USE PLANNING

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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**: Remote ,Sensing ,Gis*

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.

Land use and land cover change modelling

First and foremost in land use and land cover change modelling is the generation of scenarios. This is because the relationship of the people with the land has the same origin as their evolution –the ability to modify their surroundings to suit themselves. Land use change is a locally pervasive and globally significant ecological trend. On a global scale, nearly 1.2 million km2 of forest have been converted to other uses during the last three centuries while cropland has increased by 12 million km2 during the same period. Currently, humans have transformed significant portions of the earth's land surface: 10–15% is dominated by agriculture or urban industrial areas and 6–8% is pasture. These changes in land use have important implications for future changes in the earth's climate and, in turn, greater implications for subsequent land use and land cover change. The surface heat and moisture budgets depend very much on land use and land cover which, in turn, affect atmospheric instability. Simulations of the plausible human influenced landscape changes following different scenarios may reveal strategic policies that should be modified to improve the environment. For a particular region, current trends coupled with historical land use patterns are used to model future land use. Numerous models have been used to build scenarios of the future: narrative method models and hybrid methods using both qualitative and quantitative methods (Jones 2005). Agrawal et al. (2002) have provided an exhaustive study on the various available land use and land cover change models. Most land use/change models incorporate three critical dimensions. Time and space are the first two dimensions and provide a common setting in which all bio-physical and human processes operate. The third dimension is the human process or the human decision-making dimension. The three dimensions of land use change models (space, time and human decision-making) and the two distinct attributes for each dimension (scale and complexity) are the foundations of the land use change models.

Applications and Challenges of LULC modeling

Applications

- Provides support to understand the cause-effect relationships of land use dynamics
- Helps in sustainable land use planning and optimizing policy making decisions
- Valuable for unravelling the multifaceted suite of biophysical and socio-economic forces that impact the rate and spatial pattern of land use change

- For estimating the possible impacts of changes in land use

Challenges

- Primary challenge is the availability of spatially and temporally varied consistent data which are representative of driving forces.
- Linking remotely sensed outputs with social science analyses.

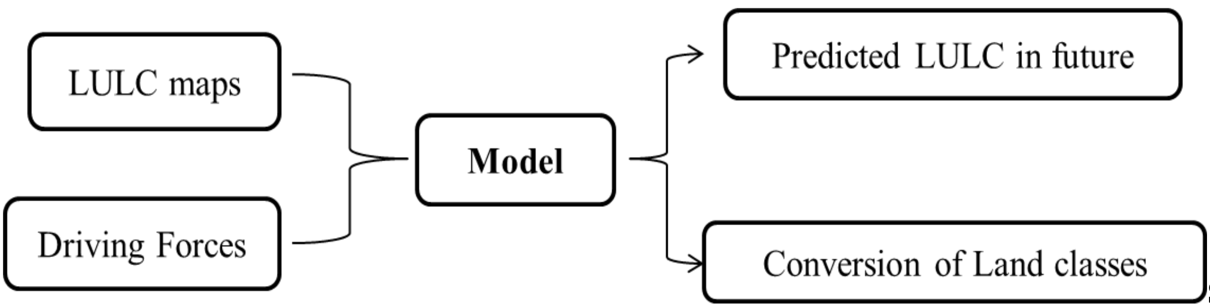
Basic Requirements for LULC modeling

- Scenarios generation
- Historical and current land-cover maps
- Socio economic, biophysical and environmental data
- Identification of the driving forces

Models used for LULC change

ModelName	Dependent Variable	OtherVariables	Strengths	Weaknesses
ConversionofLandUseandItsEffects-CLUE Model(Veldkamp and Fresco1996)	Predictsfutureland cover scenarios	Human & Biophysicaldrivers	Widerangeofbiophysicalandhumandriversoverseveral temporalandspatialscales	Inadequateconsiderationofinstitutional andeconomicvariables
Cellular Automata model • RIKSmodel(Engelenetal, 1997) • SLEUTHmodel(Clarkeet al,1997) • FuzzyCAmodel(Wu,1996) • ANN CAmodel(Li et al,2001a)	Periodicalchangeinurbanareas	Roads&Extentof urban areas,Elevation & Slope,	Allowseachcellto act independentlyaccording torules,analogousto city expansionas a result ofhundreds ofsmall decisionsFine-scaledata,registeredtoa30mUTM grid	Does not unpackhuman decisionsthatleadtospreadofbuilt areas Does not yetinclude biologicalfactors
LUCAS(Landuse ChangeAnalysis	Transition probability	Landcovertype (vegetation)	Model shows process, output	LUCAS tended to

System) (Berry et al. 1996)	matrix (TMP) (of change in land cover) Module 2 simulates the landscape change Module 3 assesses the impact on species habitat	Slope, Elevation Land ownership population density, Distance to nearest road Age of trees	and impact uses low-cost open source GIS software	fragment the landscape for low-proportion land uses, Patch-based simulation would cause less fragmentation
Area based model (Hardie and Parks 1997)	County level LULC predictions	Country level per acre basis land base, average farm revenue, crop costs, standing timber production costs & prices, Population	Uses free available data and landowner characteristics and population density Land heterogeneity Proivde county-level sampling error	Long-term forecasts run the risk of facing an increasing probability of structural change, calling for revised procedures



Stepsof LULCmodeling:

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 modeled 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.

1.2 REMOTE SENSING AS MONITORING TECHNIQUE

Urban planning requires data on changing land use, urban sprawl and the environment. This leads to the needs for monitoring by updating the knowledge to support the decision making at the suitably frequent intervals. Monitoring of the land use / land cover requires the support of two parameters-spatial resolution and temporal frequencies. Based on these two properties, Townshed (1977) has defined four of phenomena to be monitored and consequently four types of monitoring system. The relationship among four types of phenomena and monitoring system can be elaborated as:

- Rapid changes of large object .For this a low spatial resolution and high temporal frequencies are required.
- Rapid changes of small objects. These require both high spatial and temporal resolution.
- Slow changes of large objects. This needs a low temporal frequency and low spatial resolution.
- Slow changes of small objects. For this a high spatial resolution are required and low temporal resolution are required.

1.1 Remote Sensing for Ecosystem Management

The continuing capacity of ecosystems to maintain biological processes in order to provide their multitude of benefits is the corner stone of life on this planet. Yet, for too long in both rich and poor countries, development priorities have focused on how much humanity can take from ecosystems, and too little attention has been paid to the impact of our actions (White et al. 2000). Recent awareness of the importance of identifying, surveying, delineating, monitoring and reporting of globally and locally important ecosystems has been reflected at high-level global environmental keynote meetings such as the Convention on Biological Diversity (CBD), the Convention on International Trade in Endangered Species (CITES), the Convention on Migratory Species (CMS), the Ramsar Convention on Wetlands of International Importance, United Nations Convention to Combat Desertification (UNCCD), The World Heritage Convention (WHC) and others. However, intensive ground surveys cannot keep pace with the rate of land use/land cover changes over large areas and developing and applying new methods is necessary. Information and data needs on the other hand have been growing in scope and complexity.

For the past couple of decades the application of remote sensing (RS) not only revolutionised the way data has been collected but also significantly improved the quality and accessibility of important spatial information for natural resources management and conservation. The rapid acceptance of the use of remote sensing for conservation and nature protection coincides with the frequent reporting of wide spread modification of natural systems and destruction of wildlife habitats during the past three to four decades. Concerns about the increase in adverse environmental conditions prompted the remote sensing experts and users to quickly catch up with the evolving technology. The parallel advance in the reliability of Geographic Information System (GIS) has allowed the processing of the large quantity of data generated through remote sensing .

It is now more or less up to the commitment and seriousness of the international and local natural resources and biodiversity management organizations to make sure their institutional systems are ready to fully seize this opportunity, in order to develop the required capability of natural resources mapping and periodical monitoring. Undoubtedly the remote sensing and GIS technology has enabled ecologists and natural resources managers to acquire timely data and observe periodical changes. Although space borne and airborne generated data are becoming basic tools for the day-to-day activities of natural resources managers, ecologists, conservationists and others, its full potential and reliability are still unused in many of ecosystem conservation programmes. The trend and extent of wild animal species range and habitat within such ecosystems are even less known. Mapping ecosystems with all their habitats and associated components is hardly possible (Edwards et al 1996). Habitats or ecosystem are dynamic, interrelated and change through time either due to environmental factors (Lamb et al 2001) or anthropogenic pressures.

In the recent past, acquiring the necessary data to generate information for this purpose had been time consuming and expensive. Consequently, our knowledge of internationally important ecosystems and habitats, which are situated in economically poor countries, is inadequate. Since the invention of satellite remote sensing techniques and the advent of affordable powerful computing devices, such areas are also getting the deserved international attention with detailed studies as well as mapping. This is a big step forward towards monitoring global biodiversity and towards supporting the efforts of national and regional natural ecosystems conservation.

Conclusions

Remote sensing is a very important tool for studying the change analysis of land use and land cover. LULC change negatively affects the patterns of climate and socio-economic dynamics in global and local scale.

LULC models that link remote-sensing information with social data can greatly increase understanding of the primary drivers of LULC change. There is a vast scope of research on modelling LULC change dynamics over North-Eastern part of India that can give an insight of future projections on land use change.

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