LAND AND FOREST MANAGEMENT BY LAND USE/ LAND COVER ANALYSIS AND CHANGE DETECTION USING REMOTE SENSING AND GIS

ANKANA

Department of Geography, Institute of Science, Banaras Hindu University, Varanasi-221005

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ABSTRACT

Remote sensing and Geographical Information System (GIS) are the most effective tools in spatial data analysis. Natural resources like land, forest and water, these techniques have proved a valuable source of information generation as well as in the management and planning purposes. This study aims to suggest possible land and forest management strategies in Chakia *tahsil* based on land use and land cover analysis and the changing pattern observed during the last ten years. The population of Chakia *tahsil* is mainly rural in nature. The study has revealed that the northern part of the region, which offers for the settlement and all the agricultural practices constitutes nearly 23.48% and is a dead level plain, whereas the southern part, which constitute nearly 76.6% of the region is characterized by plateau and is covered with forest. The southern plateau rises abruptly from the northern alluvial plain with a number of escarpments. The contour line of 100 m mainly demarcates the boundary between plateau and plain. The plateau zone is deeply dissected and highly rugged terrain. The resultant topography comprises of a number of mesas and isolated hillocks showing elevation differences from 150 m to 385 m above mean sea level. Being rugged terrain in the southern part, nowadays human encroachment are taking place for more land for the cultivation. The changes were well observed in the land use and land cover in the study region. A large part of fallow land and open forest were converted into cultivated land.

Key words: Remote Sensing, GIS, Land Use and Land Cover, Change Detection, Land and Forest Management.

INTRODUCTION

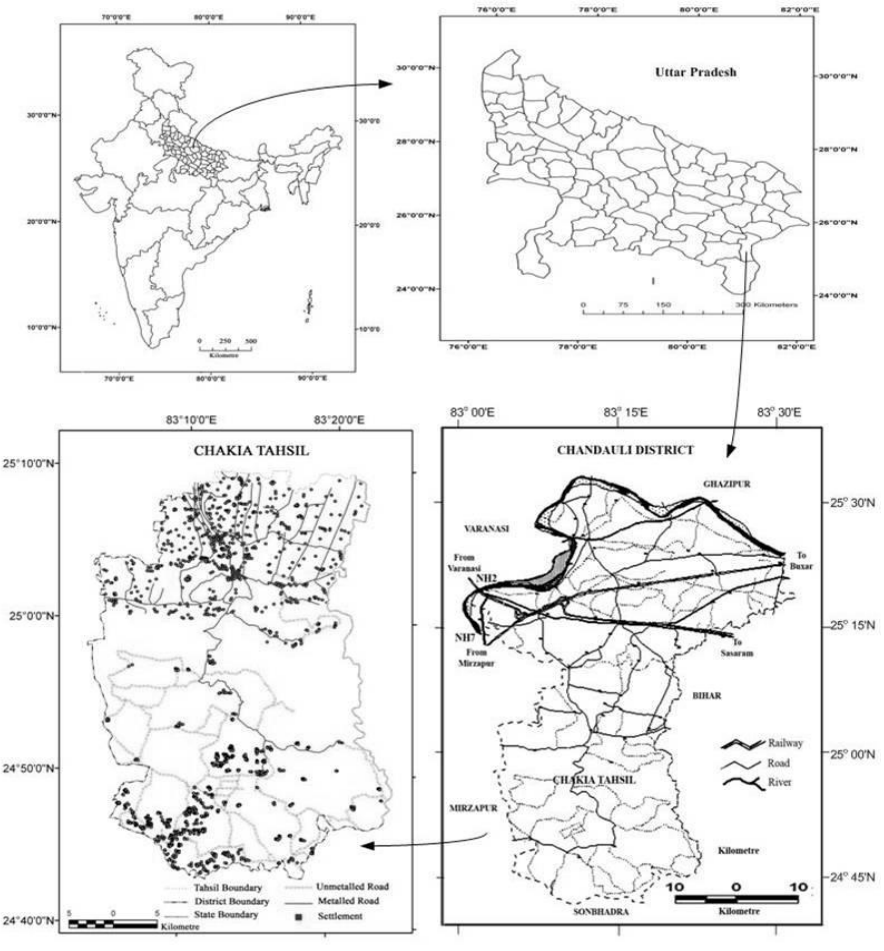
Recent changes in geospatial information technologies, especially remote sensing and geographic information science have put forward a new dimension and interactive approaches in mapping and analysis of natural resources including land resources. During the last three decades, the availability of remotely sensed data with improved spatial and spectral resolutions along with temporal and multi scale explanations have generated more momentum to establish a proper relationship amongst various associated surface elements including soil, land use/land cover (Wright *et al.*, 2009). The evaluation of land resources may be done through the analysis of its utilization of man and natural surface covers. Land use includes the man made characteristics of land resource utilization like settlement, cultivation, pasture, rangeland, recreation and so on. Land-use change at any location may involve either a shift to a different use or an intensification of the existing one. Land cover, a concern principally of the natural sciences, denotes the physical state of the land. It embraces, for example, the quantity and type of surface vegetation, water, and earth materials. Land-cover changes fall into two ideal types, conversion and modification. The former is a change from one class of land-cover to another: from grassland to cropland, for example. The latter is a change of condition within a land-cover category, such as the thinning of a forest or a change in its composition (Meyer & Turnal, 1998). Recent development in remote sensing technology and Geographic Information Systems (GIS) allow us to use landscape ecology and spatial analysis approach to address the problem of deforestation and biodiversity conservation (Menon *et. al*., 1997).

Currently, issues related to land-use and land-cover change (LUCC) have attracted interest among a wide variety of researchers, ranging from those who are modelling the spatial and temporal patterns of land conversion, to those who try to understand the causes and consequences of land-use changes (Irwin & Geoghegan, 2001; Burgi *et al*., 2004; Long. *et.al*., 2007). Remote sensing and GIS based change detection studies have predominantly focused on providing the knowledge of how much, where, what type of land use and land cover change has occurred (Weng, 2002). The GIS-based land use suitability analysis has been applied in a wide variety of situations including ecological approaches for defining land suitability/habitant (Store & Kangas, 2001) and the overlay procedures play a central role in many GIS applications (O'Sullivan & Unwin, 2003) including techniques that are in the forefront of the advances in the land use suitability analysis such as: multi-criteria decision analysis (MCDA) (Malczewski, 1999, 2006; Jiang, H., 2000), artificial intelligence (AI) geo-computation methods (Ligtenberg *et al*., 2001; Xiao *et al*., 2002) and visualization methods (Jankowski *et al*., 2001). The work of Li X. (2004) have suggested that the land use policies have influenced the direction and magnitude of landscape change. The implementation of new land policy has created profound influences on the patterns of land use and land use conversion in China. This has resulted in intensified land use conflicts and rapid depletion of agricultural land resources in many fast growing cities. The geospatial technology can be effective in the modelling of vegetation cover that can support the implementation of forest policies, watershed management or conservation strategies at regional scales (Stibig *et al*., 2007). Sherrouse *et al.* (2011) have suggested that the SolVES (Social Values for Ecosystem Services) has potential as a tool for researchers, decision makers, and stakeholders to explicitly quantify and illustrate the connections between social values, the attitudes and preferences that manifest these values, and the environmental characteristics, locations, and associated ecosystem services that elicit such values. By considering both, the social and physical contexts of values associated with ecosystem services, this tool can improve efforts to integrate publicly held values into the decision making processes of land and resource managers, even for areas where primary data regarding these values may be lacking.

In India, the work related to land use dynamics and changes is also seen in the works of various scholars. The work of Rao *et al*.(2001) on land use dynamics and landscape change pattern in a micro watershed in the mid-elevation zone of central Himalaya has found that during the last 33 years, the vegetation cover was altered drastically with increasing population pressure (both human and animal), agricultural activities and industrial wood/raw material extraction activities. Rahman (2008) in his study based on GIS model for the vulnerability of ground water contamination in Aligarh city and its surrounding areas found that GW in and around Aligarh in larger part fall under moderate to high pollution vulnerable zones. This is the major cause of concern for nearly one million populations living in Aligarh. Planning for development of natural resources without threatening the environment is a crucial issue, the world is facing today (Khorram & John, 1991 etc.). Human population growth represents the primary driving force in land use change (Vitousek *et al.*, 1997). The Land-use pattern of an area is directly related to the level of techno-economic advancement and the nature and degree of civilization of its inhabitants. Large pressure of growing population, increased demand for food, fodder and fuel wood combined with industrial activities have essentially led to rapid change in Land use/Land cover patterns particularly in developing countries. Information about the rate and kind of change in the use of land resource is essential for correct management planning and regularizing the use of such resources (Shankaranarayan & Sen, 1977).

This study aims to explore the present condition of natural resources utilization in Chakia *tahsil* (*tahsil* is an administrative division constitutes the union of blocks or is a sub District of District of a State) in terms of land and forest resources. Preparation of digital images of LU/LC of remotely sensed data of *Kharif* (rainy crop season from June to October) and *Rabi* (dry season of cultivation November to April/May) season and estimating the changes took place in the area (%) during the last ten years (2004-2014). Suggesting some possible measures for the improvementof the area based on the results obtained for LU/LC changes is the prime aim of this study.

Fig. 1: Chakia Tahsil location



STUDY AREA

With the official boundaries, Chakia *tahsil* came into existence in 1997. The region currently extends between 24º 4' N to 25º 3' N latitude and 83º 3' E to 83º 24' E longitude. The *tahsil* shares its border with the Shahabad District (Bihar) in the East, Mirzapur District in the West and Chandauli *tahsil* in the North and finally Sonbhadra District in the South. Administratively, Chakia, Shahabganj and Naugarh are the three development blocks of the *tahsil*. (Fig. 1). The general characteristics of the region are given below;

a) Physiography: Physiography largely influences the land usage and settlement pattern. The study area enjoys an excellent juxtaposed combination of Vindyan Uplands in the South and Alluvial plain in the North (Fig. 2). The Southern plateau region of the *tahsil* is highly rugged and sculpted by the major rivers like *Karmanasa* and *Chandraprabha*. The plain feature constitutes nearly 23.48% share in which 15.04% and 8.44% area is covered by *Karmanasa* and *Chandraprabha* plain respectively. The plateau region covers nearly 76.52% of the total area in which 9.79%, 57.78% and 8.95% is shared by inter-montane valley, ruggedplateau and pediment zones respectively.

Table 1: Physiographic Units and Area Covered (%)

Physiographic Unit	Area Covered (%)
Alluvial Plain	**23.48**
Karmanasa Plain	15.04
Chandraprabha Plain	8.44
Vindhyan Plateau	**76.52**
Intermontane Valley	9.79
Dissected Plateau	57.78
Pediment	8.95

Source : Image Interpretation and GIS based Computation by the author

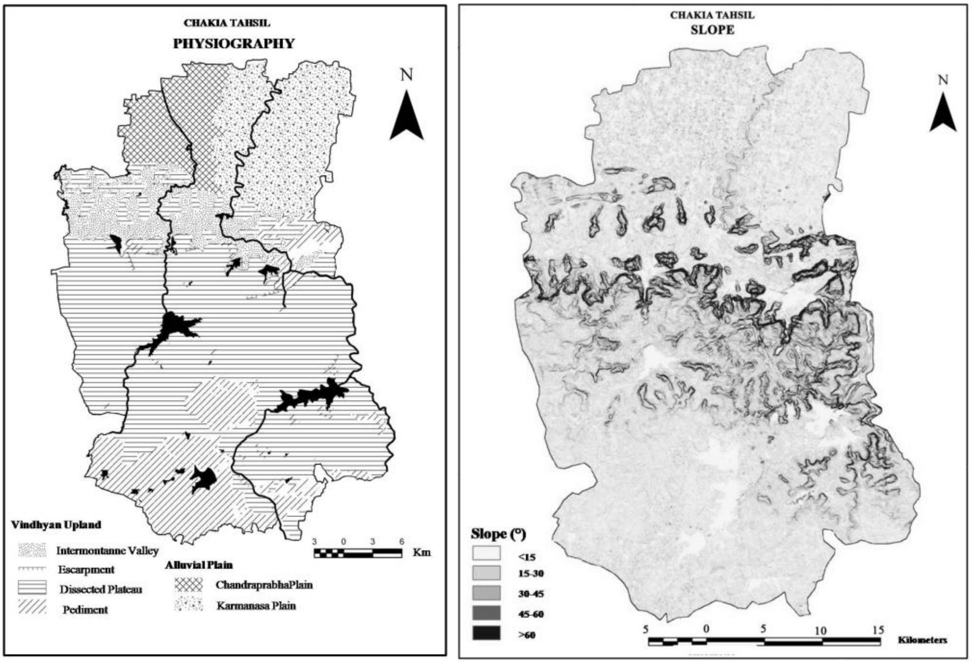
b) Relief Aspect: The slope of the entire northern and southern section area reflects more than 69.93% under level to gentle slope with some variations. Nearly 19.9% of the area falls under gentle to moderate slope. 5.01% and 4.98% of the area belongsto moderate to steep and very steep category respectively, seen in the middle part which is zone of steep escarpment. The narrow zone of escarpment running almost in the middle section reflects the very steep slope category (Fig 3 and Table 2).

Table 2: Slope and Area (%)

Slope (Degrees)	Area (%)	Nature
15 and Below	69.93	Level to Gentle
15-30	19.98	Gentle to Moderate
30-45	5.01	Moderate
45-60	4.98	Moderate to Steep
60 and Above	0.10	Very Steep

Source : Image Interpretation and GIS based Computation by the author

Fig. 2 and Fig. 3: Chakia Tahsil – Physiography and Slope



On an average the elevation ranges from 80m to 385 m above mean sea level. The relative relief with 30 m and below is obtained for the entire northern and southern portion with little variations (nearly 75.45% of area). The zone of escarpment shows appreciable variations in relief. In this section, nearly 11.43% of area is categorized under 30-90m of relative relief. 90-150 m of relative relief consists of nearly 5.78% of the area, which is running in the middle zone of the escarpment of the area. With 4.34% of the area reflects 150-210 m of value of relative relief. The high value of relative relief with 210m and above occurs in nearly 3.00%, almost in the \ zone of the escarpment (Fig. 4 and Table 3).

Table 3: Relative Relief and Area (%)

Relative Height (m)	Area (%)	Relative Height (m)	Area (%)
30 and Below	75.45	30 and Below	75.45
30-90	11.43	30-90	11.43
90-150	5.78	90-150	5.78
150-210	4.34	150-210	4.34
210 and Above	3.00	210 and Above	3.00

Source : Image Interpretation and GIS based Computation by the author

Fig. 4 and Fig. 5: Chakia Tahsil – Relative Relief and Dissection Index

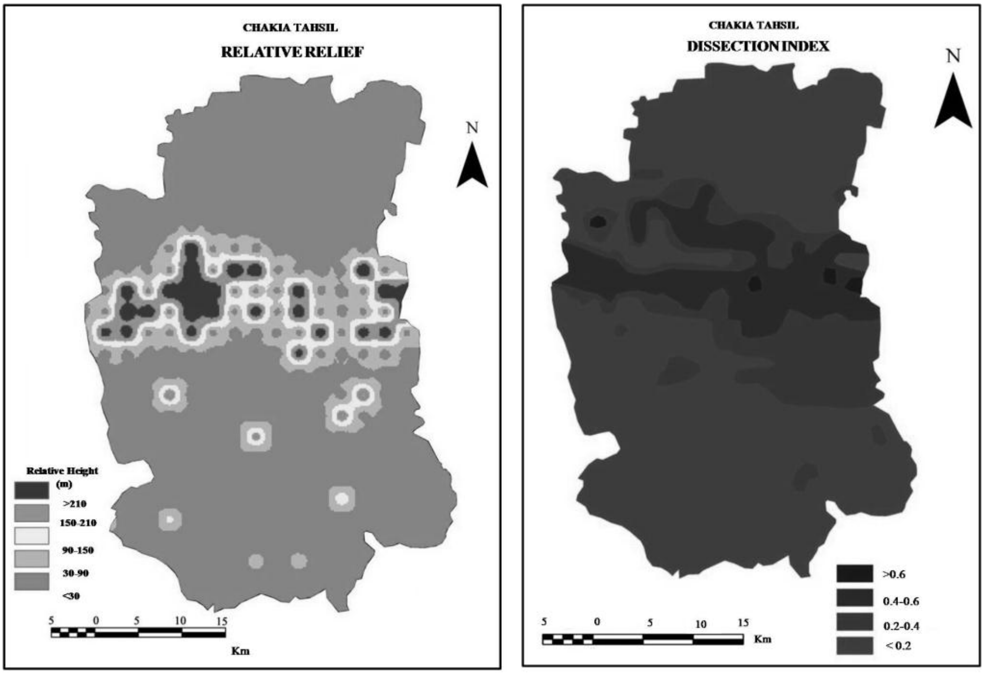


Fig. 5 and Table 4 show that the plateau zone is deeply dissected by network of *Karamanasa* and *Chandraprabha* River. The middle portion shows a comparatively higher degree of dissection with coverage of 0.37% of area. Almost southern and northern parts of Chakia display a high degree of dissection. The region reflects value 0.2 and below with 79.23% of area cover. Moderate dissection is observed in 11.48% of area with value 0.2-0.4. Moderate to high dissection with value 0.4-0.6 covers nearly 8.92% of area. Dissection can depend on many factors, but the most obvious factor is the impact of water which is sculpting the regional landforms, especially in the steep valleys and falls. Dissection index of the region is high (Ankana, 2015).

Table 4: Dissection Index and Area (%)

Dissection Index	Area (%)	Nature	Dissection Index
0.2 and Below	79.23	Low	0.2 and Below
0.2-0.4	11.48	Moderate	0.2-0.4
0.4-0.6	8.92	Moderate to High	0.4-0.6
0.6 and Above	0.37	Very High	0.6 and Above

Source : Image Interpretation and GIS based Computation by the author

c) Geology: The geology of the alluvial plain shows sediments of Quaternary age. Newer alluvial plain ismainly composed of sand, silt and clay, whereas older alluvial plain, mainly comprises clay, silt and medium to coarse grained sand. The Vindhyan Super-group in the south comprises of a stratified non-metamorphosed group of rocks, presented by sandstone, shale, sandoquartizite and limestone. The rocks are more or less horizontal bedded and are characterized by deep gorges.

d) Climate: This region is characterized by '*Monsoon*' (seasonal wind of Indian Ocean blowing southwest in summer and north east in winter in India marked with rainy season) with seasonal variations in the weather. The hot summer season starts in mid-March and lasts until mid-June to the onset of monsoonal rainfall. The average maximum temperature is in between 30 to 40°C. April, May records for hottest month. It receives its rainfall due to monsoonal winds, which start from mid-June and last until mid-September. July and August receive the highest amount of rainfall. From November to February, the season is known as the winter season, with pleasant cool weather.

e) Hydrology: Along with The *Karmanasa* and The *Chandraprabha* as the two prominent rivers, a small part of the *Garai* river also enters this region. *Latif Shah, Munsakhand, Bhainsora, Chamer, Shamsherpur, Chandraprabha, Naugarh, Muzaffarpur* dams are other important sources of water in the *tahsil*. The *Nakoiya, Baburi, Chandauli, Lehra Disty* and their tributary canals also play their role in the productivity and prosperity of this region.

f) Soil: The alluvial soil consists of sandy, sandy loam or clay loam. These soils are characterized on nearly level to level plain with loamy surfaces. They are deep to moderately deep and well drained. The fine calcareous soil lying on a level to gentle slope is characterized by slight erosion and are slight salinity. At some places, it is poorly drained. Soil of the Vindhyan plateau is characterized by sandy loam with stones. These soils are associated with moderate erosion, moderately well drained and lying on gentle slopes. Loamy sandy soil covers a major section of the Vindhyan Upland which is slightly acidic in nature.

OBJECTIVES

The major objectives of the presented investigation can be listed as:

i) Preparation of the digital files of LU/LC of satellite data using supervised classification for the year 2004, 2013 and 2014.

ii) Final LU/LC map preparation using satellite data for the year *Kharif* (2013) and *Rabi* season (2014).

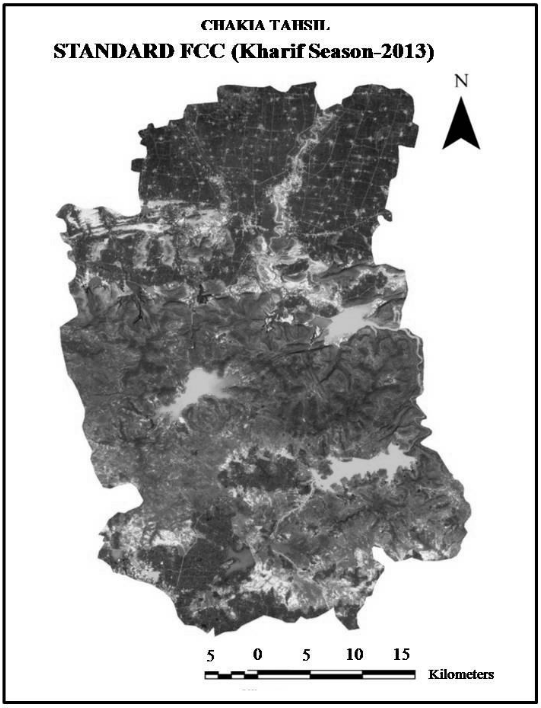
iii) Estimating the area under different LU/LC Classes and also Change in area in % for the last ten years using same season data, *i.e.*, *Rab*i season (2004 and 2014).

DATABASE AND METHODOLOGY

The study is largely based on data collected from data sources like Survey of India (topographical maps), National Remote Sensing Centre, Hyderabad (satellite imagery) and various Government offices located at district headquarters. IRS P6, LISS III (2004, 2013, 2014; Path 102, Row 54) were used for the preparation of the thematic map of land use / land cover (2013 and 2014) and the changing pattern of land use/land cover during the last ten years (2004-2014).

Digital Image Processing (DIP) techniques have been applied for LU/LC classification. Detection, recognition, analysis and classification are the four main phases (Verstappen, 1977) of image interpretation techniques through which objects of interest were taken into consideration. Training set was prepared as the first step of supervised classification under which representative training areas were identified and numerical spectral values of each LU/LC categories have been developed. Then, at the next classification stage, each pixel of the image dataset was categorized into LU/LC classes by using maximum likelihood classifier and output in the form of map and area tables were preserved in the soft copy. The two data of year 2013 (*Kharif season* of October) and 2014 (*Rabi season* of February) have merged to form final LU/LC map of the area. The areas (%) under different LU/LC classes were estimated for analyzing the changing pattern for the last ten years using satellite data of 2004 (Figs. 8 and 9) and 2014 (Figs. 7 and 6).

Fig. 6 and Fig. 7: Standard false colour compostite (IRS P6 LISS-III)



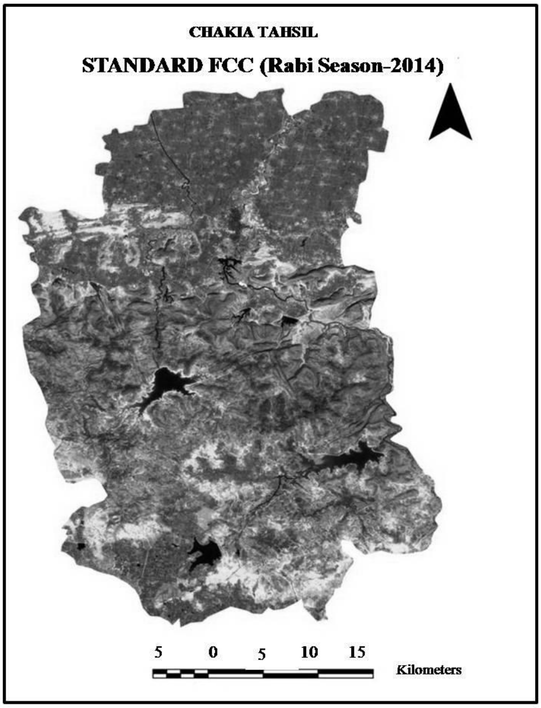
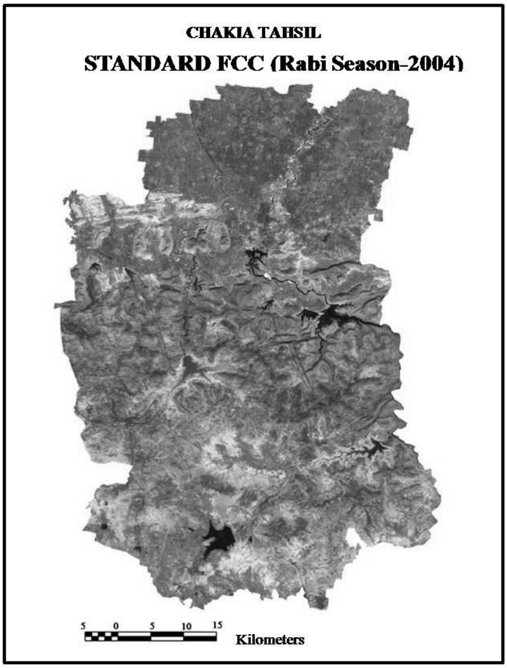
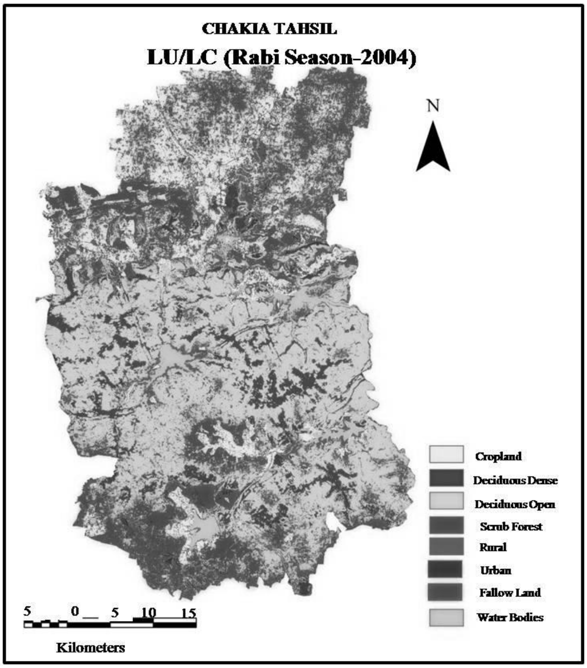


Fig. 8 and Fig. 9: Chakia Tahsil (Rabi Season-2004)





RESULT AND DISCUSSION

A) Land Use/Land Cover

It is clear from the Fig. 10 that the extreme north, north-eastern and some sections in south, patches of land are left uncultivated in *Kharif* season. Cultivation takes place in the alluvial plain, Inter-montane valleys and some patches of the southern buried pediment zones. *Kharif* season shows nearly 25.5% of the area under single *Kharif* crops. Total fallow land accounts for 3.7%. More than 50% of land is occupied by forest cover.

For the single *Rabi* season, nearly 31.9% of the areas were exposed to *Rabi* cropping and intensively cultivated. Most of the land, which had been left uncultivated in the *Kharif* season, was utilized in thatseason. Fallow land reflects nearly 3.6% of the area. Built up land represents 6.6% share of total area (Fig. 11). During the *Rabi* season full coverage of land under crop cultivation was noted over the entire northern as well as south western portion.

From the column of final LU/LC in Table 5, it can be concluded that nearly 11.5% of the land are exposed to single *Kharif* crops and 9.3% of land is taken by single *Rabi* crops. Land exposed for multiple cropping represents nearly 33.4% of land. The total of 2.8% of the land falls under fallow land. *Rabi* crop cultivation is more prominent in the extreme northwest and some significant patches in the northeastern part. In the similar way single *Kharif* cropped land is noticeable in the extreme northern section. The multiple cropped land area is shown in the northern section covering alluvial plain, valley fills, inter-montane valleys and buried pediments zones in the southern part. These areas are marked with fertile soils and good irrigation facilities. Nearly 33.7% of the total area is found under forest cover. Dense forest, open forest and scrub land accounts for 6.8%, 19.2% and 7.7%, respectively (Fig. 12).

Fig. 10 and Fig. 11: LU/LC DURING RABI and KHARIF SEASON (IRS P6, LISS-III)

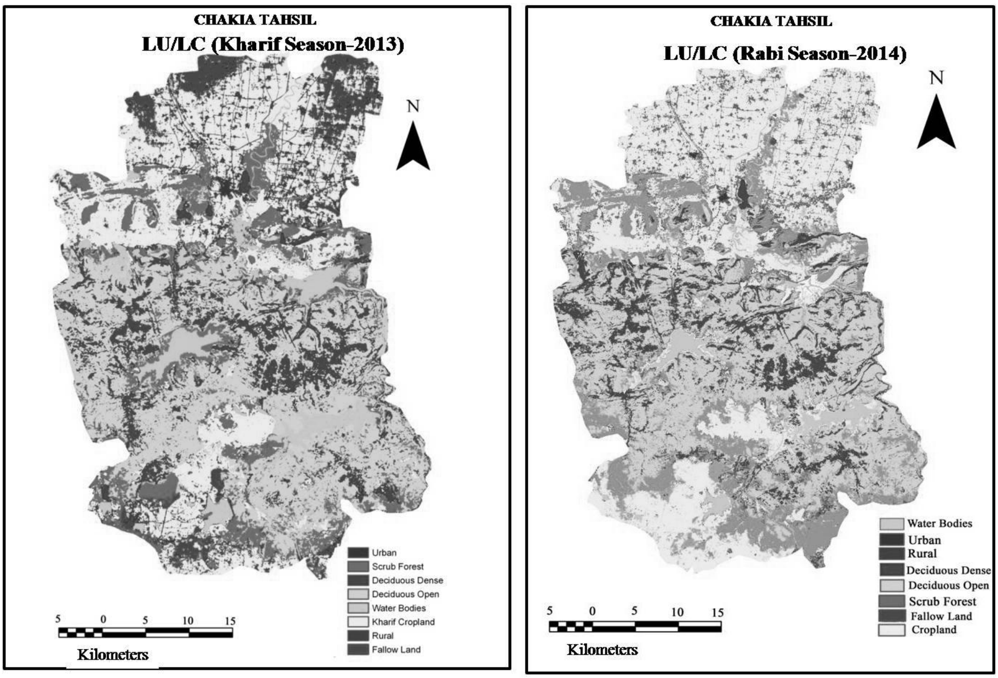
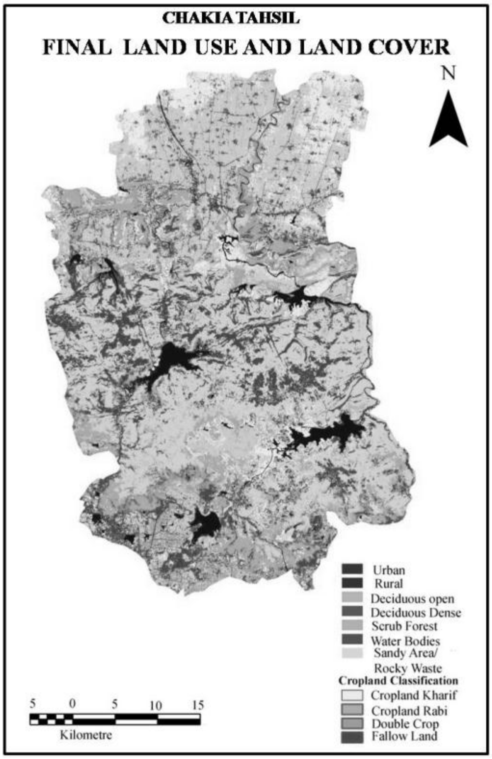


Table 5: LU/LC Classes with Estimated Areas (%)

LU/LC Category				Estimated Area (%)			
Level –I		Level-II		*Kharif* Season (2013)	*Rabi* Season (2014)	Kharif+Rabi (Final LU/LC)	Total
1	**Built-up**						6.6
		1.1	Urban	0.1	0.1		
		1.2	Rural	6.5	6.5		
2	**Agricultural land**						54.2
		2.1	*Kharif* Crop	25.5	-	11.5	
		2.2	*Rabi* Crop	-	31.9	9.3	
		2.3	Double Crop (*Karif+Rabi*)			33.4	
		2.4	Fallow Land	3.7	3.6	2.8	2.8
3	**Forest**						33.7
		3.1	Dense Forest	12.4	11.7	6.8	
		3.2	Open Forest	31.4	27.9	19.2	
		3.3	Scrub Forest	13.8	15.5	7.7	
4	**Water Bodies**			6.6	2.9		2.7
				100.0	100.0		100.0

Source: Image interpretation and GIS based computation by the author

Fig. 12: Chakia Tahsil - Final land use and Land cover



B) Estimation of Change in Area (%) During the Last Ten Years

Two year data (2004-2014) have been taken into account to analyze the pattern of LU/LC. For the year 2004, cropland area covered nearly 20% of the total area of *tahsil*. Dense forest, open forest and scrub forest constituted nearly 11.1%, 30.2% and 14% of area respectively. Fallow land covered nearly 11.1% of the area. Water bodies constituted 2.7% of the area. Other category included wasteland, sand dunes *etc.* are noted in 10.8% of the total area. Year 2014, displayed nearly 31.9% share area under the total cropland denoting an increase in nearly 59.5% during the last ten years. Dense forest covered 3.23% of enhancement of the total area, as it was nearly 11.7% in the year 2014 comparing to the 11.1% of year 2004. The area of open forest has decreased from 30.2% (2004) to 27.9% in the year 2014. This shows a decrease of 7.61% during the last ten years. Scrub forest reached nearly 10.71% area. Fallow land shows the highest change in the pattern. In the year 2014, fallow land reached to nearly 3.6%. (Table 6).

Table 6: Changing Patterns in LU/LC in Chakia Tahsil (2004-2014)

LU/LC Category	Area (%)		Change (%) 2004-2014
	2004	2014	
Dense Forest	11.1	11.7	3.23
Open Forest	30.2	27.9	-7.61
Scrub Forest	14.00	15.5	10.71
Fallow Land	11.2	3.6	-72.22
Cropland	20.0	31.9	59.5
Water Bodies	2.7	2.9	8.69
Other	10.8	6.5	-33.67

Source: Image interpretation and GIS based computation by the author

It is clear that the demand has forced to encroach the forested area in the study area. The results indicated that an appreciable amount of land cover changes have occurred in croplands (+59.5%), open forest (-7.61), scrub forest (+10.71%). The change for the last ten years shows rapid utilization of land resources and their conversion. Some open forest areas are added into scrub forest areas due to the human intervention. The dense forest shows slight increase in the cover. Other category in LU/LC classes (includes the features like wasteland, sandy areas and water logged areas) displayed an appreciable decrease in the area. These land features were also included during last ten years in cultivation by adopting suitable cultivation techniques.

Underlying causes of LULC changes leading to deforestation and land degradation include rapid economic development, population growth and poverty (Giri, *et.al*. 2003, Bolland, *et.al*., 2007). For sustainable utilization of the land ecosystems, it is essential to understand the natural characteristics, extent and location, their quality, productivity, suitability and limitations of various land uses (Ram & Kolarkar, 1993). Satellite remote sensing is potentially powerful means of monitoring land-use change at high temporal resolution and lower costs than those associated with the use of traditional methods (El-Raey *et al*., 1995). The study of land use/land cover (LU/LC) changes is very important for correct and apropriateplanning and utilization of natural resources and their management (Asselman and Middelkoop, 1995). The digital data in the form of satellite imageries, therefore, enable to accurately compute various land cover/land use categories and help in maintaining the spatial data infrastructure which is very essential for monitoring urban expansion and land use studies (Mukherjee, 1987) and change detection is useful in such diverse applications as land use change analysis, monitoring of shifting cultivation, assessment of deforestation, study of changes in vegetation phenology, seasonal changes in pasture production, damage assessment, crop stress detection, disaster monitoring snow-melt measurements, daylight analysis of thermal characteristics and other environmental changes. Manual handling of data for change detection using sequential imagery is a formidable task (Adeniyi, 1980).

CONCLUSION AND SUGGESTIONS

This paper focuses on the importance of recent remote sensing and GIS technology in the assessment of land use dynamics and changing pattern in the study area. During the study, it became obvious that rapidly changing land cover is one of the critical issue in this region. Another main aspect is that the southern hilly region is covered with dense and open forest and hilly tracts do not offer suitable condition for cultivation practices. Although need has forced humans to reach in these forest regions, too, but the result is seen in the form of deforestation and conversion of open forest into scrub forest.

For the sustainable development of the area, following suggestions can be listed:

(i) To increase the per hectare production, correct land care, scientific treatment of land and relevant irrigation through the construction of *bandhies* (small ponds) and extension of existing canals may be suggested in the region.

(ii) Land under single cropped cultivation in the region should be promoted for multiple cropping by adopting a cropping pattern and technology. The land of permanent fallow and rocky waste may be used for fodder and fuel plantation.

(iii) Arrangements should be made to check further depletion in dense forest. Plantation work may be encouraged with the help of local people inhabiting the pediment zones. Proper training should be given to local people to protect the forest at share basis in forest products so that their interest may be created.

(iv) Cultivation practices are encroaching day by day in the hilly areas, which mean the destruction of forests. The farmer should be encouraged to agroforestry and social forestry.

(v) Forest resources based industries should be established with involvement of local people along with providing knowledge and practices of forest conservation. Forest resource based industry can be helpful in the socio-economic development of the region.

(vi) Dense forest cover should be managed and commercialized. Some areas of open forest may be converted into dense forest cover. Scrub forest region should be promoted for forest plantation.

Eco-Tourism and Sustainable Development: The major advantage of the study region is that it has immense potential for eco-tourism development. Forest, rivers, waterfalls, dams, hilly tracts etc. make this place ultimate but the region is still unexplored and less developed part in the Chandauli District. Doedari (15 m) and Rajdari (43 m) falls on the Chandraprabha river, Nakatidari fall (45 m) on the Jharwania Nala, Deodari fall (58 m) and Talruhwa Nala fall (42 m) on the Karmanasa river are some of the waterfalls observed in this region. Some gorge features are also noted with short extent in the upper courses of the rivers Karmanasa and Gurwat.

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