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MAPPING AND MONITORING OF LAND TRANSFORMATION DUE TO URBAN SPRAWL IN REWARI CITY

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Abstract

Like other human-induced land cover change, urbanization represents a response to specific economic, demographic or environmental conditions. We use the Rewari city area as a case study to relate satellite derived estimates of urban growth to demographic drivers. Large scale land transformation process has been witnessed presently in and around Rewari city. Here the study attempts to map and monitor the urban land use changes in Rewari City of Haryana covering an area of 1174.63 ha. The Landsat data archive we have created a three epoch time series for urban growth for the period of 1973-2007. The basic data comprised of Landsat 1 (MSS) False Colour Composite (FCC) of 1973, Landsat 5 (TM) FCC of 1989, Landsat 7 (ETM+) FCC of 2000 and high resolution satellite images from Google Earth for the year 2007. The following analysis looks into issue of land transformation with focusing on the loss of cultivated and agricultural land put to non agricultural uses. The result shows that during the last 34 years the city population has increased 4.1 times and area has increased 6.6 times, consuming 85 percent of good fertile cultivable land.

Keywords: *Remote Sensing; GIS; Urban Sprawl; Landuse /Land Cover; Monitoring.*

Introduction

Land is always in a constant flux of continual change due to transformations resulting from natural processes and human activities and this modification is an issue of great concern to planners, geographers, environmental scientists as well as decision makers all over the world. From a broader perspective urbanization is just one of many ways in which humans are altering the land cover of the globe which usually does not follow any simple plan. During the last century unprecedented concentration of humans in urban areas has been seen around the globe (Cohen, 1995). Due to rapid urbanization and industrialization, India is changing and the effect of land transformation is being felt on the countryside. Some of the causes of urban expansion such as population growth, economic development, migration infrastructural innovations resulting in transformation of villages into towns, towns into cities and cities into metros (Singh, et.al, 2008). This rapid growth of all the major cities in the country today, culminating in large scale land transformations– both positive and negative. This unabated trend of growth in urban sprawl is causing wide spread conversion of physical landscape in to urban landscape. The process of urban development is resulting in a variety of urban landuse patterns which are measurable and useful to the urban planners, managers and researchers. Such land transformation process is presently being witnessed in and around Rewari city. Some of these man-made changes are very dynamic and rapid and uncontrolled land transformation affect social, economic and physical subsystem and sustainability of the city.

It is exceptionally difficult to assess and monitor the urbanization and land transformation at regional and global level due to lack of accurate statistics. In this regard satellite based remotely sensed data, provides reliable, accurate and repetitive information on the changing urban land use patterns. After realizing the importance of Remote Sensing and GIS technology in urban planning several studies have been conducted with different perspectives (Jensen, 1981; Jensen et.al, 1982; Toll, 1985; Haack et.al, 1987; Griffiths, 1988; Martin et.al, 1988; Royer and Charbonneau, 1988; Green et.al, 1994; Ridd and Liu, 1998; Lo and Yang, 2002; Xia and Anthony, 2004; Minakshi et.al, 2005; Raghavswamy et.al, 2005; Haack and Rafter, 2006; Kumar et.al, 2007; Bhatta et.al, 2010; Tamilenthi et.al, 2011).

Objectives

A temporal study helps in understanding the changing land use patterns and their impacts on the environment. Here, the scope lies in mapping such transformations using satellite data for landuse and its management in Rewari city. The present study aims at analyzing the following set of objectives:

- To map out the urban land use change of Rewari city, using satellite data and GIS techniques.
- To monitor urban land use patterns resulting due to land transformations
- To establish the relationship between population growth and urban sprawl.

Data Base and Methodology

To generate time-series of urban growth in Rewari City, we obtained Landsat scenes from 1973, 1989, 2000 and

Quick Bird data for the year of 2007 has been downloaded from Google Earth. The earliest image (1973) is acquired with 79 m spatial resolution Landsat Multispectral Scanner , while Landsat 5 Thematic Mapper for 1989 and Landsat 7 Enhanced Thematic Mapper + for 2000 with 28.5 m spatial resolution from the Global Land Cover Facility (http://glcf.umiacs.umd.edu/data/) server website. The different bands of imageries have been also stacked to produce a False Colour Composite (FCC). The whole Remote Sensing data which is used in this study enables to freely download from the internet. Gross urban Built up area of the year 2007 has been taken as base for studying the sprawl of Rewari city. Image-to-map rectification has been performed on Landsat ETM+ (2000) image using a first-order polynomial transformation and a nearest-neighbor resampling technique. Image coordinates has been identified for nine ground control points selected throughout the Landsat ETM+ (2000) image and matched with easily identifiable features on Survey of India toposheet no (53 D/12) 1: 50000 scale. Image-to image registration has been performed for all remaining images using the Landsat ETM+ (2000) image as the master image. Root-mean-square errors are less than 15 m for the TM and ETM+ images and less than 40 m for the MSS images (half the pixel size in field of view (Table 1). The coarse resolution MSS image has been resampled to 28.5 m resolution as part of the georegistration procedure. Image georegistration processing has been performed with Erdas Imagine software. Data from Google Earth for 2007 has been downloaded in different tiles and then mosaicked using Adobe Photoshop software and later geometrically rectified with respect to LANDSAT 7 ETM+ image. After all images has been registered and stacked, polygons of the built-up area boundary for the period of 2007 has been vectrozied and then subsetted from the images for the year 1973, 1989 and 2000 from the full path/row image.

Strategies for Urban Change Detection

A variety of land covers change detection techniques exist for satellite imagery. In the present study broadly we have used two approaches. In first, detection of changes has been identified through supervised classifications using the ISODATA algorithm and maximum likelihood decision rule to perceive three classes: agricultural land, open space and urban area which has been taken in consideration (Jensen, 1996). The advantage of this approach is that the semantic meaning of the land cover change is immediately obvious to avoiding confusion between different kinds of land cover change. This is probably the most common change detection technique in which major errors can occur when the amount of change is very small as compared to the total area under consideration. Improved estimates of urban growth have been attained by using the second methodology, directly comparing the radiometry between subsequent images that include band-by-band image differencing, image ratioing, change vector analysis, and vegetation index differencing. (Malila, 1980, Lambin and Strahler, 1994). Several studies have proposed to change detection techniques for monitoring urban growth based on changes in the Normalized Difference Vegetation Index (NDVI). Defined as the normalized difference between near-infrared and visible reflectance, NDVI can be directly related to the amount of photosynthetic (green) biomass within a pixel (Rouse et al. 1973, Tucker et al. 1981). Since urbanization in non-arid regions replace vegetation (high NDVI) with building materials (low NDVI), sudden decreases in NDVI will indicate urban development. Howarth and Boasson (1983) have found that changes in vegetation indices are strongly correlated with urban growth. It is not possible to differentiate diverse landuse details because of similar spectral response and low spatial resolution, such doubtful areas have been verified on the ground and finally the corrected details have been transferred on the base map. The changing landuse patterns are shown in figure. 2 and 3 and the areas under different landuse for respective years of 1973, 1989, 2000 and 2007 are shown in Table 2. The area figures of 2007 have been considered to explain the variations in land use. No validation with the official figures has been attempt in the study.

Table 1. Details of the Data

Source of Data	Satellite	Sensor	Year of Acquisition	Spatial Resolution	Spectral Resolution	Temporal Resolution
GLCF	LANDSAT 1	MSS	1973	79 m	0.6-0.7 0.7-0.8 0.8-1.1	18 days
GLCF	LANDSAT 5	TM	1989	28.5 m	0.52-0.60 0.63-0.69 0.76-0.90	16 days
GLCF	LANDSAT 7	ETM +	2000	28.5 m	0.52-0.60 0.63-0.69 0.76-0.90	16 days
Google Earth data for the year 2007						
Survey of India Toposheet No. 53 D/12						
Census of India, 1971, 1981, 1991, 2001 and 2007 (Observed population)						

Study Area

The Rewari city is the administrative headquarter of the Rewari district in Indian state of Haryana. It covered about 1174.63 ha area in 2007 considered as the base of the study. The geographical extension of Rewari city is 27° 50′ to 28° 52′ North to 76° 0′ to 76° 5′ East (Figure. 1). It is situated on Jaipur-Delhi section of Northern Railway, 85 km away from the national capital Delhi in the east and 260 km from Jaipur in the west. The city has been occupied by highly dense residential, industrial and institutional landuse, juxtaposed with good transport system of rail and road network having well

connection with bordering cities. The study area has an experience of hot and semi-arid climate with annual rainfall about 300-500 mm and growing period of less than 90-120 days, with extremes of temperature in summer and winter (Resources Atlas of Haryana, 2004).

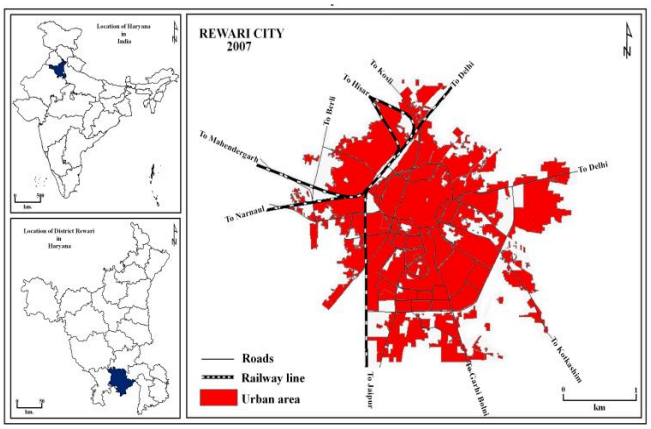

Figure 1. Location of Study Area

Results and Discussion

Spatio-temporal Patterns of Land Transformation

The classified images of 1973, 1989, 2000 and 2007 based on ISODATA algorithm for Land use and Land cover are presented in Figure. 2 and 3 and pixel based Land use and Land cover classification computed for three time period has been presented in Table 2 and 3. Table 2 reveals the changing pattern of land use from 1973 to 2007 of Rewari city. It is evident from Table 2 that agricultural area in 1973 comprised the largest proportion of 61.72 percent (724.97 ha.) of total urban area and in 1989 and 2000 it has been observed 58.17 percent (683.33 ha.) and 43.49 percent (510.83 ha.) of urban area respectively. The urban area under agriculture purposes has been completely missing by 2007. The open space in the city has been accounted for 23.18, 21.25 and 20.60 percent in 1973, 1989 and 2000 respectively and this category has been found nowhere by 2007. During the same period, the proportion of built-up area has increased significantly. It has been reported for 15.10 percent (177.41 ha.) in 1973, 20.58 percent (241.67 ha.) in 1989, 35.91 percent (421.83 ha.) in 2000 and 100.00 percent (1174.63 ha.) in 2007.

It has also been noticed that agricultural land and open space has experienced a sharp declining trend of 43.49 percent and 20.60 percent from 2000 to 2007 respectively whereas built-up land has shown the increase of 64.09 percent during same time by overlapping the area of both above said categories. On comparing the satellite data sets pertaining to 1973-1989, 1989-2000 and 2000-2007, it has been found that built up area in and around city has increased by 5.47 percent and 15.34 percent during the period of 1973-1989 and 1989- 2000 respectively whereas the total increase in built-up area during 2000-2007 has been observed 64.09 percent. This large scale raise in built-up area is the result of population growth as well as development of road network and communication facilities. The agricultural area has got highest decline of -43.49 percent in past seven years (2000-2007) while the open space has experienced the decline of -20.60 percent in the same time period. In such way, we can see that built-up area has attained the increase of 48.75 percent points from 1989-2000 to 2000-2007 at the remarkable decline of 28.80 percent points and 19.95 percent points in agriculture and open space respectively. Figure 2 represents the spatial pattern of land transformation in Rewari city from 1973 to 2007. The evolution of the city landscape of Rewari has been analyzed through different historical-time periods. The city has grown into the present form through multiple processes.

Table 2. Changing Pattern of Landuse/Cover in Rewari city

Landuse Classes	Area in ha.				Percent Change		
	1973	1989	2000	2007	1973 to 1989	1989 to 2000	2000 to 2007
Built-up Area	177.41 (15.10)	241.67 (20.58)	421.83 (35.91)	1174.6 (100)	5.47	15.3	64.1
Agricultural Land	724.97 (61.72)	683.33 (58.17)	510.83 (43.49)	0 (0.00)	-3.54	-14.7	-43.5
Open Space	272.25 (23.18)	249.63 (21.25)	241.97 (20.60)	0 (0.00)	-1.93	-0.65	-20.6
Total	1174.6 (100)	1174.6 (100)	1174.6 (100)	1174.6 (100)	0.00	0.00	0.00

Real development of the town took place after the formation of Haryana State in 1966 and witnessed a fast transformation in its landscape in terms of development of educational institutions, administrative infrastructure and industries. The city has passed through various phases of growth in terms of their spatial dimensions. The large scale land alteration of agricultural area into built-up area has been observed during this time and there is continuous process of urban sprawl in fringe area. Figure 2a shows that city expansion in 1973 was mostly confined with two nucleus centers, the first is within the circular road including Bada Talab, Ghanteswar Temple, caste based segregated mohallas (Punjabi Mohalla, Mahavir Nager, Shiv Colony and Shakti Nager), Old Anaz Mandi Market and Main Bazar and another is

railway station adjoing unplanned residential area such as Sadhu Shah Nager. During the time period of 1973-1989, the city expanded mainly in east between and along Bawal and Narnaul road due to administrative set up and planned residential area. The spreading out of urban built-up area in south is due to industrial set up, semi-planned and unplanned residential area whereas in north-west direction there is less expansion because of rail network. The city developed and expanded in above said directions along roads by filling the gap between old city and railway station by 2000 (Figure 2b and 2c). It has been depicted by figure 2d that by 2007, the expansion of city as built-up area has been observed in all directions but major progress has took place in south- eastern direction between Bawal and Garhi Bolni roads and Jaipur-Rewari-Delhi railway line.

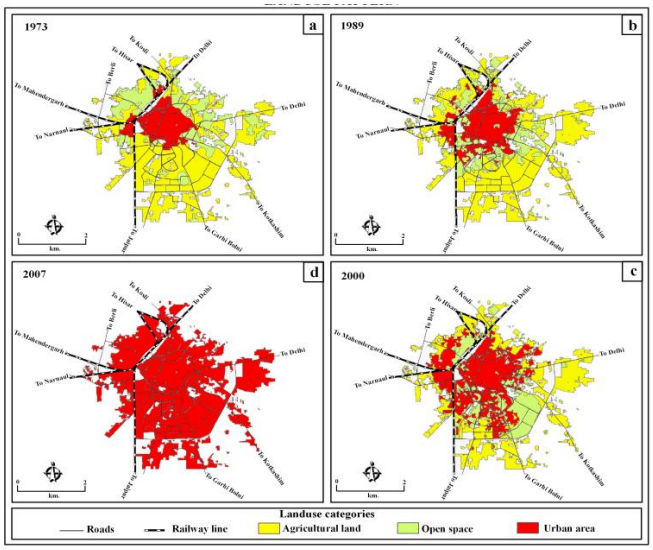

Figure 2. Changing Landuse/Cover Pattern of Rewari City

A scattered advancement also has occurred in north-western side of the city along railway line. The temporal prototype of land transformation from agricultural area to urban built-up area during 1973 to 2007 reveals that in 1973 and 1989, during this time the region was confined with old wall city inhabited by dense population and there is slow sprawl of built-up area from the center towards outside in study area. The augmentation along foremost transportation corridors outward from city center has been noticed from 1989 onwards and key expansion has occurred in southern direction followed by eastern from city center as compared to others (Figure. 3).

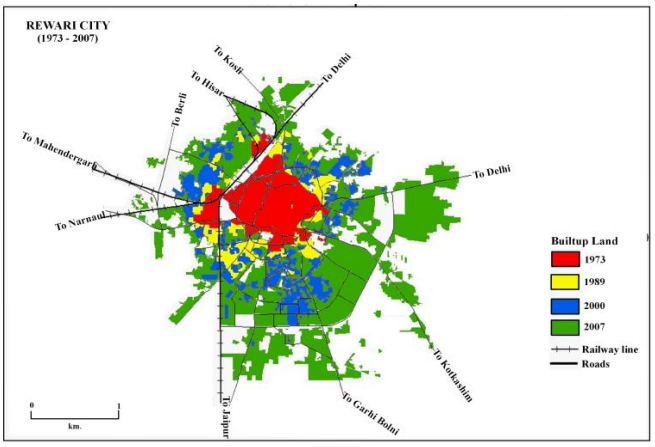

Figure 3. Pattern of Urban Sprawl

Population Growth and Land Transformation

The population growth is key driver of urban sprawl and in Rewari city major land transformation is due to increasing population and planned growth by HUDA (Haryana Urban Development Authority). As it has been shown in Figure 4 and Table 3 that city population has increased four times (43,885 to 1, 80, 110) from 1971 to 2007 while built up land has enlarged seven times (177.41ha. to 1174.63 ha.) from 1973 to 2007.

Table 3. Comparison between Population and Built-up Land

Year	Population	Percent Growth Rate	Year	Built-up Area (ha)	Percent Growth Rate
1971	43885	--	1973	177.41	--
1991	75342	71.68	1989	241.67	36.22
2001	124030	64.62	2000	421.83	74.54
2007*	180110	45.22	2007	1174.63	178.46

Population estimation based upon growth rate between 1991-2001.

Apart from this natural growth, migration from surrounding areas is also responsible for this urban land transformation. Interestingly, the built-up growth rate is 2.05 times more in 2000 (74.54 percent) than 1989 (36.22 percent) whereas there is no significant difference in the population growth rate (1991 to 2001) i.e. 74.54 and 64.62 percent respectively.

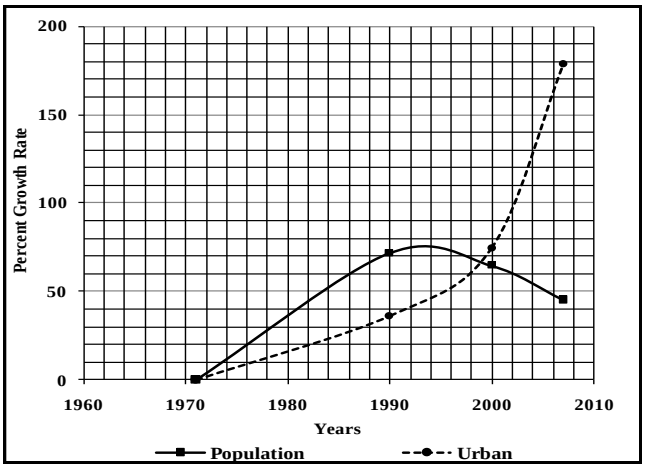

Figure 4. Population and Urban Growth Rate

Conclusions

The study shows the importance of Remote Sensing and GIS technology which is useful to understand the nature of land use and land cover and analyzing the spatial expansion of urban area because with the help of multi spectral satellite data, it is possible to prepare land-use/land cover map, to analyze the pattern of urban sprawl. . For change detection study satellite Remote Sensing and GIS plays an immense role towards the city's future development plan to be executed by decision makers. The temporal and spatial monitoring of land transformation is essential for planning of development and preserving of natural resource and environment and is also needed by urban planners to predict the further change in land utilization. It has been found from above discussed tables and figures that built-up land has mainly increased at the cost of agricultural land and major development has taken place along major transportation corridors outwards from city center towards south- eastern direction. The study reveals that 61.72 percent agriculture land and 23.18 percent open space have been captured by built-up area during the study period (1973 to 2007). The urban built-up growth rate is much higher as compared to population growth. It is interesting to note that from 2000 to 2007, area under built-up land has increased about three times from 421.83 ha to 1174.63 ha with a net increase of 752.80 ha. The analysis also shows railway line as hindrance in development of urban built-up area in north-western direction whereas its presence supports to encroachment towards eastern and southern sides of the city. The study investigates that the urban sprawl has emerged as one of the potential threats to sustainable development of the city as rapid loss of fertile agricultural land and open space have experienced considerable squeezing and paved way to physical expansion of built up use in the study area.

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