THE INTERNATIONAL JOURNAL OF HUMANITIES & SOCIAL STUDIES

Land Transformation of Rohtak City: A Study Using Remote Sensing and GIS Techniques

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Abstract:
Land transformation is one of the most important fields of human induced environmental transformation; with an extensive history dating back to antiquity.The study makes use of Geographic Information System (GIS) and Remote Sensing (RS) technique for land transformation of Rohtak city, Haryana. Located amidst fertile agricultural lands, the city has undergone rapid expansion during the recent past raising serious concern among planners and policy makers. On the basis of Toposheet and satellite images, land use/land cover of Rohtak was classified into eight classes. These classes are urban built up, rural built up, water bodies, forest area, agricultural area, open area, industrial area and parks/garden. Data used in the present paper are the Survey of India Toposheet, LANDSAT TM 1989, IRS P6 LISS-IV PAN (mono) 2005, image acquired from Google earth 2011, and Census of India. On the basis of these data the land transformation map for different time periods has been prepared and showing three time land transformation data.

1. Introduction

In recent years, cities in the less developed parts of the world have experienced rapid aerial expansion in the wake of phenomenal growth in population. Rural to urban migration has played a significance role in urban growth in such countries areas. Large towns and cities in the developing world are experiencing a constant high rate of growth in their populations and as a result, many of them are undergoing unplanned and uncontrolled expansion of settlements at the densely populated sites or on the fringes (Fazal, 2000:133).

All over the world, cities and towns are expanding through both natural increase and in-migration of people from countryside. Urbanization occurs because people move from rural areas (countryside) to urban areas (towns and cities). The pace of urbanisation is more rapid when the economy of a country is in the developing stage. Many of the less developed countries are going or passing through this stage. According to Population Research Bureau (2005) it is expected that 60 percent of the world population will be urban by 2030. It is expected that most of the urban growth in the world will occur in less developed countries during the next decades. India is no exception to it, and rapid urban growth and development have resulted in increase in the size of India's urban population from 79 million in 1961 to 285 million spread over 5161 urban agglomerations/towns in 2001 (Rahman et al., 2011:56). India's urban population in absolute term is the second largest in the world after China.

Land use and land cover scenario in India has undergone a radical change since the introduction of New Economic Policy in early 1990s and these changes involve a series of complex interaction between biophysical and socioeconomic variables (Roy and Giriraj, 2008:1346). In India number of million plus cities has increased from 5 in 1951 to 23 in 1991 and to 35 in 2001. According to Census of India 2001, about 37per cent of the total urban population lives in these million plus cities.

Urban growth has accelerated during the post-independence period, and small towns and rural peripheries are progressively incorporated into a wider and more complex urban system (Aguilar, 2008:133). From the point of view of urban expansion the spatial context of land use and land cover changes in the urban fringe is important since it comprises a critical consideration for decision-making in urban land use (Reenberg and Fog, 1995:490).

2. Study Area

Rohtak city is located on the intersection of 28°54′ N latitude and 76°35′ E longitude, at a distance of 75 kilometres to the north-west of Delhi, the National Capital of India. Delhi is a Metropolis city in the Northern Region of India. Due to its location in the close vicinity of the National Capital, the urban landscape of Rohtak has undergone change from time to time. According to the Census of India 2011, Rohtak city is the third largest city of Haryana state. Rohtak is a Class–I city with a population of 3, 73, 133 at the time of 2011 census. In 2010, Municipal Committee of Rohtak was up-graded to Municipal Corporation (MC). According to the MC limit the total area of the city was 11039.15 hectares in 2010.

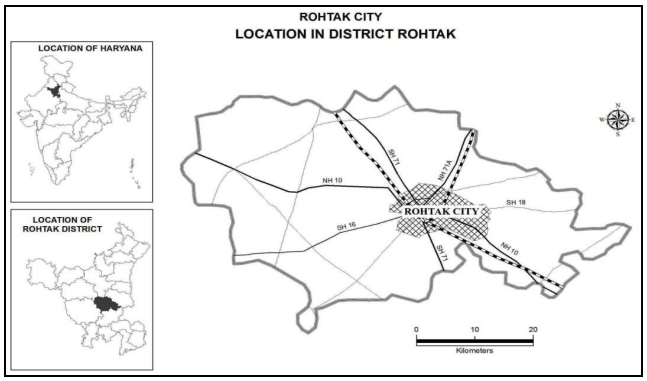

Figure 1: Study Area

3. Data Based and Methodology

3.1. Data Based

The study is spread over a period of 38 years from 1973 to 2011. An integrated geo-spatial approach i. e. remote sensing and GIS in conjunction with secondary data has been adopted in the study. The remote sensing and GIS data were handled with the help of Erdas Imagine 10 and ArcGIS Desktop 10.0 respectively. The lists of data used in the study are the Survey of India Toposheet No. H 53 D/9 and H 43 W9 at the scale of 1:50,000, LANDSAT TM 1989 (Landsat TM: path 158, row 40, 18/5/1989) downloaded from the Global Land Cover Facility (http://glcf.umiacs.umd.edu/), IRS ID LISS-III 2002 (IRS LISS III: path 95, row 51, 15/02/2002), IRS P6 (Resourcesat–1) LISS-IV PAN (mono) 2005, Image acquired from Google earth, 2011 (20/09/2011) and Census of India.

3.2. Methodology

Toposheet No. H 53 D/9 (Survey of India) at the scale of 1:50,000 have been scanned and used as a reference to perform geometric correction using Erdas Imagine 9.2 software. Approximately, 60 ground control points (GCPs) were selected in order to register the images to the Universal Transverse Mercator (UTM) coordinate system in 43 North Zone and WGS 84 Datum. GCPs were dispersed throughout the images, to make sure the RMS error less than one pixel. These raster images were later subjected to an image-to-image co-registration (i.e. pixel-to-pixel fixation) and re-sampled using a Nearest Neighbour re-sampling method to avoid any significant loss of pixel information. The images were then resample to 24 m pixels using the nearest neighbour method and first order polynomial was also used. The Toposheet used as a reference to perform geometric correction to four times satellite images i.e. for Landsat TM, 1989, IRS LISS III, 2002, IRS PAN, 2005 and for 2011 acquired from Google earth. The toposheet and Google earth image have been classified by the visual interpretation. It is because the in both of the cases the unsupervised and supervised classification are not working. They are classified based on screen digitisation. In this Shape file has been created in ArcGIS. After the completion of digitisation the topology has been cleaned and built in ArcGIS. Than these vectors are converted into raster in respective layers and resample to 24 m pixels using the nearest neighbour method. Other three time images have been used unsupervised classification in Erdas Imagine and resample to 24 m pixels.

On the basis of toposheet and satellite images, land use/land cover of Rohtak was classified into eight classes. These classes are urban built up, rural built up, water bodies, forest area, agricultural area, open area, industrial area and parks/gardens1. The Municipal committee of Rohtak became Municipal Corporation in 2010. With this up gradation of civic status, the boundary of the city was expanded and eight villages namely- Bohar, Asthal Bohar, Garhi Bohar, Majra, Kheri Sadh,Kanehli, Sunari Kalan and Sunari Khurd were brought under municipal limit. Therefore, the latest MC limit of Rohtak, 2010 has been used to analyse the growth of the city. Land use/land cover (LULC) in Rohtak has been analysed in two different ways. In the first, LULC is calculated on the basis of geographic area of the city exiting at respective time points. In the second, a common geographic area that corresponds to MC limit for 2010 has been taken as base for working put share of lands under different uses.

4. Objectives

The basic objective of the study is to examine the process of land transformation of Rohtak city.

- To analyze the land transformation within time period 1973-1989, 1989-2005 and 2005-2011

5. Land Transformation Analysis

In the present study images pertaining to four time-points were used for change detection. With the help of these images three change detection images created. The results are summarised in Figs. 2, 3 and 4. Table 1 shows the amount of land being transformed from one category of land use/land cover into other category of land use/land cover. In the table diagonal grey boxes show no change in particular land use class whereas the rest of the white boxes in the table show change in area among different land use classes.

Recently, the focus of 'urban change detection' has shifted from detection to quantification of change, measurement of pattern, and analysis of pattern and process of urban growth and sprawl. Urban growth can be quantified by measuring the built-up change between two dates (Singh 1989; Jensen 2005).

6. Land Transform During 1973-1989

During the period 1973 to 1989, a drastic transformation was witnessed in agricultural land. As Table 1 shows, 1206.27 hectare of agricultural land was transformed into open land. Further, another 119.89 hectare land previously under 'agricultural uses' went into urban 'built up land'. Likewise, 16.16 hectare land was transformed into rural, 77.41 hectare into 'water body' and 29.08 hectare into 'forest area'. Next to the agriculture land, a transformation in open area was also significant. Most of open area i.e. 334.16 hectare was converted into urban built up land. Some of the 'open land' was also transformed into 'water body' and 'rural area'. About 22 hectares of land under 'water body' transformed into 'open area'. During this period some 'water body' dried up and therefore the land was converted into open land. During this period government also acquired land for planned residential sector i.e. Sector 14 developed by HUDA. The change detection map of Rohtak city indicates that most of the newly coming up residential areas was confined in eastern direction of the city along National Highways no. 10. A significant feature of the city's landscape was the residential area along the main roads. Rohtak city is famous for educational institutions and large number of institutions came up with corresponding infrastructure development leading to the increase in built-up area. Maharshi Dayanad University come into existence in 1976. The Sugar mill and Mohan Spinning Mill in the southern parts of the city and Hafed also came up in the northern parts of the city during this period. Such a large scale land transformation clearly speaks about the urban expansion mostly on fertile land and open/waste land. During the period between 1973 and 1989 Tilyar Lake was developed for tourism purpose in the eastern side of the city on the highway connecting Rohtak with Delhi. The lake is spread over an area of 132-acre (0.53 km²) area and forms an integral part of the tourist setup, making it one of the greenest stretches in the adjoining area. The setting up of the Tilyar Complex also meant increase in the area under 'water body' (lake) and' green area' of the city.

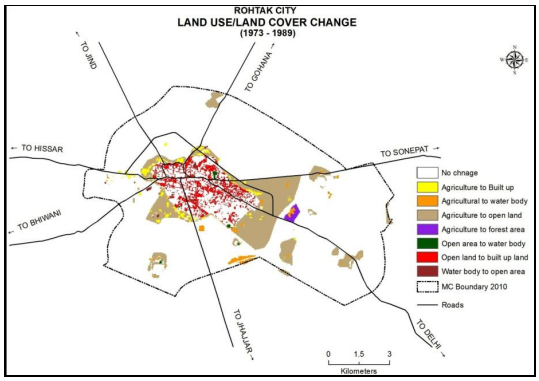

Figure 2

7. Land Transform During 1989- 2005

During 1989 to 2005 again the main transformation occurred in the case of 'agriculture land' and 'open land'. Table 1 shows that 746.51 hectare of 'agricultural land' was transformed into 'open land', 422.584 hectare into 'urban built up' land, and 69.04 hectare land into 'industrial area'. Land transformation next in magnitude was in case of 'open area'. A greater part of open area i.e. 478.54 hectare was transform into urban 'built up'. Around 100 hectare land was transformed into 'rural area', and 17.69 hectare into 'industrial area'. During 1989–2005 some more 'water body' dried up and were converted into 'open land'. The land transformation map pertaining to the period shows significant growth of newly constructed buildings mainly in the north eastern, south eastern parts of the city. The morphology of the city is characterised by narrow lanes, old type of clustered houses and crowded shops. In contrast the newly developed residential areas of north eastern and south eastern parts are modern and well planned. During this time many planned sectors and colonies were developed which finally changed the landscape of the city. Residential sectors 1, 2 and 3 were developed by HUDA (Haryana Urban Development Authority) on the eastern part of the city along National Highway No. 10 and State Highway No. 18. In addition, industrial area developed by HSIIDC (Haryana State Industrial and Infrastructure Development Corporation) on National Highway No. 10 on the western side of the city. The growth of the city continued in all directions like previous years. Actually, the patches of lands which were vacant or open land till 1989 got transformed into 'built up area' by 2005. Residential areas grow in all directions although major growth was taking place along National Highways and State Highways. Many educational institutions in the form of mainly schools came up in outer parts of the city. For example Delhi Public School in the western parts on National Highway No. 71 connecting Rohtak with Jind, Pathania Public School, Shiksha Bharti Vidyalaya, The Sanskriti School and I. B. School in the northern parts on National Highway No. 71A (Rohtak-Panipat Road), in the eastern parts Shri Baba Mast Nath educational institute, Indus Public School, D.A.V. Public School and D G V Public School on National Highway No. 10 (towards Delhi) in the eastern parts were the educational institutions that came up during the period, all these urban development took place on agricultural land.

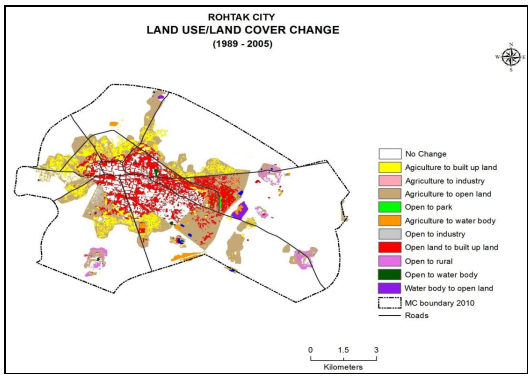

Figure 3

8. Land Transform During 2005 – 2011

Referring back to Table 1 it is seen that 2686.02 hectares of fertile 'agricultural land' was converted into 'open area', 'built up area' and 'industrial area'. Lands where permanent construction has already taken place accounts for only 5 per cent of the land diverted from agriculture. Of this, 92 per cent has been changed into 'open area' waiting for future expansion of built up area. The government has acquired agricultural lands for urban development. As already stated earlier in the chapter, this land has been acquired to develop residential, institutional and industrial area during 2005 to 2010. But till the present time major parts of the area is still open in spite of built up area. During this time government also gave land to private builders, the details of land given to private builders are shown in Table 2.

1973-1989

Land Use	Agricultural Land	Urban	Rural	Water Body	wooded area	open area	Total
agricultural land	8225.98	119.89	16.16	77.41	29.08	1206.256	9674.77
Urban	0	649.07	0	0	0	0	649.07
Rural	0	0	59.78	0	0	0	59.78
Water Body	0	0	0	223.21	0	21.93	245.14
wooded area	0	0	0	0	96.52	0	96.52
open area	0	334.16	8.1	15.43	0	1301.33	1659.02

1989-2005

Land Use	Agricultural Land	Urban	Rural	Water Body	Wooded Area	Open Area	Industrial Area	Parks	Total
Agricultural Land	6949.69	422.584	0	38.1602	0.00	746.507	69.0365	0	8225.98
Urban	0	649.07	0	0	0	0	0.00	0.00	649.07
Rural	0	0	108.52	0	0	0	0.00	0.00	108.52
Water Body	0	0	0	241.05	0	4.0898	0.00	0.00	245.14
Wooded Area	0	0	0	0	96.52	0	0.00	0.00	96.52
Open Area	0	478.54	102.33	4.0898	0	1359.046	17.6943	0	1961.7
Industrial Area	0	0	0	0	0	0	56.55	0.00	56.55
Parks	0	0	0	0	0	0	0.00	10.63	10.63

2005-2011

Land Use	agricultural land	Urban	Rural	Water Body	Wooded area	open area	Industrial area	Parks	Total
Agricultural land	4397.06	140.79	0.00	34.51	0.00	2469.48	31.84	9.40	7083.08
Urban	0.00	1261.17	0.00	0.00	0.00	0.00	0.00	0.00	1261.17
Rural	0.00	0.00	117.54	0.00	0.00	0.00	0.00	0.00	117.54
Water Body	0.00	0.00	0.00	224.86	0.00	0.00	0.00	0.00	224.86
wooded area	0.00	0.00	0.00	0.00	96.52	0.00	0.00	0.00	96.52
open area	0.00	590.23	80.95	36.1829	0.00	1214.13	40.2051	0.00	1961.70
Industrial area	0.00	0.00	0.00	0.00	0.00	0.00	50.19	0.00	50.19
Parks	0	0	0	0	0	0	0.00	21.91	21.91

Source: Calculated by the researcher

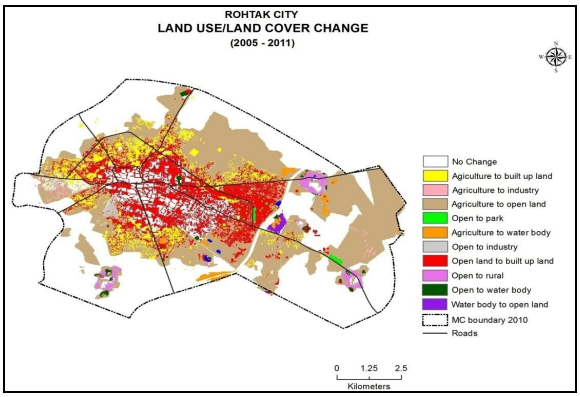

Figure 4

S. No.	Developer Name	Area in Acres	Sector No.	Licence Year
1	Ramesh Chander	4.4	-	2005
2	Omaxe Construction Ltd	77.484	26,28	2006
3	Uddar Gagan Properties Pvt. Ltd & Others	60.43	27,28,23	2006
4	Uddar Gagan Properties Pvt. Ltd & Others	51.89	27	2006
5	Sonika Properties Pvt ltd	175.638	34,35,36	2006
6	Sonika Properties Pvt ltd	173.027	34,35,36	2008
7	Sonika Properties Pvt ltd	19.97	34,35,36	2009
8	Omaxe Construction Ltd	41.91	28	2009
9	One Point Realty Pvt. Ltd	59.656	37	2010
10	Parshavnath Developers Ltd	118.188	33-A,33	2010
11	Sharad farms and holdings pvt ltd	14.813	36-A	2010
	Total	**797.406**		

Table 2: Land Acquired by Private Builders during 2005-2010
Source: Town and Country Planning Office, Panchkula

Licences to develop the land were given to private builders during 2005 to 2010. Seven private colonizers were allocated 797.4 acres of land for development of residential area. The land continued to be in the category of 'open land' up to the time of 2011 except some built up patches of Omaxe Construction. Further, much of the land acquired for IMT being developed by The Haryana State Industrial and Infrastructure Development Corporation (HSIIDC) is still 'open' up to the time data was collected.

The expansion of 'open land' is in the eastern and northern sides of the city along the National Highway No. 10, State Highway No. 18 and railway line towards Gohana. In the Northern side of the city, the Haryana Urban Development Authority (HUDA) is developing Rajiv Gandhi Sports Complex in Sector-6. This is the main reason underlying a faster expansion of 'open area' than that in other land use classes. As stated earlier this rapid growth can be attributed to political factors. The magnitude of transformation in 'open land' is next only to transformation in agricultural land. Nearly 43 per cent, of 'open area' amounting to 590.23 hectare was transformed into 'urban built up' during 2005- 2011. During the period new water storage came up for industrial and domestic uses on the agricultural land. Around 140 hectare agricultural land was transformed into built up area and 31.84 hectare was converted into industrial area. Land conversion into 'built-up' area has occurred in all the directions of the city. This transformation is however, more prominent along the major roads of the city. Expansion of many educational institutions during 2005-2011 also resulted in conversion of 'open area' into 'built-up area'. For example Maharshi Dayanad University and Jat Education Societies expanded their buildings and constructed new buildings in their campuses on the open spaces. In the university campus most of the open area was converted into 'built up area'. The magnitude of 'agricultural land' being transformed into 'open' is strikingly greater during 2005 to 2011 as compared to the past. The size of agricultural land converted into 'open land' during 2005- 2011 alone is more than three times than that during 1989 to 2005.

9. Accuracy Assessment

In order to validate the classified maps of land use/land cover map accuracy analysis has been performed. The generation of an acceptable accuracy assessment of the Land use /Land cover classification requires that a number of random sites be chosen that represent the classes in the Land use /Land cover. These sites must then be visited and described so that they can be accurately classified. Accuracy assessment was performed for the 1989, 2002, 2005 and 2011 land use/cover maps using local knowledge and ground truth. Stratified random sampling design, where the points were stratified according to the distribution of land use/cover classes, was adopted. By allowing the reference pixels to be selected at random, the possibility of bias is lessened (Congalton, 1991:37). In this study about 250 ground control points (GCP) were randomly selected over different land use/land cover classes for the three time points, in such a way that all classes are represented well.

For the year 1989, the classified map was having an overall accuracy of 85.94 per cent and the overall kappa statistics was0.84 per cent. The overall accuracy of the 2005 classification assessment was 87.89 per cent with a Kappa coefficient of 0.85. For the 2011 land use/cover map the result indicated an overall

Years	Overall Accuracy (%)	Kappa Statistics
1989	89.94	0.84
2005	87.89	0.85
2011	92.97	0.90

Table 3: Accuracy Assessment

classification accuracy of 92.97 per cent and a Kappa index of agreement of 0.90. At this time the accuracy was higher than other times because 2011 image is based on higher resolution and true colour. It has been downloaded from Google earth.

10. Conclusion

Rohtak had experienced a rapid rate of land transformation during the nearly four decades. Land transformation of the urban area had efficiently captured by remote sensing and geographic information systems (GIS) techniques. Location and its proximity to the National Capital has played a very important role in the growth of Rohtak city. Although, the city has expanded in all directions, there is a marked inclination towards the eastern side indicating the magnet effects of the national capital. The present structure of most of the Indian cities indicates successive growth around their cores in the form of encroachment on the rural fringe areas which are mainly agricultural lands. In the wake of urban expansion agricultural fields are acquired by the government agencies for urban development. The largest area under land transformation during 2005-2011 has been observed. This was an inevitable result of the fact that the present Chief Minister of the state happens to be from the city.

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