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Land Use / Land Cover Change of Delhi: A Study using Remote Sensing and GIS Techniques

Singh Bijender[1] and Singh Joginder[2]
[1]Department of geography, I.G. University, Meerpur, Rewari, Haryana, INDIA
[2]Department of Geography, M.D. University, Rohtak, Haryana, INDIA

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Abstract

Unprecedented Growth of an area measured is an important task because it play an important role for future development of that area. The change analysis was performed by post classification comparison method, comparing the data of two different sensors (Lands at TM and LISS III IRS P-6), at different time periods (years 1992 and 2004). The growth of Delhi measured between two time periods was based on the above data set. The results showed that there was rapid change in land cover/land use. It was found that there was a phenomenal change in the built-up area in watersheds, loss of forest cover and change in agriculture land. There is a great need for sustainable management of resources to maximise benefits of societal resources. On the basis of these data the land transformation map for different time periods has been prepared and showing land transformation data.

Keywords: Remote sensing, GIS, Delhi, land use/ land cover change.

Introduction

In recent years, cities all over the world have experienced rapid growth because of the rapid increase in world population and the irreversible flow of people from rural to urban areas. Specifically, in the larger towns and cities of the developing world the rate of population increase has been constant and nowadays, many of them are facing unplanned and uncontrolled settlements at the densely populated sites or fringes[1]. In India, unprecedented population growth coupled with unplanned developmental activities has resulted in urbanization, which loss the agricultural land. This also has posed serious implications on the resource base of the region. The urbanization takes place either in radial direction around a well-established city or linearly along the highways. Regular monitored of urban land cover / land use changes are necessarily for sustainable development of an area. The satellite images and aerial photographs are providing the synoptic view of an area. Also, these are covered the area with a regular interval of time so that we can compare the area with the past. These types of digital data are very useful in change detection studies. These data are handled with the help of remote sensing, geographical information Science (GIS) techniques. These types of studies are very useful in land use change and urban expansion studies[2]. Land is becoming an increasingly scarce resource due to immense agricultural and demographic pressure. Hence, information on land use/land cover and possibilities for their optimal use is essential for the selection, planning and implementation of land use schemes to meet the increasing demands for basic human needs and welfare. This information also assists in monitoring the dynamics of land use resulting out of changing demands of increasing population[3]. Various geographic and socio-economic factors largely determine the land use pattern, distribution of land values, density of traffic, and the proportion of land used for different purposes in different parts of the city. Patterns of urban structure corresponding to commercial, industrial and residential uses depend chiefly upon the rent-paying ability and modes of transport available. Within a city region land values, accessibility and history of urban growth are the main determinant factors in the arrangement of land use patterns. The centre of a modem city exhibits special features of land use, and has distinctive functions which make it the best known of the various regions found within the urban area. In addition, industries located in the urban fringe (within a city region) also influence the land-use. Usually, all urban centre is a node of transport and very valuable space is devoted for transportation. The spatial pattern of these functions expresses the morphological character of the city. Morphological transformation refers to the re-arrangement of buildings, streets and roads, and the functions of the land. The urban space is delineated by the location, intensity, and amount of land required for the various space-using functions of city like industry, wholesale trade, business, housing, recreation, education, open space and cultural activities. Location, areal extent, and interaction among the various urban functions form the core of concern of an urban geographer and the knowledge of these factors is a prerequisite for considering such problems as the determination of nature and location of internal transportation routes and facilities within cities and metropolitan areas; the allotment of the amount of land and its location for the appropriate development of each type of land use; the location of individual establishments such as factories, shops, schools and residences. Urban land use study aims at optimizing

the efficiency of each function, and thus of the city as a whole. It also seeks to evaluate a city's economic and physical patterns in relation to the direction and character of its future development. In order to estimate and understand the behaviour of such urban sprawls, which is crucial for sound environmental planning and resource management, current study was undertaken on National Capital Territory Delhi. Therefore, attempt will be made in this study to map out the status of land use/ Land cover of areas Delhi between 1992 and 2004 with a view to detecting the land use changes that has taken place in this statues using both Geographic information system and Remote Sensing data.

Study Area: The National Capital Territory of Delhi has been selected for the present study. The national capital territory of Delhi with an area of 1483 sq.km is situated between the Himalayas and Araval is range in the heart of the Indian sub-continent. The Gangetic Plain and the Aravalli Ridge converge at Delhi, giving mixed geological character with alluvial plains as well as quartzite bedrock. It is located between 28º24′17″ Nto 28º53′00″N latitudes and 76°45′30″ E to 77º21′30″E longitudes and is surrounded on 3 sides by Haryana and to the east, across the river Yamuna by Uttar Pradesh. Its greatest length is around 53 km and the greatest breadth is 48 km. Delhi's altitude ranges between 213 to 305 metres above the sea level.

Material and Methods

The study is spread over a period of 12 years from 1992 to 2004. 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 8.7 and ArcGIS Destop 9.3 respectively. The lists of data used in the study are Lands at Thematic mapper (Path-Row: 146-40, 146-41 and 156-40) 1992, IRS-P6 LISS III (Path-Row: 096-051) 2004 and Census of India. These raster images were later subjected to an image-to-image co-registration (i.e. pixel-to-pixel fixation) and resampled using a Nearest Neighbour resampling 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 two times satellite images. Delhi is the national capital of India so rapid immigration in the city due to better employment, education facility and other services. This helps the spatial growth of city and it spread in the fertile agricultural land. There has been rapid conversion of agricultural areas to non-agricultural uses. In 2001 the population density was 14,387 and 1,627 persons/ km 2 in urban areas and rural areas respectively.

Results and Discussion

Land transformation is one of the most important fields of human induced environmental transformation, with an extensive history dating back to antiquity. Since Neolithic times, the modification of the earth caused by human action has mainly involved impacts on the soil and biotic resources. Once set in motion land transformation did not abate but, rather, accelerated and diversified with the onset of the Industrial Revolution and result antexpansion of population. Of late the process has further accentuated in the wake of the globalization of the world economy. Forests were cleared, grasslands ploughed or grazed, wetlands drained and crop lands and settlements expanded, yet never as rapidly as in the last few years[4]. Almost all the lands in the world are now under one or other uses by mankind although in varying degrees of intensity. Land transformations, although localized, are having to wide-reaching consequences and their impact can be seen as systemic processes at the global level. Urban land cover is the most prominent landscape on the earth surface influenced by human activities. Not only the macroscopic change in land use and pattern caused by urbanization could be recorded objectively, but also its location and time i.e. spatial and temporal, pertaining to where/when changes occurred could be reproduced by studying land use cover change (LUCC)[5]. 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[6,7].

Land use / land cover of Delhi (1992): The urban land use / land cover map of Delhi for the year 1992 has been prepared using Landsat TM data. The broad land use classes have been taken from TM data. The classification of various classes has been improved using ground truthing. The total area of Delhi was 1487 sq. kms. in 1992. The statistics of different land uses mapped has been presented in table 1. About half of total area i.e. 52% was agriculture at that time. The residential land use is classified in high density residential, medium density residential and low density residential which has about 10%, 8% and 7% of total area respectively in above mentioned classes. Villages were uniformly distributed all over the study area. They are mainly distributed in the western and north part of the area. Total population of Delhi in 1991 was 9,420,637 residing over 39507.487 hectares of urban area in 1992. Due to such a high density and increasing trends of migration expansion of urban landscape was obvious.

Land use / land cover of Delhi (2004): The urban land use / land cover map of Delhi for the year 2004 has been prepared using LISS III P-6 data (resolution 23.5m) (refer figure). The detail land use classes have been taken from LISS III data. The classification of various classes has been improved ground truth. Of the total 148675 hectares, agriculture as a whole constitutes 54152 hec. land which constitutes 37% of the total area. During the study period it suffered the sharpest decline in the last decade because of the increasing share of residential land use. As the table 4.2 shows the second largest share is of residential area (38%) which is increasing at the cost of other non buildup classes mainly fertile agriculture land. The most distinguishing

land cover of Delhi is its Ridge (an eminent of oldest folded mountain Aravalies), it still constitutes 5.5% of total land cover in 2004.Population of Delhi was13,782,976 in 2001 residing over 57927.89 hectares of urban area in 2004. But the actual picture comes when we see the percentage of high density residential share i.e. nearly 23 % in 2004 while in 1992 it was nearly 10 %.

Table-1
District Wise Population of Delhi (1991–2001)

		1991		2001		
District	**Area (km²)**	**Population (In lakhs)**	**Density (pers./km²)**	**Population (In lakhs)**	**Density (pers./km²)**	**Decadal growth 1991–2001**
North-West	440	1,778,268	18,088	2,847,395	29,395	60.12
South	250	1,502,878	26,261	2,258,367	25,760	50.27
West	129	1,434,008	15,986	2,119,641	22,637	47.81
North-East	60	1,085,250	11,116	1,763,712	16,431	62.52
South-West	420	1,084,705	11,471	1,749,492	12,996	61.29
East	64	1,023,078	6,012	1,448,770	9,033	41.61
North	60	688,252	4,042	779,788	6,471	13.3
Central	25	656,533	4,791	644,005	4,909	–1.91
New Delhi	35	167,672	2,583	171,806	4,165	2.47
Total NCT Delhi	1483	94,20,644	6352	137,82,976	9,294	46.31

Source: Census of India.

Table–2
Land Use/Land Cover Statistics of Delhi (1992 and 2004)

	1992		2004	
Land Use	**Area (Hectares)**	**Percentage**	**Area (Hectares)**	**Percentage**
Highly Dense Resident	15348.87	10.39415	34123.04	22.95132
Medium Dense Resident	12039.75	8.153237	10706.75	7.201413
Low Dense Settlement	10661.8	7.2201	10324.3	6.944176
Rural Settlement	1457.066	0.986715	2773.801	1.865672
Commercial	396.867	0.268756	527.8605	0.355042
Airport	2261.665	1.531583	2160.016	1.452838
Institutional	1718.188	1.163545	1951.316	1.312464
Industrial	689.6771	0.467045	576.0304	0.387441
Parks And Zoo	1650.914	1.117988	1429.429	0.961441
Stadium And Playground	241.0723	0.163252	383.2164	0.257753
Historical Monument	1280.429	0.867097	1293.939	0.87031
River	1728.6	1.170596	1075.87	0.723635
Drainage	920.3121	0.623229	1088.398	0.732062
Water Body And Reservoir	183.9678	0.124582	189.0788	0.127175
Canal	142.9531	0.096807	185.7018	0.124904
Agricultural Land	65214.21	44.89011	54152.63	36.93953
Scrub Land	3721.427	2.520125	3615.579	2.431856
Forest	2331.062	1.578579	2127.343	1.430861
Ridge	9874.868	6.687192	8211.805	5.5233
Pasture Land	3286.048	2.225289	554.2501	0.372791
Urban Agriculture	8102.817	5.487171	4755.277	3.198422
Riverine Green	177.4143	0.120144	164.484	0.110633
Open Land	3507.948	2.375558	5538.115	3.724963

Source: Computed by researcher

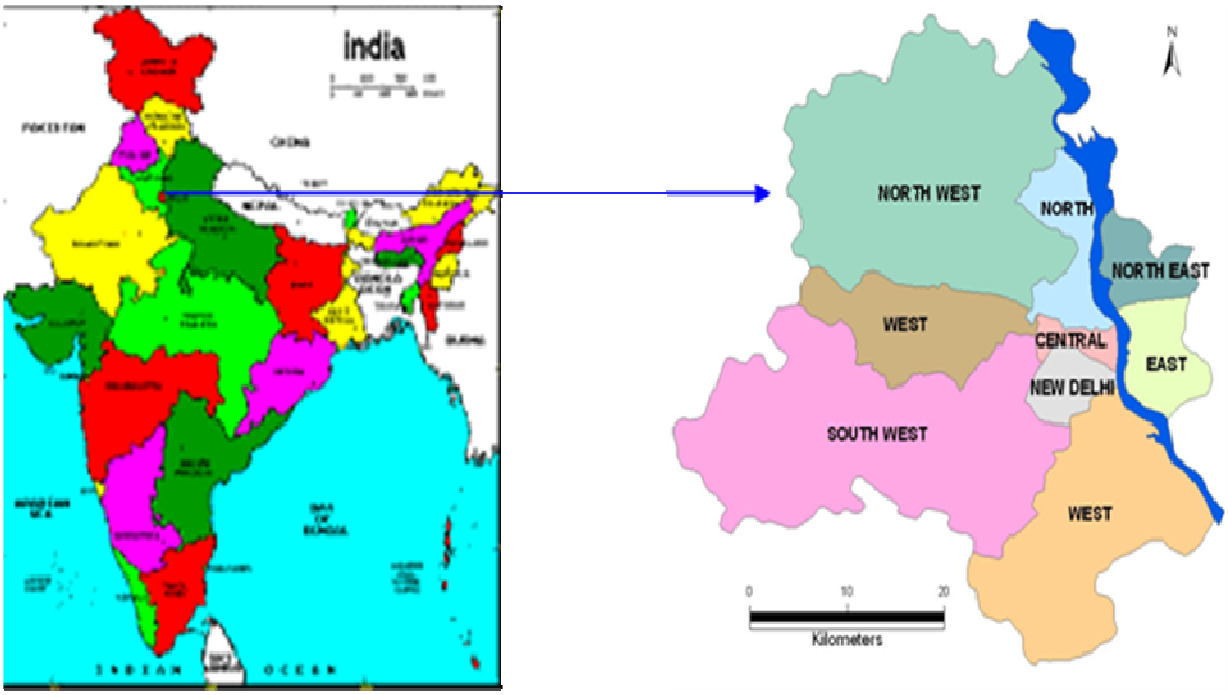

Figure-1
Location of study area

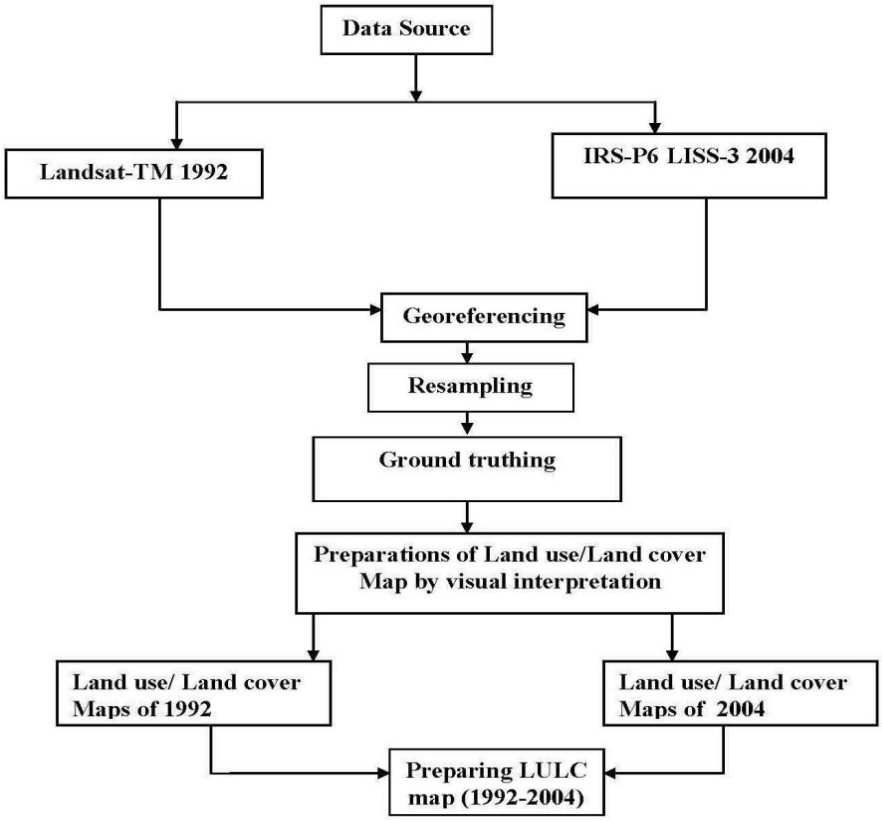

Figure-2
Methodology flow chart

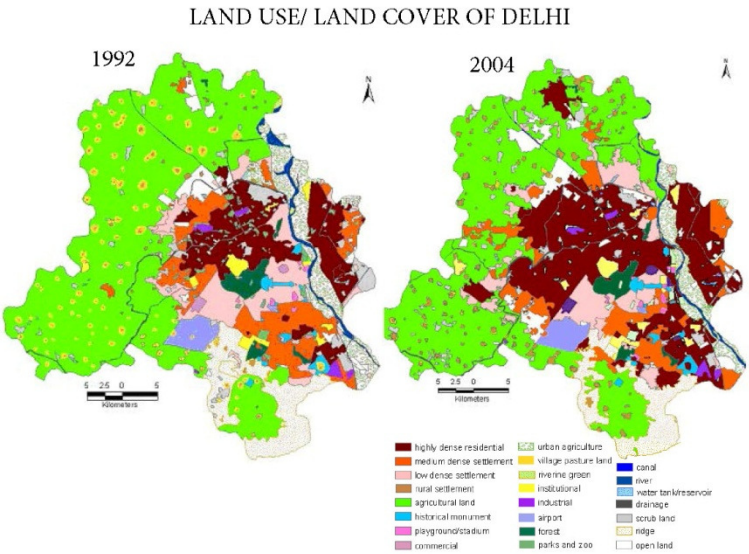

Figure-3
Land use/ land cover of Delhi (1992 and 2004)

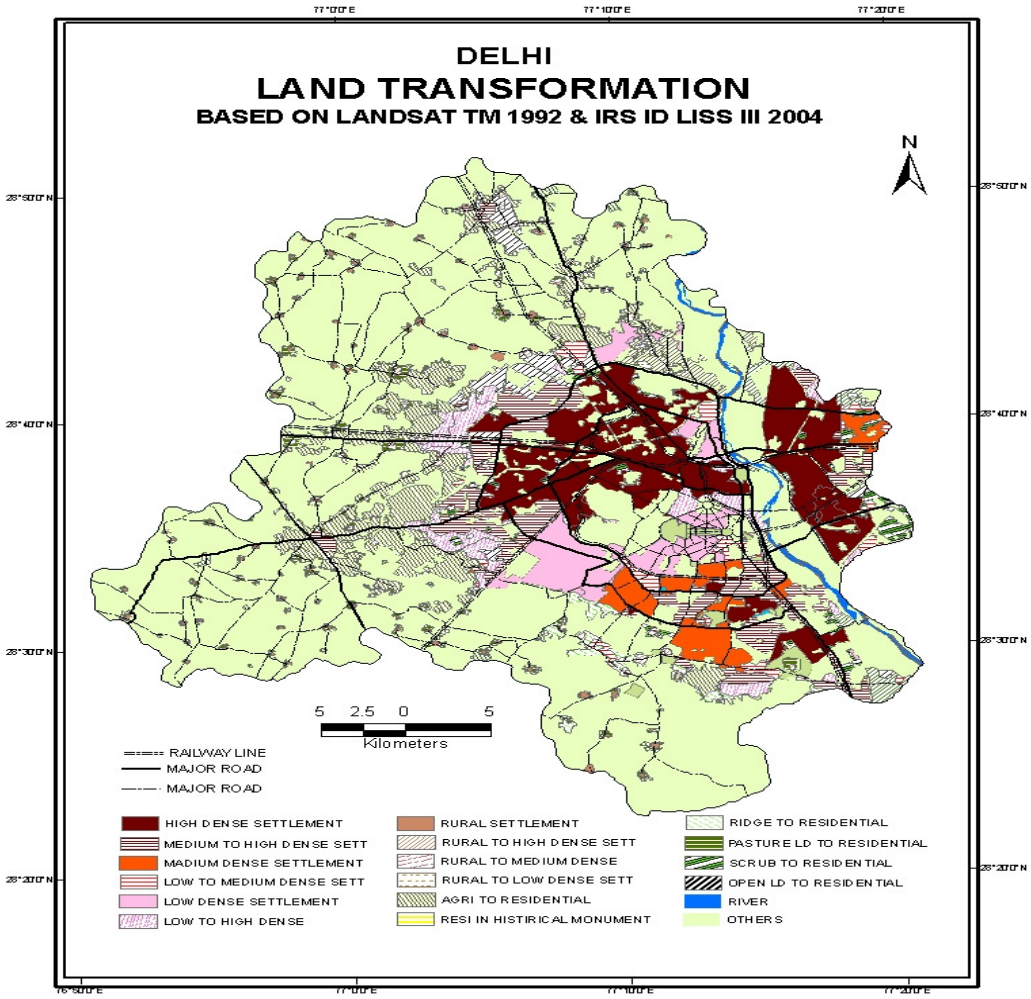

Figure-4
Land Use/ Land Cover change of Delhi (1992-2004)

Land Use/ Land Cover Change during 1992-2004: Out of the total geographical area of 144312 hectares agriculture constitutes 54152 hectare in 2004, which was 65214 hectare in 1992. Major cause of this unprecedented decline in area under agricultural use was a tremendous increase in urban area. Table prepared using GIS tech shows that 11387 hectares of fertile agricultural land was lost as unrecoverable, i.e. land where permanent construction has taken place and 3712 hectare as a vacant land left open, showing next expansion site for built-up. The main factors affecting the urban fringe land transformation are growth of industrial, commercial and institutional activities. Secondly due to urbanization and increasing trend towards urban migration for employment and other developmental opportunity the layout of Delhi is not a well-planned or well-executed whole. Transformation along major corridors is the distinguishing feature of urban sprawl in this period. Delhi in its previous phase grown towards east but in the last 15years it expanded along different national highways (especially towards south west).

Finding: The built-up area has increased in all directions but this is more pronounced to the west and north of the city than the east, where already near saturation is achieved. The study has recorded a significant increase in residential area to accommodate the city's rapidly growing population but these have been more pronounced in unplanned residential areas. Also, some planned area developed during this time span such as Dawharka, Rohini etc. The residential area of Delhi was 39507 hec. in 1992 increased 57928 hect. in 2004. The total area increased 18421 hec. in twelve years (1992-2004) and growth rate is 46.6 % during the study period. There has been rapid conversion of agricultural areas to non agricultural uses. The total agriculture land was 65214 hec. in 1992 decreases 54152.6 hec. in 2004. The share of agriculture land was 45% of land in 1992 which decreases 37% of the total land in 2004. Urban expansion of city has destroyed 11062 hect. of fertile agricultural land between 1992 and 2004. Transformation along major corridors is the distinguishing feature of urban growth in this period i.e. it expanded along different national highways. Ridge and forest area in this period of time remained unchanged although greenery in Delhi improved. As shown in figure 4 village pasture land declined significantly because of rural expansion as well as agricultural encroachment.

Conclusion

The study with the help of Geographic Information System (GIS) and Remote Sensing technique is very useful tool for urban land transformation. The measurement of land use/ land cover change is very useful for future urban planning at local and global level. Finally, although urban expansion cannot be stopped, with proper management and planning it can be restricted and directed in a desirable and sustainable way, protecting fertile agriculture lands. It is planned by The government that outer growth of the city has occurred only by planned residential area like Dhawarka.

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