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Trends and patterns of land use and land cover changes in the NCT of Delhi

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Abstract

Urbanization and industrialization have altered the landscape of NCT of Delhi through the developmental processes and these developmental processes resulted in widespread expansion of grey infrastructure and the decline in vegetation cover. These changes in grey infrastructure and vegetation cover have considerable impact on the land use and land cover of the NCT of Delhi. The present research study attempts to analyze the spatial and multi-temporal land use and land cover change in the NCT of Delhi by using Geographical Information System (GIS) and Remote Sensing. The present research study is based on the remote sensing data of Landsat – 7 (TM), Landsat – 7 (ETM+) and IRS – P6 LISS III of 1987, 1999 and 2006 respectively. The data interpretation and analysis of LULCC in the NCT of Delhi helps in understanding the changes in LULCC, their causes and their impact on urban environment.

Key words: Urbanization, Grey Infrastructure, Land Use, Land Cover, Urban Environment

Introduction

The rapid pace of urbanization has drastically altered the landscape of NCT of Delhi. As Per Census of India, the urban area has increased from 46.21% (1991) to 75.09% (2011) while the rural area decreased from 53.79% (1991) to 24.91% (2011). Consequently, Urban Built Environment undergone expansion and is dominated by the cultural features like Multi-storey Buildings (both Commercial and Industrial), Malls, Real Estate Township, Multi-Level Parking, broad roads, fly-overs, metro rail with reduced 'Urban Open Spaces'. Likewise, the land use and land cover is dominated by the grey infrastructure or urban built-up on the one hand while the decreasing vegetation cover on the other.The increased area under urban built-up in the NCT of Delhi has resulted in micro-climatic changes like Urban Heat Island Effect and the intensification of Heat-Waves during the summer season. Further, there is growing socio-economic disparity (epidemic breakouts, social disparity, informal economy). Hence, the urban environment in the NCT of Delhi is under the severe stress due to the pressure of rapid urbanization. Consequently, urbanization has deteriorated the overall quality of the urban environment in the NCT of Delhi. To mitigate and minimize the detrimental effects of urban growth on the urban environment and to maintain optimal ecosystem functioning, spatial and temporal land use/land cover and the factors affecting these changes are considerably important in developing rational economic, social and environmental policies.The present research study is focused to quantify the sprawl of urbanization and consequently, the built-up area was extracted and used to assess the urbanization.

Objectives of the Study

The objectives of the present research study area as follows:

- To assess the spatial and multi-temporal Land use and Land cover changes in the NCT of Delhi.
- To analyze the deriving forces of land use and land cover change and urban expansion.

Methodology

The procedure adopted in the present research work is given in the Figure. 1 and this procedure forms the base for deriving statistics of Land Use and Land Cover and subsequently, the change. The land use and land cover of the NCT of Delhi was carried out from satellite data of Landsat – 7 (TM), Landsat – 7 (ETM+) and IRS – P6 LISS III for the three different time periods 1987, 1999 and 2006.

3.1 Data Source

The satellite imageries (Table. 1) of the NCT of Delhi for three different periods that is 1987, 1999, 2006 were obtained from the following sources:

- Global Land Cover Facility (GLCF).

- NRSA, Hyderabad, India.

3.2 Tools of Analysis

- To calculate the 'Rate of Change Per Year', we will use the following formula (Chebet, C. 2013):

$$R = \frac{Y - X}{T}$$

Where,R = rate of change,Y = the area (km^2) of the study area in the final year,X = the area (km^2) of the study area in the initial yea rand T = the time difference in years

3.3 Software and Platforms

The following software and platforms are involved in the present research study:

- ERDAS Imagine ver. 9.1
- ArcGIS ver. 9.1

4. Study Area

The present research study has been carried out on the NCT of Delhi (Figure. 2), the capital city of India located between the 28° 24′17″ N to 28° 53′00″ N latitudes and 76° 45′30″ E to 72° 21′30″ E longitudes. The NCT of Delhi is situated near the western bank of river Yamuna which spreads over an area of around 1,483 km^2 is surrounded by the Himalayas in the North and the Aravalli in the South-west. The hottest months are May and June with temperatures touching 48°C, whereas, the lowest falls to about 5°C at the end of December-January. The monsoon season lasts from July to September with maximum rainfall in the month of July to September with maximum rainfall in the month of July (around 300 mm). The total population of Delhi was nearly 0.4 million in 1901, which increased slowly and reached 1.74 million in 1951 (4.35 times in Century) and reached 13.78 million in 2001 implying about 34.45 times increase in one century.

Results and Discussion

Land Use and Land Cover of 1987

The study area has an area of 148304.49 ha. The land use/land cover categories occupying major share includes built-up area (24.98%), waste land (20.34%), cultivable land (16.87%), open forest (17.65%). The land use/land cover categories occupying moderate share includes plantations (8.42%) and Dense forest (5.14%). The land use and land cover categories occupying minor share includes road/rail network (2.44%) and river/water body (4.16%).

The careful observation of the land use/land cover map of 1987 of the NCT of Delhi shows that urban built-up is majorly concentrated in the north-eastern part, eastern part, south- eastern part. On the other hand, northern, north-western, western, south-western and southern part is dominated by the cultivable land area. Though, the wasteland can be observed throughout the map but major part is in southern part of the NCT of Delhi. The other categories like road/rail network and river/waterbody are not having much role to play (Figure. 3, Table. 2).

Land Use and Land Cover of 1999

The study area has an area of 147780.06 ha. The land use/land cover category of urban built-up experienced tremendous increase from 24.98% (1987) to 41.25% (1999). Though, the category of dense forest also experienced the slight increase from 5.14% (1987) to 6.74% (1999). The other categories experienced the slight experiencing the decline includes Open forest [17.65% (1987) & 11.05% (1999)], plantations [8.42% (1987) & 7.82% (1999)], cultivable area [16.87% (1987) & 13.32% (1999)], road/rail network [2.44% (1987) & 1.43% (1999)], river/water body [4.16% (1987) & 1.65% (1999)], waste land [20.34% (1987) & 16.74% (1999)].

The land use/land cover map of 1999 of the NCT of Delhi showsthat the urban built-up experienced the westward expansion with maximum growth in northern part and comparatively, less growth in southern part. The urban- built has increased at a tremendous rate and such increase can be attributed to the fact like rapid increase in population, rapid pace of urbanization. Except some patches in north-western, western and major part in south-western which were under the cultivable land area along with the presence of waste land in the south-western part of the NCT of Delhi. the dark green patch representing Dense forest has increased in south-eastern part of the NCT of Delhi and there is complete absence of green patches or dense forest in the northern, western and southern part of the NCT of Delhi (Figure. 3, Table. 2).

Land Use and Land Cover of 2006

The study area has an area of 148300.00 ha. The land use/land cover categories experiencing drastic increase includes road/rail network [1.43% (1999) & 4.90% (2006)] and waste land [16.74% (1999) & 20.78% (2006)]. Unlike the previous year of 1999, the urban built-up experienced only slight increase that is from 41.25% (1999) to 42.58% (2006) along with the Open forest [11.05% (1999) & 11.21% (2006)]. The other categories which experienced the decline includes Dense forest [6.74% (1999) & 3.89% (2006)], plantations [7.82% (1999) & 5.28% (2006)], cultivable area [13.32% (1999) & 9.78% (2006)], and river/water body [1.65% (1999) & 1.52% (2006)].

The urban built-up covers almost the whole of the NCT of Delhi except the southern-most part (under cultivable land) and the central eastern part (under the dense forest). The core of the NCT of Delhi is characterized by the dense network of urban built-up while the density of urban built-up decrease towards periphery. Further, density of the green patch representing dense forest also decreased in Central eastern part of the NCT of Delhi. Further, the map shows presence of cultivable land in the southern part of NCT of Delhi. this southern part was earlier under the urban built-up category (Figure.3, Table. 2).

Land Use/Land Cover Changes During 1987-2006

The changes in the Land Use/Land Cover in the study area were estimated from 1987-2006.

Forest

The area of crops rose in the forest and grazing lands or areas open for grazing within the forests should remain included under the forest area. It is an area notified for forestry boundary, predominantly with trees and other vegetation capable of producing either timber and other forest produce. Approximately, 11,000 ha. of forest lands (Open forest and Dense forest) were lost during the study period. Moreover, the NCT of Delhi is covered with open forest rather than the dense forest, therefore, conversion of open forest to other land uses was more prevalent.The land area under the dense forest increased from 5.14% (1987) to 6.74% (1999) but in the year 2006, the land area under the dense forest decreased to 3.89%. The discussion over the land use/land cover change shows that there was an increase of 2337.72 ha. of land under the category of dense forest during the year 1999 but the increased demand of land for grey infrastructure resulted in the loss of 4191.47 ha. land. Open forest being more vulnerable experienced large scale of decrease from 17.65% (1987) to 11.05% (1999) with slight increase of 0.22% in the year 2006 (Table. 3, Table. 4 and Table. 5).

Agricultural Land

It is defined as the land primarily used for farming and production of food crops, commercial crops and horticulture crops. It includes the land under irrigation and rain-fed crops, which are growing under different season in different farming activities. During 19 years, an area of around 10,000 ha. of agricultural lands was lost to built-up areas and road infrastructure. These agricultural lands were prominently spread in the north-western and western part of the NCT of Delhi up to 1987.The agricultural land in the NCT of Delhi have declined considerably during the study period. The agricultural land decreased to 13.32% (1999) from 16.87% (1987) and in the year 2006, the land area under agriculture was reduced to the 9.78% (2006) from 13.32% (1999). Near about 5333.9 ha of land was lost during 1987-1999 & 5180.57 ha of land was lost during 1999-2006 (Table. 3, Table. 4 and Table. 5).

Urban Built-Up

It is defined as an area of human habitation developed due to non-agricultural lands which covers the buildings, industrial structures, transportation network etc. a simple superimposing technique was used to assess the spatial growth of built-up area for the given period of 19 years. All the three-land use and land cover maps of the NCT of Delhi are predominantly covered with built-up area. The map is extracted in tabular form, the built-up area is predominantly covered with 25% of the total area of Delhi-NCT. During 1999, built-up area had increased to 41%, with sharp decrease in open forest, wasteland and agricultural land areas. Between the year 1999 and 2006, there was slight increase in built-up class with only 1% increase i.e. 42% of the total administrative area of the NCT of Delhi comprised built-up space. Over the period of 19 years, built-up area had increased to 18% in the NCT of Delhi. However, when the two Land use/land cover maps of 1999 and 2006 were compared, one can observe the marked difference in the western part of the NCT of Delhi

Wasteland

The wastelands, which are described as the degraded land, can be brought under the vegetative cover with reasonable effort. But at present, they are utilized and are deteriorating due to the lack of appropriate land, water and soil management or because natural causes. It is described as the degraded land which can be brought under vegetative cover with reasonable effort, and which is currently under-utilized and deteriorates due to lack of appropriate water and soil management due to natural causes (National Wasteland Development Board, NWDB, 1987). During the period of 19 years, the wasteland, in the NCT of Delhi, decreased to 16.74% (1999) from 20.34% (1987) between the period of 1987-1999. But it increased during the period of 1999-2006 from 16.74% (1999) to 20.78% (2006).

Water Bodies

It is a natural or man-made enclosed water body with regulated flow of water. It is a natural course of water distributed over the land. It includes ponds, lakes, rivers and streams.During the period of 19 years, the land area under the class of water body decreased consistently from 4.16% (1987) to 1.65% (1999) and finally attaining the value of 1.52% (2006).

'Rate of Change' of Land Use/Land Cover During 1987-2006

The table contains the calculated data of 'Rate of Change' of land use/land cover for the period 1987-2006 in the NCT of Delhi. During the period of 19 years, built-up area shows the positive rate of change and attains the highest value of +1374 among all categories of land use/land cover in the NCT of Delhi. The other categories which experienced an increase in land use/land cover include road/rail network (+191) waste land (+34). On the other hand, Forest and cultivable area shows the negative rate of change of -595 and -553 respectively. The negative change in the forest land and the cultivable land shows that these two categories of land use/land cover experienced the loss of land and this loss of land took place due to the developmental activities involved in built-up area and road/rail network. The other categories which face negative growth of land includes Plantation and river/waterbody with rate of change -245 and -206 respectively (Table. 6).

Conclusion

The land use/land cover analysis in GIS and Remote Sensing data, helped in bringing out the maps and statistics with useful options for alternate land use plans in the study area. While analyzing the status of land use from 1987-2006, it is noticed that there is considerable change. The vast expansion in built-up area and shrinkage of forest and cultivable area are issues of major concern. The over-expansion and over-dominance of grey infrastructure has resulted in the micro-climatic changes in the NCT of Delhi. These micro-climatic changes include Urban Heat Island effect (UHI) and intensification of heatwave during summer season. Therefore, NCT of Delhi needs revised and efficiency planning to minimize the micro-climatic changes. Urban green spaces, road side greenery, track side greenery, green roofing are some provisions which if followed in proper and efficient way will result in positive outcome.

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Table 1
Details of Satellite Imageries

Satellite	Sensor	Path/Row	Date	Data Type	Bands
IRS-P6	*LISS III*	096/051	02-01-2006	*Digital*	2,3,4,5
LANDSAT-7	*ETM +*	146/040	22-10-1999	*Digital*	1,2,3,4,5,7
LANDSAT-7	*TM*	157/040	08-03-1987	*Digital*	1,2,3,4,5,7

Table 2
Area under Different Land Use and Land Cover Changes, 1987-2006, NCT of Delhi, India

Land Use/Land Cover Categories	1987		1999		2006	
	Area (ha)	%age	Area (ha)	%age	Area (ha)	%age
Dense Forest	7622.62	5.14	9960.34	6.74	5768.87	3.89
Open Forest	26174.95	17.65	16329.70	11.05	16718.24	11.27
Plantations	12486.86	8.42	11556.40	7.82	7835.07	5.28
Cultivable Area	25018.21	16.87	19684.31	13.32	14503.74	9.78
Built-Up Area	37045.34	24.98	60959.29	41.25	63146.14	42.58
Road/Rail Network	3618.52	2.44	2113.26	1.43	7261.53	4.90
River/Waterbody	6169.28	4.16	2438.37	1.65	2254.16	1.52
Waste Land	30164.22	20.34	24738.39	16.74	30816.74	20.78
Total	148304.49		147780.06		148300.00	

Source: Compiled by Author and Calculated from Satellite Images

Table 3
Difference in Area and Increase/Decrease in Forest Area & Cultivated Area, 1987-99, NCT of Delhi, India

Land Use Categories	1987		1999		Difference	
	Area	%age	Area	%age	Area	%age
Forest (Dense & Open)	33797.57	22.79	26290.04	17.79	-7507.53	-5.00
Cultivated Area	25018.21	16.87	19684.31	13.32	-5333.90	-3.55

Source: Calculated and Compiled by the Author
Note: Positive sign (+) indicates an increase while the Negative sign (-) indicates decrease in area.

Table 4
Difference in Area and Increase/Decrease in Forest Area & Cultivated Area, 1999-06, NCT of Delhi, India

Land Use Categories	1999		2006		Difference	
	Area	%age	Area	%age	Area	%age
Forest (Dense & Open)	26290.04	17.79	22487.11	15.16	-3802.93	-2.63
Cultivated Area	19684.31	13.32	14503.74	9.78	-5180.57	-3.54

Source: Calculated and Compiled by the Author
Note: Positive sign (+) indicates an increase while the Negative sign (-) indicates decrease in area.

Table 5
Difference in Area and Increase/Decrease in Forest Area & Cultivated Area, 1987-06, NCT of Delhi, India

Land Use Categories	1987		2006		Difference	
	Area	%age	Area	%age	Area	%age
Forest (Dense & Open)	33797.57	22.79	22487.11	15.16	-11310.46	-7.63
Cultivated Area	25018.21	16.87	14503.74	9.78	-10514.47	-7.09

Source: Calculated and Compiled by the Author
Note: Positive sign (+) indicates an increase while the Negative sign (-) indicates decrease in area.

Table 6
'Rate of Change' of Land Use/Land Cover, 1987-2006, NCT of Delhi, India

Sl.No.	Land Use/Land Cover	1987-1999 Area (ha)	1999-2006 Area (ha)	1987-2006 Area (ha)	$R = \frac{Y - X}{T}$
1	Forest	-7507.53	-3802.93	-11310.46	-595.29 ~ -595
2	Plantations	-930.46	-3721.33	-4651.79	-244.83 ~ -245
3	Cultivable Area	-5333.90	-5180.57	-10514.47	-553.39 ~ -553
4	Built-up Area	+23913.95	+2186.85	+26100.80	+1373.72 ~ +1374
5	Road/Rail Network	-1505.26	+5142.27	+3643.01	+191.42 ~ +191
6	River/Waterbody	-3730.91	-184.21	-3915.12	-206.05 ~ - 206
7	Waste Land	-5425.83	+6078.35	+652.52	+34.34 ~ +34

Source: Calculated and Compiled by the Author
Note: Positive sign (+) indicates an increase while the Negative sign (-) indicates decrease in area.

Figure 1
Flow Chart of Research Methodology

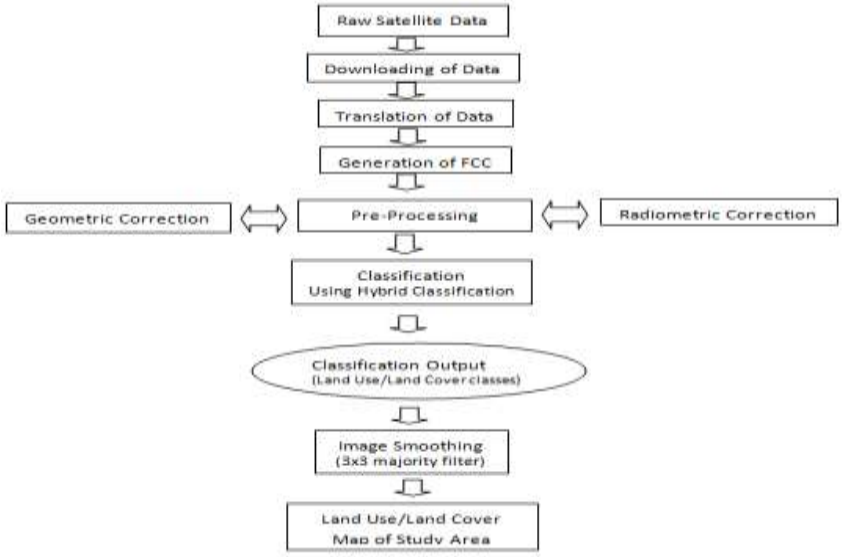

Fig 2 : Map of Study area , NCT of delhi

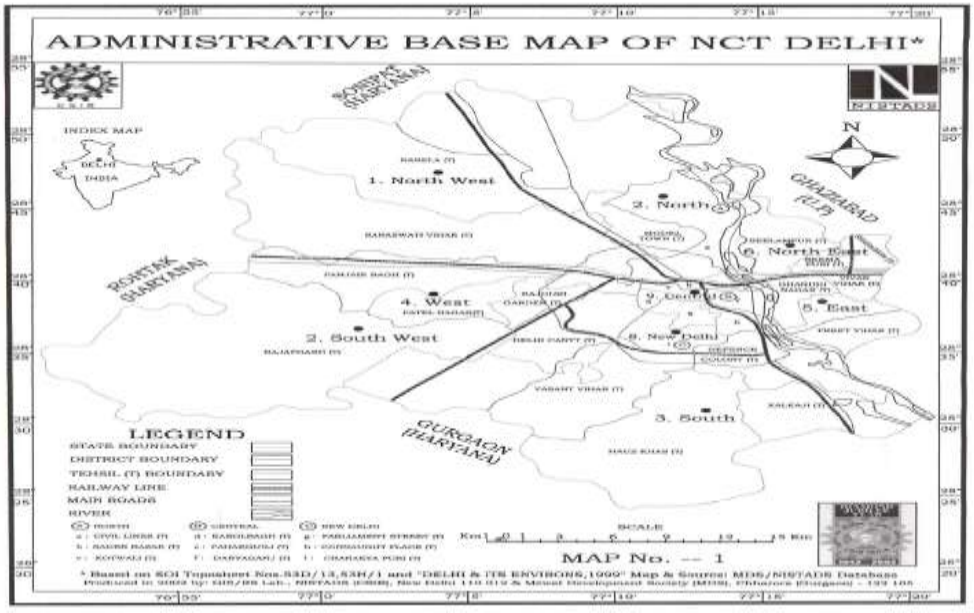

Figure 3
Land Use and Land Cover Maps (1977-2012), NCT of Delhi, India