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DISTRICT-WISE CHANGE ANALYSIS OF LAND USE-LAND COVER IN DELHI TERRITORY USING REMOTE SENSING & GIS

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Abstract: Digital change detection is the process that helps in determining the changes associated with Land use and Land cover properties with reference to geo-referenced multi-temporal remote sensing data. It helps in identifying change between two or more dates that is uncharacterized of normal variation. This work is an attempt to assess the district-wise changes in land use/land cover in Delhi, India. The study made use of LISS -III imageries of 2008 and 2012 year. The images were classified using Maximum Likelihood classification method. The output can be useful in many applications such as Land use changes, habitat fragmentation, rate of deforestation, urban sprawl and other cumulative changes through spatial and temporal analysis. The study shows that Delhi land cover in duration of 2008 to 2012 show major changes in the landscape as there is high growth in the fallow and built up area. Agriculture land decreased by 4.5% and forest area has reduced marginally by 1.5%, Built up increased by 1.8% and water body is showing almost a constant condition over time.

Keywords: GIS; remote sensing; land use-land cover; LISS-III; spatial

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INTRODUCTION

Land use/land cover change is a key driver of global change (Vitousek, 1992) and has significant implications for many international policy issues (Nunes & Auge, 1999). In particular, land use/land cover (LU/LC) changes in tropical regions are of major concern due to the widespread and rapid changes in the distribution and characteristics of tropical forests (Myers, 1993; Houghton, 1994). However, changes in land cover and in the way people use the land have become recognized over the last 15 years as important global environmental changes in their own right (Turner II, 2002). To understand how LULC change affects and interacts with global earth systems, information is needed on what changes occur, where and when they occur, the rates at which they occur, and the social and physical forces that drive those changes (Lambin, 1997). The information needs for such a synthesis are diverse. Remote sensing has an important contribution to make in documenting the actual change in land use/land cover on regional and global scales from the mid-1970s (Lambin *et al.*, 2003). Land cover change is a major concern of global environment change (Bhagawat, 2011).

Land cover refers to the actual surface cover for a given location (e.g., vegetation type, anthropogenic structure, etc.). Remote-sensing data have a long history of being used for deriving land-cover maps, even before the launch of the first Landsat platform in 1972. Aerial photography served as a primary source of information on land cover before the availability of satellite imagery, and it remains an important source of land-cover information even today.

Unlike land cover, which can be directly observed and monitored from remote-sensing data, land use typically must be inferred through a combination of remote-sensing observation, regional and local knowledge (including field observation), and other ancillary information that links a given land cover in a region with a given land use. Availability of high resolution satellite data provides opportunity for acquiring detailed spatial information for identifying and monitoring a number of environmental issues of urban regions.

The purpose of this paper was to investigate the changes in LULC over a period of 5 years in Delhi, India using remote sensing and GIS techniques and deriving factors behind the changes and the adverse effects of these changes on the livelihood of the people and the local environment.

Study Area & Data Used

Delhi is located in north direction of Indian subcontinent between the latitudes of 28° 24′ 17″ and 28° 53′ 00″ North and longitudes of 76° 50′ 24″ and 77° 20′ 37″ East (**Fig. 1**). Delhi territory has boundary lines with the States of Uttar Pradesh and Haryana. Delhi has an area coverage of 1 483 sq. km. Its maximum length line is 51.90 km and maximum width is 48.48 km. Delhi is placed on the right bank of the Yamuna river (India)

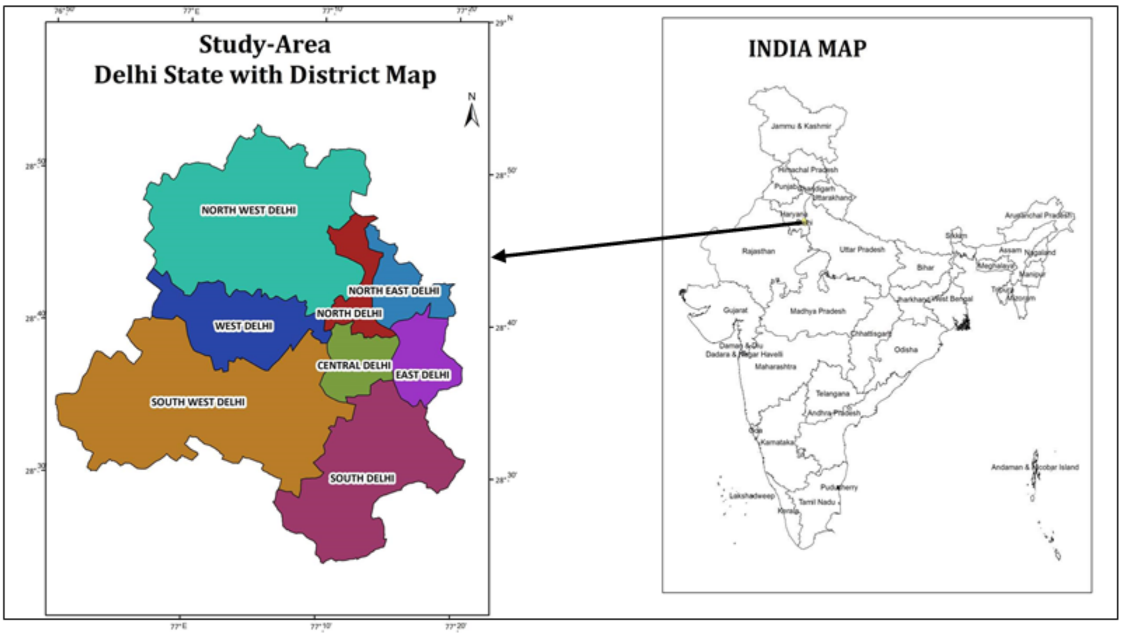

Fig. 1 Location Map of the study Area

Table 1. Satellite Images and their characteristics

S. No.	Image type & Year	Sensor	Spectral Resolution (Bands)	Spatial Resolution (m)	Swath (km)	Source
1.	IRS P6, 2008	LISS-III	Green 0.52-0.59 Red 0.62-0.68 NIR 0.76-0.86 SWIR 1.55-1.70	23.5	141	NRSA Hyderabad
2.	IRS P6, 2012	LISS-III	Green 0.52-0.59 Red 0.62-0.68 NIR 0.76-0.86 SWIR 1.55-1.70	23.5	141	NRSA Hyderabad

Table 2. Land use/Land covers classes

Land use/Land cover types	Description
Built up	Areas that have been populated with residential, commercials, industrial, transportation and facilities
Agriculture Land • Rabi Crop • Kharif Crop • Double/Triple Crop	Rain fed cropping, planted and irrigated cropping areas
Forest Land • Deciduous Forest • Plantation Forest	Areas covered with mature trees, shrubby plants and other plants growing close together
Water Bodies	Areas covered with water such as rivers and lakes, ponds
Fallow Land	Areas rarely covered mainly with herbaceous vegetation/no crop

at the outer edge of the Gangetic plains. It lies a little north of 28N latitude and a little to the west of 78E longitudes. To the west and south-west is the great Indian Thar desert of Rajasthan state, formerly known as Rajputana province and, to the east lies the river Yamuna across which has spread the greater Delhi of today. The ridges of the Aravalli ranges extend right into Delhi proper, towards the western side of the city, and this has given an undulating character to some parts of Delhi.

Remote Sensing Data

Indian Remote Sensing (IRS-P6) Linear Imaging Self Scanning Sensor (LISS-III) images for year 2008 and 2012 were procured from National Remote Sensing Agency, Hyderabad, India.

Methodology

The selection of remotely sensed data depends on factors such as the scale of study area, availability of image data and time. Based on the combination of ancillary data, literature provided, close visual inspection of remotely sensed data, five easily identifiable broad classes were identified (**Table 1**).

Different methods are available for classification and choosing a method depends on the resolution of the image and availability of classification software (Lu *et al.*, 2011). For this study a supervised approach was used. In supervised classification, known representative training areas are picked by the image analyst to describe the spectral attributes of each feature type of interest (Lillesand and Kiefer, 2008). A minimum distance algorithm was used for the classification of the images. Lu *et al.* (2011) mention that spectral information is important in medium resolution images as there is a loss of spatial information and parametric classification algorithms are often used if imagery is spectral based. Guided by the ancillary data, spectral signatures were acquired to train the classification through visual interpretation of the satellite images and local/expert/interpreter knowledge of area. The area of Interest tools and seed growing tool in ERDAS Imagine were used in acquiring the signatures. Maximum Likelihood algorithm (MLC) is one of the most popular supervised classification methods used with remote sensing image data. This method is based on the probability that a pixel belongs to a particular class. The basic theory assumes that these probabilities are equal for all classes and that the input bands have normal distributions. Evaluating the quality of a classification result is of high importance in remote sensing since it gives evidence of how well the classifier is capable of extracting the desired objects from the image. After Supervised classification of the images, the next step involved recording of land use covers and further modification. It is most important aspect to assess the reliability of map. To determine the accuracy and correctness of classification, a set of sample of pixels are selected on the classified image and their class identity is compared with Thematic map to draw conclusion, Google high resolution photography (Google Earth), visual interpretation of the satellite image in comparison to thematic maps and knowledge of the area were integrated to improve the accuracy of the land cover maps. Modification of land use cover is one of the processing roles after classification (Lu *et al.*, 2011). The next step is the removal of the "salt and pepper effect". The salt and pepper effect is the result of a spectral signature-based per pixel classification of a complex or heterogeneous landscape. The error matrix and Kappa methods were used to assess the mapping accuracy.

For performing land use/land cover change detection, a post-classification detection method was employed. A pixel-based comparison was used to produce change information on pixel basis and thus interpret the changes more efficiently.

RESULTS AND DISCUSSION

From **Tables 3–10**, we found that changes in Built Up and forest area from 2008 to 2012 is +5.5% and -5.7% respectively in Central Delhi. Growth in Built up and Fallow land are +3.5% and +2% respectively while forest cover decreased by -3.1% in East Delhi. The Agriculture land decreased by -25% and growth in Built up, Fallow land and Water bodies with 16.6%, 5.6% and 5.4% respectively in North Delhi. Changes in Water bodies and Agricultural area from 2008 to 2012 is +3.8% and -3.2% respectively in North East Delhi.

In North West Agriculture land was 63.2% in 2008 and that in 2012 became 57.7% with decrease in agriculture land is by 5.6% while Fallow land showing increase by 5.2%. In South Delhi Agriculture land decreased by 3.8% and increased in Fallow land by 3.3%. The Agriculture land decreased by -3.2% and growth in Built up and Fallow land with 3.6% and 2.8% respectively in South West Delhi. Growth in Fallow land is 8.2% and decrease in Agriculture land is 6.7% in West Delhi.

We can get result that Built up Delhi was 39.5% in 2008 and it is 41.2% in 2012, showing overall growth in Built-up by 1.8% 9 (**Table 11**). Agricultural land was 39.4% in 2008 and it becomes 34.8% in 2012, so overall decrease by 4.5%. The Forest cover was initially 17% in 2008 but unfortunately it became 15.5% in 2012 so overall decrease of Forest cover in Delhi by 1.5%.

The **Figs. 11–15** shows district wise change (%) of different LU/LC classes of Delhi territory, India. **Figure 11** represents that all districts of Delhi shows downward trend in Agricultural land cover. Among the areas, North Delhi has the maximum fall of land cover (24.9%) which is overall decrease by 4.5% in whole Delhi territory. **Figure 12** shows that all districts of Delhi have increasing trend in Built up area cover except West Delhi (-1.2%) and North East Delhi (-1.2%). North Delhi has the maximum increase in built-up cover (16.6%), while overall increase by 1.8% in Delhi territory. **Figure 13** shows that all districts of Delhi have increase trend in Fallow land cover. Among them, West Delhi has the maximum increase in fallow land cover (8.2%) from all districts. Overall increase in fallow land cover is by 4% in whole Delhi territory. **Figure 14** shows that all districts of Delhi have decreasing trend in Forest Cover. In North West Delhi (+0.1%) and Central Delhi has the maximum fall (+5.7%). Overall fall in forest cover is by 1.5% in whole Delhi territory. **Figure 15** shows that all district of Delhi have an increasing trend in Water Bodies cover except West Delhi (-0.2%), North West Delhi (-0.1%) and East Delhi (-0.7%). In North Delhi, the maximum rise in water body cover (5.4%) and overall increase by 0.2% in complete Delhi territory.

CONCLUSION

The LULC change detection has long been regarded as an active research topic, and different techniques have been developed and implemented in recent decades. The availability of more and different types of Remote-sensing sensor data and different ancillary data along with a need for more detailed and accurate change detection information provides new challenges for developing suitable change detection techniques for specific purposes. This study of Delhi land cover from 2008 to 2012 shows rapid changes in the landscape as there is high growth in the fallow and built up area. Agriculture land and forest cover area has reduced marginally and water body is showing almost stagnant condition over time. Urban built-up area has extended outwards from the central eastern part to the rest of the region and has covered most of the areas in northern,

Table 3. Comparison of changes of the five LU/LC classes between 2008 and 2012 of Central Delhi

LU/LC Class	2008		2012		% Change between 2008 and 2012
	Pixel Count	%	Pixel Count	%	
Built-up	10597	62.7%	14252	68.2%	5.5%
agriculture land	657	3.9%	600	2.9%	-1.0%
Fallow	1	0.0%	201	1.0%	1.0%
Forest	5002	29.6%	4987	23.9%	-5.7%
Water Bodies	640	3.8%	860	4.1%	0.3%

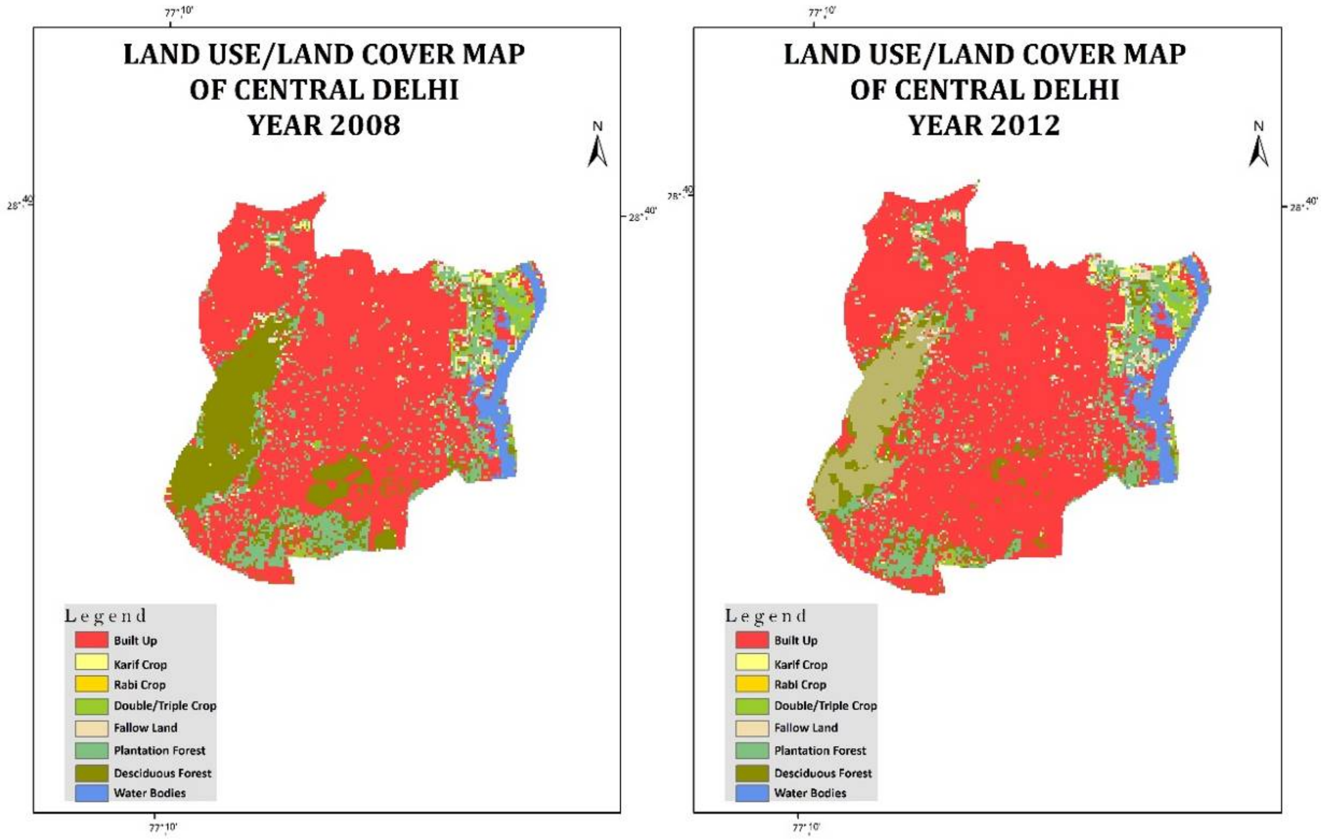

Fig.2 LU/LC map of Central Delhi for 2008 and 2012.

Table 4. Comparison of changes of the five LU/LC classes between 2008 and 2012 of East Delhi

LU/LC Class	2008		2012		% Change between 2008 and 2012
	Pixel Count	%	Pixel Count	%	
Built-up	14566	77.5%	18167	81.1%	3.6%
Agricultural land	1214	6.5%	1056	4.7%	-1.8%
Fallow	3	0.0%	444	2.0%	2.0%
Forest	2289	12.2%	2039	9.1%	-3.1%
Water Bodies	719	3.8%	707	3.2%	-0.6%

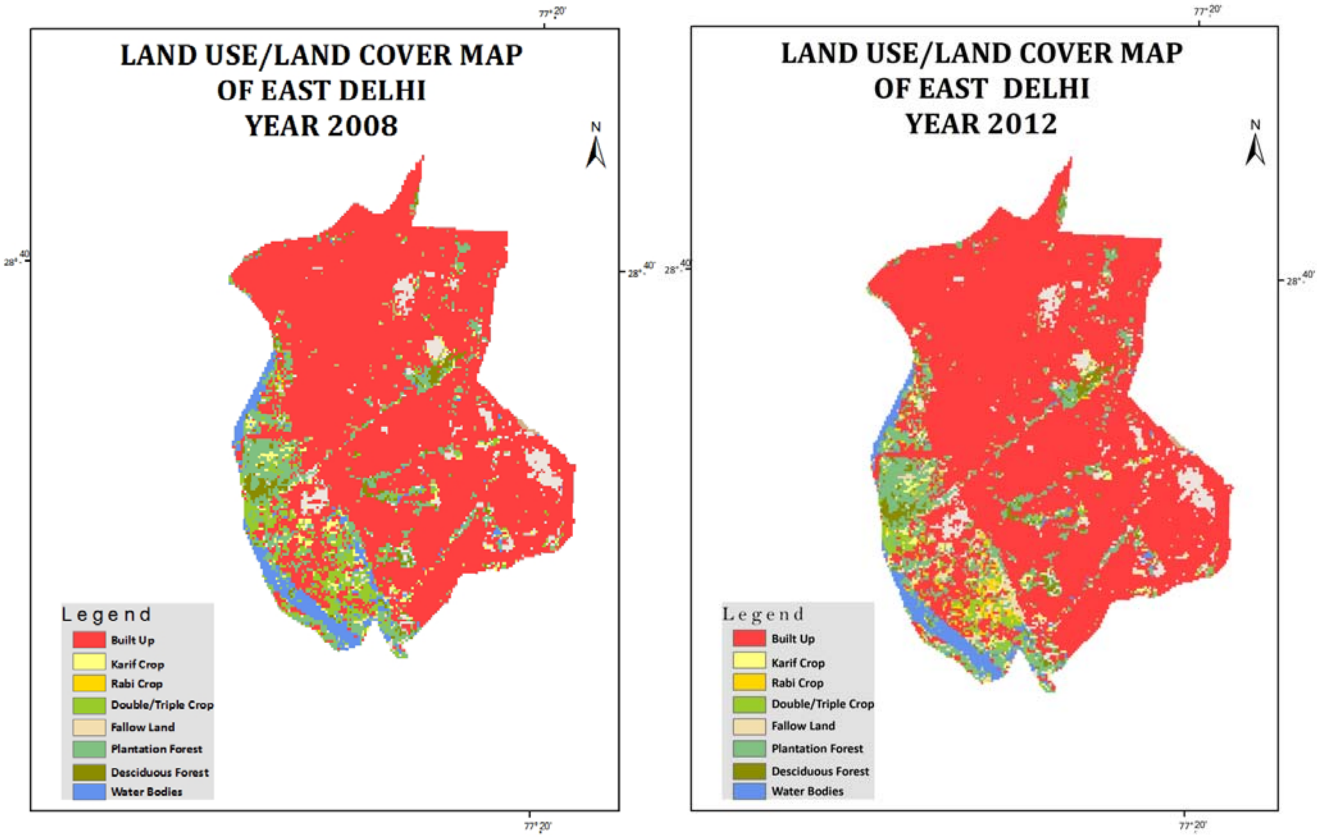

Fig. 3 LU/LC map of East Delhi for 2008 and 2012.

Table 5. Comparison of changes of the five LU/LC classes between 2008 and 2012 of North Delhi

LU/LC Class	2008		2012		% Change between 2008 and 2012
	Pixel Count	%	Pixel Count	%	
Built-up	6505	44.8%	7876	61.4%	16.6%
Agricultural land	4055	27.9%	382	3.0%	-24.9%
Fallow	24	0.2%	741	5.8%	5.6%
Forest	2474	17.0%	1846	14.4%	-2.6%
Water Bodies	1470	10.1%	1985	15.5%	5.4%

Table 6. Comparison of changes of the five LU/LC classes between 2008 and 2012 of North East Delhi

LU/LC Class	2008		2012		% Change between 2008 and 2012
	Pixel Count	%	Pixel Count	%	
Built-up	11522	69.1%	14012	68.0%	-1.2%
Agricultural land	1732	10.4%	1481	7.2%	-3.2%
Fallow	48	0.3%	377	1.8%	1.5%
Forest	2395	14.4%	2760	13.4%	-1.0%
Water Bodies	969	5.8%	1990	9.7%	3.9%

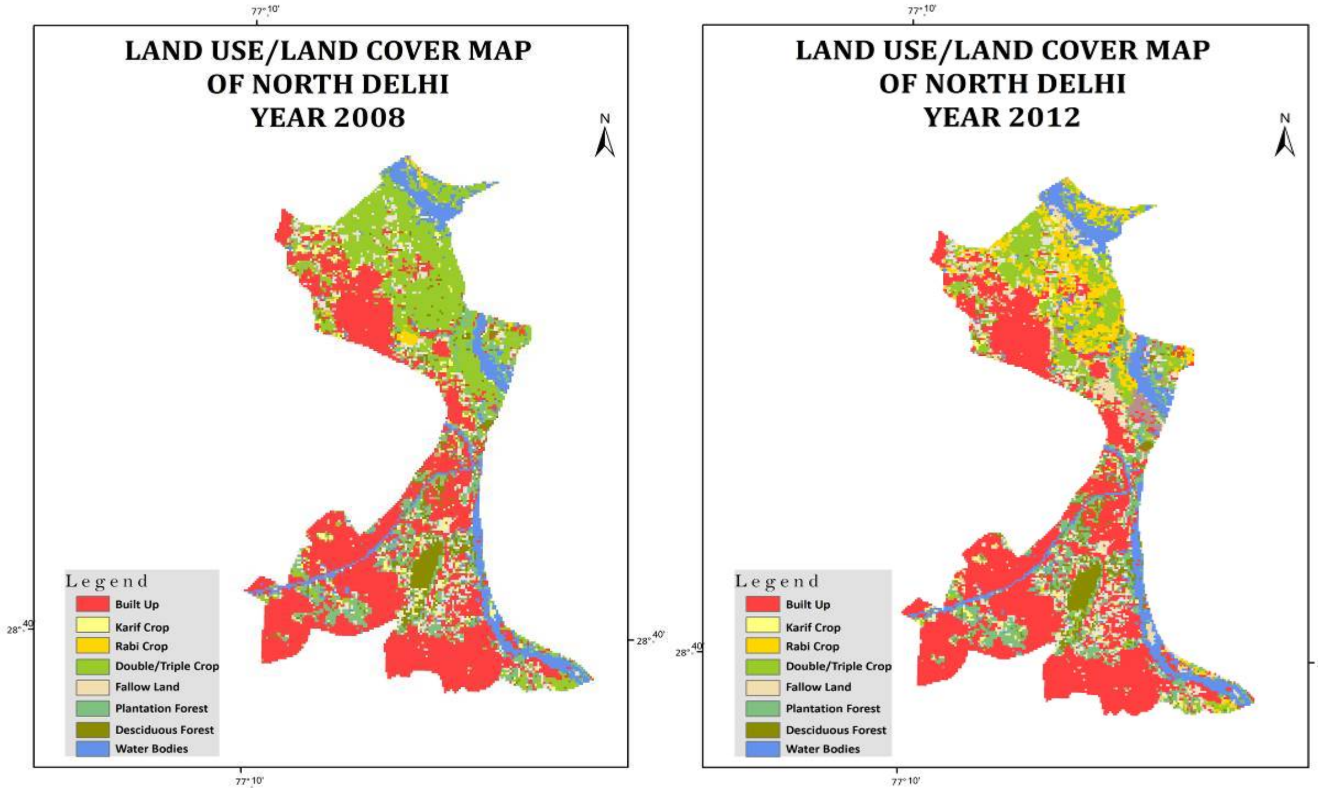

Fig. 4 LU/LC map of North Delhi for 2008 and 2012.

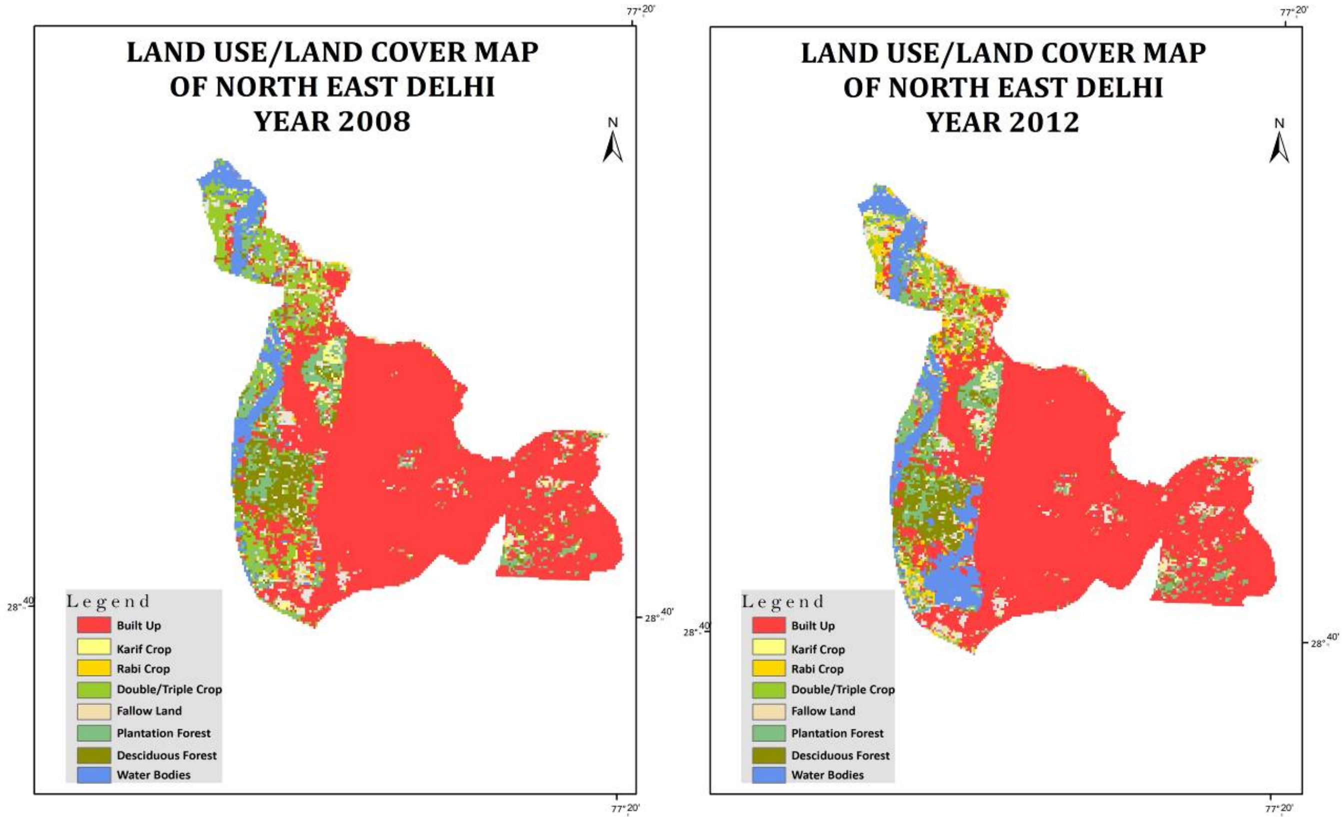

Fig. 5 LU/LC map of Northeast Delhi for 2008 and 2012.

Table 7. Comparison of changes of the five LU/LC classes between 2008 and 2012 of Northwest Delhi

LU/LC Class	2008		2012		% Change between 2008 and 2012
	Pixel Count	%	Pixel Count	%	
Built-up	29069	27.1%	36571	27.6%	0.5%
Agricultural land	67760	63.2%	76456	57.7%	-5.5%
Fallow	298	0.3%	7207	5.4%	5.2%
Forest	8272	7.7%	10322	7.8%	0.1%
Water Bodies	1737	1.6%	1958	1.5%	-0.1%

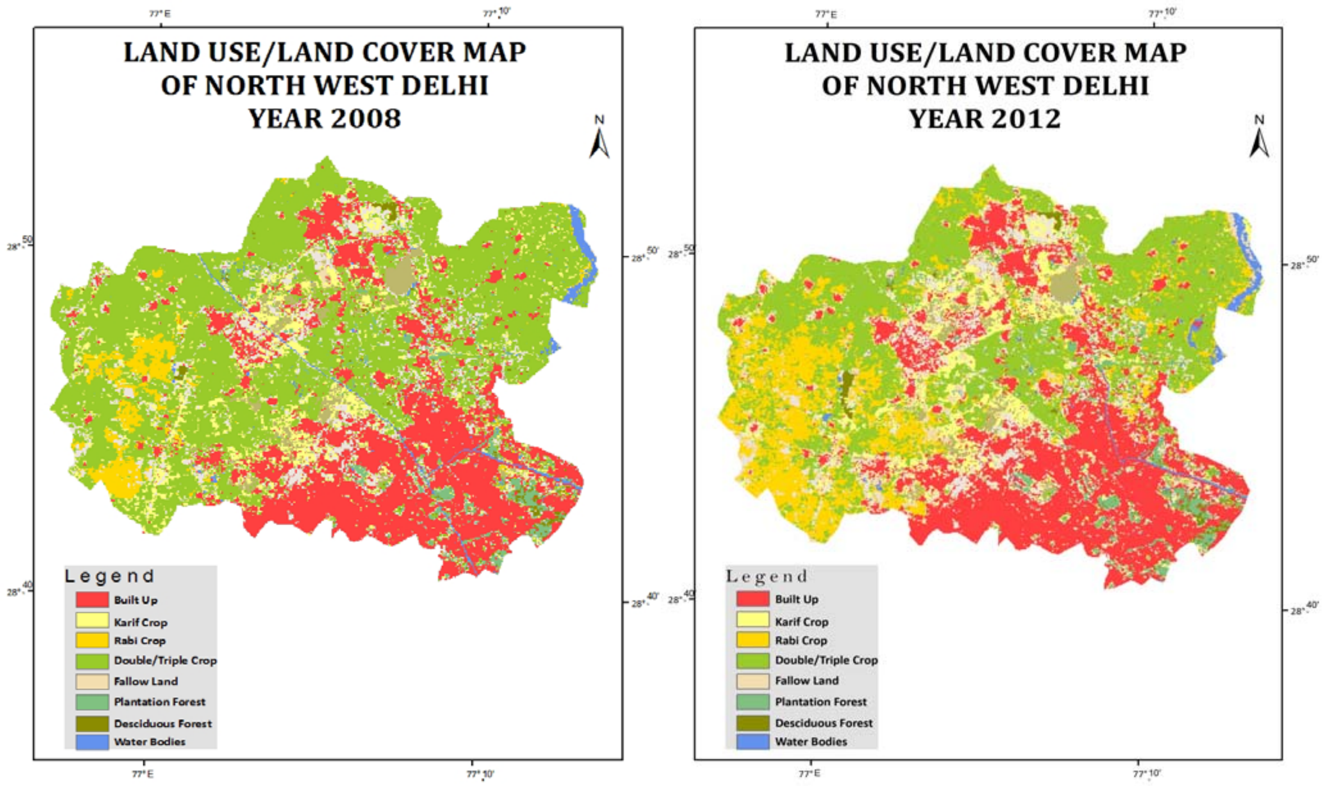

Fig. 6 LU/LC map of North West Delhi for 2008 and 2012.

Table 8. Comparison of changes of the five LU/LC classes between 2008 and 2012 of South Delhi

LU/LC Class	2008		2012		% Change between 2008 and 2012
	Pixel Count	%	Pixel Count	%	
Built-up	24756	37.7%	30876	38.1%	0.4%
Agricultural land	14158	21.6%	14418	17.8%	-3.8%
Fallow	88	0.1%	2761	3.4%	3.3%
Forest	25303	38.5%	31185	38.5%	-0.0%
Water Bodies	1352	2.1%	1810	2.2%	0.1%

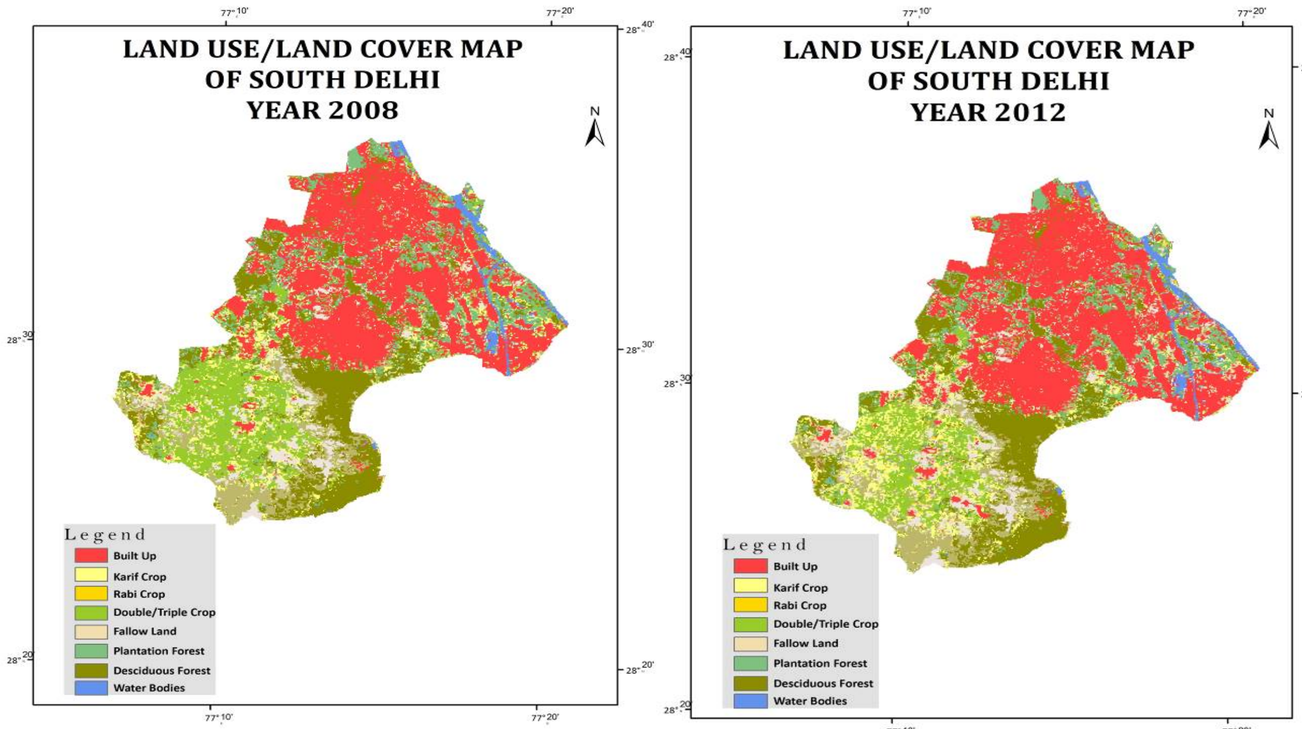

Fig. 7 LU/LC map of South Delhi for 2008 and 2012.

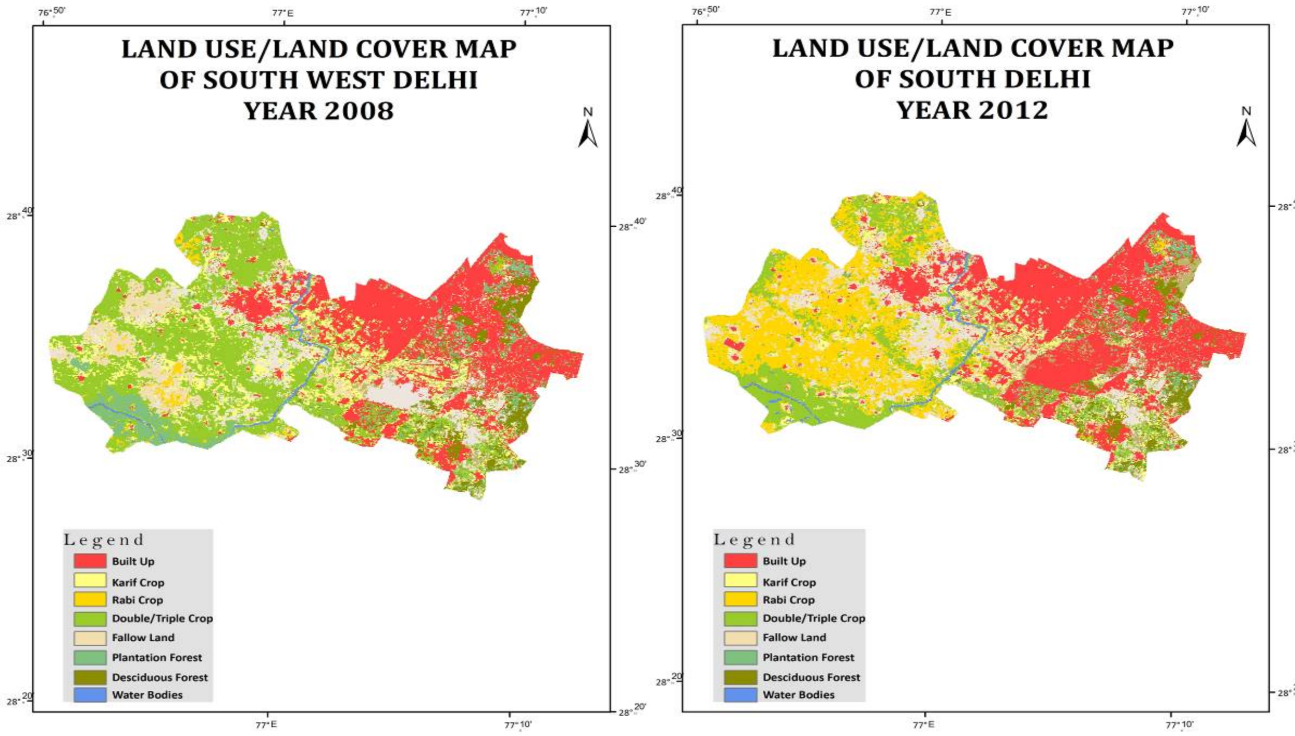

Fig. 8 LU/LC map of South-West Delhi for 2008 and 2012.

Table 9. Comparison of changes of the five LU/LC classes between 2008 and 2012 of South-west Delhi

LU/LC Class	2008		2012		% Change between 2008 and 2012
	Pixel Count	%	Pixel Count	%	
Built-up	32024	28.9%	45275	32.4%	3.5%
agricultural land	53264	48.0%	62564	44.8%	-3.2%
Fallow	6820	6.1%	12483	8.9%	2.8%
Forest land	17805	16.0%	17894	12.8%	-3.2%
Water Bodies	1081	1.0%	1488	1.1%	0.1%

Table 10. Comparison of changes of the five LU/LC classes between 2008 and 2012 of West Delhi

LU/LC Class	2008		2012		% Change between 2008 and 2012
	Pixel Count	%	Pixel Count	%	
Built-up	24479	63.7%	30478	62.5%	-1.2%
Agriculture land	10280	26.8%	9776	20.0%	-6.8%
Fallow	50	0.1%	4078	8.4%	8.3%
Forest land	2420	6.3%	3024	6.2%	-0.1%
Water Bodies	1192	3.1%	1432	2.9%	-0.2%

Table 11. Comparison of changes of the five LU/LC classes between 2008 and 2012 of of Delhi

LU/LC Class	2008		2012		% Change between 2008 and 2012
	Pixel Count	%	Pixel Count	%	
Built-up	153518	39.5%	197507	41.2%	1.7%
Agricultural land	153120	39.4%	166733	34.8%	-4.6%
Fallow	7332	1.9%	28292	5.9%	4.0%
Forest	65960	17.0%	74057	15.5%	-1.5%
Water Bodies	9160	2.4%	12230	2.6%	0.2%

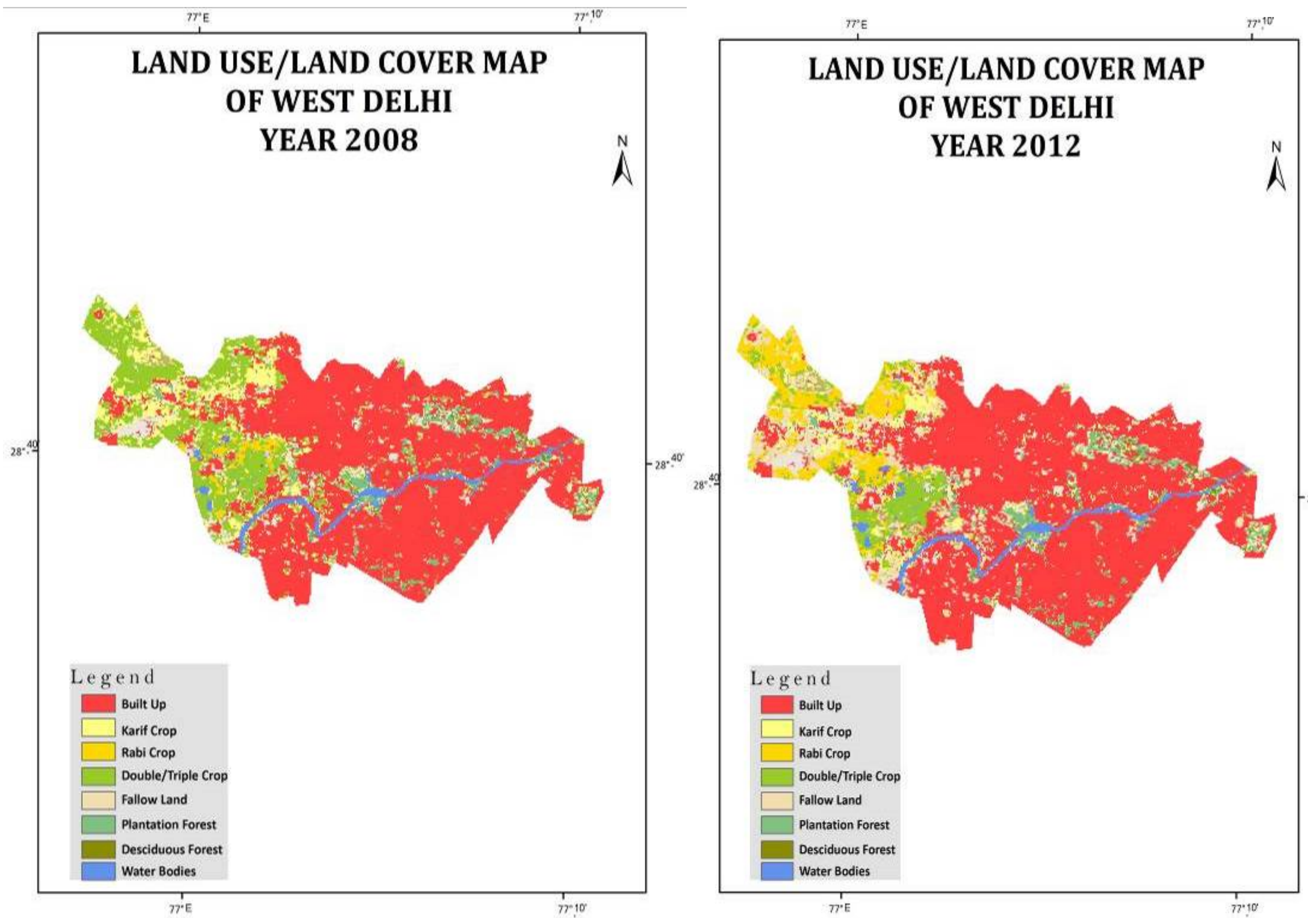

Fig. 9 LU/LC Map of West Delhi for 2008 and 2012.

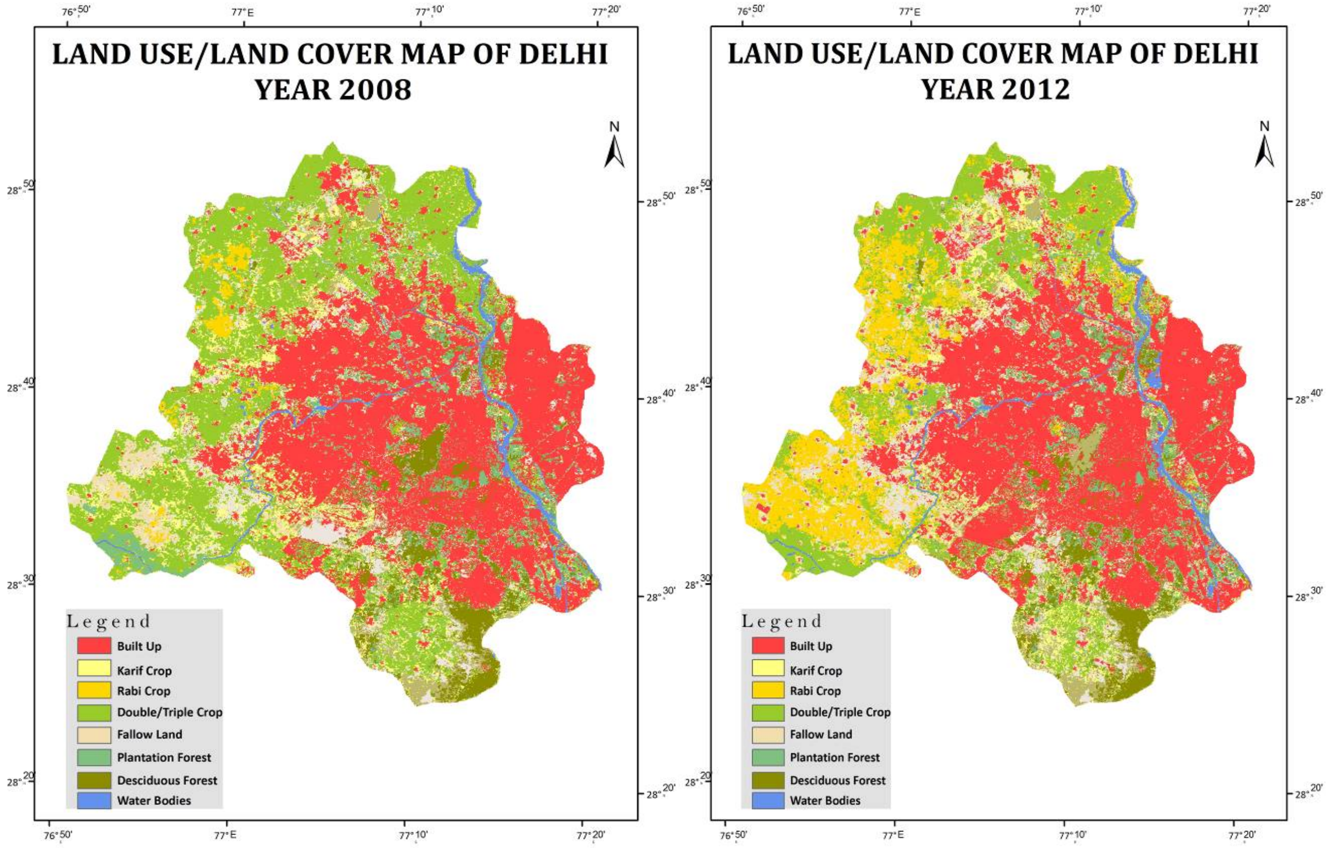

Fig. 10 LU/LC Map of Delhi for 2008 and 2012.

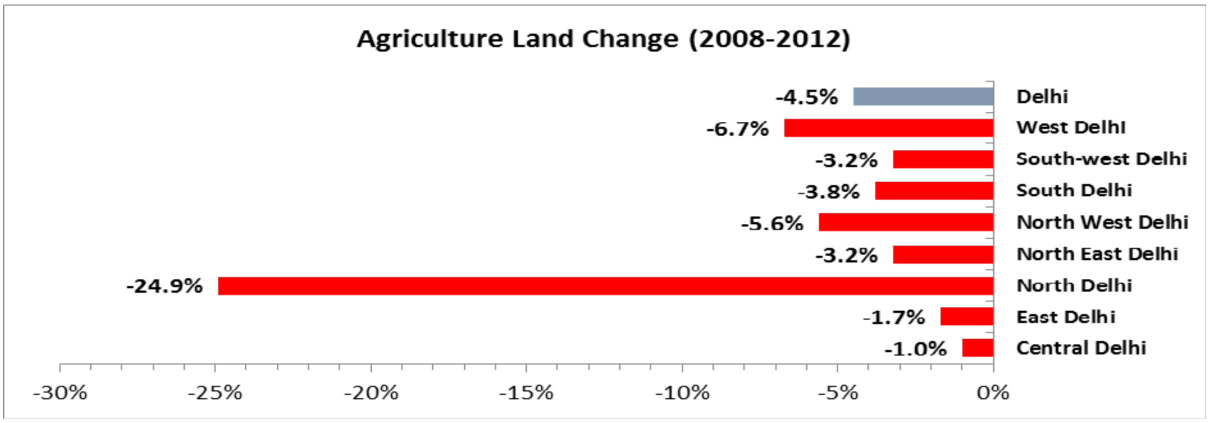

Fig. 11 District-wise Change % from 2008-12 in Agriculture Land.

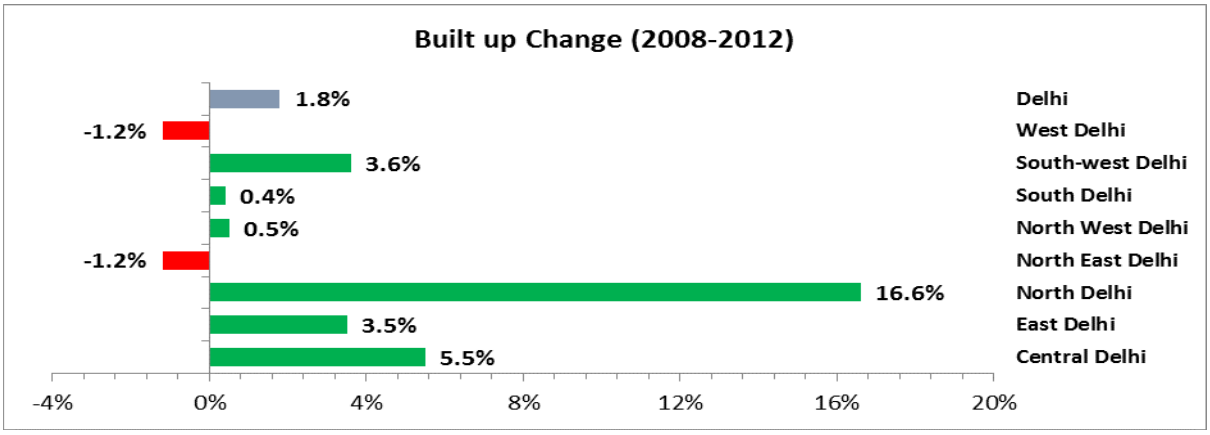

Fig. 12 District-wise Change % from 2008-12 in Built up.

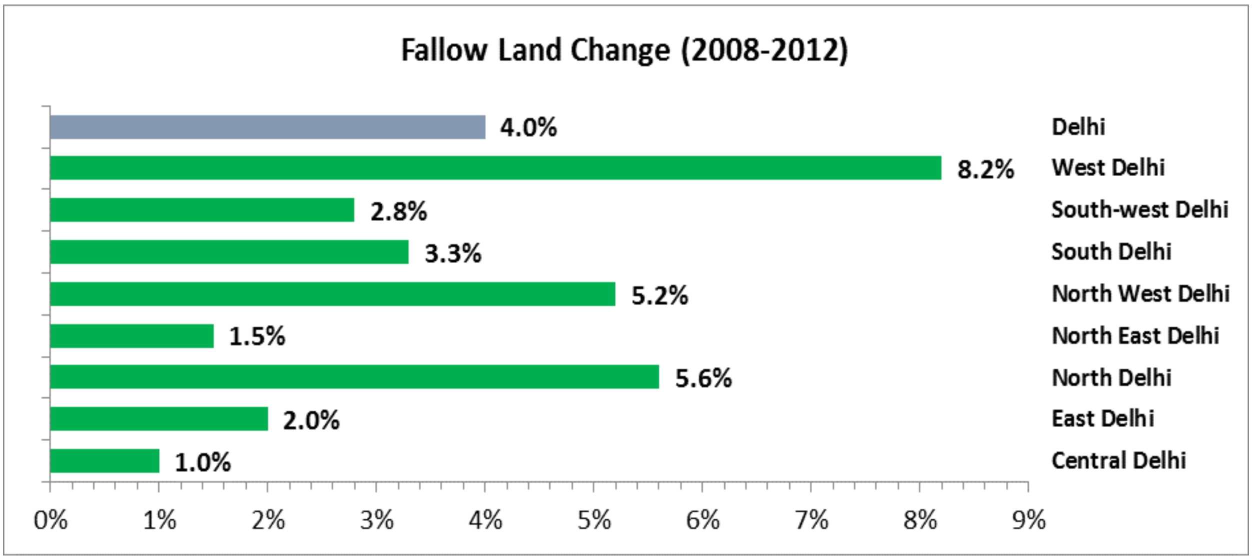

Fig. 13 District-wise Change % from 2008-12 in Fallow Land.

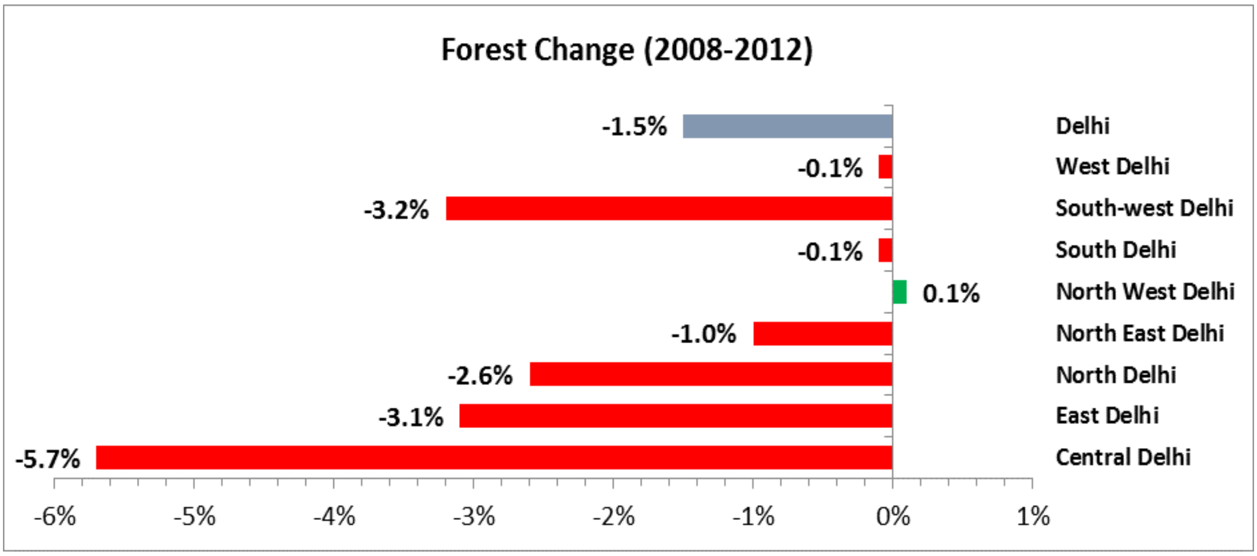

Fig. 14 District-wise Change % from 2008-12 in Forest Cover.

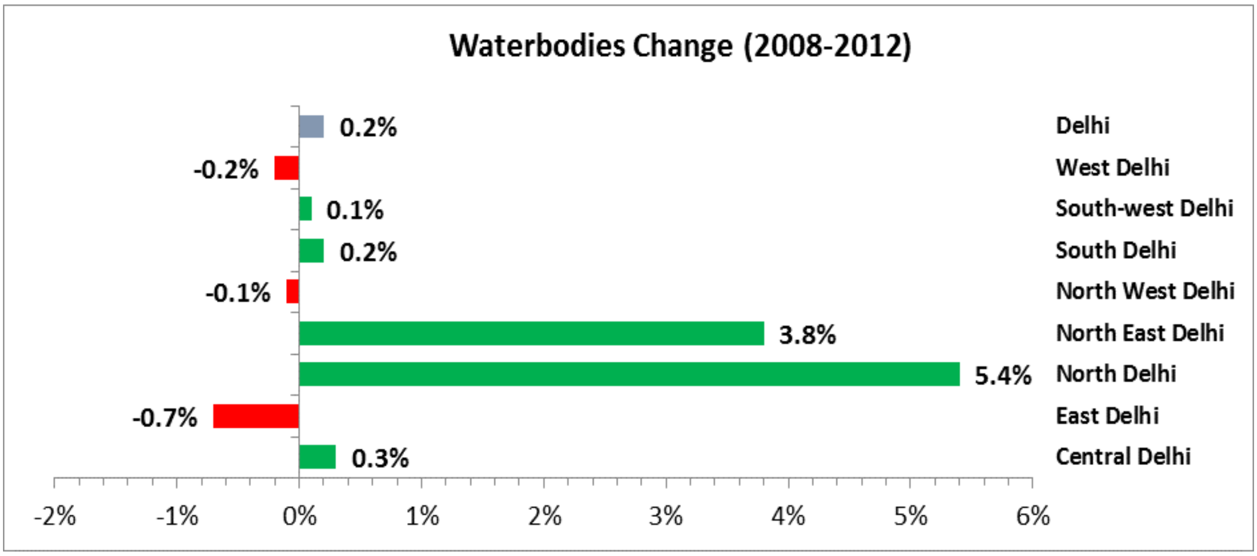

Fig. 15 District-wise Change % from 2008-12 in Waterbodies.

western and southern part. The present trend of growth continues, then most of the vegetated areas will be converted into built-up area in near future which may create ecological imbalance and affect the climate of Delhi state.

RECOMMENDATIONS

(a) A perfect balance between natural cover and built up area should be maintained by encouraging the town planning in vertical growth instead of horizontal growth.

(b) Prepare town planning by keeping in view on the natural cover untouched to maintain the ratio.

(c) Judicious use of land for construction purposes by planning for multiple purposes i.e. by using underground techniques and flyovers for communication on the same land and also encouraging basements for housing schemes to restrict horizontal growth.

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