Innovations

Geospatial Analysis of Land Use and Land Cover of Delhi

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Abstract:
The LULC monitoring in rapidly urbanizing environments using remote sensing and GIS for quantifying and analysing urban landscape change dynamics and managing healthy urban ecosystems. The key cause of LULC changes is the transfer of other forms of land to uses related to population development and economic activities. As a result, LULC are complex in nature and must be controlled on a regular basis to ensure long-term development. So, land use refers to how humans use the land and its resources, such as agriculture, grazing, logging, etc. The present paper necessitated a wide range of data. SOI Toposheets, satellite pictures, and a wealth of literature are all included. This paper is a micro-level investigation that covers an entire city. The data required for the study comprised of topographical maps, satellite images and secondary data. In order to study the change in LULC, and LANDSAT data (1992-2020) were used to generate different layers of maps. Spatial-temporal information on the LULC and its changes were determined by GIS and RS techniques. The selected datasets from 1992, 2001, 2010 and 2020 are the result of two separate Landsat satellite series sensors. Sensor data from the Thematic Mapper (TM) sensor from 1992 to 2010, as well as the Operational Land Imager and Thermal Infrared Sensor (OLI/TIRS) sensor from 2020. The present study analyzed the Spatio-temporal pattern change and urbanisation of Delhi.

Key Words: 1.*GIS, 2.Remote Sensing, 3.Land Use Land Cover, 4.Urbanisation, 5.Delhi*

Introduction

Land uses are primarily the result of human actions and decisions on land. In fact human activities arising from a multiplicity of social objectives are the immediate source of land cover change. Biophysical driving forces and shocks (such as geomorphic processes, global and local climate change/ variability, etc.) are also responsible for changes in land cover and ultimately the land use (Liu et al., 2017).India being one of the fast growing countries of the world experienced a massive growth of urban area. In India, urban areas have experienced a gradual increase in the percentage share of population during 1901-2001. It is noteworthy that the percentage share of urban population has increased from 17.97 per cent in 1961 to 31.16 per cent in 2011 (Census of India, 2011). Less than 3% of total earth's land surface is covered by cities which is residence of more than half (54%) of global human population (Liu *et al.*, 2014; United Nation, 2014). The LULC monitoring in rapidly urbanizing environments using remote sensing and GIS for quantifying and analysing urban landscape change dynamics and managing healthy urban ecosystems (Mugiraneza, Ban & Haas, 2019). It is critical to reveal the temporal and spatial shifts in built-up land expansion and population growth in order to ensure the city's long-term viability (Luo et al., 2018). National Capital Region (NCR) is a one of the fastest growing region in India by economic and population growth is situated in northwestern region of Indo-Gangetic plain. As per the 2014-15 economic survey, GDP (Gross Domestic Product) grown up by 78% as

compared to the 2009-10. According to census-2011, a decadal growth of population is 21.2% in between 2001 to 2011. The fast growing economy and population induced enormous alteration of a pristine natural landform composition or Land-use and Land cover (LULC) change in entire NCR. Delhi has witnessed a phenomenal population growth during the past century. The population census data the population of Delhi has dramatically increased from 0.46 million in 1901 to 16.7 million in 2011 (Census, 2011). Now Delhi has (4.1%) of highest population growth of all the mega cities in the world (Taubenbock*et.al*, 2009). With the population growth, built-up areas in Delhi are rapidly increasing and it is leading to several environmental consequences (air and water pollution, traffic congestion, urban heat island formation, etc.) On the other hand there is growing socio-economic disparity (epidemic break outs, social disparity, and informal economy). Hence the urban environment in Delhi is under severe stress due to the pressure of rapid urbanization. Consequently urbanization has deteriorated the overall quality of the urban environment in Delhi. Thus, the study of land use and land cover change helps to understand the pressure of land and its transformation from one class to another. The land use and land cover analysis is very beneficial for the sustainable planning of the cities, as it is very useful in monitoring and modelling the urban growth.

Database and Research Methodology

Remote sensing has been used widely to assess and map natural resources as well as other environmental issues. It is used to monitor the earth's surface because of its capacity to capture large areas at once. Remotely sensed data and GIS have showed success in computing changes in Land Use and Land Cover (LULC), post-disaster damage, tracking recovery and restoration progress after disasters, and other related information using high resolution imagery and active sensors. The integration of GIS with remotely sensed data has given remote sensing a new dimension. Data was also gathered from a variety of sources, including hydro-meteorological data from government offices and regional divisions, as well as various websites. To use and validate the data, some methodological aspects were implemented.

The study focuses on mapping out LULC changes in NCR Delhi, India, using topographic sheets and LANDSAT satellite data for different years with the help of GIS, recognizing the importance of LULC monitoring in the management and planning of land resources. The research was carried out using three scenarios from 1992 to 2020.

Data Used

The Landsat series satellite data were used to analyses land use and land cover in the research area for the years 1992, 2001, 2010 and 2020. The information was obtained from the website of the United States Geological Survey (USGS) (Table 3.2). Different temporal data sets for National Capital city were available in the Landsat archives.

Table 3.2: Data Used

S. No.	Satellite	Sensor	Date and Year	Resolution (Meters)
1	Landsat 5	TM	February, 20, 1992	30
2	Landsat 7	TM	March, 24, 2001	30
3	Landsat 8	OLI	March, 12, 2010	30
4	Landsat 8	OLI	April, 26, 2020	30

Source: Prepared by the researcher based on USGS data

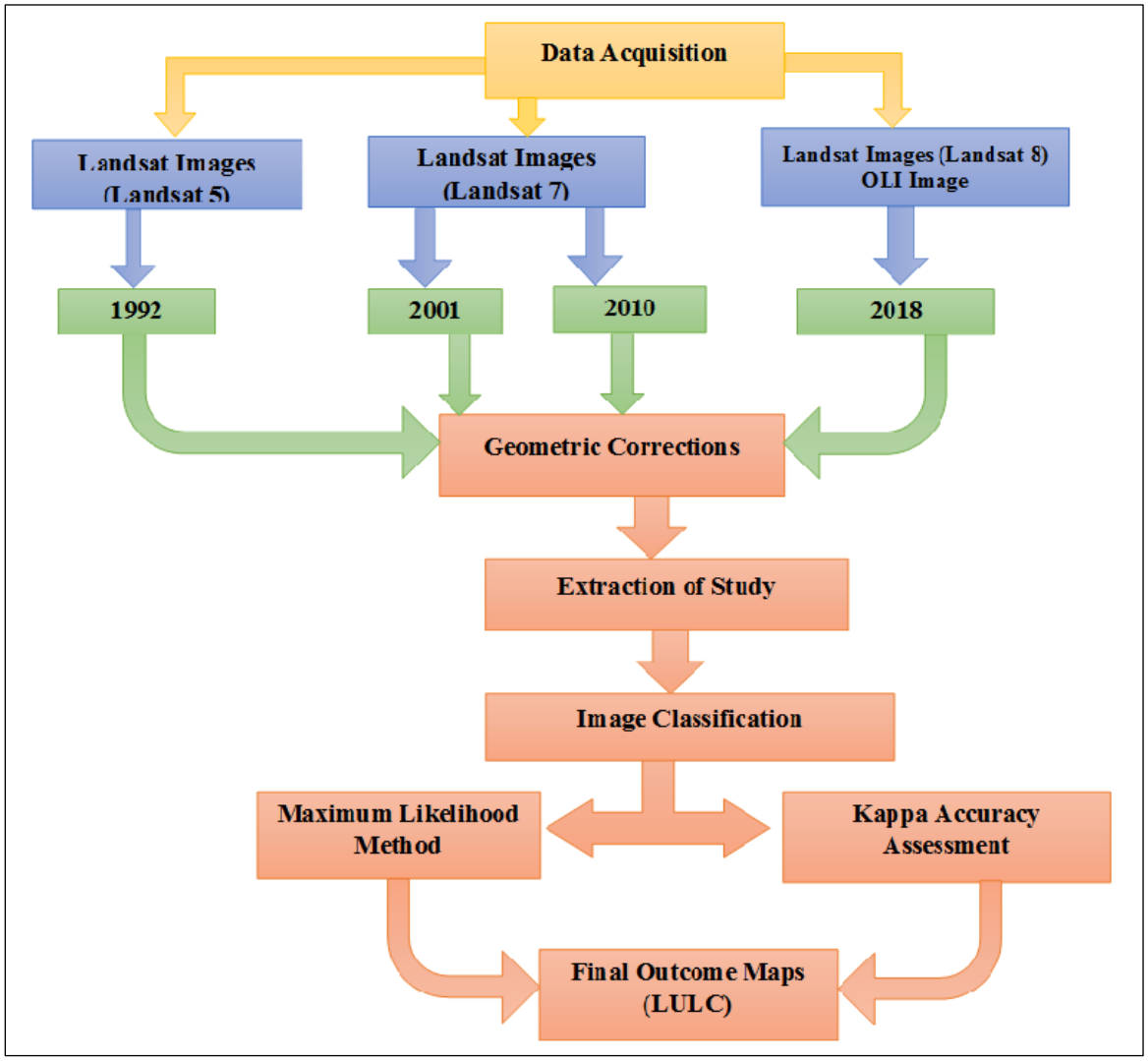
The selected datasets from 1992, 2001, 2010 and 2020 are the result of two separate Landsat satellite series sensors. Sensor data from the Thematic Mapper (TM) sensor from 1992 to 2010, as well as the Operational Land Imager and Thermal Infrared Sensor (OLI/TIRS) sensor from 2020. In addition to the Thematic Mapper (TM) sensor, Landsat 5 included the Multispectral Scanner (MSS). The TM sensor (Table 3.2) features additional bands in the shortwave

infrared (SWIR) region of the electromagnetic spectrum, with spatial resolution of 30 metres for visible, near-IR, and SWIR bands, and 120 metres for the thermal band.

The Thermal Infrared Sensor (TIS) and the Operational Land Imager (OLI) are both on Landsat 8. (TIRS). OLI collects data with a 30 metre spatial resolution and a 15 metre panchromatic band resolution. Bands 10 and 11 of the TIRS are thermal bands.

Database

Data is the backbone of any study. Topographical maps, satellite pictures, and secondary data were among the data needed for the study. LANDSAT data (1992-2020) was used to construct several layers of maps in order to analyse the change in LULC. GIS and RS approaches were used to determine spatial-temporal information on the LULC and its variations (Figure 3.1).



Source: Prepared by Researcher

Figure 3.1 Data Source and Methodology

Land Use and Land Cover Classification

For Land use and Land Cover analysis, Supervised Classification has been followed using Maximum Likelihood Classifier (MLC) for the year 1992, 2001, 2010 and 2020 for the study area. Training sets has been selected using

the various spectral signature obtained by the formation of False Colour Composite (FCC) image. The False Colour Composite (FCC) image helps in distinguishing heterogeneous patches on the satellite data in which, each distinct patch corresponds to different land use and land cover type in the study area. Thus, the satellite data has been classified into various land cover and land use classes based on these spectral signatures. To validate the classification accuracy, a stratified random sample strategy (Jensen, 2005) has been used to select 30 samples for each class during classification, totalling 150 or more points per image. The various classes obtained in the classification of the image have been further re-classed and recoded to get accuracy and pixels have been assigned their classes accordingly. As a result, five land cover and land use classes have been obtained in the study area on 30 m, spatial resolution.

Result and Discussion

Land Use and Land Cover Classification

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 ant-expansion 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 (Fazal**, 2000)**. 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 (Liu et al., 2008).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 (Zhang et al., 2006).

In the study, maximum likelihood classifier has been used to classify the image into various land use and land cover classes. Since, the spatial resolution is 30 m, only five major classes of land use and land cover has been identified on the satellite data. These five classes have been built up- which included impervious surface, water body- included rivers and streams, crop land- included cultivable land, vegetation-included forests and vegetation and others- which included bare soil, rocky surfaces. These classes have been identified based on the spectral signatures of each land use and land cover class. The satellite data has been observed in False Colour Composite (FCC) and corresponding signatures of each land use and land cover class has been studied and based on that the area has been demarcated under that particular land use and land cover class. For example, in the FCC image red colour shows the vegetation and agriculture. The tonal variation in red colour along with the various elements of image interpretation (ancillary information, shape and size) helped in differentiating the agricultural areas from vegetation. Built up areas has been shown in cyan colour. To validate the classification precision, a stratified random sample strategy has been used to select 30 samples for each class during classification, totalling 150 or more points per image. The various classes obtained in the classification of the image have been further re-classed and recoded to get accuracy and pixels have been assigned their classes accordingly.

Land use / land cover of Delhi in 1992

Land Use and Land Cover Dynamics in Dehradun (1992-2020)

The spatio-temporal pattern of Land Use and Land Cover has been studied from 1992 to 2020 with respect to last four decades time period, i.e. Land Use and Land Cover of 1992, Land Use and Land Cover of 2001, Land Use and

Land Cover of 2010 and Land use and Land Cover of 2020. In this section, the land use and land cover for each year has been discussed.

Land use and Land Cover of Delhi 1992

Theland use and land cover of NCR and its surroundings for year 1992 has been studied using the Landsat 5 TM data. Five major land use and land cover classes have been identified in the study area in 2001 (Table 3.5, Figure 3.2 and Figure 3.3).

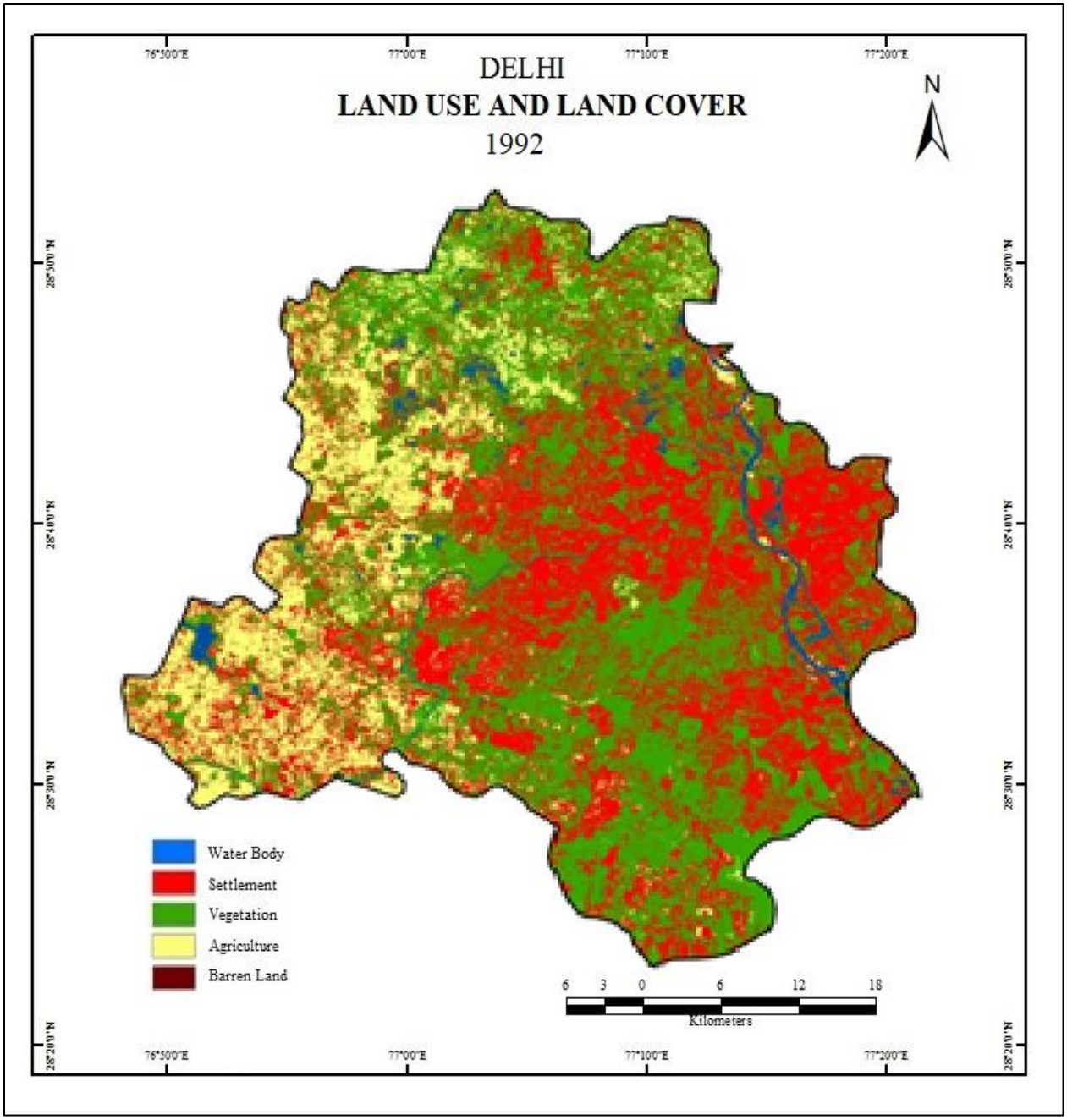
Land use land cover change provides information about the resources and its utilization for specific purposes. These changes are produced in map to understand the reality of surface accurately. In 1992, the water bodies had occupied second smallest part of this study area after barren land 1.82 and 0.64 per cent respectively. These were mostly concentrated in Yamuna river catchment and barren land is associated with river catchment and little bit towards the agriculture field surrounding and along with river catchment. This region had some vegetation cover in the form of parks and ridge, it occupied the 45.70 per cent area, including fallow lands (Figure 3.).

Table 3.5: Land Use and Land Cover of Delhi in 1992

Land use & land cover	Area in Sq.km	Area in Percent (1992)
Water Body	27.02	1.82
Settlement	551.94	37.22
Vegetation	677.70	45.70
Agriculture	216.79	14.62
Barren Land	9.56	0.64
Total	**1483.00**	**100**

Prepared by the researcher based on USGS data

The third largest occupant in this study area was agriculture which had covered the 14.62 per cent of total study area. Overall, vegetation, settlement and agriculture had occupied more than 97 per cent of total study area together.



Prepared by the researcher based on USGS data

Figure 3.2 Land Use and Land Cover of Delhi in 1992

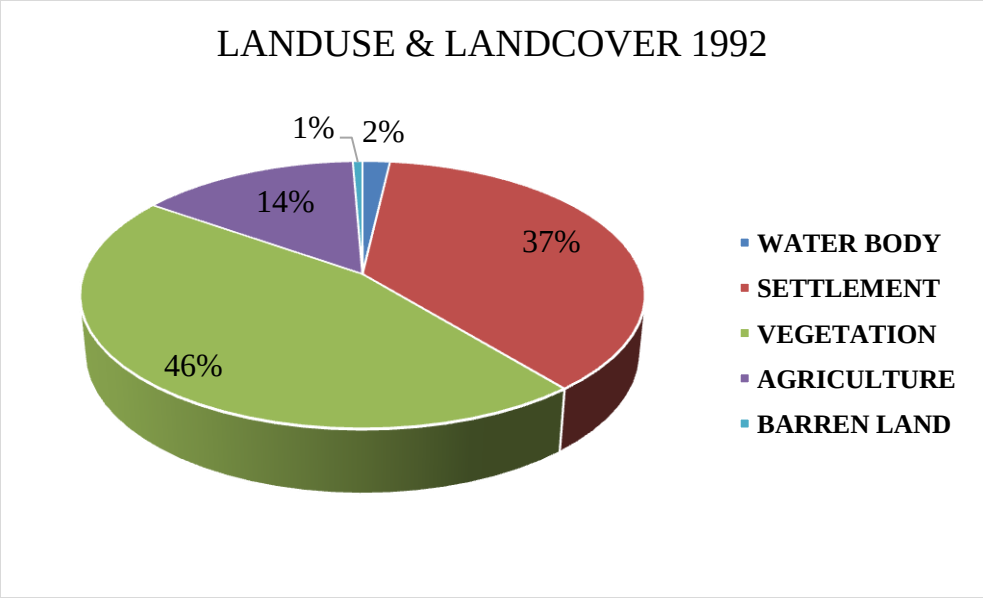


Figure 3.3: Land Use and Land Cover of Delhi in 1992

Land Use and Land Cover for the year 2001

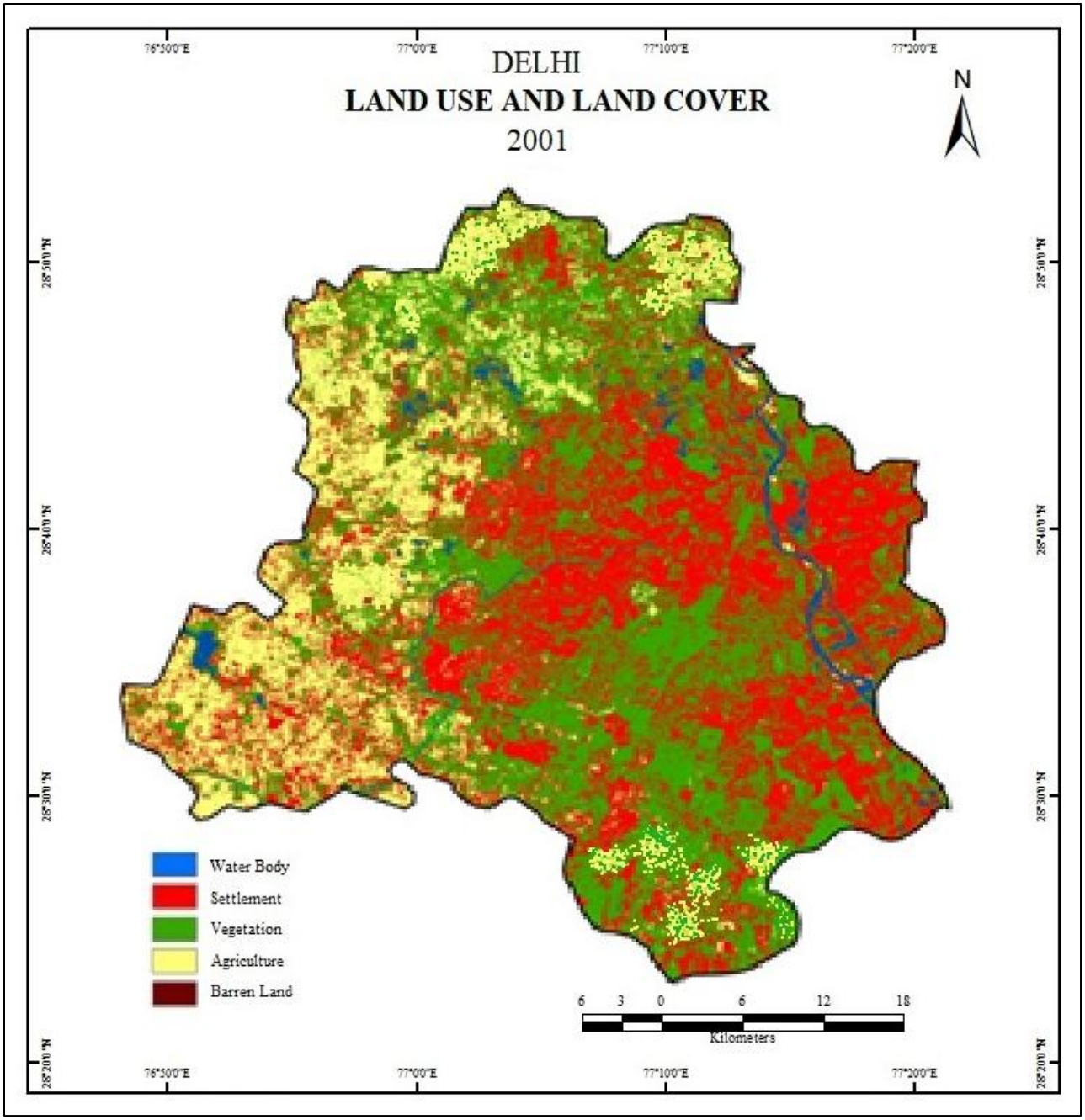
According to land use/ land cover classification for the year 2001 and it is revealed that in Delhi mostly covered by settlement and Vegetation cover .Agriculture land found in north-western part and also found in along with Yamuna River Catchment area. Scrubs land found are Southern part. Barren land are found in eastern & middle part of the city. Yamuna is the one major river of this area, present in lower and north eastern part of Delhi.

Table 3.6: Land Use and Land Cover of Delhi, 2001

Land us and Land Cover 2001	Area in Sq.km	Area in Per cent (2001)
Water Body	22.57	1.52
Settlement	584.57	39.42
Vegetation	516.05	34.80
Agriculture	347.29	23.42
Barren Land	12.52	0.84
Total	**1483.00**	**100.00**

Prepared by the researcher based on USGS data

Theland use and land cover of NCR and its surroundings for year 1992 has been studied using the Landsat 5 TM data. Five major land use and land cover classes have been identified in the study area in 2001 (Table 3.6, Figure 3.4 and Figure 3.5).



Prepared by the researcher based on USGS data

Figure 3.4: Land Use and Land Cover of Delhi, 2001

The study depicts that 1483 sq.km of land area which is 34.80 per cent of the study area has been under the class vegetation. So, it has been the second dominant class in the region in 2001 after that settlement 34.80 and 39.42 respectively. The total area under agriculture land has been 347.29 sq.km which account to 23.42 per cent of the study area. It is the third prominent class has of the study region. The water body occupied only 1.52 per cent (22.57sq.km) of the area and barren land is0.84 per cent 12.52 sq.km)., it is smallest class under the total area.

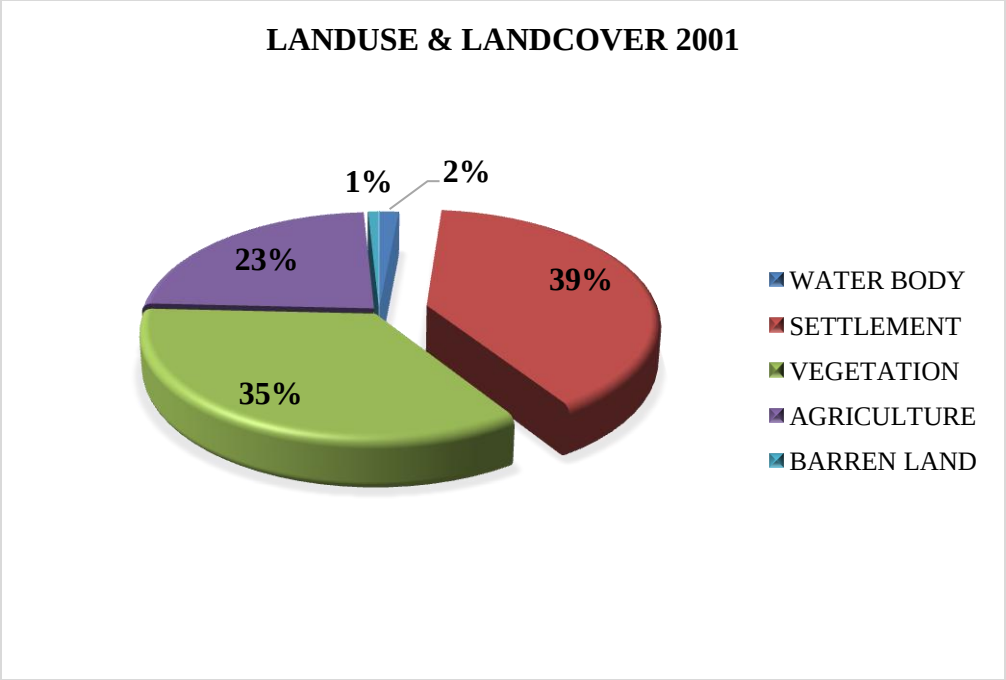
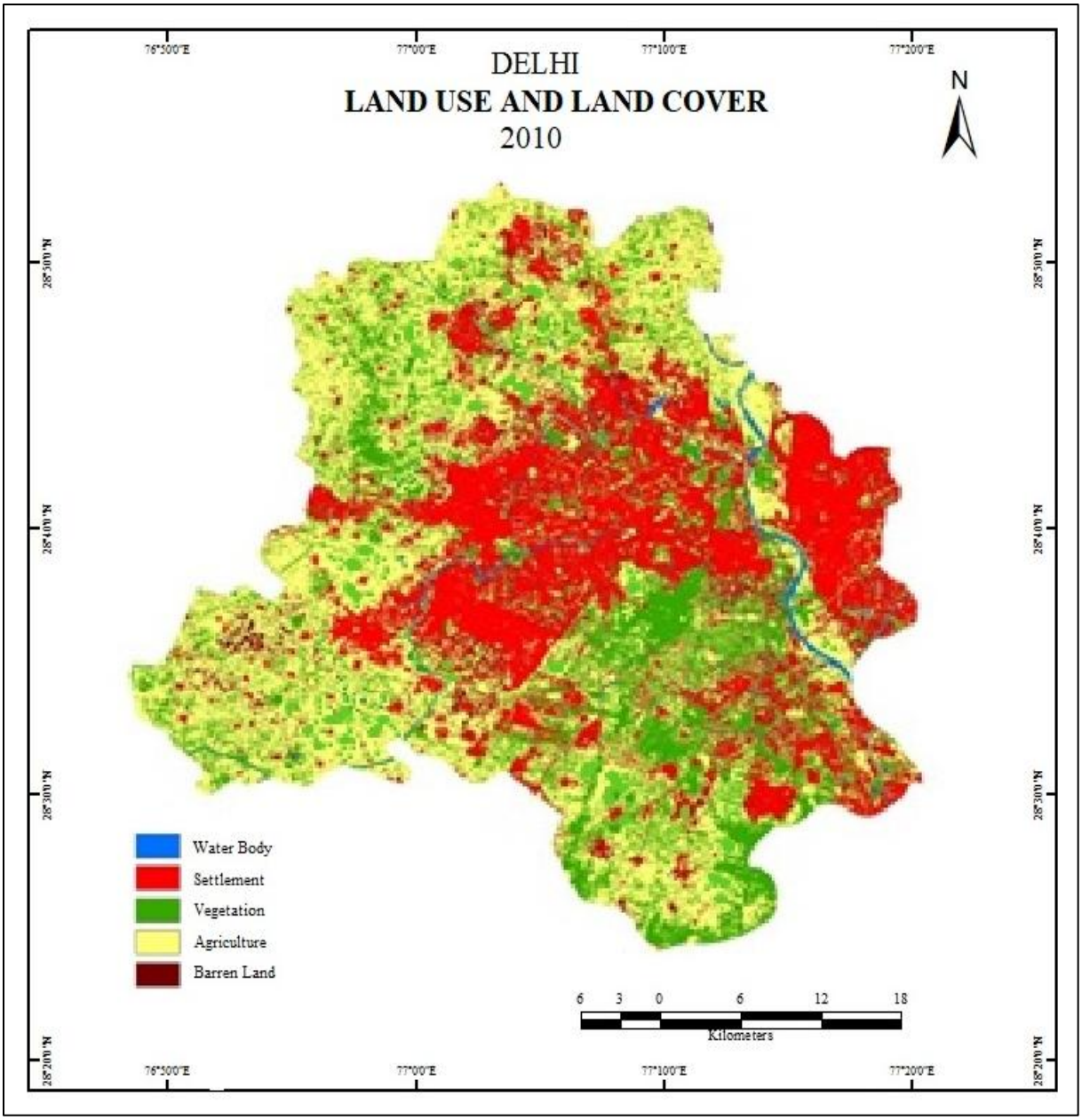


Figure 3.5: Land Use and Land Cover of Delhi, 2001

Land Use and Land Cover for the year 2010

The city's land use has been changed in comparison to previous time. Now, city is not predominantly concentrated in three sections as it was in 1992s. The most of settlements have developed on vegetation field and city is in state of continuous growth. The Vegetation cover is reduced in the land use land cover map of 2010 to 25.55 which reflect the change in economic and Urbanization activities in the area. The barren land has increased to 1.06 per cent (15.65 sq.km) which is river catchment or cross sectional area and some spots visible between the agriculture fields in the map. Most of the catchment is observed to be dry and barren land can be easily demarcated on the map in the southern and Western part of river Yamuna.



Prepared by the researcher based on USGS data

Figure 3.6: Land Use and Land Cover of Delhi, 2010

The land use and land cover classes statistics depict that around 1483 hectares of land area which is 41.12 per cent of the study area has been under the class Settlement. So, that the trend has been changed, in 1992 the dominant class is vegetation and in 2010, it is shift to the settlement class in the region. The total area under vegetation has been 378.96 Sq.km which account to 25.55 per cent of the study area. The second prominent class has been agriculture in the study area, which has 31.33 per cent (464.63 sq.km) of the study region. The water body occupied only 2.94 per cent (13.89 sq.km) of the study area.

Table 3.7: Land Use and Land Cover of Delhi, 2010

Land use & Land Cover (2010)	Area in Sq.km	Area in Percent
Water Body	13.89	0.94
Settlement	609.88	41.12
Vegetation	378.96	25.55
Agriculture	464.63	31.33
Barren Land	15.65	1.06
Total	1483.00	100.00

Source: Prepare by Author *based on Landsat data*

The water bodies have partially decreased to 0.94 per cent and are continuously increasing according to the prepared maps from the last 1992 in the study area. The vegetation is partially reduced to 25.55 per cent and it is mostly visible near by the settlement and catchment areas. The western and some part of northern in city is covered with the vegetation. There is some agriculture growth observed in western and northern margin of Delhi city previously occupied by vegetation cover. Vegetation lands have been converted into settlements and are continuously spreading towards the settlement areas.

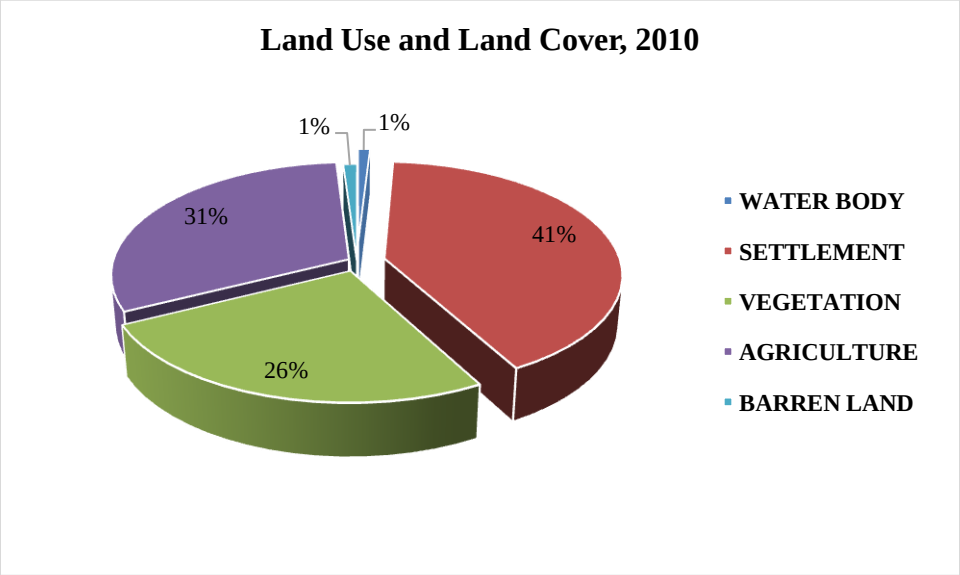


Figure 3.7: Land Use and Land Cover of Delhi, 2010

Land Use and Land Cover, 2020

The land use and land cover map of 2020 contemporary scenario of Delhi for the study and most of the information of map can be evaluated with ground reality check of the study area. Now, the city is more congested and providing more accommodation to residence and industries. The city has developed as well-known Metropolitan and

Administration city. Therefore, the land use has been changed in comparison quite vastly.Most of the settlements have developed on the Vegetation field and city is continuous growth.

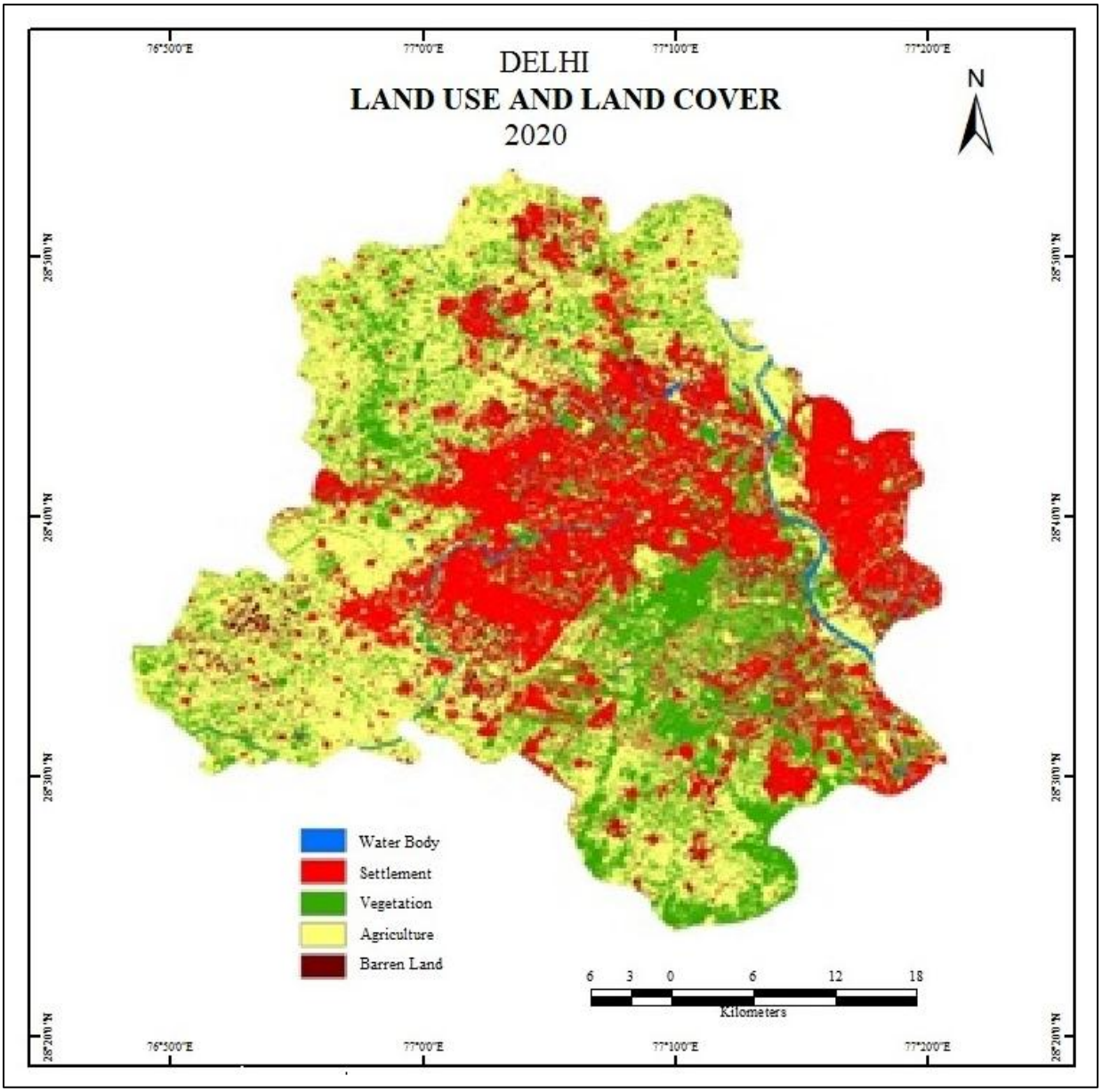


Figure 3.8: Land Use and Land Cover of Delhi, 2010

The land use and land cover classes statistics depict that around 1483 sq.km of land area which is 42.92 per cent of the study area has been under the class Settlement. It is the most dominate class.

Table 3.8: Land Use and Land Cover, 2020

Land Use and Land Cover, 2020	Area in Sq.km	Area in Percent
Water Body	3.51	0.24
Settlement	636.57	42.92
Vegetation	239.55	16.15
Agriculture	584.76	39.43
Barren Land	18.61	1.26
Total	1483.00	100.00

Prepared by the researcher based on USGS data

The agriculture is seen to have increase in the land use land cover map of 2020 to 39.43 which reflect the change in economic activities in the area and it is the second predominant class in the study area. Next predominant class is vegetation in the study area, its cover almost one sixth (16.15%) area out of total study area.

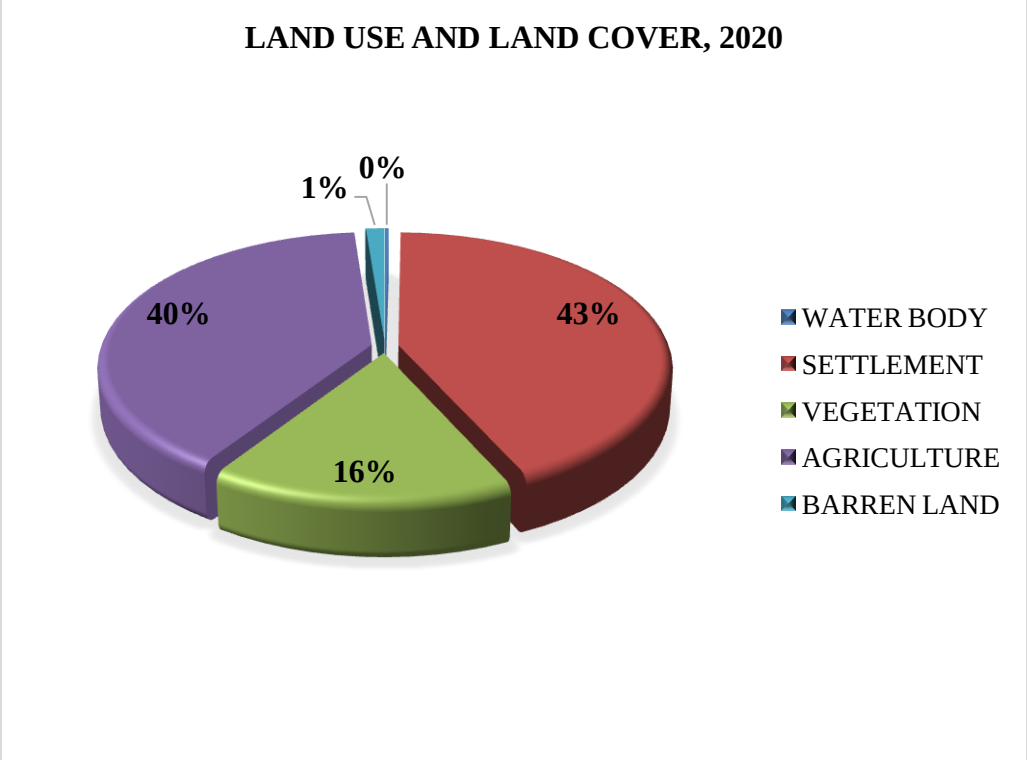


Figure 3.9: Land use Land Cover, 2020

The barren land is increased to 1.26 per cent which is river catchment or cross sectional area and some spots visible between the agriculture fields in area of southern part of the map. The area under water bodies category has partially reduced to 0.24 per cent and is continuously decreasing as per maps from the in the last few decades map of study area. The vegetation has been also reduced to 16.15 per cent and it is mostly visible near by the settlement and catchment areas (Table 3.8). The settlement is very congested near the Yamuna River and its surrounding area. The central part of highly congested and denes area of the study area.

Land Use and Land Cover Change Detection, 1992-2020

Spatio-temporal Change Detection 1992-2001

The analysis satellite images of metropolitan city of Delhi have provided different outcomes which show change in all the classes. Change detection has been done to study the impact of urban growth on the land use and land cover. The study has revealed the transformation of the various land use and land cover classes from 1992 to 2001. However, the change has not been equal in every land use and land cover class.

Table 3.9: Land Use Change during the Period of 1992-2001

Land Use & Land Cover	Change In Sq.km	Change in 1992-2000
Water Body	-4.45	-19.71
Settlement	32.63	5.58
Vegetation	-161.65	-31.32
Agriculture	130.50	37.57
Barren Land	2.97	23.68

Source: Prepare by Author *based on Landsat data*

All the classes analyzed in the classification have undergone positive change with the exception of vegetation and water body (Table 3.9). The vegetation areas have registered rapid decreased in percentage from 1992 to 2001, it has recorded negative growth of -31.32 per cent. Water body have registered second largest negative growth with 19.71 percent. Whereas, Agriculture area have registered highest positive growth during 1992-2001, it has recorded positive growth with 37.57 percent.The 5.58 per cent of growth under the settlement cover it has shown the growth in urbanization of Delhi.

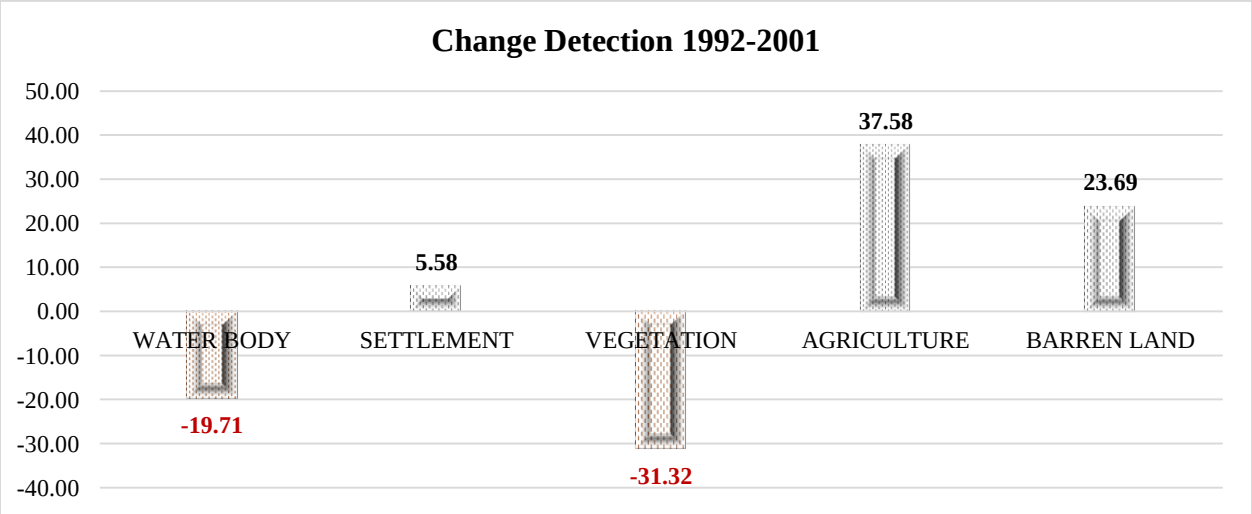


Figure 3.10: Land Use Change during the Period of 1992-2001

Spatio-temporal Change Detection 2010-2020

The change which has taken place in this period is recognizable. The water body and vegetation cover shown in during the last decade (2010-2020) are major land uses which lost their area and it is show continuously decline trends from 1992-2020. Agriculture and barren land gained the area from both the land uses. The settlement cover have smoothly increasing in last few decades and the trend shows that the area under settlement are also increasing in during last decades from 2010 to 2020, with increase in area with the value of 4.19 per cent. The vegetation has deceased and this change was taken place in western margins of the maps with decreasing of -58.19 per cent and it is second largest declining class between 2010 to 2020. The barren land has been increased with 15.94 per cent area. Similarly the agriculture is also increasing their area for same reason like settlements (table 3.10).

Table 3.10: Land Use Change during the Period of 2010-2020

Land use & Land cover	Change in Sq.km	Change in 2010-2020
Water Body	-10.38	-295.83
Settlement	26.69	4.19
Vegetation	-139.40	-58.19
Agriculture	120.12	20.54
Barren Land	2.97	15.94

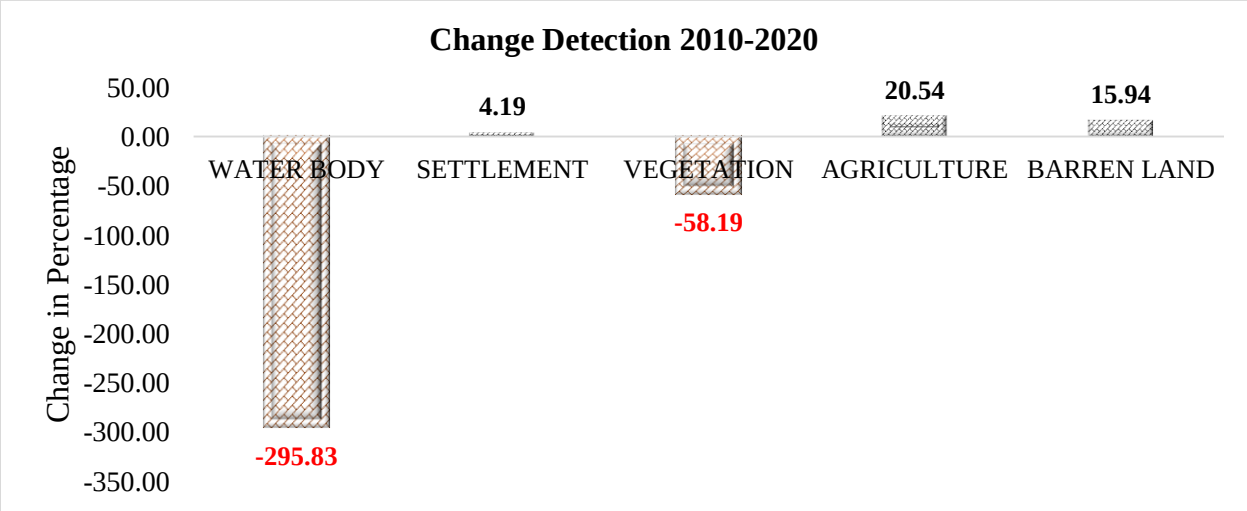


Figure 3.11: Land Use Change during the Period of 2010-2020

Spatio-temporal Change Detection 1992-2020

Land use and land cover change is the result of nature and human acts. Land use land cover is method to trace this change and find out the changing pattern. During the period of 1992 and 2020 agriculture had growing in outer belt of the city and trend shows it is continuously increasing in every decades. The water bodies have largest decreasing class from 1992 to 2020 respectively 1.82 to 0.23 percent per cent in the total area.

Table 3.11: Decadal Spatio-Temporal Change Detection 1992-2020

Land use & Land cover	Percent (1992)	Percent(2001)	Percent(2010)	Percent(2020)
Water Body	1.82	1.52	0.93	0.23
Settlement	37.21	39.41	41.12	42.92
Vegetation	45.69	34.79	25.55	16.15
Agriculture	14.61	23.41	31.33	39.43
Barren Land	0.64	0.84	1.05	1.25
Total	**100**	**100**	**100**	**100**

Prepared by the researcher based on USGS data

The vegetation lost their most of the area during this period with decline of 16.15 per cent. Agriculture increasingmore than double area during this period because people convert vegetation and barren land to agriculture land in outer ring of the city. The settlement had increased with good portion of their total area with 4.19 per cent increase. Vegetationhas registeredsecond highest declining after water body with 16.15 per cent increase in area in 2020. This barren land is mostly abandoned river channel which was refill during the rainy seasons (table 3.11).

Conclusion

The land use land cover change is a dynamic phenomenon which changes with passage of time. The land use and land cover is predominantly more active in urban area. Delhi represents the dynamic character of Agriculture because this is the only class which is continuously increasing in area due to economic activity and spreading the city. The settlement has been increasing after globalization in 1990, because after that Delhi has been emerge as a global administrative and metropolitan center. The catchment size has been modified by the people through encroachment in catchment area and illegal construction nearby and in the catchment area. The act like encroachment in along with Yamuna river catchment is responsible cause for the flood disaster and loss of property and life during the excess of water in the basin. Therefore, this region gets number of organized settlements. The water bodies have rapidly negative change in the city as per the analysis of maps of study area. Vegetation covers the highest area continuously declining from 1992 and it is continuously decreasing afterwards.

Thus, the process of urban sprawl is taking place at the expense of various other classes, for example, agriculture land and open spaces. Analysis of land use and land cover in the city and its surroundings would enable the urban planners and decision makers in making suitable development policies to counter negative impacts urban growth on the environment. Since, the result of analysis indicates significant reduction in vegetation, water bodies. This unprecedented growth has taken deleterious effect and has resulted in a chaos, traffic congestion, overcrowding and mass encroachments on the drainage system of the city and lowering of ground water levels. Thus, Government needs to play a prominent role in planning sustainable and resilient cities with the healthy urban environment and sustenance of natural resources (vegetation, water bodies and open spaces).

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