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Monitoring Land Use & Land Cover Changes In Delhi-Faridabad Corridor Using Multi-Temporal Satellite Data

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Abstract: The land use land cover change in the Delhi National Capital Region have been playing major role in changing landscape. The urbanisation trend in the developing world is mostly due to rural–urban migration, spatial expansion of urban regions via vocations, and the conversion and reclassification of rural villages into peri-urban communities. The influxes of new migrants, as well as the suburbanization of the middle class, are driving the growth of the metropolitan periphery.The LULC dynamics have recently change drastically. LANDSAT data (1990-2018) were used to construct several layers of maps in order to analyse the change in LULC. GIS and RS approaches were used to derive spatial-temporal information on the LULC and its changes. From 1990 to 2018, Faridabad district in the Delhi NCR region has undergone significant change. LANDSAT data (1990-2018) were used to construct several layers of maps in order to analyse the change in LULC. The built-up area has grown throughout time, but in 2018, a number of pockets have emerged in remote locations around the map.

Keywords: *Land use land cover, Landsat, Spatio-Temporal, Metropolitan Rural-Urban Migration*

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The land use land cover change in the Delhi National Capital Region have been playing major role in changing landscape. Land use land cover (LULC) is the outcome not only of physical phenomena, altitude and slope but also socio-economic and cultural setups (Rai, Sharma, & Sundriyal, 1994). The urbanisation trend in the developing world is mostly due to rural–urban migration, spatial expansion of urban regions via occupations, and the conversion and reclassification of rural villages into peri-urban townships. The entrances of new migrants, as well as the suburbanization of the middle class, both contribute to the extension of the metropolitan periphery. During recent time, the LULC dynamics has been changed vigorously. This transformation in LULC change has been carried by both anthropological as well as natural factors (Hassan et al., 2016).Similarly, changes in urban land cover and land use pattern have been observed in Faridabad district of the NCR Delhi area from 1990 to 2018. There are significant flat areas of land in and around Faridabad, which is positioned between a Ridge in the west and the River Yamuna in the east. Aside from that, the land is quite affordable in comparison to Delhi, where the price of land has lately skyrocketed. This is one of the major causes that may have contributed to the spread of urban settlements and industry from Delhi to Faridabad. The land use changes are active in nature and are caused by various aspects functioning on local, regional and global scales (Hassan et al., 2016; Rahman, Kumar, Fazal, & Siddiqui, 2012).In terms of productivity and development, metropolitan economies are considered to be the engines of economic growth. As a result, the spread of economic activity from the centre to the periphery must be sufficient to allow such expansion. Land Use/Land Cover (LULC) studies have evolved into critical components for managing natural resources and understanding the varied consequences of human activities on the environment. The high pace of urbanisation is one of the primary drivers of LULC transformation. 'Urbanized societies,' in which a large proportion of people live in cities, progressed most effectively in the nineteenth and twentieth century. The unrestricted and dynamic population growth coupled with economic growth and industrial development has been continuously changing the land use.Some activities or factors are known to directly influence or modify the proportion of utilization of land such as agriculture expansion, industrialization or urbanization etc. (Turner and Meyer, 1994). Physically, the direct factors

are of greater importance than the indirect factors but indirect factors are responsible for influencing these factors which culminates into changes in the landscape. These indirect factors have very complex structures which controls the change on land use and human activities. The growing population and economic change very often influence the land use and land cover change. Land cover changes are predominantly controlled by human activities. The land use and land cover are complementary to each other, bringing a change land cover automatically brought a change for land use.

Study Area

South District and Faridabad is located at the intersection of 28° 25' 16" North range and 77° 18' 28" East longitude. The city is bordered to the north by Delhi State, to the east by the Agra and Gurugram canals, and to the west by the Aravali Hills. The Yamuna runs quite close to the city in the north and moves away in the south. Faridabad is a suburb and peripheral city of Delhi which lying along with the districts of south Delhi and south east Delhi. Faridabad is one of the city located near to Delhi, this is transforming to more alluring areas by interrogating and exploring their own urban identity, improving citizen integration and social cohesion to fulfill a new role within their metropolitan areas. Faridabad is a city in transition which is in a quest of newer identities. To survive in our fast-paced world, cities must constantly alter and reimagining themselves.

Methodology

Data Source

The data required for the study comprised of topographical maps, satellite images and secondary data. LANDSAT data (1990-2018) were used to construct several layers of maps in order to analyse the change in LULC. GIS and RS approaches were used to derive spatial-temporal information on the LULC and its changes.LULC classification is one of the methods for collecting the information from satellite images (Srivastava, Han, Rico-Ramirez Bray, & Islam, 2012).The most important stage in creating the LULC map is deciding on a LULC categorization system. In general, the LULC categories should generally correspond to the standard categories

provided by the US Geological Survey. Taking into account the conventional categories as well as local considerations such as terrain, land use, and so on, five distinct LULC classifications were defined: built-up, fallow land, forest cover, water bodies, and agriculture. Prior to categorization, all satellite pictures were examined using spectral and spatial profiles to ensure the Digital Numbers (DNs) of distinct LULC categories. For ground reference, topographic sheets from the Survey of India's South, South East Delhi, and Faridabad were utilized. A series of Landsat Multi Spectral Scanner (MSS) and Enhanced Thematic Mapper (ETM) multispectral images acquired for the years 1990, 2000, 2010 and 2018 have been used for the identification of different LULC classes and preparation of LULC map. These datasets are produced by the United States Geological Survey (USGS) with the spatial resolution of 30m x30m and are freely available from USGS Earth (Table 1)

Table 1 Data source of Satellite Imageries

Satellite	Sensor	Date of acquisition	Data type and bands
Landsat 7	OLI	9 November 2018	Digital (1,2,3,4,5,6,7)
Landsat 5	LISS IV	9 November 2010	Digital (1,2,3,4,5)
Landsat 5	LISS IV	1 November2001	Digital (2,3,4)
Landsat 5	LISS IV	1 January1990	Digital (2,3,4)

Source: USGS, 2020

Image processing

Image processing was carried out by standard method followed by ground truth collection. Thematic maps were created from digital satellite data using ERDAS Imagine 10 and ArcGIS 10.3 software. For vegetation mapping and auxiliary information such as elevation and landforms, standard methods of digital image processing were used, which included the

utilisation of picture components such as tone, texture, shape, position, association, pattern, and so on. Following the completion of these interpretation elements, an interpretation key was created. The purpose of image classification is to automatically group all pixels in a picture into land cover classes or themes. Typically, multispectral data are utilised for classification, and the spectral pattern existing within the data for each pixel is employed as the numerical foundation for categorization. That is, based on their intrinsic spectrum reflectance and remittance qualities, various feature types display distinct combinations of DNs. The term "spectral pattern recognition" refers to the family of classification techniques that use this pixel-by-pixel approach.

Maximum Likelihood Method

Maximum Likelihood (ML) is a supervised classification method derived from the Bayes theorem. In this procedure, each pixel is allocated to the class with the highest likelihood or labelled as unclassified if all of the probability values are less than a user-specified threshold. The following are the general ML procedures:

1. The number of land cover types within the South, south east Delhi and Faridabad is determined.

2. The training pixels for each of the desired classes are chosen using land cover information for the South, south east Delhi and Faridabad. The outcome of ML classification after assigning the classes with suitable colours, is: forest (green), water bodies (blue), agriculture (yellow), barren land (brown) and settlements (red). The areas in terms of percentage and square kilometers were also computed

Result and Discussion

Land Use Land Cover Analysis of Delhi

The urban areas such as Delhi, Noida, Faridabad and Gurgaon have experienced a rapid population growth due to migration of a large labour force (Rahman et al., 2012).The evidences

from previous researches suggest that the LULC change in peri-urban areas occurs mostly in the form of built-up expansion at the cost of agricultural land, vegetation cover and barren lands (Chen et al., 2014; Dutta, 2012; Kleemann et al., 2017). The city has grown in build up area over period of time. There has been a radial outward expansion from the oldest urban establishments, namely South Delhi and Faridabad. In the trans-Yamuna area, urban expansion has reached near spatial saturation, although newly created colonies such as Hauj Khas, Green Park, and Kalkaji are still exhibiting signs of further growth. A similar research on Delhi's South District gave a comparative analysis on the variations in LULC change in specific district vs the entire city. Data interpretation is based on comparisons across classes during a 30-year period. Currently, urban constructions cover around 40% of the land in Delhi. Mazumdar (2010) states that mid 1990's onwards is the period of rapid economic growth, characterized by private sector driven decision enforcement of service sector. The growing service industry requires additional infrastructural land as well as more living areas for the working population. It also meant a lower contribution from the agriculture sector in Delhi. Combined with rising overall population pressure, the built-up area is going to grow. This enormous change in Delhi's built-up area coincides with the time of economic reform. As a result, it can be stated that the shifting economic pattern had a significant impact in the dynamics of LULC in the national capital. Transportation and connection undoubtedly contribute to the growth of metropolitan regions.

Land use and land cover change in 1990 and 2018

The vegetation has maximum occupancy of land in 1990 with 39 percent (Figure 1). The settlements occupied the 29 percent of total land in Delhi in 1990 which was concentrated in central and south Delhi. These sections on the map are clearly visible in red patches. The settlement in 1990 comprises second highest land area in total area of land in Delhi. The population explosion has hit mainly six districts out of nine districts. Largest chunk of population has gone toward South and south east Delhi, more than 3.65 million population

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residing right now. These urban areas have increased on the maps and the red patches on the map seem spreading in all direction in very smooth way and these red patches are dominant

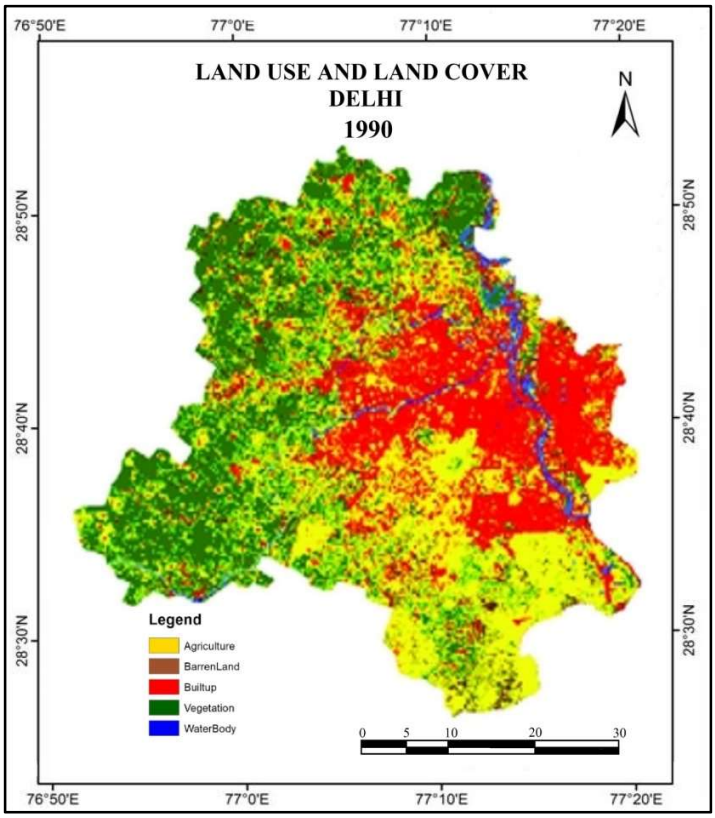

Figure 1 Land Use Land Cover of Delhi, 1990

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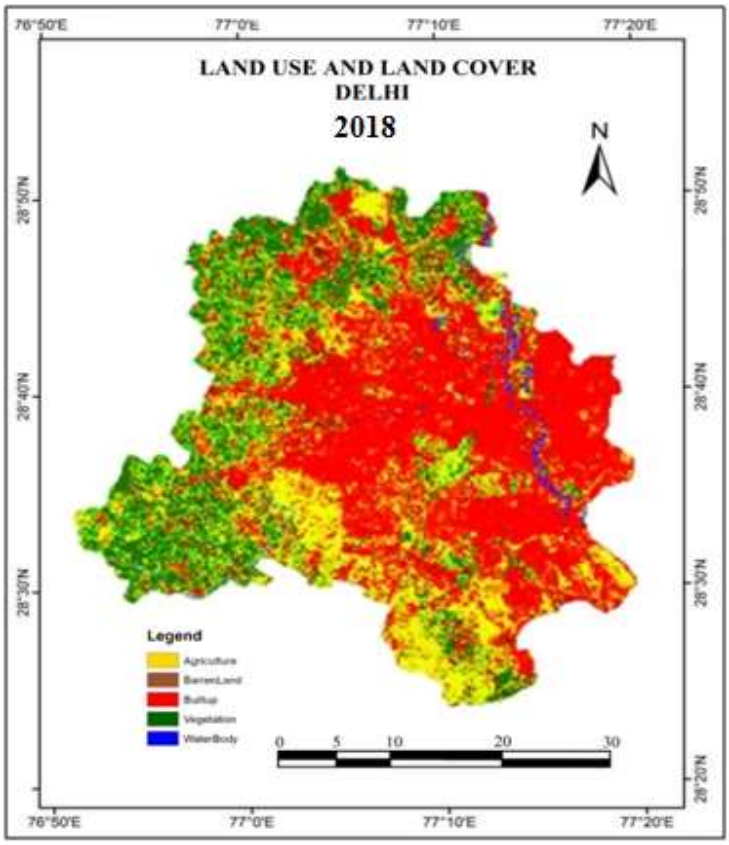

Figure 2 Land Use Land Cover of Delhi, 2018

in south ward not the west or northward. It means the urban growth is very steep into downward of the map and congested in south and south east Delhi (Figure 2). The south central sections of the map are highly dense with red patches. More than 2.5 million populations are residing in west Delhi famous towns are Hauz Khas, Green Park, Nehru Place, etc. Southeast Delhi holding similar population around 2.2million each. The percentage change in land occupancy by settlement area is also increased in 2018. The urban occupancy in the form of settlement in year 2018 has increased to 42 percent which was only 29 percent in 1990 in Delhi.

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LandUse LandCover (LULC) Analysis in South Delhi, South East Delhi and Faridabad

Land use land cover change provides information about the resources and its utilization for specific purposes. These changes show on map to understand the reality over the surface. The city had a relatively moderate population growth rate until 1941, and then it became very rapidly developing, with a growth rate of 225.36 percent as a huge number of refugees from Pakistan settled down. The growth rate decrease from 1951 to 1961, when it was 57.89 percent, which increased again, reaching over 100 percent from 1961 and 1981. The development rate slowed again between 1981 and 2001, although altogether, the city grew to its full capacity, reaching 105.59 percent of the allotted population according to the NCR Plan - 2001.

LandUse LandCover Analysis in 1990

In the land use land cover of south , south east Delhi and Faridabad had major agriculture occupancy all over the map of year (1990) during the central and northern part is showing little bit concentration of built up land but that is very sparse not congested. The barren land and agriculture is dominating in the map during the year of 1990. Some lower section of South, south east Delhi and Faridabad also reflects the stagnation of water in city which can be seen in the form of blue spot on the map (Figure 3). These spots were developed because of seasonal lakes and drains. The barren land lies in western section of the map which could be hilly rocky area. The table shows that, in the year of 1990, the barren land had occupied almost 41.8 per cent of total South, south east Delhi and Faridabad. This barren land had associated with the hilly zones and agriculture field. The vegetation cover had 8.2 per cent and built up had only 6.1 per cent (Table 2). Agriculture had 42.32 per cent which was highest during the period of 1990.

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Table 2 Land Use Land Cover Class for the Years 1990

S.No	Class Name(1990)	Area in Hectare	Area in Sq. Km	Area in Percent
1	Barren Land	43141.3	431.31	41.75086267
2	Agriculture	43733.6	437.33	42.32407293
3	Water Body	1507.05	15.07	1.458478015
4	Built Up	6377.04	63.77	6.171509001
5	Vegetation	8571.33	85.71	8.295077379
		103330.32	1033.19	100

Source: USGS, 1990

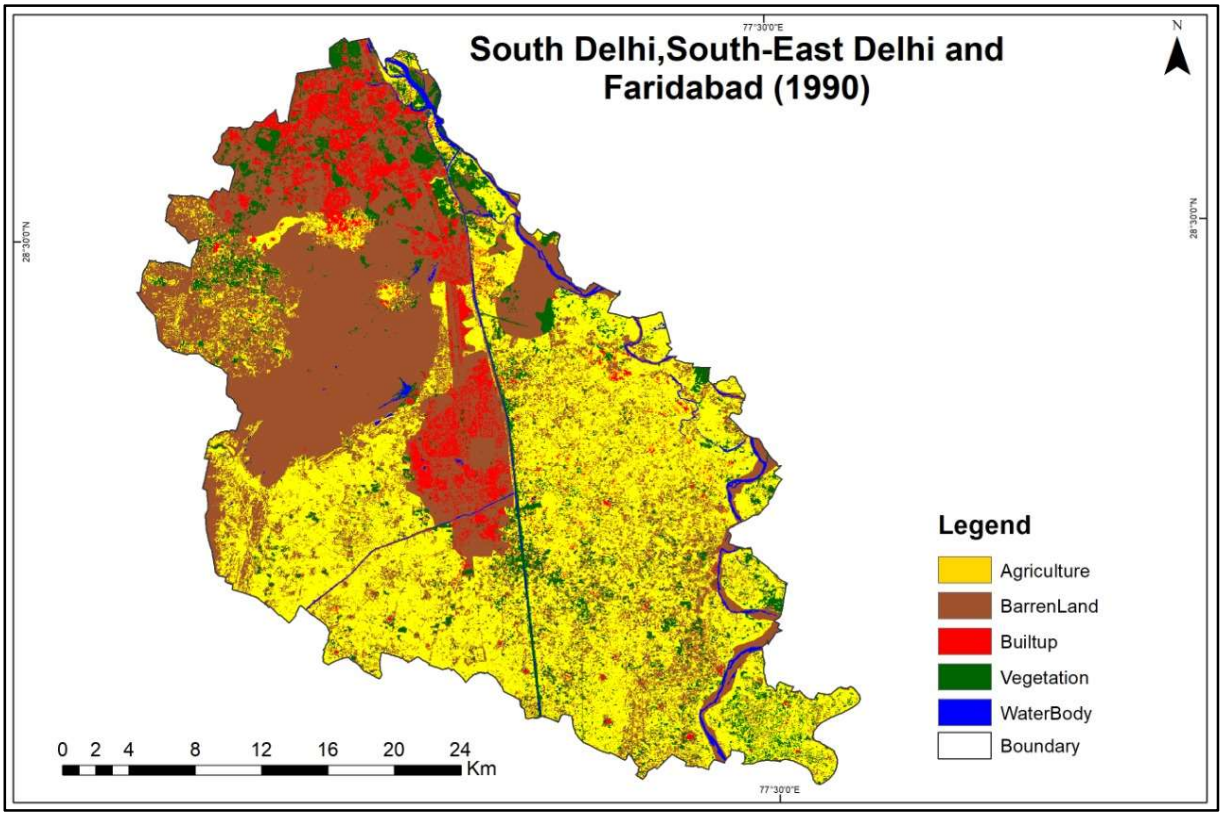

Figure 3 Land Use Land Cover of 1990

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LandUse LandCover Analysis in 2000

During the period of 2000 the major development occurred in the agriculture and barren land and built up area in South, south east Delhi and Faridabad. The built up area increased and spread marginally in westward and southward. The map shows the reduction in barren land which loses it occupied area to agriculture on the map (Figure 4). It is observed that the water body gain some land from barren land area. Vegetation is almost stagnant in this period but very partial changes can be observed in vegetation also. The built up area in southern part of map is growing along with barren land as well as agriculture land.

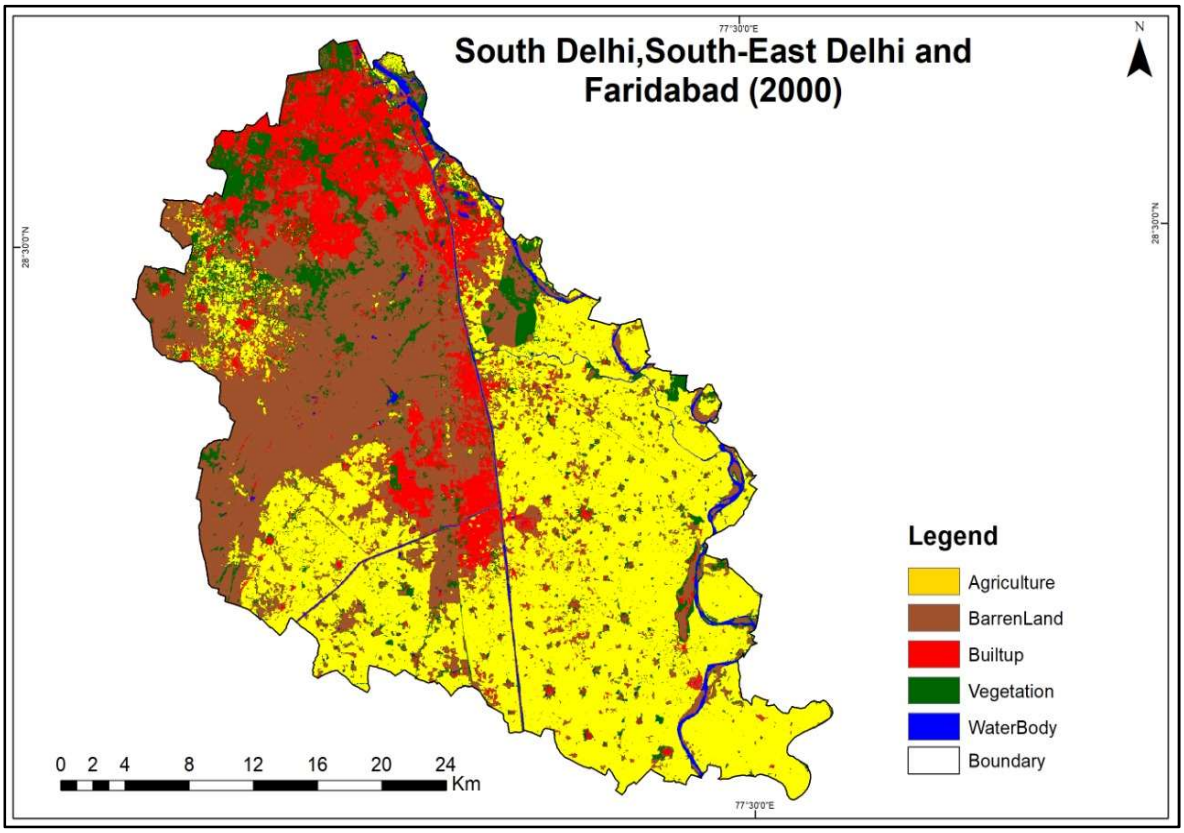

Figure 4 Land Use Land Cover of 2000

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Table 3 Land Use Land Cover Class for the Years 2000

S.No	Class Name(2000)	Area in Hectare	Area in Sq. Km	Area in Percent
1	Barren Land	32157.5	321.57	31.12128368
2	Agriculture	46858.1	468.58	45.3487922
3	Water Body	1637.73	16.37	1.584275317
4	Built Up	12926.4	129.26	12.50967792
5	Vegetation	9750.51	97.5	9.435970889
		103330.24	1033.28	100

Source: USGS, 2000

This type of growth has always taken place under the planned construction because mostly fellow land has used by the planners to develop the urban facilities. In the built up area has extended to north eastern part of the South, south east Delhi and Faridabad with the value of 12.5 percent. Highest land is still occupied by agriculture with the value of 45 percent of total land area as previously it occupied but the losses occurred in the areas of barren land 31.45 percent and vegetation area 9.4 percent (Table 3). The water bodies had occupied smallest part with 0.8 percent of this South, south east Delhi and Faridabad. The built up and agriculture has gained the area in 2000. The barren land is present in huge amount in 2000 because these were previously used as agriculture land or it was vegetation land previously. Therefore, vegetation cover is very less with 9 percent land but built is also not occupying major shared over the map that comprises only 12 percent of the total land.

LandUse LandCover Analysis in 2010

The South, south east Delhi and Faridabad land use land cover has changed in comparison to previous time. Now, city is not predominantly concentrated in north central sections as it was in expanding from north to south direction. The most of built up area is occupied the barren land area and it growth is mostly on western side. The barren land has decreased and major loss is

visible at the barren land area (Figure 5). The urban expansion is clearly visible in 2010 map because urban area growing all over the map and these built up spot are clearly indicating the urban sprawl. The built up growth has been taken place in all the agriculture dominating areas in the form of spots. The continuous formation of built up patches over the map without distortion represents the continuous urban expansion in the South, south east Delhi and Faridabad. The water bodies have partially increased and are continuously increasing according to the prepared maps.

Table 4 Land Use Land Cover Class for the Years 2010

S.No	Class Name(2010)	Area in Hectare	Area in Sq. Km	Area in Percent
1	Barren Land	25101.6	251.01	21.59337256
2	Agriculture	47138.1	471.38	40.55091015
3	Water Body	1450.24	14.50	1.247548261
4	Built Up	20870.2	208.7	17.95361481
5	Vegetation	8633.7	86.33	8.36619869
		103193.84	1031.93	100

Source: USGS, 2010

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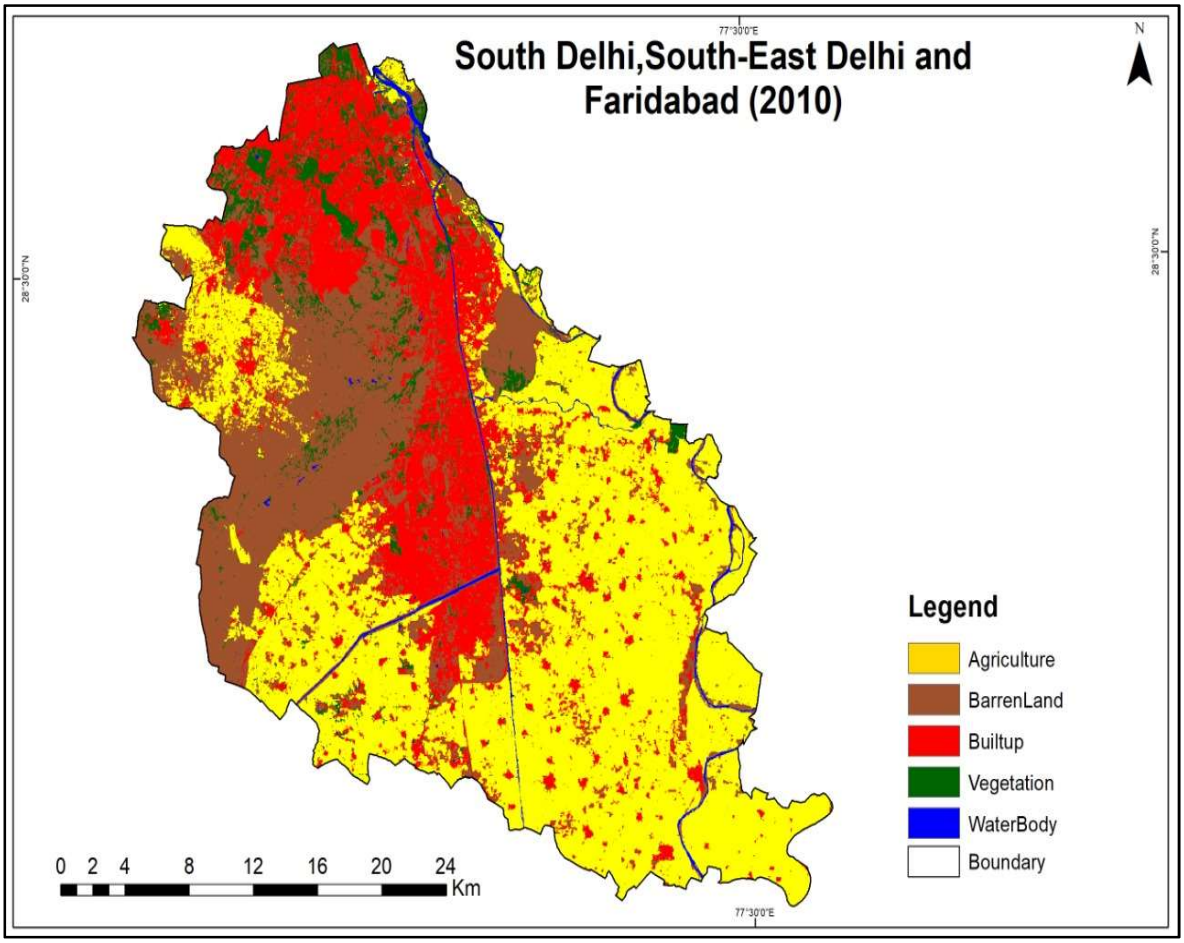

Figure 5 Land Use Land Cover of 2010

The barren land has declined to 21. 5 percent and agriculture still occupies the highest land area in the total area. The vegetation cover had marginally declined to 8.3 percent and built up area is high gainer of land with 17.9 percent (Table 4). The area under built up land is continuous increasing in the South, south east Delhi and Faridabad and positive for the urban development. The agriculture also increased in the area because vegetation cover has been continuously removed for gaining some financial or economic profits. The vegetation has been reduced to 8 percent but built up grow to 17.9 percent in this period.

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LandUse LandCover Analysis in 2018

The land use lands cover during the period of 2018 very present scenario of urban occupancy and urban development. The built up area is increased throughout the time period but in 2018 there are number of pocket has been developed in far area of urban congestion. The agriculture land is reduced and barren land is added. The vegetation cover increased to the land of waters body (Figure 6). The built up area increased with replacing the agriculture

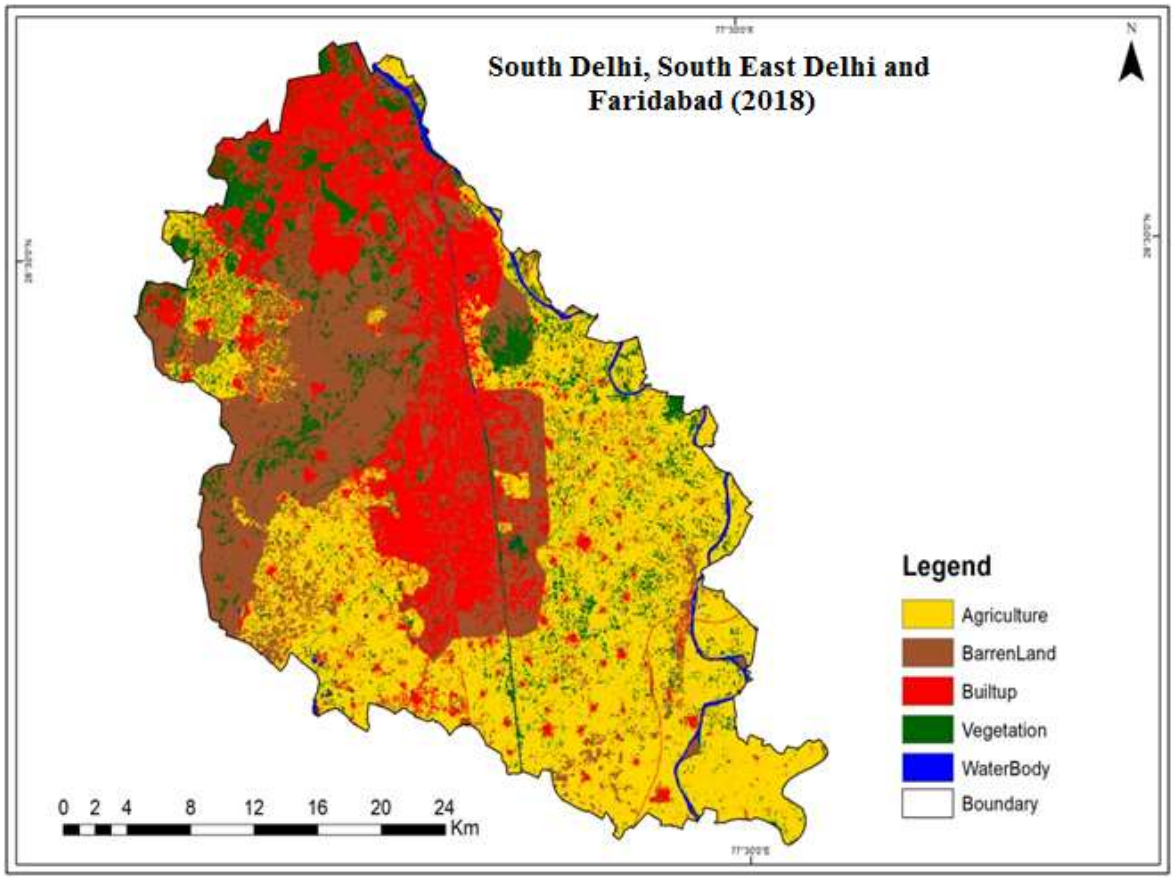

Figure 6Land Use Land Cover of 2018

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Table 4.11 Land Use Land Cover Class for the Years 2018

S.No	Class Name(2018)	Area in Hectare	Area in Sq. Km	Area in Percent
1	Barren Land	27449.8	274.49	26.600188
2	Agriculture	41112.4	411.12	39.84068378
3	Water Body	1156.97	11.56	1.120252735
4	Built up	23238	232.38	22.51940576
5	Vegetation	10236.6	102.36	9.919469721
		103193.77	1031.91	100

Source: USGS, 2018

land. The vegetation patches also visible throughout the map in all direction and barren land also increased. Built up growth is massive and affectionate because it grows faster in recent period. The overall urban growth is very clear in 2018 because number of red patches have been developed over the map in all the direction. There is barren land which is increased to 26 percent because of number of development activities which does not considered as built up till now. Therefore, barren land is showing increased. The agriculture loses its land with it present occupied area is still high 39 percent. The vegetation is almost covering 10 percent of the total land and built is third highest category with the value of 22 percent of total land. Overall the built up area is highest gainer throughout the period of analysis (Table 5). The barren land has continuously moving southward in increasing pattern. The vegetation and water bodies are having the second lowest and lowest share in the South, South east Delhi and Faridabad with 9 and 1 percent respectively.

Changes in Built Up Area from 1990-2018

The built up comprise of houses, commercial centers, ashrams etc. all these are characteristics of South, south east Delhi and Faridabad. It is a commercial hub cum residential area. Therefore, number of people came here for job and other services. Transportation affects the built up in every manner because increasing transportation pushes the growth of the region and job opportunity creates the continuous growth in built up and urban sprawl in the region (Table 6). In the year 1990, the built up area was only 63 sq. km which increased to 232.4 sq. km in 2018. The trend of urbanization can be observed in the area through this rapid growth story of built up and it also reflects the positive growth of economy as well. The built up category is continuously gaining the land with increasing pattern throughout the period of last 30 years. The built up has occupied the maximum land from agriculture because this category is easy to occupy.

Table 6 Changes in Built Up Area from 1990-2018

Year	Built up area (In Sq. Km)
1990	63.77
1995	92.43
2000	129.26
2005	145.7
2010	208.7
2015	224.07
2018	232.38

Source: USGS, 1990, 1995, 2000, 2005, 2010, 2015,2018

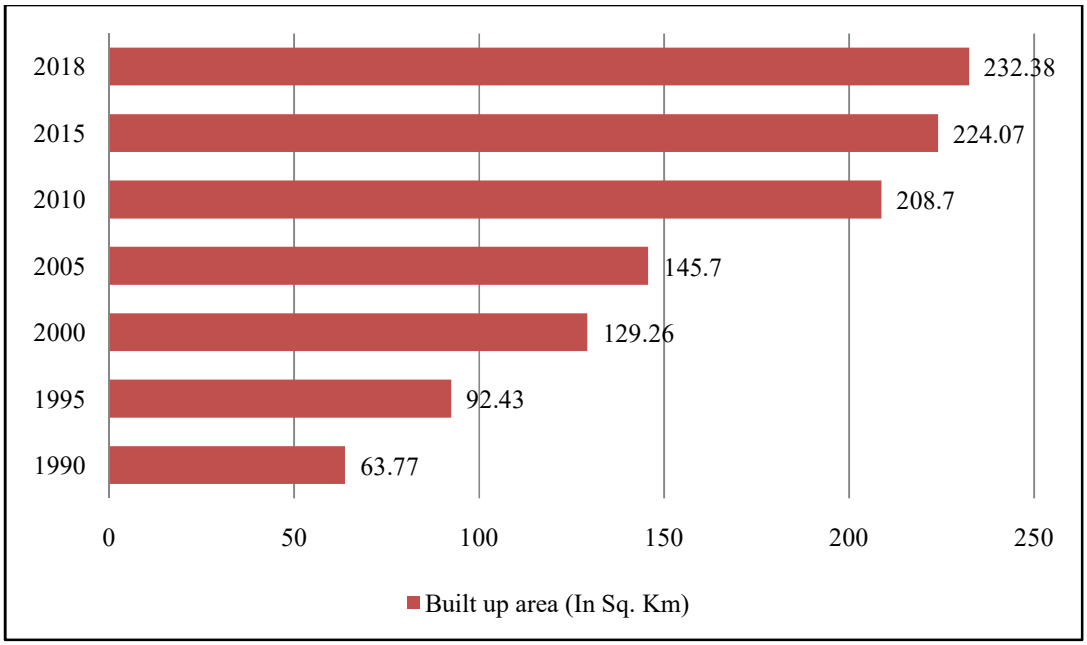

Figure 7 Change in Built Up Area from 1990-2020

These two are demarcated for the development purposes in the South, south east Delhi and Faridabad during the tenure of the study (Figure 7). The highest jump in built up area has taken place in 2000 because continuous outgrowth of people towards outside of Delhi.

Conclusion

Over the previous three decades, the National Capital Region (NCR) of Delhi's urban land cover land use pattern has changed. From 1990 to 2018, the existing urban land cover land use pattern in the Faridabad district of the NCR Delhi area was constantly changing. LANDSAT data (1990-2018) were used to construct several layers of maps in order to analyse the change in LULC. GIS and RS approaches were used to derive spatial-temporal information on the LULC and its changes.During the period of 2000 the major development occurred in the agriculture and barren land and built up area in South, south east Delhi and Faridabad. The built up area increased and spread marginally in westward and southward. All the maps were showing the variation in barren land area that loses it land area to agriculture in most of the time over the maps. It was observed

that the water body has also occupied some land area from barren land area. Vegetation was almost stagnant in this duration but it partially changed. The land use lands cover during the period of 2018 is shows present scenario of urban occupancy or urban built ups. The built up area is increased throughout the time period but in 2018 there are number of pocket has developed in distant areas over the map. The agriculture land was reduced and barren land area was increased.

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