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LAND USE AND LAND COVER DYNAMICS IN DEHRADUN CITY AND ITS SURROUNDINGS

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ABSTRACT :
Land Use and Land Cover (LULC) of a city has been a significant way to determine the level of urbanization and quality of city life. In the past few decades India as well as the globe have observed the rapid growth in urbanization. Cities in India also have observed lot of problems due to Urban sprawl and therefore in the study change of land use and land cover has been analyzed for Dehradun city and its surroundings using Landsat satellite images. Landsat images for the year 2001, 2011 and 2017 have been obtained from United States Geological Survey,(USGS). Classification of satellite images has been done in five classes, with respect to crop land, built up area, water body, vegetation and other classes. The accuracy assessment of the classification has been a very significant step for result validation and it has yielded significant result in overall accuracy (90.40per centfor 2001, 89.05per centfor 2011 and 95.25per centfor 2017) and Kappa Coefficient (0.82 for 2001, 0.86 for 2011 and 0.94 for 2017). Urban sprawl has increased in Dehradun city with the passage of time (2001 – 2017). Change detection results have shown the rapid and continuous positive growth in built up area from 20.76per centin 2001 to 35.68per centin 2017. On the other hand, negative growth has been found in other classes i.e. cropland water body and vegetation cover. The rapid growth in built up area at the expense of agricultural lands, natural vegetation and open spaces has bound to have serious environmental consequences for the already vulnerable and earthquake prone city of Dehradun and therefore sustainable planning is required to make the city resilient.

KEYWORDS: *Land Use Land Cover, Urban sprawl, Dehradun and Landsat*

1. INTRODUCTION

The world urban population has been 39.4 per cent during 1980s that increased to 52.8 per cent in the year 2010 and is expected to rise to 67 per cent in next 50 years. During the period from 1980 to 2010, the developing countries have experienced tremendous increase in urban population as compared to the developed countries (Grimm et al., 2008). The last century has witnessed a dramatic growth of urban population followed by excessive demand of land within cities. It has been estimated that the urban population of Asia and Africa will be doubled within 2030 and developing countries will have 80 per cent of the world's urban population (United Nations, 2006).

Being one of the fastest growing countries in the developing world, India has been experiencing a massive growth of urban area. In India, urban areas have experienced a gradual increase in the percentage share of population during 1901-2001. Thetotal population has increased 4.3 times whereas the urban population has increased more than 11 times during the last century which is mainly due to natural increase of population, rural to urban migration and reclassification of rural areas to urban areas. Urban Population in India has mainly been confined to class I cities (Kundu, 2006). It has been noteworthy that the percentage of urban population increased from 17.97 per cent in 1961 to 31.16 per cent in 2011 (Census of India, 2011).

Since land has been a limited resource, the rapid growth of population demands optimumefficiencies in land use. Sustainable land use practices should be adopted as they would fulfill the socio-economic aspirations of population and ensure long term availability of land resources to support increasing population (Singh and Kumar, 2012). The growth of settlements and associated human activities, most importantly rapid urbanization, plays a significant role in the land use and land cover change, which leads to variations in ecological processes on local to global level. At almost all thelevels urbanization is an integral part of the developmental process but high rate of urbanization is increasing the vulnerability of the region (Singh and Singh, 2011). As cities have been growing very rapidly leading to the process of urban sprawl. This urban sprawl has been basicallyurban expansion at the cost of the surrounding land parcels such as agricultural fields, forestlands or wetlands due to immigration of people into existing urban area, resulting in major agglomerations. The quality of land, accessibility, industrial development, are the factors on which direction and rate of growth of urban sprawl depends(Pathan et al., 1993; Xu et al., 2000; Kundu, 2006; Knox, 2009).

The intensity of urbanization is one of the process, which leads to the change in the pattern of land use in an area. Rapid and unplanned urban growth put an impedance in the route leading to sustainable development, as the essential infrastructure to support the large addition of people due to urbanization, is not developed.

The rapid growth of urban population exercises huge pressure on land within cities and its surroundings. The rapid urban growth is responsible for the alarming Land Use/Land Cover (LULC) changes, where in the built-up areas are increasing rapidly at the cost of agricultural land, vegetation and open spaces. This LULC changes have detrimental ecological and environmental effects which affect at local and regional levels, especially the urban heat island (Gallo and Owen, 1998; Streutker, 2003; Ahmed et al., 2013; Buyadi et al., 2013; Islam and Islam, 2013; Julien et al., 2011). In developing countries, problem of urban poverty and slum have been very widespread, which led to mismanagement of the development leading to heath issues, mismatch between resources and population (Singh and Grover, 2015).

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 are very beneficial for the sustainable planning of the cities, as it very useful in monitoring and modelling the urban growth. Remote sensing and GIS have the capability to offer a vivid scope to monitor spatial changes both in terms of time as well as the cost for the land use and land cover analysis. Change detection provides unique technique to identify the process of growth and development of cities by monitoring the land use and land cover changes using multi- temporal satellite data (Ramachandra and Kumar, 2004).

2.Study Area

The study area, has been the Master Plan area covered in the Amended Master plan for Dehradun made by Town and Country Planning department for the year 2005-2025.The latitudinal and longitudinal extent of the study area lies between 30°20'52.68"Nto 30°18'23.75"N and 78°0'43.34"E to 78°3'57.63"E.It includes Dehradun Urban Agglomeration, Mussoorie Municipal area, Dehradun Cantonment, Forest Research Institute (FRI), Census Towns and surrounding 185 Revenue Villages in Dehradun District. According to 2011 census, the study area has a population of 9,37,597 and population density as 2,604 persons per sq. km.

3. Database and Methods

3.1 Database

The LULC analysis for Dehradun city has been done using the Landsat series satellite data, for year 2001, 2011 and 2017. The data has been downloaded from the United States Geological Survey (USGS) website (Table1). There has beenvarious temporal datasets available for the Dehradun city in the Landsat archive, Landsat data for the above mentioned years has been selected by keeping in view the time when Uttarakhand has been made a separate state with Dehradun as its capital and the seasonal effect on the datasets for the subsequent time periods. For the study, winter season dataset found suitable due to presence of cloud free environmentand images of good qualitydata. In order to minimize the seasonal effects, monsoon time was avoided and data sets for the three-time period were searched. All of the multi temporal datasets collected for the study area, has been acquired in the month of January and beginning of February, when the sky remains clear and cloud free.

Table 1: Satellite images used for the study

S. No.	Satellite	Sensor	Date and Year	Resolution (Meters)
1	Landsat 5	TM	January, 20, 2001	30
2	Landsat 5	TM	January, 16, 2011	30
3	Landsat 8	OLI	February, 1, 2017	30

Source: Prepared on the basis of USGS data

The selected datasets of the year 2001, 2011 and 2017 are the products of two different sensors of the Landsat satellite series. The Thematic Mapper (TM) sensor data for year 2001 and 2011 and the Operational Land Imager and Thermal Infrared sensor (OLI/TIRS) for 2017.

3.2 Methodology

The Land use and land cover dynamics was studied using satellite data of the period 2001 to 2017.The time series data was acquired from Landsat satellite images. For the year 2001 and for the year 2011, Landsat 5 Thematic Mapper sensor (30m) and 2017 Landsat 8 Operational Land Imager sensor (30m) satellite data has been obtainedfrom United States Geological Survey, (USGS) website.

The Landsat series data downloaded from United States Geological Survey (USGS) website, for the three-time period were layer stacked and sub-setting of the data with respect to the study area was done. The data were geo-referenced with the help of ground control points (such as road intersections, etc.). Cropping of the area was done in accordance with the amended Master Plan 2005-2025 published by the Mussorie Dehradun Development Authority.

For Land use and Land Cover analysis, Supervised Classification has been followed using Maximum Likelihood Classifier (MLC) for the year 2001, 2011 and 2017, for the study area. Training sets were selected using the various spectral signature obtained by the formation of False Color Composite (FCC) image. The False Color Composite (FCC) image helps in distinguishing heterogeneous patches on the satellite data in which, each distinct patch corresponds to different LULC type in the study area. Thus, different spectral signatures has been used to classify the satellite images into various Land cover and land use classes. To validate the classification precision, a stratified random sample strategy (Jensen 2005) was 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 were further re-classed and recoded to get accuracy and pixels were assigned their classes accordingly. As a result, five land cover and land use classes has been formed for the study area on 30m, spatial resolution. The accuracy assessment was also performed for each year i.e. 2001, 2011 and 2017. The three accuracies- Producer's Accuracy, User's Accuracy and Overall Accuracy and Kappa Coefficient were calculated. While performing the classification and accuracy the Anderson Rule of minimum 85% accuracy Anderson (1971) and Anderson et al., 1976 has been followed.

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 has been 30m, only five major classes of land use and land cover has been identified on the satellite data. These five classes were 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 were identified based on the spectral signatures of each land use and land cover class. The satellite data had been observed in False color composite (FCC) and corresponding signatures of each land use and land cover class has been studied and based on that the area was demarcated under that particular land use and land cover class. For example, in the FCC image red color shows the vegetation and agriculture. The tonal variation in red color along with the various elements of image interpretation (ancillary information, shape and size) helped in differentiating the agricultural areas from Forests. Built up areas has been shown in Cyan color. To validate the classification precision, a stratified random sample strategy was 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 has been further re-classed and recoded to get accuracy and pixels has been assigned their classes accordingly.

4. Result

4.1 Land Use and Land Cover Dynamics in Dehradun (2001-2017)

The spatio-temporal pattern of Land Use and Land Cover has been studied from 2001 to 2017 with respect to three time period, i.e. Land Use and Land Cover of 2001, Land Use and Land Cover of 2011, Land Use and Land Cover of 2017. In this section, the land use and land cover for each year has been discussed.

(i) Land Use and Land Cover, 2001

Theland use and land cover of Dehradun city and its surroundings for year 2001 has been studied using the Landsat 5 TM data. Five major land use and land cover classes has been identified in the study area in 2001 (Table 2, Fig. 1 and Fig. 2).

Table 2: Land Use and Land Cover

2001		
LULC Classes	**Area in hectares**	**Area in Percentage**
Crop land	9205.56	24.92
Built up	7669.80	20.76
Water body	1150.56	3.11
Vegetation	18252.70	49.41
Others	664.15	1.80
Total		100.00

Source: Prepared bythe author based on Landsat 5 data

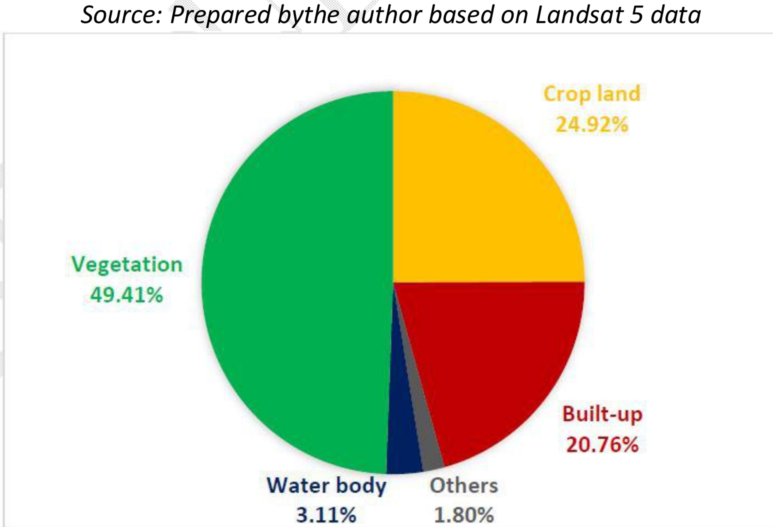

Fig. 1. Land Use and Land Cover, 2001

Source: Prepared by theauthor based on Landsat 5 data

Around 18252.7 hectares of land area which is 49.41 per cent of the study area was under the class vegetation. It included forests as well as other forms of vegetation. So, it was the dominant class in the region followed by crop land. The total area under cropland was 9205.56 hectares which account to 25 per cent of the study area. The next prominent class was the built-up area, which had 21 per cent (7669.8 hectares) of the study region. The Water body occupied 3 per cent (1150.56 hectares) of the area and others 2 per cent (664.15 hectares).

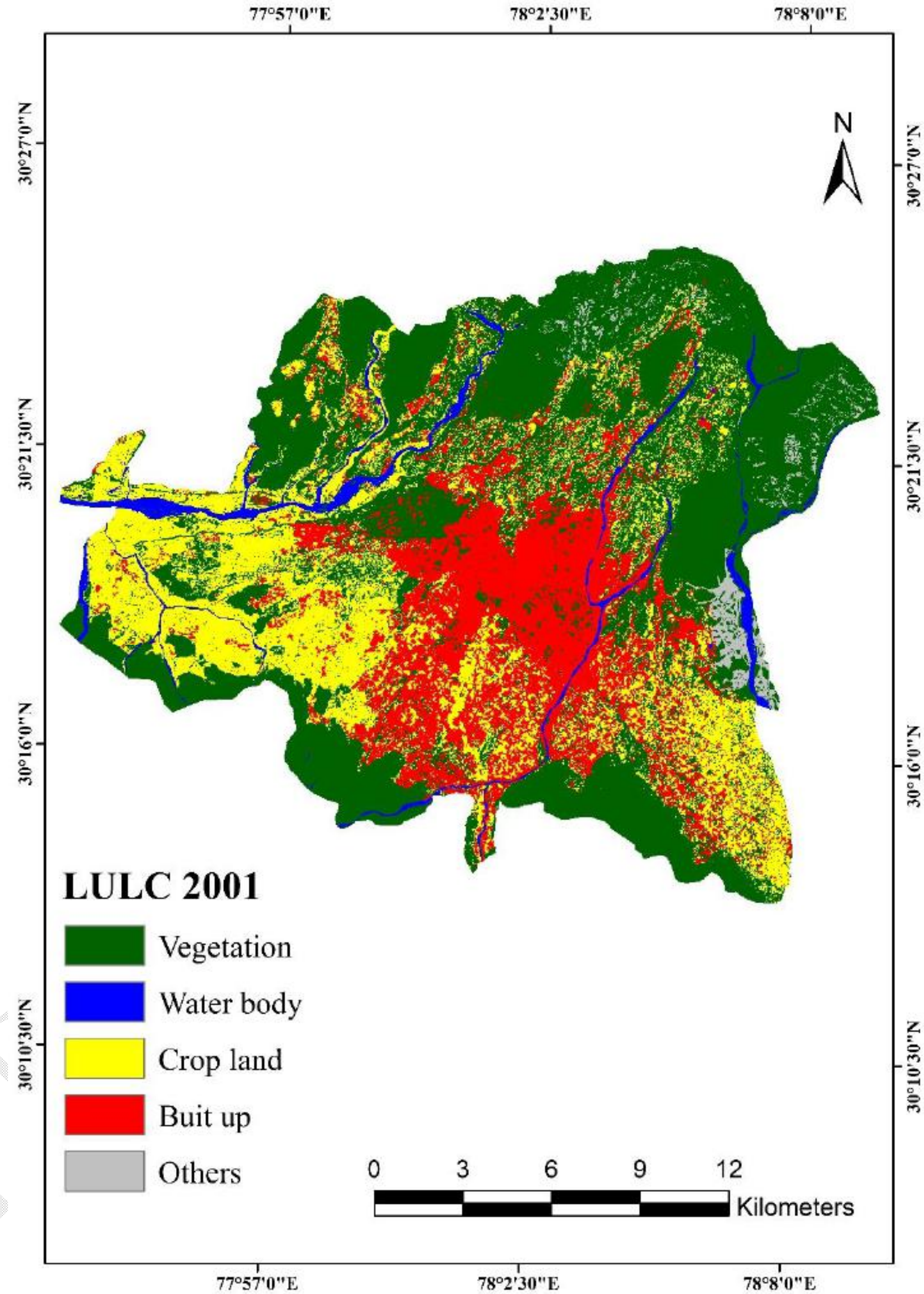

Fig. 2. Land Use and Land Cover, 2001

Source: Prepared by the authorbased on Landsat 5 data

(ii) Land Use and Land Cover, 2011

Theland use and land cover of Dehradun city and its surroundings for year 2011 was studied using the Landsat 5 TM data. Five major LULC classes were identified in Dehradun city in 2011 (Table 3 and Fig. 3 and Fig. 4)

Table 3: Land Use and Land Cover, 2011

2011		
LULC Classes	**Area in hectares**	**Area in percentage**
Crop land	8653.50	23.42
Built up	11376.10	30.79
Water body	1041.57	2.82
Vegetation	15379.30	41.63
Others	492.30	1.33
Total		100.00

Source: Prepared by the authorbased on Landsat 5 data

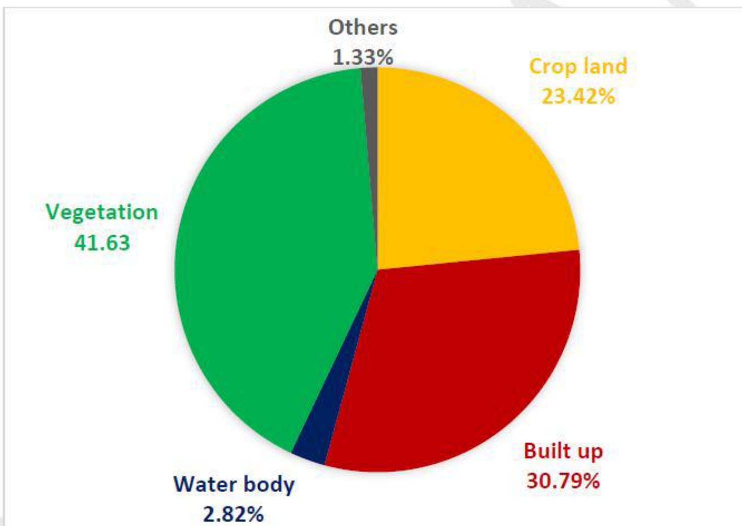

Fig. 3 Land Use and Land Cover, 2011

Source: Prepared by the authorbased on Landsat 5 data

The study depicts that 15379.3 hectares of land area which is 41.63per cent of the study area was under the class vegetation. So, it was the dominant class in the region in 2011 as well. It was followed by built up area. The total area under built up class was 11376.1 hectares which account to 31 per cent of the study area. The next prominent class was the crop land, which had 23 per cent (8653.5 hectares) of the study region. The Water body occupied 3per cent (1041.57 hectares) of the area and others 1per cent (492.3 hectares).

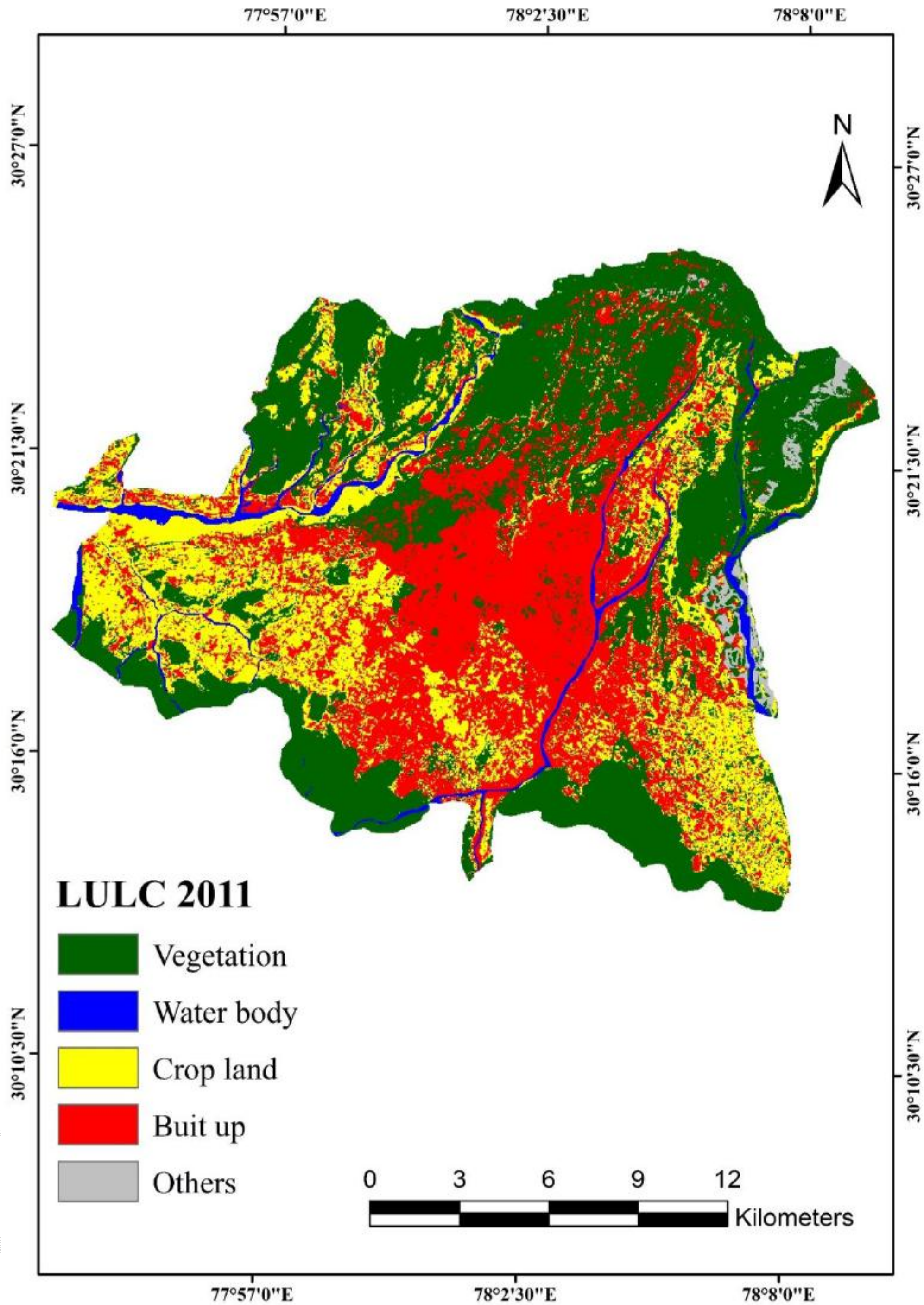

Fig. 4 Land Use and Land Cover, 2011

Source: Prepared by the author based on Landsat 5 data

(iii) Land Use and Land Cover, 2017

Theland use and land cover of Dehradun city and its surroundings for year 2017 has been studied using the Landsat 8 OLI/TIRS data (Table 4 and Fig. 5 and Fig. 6).

Table 4: LandUse and Land Cover, 2017

	2017	
LULC Classes	**Area in hectares**	**Area in Percentage**
Crop land	7388.75	20.00
Built up	13180.90	35.68
Water body	893.98	2.42
Vegetation	15037.20	40.70
Others	441.90	1.20
Total		100.00

Source: Prepared by the author based on Landsat 8 data

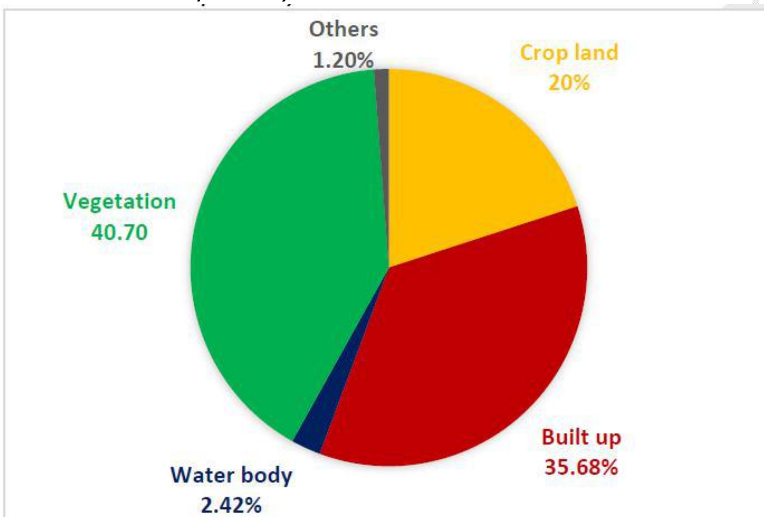

Fig. 5 Land Use andLand Cover, 2017

Source: Prepared by the authorbased on Landsat 8 data

The land use and land cover classes statistics depict that around 15037.2 hectares of land area which is 40.70 per cent of the study area was under the class vegetation. So, following the trend it remained the dominant class in the region in 2017 as well. It was followed by built up area. The total area under built up class was 13180.9 hectares which account to 35.68per cent of the study area. The next prominent class was the crop land, which had 20 per cent (7388.75 hectares) of the study region. The water body occupied 2.42per cent (893.98 hectares) of the area and others 1.20per cent (441.9 hectares).

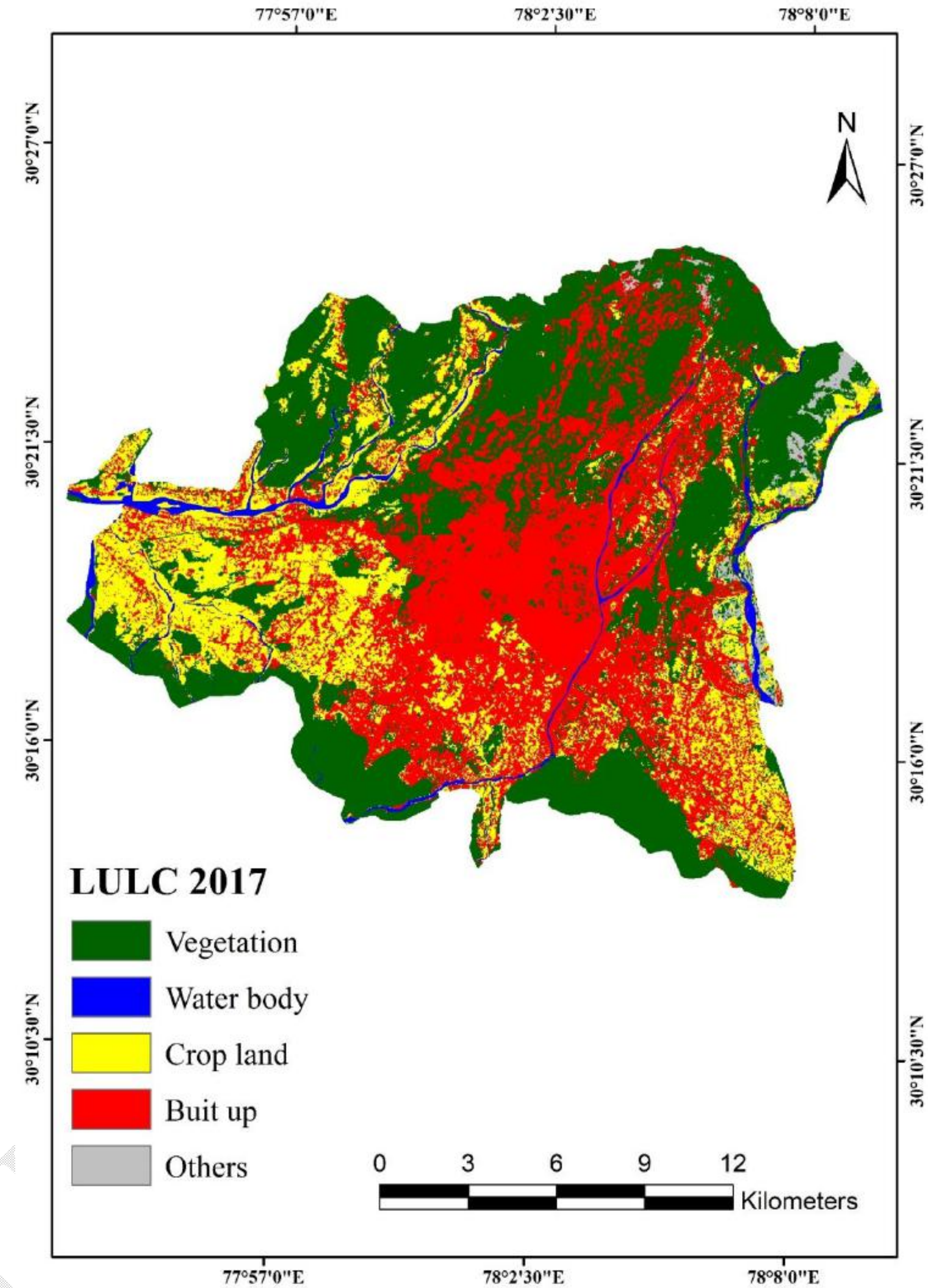

Fig. 6 Land Use and Land Cover, 2017

Source: Prepared by the authorbased on Landsat 8 data

4.2Accuracy Assessment of LULCClassification

In order to evaluate the accuracy of the land use land cover classification, accuracy assessment was carried out for land use and land cover maps for the year 2001, 2011 and 2017. All the three accuracies i.e. Overall Accuracy, User's Accuracy, Producer's Accuracy along with Kappa Coefficient has been calculated for the classification (Table 5, Table 6, Table 7 and Table 8).

Table 5: Classification Accuracy, 2001

Data	Water body	Forest/vegetati on	Other s	Crop land	Built up	Row Total	User Accuracy
Water body	45	0	1	2	1	49	91.84
Forest/vegetation	1	30	2	1	2	36	83.33
Others	2	0	38	0	0	40	95.00
Crop land	1	1	0	28	4	34	82.35
Built up	0	0	0	1	38	39	97.44
Column total	49	31	41	32	45	198	
Producer Accuracy	91.84	96.77	92.68	87.50	84.44	90.40	Over all Accuracy

Source: Prepared by the authorbased on Landsat 5 data

Table 6:Classification Accuracy, 2011

Data	Water body	Forest/vegetati on	Other s	Crop land	Built up	Row Total	User Accuracy
Water body	45	0	1	1	5	52	86.54
Forest/vegetation	0	30	0	5	0	35	85.71
Others	1	0	38	0	5	44	86.36
Crop land	0	1	0	28	1	30	93.33
Built up	1	0	1	0	38	40	95.00
Column Total	47	31	40	34	49	201	24
Producer Accuracy	95.74	96.77	95.00	82.35	77.55	89.05	Over all Accuracy

Source: Prepared by the author based on Landsat 5 data

Table 7:Classification Accuracy, 2017

Classified Data	Water body	Forest/vegetati on	other s	Crop land	Built up	Row Total	User Accuracy
Water body	88	0	0	2	2	92	95.65
Forest/vegetation	0	67	0	1	1	69	97.10
Others	2	0	64	0	1	67	95.52
Crop land	2	2	4	79	0	87	90.80
Built up	0	0	0	1	63	64	98.44
Column Total	92	69	68	83	67	379	
Producer Accuracy	95.65	97.10	94.12	95.18	94.03	95.25	Over all Accuracy

Source: Prepared by the author based on Landsat 8 data

Table 8: Overall Accuracy for LULC

Year	Overall Accuracy	Kappa Coefficient
2001	90.40	0.82
2011	89.05	0.86
2017	95.25	0.94

Source: Prepared by the authorbased on Landsat 5 and Landsat 8

The Anderson (1971) rule of minimum 85per cent accuracy and Anderson et al., (1976) has been followed to be acceptable and accurate for any image classification. It could be observed that overall accuracy of classification as well as Kappa coefficient is acceptable for the three-time period.

5. Discussion

(i) Spatio-temporal change Detection 2001-2011

In order to observe the urbanization and associated LULC changes, change detection has beenperformed. The study brought out that areas under different LULC has changed within in the period from 2001 to 2011 and the extent of change is not the same in all the classes. All the classes analyzed in the classification has undergone negative change with the exception of built up area (Table 9). The built-up areas had registered rapid increase in percentage from 2001 to 2011, it has recorded growth of 48.92 per cent. Whereas, all other classes had shown decrease, others (25.88per cent), vegetation (15.74 per cent), water body (9.47per cent) and cropland (6per cent).The 48.92per cent of tremendous increase in the built area could be attributed to the fact that Uttarakhand was declared a separate state with Dehradun as its capital during this time period, which has accelerated the urbanization process. To meet the demands of process of urbanization the pervious surfaces were converted to impervious surfaces.

Table 9: Land use and land cover change 2001-2011

LULC Change in 2001 to 2011		
LULC Classes	**Change in hectares**	**Change in Percentage**
Crop land	-552.06	-6.00
Built up	3706.3	48.32
Water body	-108.99	-9.47
Vegetation	-2873.4	-15.74
Others	-171.85	-25.88

Source: Prepared by the author based on Landsat 5 data

(ii) Spatio-temporal change Detection 2011-2017

From 2011 to 2017, all the classes analyzed in the classification has undergone negative change with the exception of built up area (Table 10). The built-up areas had again increased in percentage from 2011 to 2017, it has recorded growth of 15.86 per cent. Whereas, all other classes had shown decrease, others (10.23per cent), Vegetation (2.2 per cent), water body (14.17 per cent) and cropland (14.62 per cent). The built-up area has increased but not in same percentage as it was from 2001 to 2017 but data depicts lower percentage growth in from 2011 to 2017. But it could be to fact that satellite data is only able to capture horizontal growth not vertical, which is more common in Dehradun these days.

Table 10: Land Use and Land Cover Change 2011-2017

LULC Change in 2011 to 2017		
LULC Classes	**Change in hectares**	**Change in Percentage**
Crop land	-1264.75	-14.62
Built up	1804.80	15.86
Water body	-147.59	-14.17
Vegetation	-342.10	-2.22
Others	-50.35	-10.23

Source: Prepared by the author based on Landsat data

6.Conclusion

The Land use and cover change analysis indicates that there are been rapid increase in the built-up area in the study region from 2001 to 2017. In 2001, the built-up area was 20.76 per cent of the total area in the study region and in 2011 it rose to 30.79 per cent. The percentage of built up area has further increased to 35.68 per cent in the year 2017. The main reason for this high increase could be attributed to the fact that Dehradun had become the capital city of newly formed state of India in 2001 i.e. Uttarakhand. Following this change in status of Dehradun, there had been various government's policy that aspired to bring various forms of institutional and commercial activities to come up in Dehradun. The remaining four classes i.e. -Cropland, Water body, Vegetation and Others have recorded decrease in the area occupied by them over the time period from 2001 to 2017.Vegetation has decreased from 49.41 per cent in 2001 to 40.70 per cent in 2017. Cropland has decreased from 24.92 per cent in 2001 to 23.42 per cent in 2011 to further 20 per cent in 2017. Area under Water body has decreased from 3.11per cent in 2001 to 2.82 per cent in 2011 to further 2.42 per cent in 2017. Area under others class has decreased from 1.80 per cent in 2001 to 1.33 per cent in 2011 to further 1.22 per cent in 2017. The built up has been increasing basically from the conversion of vegetation, cropland, water body and others areas into built up area.

Thus, the process of urban sprawl is taking place at the expense of lot of other classes for example farm land and open spaces. Analysis of land use and land cover in the city and its surroundings would enable the decision-makersurban planners 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 and agricultural lands. This calls for integrated approaches in planning of resources for sustainable city development. Since, becoming the capital of the Uttarakhand state in 2001, the city Dehradun started serving not only the area in its proximity but also the entire Garhwal region thus attracting huge hill population. This unprecedented growth has taken deleterious effect on the environment and has ledto the huge traffic congestion problems as well as harmful vehicular gases emitted from the vehicles, encroachment related problems on the river banks; leading to growth of squatters, rise and intensification of temperature in the city and lowering of ground water levels. All these factors collectively have been posing a challenge in front of urban planners. Thus, Government will have to play a prominent role in planning sustainable and resilience cities.

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