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Land Use/Cover Change Detection in the Western Part of Upper Indo-Gangetic Plains of Uttar Pradesh, India - A Geospatial Approach

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ABSTRACT

The satellite data of 2004, 2010 and 2017 were classified employing supervised classification techniques. The land use/cover was classified as: forest, grassland, agriculture, wasteland, settlement, wetland and waterbody all categories are used. The accuracy assessment of land use/cover showed overall accuracy of 76.05% with kappa statistic (Khat-0.68) was 0.75. The result showed significant changes in land use/cover classes during the six year period. In 2004, of the total of 850 km^2, the maximum area was occupied by agriculture 521.86 km^2 (61.04 %) followed by wetland 124.97 km^2 (14.70 %), grassland 106.07 km^2 (12.48 %), wasteland 51.59 km^2 (6.07%), settlement 26.27 km^2 (3.09%), forest 13.85 km^2 (1.63%) and waterbody 5.39 km^2 (0.63%). However, within a span of six years in 2010 the land use pattern showed drastic changes. Due to urbanization, area under settlements increased by adding 223.08 km^2 (47.76%) at the expanse of agriculture (26.17%), wetland (57.17%), wastelands (23.67% and grassland (20.92%). Loss of agricultural land (121.32 km^2) due to expansion of settlements got compensated by conversion of grassland (93.20 km^2), wasteland (44.94 km^2) and wetland (102.25 km^2 into cultivated lands. The significant loss was observed in wetlands on a total of 159.42 km^2 of wetlands were lost to agriculture 102.25 km^2 (22.06%) and settlements 57.17km^2(12.33%) accounting for a total loss of 34.39% area under wetland. Loss of biodiversity rich wetland is likely to affect migratory birds' habitat. The paper discussing and needs the importance of digital change detection techniques for land use/cover changes for a land management and policy planning approach for NCR region of Uttar Pradesh

Key Words: Remote Sensing; Land Use/cover; Change Detection Techniques; Upper Gangetic Plains; Urbanization

INTRODUCTION

Western Uttar Pradesh is a part of India's fifth largest and most populous state, Uttar Pradesh, situated in highly fertile upper Gangetic plains. Fertile land and availability of water have led to Gangetic plains leading agriculture production areas in India (Singh and Islam 2010). However, in recent times population growth and urbanization have put considerable pressure on agriculture land resulting in decreasing size of land holding, decreasing ground water, degradation of land fertility and reduction in agricultural areas. This is evident from per capita net sown area which reduced from 0.145 ha in 1991 to 0.119 ha in 2001 in Bulandshahr district, in western Uttar Pradesh (Singh and Islam 2010). In the adjacent district of Gautam Buddha Nagar, agriculture land was the dominating land use with 50% of the total land area and built-up (settlement) occupying about 19% of the total area in 1986. However, due to phenomenal urbanization/urban growth by the year 2000 agriculture was reduced by 11%, water bodies got reduced from 2605.40 ha 1986 to 1200.06 ha in 2011 accounting for 53.93% loss in water bodies, mainly wetlands. Urbanization affects both the wild and cultivated plants as well as animal diversity due to tree felling and conversion of agriculture land, wetlands, grassland, wastelands into urban settlements (Krishna 2012). Of all the land uses the wetlands, store house of biodiversity, are one of the most threatened in the world. Wetlands in India are increasingly facing several anthropogenic pressure and conversion to other land uses. In India, rapidly expanding human population, development/infrastructure projects and improper use of watersheds have resulted in large scale changes in land use/cover causing substantial decline of wetland resources over the past five decades thus affecting this unique ecosystem (Prasad et al. 2002).

Secunderabad, an agricultural dominated society was selected for the study being a part of upper Gangetic plains; National Capital Region (NCR) of Delhi and adjacent to Gautam Buddha Nagar which has seen tremendous urban expansion during the past decades affecting land use/cover changes in various categories of the landscape, specially agriculture, wetlands, wastelands, and grasslands which harbor rich plant and animal diversity. The present study focus on preparation of land use/cover maps of 2004, 2010 and 2017 maps and change detection analysis from 2004 to 2017.

STUDY AREA

Sikandrabad, situated about 50 km from New Delhi and 15 km from Greater Noida, Gautam Buddha Nagar, Uttar Pradesh, is a municipal town in Bulandshahr district in the state of Uttar Pradesh, northern India (Figure 1). The study area lies between Latitude 28° 24’ 14.73” N Longitude: 77° 32’ 33.87” E and an altitude 200 m above sea level. The administrative boundary of Sikandrabad is surrounded by district Ghaziabad in the north-east and Dadri town (Gautam Buddha Nagar district) in north-west. In the south are Khurja and Aligarh, districts and Haryana state in the south-west. The town has a population of 69,902; males constitute 52% of the population and females 48% (Census 2011).

Climate

The climate of the study area is sub-humid and characterized by hot summer and bracing cold season. After February there is continuous increase in temperature till May which is generally the hottest month. In summer, from March-June, the weather remains hot and the temperature ranges from a maximum of 45 °C to a minimum of 23 °C (Joshi 2008-09). Temperature falls substantially down to as low as 3-4°C at the peak of winter. In the month of December - January a dense fog covers the study area and it reduced poor visibility of the object. Monsoon season prevails during mid-June-September with an annual average rainfall of 93.2 cm.

Soils

The soils range from pure sand to stiff clays and including all combination of the two extreme litho units. The mixture of sand and clay in equal proportion forms loam, a good agriculture alluvial soil is widespread. The study area has alluvial soil containing fine sand, silt and clay, characteristic of soils represented in the western part of Upper Gangetic Plain (Sharma et al. 2012; Tripathi et al. 2019).

Agriculture

The major agricultural crops of Bulandshahr district are: wheat (*Triticum aestivum* L.), maize (*Zea mays* L.), barley (*Hordeum vulgare* L.), rice (*Oryza sativa* L.), pigeon pea (*Cajanus cajan* (L.) Millsp.), pearl millet (*Pennisetum glaucum* (L.) R.Br.), Potato (*Solanum tuberosum* L.) and sugarcane (*Saccharum officinarum* L.). The existing cropping pattern of the district shows that out of 82.49 % gross cropped area under the nine major crops, wheat covers 38.15% of the area in the district followed by maize, rice and other crops (Khan and Khan 2014). Singh and Islam (2010) have reported decrease in size of agricultural land holding in Bulandshahr district during 1991-2001.

Flora and Fauna

The study area is inhabited by numerous large to small sized trees such as: *Azadirachta indica* A. Juss., *Butea monosperma* (Lam.) Taub., *Cordia dichotoma* G. Forst., *Dalbergia sissoo* DC., *Ficus religiosa* L., *Holoptelea integrifolia* Planch., *Mitragyna parvifolia* (Roxb.) Korth., *Neolamarckia cadamba* (Roxb.) Bosser., *Prosopis cineraria* (L.) Druce, *P. juliflora* (Sw.) DC., *Phoenix sylvestris* (L.) Roxb., *Sesbania sesban* (L.) Merr., *Syzygium cumini* (L.) Skeels, *Tamarix ramosissima* Ledeb. and *Terminalia arjuna* (Roxb. ex DC.) etc. The study area is rich in the plant herbal diversity including economically and medicinally important plant species are: *Amaranthus viridis* L., *Achyranthes aspera* L., *Artemisia scoparia* Waldst. & Kitam., *Centella*

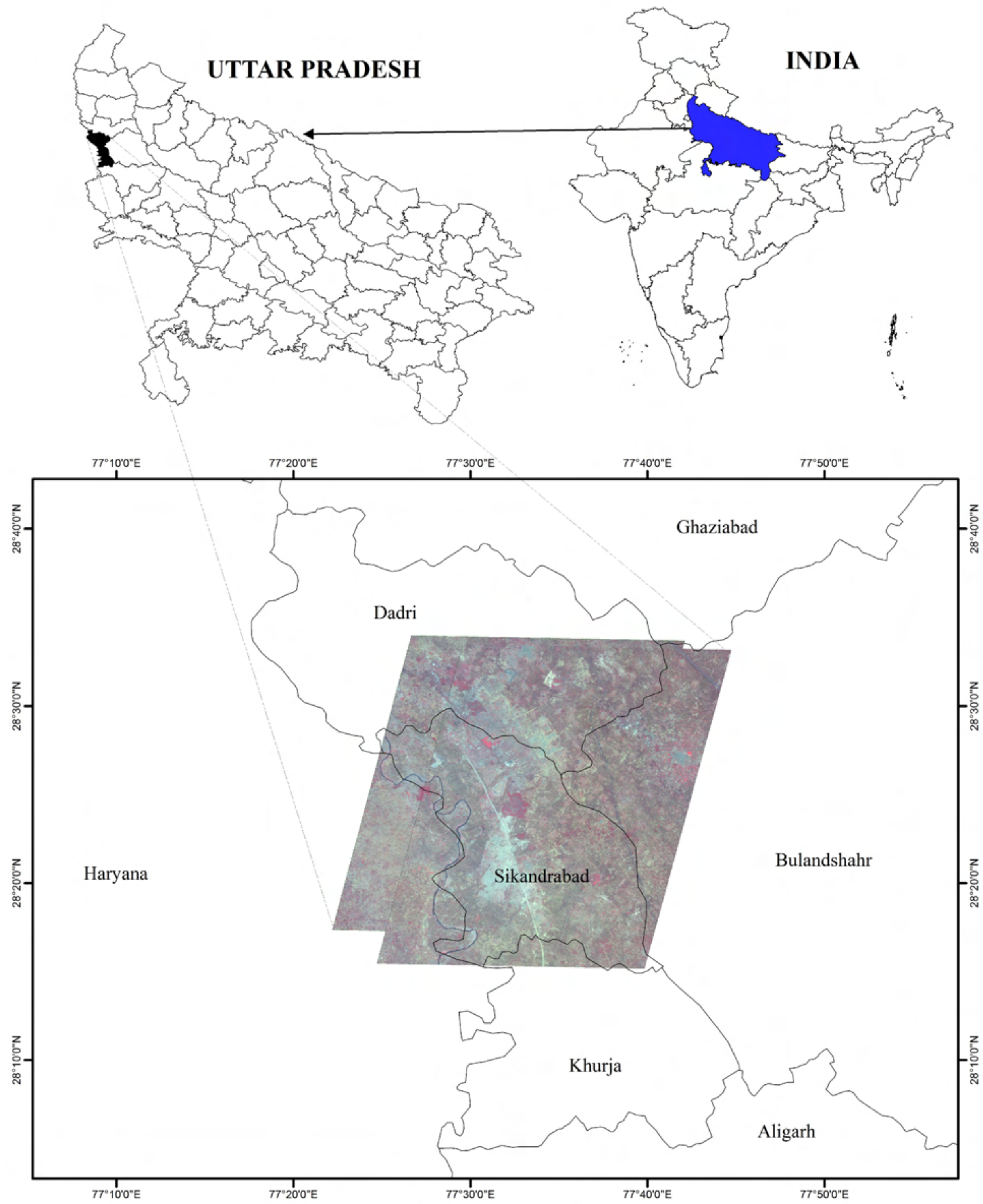

Figure 1. Location of the study area in western Uttar Pradesh, India.

asiatica (L.) Urb., *Bacopa monnieri* (L.) Wettst., *Calotropis gigantea* (L.) Dryand., *C. procera* (Aiton) Dryand., *Cannabis sativa* L., *Chenopodium murale* L., *Citrullus colocynthis* (L.) Schrad., *Convolvulus prostratus* Forssk., *Croton bonplandianus* Baill., *Dysphania ambrosioides* (L.), *Digera muricata* (L.) Mart., Mosyakin & Clemants, *Eclipta prostrata* (L.) L., *Heliotropium ellipticum* Ledeb., *Ricinus communis* L., *Oxystelma esculentum* (L.f.) Sm., *Phyllanthus niruri* L., *P. maderaspatensis* L., *Phyla nodiflora* (L.) Greene, *Physalis peruviana* L., *Stellaria media* (L.)Vill. and *Tribulus terrestris* L., *Withania somnifera* (L.) Dunal etc., (Alam and Anis 1987, Singh and Islam 2010, Aggarwal et al. 2012, Chaudhary and Narayan 2013, Sharma et al. 2018).

The study area has rich bird diversity including that of migratory birds *viz.,* Asian Open bill Stork (*Anastomus oscitans*), Painted stork (*Mycteria leucocephala*), Pond heron (*Ardeola*), Purple swamphen (*Purple swamphen*), White-necked Stork (*Ciconia episcopus*), Whistling teal (*Dendrocygna javanica*), Cormorant, Darter, White-throated Kingfisher (*Halcyon smyrnensis*), Black-crowned Night Heron (*Nycticorax nycticorax*) and Black-headed Ibis (*Threskiornis melanocephalus*). Significantly, the study area supports some of the rare breeding birds like Bristled Grass bird (*Chaetornis striata*), Black-necked Stork (*Ephippiorhynchus asiaticus*) and Sarus Crane (*Grus antigone*). Apart from large population of avifauna, the study area has seven species of mammals includes Nilgai (*Boselaphus tragocamelus*), Indian Grey Mongoose (*Herpestes edwardsii*), Indian Hare (*Lepus nigricollis*), blackbuck deer (*Antilope cervicapra*), Leopard (*Panthera pardus*), Golden Jackal (*Canis aureus*), and Wild boar (*Sus scrofa*).

MATERIAL AND METHODS

Data Used

Satellite images of IRS P6 LISS - IV of the study area for the year 2004 and 2010 were obtained from the National Remote Sensing Centre, ISRO, Hyderabad, India. The satellite data were geometrically corrected using Landsat TM data with 30 m spatial resolution. The other satellite data of Landsat TM OLI procured from USGS (https://earthexplorer.usgs.gov/) (Table 1). The radiometric corrections viz., histogram equalization, dark pixel subtraction, contract enhancement and image stretching were done on all bands which were combined

Table 1. Details of satellite images used in the present study.

Sensor	Altitude (km)	Orbit Inclination (degree)	Period Min	Repeat cycle (Days)	Cross time	Spectral Resolution (µm)	WRS Path	Row	Date of Pass
Satellite Resourcesat-1 (launched 17 October 2003)									
LISS-IV Monomode	817	98.69	101.35	5	10.30 am	B2:0.52-0.59, (Green) B3:0.62-0.68,(Red) B4: 0.77-0.86 (NIR)	120	58	11 April 2004 & 4 April 2010
Landsat 8 (launched 11 February 2013)									
OLI	705	98.2	98.9	16	10:00 am	Band - 1 (Coastal) 0.43 - 0.45 Band – 2 (Blue) 0.45 - 0.51 Band-3 (Green) 0.53 - 0.59 Band - 4 (Red) 0.63 - 0.67 Band - 5 (NIR) 0.85 - 0.88 Band - 6 (SWIR 1) 1.57 -1.65 Band - 7 (SWIR 2) 2.11 -2.29 Band - 8 (Pan) 0.50 - 0.68 Band - 9 (Cirrus) 1.36 -1.38 Band -10 (TIRS 1) 10.6 -11.19 Band -11 (TIRS 2) 11.5 -12.51	146	40	06 April 2017

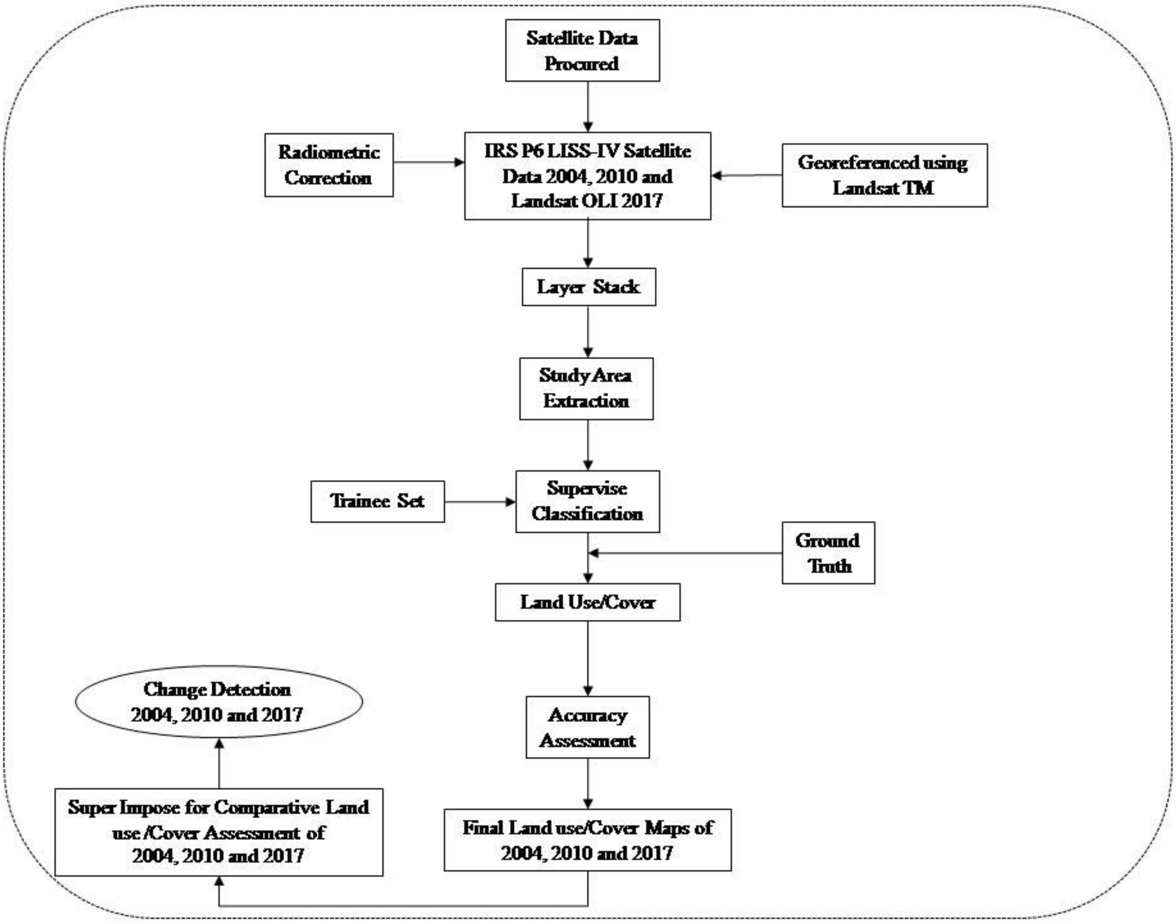

Figure 2. Methodology

into a single file using layer stacking techniques (Lillesand et al. 2007). The complete methodology is shown in Figure 2. The satellite images were converted into False Colour Composite (FCC) for identification of tonal characteristics (Figure 3 and Figure 4). For image classification satellite image processing steps were involved in starting from processing of IRS P6 LISS-IV satellite images for radiometric and geometric corrections. The training data set taken in different places for supervised classification of satellite images of 2004, 2010 and 2017 were based on delineation of different land features *viz.,* forest, agriculture, settlement, wasteland, wetland, grassland and waterbody. The classified 2004, 2010 and 2017 satellite images were checked in the field and based on the ground truth, land use/cover map of 2004, 2010 and 2017 were prepared (Figure 5a and Figure 5b).The information provided by the satellites in combination with other sources to quantify the various parameters for efficient mapping of land use/cover of the upper Indo-Gangetic plains was evaluated by applying various image processing steps using ERDAS Imagine *ver.* 9.3 and ArcGIS *ver.* 10.1.

Satellite Data Processing

The georeferencing of satellite imagery is essential for analyzing land use/cover pattern of a particular geographic area. The atmospheric corrections/ radiometric corrections is an important part of remote sensing images, which are more pronounced in the shorter wavelength regions, which cause some additional contribution to spectral reflectance. In the present study, satellite data were geometrically corrected for the distortions and degradations caused by the errors due to variation in altitude, velocity of the sensor platform, earth curvature and relief displacement. The images of IRSP6 LISS-IV satellite data were geometrically corrected and geocoded to the WGS 1984 datum with Lambert Conformal

Conic (LCC) projection coordinate system by using a reference image of Landsat TM satellite data with spatial resolution 30 m. A minimum of 15 regularly distributed ground control points were selected from the images. The georeferencing was performed using first order polynomial transformation, resampling using a nearest neighbor algorithm. The transformation with a Root Mean Square Error (RMSE) was 0.005. Image enhancement, dark pixel subtraction, histogram equalization, contrast stretching and false colour composites were also worked out (Jensen 2005).

Change Detection Analysis

The land use/cover maps were produced from the IRS P6 LISS-IV and Landsat OLI satellite data employing supervised classification. The training sites and extraction of signatures from the images were taken and then classification of the images was attempted. Training data extraction was a critical step in supervised classification as these must be selected from the regions representative of land use/cover class under consideration. Thus, the satellite data were collected from relatively homogeneous areas consisting of these classes. After the training site areas were digitized, the statistical characterization of the information was created called signatures. Finally, the classification methods were applied. All the classification techniques like the Maximum Likelihood Classification (MLC), Parallelepiped and Minimum Distance to Mean classification were applied for the images and the best classification technique was then selected. It was observed that Maximum Likelihood Classification (MLC) gave good results as compared to the other two techniques.

To determine the accuracy of classification, a simple testing pixel was selected on the ground truth reference data. For assessing the temporal changes in the land use/cover map was prepared using IRS P6 LISS-IV geocoded FCC of 2004, 2010 and 2017 data on 1: 50,000 scale. The vegetation areas were delineated from their red tone and contiguous pattern. These classes were identified from their red tone, coarse texture and scattered pattern. The agriculture and settlement were identified from the light reddish-brown tone and regular pattern and wetlands from dark and light blue tone. Necessary ground truth was carried out and correction was made at required places and the various classes' *viz.,* forest, wasteland, agriculture, grassland, settlement, waterbody and wetland were identified. Thus, a thematic layer depicting the various land use/cover classes were generated. The primary land use/cover map was prepared based on field observation and image interpretation. Then, using software such as ArcGIS *ver.*10.1 and ERADS Imagine *ver.* 9.3 classified land use/cover map was prepared. Finally, the status of change detection was analyzed from 2004 to 2017 (Table 2). The land use/cover maps were assessed by overlaying the maps of 2004 to 2017.

Accuracy Assessment

In thematic mapping from remotely sensed data, the accuracy, and the degree of correctness was calculated. Accuracy measures the arrangement between a standard (assumed to be correct) and a classified map. This represents the correctness of the classified map. If the final map cross ponds closely to the standard the classified map is considered to be accurate with the resulting images, change detection analysis was performed to perfectly correctly identify the change (Congalton 1991).

RESULTS AND DISCUSSION

The accuracy assessment of land use/cover showed overall accuracy of 76.05% with kappa statistic (Khat-0.68) was 0.75. For user accuracy of 219 reference points and 228 classified points, 167 correct points were checked in the field (Table 3). Higher accuracy was found in settlement followed by agriculture and grassland. Wetland had medium accuracy due to less correct numbers. The present study demonstrates the capability of geospatial technology to capture the land use/cover categories in a semi-arid region of upper Gangetic plains of Uttar Pradesh, India, which is important from the point of view of sustainable utilization of natural land resources, biodiversity conservation and management planning.

The results showed that land use/cover classes were altered remarkably in the study area during the six-seven year period from 2004-2010 and 2010 to 2017. Singh and Islam (2010) reported 16.74 % increase in population in Bulandshahr district during 2001-2011.In 2004, of the total of 850km^2 the maximum area was occupied by agriculture 521.86 km^2 (61.04 %) followed by wetland 124.97 km^2 (14.70 %), grassland 106.07 km^2 (12.48 %), wasteland 51.59 km^2 (6.07%), settlement 26.27 km^2 (3.09%), forest 13.85 km^2 (1.63%) and water body 5.39 km^2 (0.63%). However, within a span of six years, in

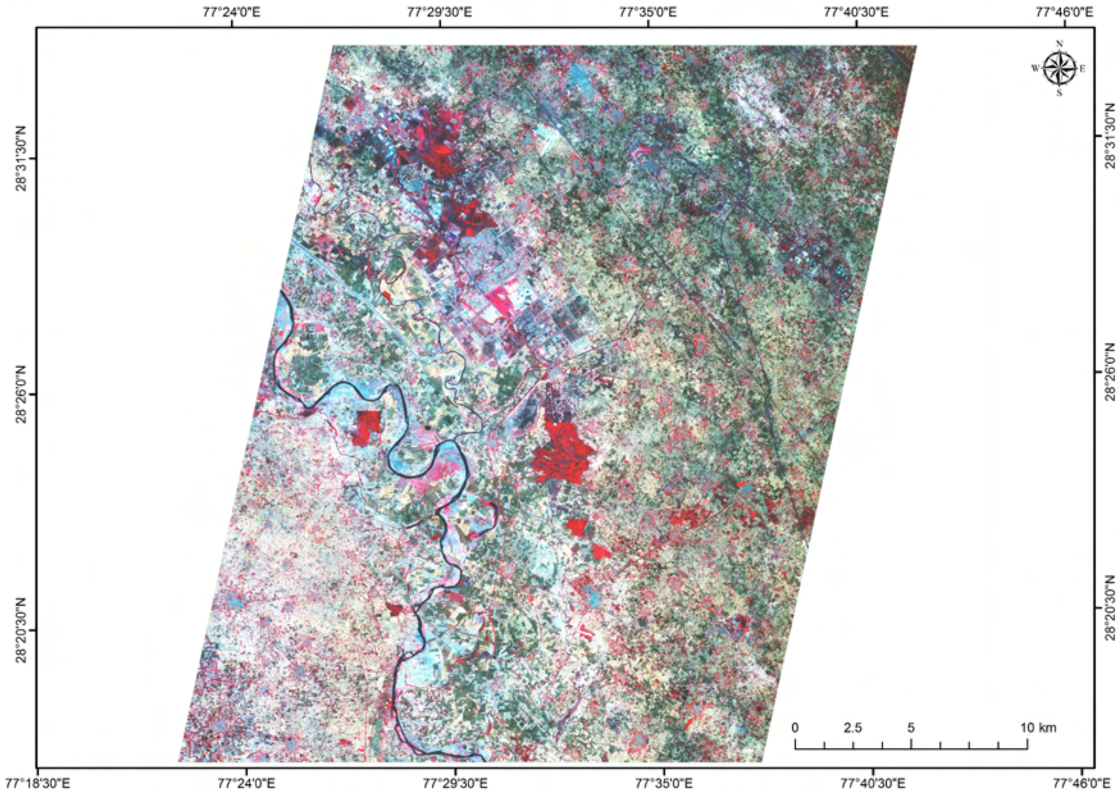

Figure 3. False Color Composite of 11 April 2004.

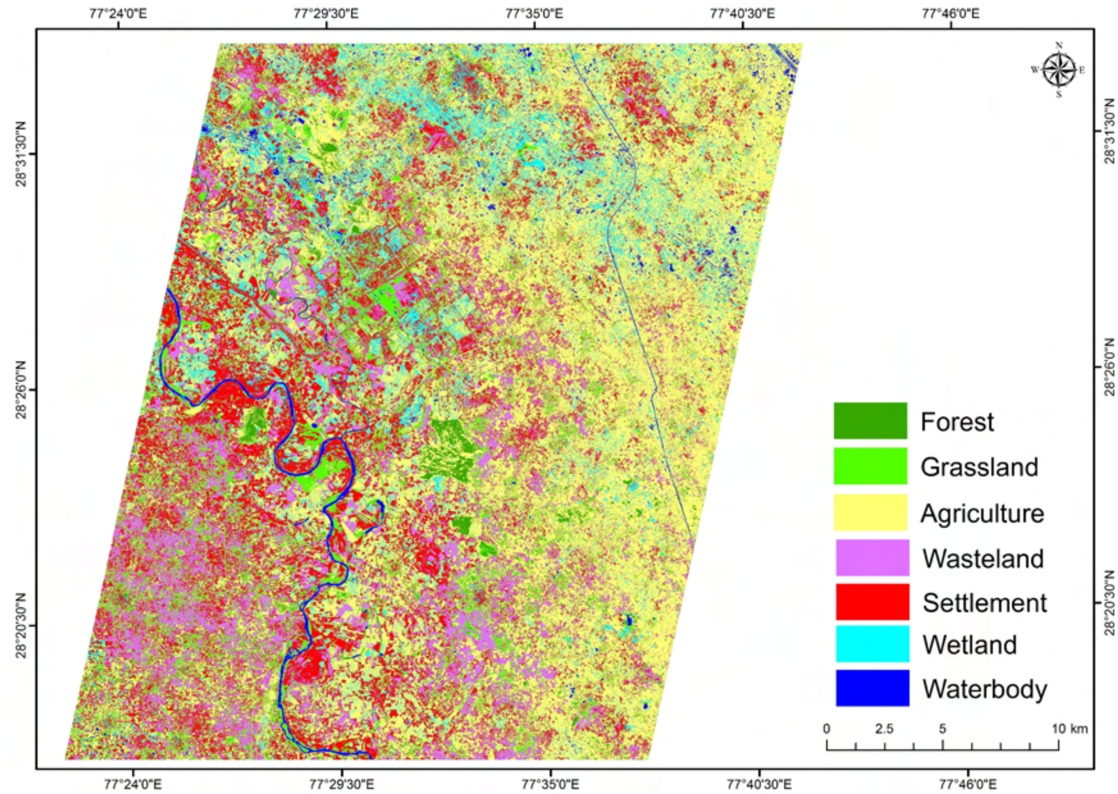

Figure 3a. Land use/cover map of 11 April 2004.

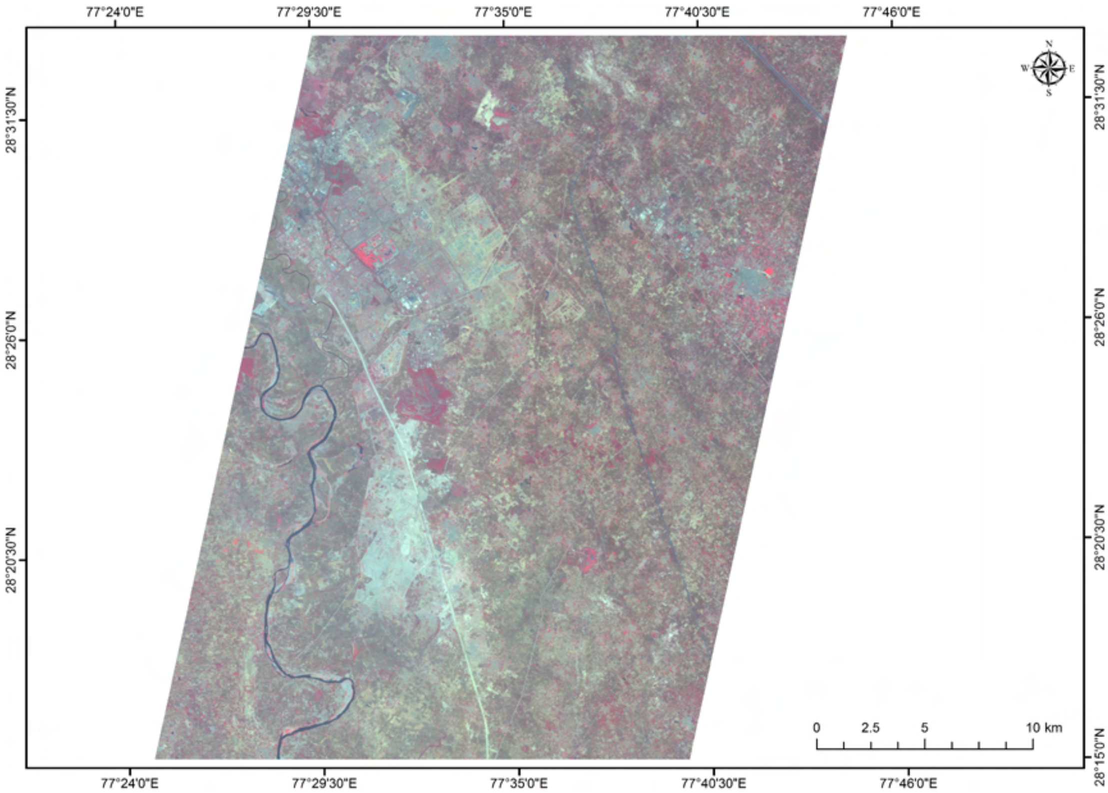

Figure 4. False Color Composite of 04 April 2010.

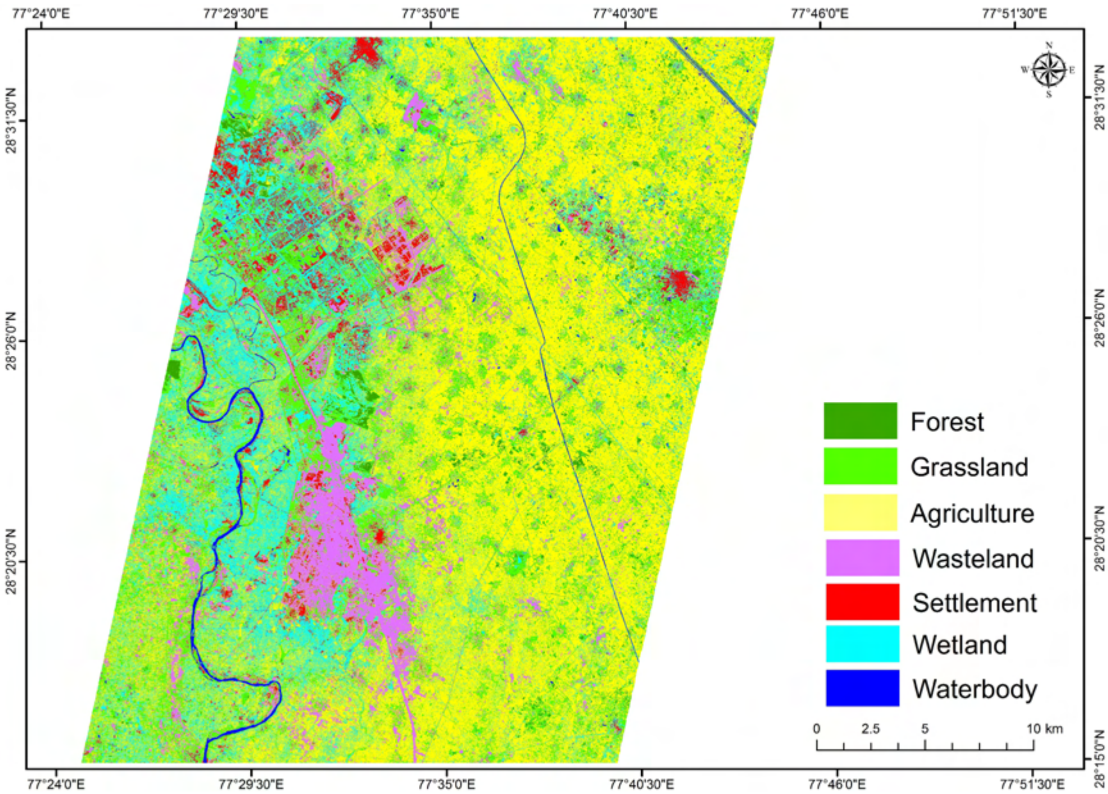

Figure 4a: Land use/cover map of 04 April 2010.

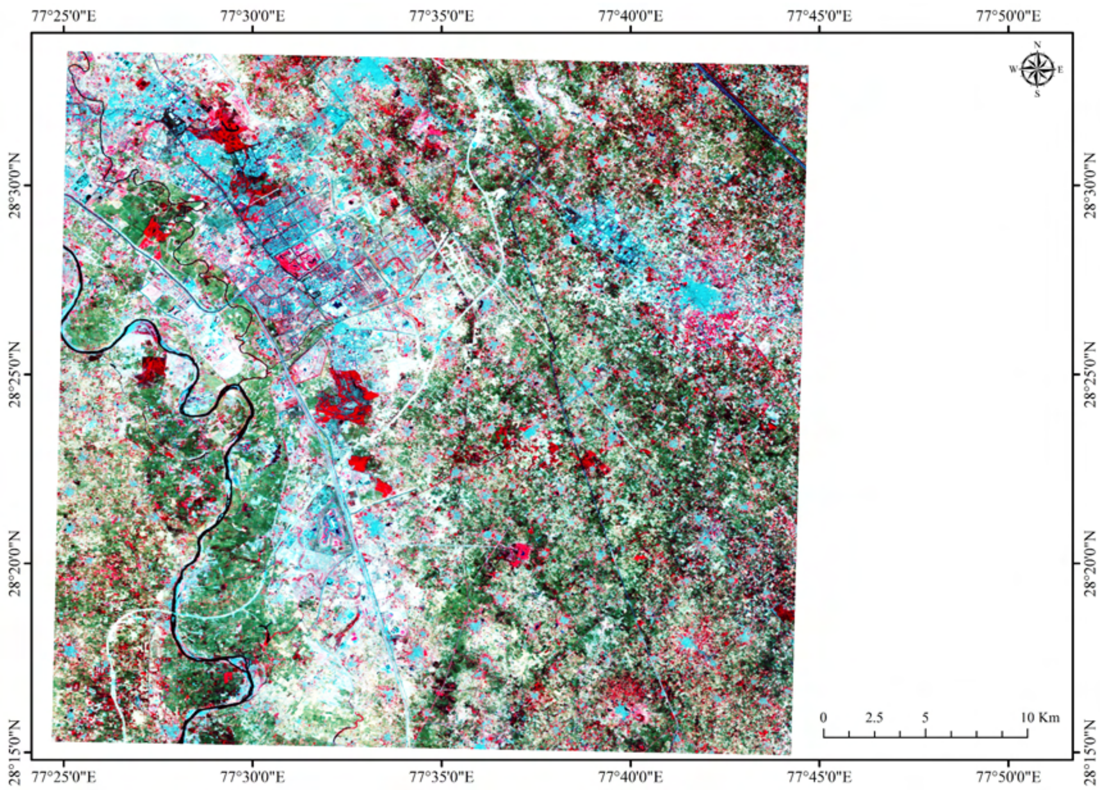

Figure 5. False Color Composite of 06 April 2017.

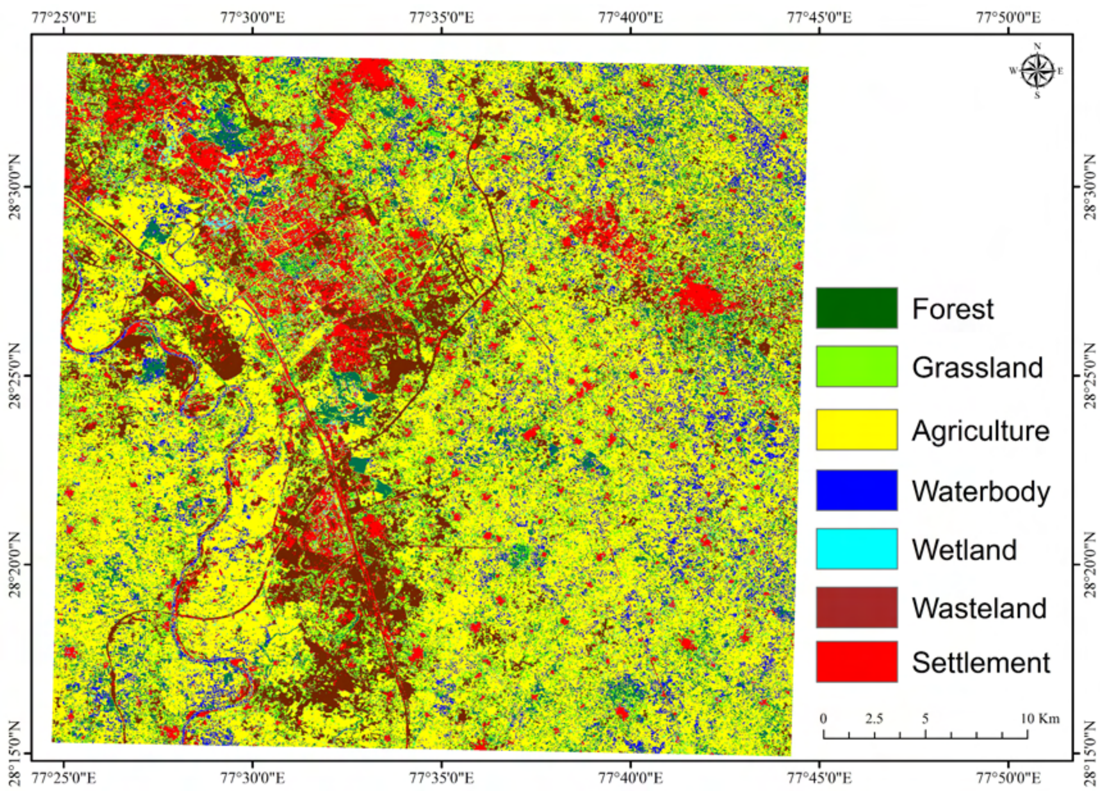

Figure 5a: Land use/cover map of 06 April 2017.

Table 2. Area (actual and % of total) covered under different land use/cover categories.

Land use/cover	2004		2010		2017		Change during 2004-2010		Change during 2010-2017	
	km^2	%	km^2	%	km^2	%	km^2	%	km^2	%
Agriculture	521.86	61.40	498.25	58.62	375.00	44.12	23.61	2.78	123.25	14.50
Forest	13.85	1.63	11.51	1.35	12.57	1.48	2.34	0.28	-1.06	-0.12
Grassland	106.07	12.48	60.85	7.16	115.26	13.56	45.22	5.32	-54.41	-6.40
Settlement	26.27	3.09	125.9	14.81	152.15	17.90	-99.65	-11.72	-26.23	-3.09
Wasteland	51.59	6.07	80.38	9.46	115.20	13.55	-28.79	-3.39	-34.82	-4.10
Water body	5.39	0.63	11.65	1.37	47.42	5.58	-6.26	-0.74	-35.77	-4.21
Wetland	124.97	14.70	61.44	7.23	32.40	3.81	63.53	7.47	29.04	3.42
Total	850.00	100	850.00	100	850.00	100				

Table 3. Accuracy assessment of land use/cover.

Land use/cover	Reference Points	Classified Points	Correct number	Producer Accuracy (%)	User Accuracy (%)
Agriculture	38	34	31	81.58	91.18
Forest	37	35	32	86.49	91.43
Grassland	34	30	27	79.41	90.00
Settlement	8	13	08	100.00	61.54
Wasteland	28	31	27	96.43	87.10
Water body	25	25	22	88.00	88.00
Wetland	30	32	28	93.33	87.50
Total	200	200	175		

Overall classification accuracy = 87.50% Overall Kappa Statistics = 0.8522

2010 the land use pattern showed drastic changes. Although, the maximum area remained under agriculture (498.25 km^2) (58.62 %) albeit at reduced level by 2.32%. This was followed by settlement 125.92 km^2 (14.81%), wasteland 80.38 km^2 (9.46 %), wetland 61.44 km^2 (7.23%), grassland 60.85 km^2 (7.16%), waterbody 11.65 km^2 (1.37%) and forest 11.51 km^2 (1.35%) (Figure 6).This showed significant incremental changes in settlement by 11.72% and reduction in wetland by 7.47% and grassland by 5.32% followed by agriculture (2.79% and forest (0.28%). This change in different land use/cover classes has been as a result of vigorous anthropogenic activities, rapid urbanization and population increase in the study area. The land use/cover-wise change detection analysis brought out very interesting trends in change in land use pattern from 2004 to 2017.

Due to urbanization, the area covers under settlements increased by adding 223.08 km^2 (47.76%) at the expanse of agriculture (26.17%), wetland (57.17%), wastelands 23.67% and grassland (20.92%). Loss of agricultural land121.32 km^2 (26.67%) due to expansion of settlements got compensated by conversion of grassland 93.20 km^2 (20.13%) wasteland 44.94 km^2 (9.69%) and wetland 102.25 km^2 (22.06%) into cultivated lands (Table 4). Hence, there was a gain in area under agriculture by 119.17 km^2 (4.12%). The areas rich in wild biodiversity such as wetlands (34.39%), wastelands (4.80%) and grasslands (24.64%) and were greatly affected due to expanding settlements and agriculture showing a decline in the land area under these categories over the six year period (Figure 7).

Significant loss was noticed in the case of wetlands. A total of 159.42 km^2 of wetlands were lost to agriculture 102.25 km^2 (22.06%) and settlements 57.17 km^2(12.33%) accounting for a total loss of 34.39% area under wetland (Table 5). Krishna (2012) reported a decrease of water bodies by 50% during 1986-2011 in

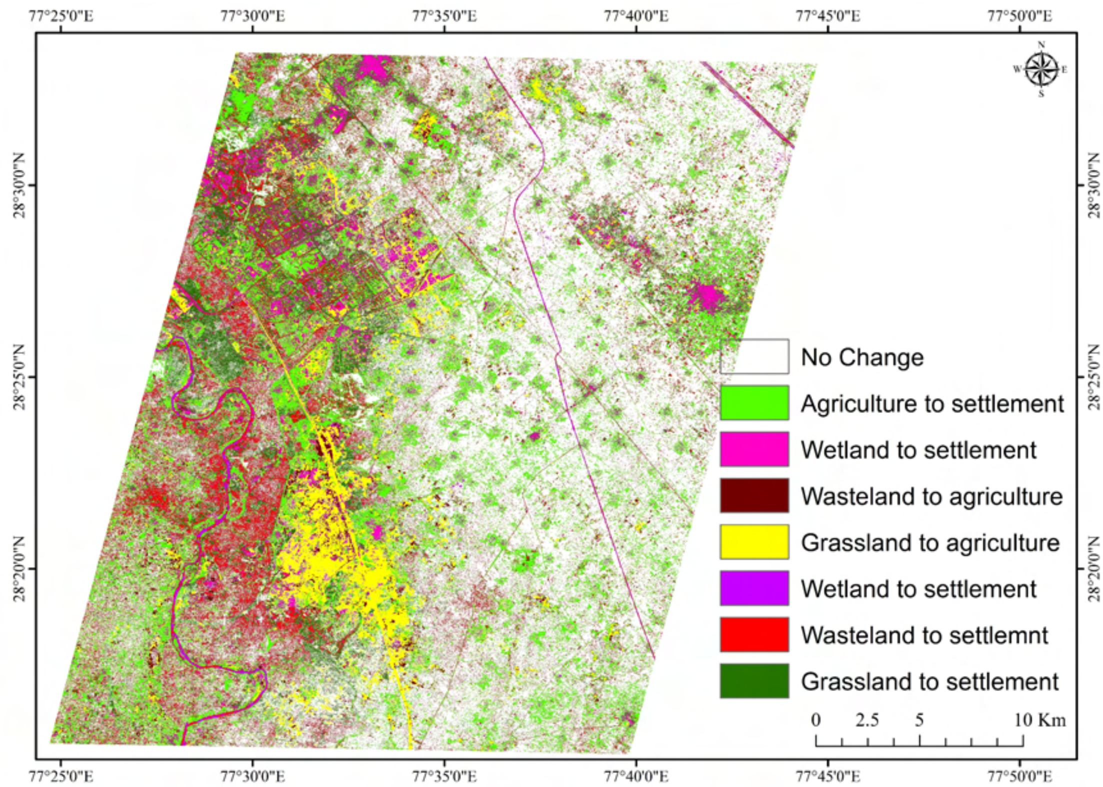

Figure 6. Land use/cover change in Sikandrabad & adjoining area from April 2004 to 2010.

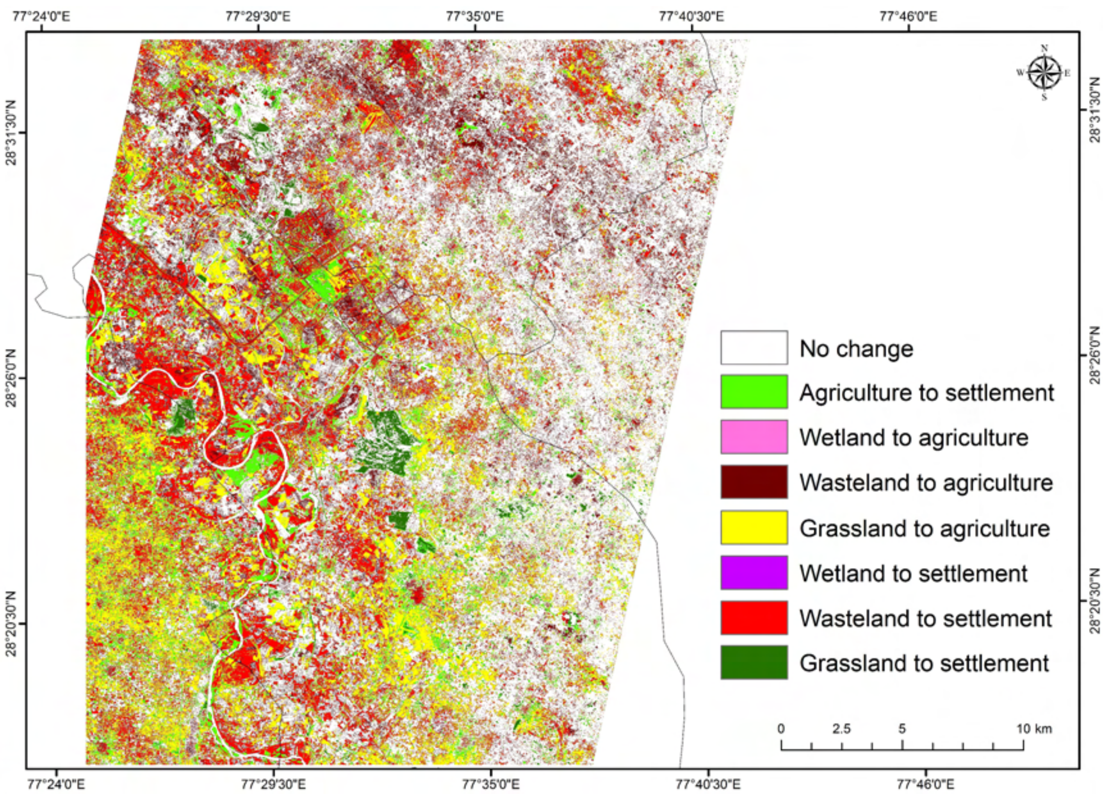

Figure 7. Land use/cover change in Sikandrabad & adjoining area from April 2010 to 2017.

Table 4. Area covered under different land use/cover change categories from 2004 to 2010.

Land use/cover	Area, km^2	Area (%)
Agriculture to settlement	121.32	26.17
Grassland to agriculture	93.30	20.13
Grassland to settlement	20.92	4.51
Wasteland to agriculture	44.94	9.69
Wasteland to settlement	23.67	5.11
Wetland to agriculture	102.25	22.06
Wetland to settlement	57.17	12.33
Total change	463.56	100.00
No change	386.44	45.46
Total	850.00	

Table 5. Changes in land use/cover from 2004-2010 based on Table 4.

Land use/cover	Area, km^2	Area (%)
Agriculture to settlement	121.32	26.17
Wetland loss	159.42	34.39
Conversion to agriculture	240.39	51.88
Grassland loss	114.42	24.64
Wasteland loss	068.61	04.80

Table 6. Area covered under different land use/cover change categories from 2010 to 2017.

Land use/cover	Area, km^2	Area (%)
Agriculture to Grassland	176.51	34.79
Agriculture to Wetland	77.10	15.20
Wetland to Settlement	127.17	25.06
Wasteland to Settlement	67.05	13.21
Grassland to Settlement	25.57	5.04
Wetland to Forest	14.80	2.92
Forest to Grassland	4.06	0.80
Grassland to Agriculture	15.14	2.98
Change	507.40	100.00
No Change (out of total)	343.00	40.3
Total	850.00	

adjacent Gautam Buddha Nagar district. He ascribed the major cause for this decrease to widespread urbanization. In the study area also, wetlands rich in aquatic and avian diversity, were the worst affected which is a serious concern. Wetlands are one of the most threatened of all biomes as they become the first land use victim of development (Panigrahy et al. 2012).Wetlands, also called "biological supermarkets" because of extensive food chain they support, play a crucial role not only in the hydrological cycle but in the ecosystem (Prigent et al. 2001, Varghese et al. 2008). Prasad et al. (2002) reported that rapidly expanding human population, large scale changes in land and improper use of watersheds have all caused a substantial decline of wetlands resources of the country. These significant losses have resulted from its conversion to agriculture, urbanization and other developmental activities similar to our findings in the study area. It is possible that excessive use of ground water through numerous unauthorized bore wells may also have resulted in drying of wells (Sikka 2002).

The loss of wetland habitat will definitely affect the migratory birds in western Uttar Pradesh. Dadri wetlands, near BilAkbarpur in Dadri harbor more than 220 migratory birds. A rare and endangered species bristled grass bird (*Chaetornis striata*) was recorded in 2010 with breeding nest in Dadri wetlands. Possibly it was the first record in India (Anon. 2010). As wetlands are destroyed some birds may move to other less suitable habitats putting survival as well as future migration in danger. Thus, many wetland birds are edging very close to extinction through disturbance and conversion of their habitats (Kumar et al. 2005).

Similarly, the grasslands, which also provide ecologically unique ecosystem were adversely affected and an area of 114.22 km^2 (24.64%) was converted to agriculture 93.30 km^2 (20.13%) and settlement 20.92 km^2(4.51%). Grasslands, mostly occupied by grasses such as: *Saccharum spontaneum* L., *S. bengalense* Retz., and *Phragmites karka* (Retz.) Trin. ex Steud., are common in Gangetic plains with scanty populations of other weeds such as: *Parthenium hysterophorus* L., *Cannabis sativa* L., *Chenopodium album* L., etc. Grass-lands provide traditional livelihood to local people as they utilize these grasses for various household purposes as well as products for sale.

A total of 68.61 km^2 (4.80%) of wastelands, which harbor rich wild plant diversity were also lost during the six year period as this land use was converted to agriculture 44.94 km^2 (9.69%) and settlement 23.67 km^2 (5.11%). Loss of wastelands will result in loss of rich wild plant diversity as a number of ethno-botanical studies on wild/weed flora of waste lands of Bulandshahr district reported a number of valuable medicinal plants which are being used in traditional medicines by local people (Alam and Anis 1987, Singh and Islam 2010, Aggarwal et al. 2012, Chaudhary and Narayan 2013). Disappearance of herbal flora in wastelands will deprive people of these medicinal herbs occurring in the wild and practicing the traditional way to cure various ailments by local population.

Overall, this study revealed significant changes in various land use land cover classes in Sikandrabad and surrounding areas in upper Gangetic plains of western Uttar Pradesh, India using remote sensed satellite images of 2004 and 2010 and GIS techniques. Sikandrabad town (Bulandshahr district) and area of Dadri in Gautam Buddha Nagar district being closer to National Capital Region (NCR), especially townships of Greater Noida and Gurgaon (Krishna 2012, Sharma et al. 2013) which are moving at a tremendous pace towards a massive urban expansion, it is essential that the future development is on a sustainable model without adversely affecting the natural resources especially biodiversity rich water bodies. There is already population increase reported by Singh and Islam (2010) for Bulandshahr district from 29.13 lakhs in 2001 to 34.99 lakhs in 2011 as well as population density which increased from 656 to 776 during the same period. To accommodate this growing population, expanding urbanization and other developmental activities it is imminent that in the near future the area will see a great change in terms of land use land cover due to conversion of land for various activities (Rahman et al. 2011). Such changes will cause environmental degradation with loss of valuable biodiversity and fertile agricultural land due to negative impacts of unplanned urbanization. With these in view future studies are strongly recommended to develop a sustainable model of development in the NCR region for sustainable utilization of natural resource and their conservation. In 2017, the maximum area covered by agriculture 375.00 km^2 (44.12%) followed by settlement 152.15 km^2 (17.90%), grassland 115.26 km^2 (13.56%), wasteland 115.20 km^2 (13.55%) water body 47.42 km^2 (5.58%) and wetland 32.40 km^2 (3.81%). Due to urbanization maximum changes were observed in agriculture 123.25 km^2 followed by grassland 54.41 km^2 (6.40%), waterbody 35.77 km^2 (4.21%) and wasteland 34.82 km^2 (4.10%). It was observed that during 2010 to 2017 the maximum area conversion in agriculture to grassland was 176.51 km^2 (34.79%) followed by wetland to settlement 127.17 km^2 (25.06%), agriculture to wetland 77.10 km^2 (15.20), grassland to settlement 25.57 km^2 (5.04%), wetland to forest 14.80 km^2 (2.92%) and grassland to agriculture 15.14 km^2 (2.98%). It was also noticed that no changes were found 343.00 km^2 (40.35%). The main reason of changes in these areas is conversion of rural agriculture to urban ecosystem. The construction of highways, industry, academic institutions, and residential complexes etc., are the main reason of urban development in NCR region. Its main adverse impact affects the loss of local biodiversity, wetland and agriculture ecosystems. Due to the loss of wetland the water label is going down and its adverse impacts on flora and fauna, migratory birds etc.

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