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Monitoring of Landuse and Landcover Changes in a Part of Central Ganga Plains of Uttar Pradesh using Remote Sensing and GIS

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ABSTRACT

The present research work was conducted for monitoring of landuse and landcover changes in Central Ganga Plains covering in Farrukhabad, Kannauj and Hardoi districts of Uttar Pradesh state in India. Remotely sensed data Landsat-1 MSS and Sentinel-2 for the years 1975 and 2018 were classified using supervised classification technique with the help of ArcGIS software. The categories identified in the study area are builtup, crop land, vegetation, uncultivable land/wastelands, and waterbodies. The classified images were assessed for its accuracy using error matrix. The significant changes recorded in builtup category was overall 72% in a span of 40 years. Agricultural crop land occupies nearly 80% of the total geographical area of study area. The inhabitants mainly grown the crops in the region are Jawar, Bajra and Makka during *Kharif* season while wheat, rice, and sugarcane cultivated in *Rabi* season. The advancement of agricultural operations through heavy machinery is also being affected vegetative cover leading to potential flood losses. This study provides the baseline information for managing resources effectively at the local level.

Key Words : Landuse and landcover, Remote sensing and GIS, Supervised classification, Error matrix

INTRODUCTION

Monitoring of the land use and land cover (LULC) changes through remote sensing and geographical information system is recognized as an important activity in several region of the world. It helps for framing policies and assessment or flood risk zonation, river basin resources, and various urban-rural developmental activities, etc. Land is one of the important natural resources on the globe. The over growth of population is being put pressure on the land for crop production, plantation, urban and industrial uses (Molla, 2015; Saxena *et al.,* 1990). Analysis of LULC changes over a period of time will significantly help in detecting the extent of human influence on natural environment. The increase of builtup structures in urban and rural areas creates impervious surfaces that impacts runoff leading to flooding and associated flood havocs. The flood incidences have largely been increased in recent days due to large scale changes in landuse and landcover patterns at global as well as local levels. Several studies have been conducted to quantify particularly the impact of urban development and construction of dams/reservoirs in many places because it relates to flash floods. Bhatt and Rao (2016) conducted the research to assess the flood situation along the Ganga river region covering Kannuaj and Ankinghat areas with the help of pre- and post-flood satellite images, coupled with hydrological and meteorological data.

Remote sensing often combined with GIS has been used extensively in mapping of LULC features and the analysis of their dynamics. Satellite remote sensing provide synoptic view of inaccessible region with temporal resolution giving useful information on land use

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and land cover dynamics. GIS can efficiently be used for analyzing the effects of various factors on land cover changes including population distribution, slope, dying of water bodies, road network etc. (Fichera *et al.,* 2011). In the past two decades, there has been a growing trend in the development of change detection techniques using remote sensing data.

The present study area is being affected frequently by floods due to the construction of reservoirs and dams at the upper course, modification of channels and canals, changing agricultural practices and other human activities. The excavation of fertile soils and unauthorized sand and gravel mining and alteration of vegetation cover are also dominant in recent days resulting to flash floods because of high velocity of water flow. Keeping this in view, an investigation has been carried out in parts Central Ganga Plains covering in the districts of Farrukhabad, Kannauj and Hardoi of Uttar Pradesh to detect the landuse and landcover changes using multi-temporal satellite imageries for the period of 40 years during 1975 to 2018.

Study area :

The area under study is a part of Central Ganga Plain spreading in Farrukhabad, Kannauj and Hardoi districts of Uttar Pradesh state. It lies between 27°01' N - 27°18' N latitude and 79°38' E - 80°00' E longitudes falling in Survey of India (SOI) topo sheet nos. 54M/11, 54M/12, 54M/15, 54M/16 on 1:50,000 scale covering with an area about 1121 sq km (Fig. 1). The river Ganga, Ramganga, Garra and Kali are draining through this study area. River Ganga is the trunk stream flowing a length of 60 km varying width 2-5 km at some places. The Ramganga joins the Ganga at a distance of 10 km north of Kannauj. The river Garra flows about 30 km in length and varies from the width of 0.5 to 1 km. Another important tributary of the river Ganga is the Kali river flows through the districts of Kannauj and Hardoi and it merges with the river Ganga after flowing about 60 km distance. The region experiences sub-tropical humid type climate and receives rainfall about 881 mm per year (average). Most of the rain receives form South-West monsoon between the months of June to September. The lowest temperature is 8°C recorded in the month of January and maximum temperature reaches up to 41°C in May. The study area which is underlain by Quaternary alluvium like older alluvium or Bhagar and newer alluvium or Khadar. The surface elevation of the area ranges between 92 m and 166 m. The area is inhabited with nearly 0.9 million population accounting to 77 % of rural and 23% of urban population. As per the 2011 census, the density of population is 900 persons per sq km while it was 820 persons per sq km in 2001.

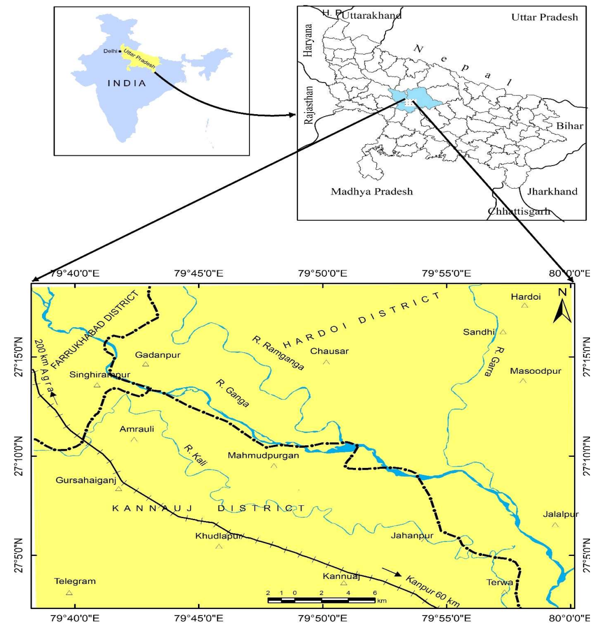

Fig. 1 : Location map of the study area

Satellite data used:

In this study, we used two different data sets including a high-resolution Sentinal-2 (MSI) image and Landsat -1 (MSS) for LULC classification. The two images were acquired from USGS Earth Explorer (www.earthexplorer.usgs.gov). Table 1 provides the important specifications of the data. MSS was acquired for the year 1975 that consists of 4 multispectral bands-green, red and two infrared with a spatial resolution of 80 meters. Sentinal-2 carries multispectral instrument (MSI) for the year 2018 comprising 13 bands with a spatial resolution of 10 m B 2, B 3, B 4 and B 8, 20 m B 5, B 6, B 7, B 8a and B 12, 60 m B 1, B 9 and B 10 and TCI band.

METHODOLOGY

LULC categories in the study area were grouped into five major types such as builtup (including urban and rural), crop land (agricultural area), vegetation (forest, plantation and scrub areas), wastelands (sand and other unutilized lands) and water (river and water bodies).

Table 1 : Datasets used in the present study

Satellite	Sensor	Spatial resolution	Spectral band	Spectral resolution (μm)	Application
Landsat-1	Multi- spectral scanner	80 m	B 4: Visible green	0.5-0.6	Water and land interface, monitoring vegetation cover and soil moisture.
			B 5: Visible red	0.6-0.7	
			B 6: Near infrared	0.7-0.8	
			B 7: Near infrared	0.8-1.1	
Sentinel- 2	Multi-Spectral Instrument	10 m	B 2: Blue	0.49-0.52	Land cover, crop, application, vegetation, forest covers and water monitoring, flood mapping
			B 3: Green	0.54-0.57	
			B 4: Red	0.65-0.68	
			B 8: Near infrared	0.7-0.8	
		20 m	B 5: Vegetation red edge	0.69-0.71	
			B 6: Vegetation red edge	0.73-0.74	
			B 7: Vegetation red edge	0.77-0.79	
			B 8A: Narrow NIR	0.85-0.87	
			B 11: SWIR	1.5-1.6	
			B 12: SWIR	2.1-2.2	
		60 m	B 1: Coastal aerosol	0.44-0.46	
			B 9: Water vapour	0.94-1.1	
			B 10: SWIR Cirrus	1.3-1.4	

Source: www.earthexplorer.usgs.gov

Handheld GPS along with google earth tools were used in collecting the ground truth information of different LULC classes. An extensive field work was conducted using GPS instrument.

The data was used in the classification for the creation of signature files. A supervised signature extraction with the maximum likelihood algorithm was used for classifying data. The user requires the knowledge of field sites, so that data could be used in the supervised classification to produce better results. ArcGIS 10.4 software was used for spatial and image analysis. A total of five classes were selected for supervised classification. For each class, 15 training areas were selected with cumulative of 75 sites covering in the entire study area. Field visit was carried out for verification of the classification results. The classified LULC images were used in identifying the changes of each land use category between 1975 and 2018.

Assessment of Classification Accuracy:

The classification accuracy must be conducted for the classified image by testing the sampling area pixels of output map. The testing sites of classified image with the reference data or ground truth data was done through error matrix. The agreement and disagreement of testing pixels of classified classes in the form of error matrix is given in Tables 2 and 3. User accuracy, producer accuracy and overall accuracy were estimated.

Table 2 : Accuracy assessment of classified image-1975

Category	Builtup	Crop land	Vegetation	Wastelands	Water	Reference total	User accuracy (%)
Builtup	43	4	2	1	0	50	86
Crop land	1	43	4	1	0	50	86
Vegetation	2	3	45	1	0	50	90
Wastelands	0	3	1	44	2	50	88
Water	0	0	1	1	48	50	96
Total (Producer)	46	53	53	48	50	250	------
Producer accuracy	93.47	81.13	86.79	91.66	96	------	------

Overall accuracy = 89.2%

Table 3 : Accuracy assessment of classified image-2018

Category	Builtup	Crop land	Vegetation	Wastelands	Water	Reference total	User accuracy (%)
Builtup	47	1	2	0	0	50	94
Crop land	1	49	0	0	0	50	98
Vegetation	2	0	46	2	0	50	92
Wastelands	0	2	1	47	0	50	94
Water	1	0	1	0	48	50	96
Total (Producer)	51	52	50	49	48	250	-------
Producer accuracy	94	94.23	92	95.91	100	-------	-------

Overall accuracy = 94.8%

RESULTS AND DISCUSSION

The satellite imageries in two different periods were taken into consideration for identifying LULC changes in the study area using remote sensing and GIS techniques. Based on the image interpretation, field surveys, and the prevalent conditions of the study area, a total of five categories have been identified in 1121 sq km area. The classes are built-up, crop land, vegetation, wastelands and water. The resultant maps are presented in Fig. 2 and 3 for the years 1975 and 2018, respectively. Table 4 gives the statistical results of LULC changes.

Comparison of LULC in 1975 and 2018 indicates that the built-up area comprising of urban-rural habitations developed for nonagricultural uses like building, industry, transport, and communications was increased to 39 sq km from 22 sq km. In a span of 40 years, the changes occurred in the built-up account to 72.21% increase. It was found that some of small to medium sized villages in 1975 upgraded to urban centers in the form of cities. Also, some new habitations have emerged up as villages which didn't exist in 1975. Major urban centers identified in the study area are Hardoi (136,851), Kannauj (84,862), Gursahaiganj (46,060), Bilgram (25,292), Kamalganj (14,659), and Sandi (12,607).

Crop land which is a piece of land primarily used for production of food under agriculture area was recorded 855.3 sq km (1975) and increased to 904.4 sq km (2018). Crop land occupies nearly 80% of the total geographical area of study area. The older alluvium or younger alluvium supports the extensive growth of agriculture in the study region. The inhabitants mainly depend on agriculture for their subsistence. The major crops grown in the region are Jawar, Bajra and Makka during *Kharif* season (July to October). Wheat, rice, and sugarcane are grown in irrigated fields while peas, mustard, barley and other cereals and pulses largely grown rainfed regions during *Rabi* season (October to March).

Vegetation occupied was 123.7 sq km in 1975 and decreased to 70.2 sq km area of TGA. Plantations including mango, guava, banana, neem, pipal, and grass (moonj) patches identified on the bunds, and road sides that were demarcated under vegetation category. The highest negative change was occurred in vegetation cover *i.e.* 43%. The declining trend may possibly due to the expansion of built-up and cultivated areas.

Waste lands comprise of sand in river course, gullies, thorny bushes in waterlogged areas were occupied 68.6 sq km area in 2018 with a change of 4.25%. This category spread mainly along the active river channels and covering the areas of Bargaonand, Terarabbu, Adampurand, Rohli, Tusauli, Narmau, Terarabbu, Bargaon, Narmau, Tilpai Digsara, Mahadewakhas, Jagdishpur, Bhau Buhurg, Nonkhara, Panthora and Kanchana etc., villages. The gullies or ravinious lands are distributed along the rivers and nallas of the study area. By planting multi-purpose

Table 4 : Statistics of landuse and landcover changes in the study area

Category	LULC 1975		LULC 2018		Change 1975 to 2018	
	km^2	%	km^2	%	km^2	%
Built-up	22.93	2.04	39.49	3.52	16.56	72.21
Crop land	855.24	76.36	904.36	80.75	49.12	5.74
Vegetation	123.65	11.04	70.21	6.26	- 53.44	- 43.21
Wastelands	65.80	5.87	68.60	6.12	2.80	4.25
Water	52.30	4.66	37.26	3.32	- 15.04	- 28.75

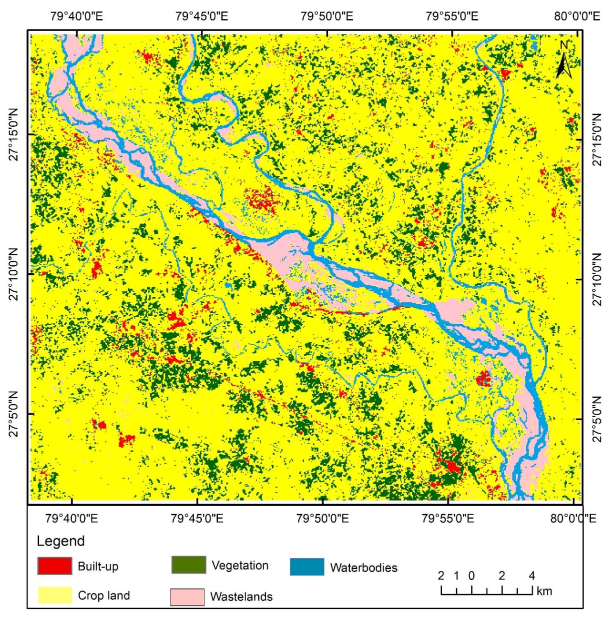

Fig. 2 : Landuse and landcover map of the study area for the year 1975

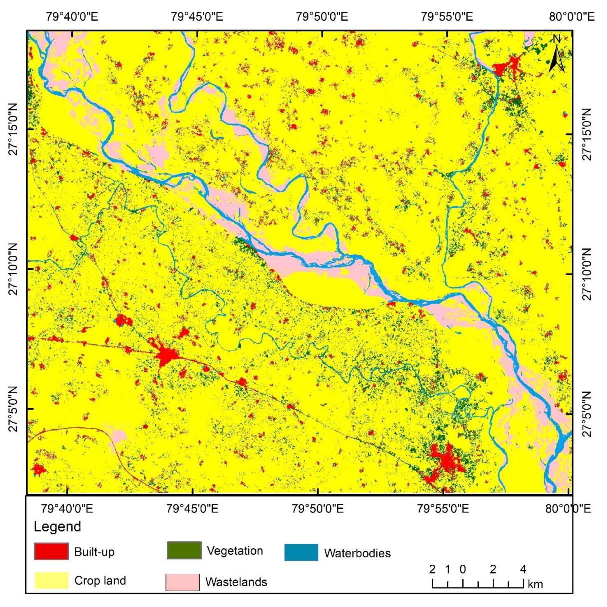

Fig. 3 : Landuse and landcover map of the study area for the year 2018

trees through social agro-forestry activities in the wasteland areas would be benefitted to the habitants towards the improvement of economy.

Waterbodies covering 37.26 sq km of TGA which accounts 3.32% (2018). These are mainly found in the form of active river channels, ponds or tanks. These include Ganga, Ramganga, Kali and Garra rivers which are considered as a good source of water for carrying agricultural activities. Water present in the ponds and tanks has substantially reduced due to the deposition of sand and silt carried out by streams and unauthorized farming activities. During winter season, inhabitants of the region start practicing agriculture near the active channels which also affects the river flow.

The classified images showing various LULC classes for the years 1975 and 2018 was assessed their classification accuracy by error matrix (Tables 2 and 3) Pixel data judges the comparison between classified images and reference data sets. It was found that the classification overall accuracy produced to be 89.2% (1975) and 94.8% (2018), respectively. User's accuracy ranges between 86% and 98% whereas the producer's accuracy varies from 81% to 100% during the time periods. In the study area, cropland is the major category and mostly mixed with habitations (builtup). Due to this reason, the cropland pixels were misinterpreted hence produced low accuracy. Further, vegetation are also intermingled with crop fields. The high accuracy was found in water categories in both the years.

Conclusion:

The temporal assessment of landuse and landcover changes in an area provides a significant knowledge which will help to overcome the problems related to flooding, environmental quality, loss of agricultural lands and productive ecosystems, etc. The rapid growth of human population, unscientific methods of agricultural activities, sand mining in river courses, ignorance of authoritative bodies are main causes behind in changing LULC patterns. The study area has witnessed substantial increase in population and large scale unauthorized occupations of water courses tremendously created negative impact on the environmental health of the region. The flooding is very common in rainy seasons which may be because of natural as well as anthropogenic activities. In the present study, various land use and land cover classes such as built-up, crop land, vegetation, wastelands and waterbodies were mapped using temporal satellite data during 1975-2018 with the help of remote sensing and GIS techniques. The results revealed that there is an increasing trend in the built-up between 1975 and 2018. The study area is mostly covered under the cropland.

Changes occurred in the croplands and wastelands categories which remains nominal during the last 40 years. Vegetation is largely affected contributing 43% decrease. Waterbodies in the study was decreased may be of the deposition of sand and silt brought by the nalas and also due to the practice of agricultural activities. Geospatial technologies are proved to be efficient in LULC change detection studies. The conclusions drawn from the present study will help to prepare environmental impact assessment plans and also to assess the future impacts related to quality of environment in the flooded Ganga plains of the study area.

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