Original Research Article

Assessment of Land Use-Land Cover Changes in Samastipur District of Bihar (India) Using Geo-informatics

Abstract

The assessment and analysis of land use/land cover (LULC) changes are required to identify the land use changes from year to year which plays a critical role in planning and implementation of developmental activities. The present study aims to assess LULC changes in Samastipur district of Bihar using remote sensing (RS) and geographical information system (GIS). The LULC maps were prepared using LANDSAT-5 and LANDSAT-8 images by adopting object based image classification technique. Assessments of LULC changes were done @ 5 years, @ 10 years and @ 20 years during 2000-2020. The results indicated that the agriculture land coverage increased at high rate during 2000-2005 and 2005-2010; and after that it is increasing at slow rate. The natural vegetation coverage is continuously decreasing during years 2000-2020 while settlement is continuously increasing during this period with notable increase during 2000-2005 and 2015-2020. In the time interval of 10 years (2000-2010), the agriculture land area increased by 22.17%; natural vegetation area decreased by 38.04%; the water-bodies decreased by 46.69%; sand and barren land decreased by 61.27% and settlement area increased by 15.62%. Over the next 10 years (2010-2020), area covered by agriculture land, settlement, water-bodies and sand and barren land increased by 8.05%, 38.30%, 26.27% and 44.65% respectively while area covered by natural vegetation decreased by 75.24%. During time interval of 20 years (2000-2020), agriculture land area and settlement area increased by 32% and 59.91% respectively while natural vegetation, sand and barren land and water-bodies decreased by 84.66%, 43.98% and 32.68% respectively. The analysis of the results indicates that the natural vegetation has decreased at fast rate in the recent years. Therefore, proper attention is required towards stopping of cutting of natural vegetation in the district to save the environment.

Key words: Land use, Land cover, RS and GIS, natural vegetation area

1. INTRODUCTION

The LULC change detection plays an important role in planning and management of land and other natural resources. Various LULC classes and their distributions are basic data essential for a wide range of studies in the physical and social sciences. Geo-informatics especially Remote sensing (RS) and Geographical Information Systems (GIS) techniques joint together provides easier and faster way to detect urban encroachments than the traditional methods of surveying. Remote sensing method has minimized field work to a large degree and it delineates soil boundaries more precisely than conventional methods (Thilagam and Sivasamy, 2013). Further, the satellite images used in this method provide latest and comprehensive knowledge required for organized and scientific planning of watershed management actions. On the other hand, a GIS is an efficient technique for storing, analyzing and displaying spatial information. RS and GIS hold great promises for recuperating the convenience and accuracy of spatial data, better productive analysis and better data access.

The assessment and analysis of LULC information is required to know the quantity of land under particular use and to recognize the year-wise changes in land use. The information on LULC changes during certain period helps in developing strategies for proper development of the region. The change in LULC is a wide-spread and accelerating process, which impacts the natural ecosystem. Hence, many researchers have worked on this aspect for different regions using traditional techniques or modern techniques like RS and GIS techniques [Sharma *et al.* (2011), Singh and Dubey (2012), Deka *et al.* (2014), Prasad and Sreenivasulu (2014), Hazarika *et al.* (2015), Rawat et al. (2015), Hassan *et al.* (2016) Cheruto *et al.* (2016), Ahmed *et al.* (2018), Yadav (2019), Ahmad and Munim (2020), Kumar *et al.* (2020), Yadav *et al.* (2022)].

Samastipur district of Bihar state in India is one of the highly-populated districts of the state and has good potential for agricultural (especially vegetables) production. It is visually observed that urbanization and hence the settlement area is increasing day by day. Hence, the area availability for other uses of land must decrease. The assessment of such changes in LULC will be highly informative and useful for the government and non-government agencies working for the development of land, agriculture, infrastructure etc. for the district. Maps generated from the study may give valuable information especially to planners, local government and land use managers to take proper decisions for land and water management and for sustainable development of the district. Experiencing the importance of detection of LULC changes, the objective of the present study is to assess of LULC changes in *Samastipur* district of Bihar using RS and GIS.

2. MATERIALS AND METHODS

2.1 Study Area

Samastipur district of Bihar is spread over an area of about 2900 km^2. The study area is located between 25°27′ to 26°05′ N latitudes and 86°31′ to 86°23′ E longitudes (Fig. 1). Its general elevation above mean sea level is 53 m. The district comes under the monsoon tropical zone and is characterized by semi-arid to subtropical climate. The annual rainfall is about 1150 mm. Most of the annual rainfall is received during the monsoon months i.e. during June to September months. The soil is sandy loam with fairly high organic matter that is suitable for rice, maize, wheat, pulses, oilseeds, tobacco, sugarcane, spices and vegetables cultivation. Agriculture is the primary monetary profession of the district and approximately 83 percentage of the entire operating population relies upon it. This district is wealthy in agriculture, due to its fertile plain.

2.2 Data

LANDSET-5 Thematic Mapper (TM) data of year 2000, 2005 and 2010; and LANDSAT-8 Operational Land Imager/Thermal Infrared Sensor (OLI/TRIS) data of year 2015 and 2020 of the study area have been downloaded from USGS Earth explorer site (https://earthexplorer.usgs.gov) having resolution of 30 m for LULC changes analysis. The types of data collected for the present study is listed in Table 1. Google map and Google earth are regularly used for generation of ground truth data for accuracy assessment. It is well known that Google Map is a free net mapping service application and technology supplied by Google. The present study uses Google earth data as ground truth data.

2.3 Hardware and Software

ARC-GIS 10.4.1 and MS-office were used for virtual analysis, data creation and output generation. ArcGIS 10.4.1 is a set of incorporated programs that permit to carry out GIS tasks, from easy to advanced, such as mapping, geographic analysis, hydrology and spatial analysis, statistics/ modifying and compilation, statistics management, visualization, and geo-processing (ESRI User Manual, 1994). MS-Office suite was used for statistical analysis, documentation and presentation purposes.

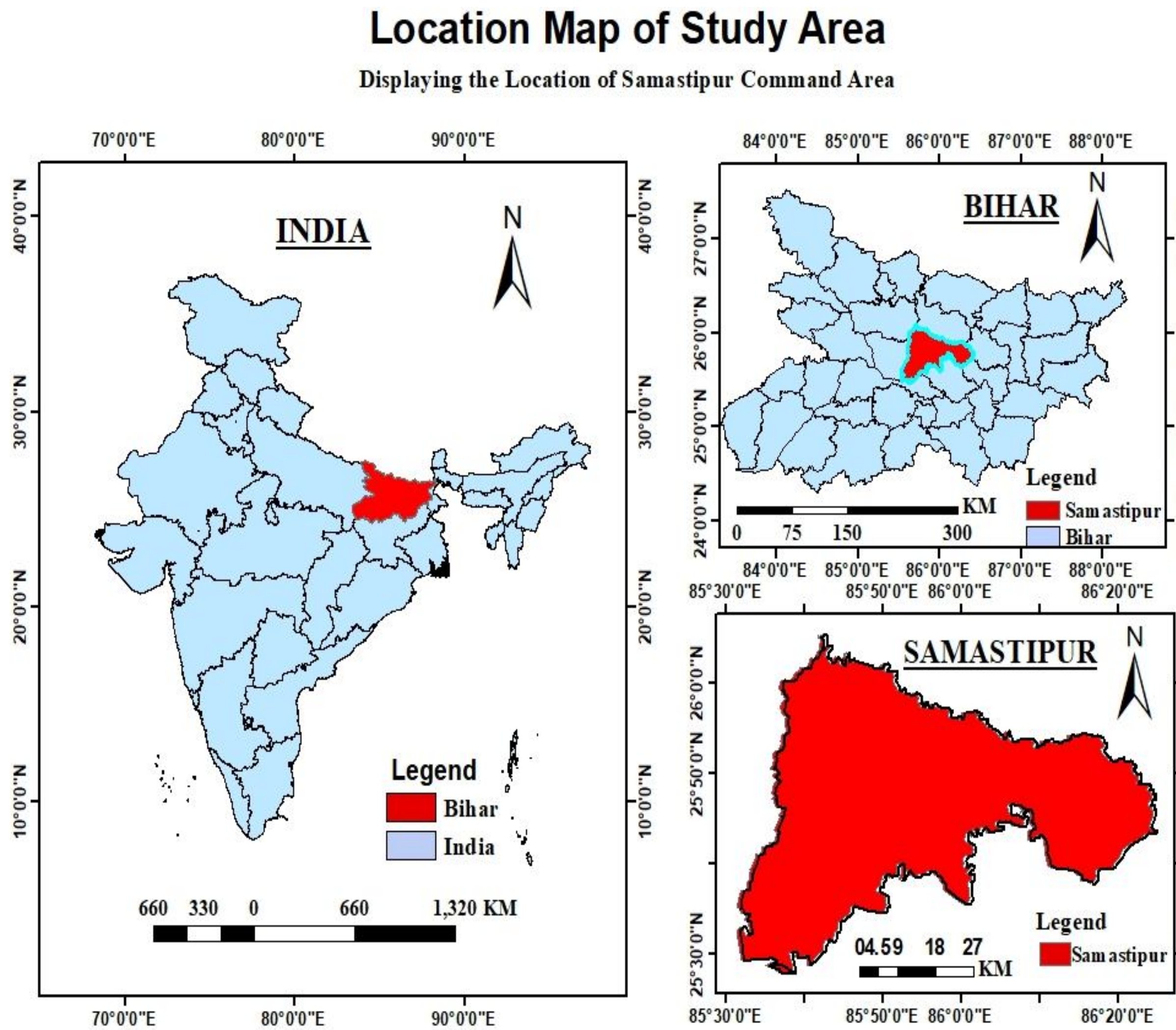

Fig. 1 Location Map of Study Area

Table 1: Data collected for the present study

S. No.	Data	Path/row	Date	Resolution
1	LANDSAT 5 (TM)	140/42	24/01/2000	30 m
2	LANDSAT 5 (TM)	140/42	05/01/2005	30 m
3	LANDSAT 5 (TM)	140/42	04/02/2010	30 m
4	LANDSAT 8 (OLI/TRIS)	140/42	02/02/2015	15 m
5	LANDSAT 8 (OLI/TRIS)	140/42	03/03/2020	15 m

2.4 LULC mapping

Land use land cover (LULC) is one of the maximum critical thematic inputs in any study as it provides the present status of land usage and its pattern. The change in LULC could be very dynamic; this is why satellite remote sensing is extensively used for its mapping. The images of LANDSAT-5 with Thematic Mapper (TM) and LANDSATt-8 with OLI/TRIS of the study area for the specific years were downloaded from on-line archive of United State Geological Survey (USGS). Five classes [agricultural land, settlement (build-up area), natural vegetation, waterbodies; and sand and barren land] of land use-land cover have been identified to develop LULC map using supervised classification.

The present study uses supervised classification for mapping of LULC. Data collected from USGS Earth Explorer having the bands in LANDSAT-5 (7 band) and LANDSAT-8 (11 bands) were imported into ArcGIS desktop and using Data management tool (*ArcTool box>Data Management tool>Raster> Raster Processing > Composite band*), they were composited. After composition of band, *false colour combination* (FCC) was setted. Using classification tool (*Classification tool > create training sample for all class > create signature file > Maximum likelihood classification),* FCC image was classified by drawing training sample of various classes and Maximum likelihood classification. Fig. 2 depicts false colour composite of *Samastipur* district of Bihar for the data of the years 2000, 2005, 2010, 2015 and 2020.

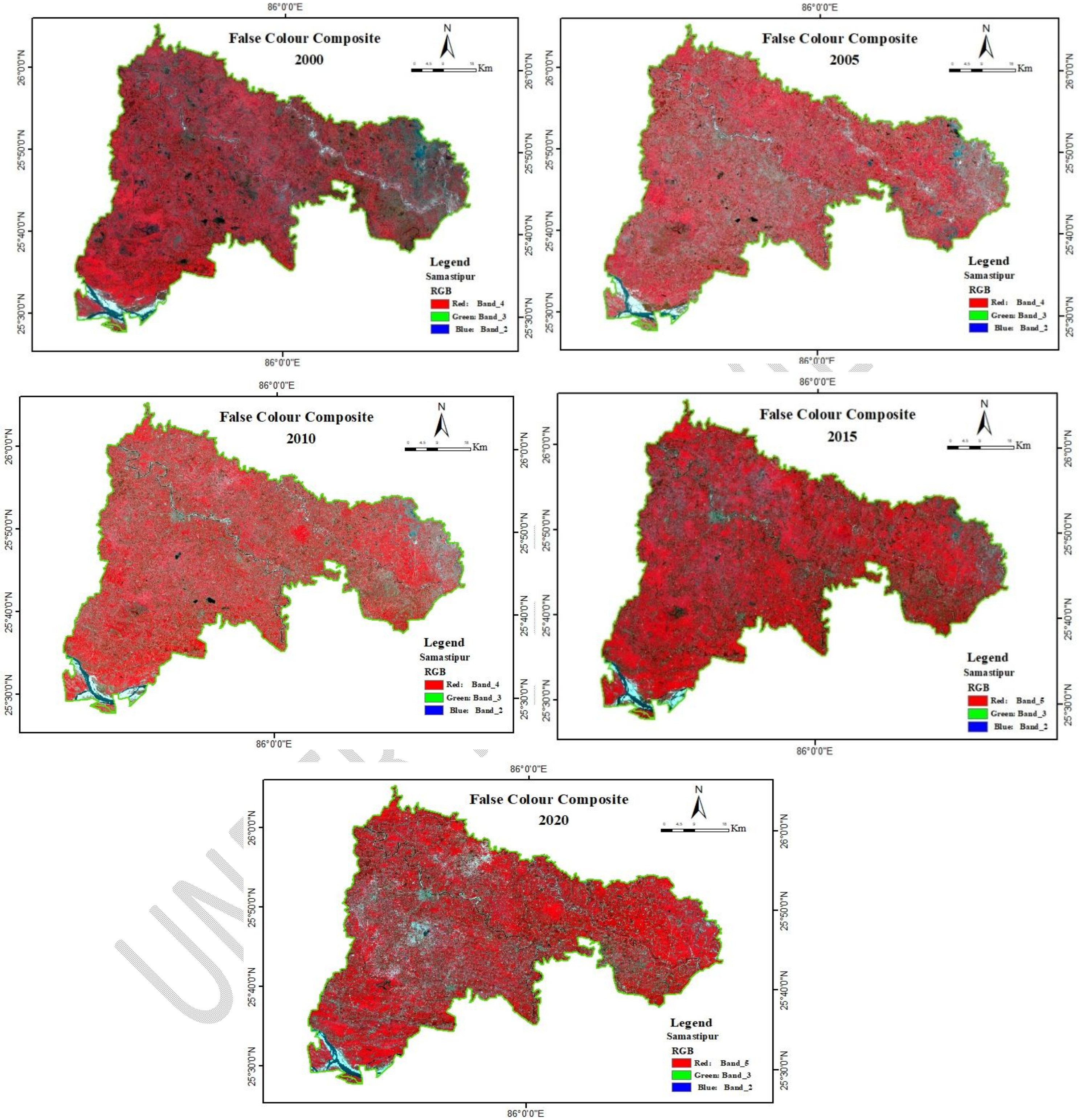

Fig. 2 False colour composite of LANDSAT-5 (bands- 4, 3 and 2) and LANDSAT-8 (bands- 5, 3 and 2) of Samastipur district of Bihar

2.5 Change Detection Technique

The characteristic tables (*Data > export data >file exported into .dbf format*) have been imported into MS-Excel and changes in all the five classes have been detected. The flow chart used in the change detection is shown in Fig. 3.

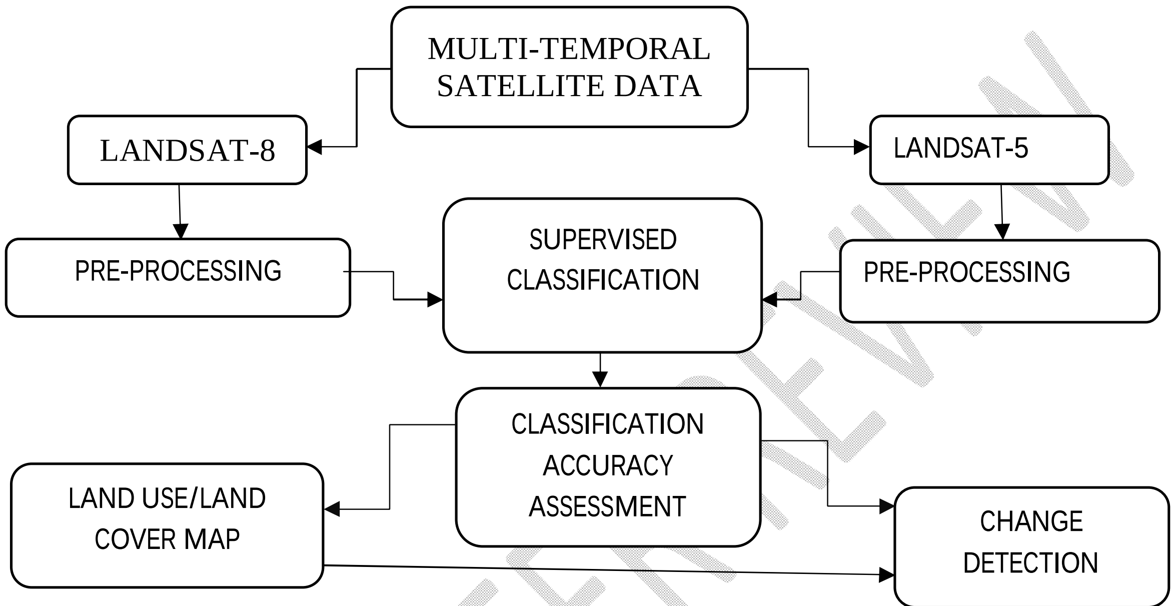

Fig. 3 Flow chart used in the change detection

2.6 Accuracy Assessment

In the present investigation, the accuracy assessment was done by computing overall accuracy and Kappa coefficient. In error matrix, the column indicates the reference statistics while the row gives the categorized generated satellite-derived statistics.

The Kappa coefficient (K) is computed as below:

$$K = \frac{N\sum_{i=1}^{r} x_{ii} - \sum_{i=1}^{r}(x_{i+} \times x_{+i})}{N^2 - \sum_{i=1}^{r}(x_{i+} \times x_{+i})}$$

Where,

r = number of rows in the error matrix

x_{ii}= number of observations in row i and column i (on the major diagonal)

x_{i+}= total number of observations in rows i (shown as marginal total to right of the matrix)

x_{+i} = total number of observations in column i (shown as marginal total at bottom of the matrix)

N = total number of observations included in matrix

K is a real dimensionless number between -1 to 1, the value close to 1 shows maximum agreement while value of -1 is totally disagreement. The ranges of K for different levels of agreement are presented in Table 2.

Table 2 Interpretation of Kappa value

K-Value	Rating	Agreement
≥ 0.81	Excellent	Almost perfect Agreement
0.81-0.61	Good	Substantial Agreement
0.61-0.41	Moderate	Moderate Agreement
0.41-0.21	Poor	Fair Agreement
0.21-0.0	Bad	Slight Agreement
<0.0	Very Bad	Less than chance Agreement

(Source: Landis & Koch (1997)

3. RESULTS AND DISCUSSION

3.1 Comparison of areas under various LULC classes

The comparison of area covered by various LULC classes in years 2000, 2005, 2010, 2015 and 2020 are presented in Table 3 while graphical comparison @ 5 years, @10 years, and @20 years are shown in Figures 4, 5 and 6 respectively. Table 3 indicates that considerable changes have occurred in many LULC classes during the period from year 2000 to year 2020.

3.2 LULC changes @ 5 years during 2000-2020

The results obtained on LULC changes occurred @ 5 years during 2000-2020 are summarized in Table 4. This table indicates considerable changes in areal distribution of different LULC classes in the study area in four different time periods (2000-2005, 2005-2010, 2010-2015 and 2015-2020). This table shows that the agriculture land area increased by 15.10% (28125 ha) in year 2005 as compared to year 2000 while natural vegetation area decreased by 34.23% (20610 ha) over this time period. Water-bodies area and sand and barren land area decreased by 37.58% (2965 ha) and 22.71% (5985) respectively whereas settlement area increased by 15.53% (1435 ha). Similarly, considerable changes occurred in other time periods (Table 4).

The results indicate that during the recent five years (2015-2020), the cutting/loss of natural vegetation has occurred at highest rate among the four time periods and in turn, settlements i.e. urbanization has increased at highest rate. Fig 4 indicates that the areas covered by water-bodies decreased continuously from year 2000 to 2015 while it slightly increased during 2015-2020. The small increase in water-bodies area during 2015-2020 might be due to construction of few small ponds in the study area during this period. Fig. 4 further shows that the agriculture land coverage increased at fast rate during 2000-2005 and 2005-2010; and after that it is increasing at slow rate. The natural vegetation coverage is continuously decreasing since year 2000 while settlement and hence urbanization is continuously increasing during the period 2000-2020 with notable increase during 2000-2005 and 2015-2020.

3.3 LULC change @ 10 years during 2000-2020

The LULC changes @ 10 years and @ 20 years in Samastipur district during years 2000-2020 are presented in Table 5. The table indicates significant changes in the LULC classes in the study area in three different time periods (2000-2010, 2010-2020 and 2000-2020). In the time interval of first 10 years (2000-2010), the agriculture land area increased by 22.17% (41295 ha); natural vegetation area decreased by 38.04% (22905 ha); the water-bodies decreased by 46.69% (3683 ha); sand and barren land decreased by 61.27% (16151 ha) and settlement area increased by 15.62% (1444 ha). Over the next 10 years (2010-2020), area covered by agriculture land, settlement, water-bodies and sand and barren land increased by 18320 ha (8.05%), 4093 ha (38.30%), 1105 ha (26.27%) and 4558 ha (44.65%) respectively while area covered by natural vegetation decreased by 28076 ha (75.24%). Graphical comparison (Fig 5) shows that agricultural land area significantly increased during 2000-2010 while it slightly increased in next 10 years (2010-2020). On the other hand, the natural vegetation coverage sharply decreased during 2010-2020 while settlement i.e. urbanization sharply increased during this period.

3.4 LULC change @ 20 years during 2000-2020

It is evident from Table 5 that during time interval of 20 years (2000-2020), agriculture land area and settlement area increased by 32% (59615 ha) and 59.91 % (5537 ha) respectively. However, natural vegetation, sand and barren land and water-bodies decreased by 84.66% (50981 ha), 43.98% (11593 ha) and 32.68% (2578 ha) respectively. The graphical comparison Fig.6 shows that agricultural land area and settlement area have increased significantly whereas natural vegetation, sand and barren land and water-bodies areas decreased significantly during the time interval of 20 years (2000-2020). The fast rate of loss of natural vegetation in the district during recent years may adversely affect the environment. Hence, proper attention is required towards immediate stopping of cutting of natural vegetation in the district to save the environment.

Table 3 Comparison of LULC in the years 2000, 2005, 2010, 2015 and 2020

Land use land cover classes	Area in 2000		Area in 2005		Area in 2010		Area in 2015		Area in 2020	
	ha	%	ha	%	ha	%	Ha	%	ha	%
Waterbodies	7889	2.72	4924	1.7	4206	1.45	3526	1.22	5311	1.82
Agriculture Land	186291	64.24	214416	73.94	227586	78.48	238186	82.13	245906	84.8
Sand and Barren Land	26359	9.09	20374	7.03	10208	3.52	14876	5.13	14766	5.09
Natural Vegetation	60219	20.76	39609	13.65	37314	12.87	21622	7.45	9238	3.19
Settlement	9242	3.19	10677	3.68	10686	3.68	11790	4.07	14779	5.1
Total	**290000**	**100**	**290000**	**100**	**290000**	**100**	**290000**	**100**	**290000**	**100**

Table 4 Assessment of LULC changes in Samastipur district @ 5 years during 2000-2020

LULC classes	Change in area coverage							
	2000-2005		2005-2010		2010-2015		2015-2020	
	ha	%	ha	%	ha	%	ha	%
Waterbodies	-2965	-37.58	-718	-14.58	-680	-16.17	1785	50.62
Agriculture Land	28125	15.10	13170	6.14	10600	4.66	7720	3.24
Sand and Barren Land	-5985	-22.71	-10166	-49.90	4668	45.73	-110	-0.74
Natural Vegetation	-20610	-34.23	-2295	-5.79	-15692	-42.05	-12384	-57.27
Settlement	1435	15.53	9	0.08	1104	10.33	2989	25.35

Table 5 LULC changes in Samastipur @ 10 years and @ 20 years during 2000- 2020

LULC Class	Changes in area coverage					
	Changes @ 10 years				Changes @ 20 years	
	2000-2010		2010-2020		2000-2020	
	ha	%	ha	%	ha	%
Waterbodies	-3683	-46.69	1105	26.27	-2578	-32.68
Agriculture Land	41295	22.17	18320	8.05	59615	32.00
Sand and Barren Land	-16151	-61.27	4558	44.65	-11593	-43.98
Natural Vegetation	-22905	-38.04	-28076	-75.24	-50981	-84.66
Settlement	1444	15.62	4093	38.30	5537	59.91

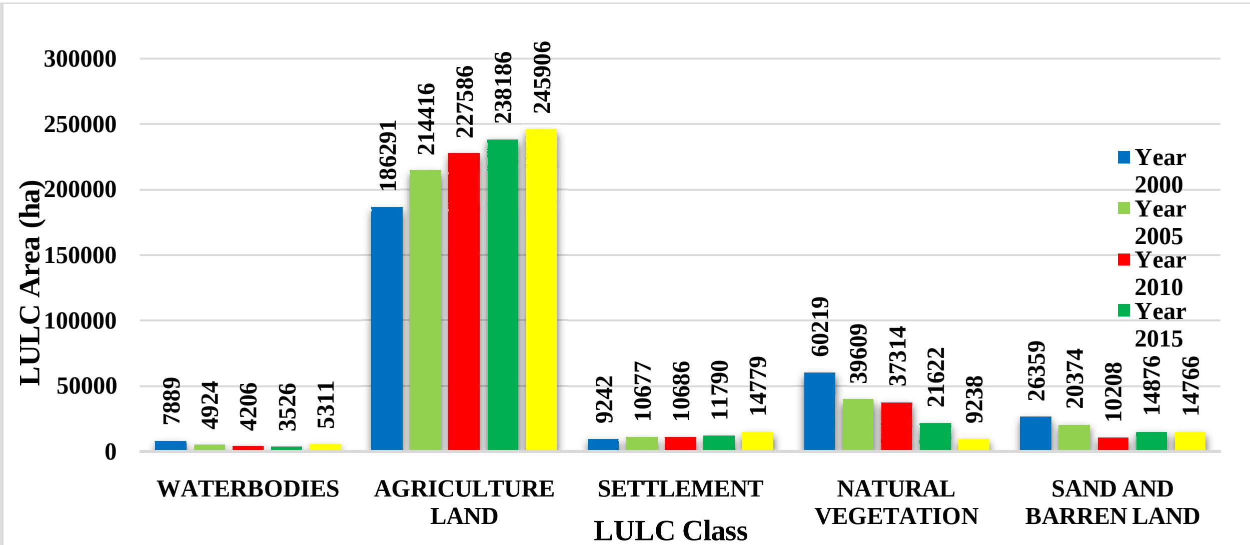

Fig 4 Graphical comparison of LULC for the years 2000, 2005, 2010, 2015 and 2020

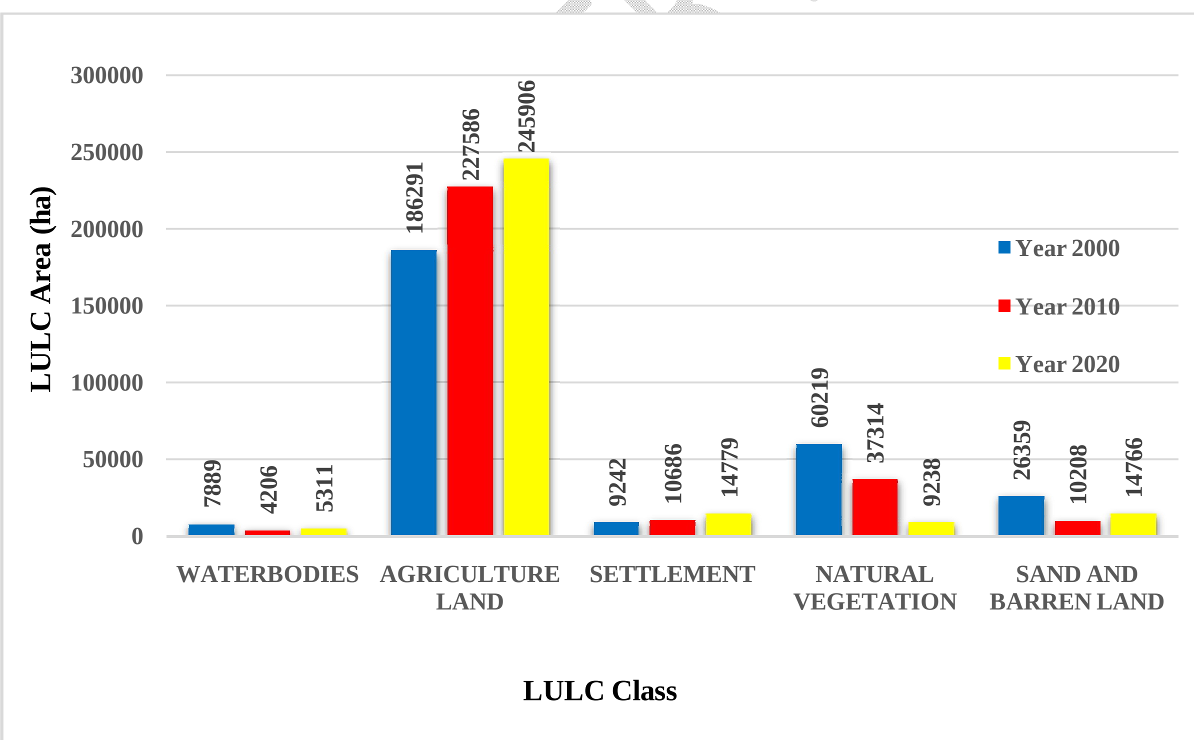

Fig 5 Graphical comparison of LULC for the years 2000, 2010 and 2020

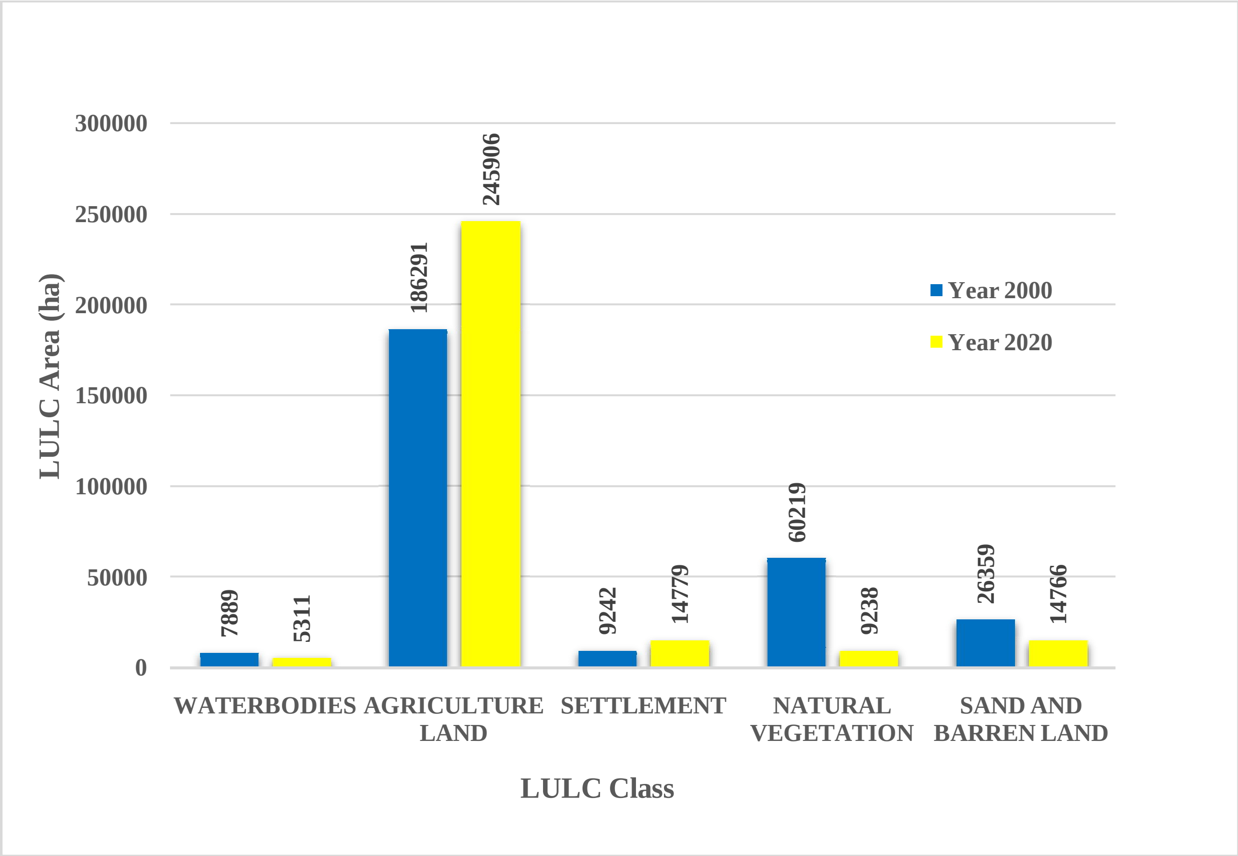

Fig 6 Graphical comparison of LULC for the years 2000 and 2020

4. CONCLUSIONS

The present study indicates that agricultural land area significantly increased during 2000-2010 while it marginally increased in next 10 years (2010-2020). Over the period of 20 years (2000-2020), agricultural land area and settlement area increased whereas natural vegetation, sand and barren land and water-bodies areas decreased. On the basis of results obtained and analyzed, the study infers that natural vegetation coverage in the district is continuously decreasing since year 2000 while settlement is continuously increasing during the period 2000-2020 with notable increase during 2000-2005 and 2015-2020. Hence, the natural vegetation has decreased at fast rate in the recent years. Therefore, proper attention is urgently required to restrict cutting of natural vegetation in the district to save the environment and the ecosystem.

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