Monitoring of Land Use Land Cover Change over the Years Due to River Course Shifting: A Case Study on Ganga River Basin near Malda District, West Bengal Using Geo-informatices Techniques

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Abstract:

The Ganga river basin is the most popular river basin in the world. Within 750,000 square kilometers of the river basin 400 million people are living. A large number of people depend on this river for sustenance and transportation. Due to Ganga river changes and anthropogenic activities, the surface of the landscape is being significantly altered in some manner. Presence of human on the landscape and their use of land has been a profound effect upon the natural environment thus resulting into an observable pattern in the land use/land cover over time. The study examine the use of Remote Sensing and GIS technique on mapping of Land Use/Land Cover (LULC) changes in the Ganga basin due to river course shifting near Malda District of West Bengal, India since 1987 to 2013. A large number of change detection methodologies and techniques, utilizing remotely sensed data, have been developed, and newer techniques are still emerging. In this work pixel based classification method namely **Image subtraction method (ISM)** and **Image Ratio Method (IRM)** has been used to highlighted changes has been made within the study area. By using some statistical calculation we try to predict probability of change each land use of after few years. This study was conducted along the river of the Ganga, which are frequently affected by the floods and due to that erosion is happening. Many socio-economic and demographic factors were changed for such natural hazards in those areas as well as it has effected to whole district. It was observed that growth of urban settlements was rapid since 1987 to 1997 and surprisingly it was decreasing from 1997 to 2013.
Keyword: LULC; IRM; ISM; TM; LISS-IV ; Landset Data & Classification scheme.

1. INTRODUCTION -Change detection is the measure of the distinct data framework and thematic change information that can guide to more tangible insights into underlying process involving land cover and land use changes than the information obtained from continuous change. Digital change detection is the process that helps in determining the changes associated with landuse and land cover properties with reference to geo-registered multi temporal remote sensing data. It helps in identifying change between two (or more) dates that is uncharacterized of normal variation. Change detection is useful in many applications such as landuse changes, habitat fragmentation, rate of deforestation, coastal change, urban sprawl, and other cumulative changes through spatial and temporal analysis techniques such as GIS (Geographic Information System) and Remote Sensing along with digital image processing techniques.

Remote sensing imagery is a precious tool for rapid mapping applications. Remote sensing data of better resolution at different time interval help in analyzing the rate of changes as well as the causal factors or drivers of changes. Hence it has a significant role in regional planning at different spatial and temporal scales. This along with the spatial and temporal analysis technologies namely Geographic Information System (GIS) and Global Positioning System (GPS) help in maintaining up-todate land-use dynamics information for a sound planning and a cost-effective decision. GIS is the systematic introduction of numerous different disciplinary spatial and statistical data that can be used in inventorying the environment, observation of change and constituent processes and prediction based on current practices and management plans. Remote Sensing helps in acquiring multi spectral spatial and temporal data through space borne remote sensors. Image processing technique helps in analyzing the dynamic changes associated with the earth resources such as land and water using remote sensing data. Thus, spatial and temporal analysis technologies are very useful in generating scientifically based statistical spatial data for understanding the land ecosystem dynamics. Successful utilization of remotely sensed data for land cover and landuse change detection requires careful selection of appropriate data set.

Ganga basin near Malda district,the state of West Bengal has witnessed remarkable expansion, growth and developmental activities such as building, road construction, deforestation and many other anthropogenic activities just like many other district of West Bengal. This has therefore resulted in increased land consumption and a modification and alterations in the status of land use land cover over time without any detailed and comprehensive attempt (as provided by a Remote Sensing data and GIS) to evaluate this status as it changes over time due to Ganga river sifting with a view to detecting the land consumption rate and also make attempt to predict same and the possible changes that may occur in this status so that planners can have a basic tool for planning. It is therefore necessary for a study such as this to be carried out present land use/landcover condition and the appropriate management plane for future.

2.OBJECTIVES:

The following specific objectives will be pursued in order to achieve the aim above.

- To delineate actual change of river courses over the year.
- To create a land use land cover classification scheme
- To determine the trend, nature, location and magnitude of land use land cover change.
- To forecast the future change pattern of land use land cover in the area.

3. DATA, METHODOLOGY AND TOOLS:

The study is planned to be carried out in two part; the first part is to identify the trends of river change from previous and recent data .and the second part is based on the Landset Imagary to show Land use Land cover pattern change difference. The specifications of the datasets is given below-

Table No 1.Satellite Data uses

Name of the Satellite	Name of the Sensor
Landsat - 5	TM
Landsat - 7	ETM+
Resourceset - 2	LISS-IV

In the planned study the following Remote Sensing and GIS software is being used.

1. ERDAS IMAGINE
2. Arc-GIS

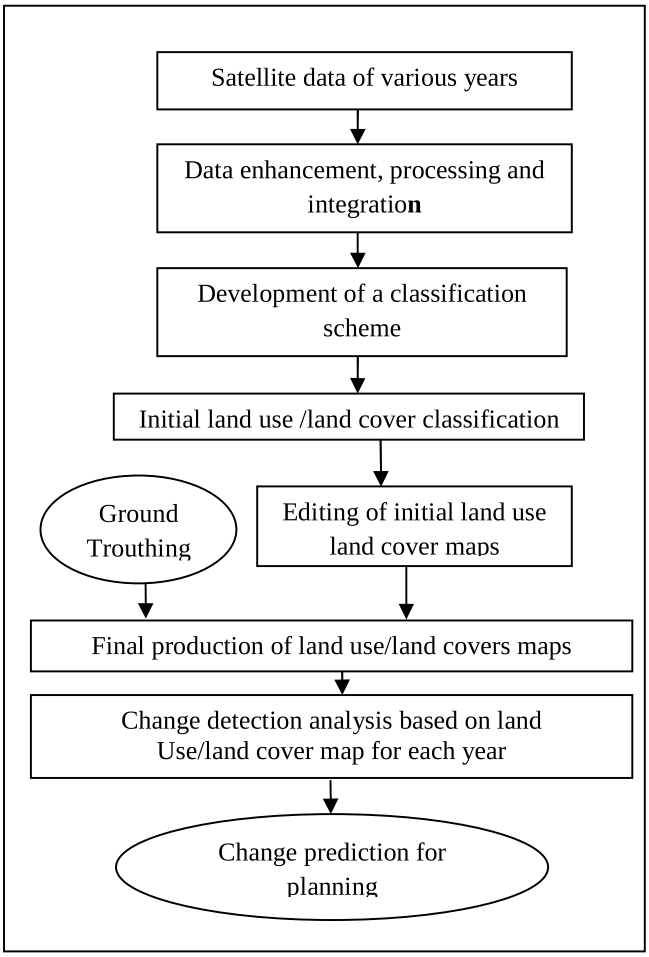
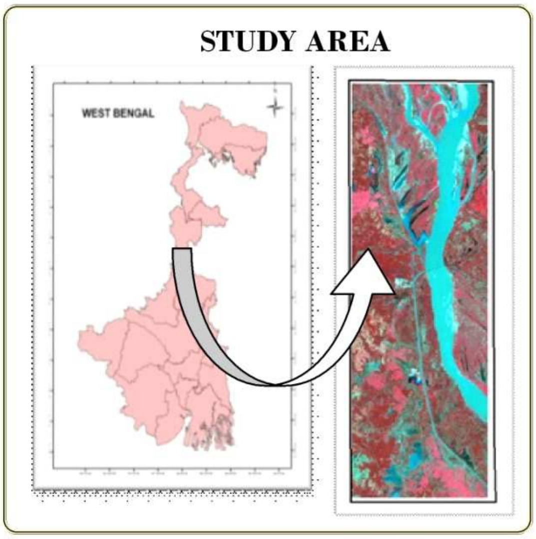


Fig.1-Flow Chart of Methodology

4. ABOUT THE STUDY AREA: The study area located between 25^{o}”N to $24^{o}33’30”$ N and $87^{o}50^{'}$E to $87^{o}59^{'}30^{''}$E, the study area is bounded to its due south by the district of Murshidabad across the river Ganga, by Bangladesh and Dakshin Dinajpur district to its east and northeast, by Uttar Dinajpur district to its direct north and by the states of Bihar to its direct west and Jharkhand across the Ganga to the southwest. the river Ganga has limited length in West Bengal, with a bank line of only 76 km on its left bank in Malda district.



4.1 Climate- Annual precipitation decreases from northern to the southern parts of the area.. The uneven spatial distribution of rainfall in the area occurs because of the patterns of variation in its topographic profile and the tracks followed by monsoon depressions. Rainfall is also unevenly distributed over the year, as a consequence of which over 90 percent of the annual precipitation descends during the monsoon months. Runoff too falls off drastically from the north to the south, and averaging only 0.538cu.m per sq.km in the vicinity of Englishbazar.

Both during summer and also the rainy months, very deep water tables occur in the Barind upland tracts located south_eastern part of the ganges river.

5. RIVER COURSE CHANGE:

This study was conducted along the river line tract of the Ganga, which are frequently changed. For this changing area is affected by regular floods and erosions. Many socioeconomic factors were changed for such natural hazards in those area and it also changed the demographical factors of the area as well as of the whole district.

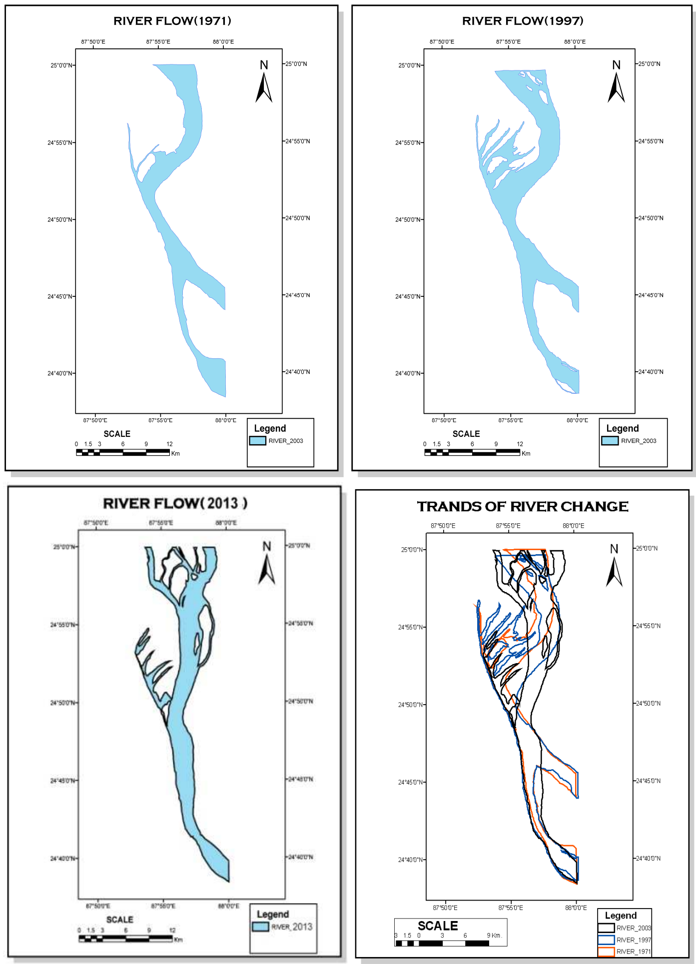


Fig. 2 -River course change from 1971-2013

6. CHANGE DETECTION METHODS

There are many types of change detection methods of multi-spectral image data. They can be classified as three categories: characteristic analysis of spectral type, vector analysis of spectral changes and time series analysis. The aim of characteristic analysis of spectral type method is to make sure the distribution and characteristic of changes based on spectral classification and calculation of different phases remote sensing images。 The methods are multi-temporal images stacking, algebraic change detection algorithm of image, and change detection of the main components of the image and change detection after classification. The aim of the method of vector analysis of spectral changes is to make sure the strength and direction characteristics of changes based on radicalization changes of images of different time especially analyzing the differences of each band. The aim of the method of time series analysis is to analyze the process and trend of changes of monitoring ground objects based on remote sensing continual observation data. Image subtraction method, image ratio method and the method of change detection after classification are three main methods to derive the changes has been made over time.

6.1. Image subtraction method

Image subtraction method is a change detection method of the most extensive application. It can be applied to a wide variety of types of images and geographical environment. It is generally conducted on the basis of gray. A subtraction image is gained from the subtracting of the gray value of corresponding pixels of images after image registration. The gray value of the subtraction image is to show the extent of changes of two images. The changed region and unchanged region is determined by selecting the appropriate threshold values of gray of subtraction image. The formula is:

$$\bar{D}x^k_{ij} = x^k_{ij}(t_2) - x^k_{ij}(t_1) + C$$

Where i, j as pixel coordinates, k for the band, $x^k_{ij}(t_1)$ for the pixel(i, j) value of k-band image, t_1, t_2 for the time of the first and the second image, C is constant.

For most change detection methods, the choice of the threshold value decides the capability of change detection. Choosing a suitable threshold value can maximum separate the areas of real change and the areas of the impact of random factors. The inspecting and the selection of a low threshold value will cause void inspecting. In the new gained image, positive or negative value of the image denotes the region whose radiation value is changed, and there is no change in the region when the image value is 0. In the 8-bit image, pixel value is ranging from 0 to 255, and its image subtraction value is ranging from -255 to 255. As the subtraction value is often negative, it can add a constant C. The brightness values of subtraction image are often approximating Gaussian distribution, the unchanged pixels are centralizing around average value and the changed pixels are in the distribution of the tail.

6.2. Image Ratio Method - A pixel value of a time image divides the corresponding pixel of another time image is the image ratio method. In this method, the ratio of corresponding pixels in each band from two images of different periods after image

$$Rx^k_{ij} = x^k_{ij}(t_1) / x^k_{ij}(t_2)$$

registration will be calculated. The formula is:

If the corresponding pixels of each image have the same gray value, namely $Rx^k_{ij} = 1$, showing that there has been no change occurred.

In the changed region, the ratio will be much greater than 1 or far less than 1 according to the different direction of changes. As in many cases, $x^k_{ij}(t2)$ may be equal to zero. In order to overcome this situation, the denominator would be added a very small value (e.g. 0.01) when the denominator is equal to zero on the computer. Because the real ratio is ranging from 1 / 255 to 255, the range of the ratio is usually normalized to 0～255 for display and processing. 1 of the ratio is usually assigned to 128 of brightness. 1 / 255 to 1 of the ratio would be transformed to 1 ~ 128 by the following linear transformation:

$$N\bar{R}x^{\mathbf{k}}_{\mathbf{ij}} = \mathrm{Int}[Rx^{\mathbf{k}}_{\mathbf{ij}} \times 127+1]$$

1 / 255 to 1 of the ratio would be transformed to 128~ 255 by the following linear transformation:

$$NRx^{\mathbf{k}}_{\mathbf{ij}} = \mathrm{Int}[128 + Rx^{\mathbf{k}}_{\mathbf{ij}}/\mathbf{2}]$$

A threshold value is needed to select to outlining significant changes region in the ratio image. The ratio image will be converted to a simple change / no change image or positive change / negative change image to reflect distribution and size of the changes. The choice of threshold value must be based on the characteristics of the regional research targets and the surrounding environment. A threshold value will vary in different regions, different times and different images. The threshold value border of "change" and "no change" pixels is often chosen from the histogram of the ratio image.

7. EFFECT ON LAND USE LAND COVER-Land use and land cover change have been among the most important perceptible changes taking place around us. Information on land use/land cover in the form of maps and statistical data is very important for spatial planning, management and utilization of resources. Here we examine major landuse/Landcover class to delineate effect of river sifting.

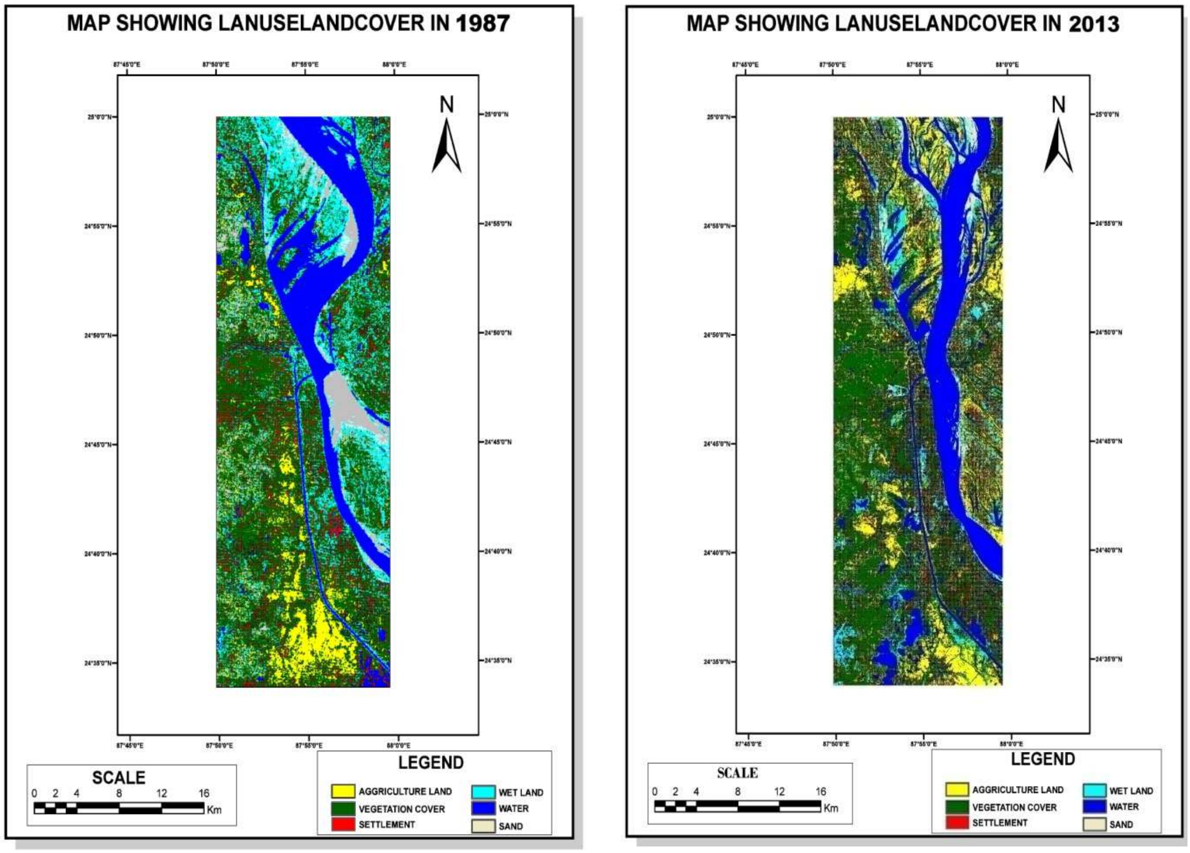


Fig.3- shows that the landuse/landcover categories

Table no.2 LULC change from 1987 to 2013.

Land use category	1987		2013	
	Area (acre)	% of area	Area(acre)	% of area
Vegetation	77147.0	39.8	64129.6	33.05
Sandy Area	12603	6.5	6780.12	3.5
Settlement	15022.89	7.74	22953	11.82
Agriculture	27715	14.28	36444	18.78
Water Body	31034.8	16.0	41053.1	21.16
Wet Land	30500	15.7	22669.6	11.68
Total	194029.3	100	194029.3	100

Table.no-2 shows that the landuse/landcover categories and its distribution in 1987 and 2013.In 1987 the river Ganga flows in meandering form which totally change in 2013 and it flows straightly, that means if sifts towards eastern side of the study area. For this reasons some land cover like settlement, agriculture, vegetation, wet land are affected very seriously, that means area of land covers are changed over time period. For that reason we represent some of feature changes given bellow

7.1. Vegetation-

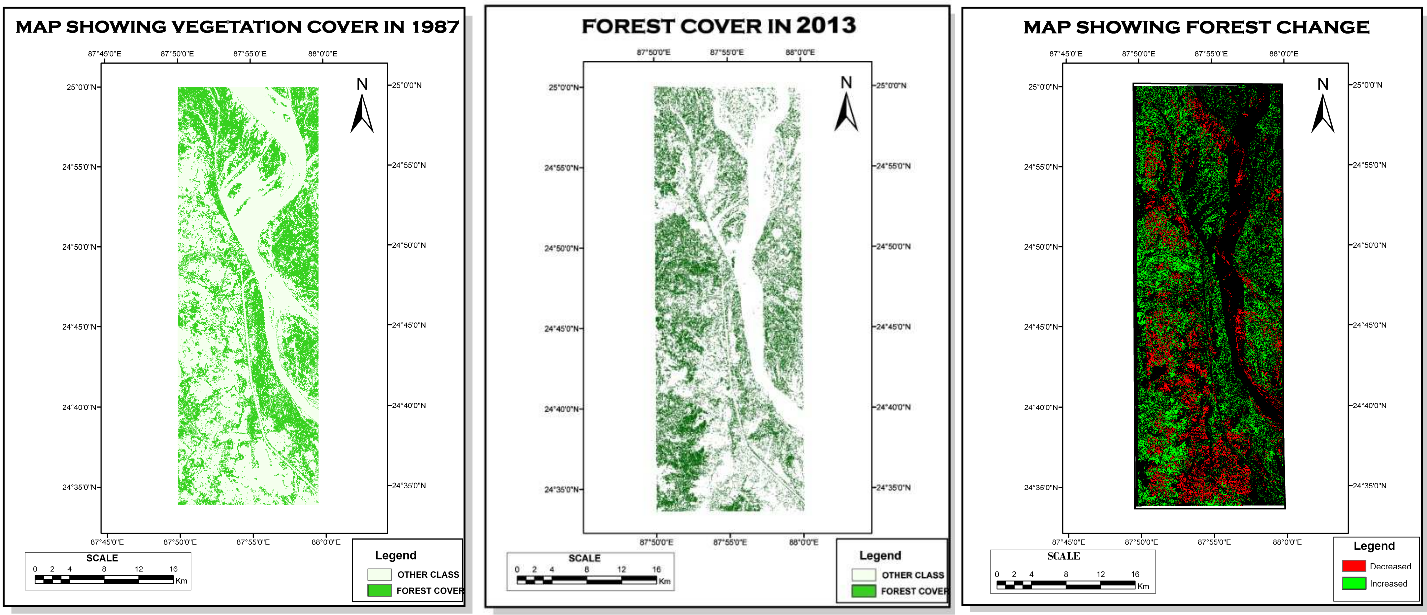


Fig.4- shows that the vegetation cover in 1987 and 2013 and its changes over time.

7.2. Agriculture-

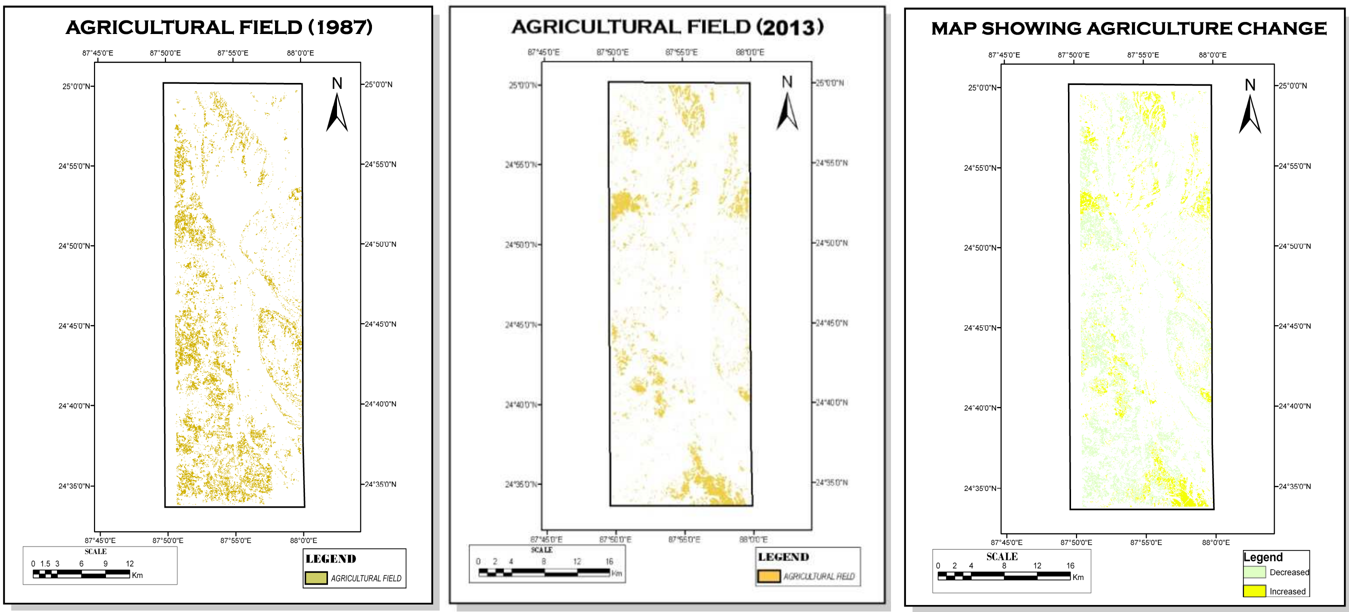


Fig .5- Represent the agricultural land distribution1987 & 2013 and its change over time .

7.3. Settlement-

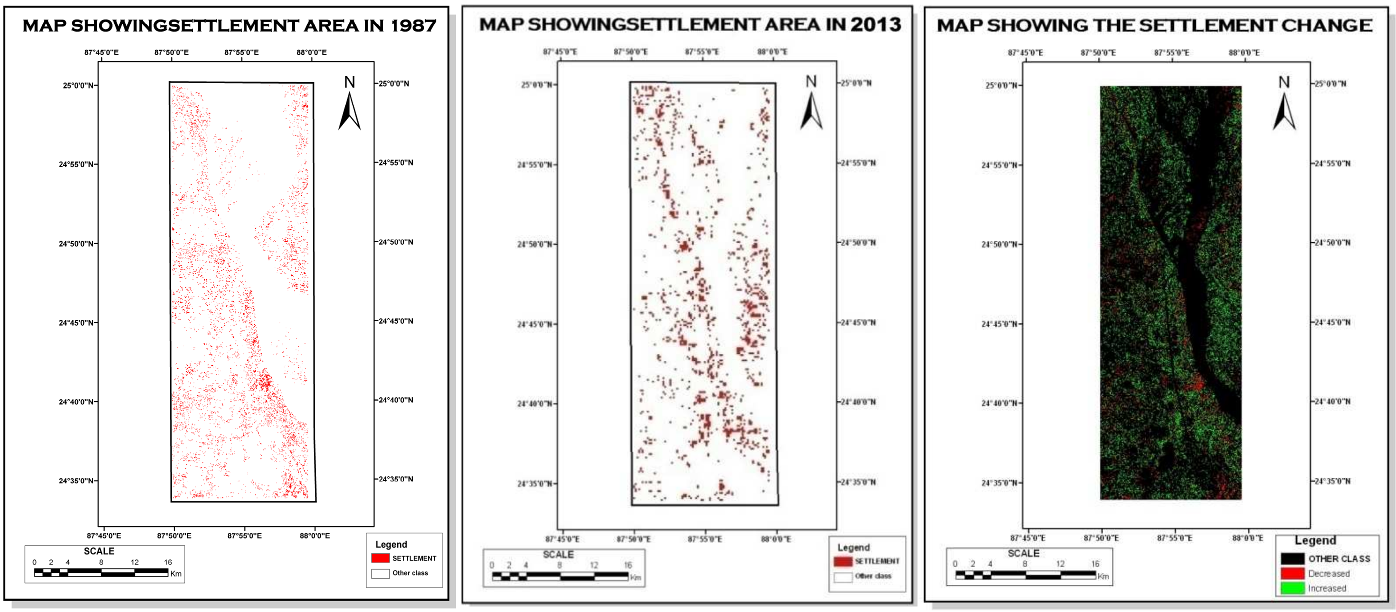


Fig-.6- Represent that the Habitat area in1987 & 2013 and its change over time .

8. RESULT AND DISCUSSION.

Transition Probability :

The transition probability records the probability that each land cover category will change to the other category. By using this statistical calculation we can predict probability of each land use of after few years. Here it predict lanuse of 2025 by using some statistical calculation steps .

- **Step-1**

Percentage change to determine the trend of change can then be calculated by dividing observed change by sum of changes multiplied by 100.

<u>Percentage change</u> = (observe change/sum of change)*100................ Equation no:1

- **Step-ii)**

In obtaining annual rate of change, the percentage change is divided by 100 and multiplied by the number of study year 1987 – 2003(12years).

<u>Annualchange</u> = (percent change/100)*study year(12) ....equation no:2

Table no.3 Annual change rate, using equation no. 1&2

Landuse category	Area change	Percent change	Annual change rate
Vegetation	-13024.4	-24.4	2.928
Sandy Area	-5822.88	-10.9	1.308
Settlement	7930.11	14.86	1.7832
Agriculture	8729.0	16.36	1.9632
Waterbody	10019.0	18.77	2.2524
Wet Land	-7830.0	-14.68	1.7616
Total	53355.79		

Table no.4- projected Land use/Land cover distribution from 1987-2025

Sl. No	Land use categor	1987		2013		2025	
		Area(acre)	% of are	Area(acre)	% of are	Area(acre)	% of are
1	Vegetation	77147.0	39.8	64129.6	33.05	26348.0	13.5
2	Sandy Area	12603	6.5	6780.12	3.5	9635.32	4.9
3	Settlement	15022.89	7.74	22953	11.82	33701.79	17.3
4	Agriculture	27715	14.28	36444	18.78	54410.08	28.0
5	Water Body	31034.8	16.0	41053.1	21.16	69902.78	36.0
6	Wet Land	30500	15.7	22669.6	11.68	14012.00	7.2
	Total	194029.3	100	194029.3	100	194029.3	100.0

Table no 4 shows that the projected landuse/landcover distribution in 2025 The area of settlement were 15022 acres in 1987 and it increases gradually in 2013 where it covered 22953acres. The population near the Ganga River migrates towards the eastern side due to the river change.The settlement, Agriculture & Water Body has been increase gradually in the period of 1987 to 2025.But Vegetation & sandy area has been decrease relatively in the period of 1987 to 2025.

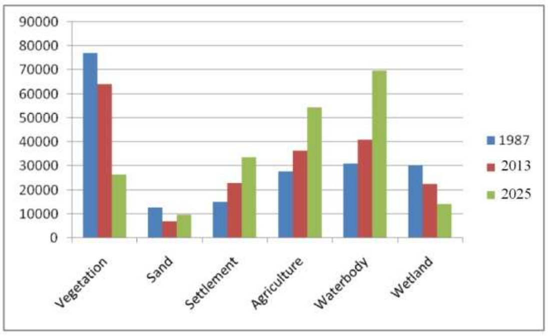


Fig.7- show the projected LULC change

9. CONCLUSION

This research work demonstrates the ability of Geoinformatics in capturing spatial-temporal data. Attempt was made to capture as accurate as possible six land use land cover classes as they change through time. Besides, to prepared year wise river course change map. The six classes were distinctly produced for each study year (1987 to 2013) but with more emphasis on settlement land as it is a combination of anthropogenic activities that make up this class; and indeed, it is one that affects the other classes.

However, the result of the work shows a rapid growth in settlement land between 1987 and 1997 while the periods between 1997 and 2013 witnessed a reduction in this class. It was also observed that change by 2025 may likely follow the trend in 1987 to 2013 all things.

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