MONITORING LAND USE / LAND COVER CHANGES USING REMOTE SENSING AND GIS: A CASE STUDY ON KANCHRAPARA MUNICIPALITY AND ITS ADJOINING AREA, WEST BENGAL, INDIA

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Abstract

Changes in land use are a very important issue. Through the discussion of land use change it is easy to know the relationship of a person living in that place with that place. This paper demonstrates the land use changes of Kanchrapara Municipality and its adjoining area through the use of some techniques of remote sensing and GIS (Geographical Information System). Two Landsat satellite images with a range of twenty years have been used to apply these techniques. These images were of the Landsat-7 ETM+ (Year 2000) and Landsat-8 OLI-TIRS (Year 2019). ArcGIS 10.5 software has been used for pre-processing of these images. Then the supervised classification method has been used for the classification of those images using QGIS 3.4 software using the maximum likelihood algorithm. Four types of land use categories have been identified by image classification based on satellite images and Google maps. These were water bodies, vegetation coverage area, bare soil and built up area. Of these, only the amount of bare soil has increased (+17.22%) and the rest of land use categories decreased comparatively. The reasons for the increase and decrease of this level were also discussed here. Accuracy assessment has been also done to determine the accuracy of image classification. Where the overall accuracy of two decades was 82.39 % and 83 % respectively, with the Kappa coefficient was 0.75 and 0.76 respectively. Finally, there is a comparative discussion of two decades of land use using change detection techniques.

Keywords: Land use/ land cover changes, Image processing, Accuracy assessment, Kappa Coefficient, Change detection technique

JEL classification: C00, C89, R14, R52

1. Introduction

In the context of global environment, land use/ land cover (LULC) changes are major changes. Land cover describes the variations in the region or type of physical materials on the Earth's surface, like as water, forest, grass etc., which can be directly observed by the remote sensing techniques (Fisher et al., 2005). Land cover is a primary parameter, which describe the Earth's surface. Different parts of human and physical environments are also linked with this parameter (Foody, 2002). On the other hand, land use means the use of land. According to Nanavati (1957), "Land utilization is the conversion of land from one major use to another general use. Land is the basic natural resource which provides space and many raw materials for various development and other activities." But in the present context, this component is used in a frequently manner due to the human activities. For this reason uses of land are changed continuously. One of the reasons for the change in land use is the growing socio-economic needs. As a result, unplanned and uncontrolled land uses changes (Seto et al., 2002). LULC change usually results from mismanagement of settlements, cultivation, deforestation and other uses for water bodies. It also results in various environmental problems.

On the basis of different techniques of Remote Sensing and GIS, this type of land use change is clearly observed. Remote Sensing and GIS techniques are very useful to mapping the land use/ land cover change and detailed method to enhance the selection of areas designed to agricultural, urban and industrial areas of a particular region (Selcuk et al., 2003; as cited in Rawat et al., 2013).

The accuracy of spatial data has been defined by the United States Geological Survey (USGS) as: "The closeness of results of observations, computations, or estimates to the true values or the values accepted as being true" (USGS, 1990; as cited in Banko, 1998). For the process of analyzing remote sensing data accuracy assessment is an important step. It sets the data value of the result data to the user. Overall accuracy of the classified image is explained that out of all of the references sites what proportion were mapped correctly. Omission error indicates the reference sites which were omitted from the correct class in the classified map and its help to calculate the producer's accuracy. Another type of accuracy is user's accuracy, which is calculated form commission error. User's accuracy expresses that how often the class on the map will actually be present on the ground (Rwanga et al., 2017). Error matrix and Kappa coefficients are currently used to accurately assess the accuracy of accuracy assessment.

Change detection technique is one of the various strategies that have been developed to understand the past and present situation of land. Change Detection process is identifying variety of an object in a region through the time, which provides to study the pattern and processes of ecosystems at a range of geographical and temporal scales (Singh, 1989). "Remote sensing has been widely used in updating land use/cover maps and land use/cover mapping has become one of the most important applications of remote sensing" (Lo, 2004; as cited in Rawat et al., 2013).

2. Objective

The main objective of the study is to analyze the land use/ land cover (LULC) changes using remote sensing and GIS techniques within two decades of the study area.

3. Study Area

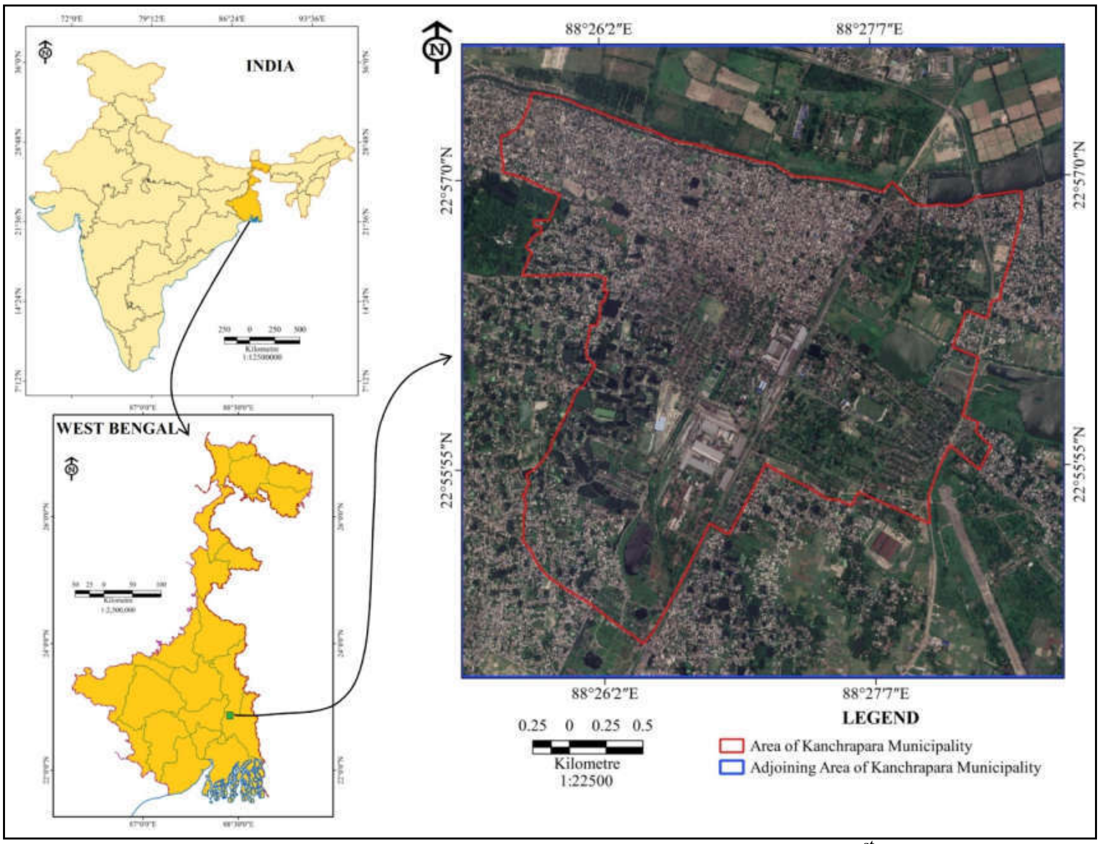
In this study, Kanchrapara Municipality and its adjoining areas have been taken as study area. Locationally, the study area belongs to the Barrackpore-I sub-division of North 24 Parganas district in the Indian state of West Bengal. The study area belongs to the Kolkata Metropolitan District Area (KMDA). The study area is 17.88 sq. km. (Based on Landsat-8 satellite image) and its latitudinal extension is 22°55′09″N to 22°57′30″ N and longitudinal extension is 88°25′28″E to 88°27′53″E (Figure 1). Its average elevation is 10 metre from mean sea level (Banerjee et al., 2014).

Geographically, the study area belongs to the lower Gangetic plain on the east bank of the Hooghly River. As a result, the surface area (Figure 2) of the land is almost equal. Usually the height of the land here is 8 metre to 22 metre (Google earth pro, 2020). In the study area, part of a lake called Mathura Lake (local name Mathura Jhill) is located to the east, which is the Oxbow lake of Hugli river (Rudra, 2012).

Geologically, the study area was formed in the Holocene and late Holocene (Meghalayan) age. This is also a newer alluvium sub-region of the lower Gangetic Plain; basically here four types of formation are found namely Panskura (western side), Chinsura (southern side), Bhagirathi-Ganga (northern side) and present day formation. Study area belongs to the present day formation which is formed by the sand, silt, clay and yellowish brown fine sand (Figure 3).

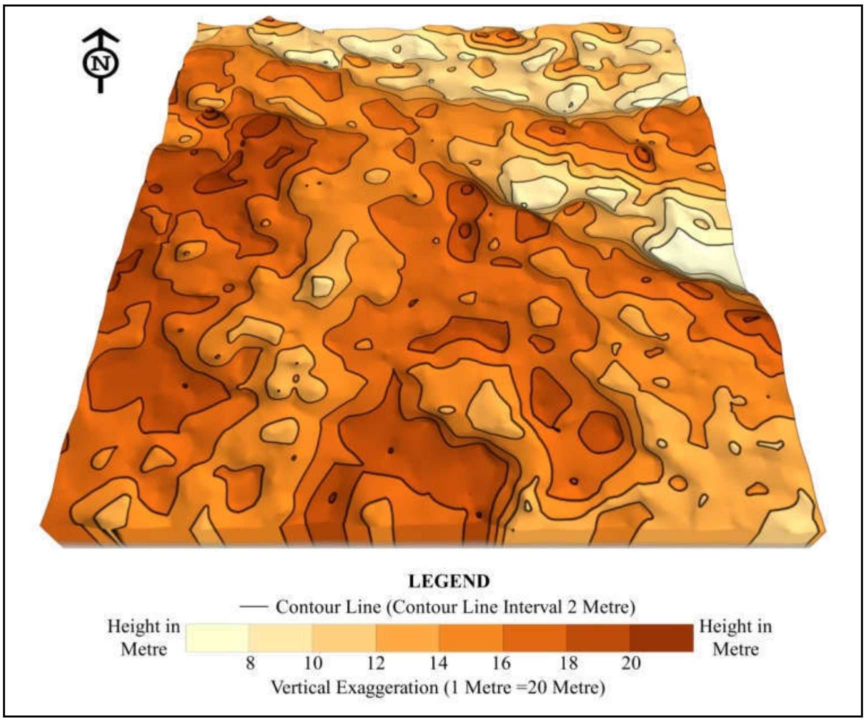
Study area is belonging to the monsoonal climate. Its maximum temperature and minimum temperature are 39°C and 8°C respectively (District Census Hand Book, North Twenty Four Parganas, 2011). The distribution of rainfall is uneven across the year. Total annual rainfall is 1693mm (State Statistical Handbook 2015). Most of the rainfall is found to occur during the months of May, June, July, August, September and October (District Census Handbook, North 24 Parganas, 2011).

Figure 1: Location Map of the Study Area



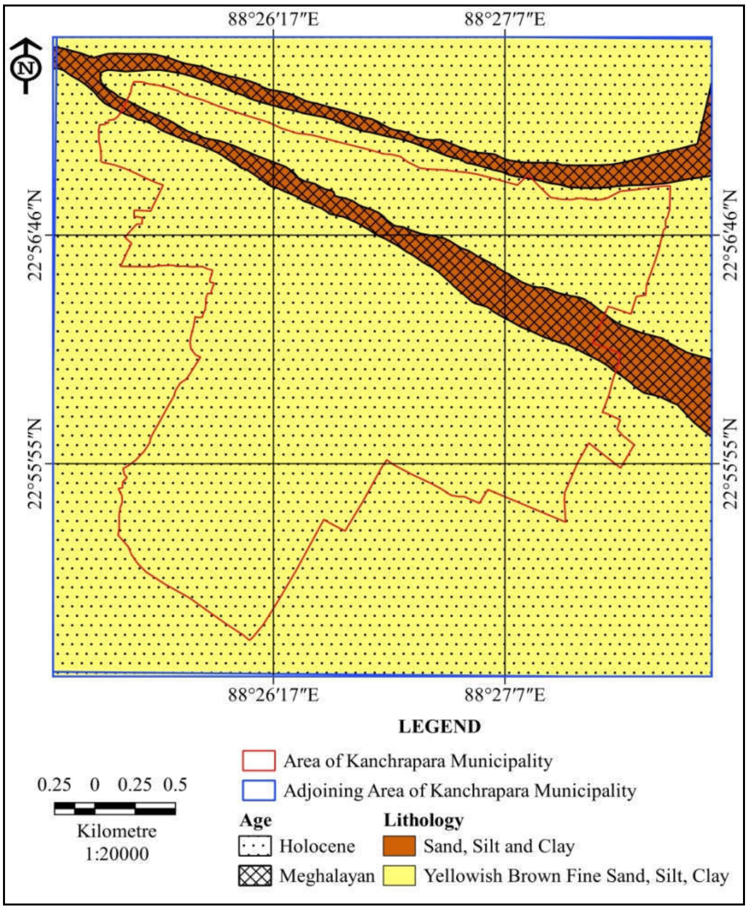
Sources: West Bengal Secondary School Atlas (NATMO, DST, Govt. of India, 1st edition2010), Census of India (2011), Kanchrapara Municipality and Google Earth Pro, 2020

Figure 2: Land Surface of the Study Area



Source: Google Earth Pro, 2020

Figure 3: Geology of the Study Area



Source: Totosheet no. 79B05, Geological Survey of India

4. Methodology

4.1. Data

Landsat ETM+ and Landsat 8 OLI/TIS images (path 138 and row 044) were used in this study. The Landsat ETM+ (acquisition date 17th November 2000) and Landsat 8 OLI/TIS satellite images (acquisition date 6th may 2019) were downloaded from United States Geological Survey (USGS) Earth Explorer (https://earthexplorer.usgs.gov/). The dates of the selected Landsat satellite images (Table 1) were chosen to be closely as possible in the same season. Spatial resolution is 30 metre of the both Landsat satellite images. All visible bands were included in the analysis. In this study, using Arcgis 10.5 and QGIS 3.4 software for the purpose of image processing.

Table 1. Details of Satellite Images

Satellite	Path/row	Projection	Layers	Date of acquisition	Spatial resolution
Landsat 7 ETM+	138/044	UTM-WGS84	8	17th November 2000	30 m
Landsat 8 OLI/TIS	138/044	UTM-WGS84	11	6th May 2019	30 m

Source: United States Geological Survey (USGS) Earth Explorer

4.2. Preprocessing of the Satellite Images

Both Landsat satellite images were georeferenced to the Universal Transverse Mercator (UTM) coordinate system and WGS_84 datum. Pre-processing such as georeferencing, layer stacking, geometric correction and radiometric correction were done in the ArcGIS 10.5 software.

4.3. Image Classification

In this study, only supervised classification method was used for compared the two dated Landsat satellite images. According to supervised classification report only four LULC classes were founded as water bodies, vegetation coverage area, bare soil and built up area. Land cover classes descriptions are presented in table 2. Both images are independently classified in supervised classification method with the help of maximum likelihood algorithm using QGIS 3.4 software. The supervised classification was applied after identified the area of training classes. The training classes were selected based on Landsat image, Google Earth and Google map.

Table 2. Land Cover Classification Scheme

Land cover classes	Description
Water body	Lakes, ponds
Vegetation coverage area	Mixed forest with higher density of trees (mango, jack fruit, sal tree etc.) Shrub, agricultural land
Bare soil	Areas with no vegetation cover, uncultivated agricultural land, land with exposed soil, bare ground
Built up area	Residential area, industrial area, commercial services, transportation and other manmade structures

4.4. Sample Selection

After the supervised classification, the next stage was to calculate sample size (Kothari et al., 2019) based on pixel value of the training classes. For which this formula has been applied here

$$n = \frac{z_{\alpha/2}^2 . p . q . N}{e^2(N-1) + z_{\alpha/2}^2 . p . q} \quad (1)$$

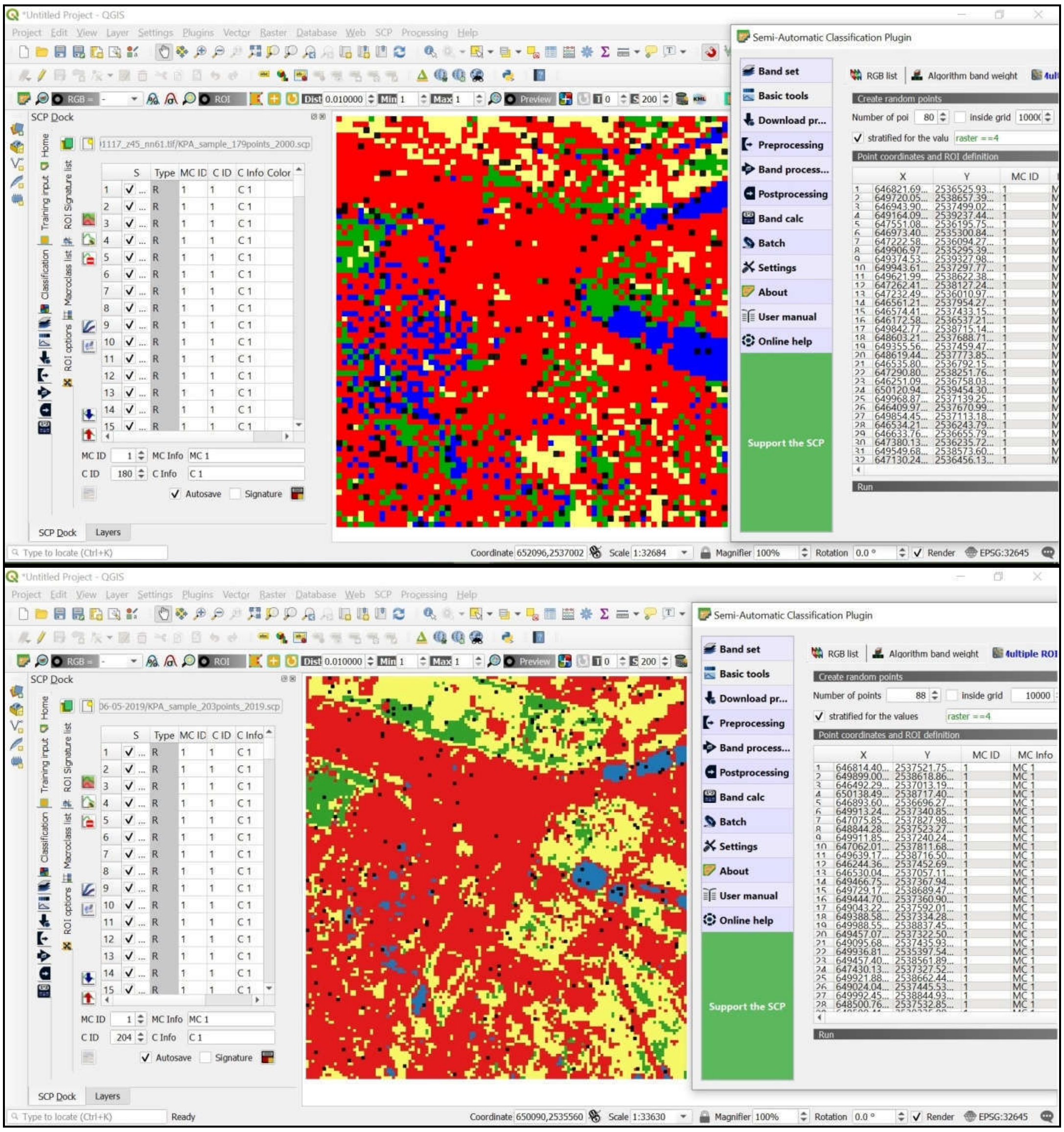
where, n = sample size, N = total sample, $z_{\alpha/2}$ = 1.96 (as per table of area under normal curve for the given confidence level of 95%), p= proportion of the total number of sample (0.51), q= $(1-p)$, e = estimation error (0.03)

After determining sample size, the stratified sample method has been used for random point selection of the training classes.

4.5. Accuracy Assessment

Accuracy assessments determine the correctness of the classified image. Accuracy is a measure of the agreement between a standard that is assumed to be correct and a classified image of unknown quality. If the image classification corresponds closely with the standard, it is said to be accurate (Bhatta, 2013). There are several ways to complete the accuracy assessment, one of which is to compare the reference image with the classified image. In this study, to generated some random set of point and compared the classification results with the ground truth data through the Google earth, Google map and satellite images (Figure 4).

Figure 4: Landsat Classified Image (year 2000 and 2019 respectively) of the Study Area Covered with Points from Random Sampling



Error matrix is in the most common way to present the accuracy of the classification results (Fenglei et al., 2007 as cited in Selçuk, 2008). In this matrix, classification result is shown as row wise and ground truth result is shown as column wise for each sample point. The diagonal elements in the error matrix indicate the correct data, which is already compared between the reference data and ground truth data. Overall accuracy, producer's accuracy and Kappa statistics were derived from the error matrix (Gebhard, 1998 and Sophia, 2017). The Kappa coefficient (K) has been computed by this equation:

$$K = \frac{N\sum_{i=1}^{r} X_{ii} - \sum_{i=1}^{r}(X_i + X_{+i})}{N^2 - \sum_{i=1}^{r}(X_i + X_{+i})} \quad (2)$$

where, N = total number of observations (pixels), r = number of rows and columns in error matrix, X_{ii} = number of observation in row i and column i, $X_i +$= marginal total of row i, and X_{+i}= marginal total of column i

If the value of Kappa coefficient is equal to one that the agreement is perfect, and if it is close to zero that it is not better as expected. As per (Rwanga, 2017) categorization of Kappa statistic is widely referenced which is re-produced in (Table 3).

Table 3. Rating Criteria of Kappa Statistics

Sl. No.	Value of K	Strength of agreement
1	<0.00	Poor
2	0.00 – 0.20	Slight
3	0.21 – 0.40	Fair
4	0.41 – 0.60	Moderate
5	0.61 – 0.80	Good
6	0.81 – 1.00	Very good

Source: Rwanga, 2017

The overall accuracy represents the sum of all correctly classified samples (pixels) divided by the total number of reference samples (test pixels). For expressing the overall accuracy this equation (Bhatta, 2013) has been applied:

$$\omega = \frac{\sum_{i=1}^{nc} e_{ii}}{NT} \times 100 \quad where, NT = \sum_{i=1}^{nc}\sum_{j=1}^{nc} e_{ij} \qquad (3)$$

Where, ω= overall accuracy in percentage, nc= total number of class, e_{ii}= element in i^{th} row and i^{th} column, NT= total number of samples, e_{ij}= element in i^{th} row and j^{th} column

The mapping accuracy for each land use land cover class is known through comparative discussions between producer accuracy and user accuracy. The more errors of omission and commission exist, the lower producer's accuracy and also lower user's accuracy. To calculate the producer's accuracy and user's accuracy (Abdelkareem et.al., 2018) using the following equations:

$$\text{Producer's accuracy} = \frac{aii}{\sum_{i=1}^{n} a_{i+}} \qquad (4)$$

$$\text{User's accuracy} = \frac{aii}{\sum_{i=1}^{n} a_{+i}} \qquad (5)$$

Where, aii= number of samples correctly classified, a_{i+}= column total for class i, a_{+i}= row total for class i

5. <u>Result and Discussion</u>

5.1. Land Use/ Land Cover (LULC) Classification in 2000 and 2019

Land use land cover classification was done in the study area under the supervised classification method using maximum likelihood algorithm. On the basis of the number of pixels count the area of each class was calculated. Thus the allocations of each classified area are tabulated in Table 4 and shown in the Figure 5.

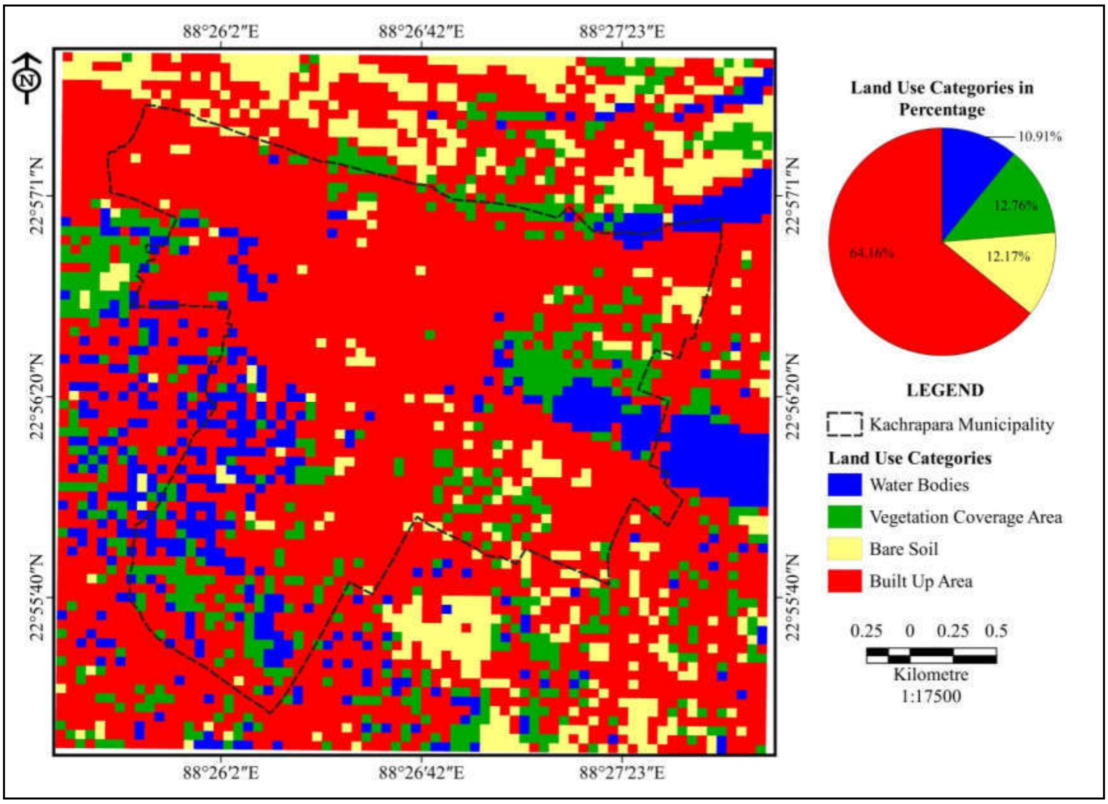
Table 4. Land Use/ Land Cover (LULC) Categories of the Study Area in 2000

Land use / land cover categories	Area in Sq.Km.	Percentage (%)
Water bodies	1.94	10.91
Vegetation cover	2.27	12.76
Bare soil	2.16	12.17
Built up area	11.41	64.16

Source: Data Computed by Authors from Landsat 7 ETM+ Satellite Image (2000)

Based on the land use land cover map of 2000 (Figure 5), the area and percentage of areas as classified are water bodies 10.91 % (1.94 Sq.Km.), vegetation coverage area 17.76 % (2.27 Sq.Km.), bare soil 12.17 % (2.16 Sq.Km.) and built up area 64.16 % (11.41 Sq.Km.). The dominated land use class was built up area, which is occupied around 64% of the total study area.

Figure 5: Land Use/ Land Cover (LULC) Map of the Study Area, 2000



Source: Landsat 7 ETM+ Satellite Image, 2000

But in the year of 2019, some changes are going to be noticed in the study area. During the field survey and also through Landsat satellite images and also satellite view through the Google Earth it is observed that maximum area under the residential and commercial used.

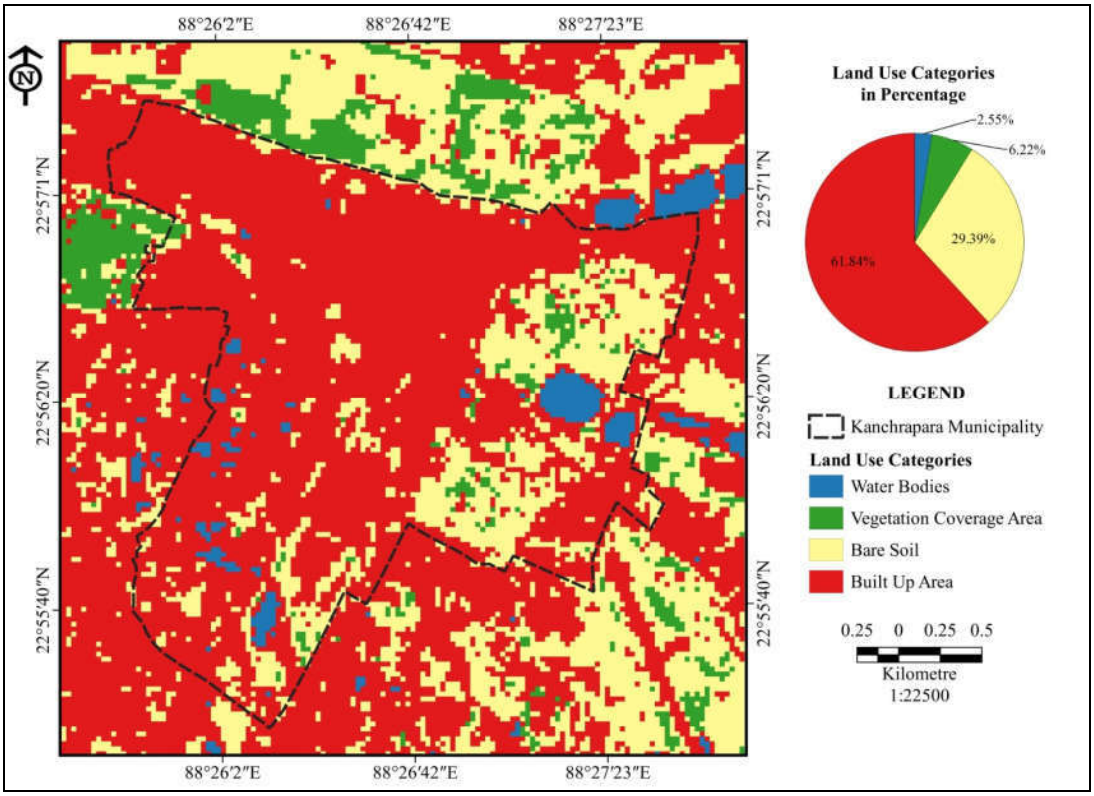
In the land use land cover map of 2019 (Table 5 and Figure 6), area and percentage of classified land use classes are water bodies 2.55 % (0.46 Sq.Km.), vegetation coverage 6.22 % (1.11 Sq.Km.), bare soil 29.39 % (5.25 Sq.Km.) and built up area 61.84 % (11.06 Sq.Km.). Even at this time the amount of built up area is more than other land use classes, with the amount of bare soil were also increased.

Table 5. Land Use/ Land Cover (LULC) Categories of the Study Area in 2019

Land use / land cover categories	Area in Sq.Km.	Percentage (%)
Water bodies	0.46	2.55
Vegetation cover	1.11	6.22
Bare soil	5.25	29.39
Built up area	11.06	61.84

Source: Data Computed by Authors from Landsat 8 OLI/TIS Satellite Image (2019)

Figure 6: Land Use/ Land Cover (LULC) Map of the Study Area, 2019



Source: Landsat 8 OLI/TIS Satellite Image, 2019

5.1. Classification Accuracy Assessment

The most important step of the classification process is accuracy assessment. For this purpose, 176 points for Landsat 7 ETM+ (year 2000) and 200 points for Landsat 8 OLI-TIRS (year 2019) were randomly selected to evaluate classification accuracy. Error matrix shows in the table 6 and table 7. The column of the error matrix shows the ground truth data and row show the reference data. The diagonal elements of the error matrix indicate the number of corrected classified pixels. Table 6 and table 7 are also shows the overall accuracy and the Kappa coefficient. The overall accuracy of both classified Landsat satellite images (Figure 5 and 6) were 82.39% and 83% respectively.

Table 6. Accuracy Assessment of the Landsat 7 ETM+ 2000

LULC	W	V	BS	BA	Total	CS	CE (%)	UA (%)
W	**31**	0	0	1	32	31	3.13	96.88
V	0	**31**	2	0	33	31	6.06	93.94
BS	0	3	**18**	11	32	18	43.75	56.25
BA	0	2	12	**65**	79	65	17.72	82.28
Total	31	36	32	77	**176**	**145**		
OE (%)	0.00	13.89	43.75	15.58		**Overall accuracy = 82.39 %**		
PA (%)	100.00	86.11	56.25	84.42		**Kappa Coefficient = 0.75**		

Note: LULC= Land Use/ Land Cover, **W**= Water bodies, **V**= vegetation coverage area, **BS**= Bare Soil, **BA**= Built up Area, **CS**= Corrected Sample, **OE**= Omission Error, **PA**= Producer's Accuracy, **CE**= Commission Error, **UA**= User's Accuracy

Table 7. Accuracy Assessment of the Landsat 8 OLI/TIS 2019

LULC	W	V	BS	BA	Total	CS	CE (%)	UA (%)
W	**24**	0	1	1	26	24	3.85	92.31
V	0	**31**	1	0	32	31	3.13	96.88
BS	1	5	**40**	8	54	40	25.93	74.07
BA	2	5	10	**71**	88	71	19.32	80.68
Total	27	41	52	80	**200**	**166**		
OE (%)	11.11	24.39	23.08	11.25		**Overall Accuracy = 83 %**		
PA (%)	88.89	75.61	76.92	88.75		**Kappa Coefficient = 0.76**		

Note: LULC= Land Use/ Land Cover, **W=** Water bodies, **V=** vegetation coverage area, **BS=** Bare Soil, **BA=** Built up Area, **CS=** Corrected Sample, **OE=** Omission Error, **PA=** Producer's Accuracy, **CE=** Commission Error, **UA=** User's Accuracy

In the classified LULC map of 2000, producer's accuracy ranged from 56.25% to 100% while user's accuracy ranged from 56.25% to 96.88%. The more error of omission exist in bare soil which was indicated the lower producer's accuracy. But a water bodies were found to be more reliable with 96.88% of user's accuracy.

In another classified LULC map of 2019, producer's accuracy ranged from 75.61% to 88.89% while user's accuracy ranged from 74.07% to 96.88%. The more user's accuracy reflects the more reliability of the classification to the user. In that sense user's accuracy and the producer's accuracy were also extremely high so the classification was highly reliable.

The Kappa coefficient of both classified Landsat satellite images were 0.75 and 0.76 respectively which is rated as good.

5.2. Parrallel Discussion between Two Classified Land Use/ Land Cover (LULC) Maps on the Basis of Change Detection Method

If we side-by-side compare between two land use / land cover maps we clearly understood that land use categories has been changed, and we can easily say that it is the result of human activities. It is because of most of the study area is covered by the human residential and commercial area. Here to view the amount of land use/ land cover change, change detection matrixes (Rawat et al., 2013) have been used. Area was calculated through the GIS software.

The following are the four parameters which have been considered to understand the changes in the study area (Table 7).

5.2.1. Water Bodies Area

At present many lakes and ponds were shut for the residential or commercial purposes. In the year of 2000 and 2019 water bodies area was 10.91 % and 2.55 % respectively. So, it is clear that water bodies area are decreased and its decreasing rate is 8.36 %.

5.2.2. Vegetation Coverage Area

Once upon a time the area was dominated by the vegetation namely *"Kanchra"*, which was the one type of edible plant. But in the year of 1863, Kanchrapara Railway Workshop was established. After this time residential area was developed. This trend of residential area expansion is continuing in present days.

Result of this trend, vegetation area is encroached by the other human activities. Amount of vegetation coverage area in 2000 was 12.76 %. But, in the year of 2019 its amount is 6.22 %. So its decreasing rate is 6.53 %.

5.2.3. Bare Soil

In 2000, the amount of bare soil area was 12.17 % and in 2019 its amount was 29.39 %. Rate of change is 17.22%. In that case the rate of change is positive. But during the field survey it is observed that some types of cultivated land and water bodies were converted into bare soil. Because people are buying land and enclosing it with walls, even filling the pond and encircling the area for the future.

5.2.4. Built Up Area

In the year of 2019, the total area of the municipality was fully encroached by the residential and commercial purposes. Because people are coming from different states for the purpose of job. Kanchrapara Railway Workshop is also situated in the study area, so large numbers of employee are lived in the study area. In this paper, roads, settlements, railway workshop area, defense areas are also considered as built up area.

In the year of 2000 and 2019 amount of built up area was 64.16 % and 61.84 % respectively. It decreases 2.32%. In this study area, maximum area is under the Kancharapara Railway Workshop authority. One of the reasons for the decrease in the built up area, during the field survey it is observed that the condition of the staff quarters under Kanchrapara Railway workshop is very bad at present because most of the people are leaving these quarters and moving elsewhere, as a result of which the quarters are no longer habitable and are crumbling due to lack of maintenance.

Table 8. Area and Amount of Change in Different Land Use/ Land Cover Categories in the Study Area During 2000-2019

Land Use / Land Cover Categories	2000		2019		Change 2000-2019	
	Sq.Km.	%	Sq.Km.	%	Sq.Km.	%
Water bodies	1.94	10.91	0.46	2.55	-1.48	-8.36
Vegetation	2.27	12.76	1.11	6.22	-1.16	-6.53
Bare soil	2.16	12.17	5.25	29.39	+3.09	+17.22
Built up area	11.41	64.16	11.06	61.84	-0.35	-2.32

Source: Classified Satellite Images [Landsat 7 ETM+ (2000) and Landsat 8 OLI/TIS (2019)]

In summary, from the analyses and comparative study between two land use maps, it could be found that:

i. The most effective reason for the change in land use in the area is human activity.
ii. Unplanned filling of ponds and use of the area for residential or commercial purposes is one of the reasons for the change in land use pattern.
iii. During the field observations have shown that some lands used to be agricultural field but are now lying bare.
iv. In addition of these, trees have been cut down in many places and all those lands are being used for other purposes.

6. Conclusion

The main aim of this paper is to discuss the changes in land use in Kanchrapara municipality and its adjoining areas between 2000 and 2019 through the use of Remote Sensing and GIS. One of the most important image classification method is supervised classification which is used in this paper. For the post image classification the accuracy assessment in terms of Kappa statistics and error matrixes have been used for classification results to be sure. This paper concluded with excellent producer’s and user’s accuracy, and the Kappa coefficient also rated as good strength of agreement. However, some classes reached the satisfactory level of user accuracy. The change detection method is also used here, which makes it easy to understand the extent of land use change. Thus, to achieve the high level of classification accuracy it is recommend that to use the high resolution of remotely sensed satellite data with low temporal difference.

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