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Research Article

Land Use and Land Cover Change Detection: A Comparative Approach Using Post Classification Change Matrix and Discriminate Function Change Detection Methodology of Allahabad City

Ashutosh Singh[a], Shalini Singh[b], Purushottam Kumar Garg[a], Kamlesh Khanduri[c*]

[a]Forest Survey of India (FSI), Dehradun, Uttrakhand
[b]Center for Development of Advance Computing (C-DAC), Noida
[c]Dpt.of Geography, HNBGU, JRF, FSI, Dehradun,

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Abstract

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. Remote sensing data are primary sources extensively used for change detection in recent decades. In this context, the main objective of this paper is to present the change analysis between two different techniques of change detection to analyze the variability of land use/land cover dynamics in Allahabad City (50 Sq.Km. Area), Uttar Pradesh, using multitemporal analysis of multispectral images of ETM+, TM Landsat (1990-2000) and digital SOI topographic maps. The study has produced a land use/ land cover map of Allahabad City (50 Sq.Km. Area) at two (1990, 2000) point of time in order to detect the changes that have taken place in fourteen different classes. Sixty possible changes and no change classes were identified. Ten year time period of 1990 -2000 shows some major land use changes. This paper overview the procedure used and presents some of the results of the change detection experiment.

Keywords: *Landuse, Landcover, Change Detection, Post Classification Change Matrix, Discriminate Function Change Detection.*

1. Introduction

Land use/Land cover change information has an important role to play at local and regional as well as at macro level planning. The planning and management task is hampered due to insufficient information on rates of land-cover/land-use change. The land-cover changes occur naturally in a progressive and gradual way, however sometimes it may be rapid and abrupt due to anthropogenic activities. The growing population and human activities are increasing the pressure on the limited land and soil resources for food, energy and several other needs. As the population increases particularly in the urban areas by attracting job opportunities and city spreads outward from its limit, encroachment on the surrounding available land starts. Due to increasing number of population, agricultural land starts converting into built up area and forest areas starts converting into agricultural land, built up etc. Thus, spatial and temporal analysis technologies are very useful in generating scientifically based statistical spatial data for understanding the land ecosystem dynamics.

Therefore, attempt has been made in this study to map out the status of land use land cover of a part of Allahabad district of Uttar Pradesh with a view to detecting changes that has taken place in their status particularly in the built-up land and Forest area.

2. Study Area

The present study has been conducted in part of covering 50 Square Kilometer Surrounding area of Allahabad City, Uttar Pradesh. Allahabad is located at 25°27′N 81°50′E latitude and 25.45°N 81.84°E longitude in the southern part of the Uttar Pradesh at an elevation of 98 meters (322 ft) and stands at the confluence of the Ganges, Saraswati and Yamuna rivers, which are held in highest Streams by religious minded people of India. The District Allahabad covering an area of 7261 km2. To its southwest is the Bundelkhand region, to its east and south east is the Baghelkhand region, to its north and northeast is the Awadh region and to its west is the lower Doaba of which it is a part.

3. Methodology

Methodology is a sequence of activities that starts with the

*Corresponding author: Ashutosh Singh

decision making, problem recognition and ends with recommendation. The quality of decision making depends on sequence on which the activities are undertaken

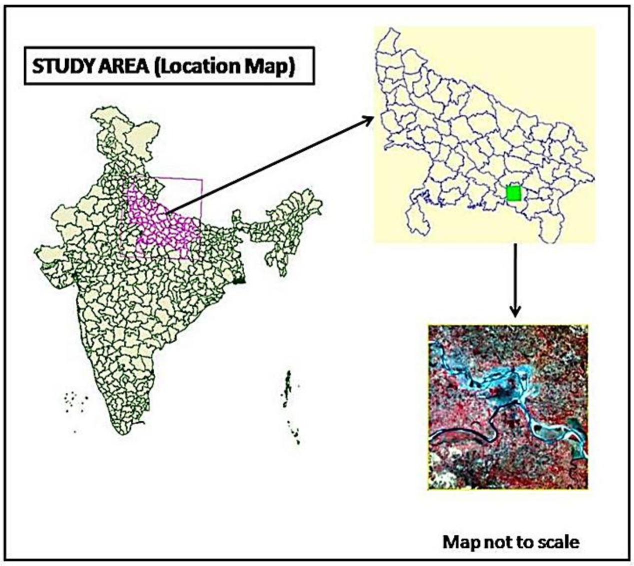

Figure 1: Study area map

The main goal of this study is to extract land use/land cover changes using multi- temporal satellite data. Digital image-processing software Erdas imagine was used for the processing, analysis and integration of spatial data to reach the objectives of the study. Erdas Imagine was used to generate the false colour composite, by combining near infrared, red and green which are bands 3, 2, 1 together for satellite images.

3.1 Change Detection

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 landcover and land use changes than the information obtained from continuous change.

3.2 Post Classification Change Matrix Calculation

In Post-Classification Change Matrix Calculation method a 4-band multiseasonal composite was created from the Nov. 17, 1990 and Nov. 11, 2000 Landsat TM & ETM+ data. Unsupervised classification using the ISODATA algorithm was applied on Nov. 17, 1990 data and separate clustering and labeling results were overlain to form a single composite classification map consisting of the fourteen classes of interest. The same repeated clustering procedure was applied to the Nov. 11, 2000 imagery to produce a final land cover classification map. The Change Matrix analysis produces a thematic layer that contains a separate class for every coincidence of classes in two layers. The Final change map is created by clustering and labeling the change matrix classes into fifty-five final change classes.

3.3 Discriminant Function Change Detection

Discriminant Function Change Detection is used to compute the probability of change per pixel from two images that depict the same area at different points in time. The process performs an unsupervised classification on the Input before Image and uses that and discriminant function analysis to compute a probability of change between the Input after Image to generate any of the Output files. The output images generated are composed of single band continuous data with pixel values in the range from 0.0 to 1.0. These values represent the probability that the pixel has changed in a significant way. The algorithm's conceptual procedure includes determination of which image is to be the base image, i.e. which image will we find change against. This algorithm is image-order variant meaning that it will yield different results depending on which image (before or after) is the base. After that an unsupervised classification on base image is to be performed into a reasonable number of spectral classes (64 – 128 classes) and use this thematic image as a zonal mask to extract a set of multivariate signatures (mean vector, M and covariance matrix, Cov) from the other image notated as change image. For each pixel in Change image compute the Mahalanobis Distance (MD) using the signature corresponding to the class to which it is affiliated from the previous step's zonal operation using the formula. The MD metric can be converted to a Probability using a Chi square lookup table. The Probability metric for each pixel is written to an output image.

The overall methodology is given Figure 2.

4. Result and Discussion

Land Use/Cover over the study area has been analyzed for the time periods of 1990-2000. The results are presented in form of maps, charts and statistical tables. Figures 2 and 3 depict the classification results for the two methods for study area. Inspection of the results reveals some similarities as well as some differences. Post classification change Matrix and Determinant function change detection produced comparable results overall. In both these cases, the classifications were the same. For post classification an independent year 1990 land cover map is cross-tabulated with year 2000 to identify change. For Determinant function change detection areas of change are based on spectral departure of class and means defined by land cover areas. Many areas of omission and commission are evident.

4.1 Analysis of the change image 1990/2000 by Post Classification Change Matrix Method

The analysis of Land use/land cover of Allahabad City for different time periods, indicate substantial changes. The major proportion in land use is the Open and agricultural land. Major changes have taken place particularly in the built-up land and Vegetative areas. Table.1 and Figure. 3 portray changes in Land uses. Land use changes reveal the

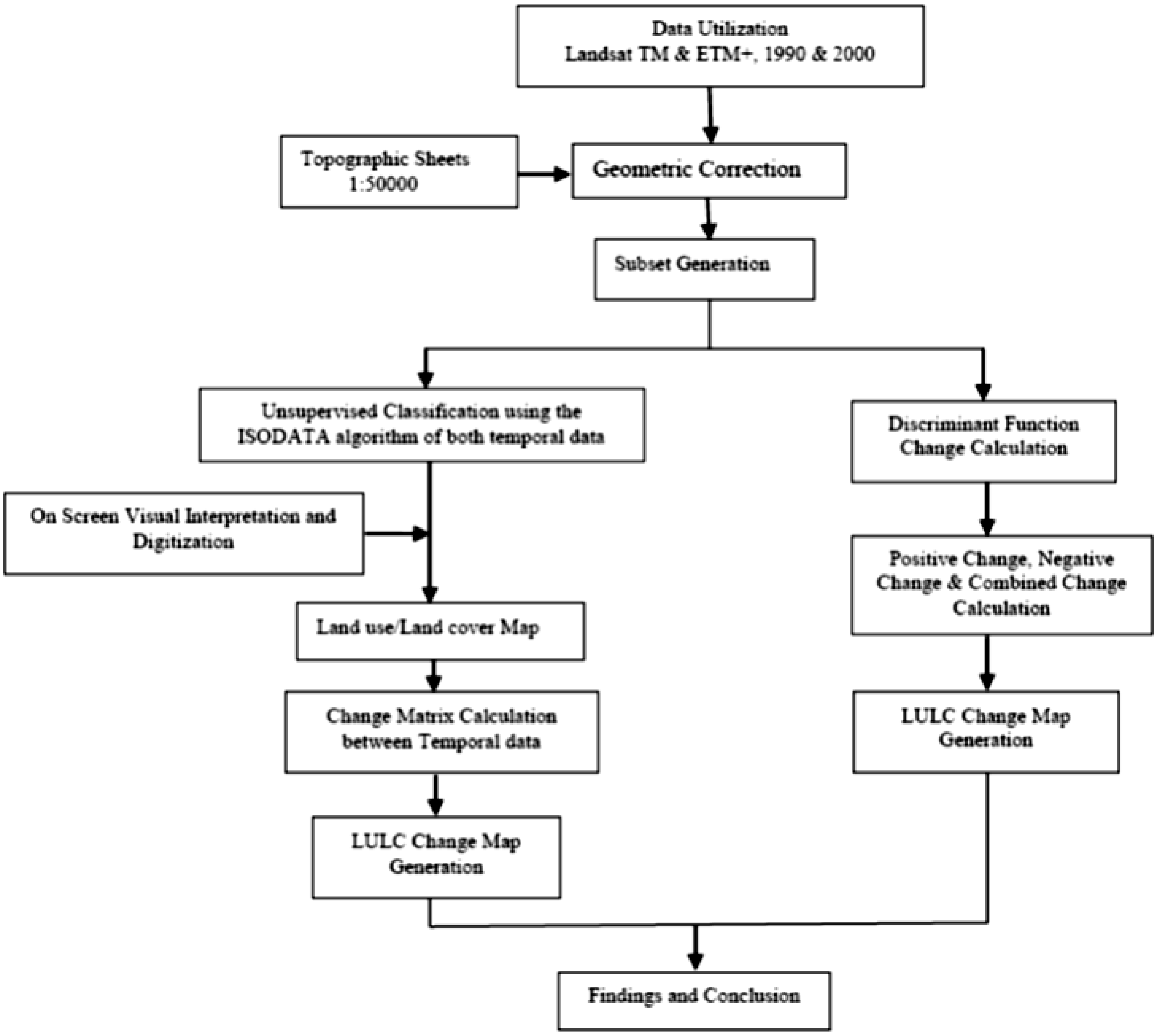

Figure 2: Methodology of research

Table 1: Land Use/Land Cover Changes (1990-2000)

Sr. No.	Landuse Category	Area in ha.		Percentage (%)	
		1990	2000	1990	2000
1	Urban Dense	1248.103	1428.829	0.5	0.57
2	Urban Sparse	1221.543	2065.633	0.49	0.82
3	Sub-Urban	1723.27	2988.755	0.69	1.19
4	Villages/ Rural area	1536.777	2457.787	0.61	0.98
5	Industrial/ Commercial	73.346	108.923	0.03	0.04
6	High Dense Vegetation	864.072	2231.088	0.34	0.89
7	Low Dense Vegetation	26597.61	24066.16	10.62	9.61
8	Lakes/Oxbow-Lakes	7705.328	6926.056	3.08	2.77
9	River	419.608	82.281	0.17	0.03
10	Other Waterbodies	199.651	144.499	0.08	0.06
11	Marshy/Swamp area	146.53	26.967	0.06	0.01
12	River Bed	15891.51	17829.46	6.34	7.12
13	Agriculture	84115.23	70886.93	33.58	28.3
14	Open land	108717.6	19216.86	43.41	47.6
	Total	250460.2	250460.2	100	100

Table 2: Analysis of Land Use/cover Changes

S.N.	CLASS NAME	AREA (Ha.)	S.N.	CLASS NAME	AREA (Ha.)
1	HDV TO URBAN DENSE	3.65513	31	OPEN LAND TO SUB-URBAN	577.347
2	HDV TO URBAN SPARSE	25.6671	32	OPEN LAND TO VILLAGE/RURAL AREA	345.937
3	HDV TO SUB-URBAN	2.51798	33	OPEN LAND TO INDUS./COMM.	17.9507
4	HDV TO LDV	280.145	34	OPEN LAND TO HDV	665.314
5	LDV TO URBAN DENSE	62.3808	35	OPEN LAND TO LDV	7374.17
6	LDV TO URBAN SPARSE	423.913	36	OPEN LAND TO RIVER	165.861
7	LDV TO SUB-URBAN	609.106	37	HDV TO AGRICULTURE	122.731
8	LDV TO VILLAGE/RURAL AREA	168.217	38	HDV TO OPEN LAND	92.8402
9	LDV TO INDUS./COMM.	16.245	39	LDV TO LAKE/OX-BOE LAKE	16.4887
10	LDV TO HDV	955.044	40	LDV TO OTHER WATERBODIES	32.1651
11	LDV TO RIVER	45.4048	41	LDV TO MARSHY/SWAMP AREA	21.6871
12	LAKE/OX-BOW LAKE TO HDV	18.1944	42	LDV TO LAKE/RIVER BED	217.602
13	LAKE/OX-BOW LAKE TO LDV	212.972	43	LDV TO AGRICULTURE	7200.27
14	OTHER WATERBODIES TO HDV	5.11718	44	LDV TO OPEN LAND	7086.88
15	OTHER WATERBODIES TO LDV	67.9853	45	LAKE/OX-BOE LAKE TO AGRICULTURE	9.99068
16	MARSHY/ SWAMP AREA TO HDV	20.0626	46	LAKE/OX-BOE LAKE TO OPEN LAND	118.832
17	MARSHY/ SWAMP AREA TO LDV	85.4487	47	OTHER WATERBODIES TO AGRICULTURE	13.6458
18	RIVER BED TO URBAN DENSE	12.8336	48	OTHER WATERBODIES TO OPEN LAND	83.8242
19	RIVER BED TO SUB-URBAN	8.4474	49	MARSHY/SWAMP AREA TO AGRICULTURE	14.0519
20	RIVER BED TO VILLAGE/RURAL AREA	3.8988	50	MARSHY/SWAMP AREA TO OPEN LAND	26.3981
21	RIVER BED TO LDV	674.249	51	RIVER BED TO AGRICULTURE	612.68
22	RIVER BED TO RIVER	6591.98	52	RIVER BED TO OPEN LAND	488.243
23	AGRICULTURE TO URBAN SPARSE	4.14248	53	AGRICULTURE TO OTHER WATERBODIES	16.976
24	AGRICULTURE TO SUB-URBAN	67.8229	54	AGRICULTURE TO RIVER BED	1769
25	AGRICULTURE TO VILLAGE/RURAL ARE	402.145	55	AGRICULTURE TO OPEN LAND	36452.3
26	AGRICULTURE TO SUB-URBAN	233.522	56	OPEN LAND TO LAKE/OX-BOW LAKE	5.68575
27	AGRICULTURE TO LDV	5628.97	57	OPEN LAND TO OTHER WATERBODIES	67.0106
28	AGRICULTURE TO RIVER	122.812	58	OPEN LAND TO MARSHY/SWAMP AREA	3.00533
29	OPEN LAND TO URBAN DENSE	101.856	59	OPEN LAND TO RIVER BED	640.134
30	OPEN LAND TO URBAN SPARSE	388.824	60	OPEN LAND TO AGRICULTURE	23497

differences in uses of land for different land use categories in different year's periods.

The developments scenario of 1990 -2000 time periods shows the area under Built Up (Urban) has increased from 4192.916 in 1990 to 6483.217 hectare in 2000 by fulfilling the growing needs of the city population. Villages/Rural area also increased from 1536.77 in 1990 to 2457.78 hectare in 2000. The vegetative and water classes show decremented changes from year 1990 to 2000. The area under Industrial/Commercial has also increased from 1990 to 2000 by rapid industrialization in the city.

As a matter of fact all landuse categories have undergone complex metamorphosis which has been mapped in Table.2 and Figure. 4. Change in Builtup area is mostly brought at the cost of Agricultural land. Agricultural land is also transferred to open land and water bodies. Similarly, Some River and River Bed area has been converted into cropland and open Land. Open land has also moved into Agricultural land, builtup area and industry as well.

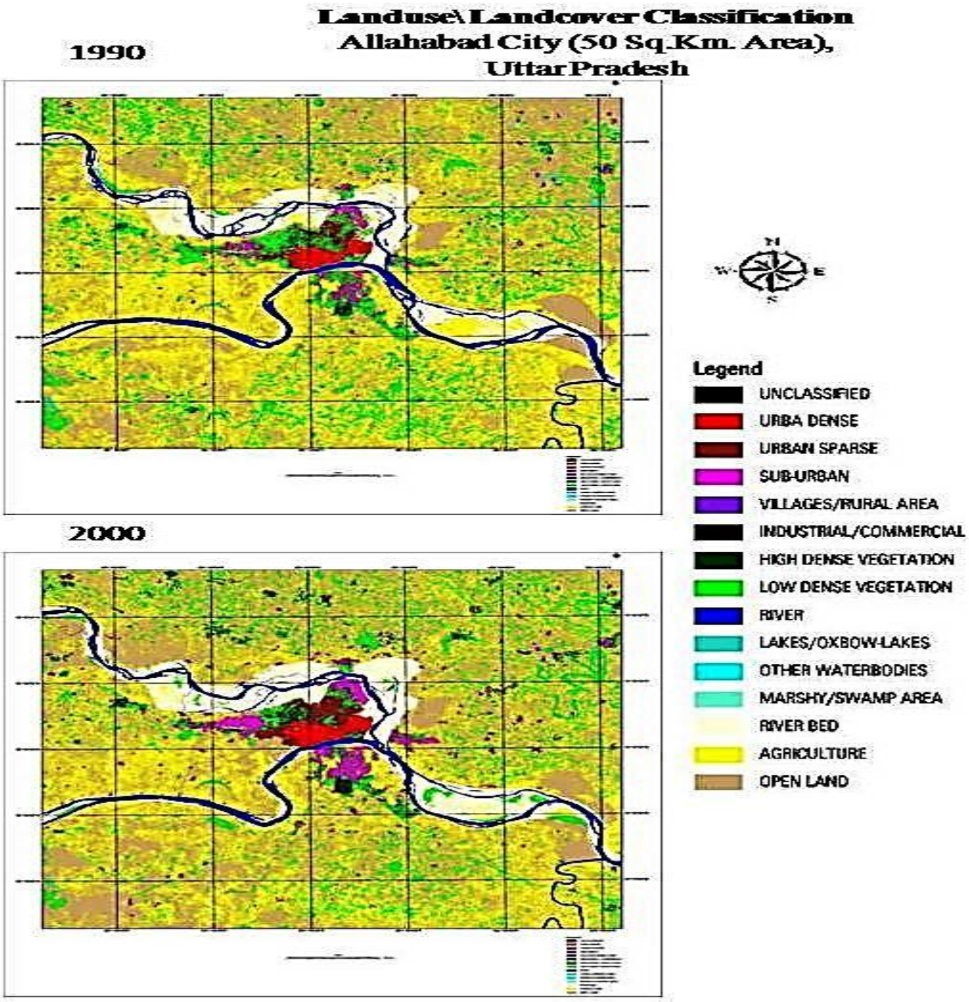

Figure 3: Landuse/ Landcover details of study area

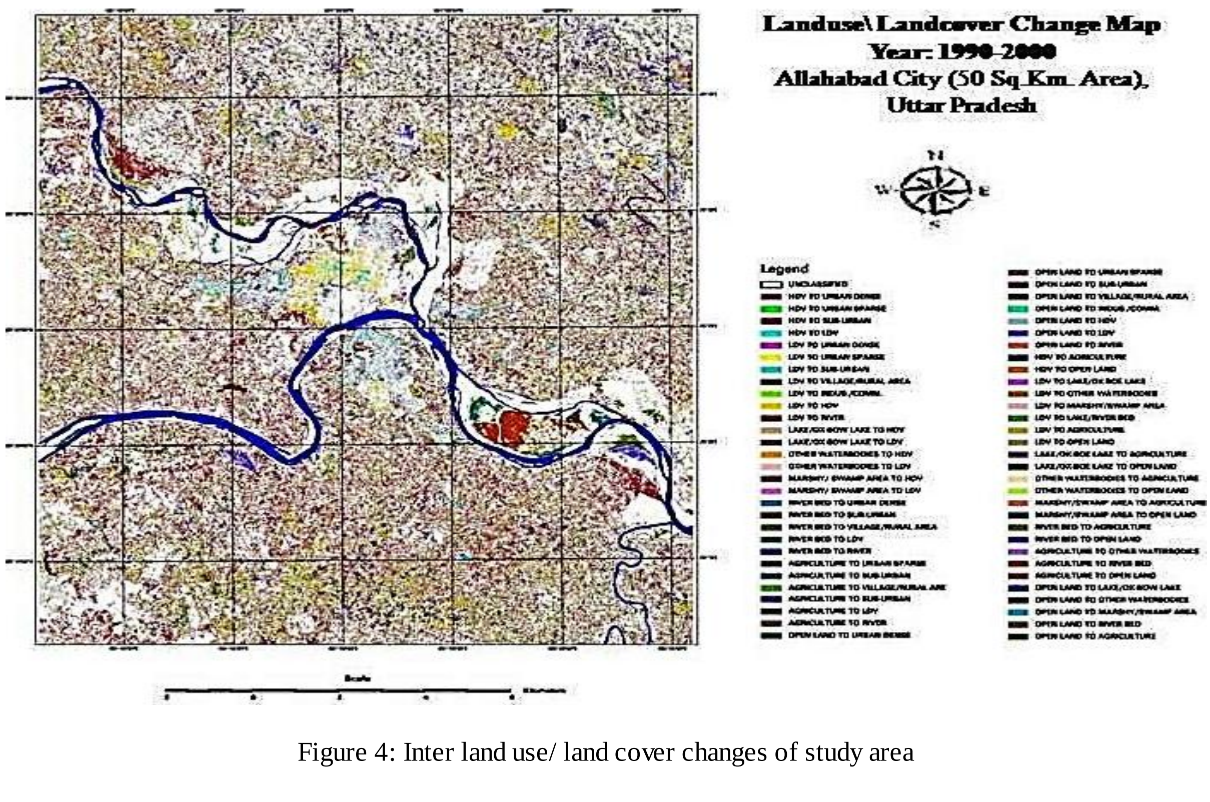

Figure 4: Inter land use/ land cover changes of study area

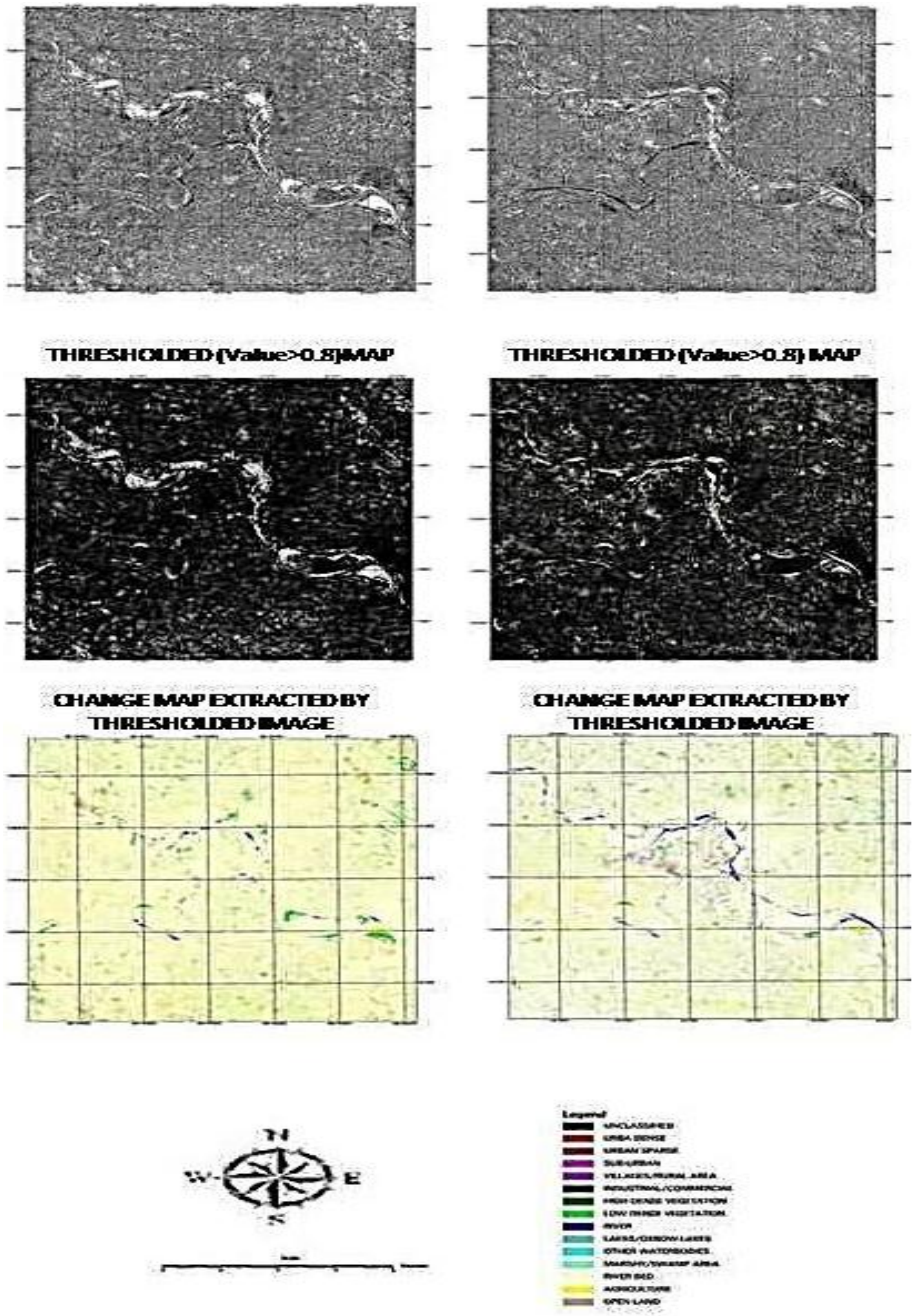

Figure 5: Land use/ Land cover changes of study area by Discriminate Function Change Detection Method

4.2 Analysis of the change image 1990/2000 by Discriminate Function Change Detection Method

Parallel to the Post Classification Change Matrix analysis, discriminate function change detection analysis was applied to the data. The results show the probability of change per pixel from two images that depict the same area at different points in time. The output image is a floating point image with values from 0.0 to 1.0. Values near 0.0 indicate a low probability of change and Values near 1.0 indicate a high probability of change.

The obtained image is threshold and clumped into raster objects using the threshold limit (Value>0.8) and compared with the classified output of Post classification change matrix method.

When compared with classified output of Post classification change matrix method, Positive Change Image (PCI) show changes that have taken place particularly in the built-up land and other class areas. The urban and village area has increased by in the time period of 1990-2000. But there is a change in Negative Change Image (NCI) area which indicates displacement of slum areas, municipal and developmental activities and increase in vertical expansion.

Table 3: Land Use/Land Cover Changes (1990-2000)

Class Name	PCI Area (Ha.)	NCI Area (Ha.)
Urban Dense	82.5246	0
Urban Sparse	212.16	10.2344
Sub-Urban	262.113	23.9614
Villages/Rural Area	161.475	55.3142
Industrial/Commercial	17.6258	0.568575
High Dense Vegetation	201.519	167.161
Low Dense Vegetation	2191.86	2966.34
River	1310.24	625.108
Lakes/Oxbow-Lakes	31.1092	30.7031
Other Waterbodies	49.9534	46.5419
Marshy/Swamp Area	20.3063	7.71638
River Bed	2266.58	3917.89
Agriculture	8058.49	6374.46
Open Land	10147.5	10467.3

Conclusion

The results of this research reveal there is merit to each of the several land use change detection methods studied, and there appears to be no single best way in which to perform change analysis. Post classification change matrix method shows good result and easy to interpret and analyze. The accuracy mainly depends on the classification accuracy which needs more interpretational skills. Discriminate Function Change is a novel process for change detection in multi-temporal image pairs. It is computed by selecting one image as the base and then detecting statistical outliers the other image. For this reason, it can separate two different types of change, finding features that are in one image and not the other. Given images collected at different dates the results can be thought as positive change (features that appear) and negative change (features that disappear) between collection dates. Because having no manual interpretational process it needs no manual efforts but requiring some experience to interpret and analyze the result and shows the good results in comparison with post classification change matrix method. The potential drawback of false positives due to entire classes being dominated by change is rare in practice.

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