International Research Journal of Earth Sciences ISSN 2321–2527
Vol. **1(5),** 1-6, October **(2013)** *Int. Res.J. Earth Sci.*

Monitoring urban Land use land cover change by Multi-Temporal remote sensing information in Howrah city, India

Sahoo Satiprasad
Department of Civil Engineering, Indian Institute of Technology Kharagpur, Kharagpur – 721302, WB, INDIA

Available online at: www.isca.in, www.isca.me
Received 3rd October 2013, revised 13th October 2013, accepted 24th October 2013

Abstract

Land use and land cover (LULC) change has become a central component in current strategies for managing natural resources and monitoring environmental changes. This paper examines the urban LULC changes that have been taken place in Howrah city, India, for the last two decades due to the rapid urbanization. This work mainly emphasizes on understanding of LULC change detection analysis using LANDSAT (MSS in 1975, TM in 1989, and ETM+ in 2000) and LISS-III (2009) high resolution imagery for the 34 years time span. Unsupervised classification techniques have been utilized for delineating five different classes: agriculture land, built up, vegetation, water body and wet land. LULC changes that occurred in this area suggesting that the spatial change of an impervious surface is a useful indicator of identifying spatial extent, intensity and potentially type of urban land use and land cover changes. It is also inferred from the analysis that land changes was taken place in this area mainly in form of built up land during specified time period.

Keywords: Classification, GIS, land use land cover change, remote sensing, time series.

Introduction

Land use and land cover (LULC) change is a major issue of global environment change. Scientific research community called for substantive study of land use changes during the 1972 Stockholm Conference on the Human Environment, and again 20 years later, at the 1992 United Nations Conference on Environment and Development (UNCED). It has already been widely recognized that land use and land cover (LULC) changes play a very important role on regional to global scales, with impacts over ecosystem functioning, ecosystem services, and biophysical and human variables such as climate and government policies [1]. Remote sensing has produced important source of data for land use/ land cover and it is an authoritative tool to keep an update of universal inventories. In digital image analysis, data and information are by no means synonymous with each other. Practically, remotely sensed data represent values or digital number of the pixel. Land degradation results mainly due to population pressure which leads to intense land use without proper management practices. Over population makes people to move towards sensitive areas like highlands. In such areas, land use without considering the slope and erodibility leads to severe erosion and related problems.

Study area: This work presents LULC change in Howrah city (Howrah district in the state of West Bengal, India). The geographic position of this city is specified by latitudes of 22 ° 32′51.98″ to 22 ° 36′38.86″ N and longitudes of 88 ° 14′35.78″ to 88 ° 21′34.64″ E and it covers an area of 4350.02 hectare as shown in figure 1.

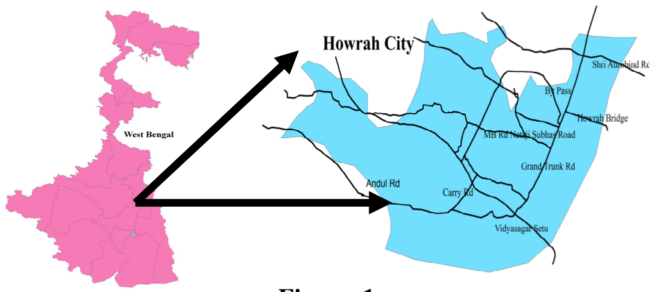


Figure-1
Location map of the study area

Material and Methods

Data acquisition: Remote sensing data are primary sources for LULC change detection[2]. Satellite data are suitable for computer processing due to the advantage of repetitive data acquisition, synoptic view and digital format. LANDSAT (MSS, TM and ETM+) and LISS-III were acquired and used to evaluate LULC changes. Table 1 shows details information about the satellite images used in this work.

Image Classification: Classification is the process of sorting pixel into finite number of individual classes. All satellite data were studied using spectral and spatial profile to ascertain the digital numbers of different LULC categories prior to classification. We used ISODATA (Iterative Self Organizing Data Analysis Technique) algorithm to perform unsupervised classification using delineates of the classification schemes[3,4].

Table-1
Characteristics of the satellite images

Band	Wavelength (nm)		Resolution (m)
	start	stop	
MSS			
Channel 4	500	600	80
Channel 5	600	700	80
Channel 6	700	800	80
Channel 7	800	1100	80
TM			
Band 5	1550	1750	30
Band 6	10400	12500	120
Band 7	2080	2350	30
Band 1	450	520	30
Band 2	520	600	30
Band 3	630	690	30
Band 4	760	900	30
ETM+			
1 VIS blue	450	520	30
2 VIS green	530	610	30
3 VIS red	630	690	30
4 VNIR	780	900	30
5 SWIR	1550	1750	30
7 SWIR	2090	2350	30
6 TIR	10400	12500	120
8 PAN	520	900	15
LISS III			
Band 1	520	590	23.5
Band 2	620	680	23.5
Band 3	770	860	23.5
Band 4	1550	1700	23.5

(Source: http://gdsc.nlr.nl)

ISODATA Algorithm: This unsupervised classification algorithm makes a large number of passes over the dataset until specified results are obtained. The algorithm starts by examining the 4 spectral bands of digital image data to determine the mean and standard deviation of the dataset as shown in table 2. The algorithm then places points and cluster means evenly across the data range, between one standard deviation on either side of the mean, equal to the number of classes the image analyst wants to generate[5]. In the first iteration, each candidate pixel is compared to each cluster mean and assigned to the cluster whose mean is closest in Euclidean Distance in spectral domain. During the second iteration, a new mean is calculated for each cluster based on the actual spectral locations of the pixels assigned to each cluster, instead of the initial arbitrary calculation. After the new cluster mean vectors are selected, every pixel in the scene is again assigned to one of the new clusters that are closest to the pixel. This process continues until there is little change between classes in new iterations. When this process is performed, all spectral bands in the dataset are used.

Change Detection: This study employed the post-classification change detection technique, which is efficient in detecting the nature, rate and location of changes, and has been successfully used by a number of researchers in the urban environment[6]. This method performs multiple time series analysis to determine the contribution of change in LULC[7].

Results and Discussion

Land use land covers changes: Integrated maps of monitoring and response data created over time allow for analysis of LULC change from past to present study. This study employed the unsupervised classification change detection techniques, which is detecting the land use and land cover location of changes. The spatial patterns of the five major land use and land cover types in Howrah city located on the west bank of the Hooghly River in 1975, 1989, 2000 and 2009 are presented in figure 2. Table 3 shows that built up land was dominant in 1975, 1989, 2000 and 2009 covering about 456.81 hectare, 900.63 hectare, 1527.78 hectare and 1920.18 hectare, respectively.

Table-2
Band collection statistics of individual layer

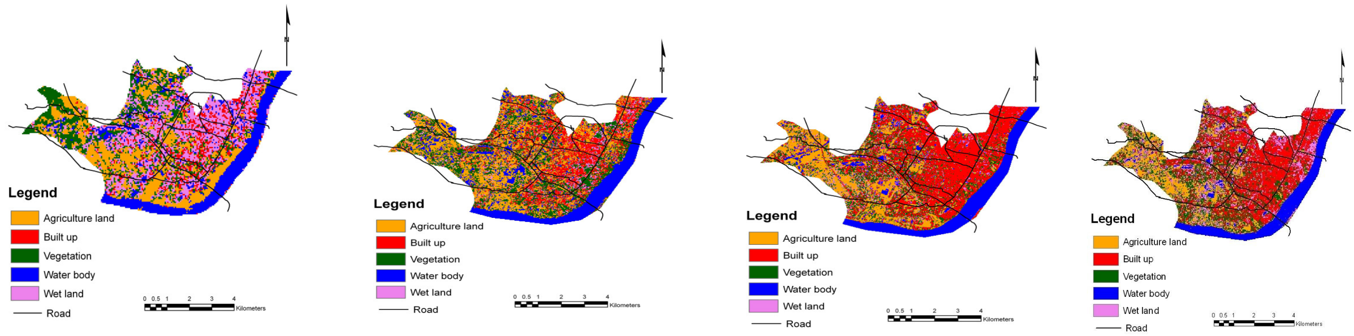
Layer	Min	Max	Mean	STD
MSS				
1	0	40	14	14
2	0	36	11.47	11.43
3	0	34	10.38	10.35
4	0	34	8.29	8.56
TM				
1	0	167	39.18	38.43
2	0	88	15.82	15.74
3	0	131	16.91	17.18
4	0	122	26.36	26.34
5	0	193	30.58	30.61
6	0	197	14.69	15.60
ETM+				
1	0	101	35.55	34.79
2	0	90	26.49	26.07
3	0	103	24.64	24.59
4	0	124	23.67	26.13
5	0	145	21.84	24.64
6	0	133	60.03	58.69
7	0	165	70.65	69.11
8	0	138	16.79	19.09
LISS-III				
1	0	103	30.14	29.42
2	0	94	21.06	20.76
3	0	92	21.46	21.95
4	0	65	11.88	12.53

Table-3
Area Statistics of Land use Land cover classification map

Categories	1975		1989		2000		2009	
	Hectare	%	Hectare	%	Hectare	%	Hectare	%
Water body	888.86	20.43	757.25	17.41	656.09	15.08	619.38	14.23
Wet land	1036.82	23.83	563.07	12.95	512.19	11.77	421.07	9.68
Vegetation	924.03	21.24	895.993	20.60	798.60	18.36	721.87	16.59
Built up	456.81	10.50	900.63	20.71	1527.78	35.12	1920.18	44.14
Agriculture land	1043.43	23.99	1232.28	28.33	855.34	19.66	667.51	15.34

More specifically, the water bodies, wet land, vegetation and agriculture land were decreased during all observed time periods, but agriculture land was increased in 1989 (figure 3).

The LULC analysis as given in figure 4 indicates the increase of built up area and decrease of agriculture land (increased in 1989), vegetation, water bodies and wet land for four periods. Judging by the rates of change, built-up lands were the most dynamic having grown at the rates of 10.50 %, 20.71 %, 35.12 % and 44.14 % respectively within the four periods. Comparison of the temporal data shows that built up has continuously increased in Howrah city showing urban sprawl in and around the center of the town at the road junction and the forest area has decreased [8, 9, 10].



1975 1989 2000 2009

Figure-2
Land Use / Land Cover Classification map (1975, 1989, 2000 and 2009)

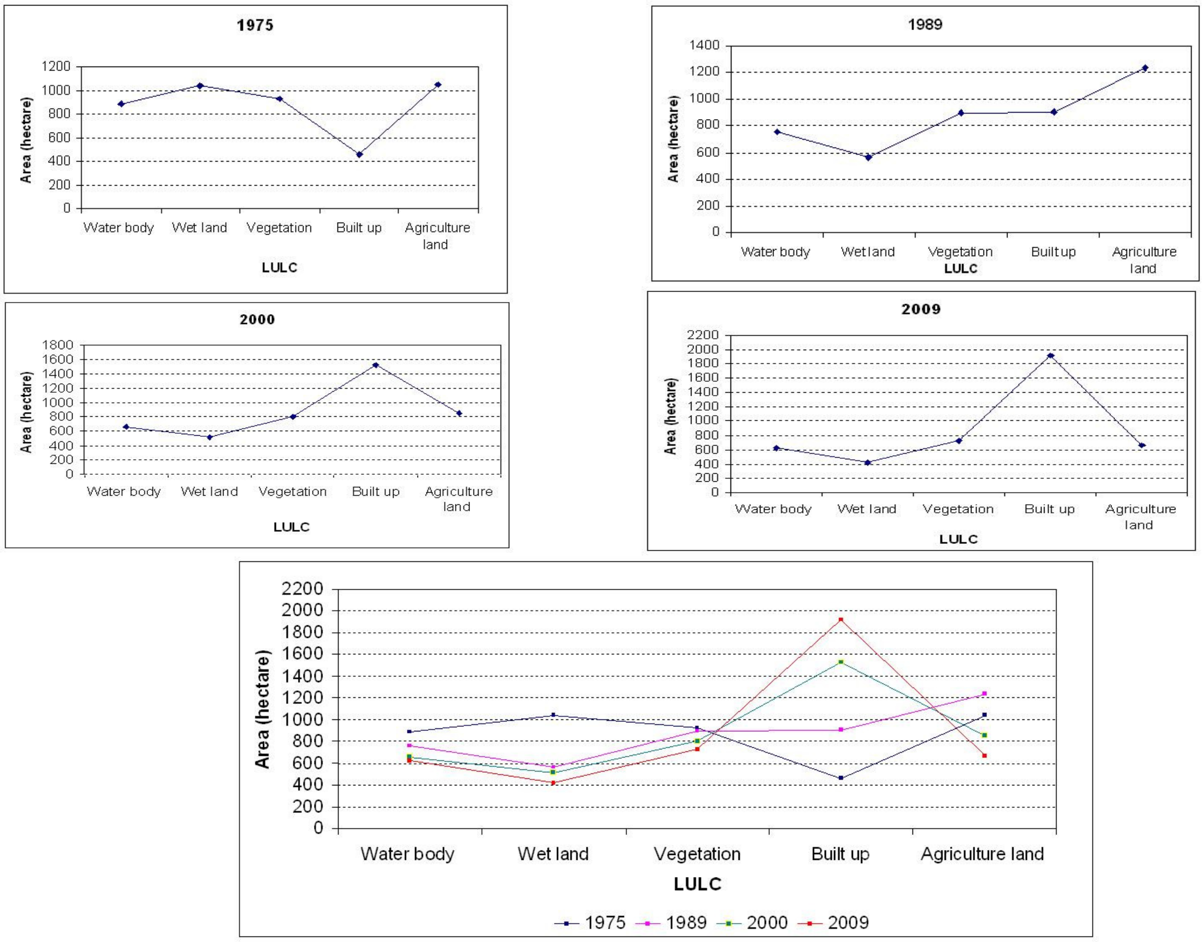


Figure-3
Areas of different land use land cover in four periods

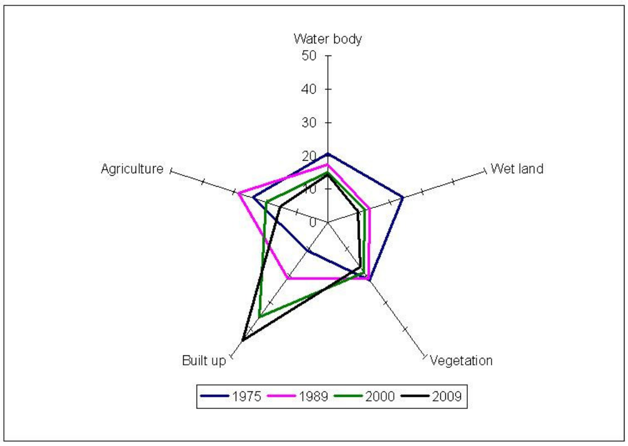


Figure-4
Percentage land use and land cover change in four time periods

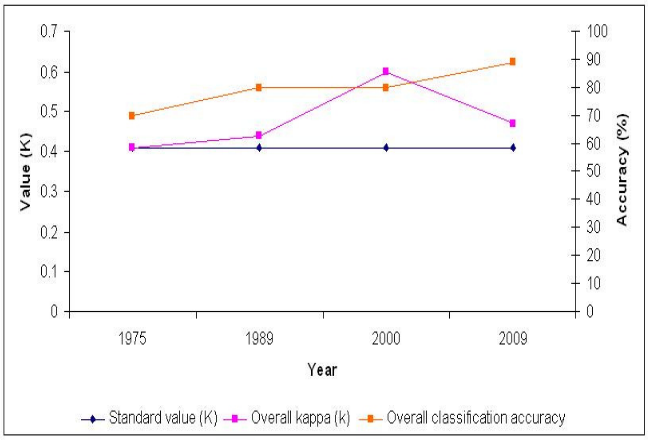


Figure-5
Comparison between overall classification accuracy and kappa analysis

Accuracy Assessment: Accuracy assessment is an important step in the classification process. The goal is to quantitatively determine how effectively pixels were grouped into the correct feature classes in the area under investigation. Yet with unsupervised classification, a resulting cluster is not automatically labeled nor identified as corresponding to a specific class. So, a class is investigated with respect to all clusters, and the cluster containing most of the pixels closest to the mean of that class is considered as its corresponding cluster. Based on the confusion matrix, the accuracy is then expressed in terms of the kappa statistic (k) where the difference between the clustering accuracy and the chance agreement between the classes and the clusters is calculated[11]. The conditional Kappa is somewhat analogous to the overall Kappa Coefficient of Agreement measure except that a Conditional Kappa Coefficient of Agreement can be derived for each category of the classification[12]. The Conditional Kappa Coefficient of Agreement measure is used to evaluate classification accuracies on a class-by-class basis. It results in a value between 0 and 1 for each classification, where 0 indicates that the clustering is no better than grouping the data by chance shown in table 4.

Table-4
Results of overall classification accuracy and kappa analysis

Year	Overall classification accuracy	Overall kappa (k) statistics
1975	70%	0.41
1989	80%	0.44
2000	80%	0.60
2009	88.89%	0.47

Kappa makes no distinction among various types and sources of disagreement. Because it is affected by prevalence, it may not be appropriate to compare kappa between different studies or populations shown in figure 5. Nonetheless, kappa can provide more information than a simple calculation of the raw proportion of agreement.

Impacts: Trends in population growth, economical developments and land use policy changes are the most likely drivers of the observed land use land cover change detection analysis. The effects of land cover conversion can be highly variable depending on the approach followed to convert from one cover type to another[13]. Ecological effects of land cover conversion include changes in soil quality, soil erosion, water quality, and biodiversity loss and habitat availability. As indicated by Tilman expansion of agriculture is expected to have most profound impacts on freshwater ecosystems[14].

Conclusion

Concerns over the degradation of the environment we live in are raised because of an increasing urban growth throughout the world. Looking at the result of this study, the direction of urban sprawl (herein referred to as the built up land) was north east to south east along the city area. The overall water bodies, wet land, vegetation and agriculture land (increased in 1989) were decreasing continuously of the time period. The urban sprawl is one of the potential threats to sustainable development. It was found that the percentage change in built up land over the 34 years time span.

References

1. Meyer W.B. and Turner B.L. II., Changes in land use and land cover: a global perspective, Cambridge: Cambridge University Press, 549 **(1994)**

2. Aplin P., Edited by Mesev V., Comparison of simulated IKONOS and SPOT HRV imagery for classifying urban areas, Remotely Sensed Cities, London, Taylor and Francis: 23-45 **(2003)**

3. Alrababah M.A. and Alhamad M.N., Land use/cover classification of arid and semi-arid Mediterranean landscapes using Landsat ETM, *International Journal of Remote Sensing*, **27(13),** 2703-2718 **(2006)**

4. Abedini Mandana, Md said Md Azlin and Ahmad, Clustering approach on land use land cover classification of Landsat TM over Ulu kinta catchment, *World Applied Sciences Journal*, **17(7),** 809-817 **(2012)**

5. Arai K., Bu X.Q., ISODATA clustering with parameter (threshold for merge and split) estimation based on GA: Genetic Algorithm, Reports of the Faculty of Science and Engineering, Saga University, **36(1), (2007)**

6. Hardin P.J., Jackson M.W. and Otterstrom S.M., Maping, measuring, and modeling urban growth, In R.R. Jensen, J.D. Gatrell & D. Mclean(Eds.), Geo-SpatialTechnologies In Urban Environments: Policy, Practice And Pixels(2ND ED.), (141-176) Heidelberg: springer-velag **(2007)**

7. Rammachandra T.V. and Kumar Uttam, Geographic resource decision support systems for land use, land cover dynamics analysis. Poceeding of the FOSS/GRASS user conference- Bangkok, Thailand **(2004)**

8. Mishra Monalisha., Mishra Kant Kamal and Subudhi A.P., Urban sprawl mapping and land use change analysis using remote sensing and GIS **(2011)**

9. Sudhira H.S., Ramachandra T.V and Jagadish K.S., Urban sprawl: metrics, dynamics and modeling using GIS, *Internatinal Journal of Applied Earth Observation and Geoinformation*, **5,** 29-39 **(2004)**

10. Sundarakumar K., Harika M., Aspiya Begum S.K., Yamini S. and Balakrishna K., Land use and land cover change detection and urban sprawl analysis of Vijaywada city using multitemporal Lansad data, *International Journal of Engineering Science and Technology* (UEST), **4(01) (2012)**

11. Lillesand T.M. and Kiefer R.W., Remote sensing and image interpretation, 4th ed. Wiley and Sons, New York, NY, USA **(2000)**

12. Viera Anthony J. and Garrett Joanne M., Understanding Interobserver Agreement: The Kappa Statistic, Wood Johnson Clinical Scholars Program, University of North Carolina, **37(5**), 360-3 **(2005)**

13. Phukan P., Thakuriah G., and Saikia R., Land use land cover change detection using remote sensing and GIS techniques – a case study of Golaghat district of Assam, India, **1(1),** 11-15 **(2013)**

14. Tilman D., Global environmental impacts of agricultural expansion: The need for sustainable and Efficient practices, Proc. Natl. Acad. Sci. USA 96: 5995–6000 **(1999)**