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Change Detection Analysis of Yamuna River Flood Plain in Delhi Using Remote Sensing Data

Saif Said

Department of Civil Engineering, Jamia Millia Islamia University, New Delhi, India
E-mail: saif_said@rediffmail.com

Abstract—*Delhi has witnessed a recent blow up in urbanization along river Yamuna passing through Wazirabad to Okhla section leading to the shrinkage in the flood plain that has considerably reduced the water levels within the river section. The present study quantifies the changes that have taken place over a period of ten years within the flood plains of river Yamuna by using two IRS LISS III images of year 2001 and 2011. Land Use Land Cover maps of the study area were prepared and areas covered in each land cover class in the two images were evaluated and compared in terms of percent increase or decrease. Results from the analysis revealed that agricultural area lying within the flood plain has been increased to 234.52 hectares in the year 2011 as compared to 164.5 hectares in 2001, thereby indicating an overall increase of 42.6%. A significant reduction of 61.6% in areas covered under dense trees has also been observed during the study period. Further, a notable increase of 59.5% in the built up/ settlement areas within the flood plain has been observed. The overall shrinkage of the flood plain during a period of 10 years is observed to have been reduced by almost 20%.The present study therefore reveals the spatial changes that have taken place within the flood plains of river Yamuna passing through the Delhi corridor during 10 years and finds its usefulness in efficient planning and management of ever shrinking flood plain.*

Keywords*: Change detection, Flood plains, GIS and Remote Sensing, Urbanization, Yamuna river, Delhi corridor*

1. INTRODUCTION

Studies have shown that there remains only few landscapes on the Earth that are still in there natural state. Due to anthropogenic activities, the Earth surface is being significantly altered in some manner and man's presence on the Earth and his use of land has had a profound effect upon the natural environment and ecology thus resulting into an observable pattern in the land use/land cover over time. Land use and land cover change has become a central component in current strategies for managing natural resources and monitoring environmental changes. The advancement in the concept of vegetation mapping has greatly increased research on land use land cover change thus providing an accurate evaluation of the spread and health of the world's forest, grassland, and agricultural resources has become an important priority [2].

Urbanization is one of the most widespread anthropogenic causes of the loss of arable land [3], habitat destruction [4], and the decline in natural vegetation cover. One of the major reasons of urbanization is rapid population growth in the urban areas or metropolitan cities. Apparently, the urban population has grown exponentially and by 2030, for the first time in human history, more people in the world will be living in cities and towns than in rural areas. Furthermore, by 2025 the developing world is likely to have become more urban in character than rural, therefore, the vast majority of urban growth is now occurring in the developing world [6]. The spatial information from the remote sensing satellites provides more effective solution for sustainable environment and urban development [5]. Land use and land cover is an important component in understanding the interactions of the human activities with the environment and thus it is necessary to be able to simulate changes. Inventory and monitoring of land-use/land-cover changes are indispensable aspects for further understanding of change mechanism and modeling the impact of change on the environment and associated ecosystems at different scales [1]. Remote sensing is a valuable data source from which land-use/land cover change information can be extracted efficiently.

The phenomena of accelerated urbanization is the main culprit, wherein besides bringing higher standard of living has also brought problems of growth of dense and unplanned residential areas, environmental pollution, non-availability of services and amenities and solid waste generation and growth of slums. Therefore, the present study is aimed at assessing the effect of urbanization in the flood plains of Yamuna river crossing through Delhi corridor over the period of 10 years (i.e., from 2001 to 2011) by using remote sensing data and spatial functionalities technique in Geographical information system (GIS).

2. STUDY AREA

The study area covers the flood plain of river Yamuna crossing the Delhi corridor, stretching out through the densely urbanized region between Wazirabad to Okhla Barrage and covering a total span of 22 km. Delhi, the capital city of India

is bisected by the river Yamuna and is located between 28° 24' 17" N to 28° 53' 00" N and 76° 45' 30" E to 77° 21' 30" E. Generally sandy loam and clay soil with varying percentages of clay and silt are found in the area and is moderately fertile. Climatologically, this area resembles the central part of India and, therefore, experiences two extreme types of climate. The summer season stretches from March to June with the maximum temperature shooting up to about 45 degrees Celsius. During the winter period, which extends from October to February, the minimum temperature falls to about 4 degree Celsius. The monsoon season starts from the first week of July and continues till the end of September. Mid-September to the end of October constitutes the post monsoon or the transition period. The normal annual rainfall in the area as recorded is 454.6 mm. The rainfall is received during the south-west monsoon months, July to September, where July and August are the rainiest months.

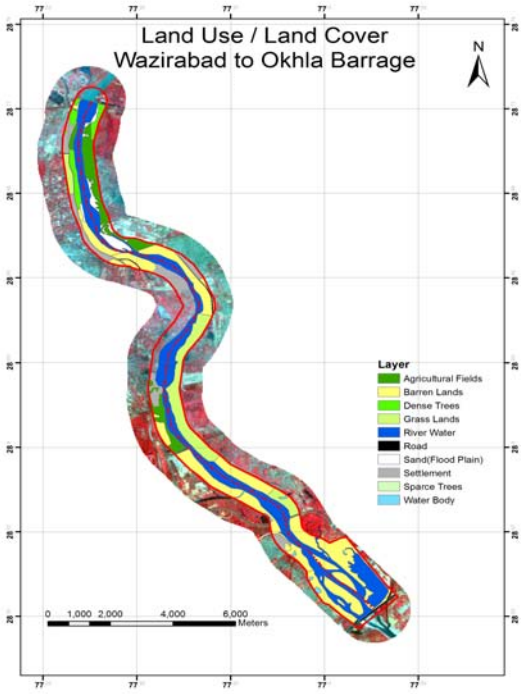
3. DATA COLLECTION AND PRE-PROCESSING

For accomplishing the objectives of the present study, two satellite images of IRS LISS III having spatial resolution of 23.5 m of periods October 2001 and October 2011 respectively, were downloaded from 'BHUVAN' ISRO's web geoportal. For keeping the atmospheric criteria to be consistent; both the images were chosen of the same month. The processing of the images as well as generation of land use Land cover images was carried out in ERDAS Imagine 9.1 software. Regular field visits were carried out for the collection of ground data that was utilized for the purpose of validation of land use land cover maps of the study area.

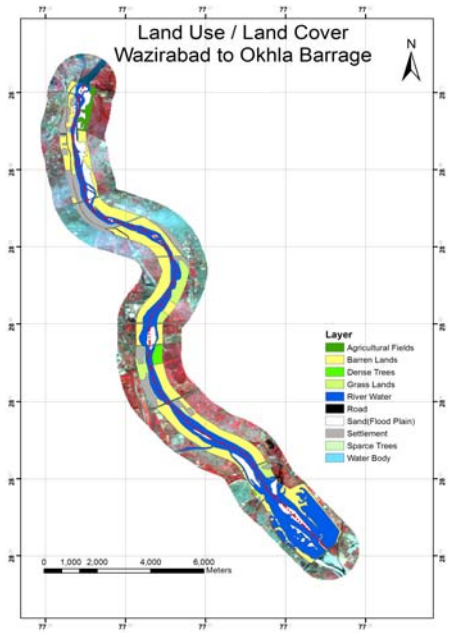
For accurate generation of land use land cover maps of the study area, the images of the two study periods were geo-referenced using sufficient number of ground control points (*GCP*), first-order polynomial transformation and nearest neighbour resampling technique. The geo-referencing enabled the sampling locations, as they appear on ground, to be easily identifiable on images. After successfully performing geo-referencing, subset images along the flood plains of the river were created in ERDAS 9.1 software from which land use land cover maps were then generated.

4. RESULTS AND DISCUSSION

Land use land cover maps from the processed subset images were generated as shown in Fig. 1 (a & b) and were analysed for temporal changes extending over a period of 10 years (i.e. from Oct 2001 and Oct 2011) were analyzed with an objective of quantifying rapid encroachment and shrinkage of Yamuna river flood plain crossing through Delhi corridor. Based on the priori knowledge of the study area for over 10 years and a detailed reconnaissance survey with additional information from previous research in the study area, a supervised classification was carried out for the two LISS III images of the study area and the total number of nine classes were selected for the classification process namely; agricultural land, dense trees, grasslands, barren land, river water, sandy area (flood plain), settlement areas, sparse trees and water bodies. Results presented in the form of maps, chart and statistical table (Refer, Table 1) are interpreted elaborately to quantify the changes within the river flood plain.



(a)



(b)

Fig. 1: Land Use Land Cover map of IRS LISS III image of year (a) 2011 and (b) 2001 with a buffer of 500 m.

Accuracy Assessments are performed on classified images to determine how well the classification process accomplished the task by generating the confusion matrix. The over all accuracy of classification for year 2001 map was 92.4% and for year 2011 was 93.6%. Table 1 below shows the areas of individual class in hectares as well as percent change in the areas for the two study periods respectively.

Results illustrated in Table 1 shows that the settlement in the flood plains has significantly increased by almost 60% with most of the unauthorised settlements having taken place at Wazirabad, Seelampur, Shahadra, Okhla, Jaitpur and Madanpur Khadar areas. Agricultural practices along the flood plain have also increased by 42.6% owing to an increase in the built up areas. Areas under other land cover types such as dense trees, grasslands, barren land, sandy areas, sparse trees and few inland water bodies showed remarkable reduction in areas which is directly attributed to the increased ungoverned human activities that are endlessly being practiced at the cost of sensitivity of ecology of the study area. Also, the total reduction in the flood plain has been observed as 20%, which is considered to be at an alarming rate. Apart from statistical analysis of the shrinking Yamuna river flood plain, the digitized layers of the river flood plain were overlaid for visual interpretation. Spatial change in areas of individual class during the study period of 10 years is also depicted in Fig. 2 as bar chart. The sensitive flood plain zones have been marked with blue coloured ovals thus revealing the ever increasing encroachment of the river flood plain as shown in Fig. 3.

Table 1: Statistics of area covered in each class and percent change in area during study period

Class ID	Land cover type	Area covered under individual class (Hectare)		Percent change in area
		2001	2011	
1	Agricultural land	164.5	234.52	-42.6
2	Dense trees	63.15	24.28	61.6
3	Grasslands	179.08	119.07	33.5
4	Barren Land	650.25	462.65	28.9
5	River water	526.92	421.08	20.1
6	Sandy area	192.21	124.81	35.1
7	built up area	79.25	126.39	-59.5
8	Sparse trees	67.9	24.22	64.3
9	Water Bodies	8.32	3.09	62.9
Total flood plain area		1931.58	1540.11	20.3

'+ ve' sign indicates percent decrease and '- ve' sign indicates percent increase

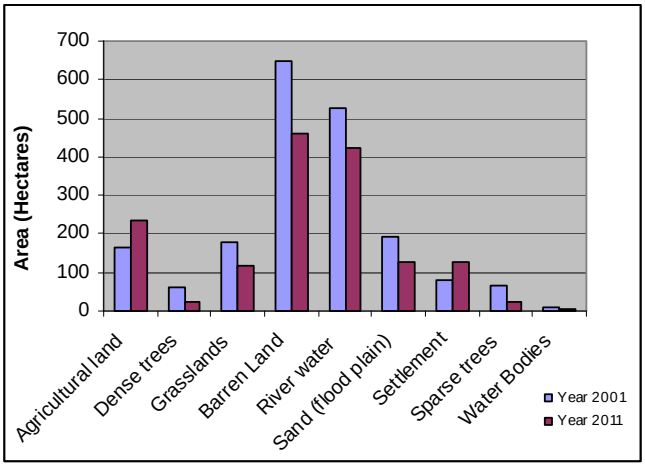


Fig.2: Spatial change in areas of individual class during the study period of 10 years.

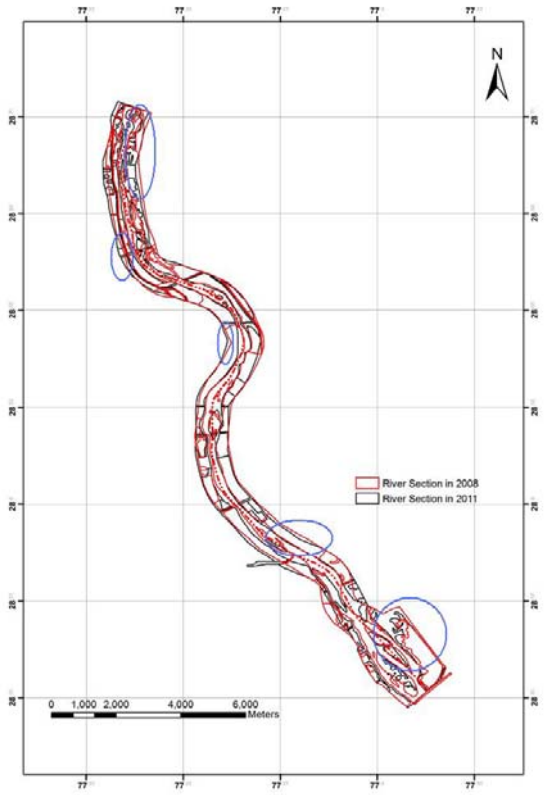


Fig. 2: Overlay analysis of flood plains of two study periods with encroachments marked in blue ovals thus depicting the sensitive zones.

5. CONCLUSIONS

Study revealed the spatial change analysis of the flood plain of river Yamuna crossing Delhi from Wazirabad to Okhla barrage due to the rapid and unauthorised influx of settlements having taken place during a period of 10 years. Built up areas with encroachment over grasslands, dense and sparse forests and water bodies have adversely affected the ecology of the area. Remote sensing and GIS have proved to be helpful for evaluating the percent change in an area due to the urban sprawl. Satellite images can effectively be used for the detection, measurement and analysis of changes in land use/land cover over a time span. The study therefore recommends timely planning and sustainable management of the environmental development of the study area on account of its ever shrinking flood plains.

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