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Land Use Land Cover Change in Active Flood Plain using Satellite Remote Sensing

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ABSTRACT

Present study is an attempt to delineate and detect Land Use/ Land Cover change in *diara* lands of river Ganga in Bhagalpur District of Bihar using remote sensing and GIS techniques. The satellite data products of LISS-III and PAN sensors of IRS-1D and corresponding Survey of India toposheets (1:50,000) were used. Necessary geometric correction and radiometric normalization were done to the acquired multidate images. Delineation of *diara* land from merged image of IRS-ID LISS-III and PAN was done using visual image interpretation technique and ground information. For change detection at two years interval, two sets of data *viz.* IRS-1D, LISS III data of November 8, 1999 and November 27, 2001 and IRS-1D, LISS III data of February 6, 2000 and March 7, 2002 were used. Land use land cover classes were derived from these products and post-classification comparison was done for land use and land cover change detection. There was a considerable change in land use/ land cover classes over *diara* land within short time frame (2 year interval) and remote sensing was found to be a suitable technique for land use land cover change detection.

Key words: *diara* land, change detection, remote sensing, land use land cover

Introduction

In view of the pressure exerted by increasing population and demand of land resources, focus is now to exploit those which have not been optimally attended till now. One of such tracts of land is *diara* land in Eastern India. The All India Coordinated Research Project on *diara* land Improvement (Anonymous, 1991) reported that about 40 m.ha. area in India is flood prone and out of which 2.64 m.ha. area is estimated to be *diara* land. *Diara* land is a landscape around the rivers especially in the northern and eastern region of India (covering states of Assam, Uttar Pradesh and Bihar) formed due to meandering, braiding and change of course of rivers. Due to the dynamic nature of the landscape, it needs periodic or, rather frequent monitoring and change detection to have real time scenario**.** Panda *et al*., (1996) have monitored *diara* lands of eastern India covering Bihar, Uttar Pradesh, Assam and Orissa states with respect to its vegetation, wasteland, soil erosion etc. through remote sensing technique. Change detection is the process of identifying differences in the state of objects, a surface or a process by observing it at different interval of times (Singh, 1989). Satellite data with their repetitive nature have proved to be useful in mapping land use/ land cover patterns and temporal changes. Methods of change detection in remote sensing typically analyze sequential images of the same area and evolve the detection and display of the image space. There are a number of such methods that are suitable for continuous monitoring the type of changes, including image differencing (Lyon *et al.,* 1998), change vector analysis (Lambin and Strahler, 1994), multitemporal Gramm-Schmidt orthogonalization (Collins and Woodcock, 1994), and some formulation of neural networks (Gopal and Woodcock, 1994). The other type of changes is categorical, in which change in time are between land cover or land use category. There are different methods that can be used in this context, including post-classification comparisons and multidate-classification (Cohen *et al*, 1998), and the use of thresholds in combination with some form of image differencing (Lyon *et al.*, 1998). Recent development of satellite carrying earth-observational sensor systems has made available enormous quantities of data about the surface of the earth, which can be quickly and economically reduced to useful information using high-speed computers. The use of Global Positioning System (GPS) has added new dimension and seems to make the technique much more efficient, reliable and accurate. The study was undertaken in order to delineate and understand land use land cover change pattern of *diara* land of river Ganga using multi-temporal satellite data.

Materials and Methods

Study area lies on both sides (North and South) of the River Ganga and called Ganga *diara* in Bhagalpur district of Bihar, extending from 25°12'50'' to 25°24'31'' North latitude and 86°43'37'' to 87°13'57'' East longitude and is covered under path 54 and row 106 of IRS-1D, LISS III sensor. IRS-1D, LISS III and PAN data of Mar., 2002 was used for delineation of *diara* land, and land use land cover change pattern detection was done using multi-date satellite data of IRS-1D, LISS III for four years *i.e.* 1999, 2000, 2001 and 2002. Along with these, other collateral data used were the Survey of India Toposheet Nos. -72 K/15, 72 K/16, 72 O/3, 72 O/4 in 1:50,000 scale.

An extensive field visit was undertaken during Mar. 1-14, 2003. GCP points and number of training sites were collected using GPS (Leica GS 5.0) connected to compaq-iPAQ pocket PC working through Arc Pad software (ver 6.0). Information related to land form, slope, extent of erosion, natural vegetation, their spatial and temporal variation and existing crop pattern were collected during ground survey including discussion with farmers. Ground truthing done through GPS were stored in shape file format, which was overlaid on the image for further processing and interpretation. For the demarcation of *diara* land, the approximate boundary was traversed by vehicle using GPS.

The IRS-1D, LISS III data of Mar. 7, 2002 was geometrically registered (map to image) with the toposheets of the same area and GCPs collected during ground truth collection, using second order polynomial transformation and nearest neighbourhood sampling method with the help of data preparation module of ERDAS Imagine (ver. 8.6) and resulting mis-registration error was approximately 0.5 pixel. Remaining LISS-III images were rectified with corrected image following image-to-image registration. A nearest neighbour resampling technique (Richards, 1995) was used for all spectral bands.

Images were rediometrically normalized to minimize the effect of atmospheric differences over different dates using the Pseudo Invariant Features (PIFs) method given by Schott *et al.*, 1988 and Hall *et al.*, 1991. For each band of every image linear transformation was used with respect to the LISS III data of 7th March, 2002 as the reference image, which has the maximum dynamic range of DN values. PIFs such as urban area, helipad etc were selected from images of different dates and its statistical information were recorded. Assumption for the PIFs was that DN values of the PIF pixels involved in correction procedure are invariant during the period under study. The methodology used is depicted in Fig. 1.

Delineation of diaraland

The *diara*land delineation was done in various steps. Geometrically rectified and radiometrically normalized image of IRS-1D, LISS III was merged with PAN image. Delineation of *diara* land was done based on the tone, texture and association of the merged image of March, 2002, information collected during the field visit, discussion with the farmers of the area as well as Survey of India Toposheets. The national highway (NH-80) in South and railway track in north of Ganga river was considered as boundary of *diara* lands of the river. Because these highly stabilized feature was found to restrict the dynamic activity of the river since long back. Both road and railway line were identified on False Colour Composite (FCC) and highly populated and stable

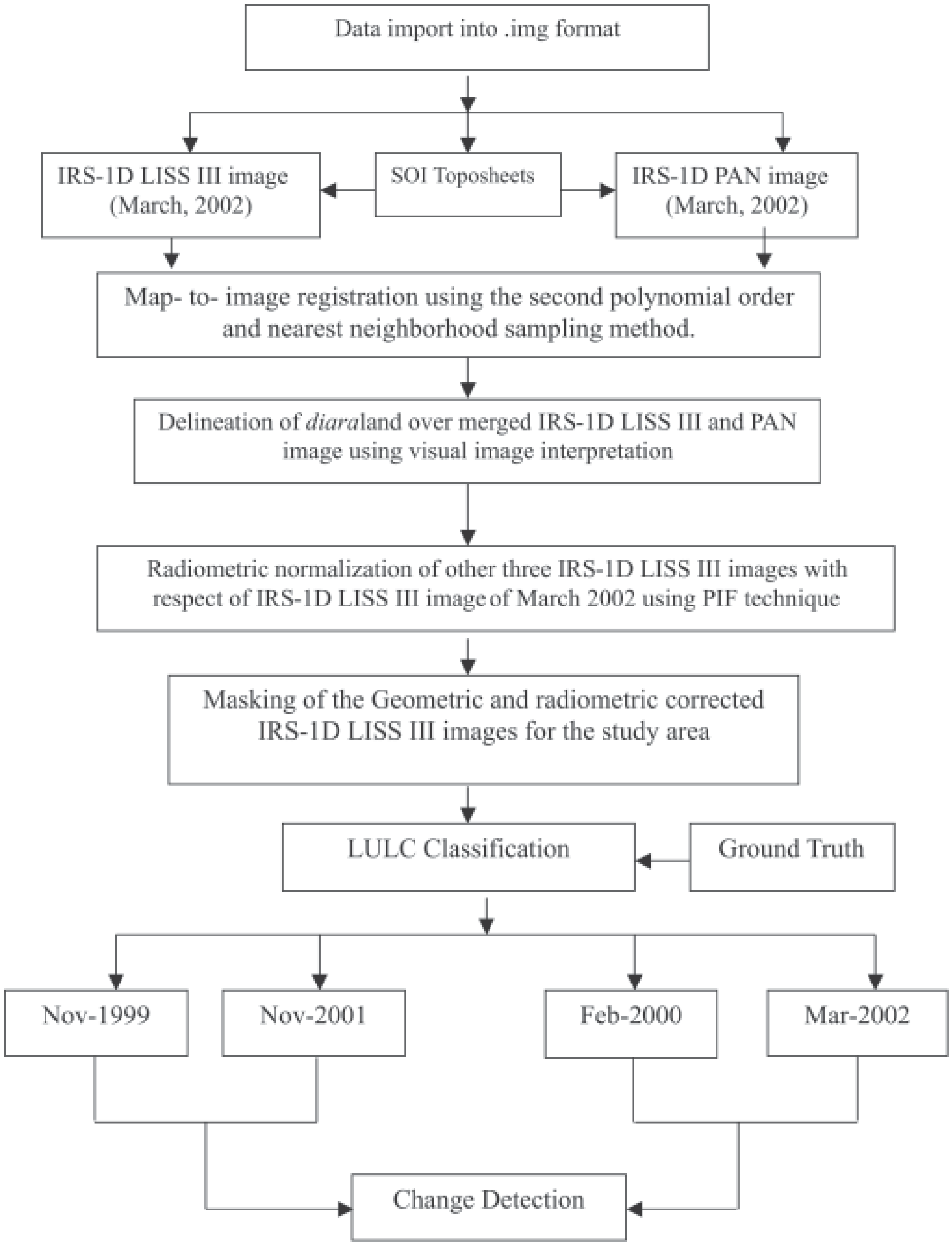

Fig. 1. Methodology for delineation and land use-land cover change detection of *diara* land using temporal data

land near the national highway was taken out after identification on merged image. District boundary of Bhagalpur was taken for East and West boundary of *diara*. Thus, four boundaries as mentioned above were digitized as polygon vector and the file was saved. The area lying within the polygon was considered as *diara* land and its vector file was converted to Area of Interest (AOI) file for further extraction of *diara* land from the other image files (Fig.2) and the total area of the *diara* land found was found to be 64973 ha.

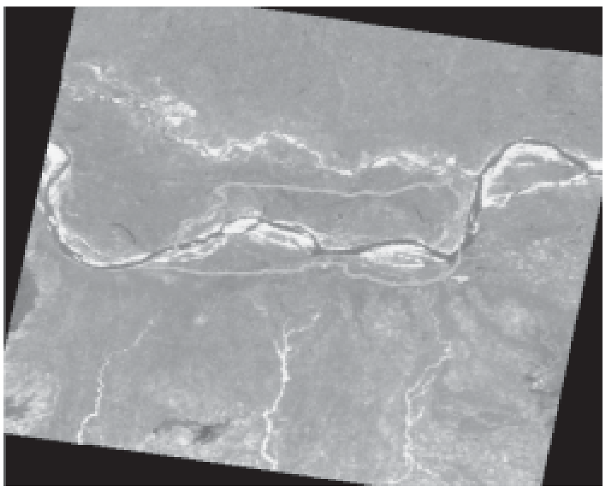

Fig. 2. Delineated *diara* land of Ganga River, Bhagalpur district

Land Use Land Cover Change

IRS-1D LISS III images of four years were used for land use and land cover change detection at two years interval *i.e.* 1999-2001 and 2000-2002. Fourth band (B5) of each image was replaced with NDVI and knowledge based classification of the images was done for 15 classes. Based on the graphical analysis of spectral profile pattern of the various classes (Fig. 3 as an example) and ground information, classes were identified and finally merged to get 6 major classes. The statistics obtained for each year were used for change detection following post-classification comparison.

Results and Discussion

For land use land cover change detection, the statistics obtained from classification of four LISS III data of IRS 1D were compared. November, 1999 image and statistics was compared with November, 2001 and February, 2000 with March, 2002 image. The area under each class and their percentage contribution (in parenthesis) is given in Table 1**.** The acreage change of different classes in two years interval and percentage change within the class is also given.

Six major classes *i.e.* water bodies, sand bed, fallow land, seasonal natural vegetation, cropped

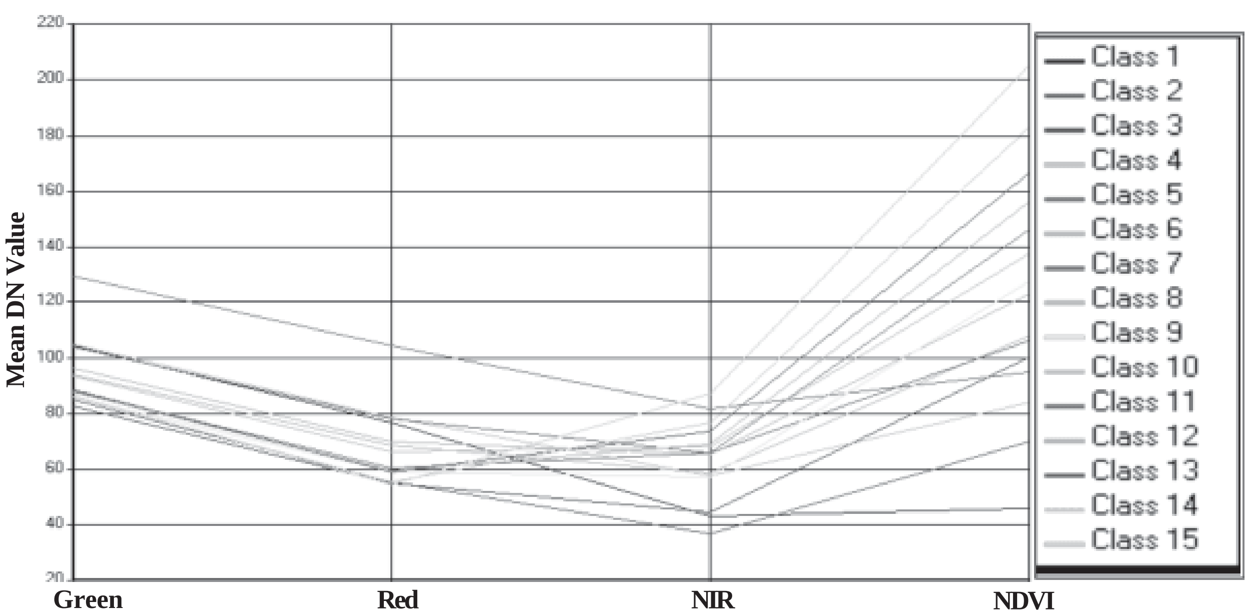

Fig. 3. Spectral profiles of different classes

land, and other permanent type of vegetation were identified for change detection study. The dominant natural vegetation species were Kans (*Saccharaum spontanium*), Jhau (*Casuarina equisetifolia*) and other gramenoids, which are seasonal in nature and mostly harvested by farmers for the purpose like thatching, fodder, rope making and fuel but not sown. Thus, area under natural vegetation seasonally changes to fallow land and even some time cultivated.

Fallow land has two-categories mainly seasonal fallow *i.e.* devoid of spectrally significant vegetation during satellite visit and permanent fallow. Water bodies change to sand beds and even to fallow land followed by natural vegetation progressively from September. Sand beds were observed to change in *diara* land even in a short span of two years. These were mainly associated with main river bodies and recently dead river channels. The classes obtained are interchangeable seasonally.

It was observed in the FCC that water bodies other than river have different tone. This is mainly attributed to different background, amount, thickness and kind of sediment they carry and movement of water. After merging the classes, based on spectral profile, ground observation and taking scientific logic as input finally six classes were obtained. From Table 1, it can be easily observed that area under water bodies was 4 % less in November, 2001 (15 %) as compared to November, 1999 (19 %). Area under sand also decreased from 6.2 to 3.8 %. Fallow land was decreased from 36.08 to 35.00 %. Natural vegetation coverage increased by about 17.7 %. There is a significant increase (21.27 %) in cropped land *i.e.* from 23.98 to 29.05 % of the study area which revealed that the farmer was taking more crops just after recession of flood water in Oct., 2001. Total land area increased during the same period is due to decrease in total area under water and sand. From Fig. 4, it can be clearly observed that a significant part of sand has been converted into soil. A major part of increase in area is the land uncovered by water. Area under permanent type of vegetation is almost constant. Comparing statistics of March, 2002 with February, 2000, the area under water bodies has decreased from 10.04 to 9.24 % ; area under sand bed has also decreased from 9.84 to 8.73 % while fallow land has increased by 7.52 % *i.e.* from 26.84 to 28.86 % of the total study area. The increase in fallow land may be due to senescence and harvest of some of the crops during March and some new land formed

Table 1. Statistics of major land use and land cover classes

Major Classes	Area in ha (%)		
	Nov-1999	Nov- 2001	Change (%)
Total water	12322 (18.96)	9729(14.97)	-2593 (-21.04)
Sand bed	4027(6.20)	2487(3.83)	-1540 (-38.24)
Fallow land	23444(36.08)	22741(35.00)	-703 (-3.00)
Seasonal natural vegetation	8194(12.61)	9645 (14.84)	1451 (17.70)
Cropped land	15578(23.98)	18876(29.05)	3298 (21.17)
Permanent type of vegetation	1408(2.17)	1496(2.30)	88 (6.05)
Total area	64973	64973	-
	Feb - 2000	Mar - 2002	Change
Total water	6523 (10.04)	6002 (9.24)	-521(-7.98)
Sand bed	6395 (9.84)	5673 (8.73)	-722 (-11.29)
Fallow land	17439 (26.84)	18751 (28.86)	1312 (7.52)
Seasonal natural vegetation	7761 (11.95)	7831(12.05)	70 (0.91)
Cropped land	25416 (39.12)	25146 (38.70)	-270 (-1.06)
Permanent type of vegetation	1439 (2.21)	1571 (2.42)	132 (9.17)
Total area	64973	64973	-

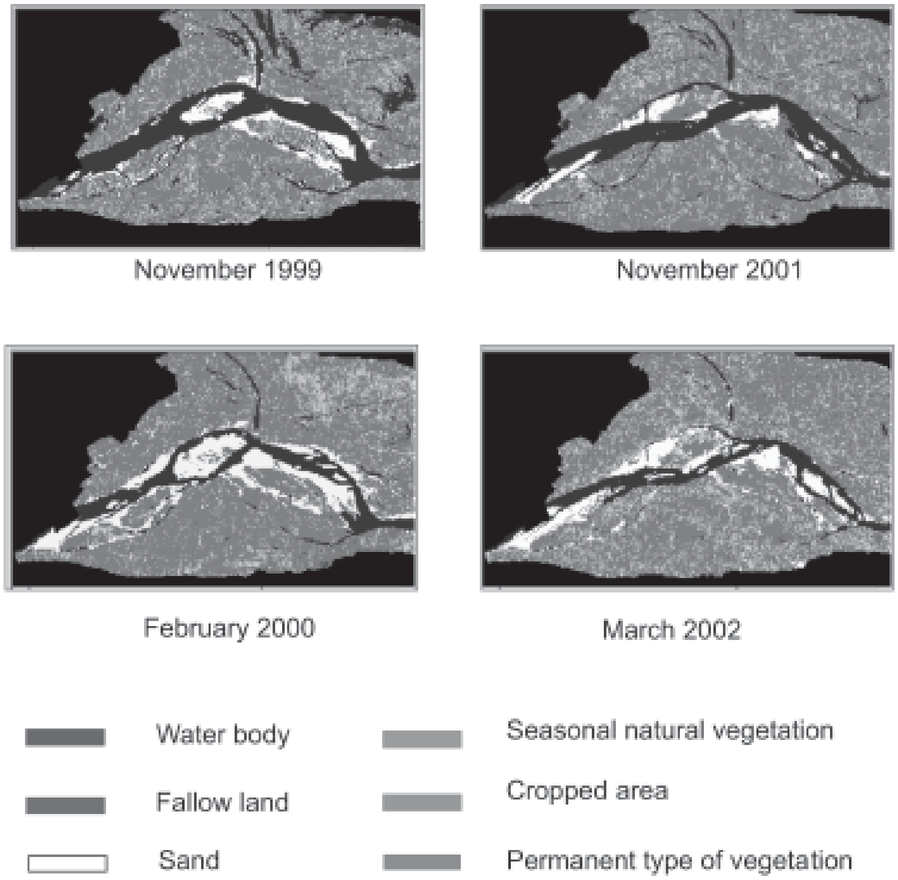

Fig. 4. Land use land cover classes of a part of the study area for different years

during preceding two years. It is clearly visible from Fig.3 that a significant area under sand in February, 2000 has been converted to new land. The river is changing its course and shifting southward at some places and northward at other places. The new land formation during a short span is a typical observable feature of *diara* land.

Summary and Conclusion

It can be concluded that the *diara* land being highly dynamic, needs frequent monitoring. Crop suffers not only from excess of water but also due to soil moisture stress. The study revealed that even after recession of flood, about $1/8^{th}$ to $1/5^{th}$ of *diara* land remains covered with water. Even during the months of February–March, 8-10 % of total area was covered with water, which can be a potential source for further irrigation during lean period. Addition of unsigned 8 bits NDVI as a fourth layer to the three commonly used bands was found to be helpful in identification of different features. New land formation within even a short time span (2 years) was found a typical event with *diara* land. Though the total statistics shows less change, but there was considerable change among the classes particularly due to the shifting of river and formation of new land (active *diara* land) from riverbed. Short term changes in *diara* land were found prominent over long term change because of a sort of periodicity on long term basis which overlook short term changes. Therefore the remote sensing techniques was found to be a potential tool to characterize *diara* land and its land use land cover changes.

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