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Mapping and Monitoring of LULCC through Integrated analysis of Multi-Temporal Images and Change Matrix in Gandheswari River Basin

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Abstract

Study of Land use and Land cover (LULC) has great relevance for find out the relationship between anthropogenic and natural territorial ecosystem. Investigation on spatio-temporal change of land use is a very important aspect to evaluate proper man-land interaction in the paradigm of sustainable development in human civilization. The LULC study through Remote Sensing (RS) and Geographical Information System (GIS) technique helps to know the real time information on spatio-temporal change of natural and manmade aspects e.g. forest cover/density, water body, soil-moisture, settlement/ built up areas and several environmental problems like forest fire, heat islands etc. The study has evaluated land use and land cover and its change over the time period (1990-2014) in Gandheswari River basin. A multispectral and multi-temporal landsat image from three time period (1990, 2002, and 2014) has been classified for the investigation. An attempt has made to discuss the possible influential factors for the LULC changes and change detection matrix has been prepared to analysis the conversion of particular land use/cover to another land use/ cover. In this study, it is found that water body, agriculture, vegetation cover have been declined by 4.7, 6.5 and 4.1 % respectively but settlement area has been increased (13.1%) which may lead to destruction of vegetation, agricultural lands and ground water regime.

Key words: Land Use/Cover, Multispectral & multi-temporal image, Change detection matrix, Gandheswari River basin

Introduction: Monitoring the locations and distributions of land cover changes is important for establishing links between policy decisions, regulatory actions and subsequent land use activities (Lunetta et al., 2006). Land use relates to the human activities or economic functions associated with a specific piece of land or land use refers to utilization of land resources by human beings. While, the land cover reflects the biophysical state of the earth's surface and immediate subsurface, including soil material, vegetation and water (Prakasam, 2010). Land use and land cover is dynamic in nature and the change in spatial pattern of any material to land use and land cover change is called Land use and Land Cover Change (LULCC) also known as land change (Brar, 2013). LULC has also been recognized as an important driver of environmental change on all spatial and temporal scale (Turner et al., 1994). Documentation of land use and land cover change (LULCC) provides information for better understanding of historical land use and future land use tragedy (Zhang et al., 2007). Though the knowledge of historical trends of land cover change, not only how much has changed but also where and when changes have occurred can help land managers identify key resources and ecological systems(Yang et a.,2015) , as well as prioritize management efforts (Shriver et al., 2005). Land is an important resource and day by day its demand is ever increasing because of increasing population with multifaceted needs. The land use pattern of any terrain is a reflection of the complex physical processes acting upon the surface of the earth. These processes include impact of climate, geology and topographic conditions on the distribution of soils, vegetation and occurrence of water (Pal and Debnath, 2012).

Drainage basin is an important base for micro regional planning. A drainage basin is an area of land that contributes water and sediment to a specific outlet point on a stream. It is separated from other drainage basins by its drainage divide; a boundary that encircles a basin along its highest, outermost ridges tops (Goudie, 2004).

Remote sensing is a proven technology that is effective for mapping and characterizing cultural and natural resources (Jensen, 1996) and as well change detection through remote sensing provides quantitative analysis of spatial distribution in an area of interests (Mahmoodzadeh, 2007). The emergence of geospatial technology has provided an easy way to detect land use and land cover change. Remote sensing is an essential tool for land change detection because it facilitates observations across larger extents of earth’s surface in short periods which is not possible by ground based observation. GIS is further beneficial for analyzing land use and land cover (Brar, 2013). Mapping land cover on plays by remote sensing techniques is much less frequent and it is usually tested with in situ observations (Ghrefat and Goodell, 2011).The application of multi-sensor satellite data for land use and land cover change detection is a proven technique (Kamini et al., 2006). Data from remote sensors capable of spectral and spatial resolution are extremely useful for analyzing changes in land use and land cover because characteristics of the area may be analyzed with sufficient precision to be exploited efficiently in the management of natural resources (Dimyati et al., 1996). Change attribute may improve predictions accuracy by distinguishing pixel level spectral conditions, year of change and magnitude of change (Zald et al., 2016). The application of Multi-temporal dimension of change detection has been increasing not only to study the current change detection but also future applications (Lu et al., 2005). There are different image classification techniques and the most widely accepted and most accurate maximum likelihood classification (MLC) (Richards, 1999) approach through pixel based image classification approach has been applied in the study.

Study Area: Gandheswari River, a tributary of Darakeswar, covers an area of 364.9 Sq.km. The basin is spread over four blocks i.e. Bankura, Saltora, Chatna and Gangajalghati in Bankura District. The latitudinal extension of the river basin is $23^{0}13'28''$N (near Banki village) to $23^{0}30'25''$N (Murlu village) and the longitudinal extension is $86^{0}53'13''$E (Jorahira village) to $87^{0}07'30''$E (Banki village). Most part of the river basin belongs to undulating surface except Eastern region (Bankura Town). The average rainfall and temperature are 1400 mm and 27°C respectively. The depth of water tables ranges from 2 to 16m b. g. l. and low yield ground water development is feasible in this part by large diameter open dug wells (District Resource Map of Bankura, 2001).

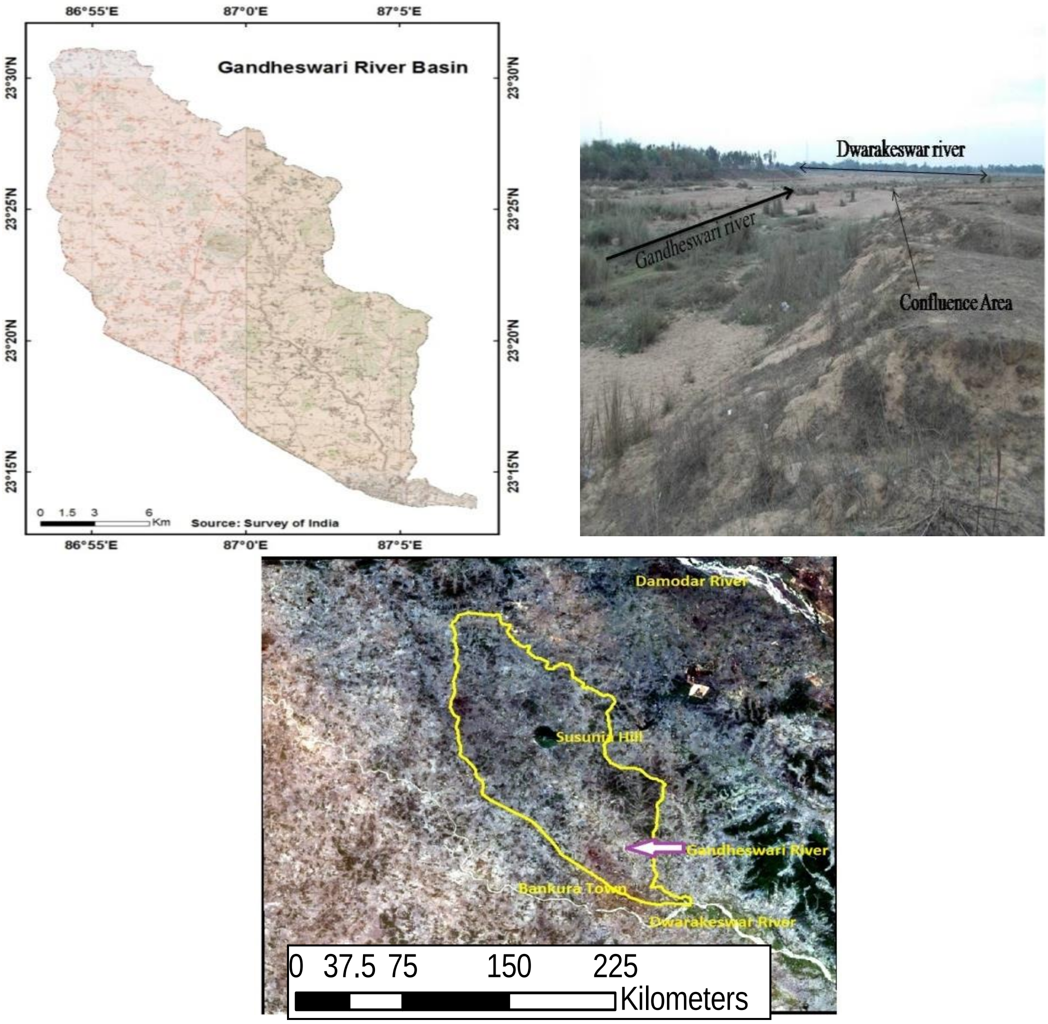


Figure No.2 Location of Gandheswari River Basin

Data Base and Methodology: Remote sensing technology has proved as a highly acceptable, reliable tool (Mukhpadhyay et al., 2013) for resource identification, monitoring, management. Satellite imagery especially landsat imagery has been recognizing as an important resources for mapping land use/ land cover and as well as spatio-temporal analysis of land use/ land cover (Samanta, 2015). This study has been done mainly by the satellite images in three different time periods. The base map i.e. river basin has been demarcated by using mosaic toposheets i.e. 73I/14, 73I/15, 73M/3, 73M/4 of Survey of India (SOI, 1972) at scale of 1:50,000. Three good quality landsat images

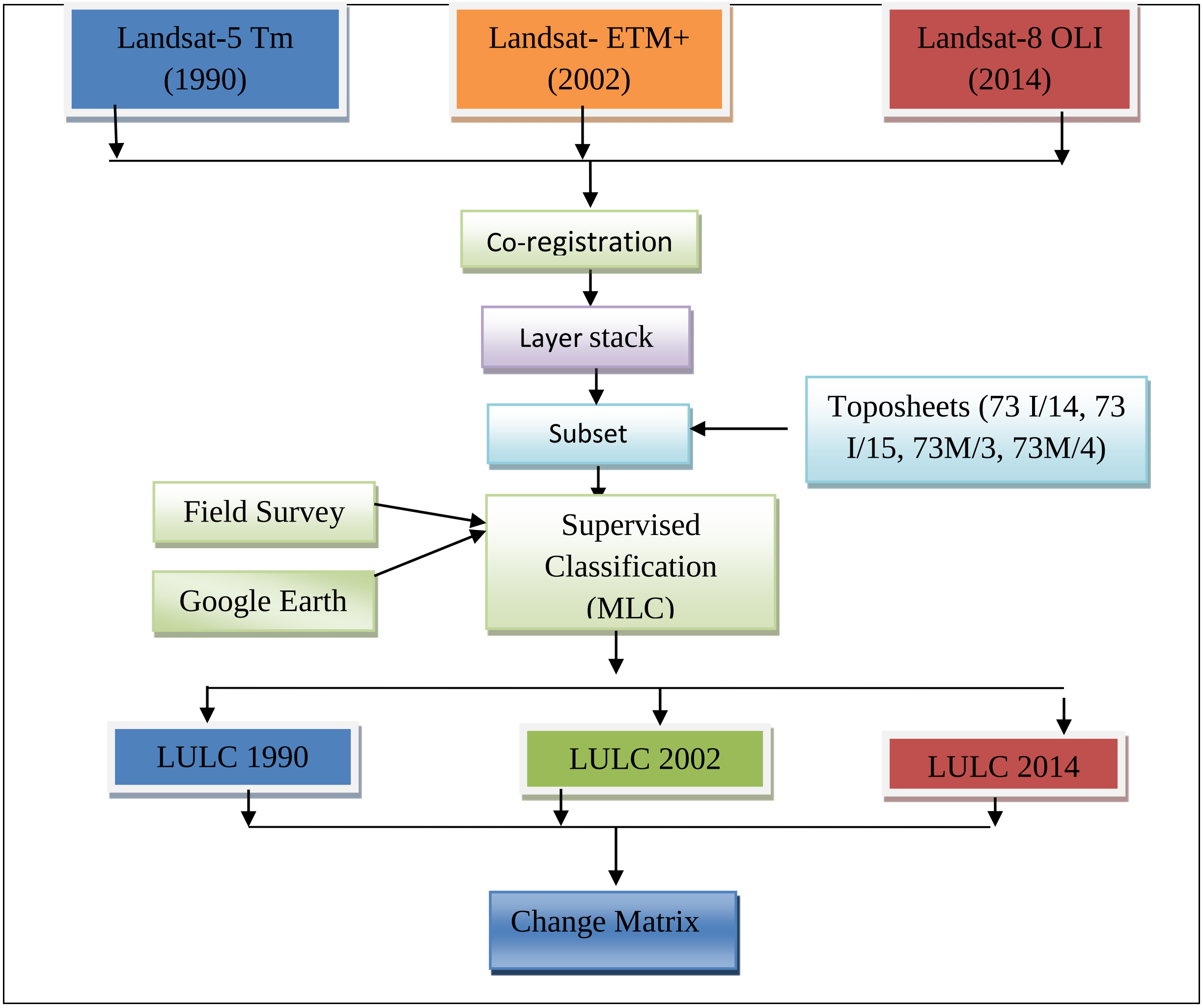


Figure No.1 Flow chart of the study

(1990, 2002, and 2014) at a spatial resolution of 30m have been classified using supervised maximum likelihood image classification approaches in ERDAS Imagine 2014 Software. Due to unavailability of open access high resolution imagery, medium resolution imagery has been taken in the study as a consistent data because of its most suitability for change detection analysis (Muttitanon, 2005, Conchedda, 2008). A detail description of data base has been given in the table no. 1. Georeferencing, layer stack of images and subset from toposheet have been done by ERDAS Imagine 2014, identification of land use and land cover categories have done through ERDAS Imagine 2014. Methodological framework of the study is given in the flow chart (Figure No.1).

Table No.1: Data Used for the Change Detection Analysis

Date Acquired	Type of Imagery / Sensor_ Id	Path	Row	Resolution (m.)	Band Used
25-12-2014	Landsat-8/ OLI	139	44	30	Band 2(Blue), Band 3(Green), Band 4(Red), Band 5(NIR), Band 6(SWIR-1),Band 7(SWIR-2)
16-12-2002	Landsat-7/ ETM	139	44	30	Band 1(Blue), Band 2(Green), Band 3(Red), Band 4(NIR), Band 5(SWIR-1),Band 7(SWIR-2)
23-12-1990	Landsat-5/ TM	139	44	30	Band 1(Blue), Band 2(Green), Band 3(Red), Band 4(NIR), Band 5(SWIR-1), Band 7(SWIR-2)

Results and Discussions

Mapping and Analysis of Land Use and Land Cover in Gandheswari River Basin: There are mainly six types of land use/cover viz. agriculture, barren land, sand, settlement, river/ water body, vegetation. The agricultural land covered almost half area (48.9 percent, 1990) of the river basin and which is the dominant land use of the river basin. With respect to the result gradually, agricultural land has been decreased. The result has shown that agricultural land has been reduced from 48.9 % in 1990 to 42.4 % in 2014 (Table No.1).

River and surface water bodies like ponds, estuaries have covered an area of about 29 % (1990). The basin has also been classified as major and minor channel mainly those which have not full of water also considered under this group as well as pond in same conditions with the knowledge of personal field visit and with the help of high resolution Google Earth. It is the second dominated category of land use/cover. But with the passes of time, this essential land use/ land cover has been in the way of demolishing. From the analysis it is cleared that the area has changed from 28.3 % in 1990 to near about 23 % in 2014 (Table No. 2 and Figure No. 4).

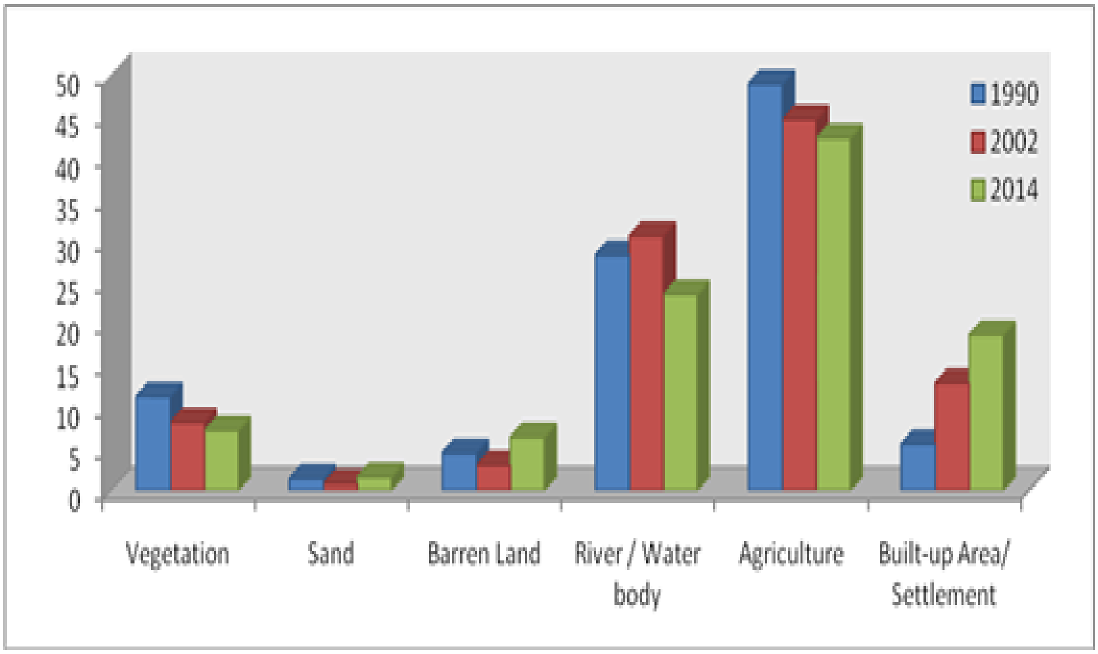
The area under settlement has increased significantly. On the basis of two overlap data it is cleared that there are a lot of changes of settlement area especially in Bankura town which is extended in surrounding peripheral space and on the other hand industrial expansion in some places boosted up settlement expansion (Figure No. 3). Almost 13 percent settlement area has been increased during the study period i.e. 24 years.

Table No. 2: Areas of Land Use/Cover in Gandheswari River Basin

LULC Classes	2014 (Area in Percentage)	2002 (Area in Percentage)	1990 (Area in Percentage)
vegetation	7.2	8.2	11.3
Sand	1.6	0.8	1.4
Barren land	6.4	3.0	4.5
Water	23.6	30.6	28.3
Agriculture	42.4	44.6	48.9
Settlement	18.7	12.9	5.6

Source: Calculated from the Classified Images

Figure No. 4: Temporal Changes of Land Use/ Cover



Surprisingly, vegetation area has been decreased over the time period. It has been reduced as about 4.1%. A significant portion of vegetation has been converted into settlement/built-up areas (Table No.5). On the other hand barren land has decreasing trend and sand area, more or less, is remained same.

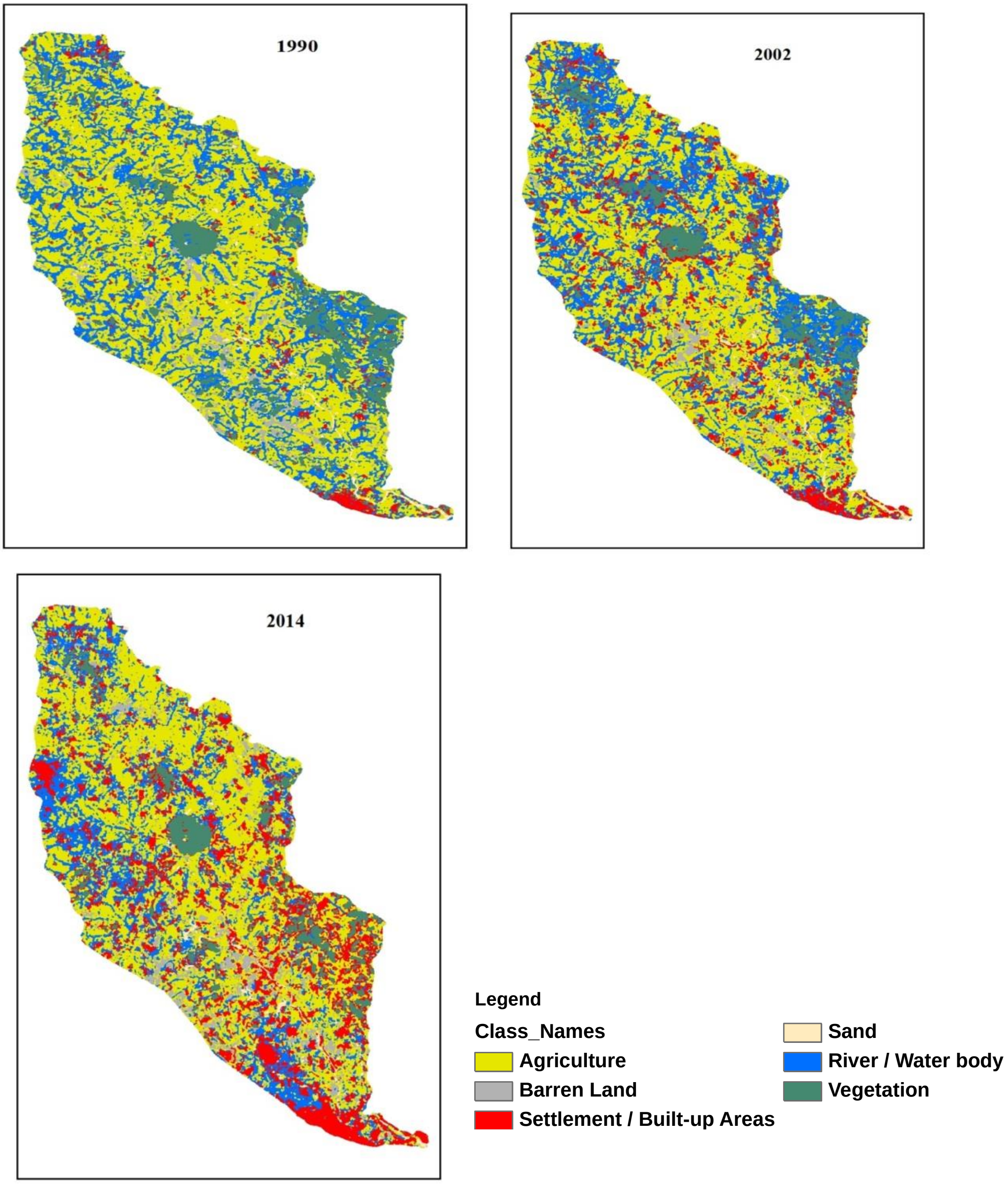


Figure No.3: Land Use and Land Cover Maps of Gandheswari River Basin

Conversion of Land Use and Land Cover (1990-2014): Change detection matrix highlights the changes which has been occurred during the given time period and its conversion from one particular use to other sort of purpose. Landsat pixel compositing and multi-temporal change metrics are an area of active research and product development (Zald et al., 2016). Change detection matrices are very useful to detect the changing pattern. Grecchi et al. (2013) have applied change detection matrices to analyzed changing pattern of annual crops, natural vegetation and planted pasture. The following change detection matrices (Table No.3,4,5) has shown that gradually significant negative changes has occurred in agriculture, water body and vegetative cover but significant positive changes occurred in case of built-up/settlement area.

Table No.3: Change Detection Matrix (1990-2002)

		1990					
		[1]	[2]	[3]	[4]	[5]	[6]
2002	Vegetation[1]	5.73	1.06	0.71	0.41	0.00	0.14
	Agriculture[2]	1.31	38.68	5.51	0.14	0.33	2.01
	River/ Water Body[3]	1.66	9.22	18.33	0.76	0.03	0.08
	Settlement/ Built-up Area[4]	2.59	3.16	2.79	2.06	0.04	0.26
	Sand[5]	0.01	0.16	0.05	0.00	0.39	0.01
	Barren Land[6]	0.11	0.78	0.13	0.00	0.12	1.21

Table No.4: Change Detection Matrix (2002-2014)

		2002					
		[1]	[2]	[3]	[4]	[5]	[6]
2014	Vegetation[1]	4.37	0.80	0.66	0.85	0.00	0.17
	Agriculture[2]	0.56	31.59	11.79	1.54	0.13	0.79
	River/ Water Body[3]	0.38	7.43	11.83	1.72	0.05	0.27
	Settlement/ Built-up Area[4]	2.75	3.81	5.22	6.73	0.06	0.32
	Sand[5]	0.00	0.41	0.07	0.03	0.28	0.38
	Barren Land[6]	0.01	3.94	0.51	0.04	0.10	0.42

Table No.5: Change Detection Matrix (1990-2014)

		1990					
		[1]	[2]	[3]	[4]	[5]	[6]
2014	Vegetation[1]	4.68	**1.27**	0.50	0.13	0.01	0.27
	Agriculture[2]	1.40	32.52	10.23	0.30	0.29	1.64
	River/ Water Body[3]	0.69	9.09	11.04	0.41	0.09	0.36
	Settlement/ Built-up Area[4]	**4.54**	**6.05**	**4.98**	2.53	0.12	0.67
	Sand[5]	0.04	0.37	0.18	0.00	0.29	0.30
	Barren Land[6]	0.05	**3.76**	0.61	0.00	0.12	0.47

If, the change detection matrix is being considered from 1990 to 2014, then, there are some significant changes occurred (Table No.5). These are mainly settlement, agriculture and river/ water body. Vegetative area has a negative rate (Table No. 2) and its conversion has occurred mainly in settlement or built up/settlement areas (Table No. 5). On the other hand, a considerable conversion has been occurred from agriculture and water body to settlement/ built up area. The conversion of agricultural land to barren land is also significant as 3.8 %. Conversion of agriculture to water body (9.09) and from water body to agriculture (10.23) is more or less same, so these are not so important. In some area agricultural land also converted into vegetation which are quantitatively 1.27 % with respect to total area.

Photo 1: River Bed during Dry Season **Photo 2**: Human Intervention on the Top of Susunia Hill

Conclusion: Summarily, there is significant change in terms of different land use and land cover categories. A remarkable change has occurred in agricultural land which has converted into settlement/built-up area within short passage of time. Sponge iron industry and adjoining expansion of settlement area, may be a role in destruction of agricultural land. The monitoring on qualitative consequences of the quantitative change of vegetative cover is urgently praiseworthy because lack of in situ conservation with indigenous plant species may appear a cosmetic surgery in the natural system what may enhance multiple ecological anomalies in future. Question of food security in general and sustainability of the peripheral rural livelihood in particular are to be address judiciously. Haphazard encroachment of land in the basin through proliferation of industry and settlement be studied with due diligence.

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