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Research article

Assessment of land use land cover change in Chakrar watershed using geospatial technique

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Abstract: Rapid urbanization, anthropogenic and socioeconomic activities and environmental changes, in local and regional area, are important component responsible for extensive land use land cover changes (LULCC). Now a day, it is important to determine LULCC at appropriate scale to determine impacts of above mentioned components. In this study an attempt has been made to analyze LULCC in the Chakrar watershed, Madhya Pradesh which is an important tributary of the Narmada River. The watershed is covered by natural forest that is out skirt forest of Achanakmar-Amarkantak Biosphere reserve of Central India. A series of systematically corrected orthorectified Landsat imageries of 1990, 2000, 2005, 2011 and 2013 were used for classification. Geospatial technique was used to assess LULCC and accuracy assessment was also done. It was obtained that natural forest cover decreased by 24.11 Km^2 and human settlement increased by 7.78 Km^2. Therefore, the study was important to assess the loss in natural vegetation that can affect natural biodiversity, ecology and biosphere reserve including environment.
Keywords: Geospatial Technology - LULCC - Chakrar Watershed - Forest degradation.

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INTRODUCTION

Change detection analysis is important for development planning and management activities and considered as essential aspect for modeling the earth system. Change detection is useful for a wide variety of subjects for example monitoring deforestation, coastal dynamics, shoreline change and river transportation on multi-temporal satellite images (Muttitanon & Tripathi 2005, Fromard *et al.* 2004, Duncan *et al.* 1993). Land use Land cover (LULC) mapping is essential for change detection analysis. Landuse refers to the way in which land has been used by humans and their habitats, usually with accent on the functional role of land for economic activities. Land cover refers to the physical characteristics of earth's surface, natural vegetation, water bodies, soil/rock, artificial cover and others resulting due to land transformation. The landcover changes occur naturally in a progressive and gradual way, however sometimes it may be rapid and abrupt due to anthropogenic activities. LULC changes especially those caused by human activities is the most important component of global environmental change with impacts possibly greater than the other global changes (Turner *et al.* 1994, Jensen 2005). Land cover change is occurring from the conversion of forests to agricultural lands and built-up lands (Delang 2002, Duram *et al.* 2004, Shalaby & Tateishi 2007, Turner *et al.* 2007, Munoz-Villers & Lopez-Blandco 2008).

Now-a-day deforestation is the main problem for biodiversity and society. Deforestation affects not only the ecosystem but also the usefulness of the forest as a resource. It involves multiple interrelated factors of people-forest interaction and results in significant environmental and social consequences (Gessesse 2007). Forests are valuable resources that provide enormous benefits for example wood and other products. Forests regulate climate and fresh water flow, protect and enrich soils, control pests and disease, maintain biodiversity, safeguard water quality offer beautiful landscapes and enrich humans spiritually (Byron & Arnold 1999, Kaimowitz &

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Angelson 1999, FAO 2005). Forest covers reduction through deforestation and conversion for agricultural purposes can alter a watershed's response to rainfall events, that often leads to increased volumes of surface runoff and greatly increase the incidence of flooding (McColl & Aggett 2007, Cebecauer & Hofierka 2008). Forests have a pervasive influence on the ecosystems, environmental and the lives of people. They support millions of local residents directly, while they are indirectly vital to many more that depend upon the water cycle regulated by them (Bruijnzeel & Bremmer 1989, Hamilton 1987). Forest cover change is a process in which the level of diversity and the density of individual species that makes up the natural vegetation structure are altered as a result of natural/internal and external factors (Belaynesh 2002). The basic cause of forest degradation is high population density and population growth rate (Dien 2004), climate change and over consumption of ecosystem services which treat and tends to the biggest challenge for the society (Sachs *et al.* 2009). Global warming is common impact of deforestation including loss of biodiversity, reduced water cycling (Dewi 2009) and loss of fuel, fodder, food (Gibson *et al* 2000, Wang *et al.* 2006). Logging, grazing and new settlements establishment have contributed to forest degradation and depletion (Bekele 2001, Nair & Tieguhing 2004).

Remote sensing and GIS (Geographical Information System) technique (combined called as Geospatial Technology) have been used extensively to provide accurate and timely information describing the extent of LULC over time. It explores new ways to detect, characterize and monitor forest change (Kasischke *et al.* 2004). Change detection analysis, employing both GIS and remotely sensed data, has been used to assess forest depletion (Jacobberger-Jellison 1994, Peters *et al.* 1993, Prenzel 2004) in the Chakrar watershed. The watershed is an important tributary of the Narmada River and is covered by natural forest which is out skirt forest of Achanakmar-Amarkantak biosphere reserve of Central India.

MATERIALS AND METHODS

Study Area

For the present study forest around Chakrar watershed was selected. The Chakrar watershed rises towards south at an altitude of 980 meter of Satpura hills of Dindori district of Madhya Pradesh and flows to the north to meet the Narmada River at an altitude of 700 meter. It is bounded by $22^0$31'12.24"N to $22^0$52'44.93"N latitude and $81^0$14'41.23"E to $81^0$28'29.42"E longitude (Fig. 1). Total catchment area of the Chakrar watershed is 415 km^2. Geologically the area is characterized by dominant basaltic lava flow of Deccan trap of Cretaceous to Palaeogene age and in the high altitude area or margin area laterite of Cainozoic age is found. Rock type is hard and compact. The study region is characterizes by high level plateau and half part by middle level plateau. Average annual rainfall is 1200–1300 mm.

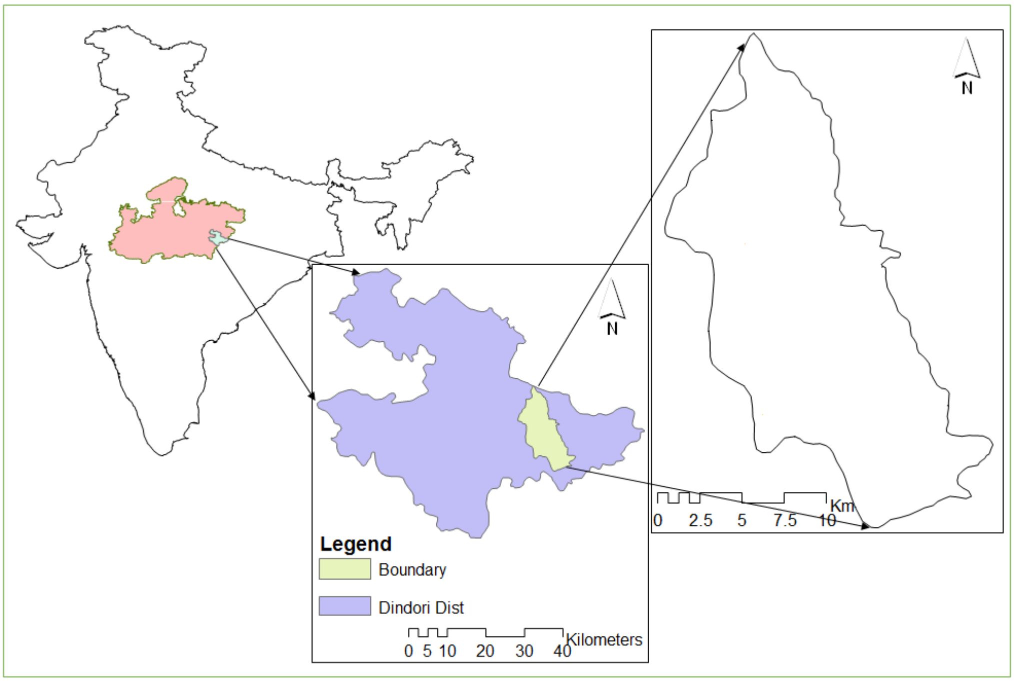

Figure 1. Location map.

The watershed is rich of biodiversity. *Shorea robusta* (Sal) is common tree of the forest including Lagerstroemia parviflora, Amla, Mahua and other tree species with different varieties of herbs and some medicinal plant. The fauna comprises tiger, nilgai, sambar, chital, leopard, wild dog, bison (gour), black buck and many others. Wheat, Paddy, Maize, Kodo-Kutki, Ramtil, Mustard, Masoor, Matar, Gram, Alsi, Soyabean are the main crops of this district.

Experiment designing

In this study Survey of India digital topographic maps (64F/5, 6, 7 & 10) were used to extract watershed boundary with a scale 1:50,000. For LULC mapping of the watershed, Landsat 5, 7 and 8 TM (path 143, row 44) satellite images of 5 different years (1990, 2000, 2005, 2011 & 2013) were used. Satellite data was procured from USGS websites (www.glovis.usgs.gov). The satellite data and collateral data were processed and field survey was conducted for ground truthing to perform supervised classification. The satellite data was processed in ERDAS Imagine 9.2 software for geometric correction to remove geometric distortions, introduced by the sensor system. It is needed to georeference the distorted data to a coordinate system. The imageries were georeferenced using ground control points with a root mean square error (RMSE) of less than one pixel. The Universal Transverse Mercator (UTM) geographic projection, WGS84 spheroid, and zone 44 North datum were used in georeferencing the images. All the imageries were resampled to a 30×30 pixel size using the nearest neighbor resampling technique (Serra *et al*. 2003). Pixel based supervised image classification with maximum likelihood classification algorithm was used to map the LULC classes. Eight LULC classes *viz*; settlement, low dense vegetation, high dense vegetation, fallow land, open land, water bodies and agriculture were identified for classification.

RESULT AND DISCUSSION

Accuracy assessment of the supervised classification of the satellite imagery was derived by using a reference template from the margining data with 40 randomly selected samples on the latest imagery, from which overall accuracy and Kappa statistics were derived. The Kappa statistics incorporated the diagonal elements of the error matrices (Yuan *et al.* 2005). Satellite imageries of 1990, 2000, 2005, 2011 and 2013 were classified and validated using error matrix and Kappa statistics. The overall accuracy was found to be 91 percent whereas overall Kappa statistics was 0.8898. The statistics shows that the result was overall good.

Table 1. Land use land cover changes from 1990–2013.

Class	1990		2000		2005		2011		2013	
	Area (Km^2)	Area (%)	Area (Km^2)	Area (%)	Area (Km^2)	Area (%)	Area (Km^2)	Area (%)	Area (Km^2)	Area (%)
Sattlement	4.91	1.18	6.41	1.54	10.96	2.64	12.29	2.96	12.69	3.06
River	2.67	0.64	2.71	0.65	2.73	0.66	2.73	0.66	2.72	0.66
Waterbodies	0.24	0.06	0.26	0.06	0.34	0.08	0.43	0.10	0.48	0.11
High Dense Vegetation	139.83	33.69	132.15	31.84	131.73	31.74	96.25	23.19	95.85	23.10
Low Dense Vegetation	54.54	13.14	58.46	14.09	54.92	13.23	75.55	18.20	74.37	17.92
Fallow Land	143.04	34.46	141.15	34.01	159.25	38.37	162.56	39.17	180.33	43.45
Open Land	16.40	3.95	11.83	2.85	17.74	4.28	16.63	4.01	17.29	4.17
Agriculture	53.39	12.86	62.07	14.95	37.35	9.00	48.60	11.71	31.29	7.54
Total	415.03	100.00	415.03	100.00	415.03	100.00	415.03	100.00	415.03	100.00

Significant changes were found in the LULC maps, prepared from Landsat imageries of 1990, 2000, 2005, 2011, and 2013 (Fig. 2) and trend analysis was carried out to compare the land cover type (Fig. 3). Regardless of the proportion of changes in size of the cover types, significant changes have been observed between 1990 and 2013. The various land cover types; settlement, low land vegetation, fallow land show almost a similar trend with dramatic increase in their areas (Table 1). In this period of 23 years, High dense vegetation (HDV) was found as most affected land cover class. This class was degraded by 10.59%. In 1990, HDV was spread over

139.83 sq km and remain to 95.85 km^2 in 2013. It revealed a decreasing trend with highly positive correlation coefficient (r^2 = 0.8419). The cause of this degradation is the converting HDV into low dense vegetation (LDW) and settlement. Low dense vegetation was increased to 17.92% (2013) from 13.14% (1990). It revealed an increasing trend with positive correlation coefficient (r^2 = 0.7274). In the watershed, reason of the forest degradation is human interferences. The settlement was increased from 1.18% (1990) to 3.06% (2013). This class revealed an increasing trend with highly positive correlation coefficient (r^2 = 0.9066). Fallow land was increased from 34.46% (1990) to 43.45% (2013) with increasing trend and high correlation coefficient (r^2 = 0.8981). Agriculture was decreased from 12.86% (1990) to 7.54% (2013). This class revealed an increasing trend with positive correlation coefficient (r^2 = 0.5458).

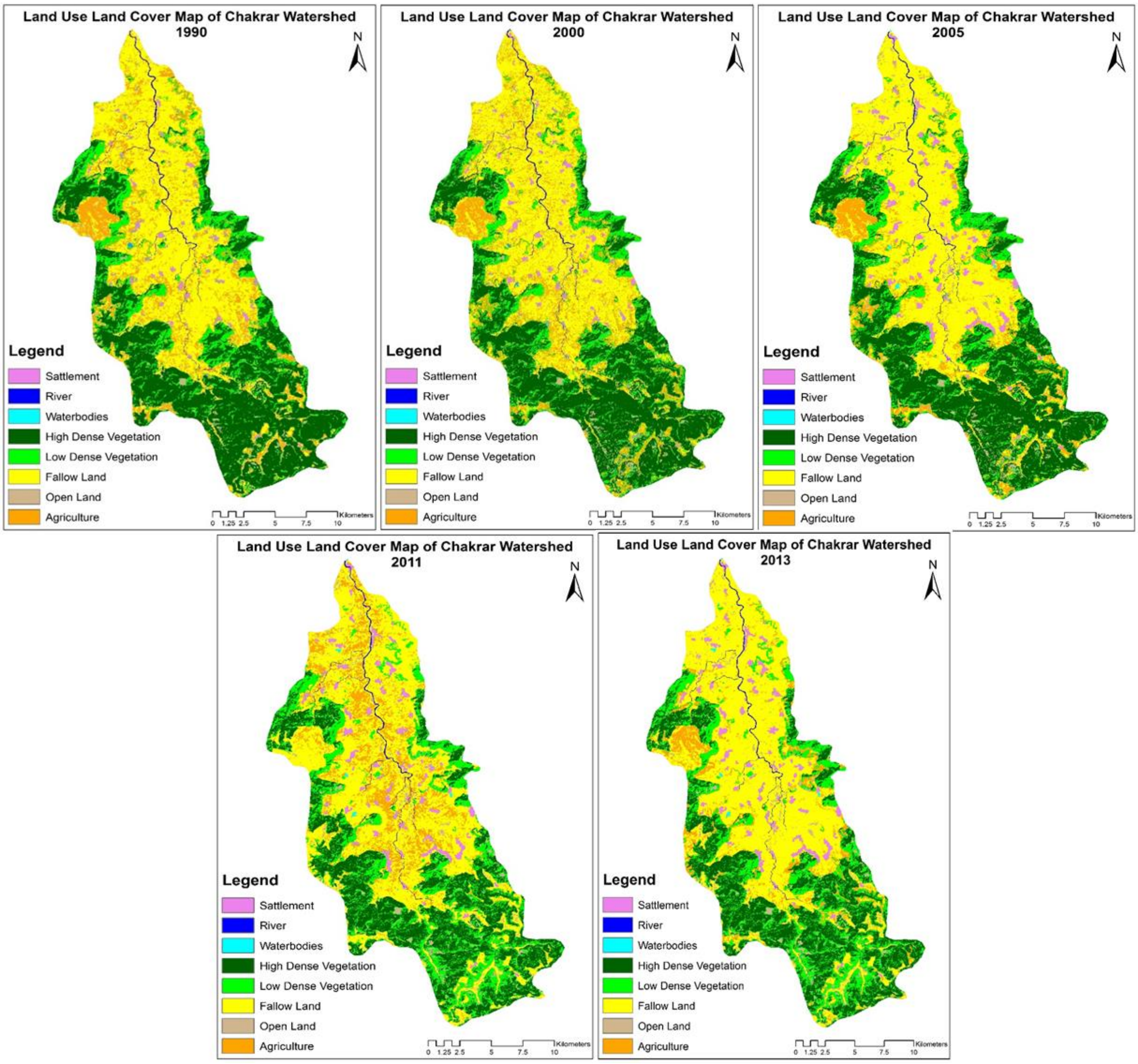

Figure 2. Land use land cover change map of 1990, 2000, 2005, 2011 and 2013.

CONCLUSION

It is concluded that the forest within the watershed is degraded from 46.83% to 41.02% in 23 years *i.e.* 5.81%. Trend of deforestation is 0.35% area per year. It is happening due to rapid urbanization, increase in settlement so. The study reveals that Remote Sensing and GIS are powerful for earth observation and environmental degradation study. They provide LULC classification schemes, land changes and dynamics characterization. The results from image classification showed that the major LULC changes in the Chakrar watershed in three decade was forest. There were decrease in high dense vegetation and increase in settlement, low dense vegetation agriculture and open land. The main transitions were observed among high dense

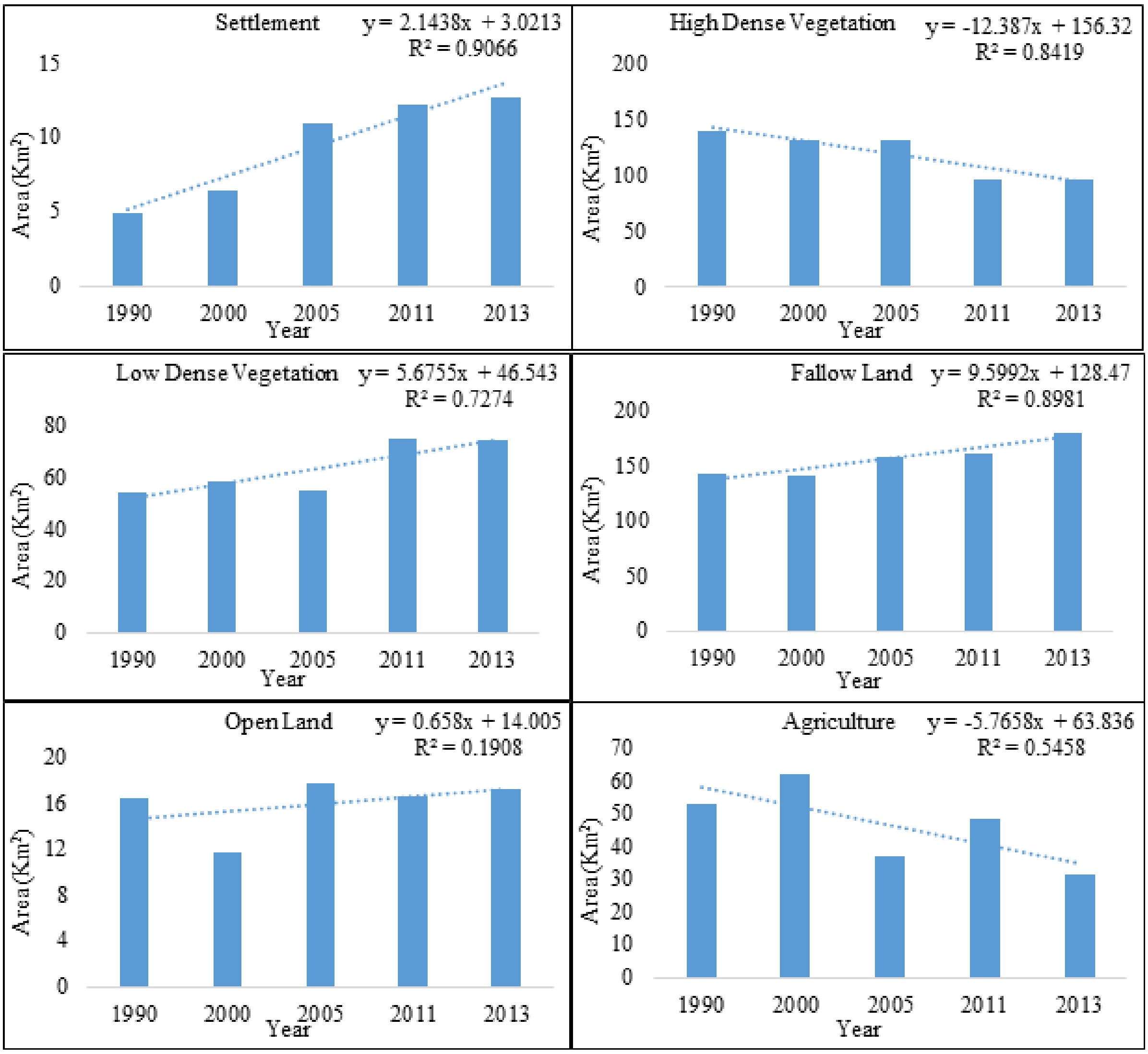

Figure 3. Trend of land use land cover classes.

vegetation that converted to low dense vegetation settlement and open lands. It is considered that deforestation in the Chakrar watershed was caused primarily due to agricultural activities and urban and rural development. Reforestation and agroforestry practices can be followed over open land and deforested land to save forest, biodiversity, biomass and natural habitat of flora and fauna.

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