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Application of geospatial techniques for land use land cover change detection in Pairi river subbasin

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Abstract

The Information on spatial and temporal changes of land use and land cover (LULC) is essential for management of agricultural land, water resource and for over all sustainable development agriculture. Here, remote sensing (RS) and geographic information system (GIS) techniques are used to assess the changes in LULC patterns in Pairi river subbasin which is a part of the Mahanadi basin for the periods 2001 to 2021 on decadal basis. Landsat satellite imagery of 30 m resolution for the year 2001, 2011 and 2021 and ArcGIS software were used to identify the changes in LULC. Maximum likelihood supervised classification was used to classify the satellite images. The classification had done using nine LULC class viz. water body, scrub land, barren land, fallow land, forest land, built up, agricultural land, river and canal. This study indicated that in the last 20 years period, agricultural land and built-up areas have significantly increased by 17.60% to 20.69% and 0.86% to 1.76%, respectively whereas forest area decreased from 75.68% to 71.74% during the study period. The water body area also increased from 1.03% to 1.41% during the period 2001 to 2021. Fallow, barren and scrub land follows the decreasing trend during the study period. Hence, appropriate land management practices may be adopted to prevent the undesirable affects LULC changes on natural resources like soil and water.

Keywords: Remote sensing, Geographic information system, Land use land cover, Pairi river subbasin

1. Introduction

After independence land use and land cover (LULC) have changed significantly in India. Various factors such as growing population, infrastructure development, industrialization, increasing food demand and various other human needs are forced the stake holders and policy makers to alter existing land use to other land use as per their suitability and needs. Changes of LULC affect both the onsite and offsite. Soil erosion, siltation of reservoir and channel, flood and loss of fertile agricultural land and other soil and environmental related problem accelerated due to change of LULC. Due to increasing anthropogenic activities and climate change, it is very much essential to assess the change of LULC on periodical basis for planning and management of other natural resources which are influenced by the change of LULC. Hence it is essential to assess the LULC change, so that its mitigation measures to combat the negative impacts of change of LULC can be planed.

Various researchers all over the world used remote sensing (RS) and geographic information system (GIS) to assess the change in LULC. The LULC is largely determined by the altitudes, slope, geological structures and ecological conditions (Mishra *et al.*, 2020) [5]. At the medium resolution of 30 m, Landsat Thematic Mappers (TM, ETM, and ETM+) data enable mapping of important crops and primary cover types (Dontree, 2003; Gao, *et al.*, 2006) [3, 4]. The GIS and remote sensing can combine many types of data in one platform for analysis and added a new dimension to the research on LULC changes at various scales (Wang *et al.*, 2013) [9]. Tewabe and Fentahun (2020) [2] used remote sensing technique and satellite images for studied the LULC changes in the Lake Tana Basin, Northwest Ethiopia for the period 1986, 2002 and 2018 and found that the agricultural and built up area continuously in increasing trend whereas forest area in decreasing trend. Using satellite images, the change detection of LULC in Yamuna river basin of India for the years 1985, 1995 and 2005 were done and it was observed that during the study period cropland and built-up area increased whereas forest area and water bodies

decreased (Bansal *et al.*, 2016) ^[1]. A study was conducted on LULC changes in India using satellite imagery found that a considerable rise in built-up and crop land where as there are decrease in fallow land, forest, and wasteland during 1985 and 2005. (Roy *et al.*, 2015) ^[6]. It was identified that there were changes in India's LULC patterns associated with a decline in the country's forest cover, an increase in its farmland, and a built-up areas. (Tian *et al.*, 2014) ^[7]. The Landsat satellite data and GIS technique were used to analyze the land use land cover changed pattern for the period 1991, 2000 and 2014 and observed that forest area significantly decreases and mining area increased (Vishwakarma *et al.*, 2016) ^[8]. In the present study Landsat satellite images have been used to assess the changing pattern of LULC in Pairi river subbasin from 2001 to 2021. The aim of the paper is to utilize the geospatial techniques to detect the spatio-temporal change of land use land cover from 2001 to 2021 on decadal basis.

2. Data and Methods

2.1 Study area: The Pairi river originates from Bhatigarh hills of Gariaband district, Chhattisgarh state which is a tributary of Mahanadi River. The catchment area of the sub-basin upto gauging point is approximately 3195 km². The major catchment area situated in Dhamtari and Gharianband districts of Chhattisgarh state and some part in Nabarangpur district of Odisha state. The geographical extension of the sub-basin lies in between 81°51'58.7"- 82°26'16.04" E latitude to 19°55'51.9"- 20°55'6.9" N longitude (Fig. 1). The elevation ranges from 280 to 964 m above mean sea level (MSL). More than 85% of rainfall occurs during south west monsoon period. Paddy is the major crops followed by maize. Major land use the study area is forest followed by agriculture.

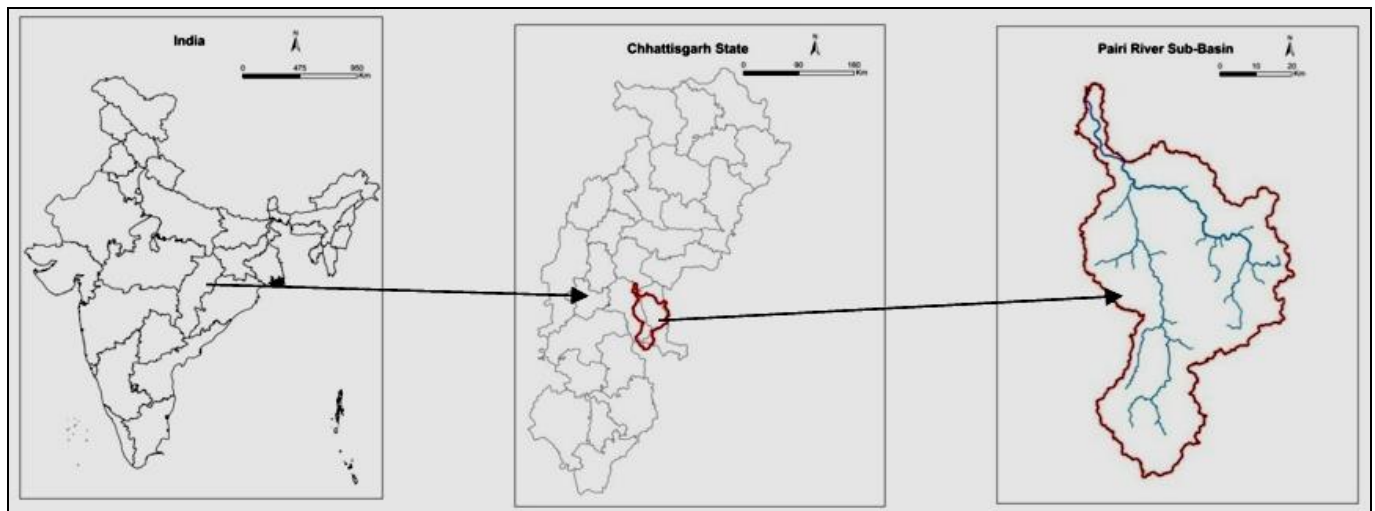


Fig 1: Location map of Pairi subbasin

Data Sources

Landsat satellite images of 30 m resolution were used to analyses the change detection of LULC of study area for the years 2001, 2011 and 2021. SRTM DEM of 30 m resolution was used to delineate the subbasin boundary of the Pairi river. All the images were downloaded from USGS earth explorer website. Apart from this, Survey of India, toposheet (1:50,000) was also used to obtain additional information about the Pairi river subbasin.

Data analysis

The Landsat imageries for the year 2001, 2011 and 2021 of the study area were used for classification of land use land cover (LULC). The numbers of LULC categories are chosen based on the requirement. Here nine classes of LULC such as Agriculture, Fallow, barren, scrub, forest, built-up, canal, river and water body class were chosen to classify the LULC of the entire subbasin area. After the choosing the of class, supervised classification method with Maximum Likelihood Classifier (MLC) module applied for classification of LULC using Geographical Information System (GIS). Signature file (.sig) was prepared by selecting the training samples for the supervised classification. Each pixel in the image data set was then categorized into the land use class which it most closely resembles. The LULC maps for the study area was prepared to identify the changes in LULC. Topographic maps, field surveys, visual interpretations, and as well as Google Earth, all used for

LULC information and validation of prepared maps.

Results and discussion

The decadal year (2001, 2011 and 2021) land-use maps were classified into nine classes. The classified LULC classes are agriculture, forest, fallow land, scrub land, barren, canal, river, water body and built up area. The area under each land use class is presented in Table 1 and land use/ cover map of study area are shown in Fig. 2.

Decadal changes of LULC revealed that agriculture land continuously increases from the year 2001 to 2021. The agriculture area in the year 2001 was 17.60% which increases to 20.69% in the year 2021. The reason behind the increase of agricultural land may be to meet the food requirement of rising population, provision assured irrigation etc. Similar trend was observed in area under water body which increases from 2001 to 2021. In the year 20001 the area under water body is 1.03% which increases to 1.41% area in 2021. The maximum percentage of area is increase from 2001 to 2011. In this period watershed activities work was undertaken in the country under the various watershed development programme which may be one of the reasons and water bodies may be constructed intensively in the subbasin also. Rising trend was observed in the case of settlement/built up area in the study area. The area under built up is continuously rises from 2001 to 2021 from 0.867% to 1.769% respectively. Development of infrastructure, growing population and better economy of resident/farmers etc.

may be the reasons for increasing the built-up area. Non-uniformly decreasing trend of forest area observed in the subbasin from 2001 to 2021. The forest area is decreases from 75.68% to 71.741% from 2001 to 2021. This may be due to conversion of forest land to other land use. During ground truthing of LULC it is observed that deforestation observed more nearer to settlement area and same has been revealed from the land use maps of the study area. Maximum decrease of forest area is found in the upper part of the subbasin. Canal and river area/length is almost constant throughout period 2001 to 2021. Decadal changes of fallow land and shrub land in the study area indicates non uniform trend for the period 2001 to 2021. The fallow land area is decrease from 1.40% to 1.24% from 2001 to 2021. The spatial distribution of fallow land is scattered manner and distributed throughout the subbasin. Due to more demand of food grain to meet the requirement of rising population, fallow land continuously changes to agricultural land in non-uniform pattern. The shrub land is decrease from 1.48 to 1.26% from the

year 2001 and 2021. Barren land generally is the common property land of the villages. Barren land forms due to faulty agricultural practices or some inherent characteristics of the soil/topographic features that land became barren land. Now a days' due to paucity of other land the farmers convert this land into other land use as per their requirement. The barren land is decreases from 0.31% to 0.24% from 2001 to 2021. The land use/land cover analysis shows that the forest area is continuously decreasing whereas agriculture and built up area have increasing trend during this period. This indicates that water demand in the study area may be increased in future due to increase in agricultural land and rising population. More water will be withdraws from the river and ground water to support the agriculture as well as for household purposes. During ground truthing of LULC it is observed that farmers are using solar pumping system to irrigate the crop mainly paddy in this period.

Table 1: Details of LULC area of the Pairi subbasin

S. No.	Class Name	Area, Km ²			Area, %		
		2001	2011	2021	2001	2011	2021
1.	Agriculture	562.414	623.349	661.102	17.602	19.51	20.692
2.	Fallow	44.774	42.594	39.897	1.401	1.333	1.249
3.	Barren	9.960	10.560	7.782	0.312	0.331	0.243
4.	Scrub	47.446	42.597	40.309	1.485	1.333	1.262
5.	Forest	2417.965	2328.91	2292.119	75.68	72.892	71.741
6.	Built up	27.690	52.309	56.527	0.867	1.637	1.769
7.	Canal	1.436	1.436	1.436	0.045	0.045	0.045
8.	River	50.375	50.657	50.764	1.577	1.586	1.589
9.	Water body	32.940	42.588	45.064	1.031	1.333	1.41

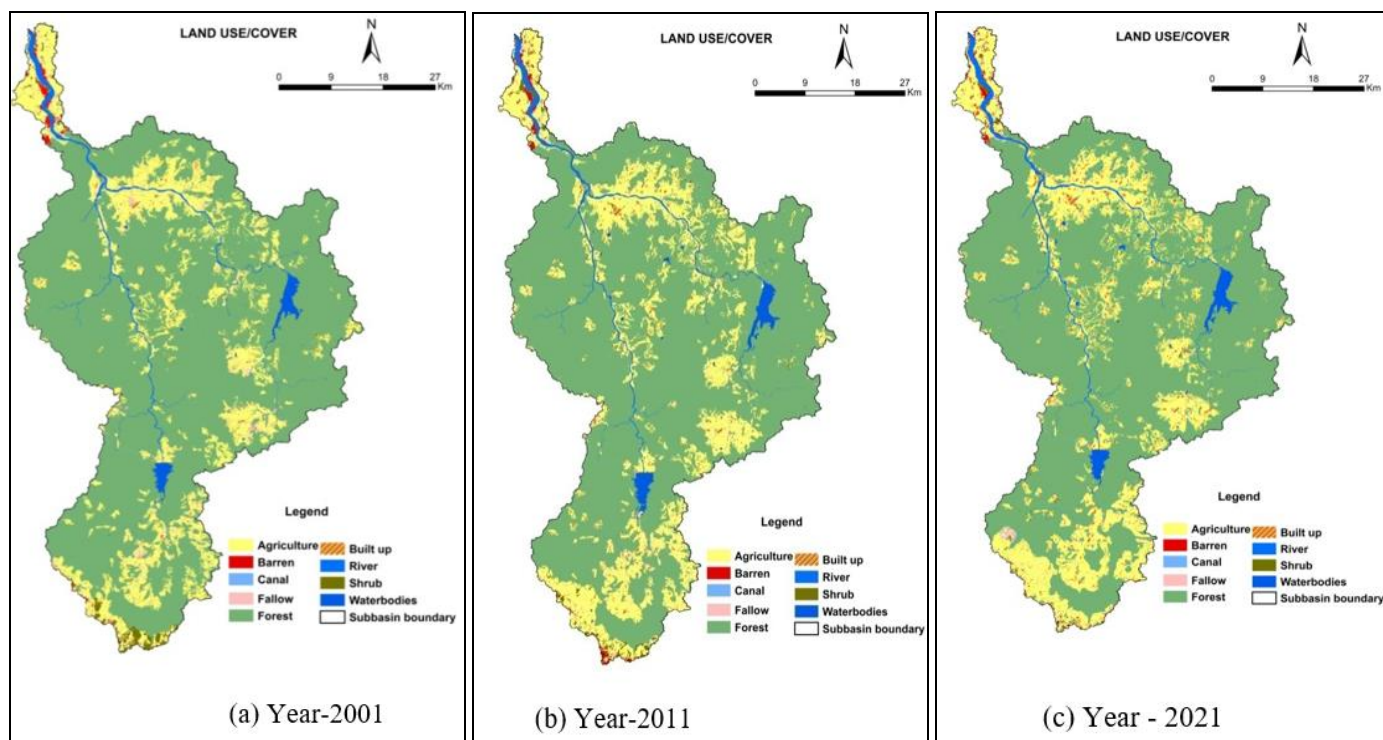


Fig 2: LULC maps of different years (a) 2001; (b) 2011 and (c) 2021

4. Conclusion

The present study applied the remote sensing and geographic information system which is one of the most important technologies for spatio-temporal analysis of land use land cover. The objective of the study was too assessed and monitored the changes in land use land cover in the pairi river subbasin using

Landsat satellite imagery for the period 2001 to 2021. There are various reason for alternation of land use land cover in the subbasin, however growing population, more food demand, infrastructure development etc. may be reasons for changes of land use land cover. The result of the study found that forest is the major land use in the subbasin throughout the study period.

However there is a decreasing trend of forest area observed from 2001 to 2021. The forest land decreases from 75.68% to 71.74% from 2001 to 2021. The second dominant land use in the subbasin is agriculture which was continuously in increasing trend from 2001 to 2021. The agriculture land is 17.60% of the total area in the year 2001 which is increased to 20.69% in the year 2021. This increase is due to conversion of other land use into agricultural land use. The water body area was continuously in increasing trend from 2001 (1.03%) to 2021 (1.40%). This is due to implementation various watershed and rural development programme in the subbasin where water harvesting structures are constructed. During the study period, barren land has been decreased from 0.31% to 0.24% may be due to conversion into agriculture and built-up area. The built up area is increased from 0.86% to 1.76% from 2001 to 2021. This may be due to various infrastructure development programme as well as to meet the residential demand of growing population. Due to increase in agriculture and built-up area, there may be more water demand both for agriculture as well as for domestic purpose. The changes of land use also influence other natural resources like per capita availability water and soil quality. The finding of the analysis will be useful for sustainable management of natural resources in the Pairi river subbasin.

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