Analyzing the spatio-temporal changes in the Hasdeo subbasin in Chhattisgarh using Sentinel-2 imagery

ABSTRACT

Understanding the dynamics of the world's landscapes is made possible by the multi-temporal change detection analysis made possible by Remote Sensing (RS) and GIS technologies. The current study provides an illustration of the spatiotemporal changes in land use/cover (LULC) of the Hasdeo subwatershed, Chhattisgarh, India, between 2016 and 2019 using Sentinel-2 imagery. To quantify the changes in the land use/cover area from 2016 to 2019, Sentinel-2 images from 2016 and 2019 were obtained. With the ERDAS Imagine software, the supervised classification method has been used. Eight different LULC classes, including forest, cultivated land, fallow land, water body, barren land, built-up land, mining and sand, were created using the image data of the research area. The outcome shows that between 2016 and 2019, there was an increase in built-up area and water body, while there was a decline in cultivated land, forest, and barren land. Kappa Coefficient accuracy is 88.00%, and overall accuracy is 92.1% according to the LULC accuracy assessment for the data analysis. The paper's data base emphasises the significance of change detection approaches for spotting significant changes in land cover and for tracking the effects of human-induced change on the hydrological environment, behaviour, and setting of the Hasdeo sub watershed.

Keywords: Hasdeo subwatershed, Land use land cover, Snetinel-2, Supervised classification

1. INTRODUCTION

The Earth's land is one of the most valuable natural resources since it contains vegetation, animals, land, and water, which together form a healthy ecosystem (Turner and Ruscher, 2004). But according to recent studies, there are very few landscapes on Earth that are in their native state. Land resources have been used to a higher extent as a result of high economic development in the form of industrialization, urbanisation, and the conversion of forest land to agricultural use (Longley et al., 2001). Land use refers to the human activities that take place on or make use of land, whereas land cover refers to the physical objects on the surface of a certain parcel of land (Prakasam, 2010). The LULC pattern of a region, particularly in a watershed, is a result of socioeconomic elements and how people use them organically across time and space (Rawat and Kumar, 2015). Rapid changes in LULC are seen all over the earth's surface as a result of extensive deforestation, agricultural encroachment, road construction, dams and irrigation, the growth of settlement areas, the modification of wetland ecosystems, mining, and the depletion of freshwater resources (Liu et al., 2014), as well as the degradation of coastal zones (Patz and Olson, 2008). In the past 300 years, 1.24 billion hectares of new agricultural land have been added, whereas more than 1.6 billion hectares of forest cover have been lost owing to deforestation, according to Lambin et al. (2000).

Changes in land use and cover pose significant problems and obstacles for environmentally beneficial, economically viable, and environmentally damaging development in any watershed area (Ruizluna and Berlangarobles, 2003). Due to the loss of plant cover, which serves as a barrier to the movement of materials into the water system and lowers runoff, LULC changes in the watershed increase the risk of water quantity and quality degradation (Notter et al., 2007). Yet, these adjustments are occasionally crucial for the enhancement and updating of the LULC dataset for better planning and management, as well as for assisting foresters, farmers, locals, and policymakers (Wardlow *et al.*, 2007; Liang et al., 2013). For proper land management and better decision-making, it is also crucial to comprehend the patterns, changes, and interactions between human activities and natural phenomena in the landscape. Earth resource satellite data are particularly suitable and helpful for LULC change detection research in the current situation (Yuan et al., 2005; Brondizio et al., 1994). Due to human interference, the terrain is changing in the Hasdeo River's Hasdeo sub watershed. To verify the conversion of the landscape, study is urgently needed. The determinants of LULC changes in the Hasdeo subwatershed have thus been examined in the current research utilising Sentinel-2 data from 2016 and 2019.

2. STUDY AREA

The Hasdeo subbasin lies in the middle portion of the Mahanadi River basin. The Hasdeo originates in Deogarh (1052 m above Mean Sea Level) in Sonhat Taluka, District - Koriya of Chhattisgarh. It flows through Korba and Janjgir-Champa districts of Chhattisgarh before joining the Mahanadi at Mauhadih. The Hasdeo river basin covers the Koriya, Surguja, Korba, and Janjgir-Champa districts. It contributes about 4.5 BCM of water to the Mahanadi. The total length of the Hasdeo is 333 km. The total area of the Hasdeo River is reported to be 9484 km^2. Rivers Gej, Bamni and Chornai joins Hasdeo at the upstream of the Minimata Bango Dam, whereas Tan and Ahiran joins at the downstream. Other than these major tributaries there are several large and small streams, locally called *naalas*, which joins the Hasdeo along its course. The Hasdeo flows from north to south, and the basin is located between 21°45'N to 23°37'N latitude and 82°00' E to 83°04' E longitude. The location of study subbasin is shown in Fig. 1.

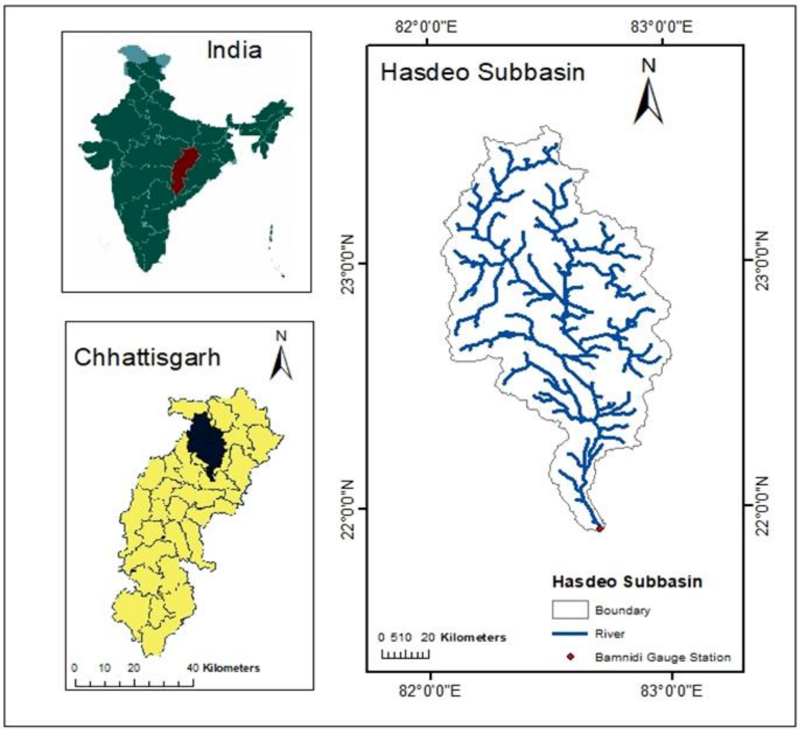

Fig. 1: Geographical location of study area (Hasdeo subbasin)

3. MATERIAL AND METHODS

Details of wave length and resolutions of each band of imageries of sentinel 2A are given in Table 1. Two sentinel images of 23rd October 2016 and two images of 10 October 2019 were used for preparing land use/cover map for Hasdeo subwatershed.

Table 1: Features of Sentinel 2A image

S. No.	Particular	Values
1.	Bands (Nos.)	13
2.	Resolution (m)	10
3.	Swath width (km)	290
4.	Revisit (days)	5
5.	Radiometric resolution (bit)	12

By evaluating the calibre of the information extrapolated from the data, the LULC classification accuracy assessment for only the year 2016 and 2019 was conducted. The study area's accuracy assessment was taken from a satellite image, and the area's LULC classes were separated using a stratified random sample approach. Statistical analysis was used to compare the reference data and classification. Kappa test was run to gauge the degree of classification accuracy. The correlation between the various LULC classes has been quantified using the Pearson correlation coefficient. The National Bureau of Soil Survey & Land Use Planning (NBSSLUP), Nagpur, India, contributed the land use classification map and data.

ERDAS Imagine software used remote sensing image data and the supervised classification method with maximum likelihood algorithm (Richard and Jia, 1999). The foundation of this method is pixel classes. As previously indicated, the eight LULC classes were located in the study area. In the region, there was also ground truthing for verification. In order to provide change information on a per-pixel basis for the LULC change detection analysis, a pixel-based comparison method was utilised. The changes were then interpreted (Rawat and Kumar, 2015). For the years 2016 and 2019, the overall changes as well as gains and losses in each category were collated and examined.

4. RESULTS

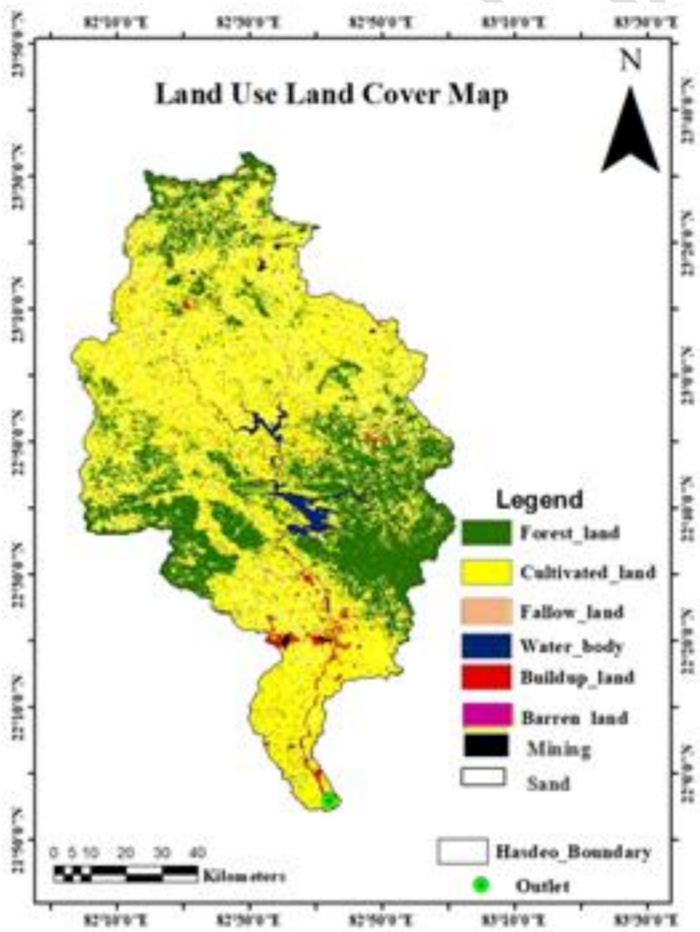

Fig. 2 LULC map of Hasdeo subbasin for the year 2016.

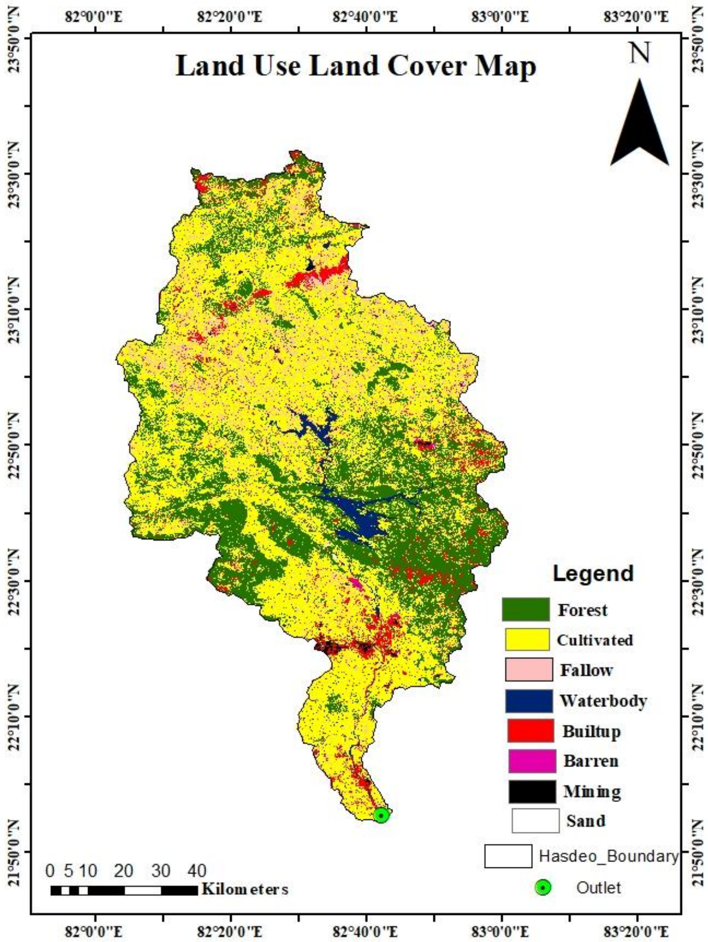

Fig. 3 LULC map of Hasdeo subbasin for the year 2019.

Fig.2 and 3 display the LULC maps and depiction of area changes for the years 2016 and 2019, respectively. Table 2 presents the percentage change in the individual classes of LULC in the Hasdeo subwatershed. The overall area under water bodies has grown by 282 km^2 (3 %) between 2016 and 2019, which might be attributed to increasing rainfall and river breadth in some regions. The research area's water resources include rivers, ponds, reservoirs, streams, etc. In the Hasdeo subwatershed, there has been a drop in the area covered by barren land between 2016 and 2019. The area of uninhabited land declined by 2.44 km^2 (2.4 %) during the time period, and the main cause of the decline was determined to be the conversion of uninhabited land into a settlement area. The settlement area grew by 124 km^2 (1.3 %) between 2016 and 2019. Increased population settlement was the cause of the growth in the built-up area.

Table 2. Changes in the LULC categories between 2016 and 2019

	Pixel Based classification				
Land Use Classes	**2016**		**2019**		**% Change**
	Area (km^2)	**% Area**	**Area (km^2)**	**% Area**	
Barren Land	1314	13.85	1083	11.41	-2.43
Fallow Land	309	3.26	374	3.94	0.68
Water body	178	1.87	460	4.85	2.97
Forest	2740	28.89	2690	28.36	-0.52
Built up	226	2.38	350	3.69	1.3
Cultivated Land	4686	49.4	4478	47.21	-2.19
Mining	11	0.11	34	0.36	0.24
Sand	20 0	0.21	15	0.15	-0.05
Total	9484	100	9484	100	

Moreover, there is a significant decrease in the extent of agricultural land from 2016 to 2019 (208 km^2 (2.2%)). The area covered by dense forests has been shrinking since 2016, from 2740 km^2 (28.9%) to 2690 km^2 (28.36%) in 2019. Deforestation, population pressure, and the conversion of forest land to cultivated land are the main causes of this change.

Remote sensing was used by Long et al. (2007) to study land-use changes in Kunshan, Jiangsu Province, China. The results of their study showed that paddy fields, dry land, and forested land in the region have moderately decreased by 8.2%, 29%, and 2.6% from 1987 to 1994, and by 4.1%, 7.6%, and 8% from 1994 to 2000, respectively. In contrast, artificial ponds, urban settlements, rural settlements, and construction land have increased by 48%, 87.6%, 41.1%, and 51.8% respectively, primarily due to pressure from the population's need for space. Moreover, between 2000 and 2013, the open forest area declined by 32.70 km2 (1.55%). The Hasdeo subwatershed's LULC pattern is marked by a decline in dense and open woodland, which is primarily turned into agricultural land and used for settlement. In the 13 years between 1988 and 2001 in the special economic zone of Xiamen, China, farmland dropped by roughly 11304.95 hectares, according to Quan et al. (2006) who examined the spatial-temporal aspects of land use changes during that time. Although the water body and rural-urban construction areas rose by 10152.24 ha and 848.94 ha, respectively, 52.5% of the farmland was transformed into rural-urban industrial land between 1988 and 2001. Changes in the rate of agricultural use throughout these times were influenced by the area's growing urbanisation.

Table 3. Performance statistics of the LULC changes

Image	Overall accuracy	Kappa coef.
Sentinal-2A 2016	90.23	0.87
Sentinal-2A 2019	92.11	0.88

Using multispectral LANDSAT imageries from 1973 to 2005, Raj et al. (2010) evaluated the LULC of the Bharathapuzha basin in South India and found that there had been a 31% loss in natural plant cover and an 8.7% loss in wetland area. Another study by George et al. (2016) revealed a 10% decline in the total forest area between 2000 and 2010 in the Aluva Taluka of Kerala's Ernakulam district, which was caused by an extraordinary pace of deforestation and the pressure of an expanding human population. Due to illegal tree cutting for firewood, charcoal, and agricultural implements, pressure on the remaining forest is intensified by the diminishing ratio of forested to agricultural lands and the growing intensity of land usage.

The primary causes of changes in the LULC in the major sub watershed area have been characterised by rural, agrarian-style settlements. As a result of locals farming the nearby forest, forest land is under pressure to become agricultural land, scrubland, or a habitation area. Rural communities cause small trees and shrubs to be cut down and the natural vegetation of the area is impacted because people use wood taken from the forest as fuel for cooking. In the forested area, villagers also let their domestic animals, such as goats, cows, and buffaloes, graze. In the sub watershed catchment area, which is either developed into a settlement or has a declining trend in the area covered by barren land.

5. CONCLUSION

The study was conducted to assess multi-temporal LULC change and analyse its driving forces in the Hasdeo subbasin, Chhattisgarh, India. For the effective planning and management of the sub watershed, precise information is provided through the monitoring and evaluation of the sub watershed using remote sensing data. Decrease in the area of cultivated land, forest, and barren land (2.4%, 0.55%, and 2.2%, respectively) and increase in the area covered by classes of fallow land (0.7 %), water body (2.97%), built-up area (1.3%), and mining (0.24%), between 2016 and 2019 indicated the LULC shift in the sub watershed area. The watershed's forest area has decreased as a result of the expansion of populated and water areas, which could cause numerous ecological and environmental issues. Since no future plan report was produced prior to land development in the study region, the uncontrolled expansion of population in the sub watershed was mostly caused by improper management and land use planning. Increased agricultural production in the catchment region as a result of population growth puts more strain on Hasdeo's water and forest resources.

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