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Land use land cover change detection analysis in kodjai watershed using remote sensing and GIS

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Abstract

Changes in Land use land cover are a dynamic process taking place on the surface and it becomes a central component in current strategies in managing natural resources and monitoring environmental changes. LULC change detection is the process that helps in determining the changes related with land use and land cover with reference to geo-rectify remote sensing data. This purpose of this study is therefore concerned with identifying the change in land use and land cover detection of the Kodjai watershed in Dapoli, Ratnagiri. To identify land cover changes detection; remote sensing data, satellite imagery and image processing techniques had done within three dates of 2017 and 2024 using Sentinel-2 images having 10m resolution. Arc GIS software had used to identify the changes. The classification had done using seven land cover (dense vegetation, agriculture, settlement, waterbody, fallow, orchards and grassland) class. Pre-processing and classification of the images had analysed carefully and accuracy assessment was tested separately using the kappa coefficient. Tewabe and Fentahun (2020) checked the accuracy of the classification using the kappa coefficient. The result of the study showed that significant change detection had observed during the study period. Settlement and orchards showed an increasing trend of 2.04% and 6.08%, respectively, while dense vegetation, agricultural land and fallow land showed a decreasing trend of 1.22%, 4.64% and 1.36% , respectively. It was also noted that there was no appreciable change in the area under the water bodies and grasslands.

Keywords: RS and GIS, sentinel-2, LULC, kappa coefficient

Introduction

Land and water are the very important natural resources on the Earth surface. Despite of it today humans are using it haphazardly. Now, a day the increase in population and human activities are increasing the demand on the land and soil resources for agriculture urban and industrial uses. Seyam *et al.* (2024) [5] studied rapidly industrializing area in Mymensingh, Bangladesh. Land cover refers to the physical characteristics of the Earth's surface like vegetation, water, soil, forest, hills and others. Land use refers changes done by anthropogenic activities. Land use and land cover change study are very essential for determining the current scenario and for the management of natural resources and environmental problem. The Land Use and Land Cover (LULC) is the type of cover covering the surface of the Earth. The conventional methods of land use mapping are tedious, time consuming and laborious. Hassan *et al.* (2016) [4] and Gondwe *et al.* (2021) [3] used satellite imagery and supervised classification algorithms, it is easy to quantify the spatial and temporal dynamics of land use/cover changes effectively. The modern technologies like Geographic Information Systems (GIS) and Remote Sensing (RS) are powerful and cost-effective tools for assessing the spatial and temporal change of LULC. Venukumar and Laxmaiah (2022) [7] emphasized the cost-effectiveness of remote sensing and GIS tools in mapping land use and land cover (LULC) and detecting changes, providing a detailed understanding of land cover change processes and their impacts. Remote sensing data is the most common source for detection, quantification, and mapping of LULC patterns due to its repetitive data acquisition, suitable for processing, and accurate geo-referencing. Amini *et al.* (2022) [1] tried to introduce an algorithm utilizing Landsat time-series data to analyse land use and land cover (LULC) change. The

objectives of this study is to prepare the maps showing the land use land cover and to compare the land use land cover changes for Kodjai watershed

Materials and Methodology

This study was conducted in Kodjai watershed in Dapoli, located in Ratnagiri district of Maharashtra. The area covers approximately about 82 km². The location of study area is 17°50'30"N Latitude and 73°5'30"E Longitude, Maharashtra. The climate in this area is tropical. During most months of the year, there is significant rainfall. The temperature in Kodjai watershed is 27.4°C to 32.9°C. The study area of the research work is shown in the Fig. 1.

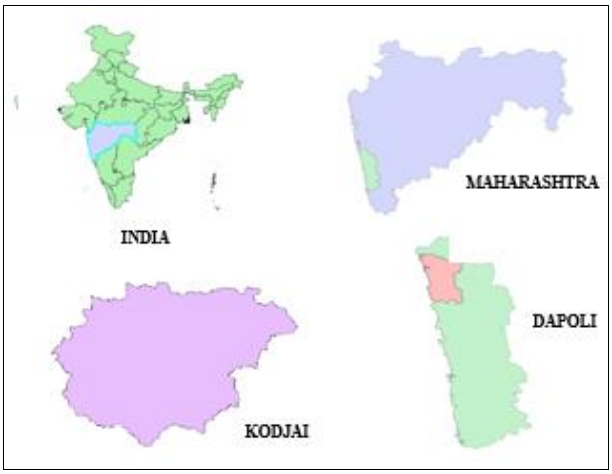

Fig 1: Location map of study area

The data used for this study with its source: 1.Sentinel-2 Image: Copernicus open access hub 2. Shape file of Kodjai watershed, Dapoli. Following is the process of detecting changes in Land Use Land Cover in Kodjai watershed for year 2017 and 2024:

Preparation of periodical land cover maps: The land use and land cover maps gives the information about the type of covering on the soil and purpose for which the land is being used. The images were classified into different land use land cover patterns such as Dense vegetation, Agriculture, Waterbody, Settlement, Fallow, Orchards, Grassland. Ayele *et al.* (2018) [2] analysed Land Cover Mapping and Change Detection in Northern Ethiopia. The study found that the area under cultivation, wood bush, shrub, grass and forest land was 63%, 12%, 8%, 6%, 4% and 2% of the total area respectively. There are various methods to identify different land use patterns using Arc GIS as iso cluster unsupervised Classification, natural neighbour classification, maximum likelihood classification, etc. The accuracy of different classification methods varies with type of data and the number of training samples provided. Among mentioned methods the supervised classification with maximum likelihood classification gives better accuracy. Therefore, this method was used to classify the study area into different land use patterns.

Accuracy assessment by using Kappa coefficient: The accuracy of land use land cover for Kodjai watershed was calculated using the Kappa coefficient. The different reference points selected from the land use maps of Kodjai watershed were compared with the Google Earth image.

Detection of changes in land use patterns: Land use and land cover is a dynamic process. The change can be detected by making maps of land use land cover patterns for different time periods. For the current study land use land cover maps for the years 2017 and 2024 were prepared. The change in the LULC was calculated by comparing the area under each LULC pattern for the years 2017 and 2024.

Area under each LULC pattern was calculated by using equation as-

Pixel count of land use pattern x cell size of one pixel (1)

The Sentinel-2 has resolution of 10 meters (2)

Therefore, the formula becomes (3)

Area (m2) = Pixel count of particular land use pattern x 10 m x 10 m.

The percent area covered by each land use pattern was calculated as-

$$\text{Area (\%)} = \frac{\text{Area under specific land use (ha)}}{\text{Total area (ha)}} \times 100$$

Results and Discussion

Preparation of periodical land covers maps

The land use land cover maps for Kodjai watershed was prepared for the years 2017 and 2024 using the Arc GIS 10.3 software. Figure No. 1 and 2 shows the land use land cover patterns of Kodjai watershed for the year 2017 and 2024. In these figures, the Dense vegetation, Agriculture, Settlement, Waterbody, Fallow land, Orchards and Grassland are shown by dark green, green, yellow, blue, pink, dark brown and dark blue, respectively. The area covered by different land use signatures in the year 2017 and 2024 is shown in the Table 1 and 2.

Table 1: Area under different LULC patterns for Kodjai watershed for the year 2017

Sr. No.	LULC Pattern	Area (sq.km)	Percent Area (%)
1	Dense vegetation	30.30	36.95
2	Agriculture	15.29	18.65
3	Settlement	25.74	31.39
4	Waterbody	0.28	0.35
5	Fallow	6.30	7.69
6	Orchards	3.36	4.09
7	Grassland	0.69	0.84
	Total	81.99	100

Table 2: Area under different LULC patterns for Kodjai watershed for the year 2024

Sr. No.	LULC Pattern	Area (sq.km)	Percent Area (%)
1	Dense vegetation	29.29	35.73
2	Agriculture	11.48	14.01
3	Settlement	27.40	33.43
4	Waterbody	0.24	0.30
5	Fallow	5.19	6.33
6	Orchards	8.33	10.17
7	Grassland	0.02	0.03
	Total	81.99	100

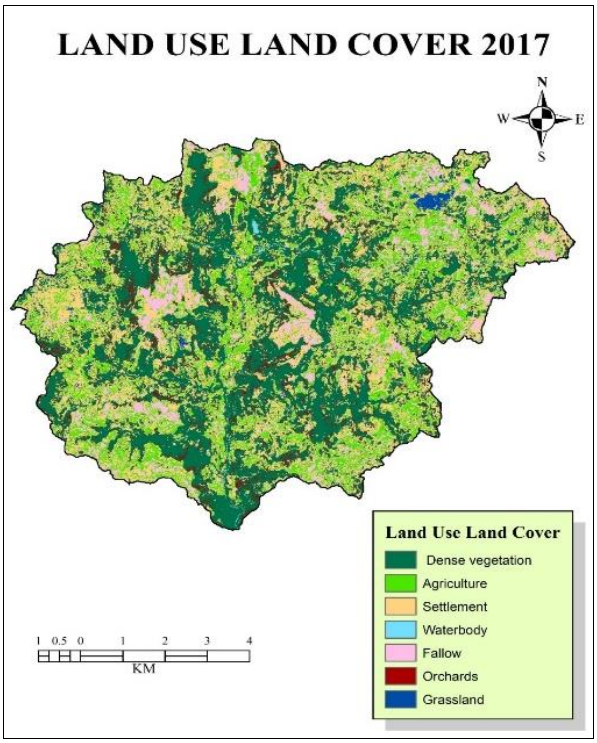

Fig 2: Land use land cover map of Kodjai watershed for the year 2017

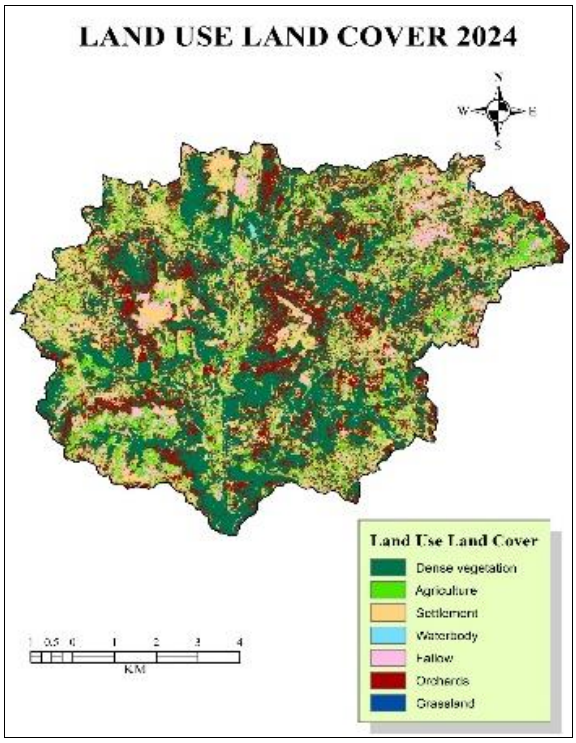

Fig 3: Land use land cover map of Kodjai watershed for the year 2024

Accuracy assessment of land use mapping

Table 3: Test of kappa coefficient values of Kodjai watershed for year 2017

Sr. No.	Land use pattern	User accuracy	Grade	Producer accuracy	Grade	Overall accuracy	Grade
1	Dense vegetation	100	Excellent	77.77	Very good	91.16	Excellent
2	Agriculture	85.71	Excellent	100	Excellent		
3	Settlement	100	Excellent	100	Excellent		
4	Waterbody	100	Excellent	100	Excellent		
5	Fallow	100	Excellent	85.71	Excellent		
6	Orchards	66.66	Very good	100	Very good		
7	Grassland	100	Excellent	100	Excellent		

Table 4: Test of kappa coefficient values of Kodjai watershed for year 2024

Sr. No.	Land use pattern	User accuracy	Grade	Producer accuracy	Grade	Overall accuracy	Grade
1	Dense vegetation	100	Excellent	60	Good	88.29	Excellent
2	Agriculture	100	Excellent	100	Excellent		
3	Settlement	83.33	Excellent	100	Excellent		
4	Waterbody	85.71	Excellent	100	Excellent		
5	Fallow	100	Excellent	100	Excellent		
6	Orchards	66.66	Very good	100	Very good		
7	Grassland	100	Excellent	100	Excellent		

Detection of the changes in land use patterns over the period

Table 5: Changes in LULC from the year 2017 and 2024

Sr. No	Land use land cover pattern	Year 2017		Year 2024		Percent change
		Area in sq.km	Percent area	Area in sq.km	Percent area	
1	Dense vegetation	30.30	36.95	29.29	35.73	-1.22
2	Agriculture	15.29	18.65	11.48	14.01	-4.64
3	Settlement	25.74	31.39	27.40	33.43	+2.04
4	Waterbody	0.28	0.35	0.24	0.30	-0.05
5	Fallow land	6.30	7.69	5.19	6.33	-1.36
6	Orchards	3.36	4.09	8.33	10.17	+6.08
7	Grassland	0.69	0.84	0.02	0.03	-0.81
	Total	81.99	100	81.99	100	0

Results

The result of the study showed that significant change detection had observed during the study period. Settlement and orchards showed an increasing trend of 2.04% and 6.08%, respectively, while dense vegetation, agricultural land and fallow land showed a decreasing trend of 1.22%, 4.64% and 1.36%, respectively. It was also noted that area under the water bodies and grasslands was decreased by 0.05% and 0.81%. The overall accuracy of land use mapping for Kodjai watershed for the year 2017 and for the year 2024 was 92.5% and 90%, respectively. At the same time, the kappa coefficient was 91.16% and 88.29% for the year 2017 and for the year 2024, respectively.

Conclusion

In this study, Land use land cover change detection over the last 8 years had analysed. The result of the study showed that significant change detection had observed during the study period. Settlement and orchards showed an increasing trend, while dense vegetation, agricultural land and fallow land showed a decreasing trend. It was also noted that there was no appreciable change in the area under the water bodies and grasslands. The validation of land use mapping was done using Kappa coefficient. It was observed that the grade of accuracy was excellent. The result revealed that the change of agriculture to settlement area which may results in scarcity of food. In this study, the change detection analysis using GIS and remote sensing could deliver useful information to understand the patterns of land use dynamics for planners and decision-makers consequently sustainable land management planning is possible.

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