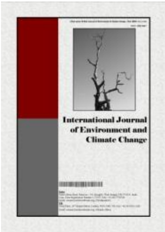

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Decadal Changes in Land use and Land Cover of Noyyal River Basin using Geo-spatial Techniques

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: River Noyyal was the life line of the people of Coimbatore, Tirupur and Karur districts of Tamil Nadu and has nurtured a rich civilization. The river is mentioned in many ancient travelogues by European travelers which suggest the importance of the river. But over the years, the condition of the river, both in terms of quantity and quality has deteriorated owing to the expanding population size and its related land use changes.
Place and Duration of Study: The study was conducted to investigate the decadal land use and land cover changes of the Noyyal basin for the year of 2000 to 2020 in the year 2021-2022.
Methodology: The study was undertaken to produce the land use/land cover map and to explore the change detection analysis of the Noyyal river basin for 20 years. Based on RS and GIS for monitoring the temporal variations of land use land cover, multi-temporal Landsat satellite 30m spatial resolution images of Landsat 4/5 MSS and TM 2000, 2010, and Landsat 8 (OLI) 2020 were obtained from the google earth engine. At the first stage NDVI calculation was done by using ArcGIS software and the second stage supervised classification maximum likelihood classification was done for 3 years 2000,2010 and 2020.
Results: The analysis suggests that Normalized Difference Vegetation Index NDVI of without any vegetation (Class1), medium density (Class3), and high density (Class4) increased by 8.37%,

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1.29%, 0.42% respectively. Low density (Class2) decreased by 10.1%. The urban area and agriculture land increased by 13.82% and 18.46%.The forest cover, waste land and barren land decreased by 12.24% 11.99% and 7.90% over the 2 decades and water bodies increased in the year of 2010 and then decreased.

Conclusion: The study has revealed a decline in area under forest and wasteland and an increase in area under built up activities and agriculture land.

Keywords: Change detection; landsat; land use land cover; NDVI; supervised classification.

1. INTRODUCTION

Land Use Land Cover Change (LULCC) is a key focus area for the global change community because of its significant impacts on biodiversity, climate change, biogeochemical cycles, and water resources. LULCC is caused by various multi-scale interactions causing elements such as demography, technology, political structures, economy, biophysical situations of the land, affluence, and people's attitudes and values. These driving factors change with time and geography; for that reason, LULCC is also heterogeneous in terms of temporally and spatially [1]. Both terms land use and land cover is regularly used interchangeably, but each term LULC has its distinct meaning [2]. Land cover (LC) refers to the surface cover of Earth's surface and, its characteristics as represented using natural elements like water, vegetation, impervious surface, bare earth, and other physical factors of the earth recognition of land cover (LC) shows the baseline details for activities like change detection analysis and thematic mapping. Land use (LU) consult to the economic purpose, activity, intended use and/or management strategy placed on the land cover type(s) using land managers or humans. Changes in management practice or intent to constitute land use (LU) change [3]. Land use land cover (LULC) of the earth is varying dramatically because of natural disasters and human activities [4]. Humans have changed over 83 percent of Earth land surface due to different Land Use (LU) [5]. Decadal Changes involve the ability to quantify temporal varies in Land Use and Land Cover (LULC) using multitemporal data sets [6,7]. During the past 3 decades, various recognition algorithms have been suggested, and they change broadly in their sophistication and performance [8]. The option of a specific method depends mainly on the specific of the study region, and the kind of the expected land cover change (LCC), and the temporal resolution and spatial resolution of the data [9]. Land cover (LC), a major scientific concern, refers to the physical condition of the land. Land-cover changes (LCC) fall into 2 ideal types, conversion and modification. Farmers are a convert from one land cover class to another. For example, changing from grassland to cultivated land. The latter are change of state or condition within the Land Cover (LC) category, such as forest thinning and changes in its composition. Based on this, it is worth mentioning that remote sensing (RS) is an important appliance for monitoring LULCC regularly. This remote sensing (RS) technology can give information on both the biological and physical conditions of LULCC (vegetation and its dynamics), and physical conditions (terrain changes and morphological features). However, standard LULCC information generated from remote sensing data over decades remains a daunting task due to the large differences in the spatial resolution of satellite data [10,11]. The worldwide use of RS and GIS in land management and planning, as well as the growing demand for Land Use and Land Cover (LULC) scenarios, draws our attention to these differences and the need to bridge them [12]. Many ways have been suggested for LULCC detection and applied to remote sensing data. [13]. LULC research depends on primarily satellite RS technology to extract multi-temporal data [14]. Geospatial techniques are used to monitor the continuous changes in LULC, which are important in the management of natural resources, the monitoring and evaluation of watershed quality, and the study of water hydrological responses and water resources flow systems. The supervised classification requires advance grip of the scene region and area, including the material and training location of interest, and is delineated and stored for use in the supervised classification algorithm. The maximum likelihood (ML) supervised classification method works by assuming the assignment of each number of pixel to the LULC class, and which has the highest probability of membership [15]. Vegetation indices derived from satellite data could be applied to track the temporal evolution of vegetation. The NDVI method was shown to be the most effective in detecting vegetation change. To detect LU types, supervised classification was mostly employed [16]. The major goal of this research is to find the change detection of land use and land cover of Noyyal river basin by using two methods of calculation NDVI differencing method and a supervised classification method which are widely used and successful.

2. MATERIALS AND METHODS

2.1 Study Area

The Noyyal basin is the main tributaries of the Cauvery River. Cauvery coming from the hills of Vellingiri Called Southern Kairayam, it flows southwest of the Coimbatore of Tamil Nadu State and ends at the Cauvery River in Kodumdi in the district of Karur. During the course, the Noyyal River pass through the districts of Karur, Erode, Tirppur, and Coimbatore. Noyyal river runs about 180 km along 3627 km^2 area. The bounding line of the Noyyal lies between latitude 10° 54′ 00″ to 11° 19′ 03″ North latitude and longitude 76° 39′ 30″ to 77° 55′ 25 ″ East longitude. The Noyyal River receives abundant water during the northeast rainy-season from September to November. The remaining of the year will remain less or more dry. The surface water aspects in the area are insufficient to reach the demands of the region, but the groundwater aspects are also not under-researched. This problem can be reduced to some extent by artificially replenishing potential aquifers. The types of soils found on the Noyyal River vary, ranging from flat, red non-limestone soils to very dark gray calcareous soils. Standard soil surveys in the Coimbatore area show the occurrence and association of 14 different soil lines in the Noyyal River. These 14 can be mainly differentiated into 5 categories: grey soil, red soil, alluvial soil, forest soil and colluvial soil [17]. The Noyyal River is covered with various high class metamorphic rocks of the peninsular gneiss complex. The mean yearly rainfall is about 700 mm and the contributions of the northeast monsoon and the southwest monsoon are 47% and 28% respectively. The main land uses are agriculture (cultivated land) forests and urbanized areas (Fig. 1).

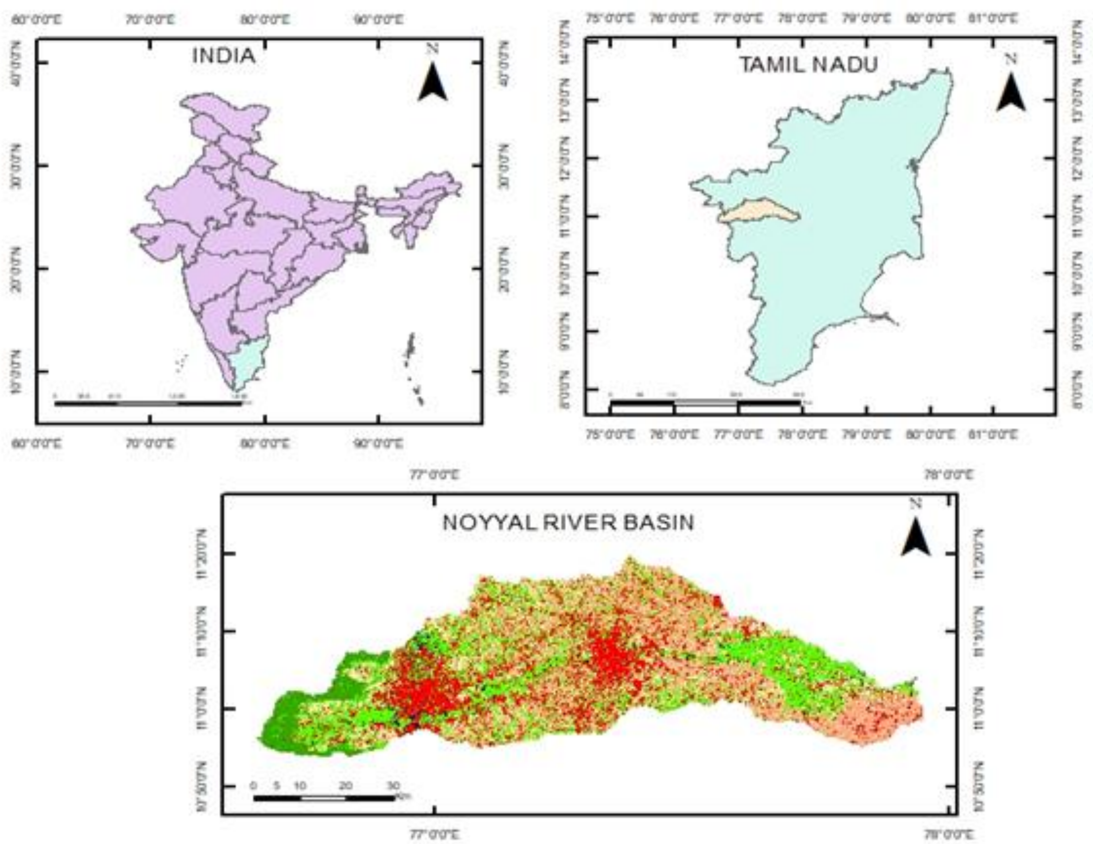

Fig. 1. Index map of Noyyal river basin

2.2 Methodology

2.2.1 Data collection

Landsat satellite images were collected from Google earth engine for the period 2000, 2010 and 2020 respectively. Landsat 4/5 (MSS/TM) of 2000, Landsat 4/5 (MSS/TM) of 2010 and Landsat 8 (OLI) of 2020 were downloaded [18].

2.2.2 Pre-processing and image classification

Preprocessing of satellite images before detecting actual changes is an important process and has the main unique goal of establishing a more direct relationship between the data collection and biophysical phenomena. Three cloud-free Landsat (MSS/TM), (OLI) images acquired on 2000, 2010 and 2020 were processed using ArcGIS 10.3.1 software. The images were classified into 4 classes. (Without vegetation, Low vegetation, Medium vegetation and high vegetation) [20].

2.2.3. NDVI Calculation

The NDVI was calculated by using the formula:

NIR = (NIR-R) / (NIR+R)

Where NDVI is a simple numerical index that is used to analyze remote sensing measurements, NIR is vegetation reflectance in the near-infrared spectral band, and RED is vegetation reflectance in the red spectral band. Bands 3 and 4 was used for Landsat 5 and bands 4 and 5 was used for Landsat 8 for NDVI classification. DN value of NDVI would be in the range of -1 to 1.

Supervised classification was done for the years of 2000, 2010, and 2020 in order to investigate the changes in each land cover type. supervised classification is performed by using Maximum likelihood classifier (MLC). LULC maps are produced for the years 2000, 2010, and 2020 to investigate changes that occurred between these periods. For testing of land use type in study area Google earth pro was used. The image classification accuracy depends on factors such as spectral bands number in the imagery, and background contrast/target, signature quality, and image quality.

3. RESULTS AND DISCUSSION

The study is done by preparing LULC maps of the study area based on LANDSAT images. NDVI DN values are divided into 4 classes that are class_1, class_2, class_3 and class_4 indicate without any vegetation cover, low vegetation cover, medium vegetation cover, and high vegetation cover respectively. The LULC classes are derived based on NRSC Level 1 supervised classification. Accordingly, 6 major types of LULC are identified forest area, urban area, agriculture land, waste land, water bodies and bare soil.

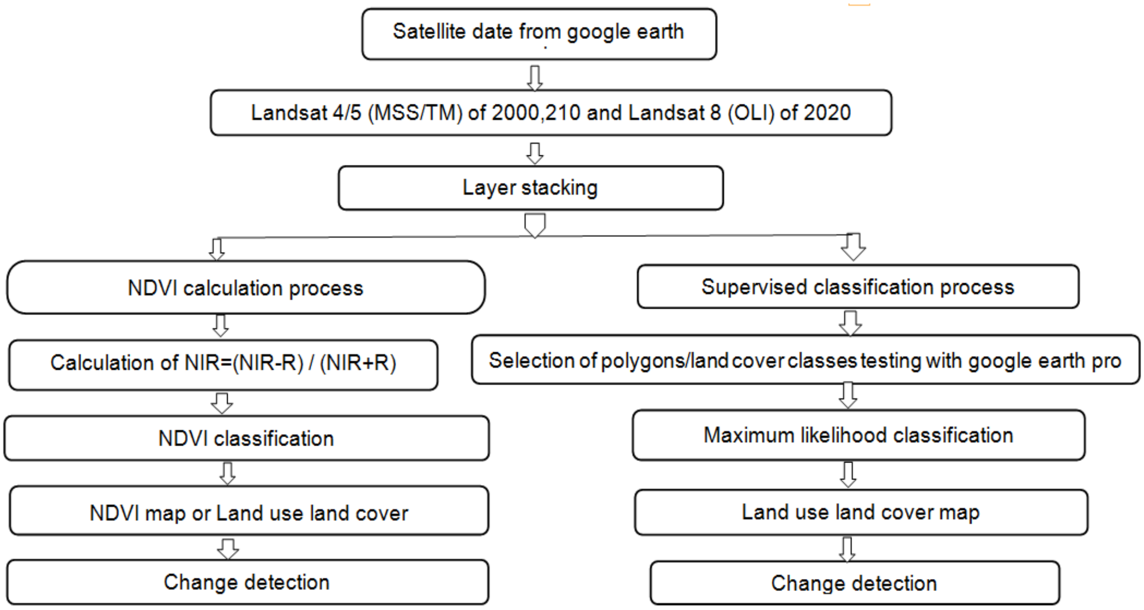

Fig. 1. Flow chart showing principle for Satellite date derived from google earth

3.1 NDVI for 2000

From the analysis, it was found that NDVI DN values ranged from 0.84 to 0.16 for the year 2000 (Fig. 2). Class_1 values ranges from 0.16 to 0.24, Class_2 ranges from 0.24 to 0.35, Class 3 ranges from 0.35 to 0.50, and Class_4 ranges from 0.50 to 0.83. The area covered by barren land in Class 1 (urban areas, water bodies, rocky areas) is 152,399 ha, Class 2 is 110,724 ha, Class_3 is 64,363.4 ha, and Class4 is 28,925 ha. The class_1 occupies the maximum area of 42.02% (Barren, rocky urban areas, water bodies) and class_4 occupies very low area of 7.97% when compared to other classes.

3.2 NDVI for 2010

The range of NDVI DN values for the year 2010 is from 0.85 to -0.11 (Fig. 3). The class_1, class_2, class3 and class_4, values ranges from -0.11 to 0.23, 0.23 to 0.32, 0.32 to 0.55 and 0.55 to 0.85 respectively. The area covered by class_1 is 17,1230 ha, class _2 is 93,720 ha, class_3 is 68,092.4 ha, and class_4 is 29,669.2 ha. In the year 2010 also, the maximum percentage area covered was under class_1 (47.21%). The low covering area was under class 4(8.18%).

3.3 NDVI for 2020

The NDVI DN values ranges from 1 to -0.1 for the year 2020 (Fig. 4). Class_1, class_2, class_3 and class_4 DN value ranged from -0.10 to 0.21, 0.21 to 0.30 and 0.30 to 0.52 and 0.52 to 1 respectively. Area covered by class_1 is 182859 ha, class_2 is 80,150 ha, class_3 is 69075.4 ha, and class 4 30,267.2 ha. Similar to 2000 and 2010, in 2020 also class_1 occupies more area (50.38%) and class 4 occupies less area (8.40%).

3.4 NDVI Change Detection from 2000 to 2020

The range of NDVI values for the all the classes between 2000, 2010 and 2020 was analyzed. The NDVI values were moderately changed for the period 2000 to 2010 and slight changes were observed during the period 2010 and 2020. The Class_1 area between 2000 and 2010 increased by 5.19% and 3.17% between 2010 and 2020 because of the increasing urban area and increasing industrialization, Class 2 area was decreased by 6.4% in 2010 and 3.65% in 2020, Class_3 area increased by 1.03% in 2010 as compared to 2000 and 0.26% in 2020 as compared to 2010, Class_4 area was increased 0.22% in the year of 2010 and 2020 so the high-density vegetation increased as compared to the year of 2000 because of increasing agriculture land or increasing of rainfall amount and conservation structures (Table 1).

3.5 Land Use Land Cover for 2000

Wasteland accounts for 35.28% of the total geographic area, including 127953.8 hectares, covering the entire eastern and central part of the study area. The second major type of land use is barren land covering 92,321.25 hectares (25.45%). This barren land mainly covers the boundaries of the survey basin. The next major land use type is agriculture, which covers an area of 36,946.62 hectares, which represents about 10.18% of the total area. Agricultural areas are more likely to be found in the central west, between the densely populated central and the forested western and eastern edges. The forest area is located at the western end of the area, occupying about 18.6% of the study area and the urban area is concentrated in the central and southern part of the area, occupying only about 35325.39 hectares (14. 77%). The final land cover type identified here is water, which occupied only 0.74% of the total area (Fig. 5).

3.6 Land Use Land Cover for 2010

LULC's analysis in the study area 10 years later depicts a slightly different situation. The main areas of changes are the increase in agriculture land (11%), urban areas (5%) and the decrease in area of wasteland (7.7%). All other features remain unchanged. The area under the barren land decreased by about 86865.77 hectares (23.94%) The area under water bodies was slightly increased with an area of 2728.35 hectares, it occupies about 0.75%. This increase may be due to the high rainfall recorded during this period. In addition, many NGOs such as Siruthuli, an environmental protection foundation in India, are engaged in activities such as water purification. This has visibly led to positive results (Fig. 6).

3.7 Land Use Land Cover for 2020

The trend of change in the LULC pattern changed in 2020 also (Fig. 7). The major changes are seen in three areas, urban area, wasteland, and agricultural land; while the area under urban has increased considerably, the area under wasteland has reduced.

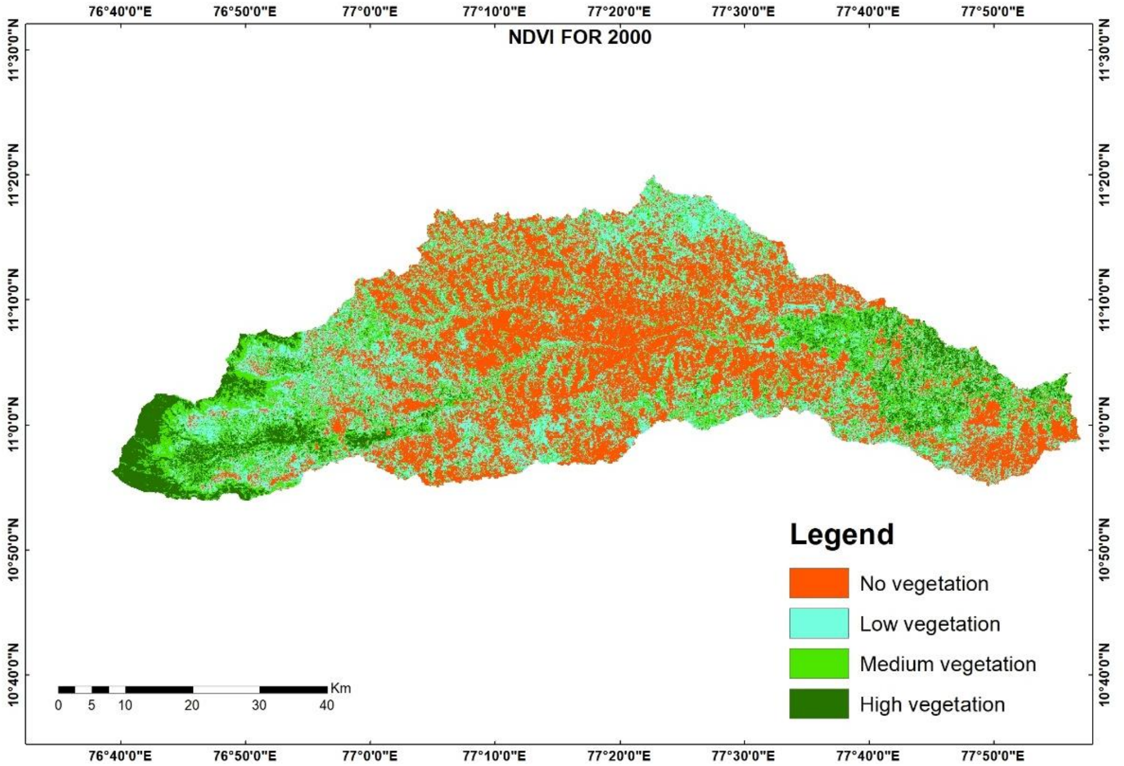

Fig. 2. NDVI for the year of 2000

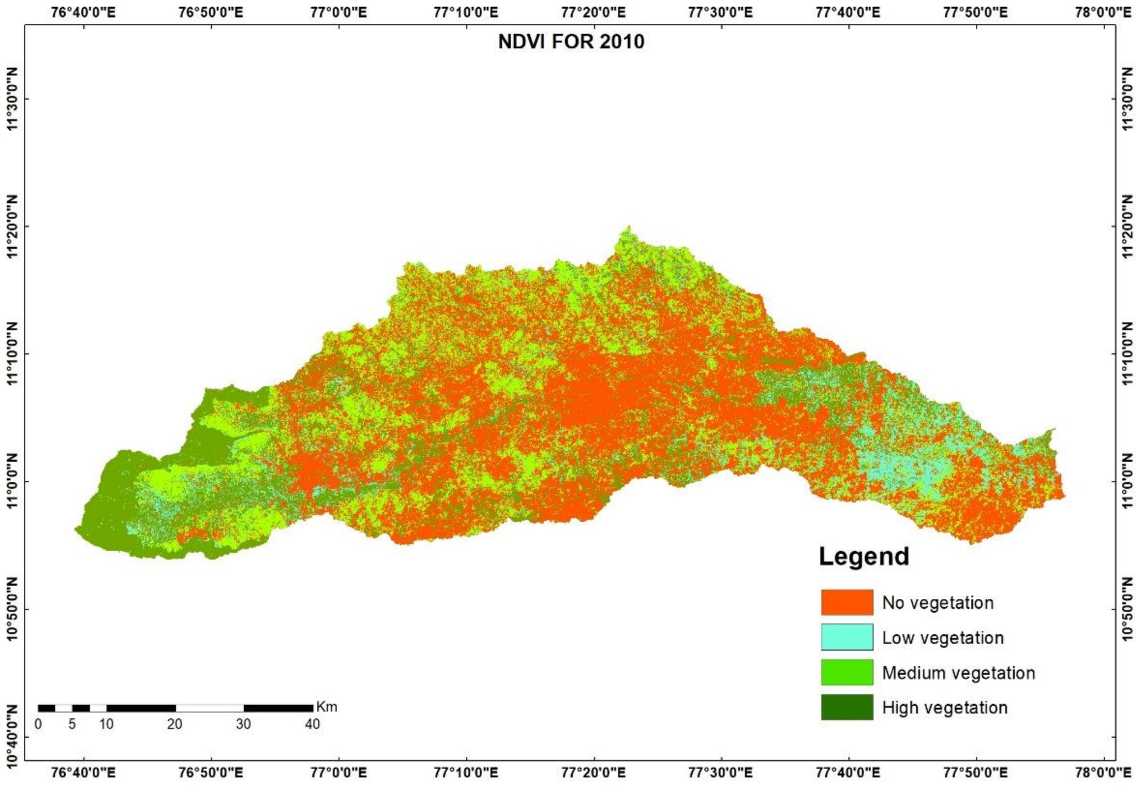

Fig. 3. NDVI for the year of 2010

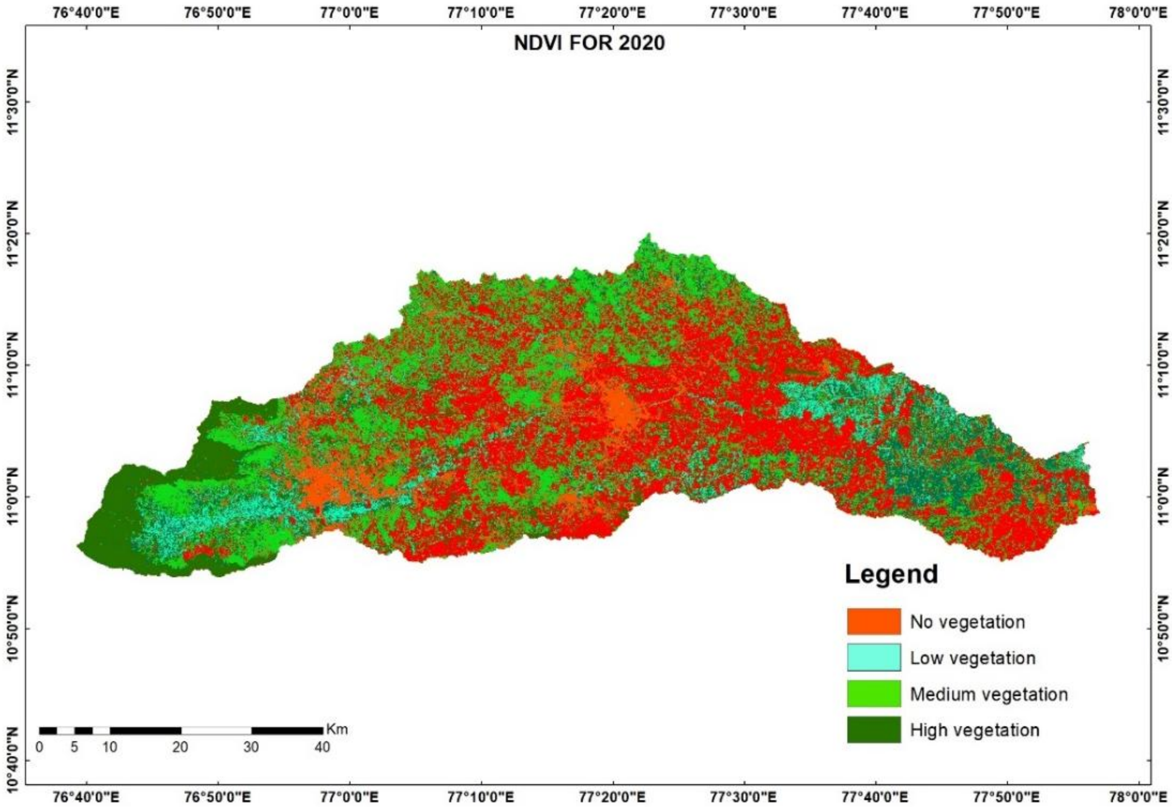

Fig. 4. NDVI changes for the year of 2020

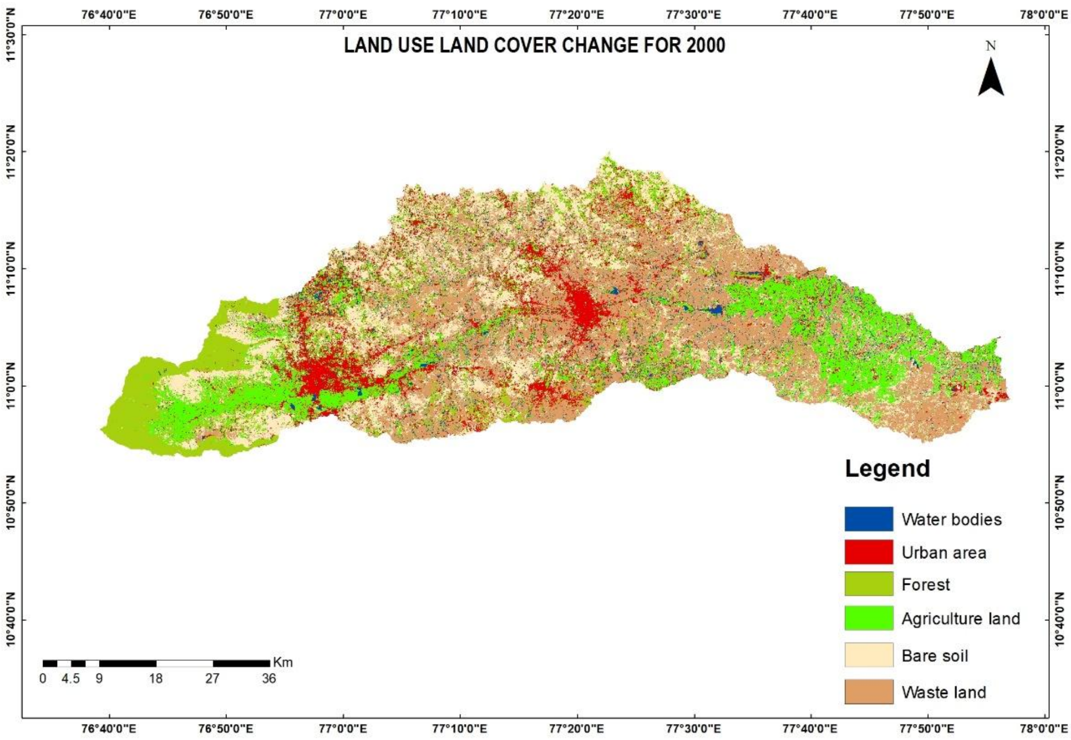

Fig. 5. Land use land cover changes for the year of 2000

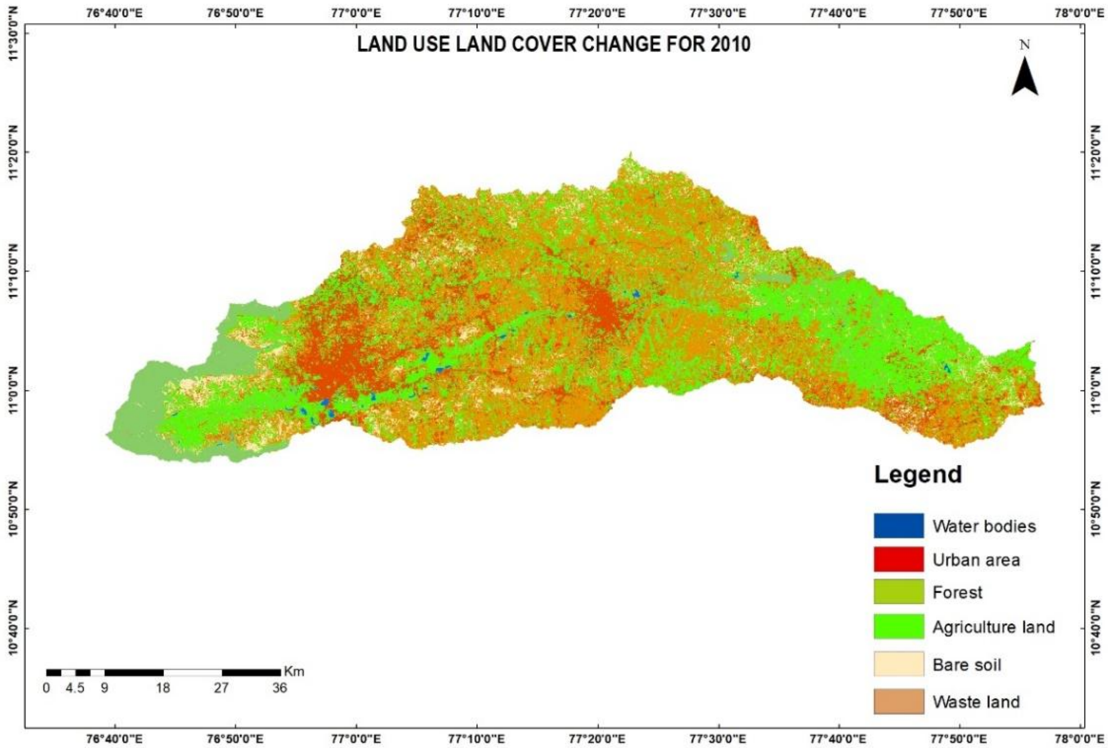

Fig. 6. Land use land cover changes for the year of 2010

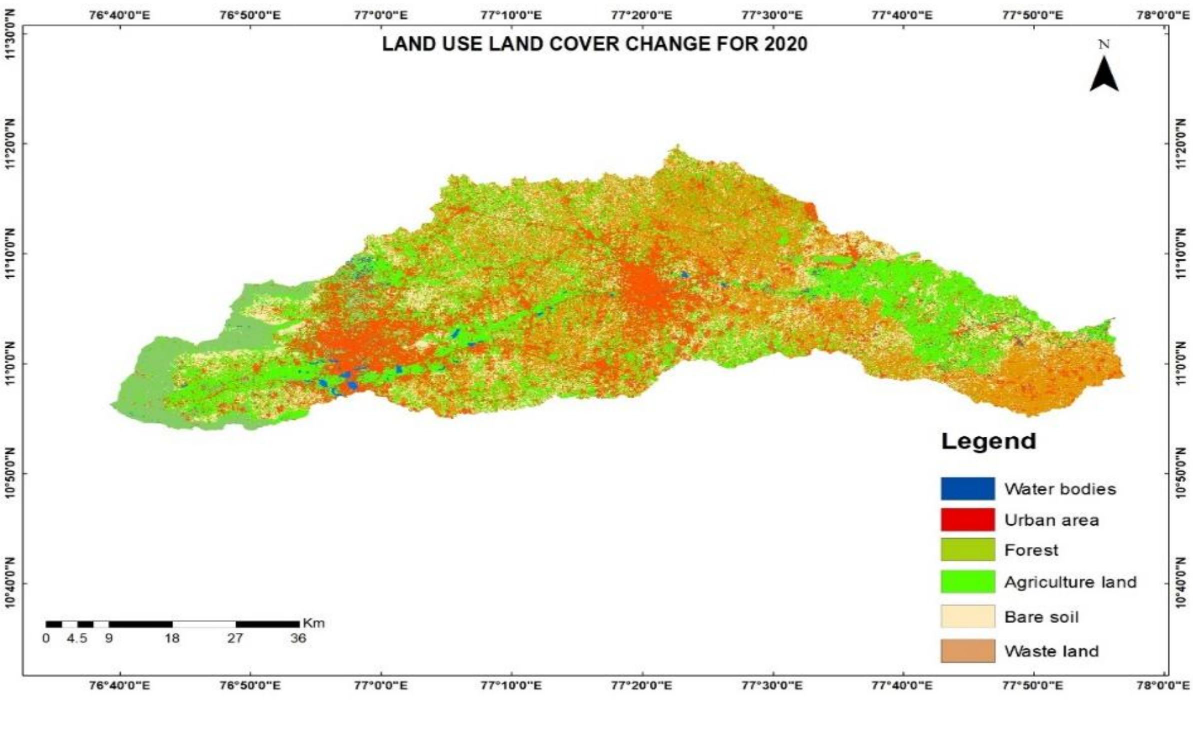

Fig. 7. Land use land cover changes for the year of 2020

Table 1. NDVI changes for the year of 2000, 2010 and 2020

		NDVI Area (ha)			Decadal changes in NDVI (%)		
Number of classes	**LULC classes**	**2000**	**2010**	**2020**	**2000 to 2010**	**2010 to 2020**	**2000 to 2020**
Class_1	Without vegetation	152399	171230	182859	5.19	**3.17**	8.37
Class_2	Low vegetation	117024	93720	80510	-6.4	-3.65	-10.08
Class_3	Medium vegetation	64363.4	68092.4	69075.4	1.03	0.26	1.29
Class_4	High vegetation	28925.2	29669.2	30267.2	0.21	**0.22**	**0.42**
	Total	**362711.6**	**362711.6**	**362711.6**			

Table. 2. Land use land cover changes for the year of 2000, 2010, and 2020

		Area (ha)			Percentage Area			Differences in area (ha)		
Number of classes	**LULC classes**	**2000**	**2010**	**2020**	**2000**	**2010**	**2020**	**2000 to 2010**	**2010 to 2020**	**2000 to 2020**
Class 1	Water bodies	2680.29	2728.35	2165.2	0.74	0.75	0.60	48.06	-563.15	-515.09
Class 2	Urban area	35325.39	53586.73	85476.89	9.74	14.77	23.57	18261.34	31890.16	50151.50
Class 3	Forest cover	67483.71	41327.83	23066.64	18.61	11.39	6.36	-26155.88	-18261.19	-44417.07
Class 4	Agriculture land	36946.62	78134.25	103912.7	10.19	21.54	28.65	41187.63	25778.40	66966.03
Class 5	Barren land	92321.25	86865.67	63641.43	25.45	23.95	17.55	-5455.58	-23224.24	-28679.82
Class 6	Waste land	127953.8	100068.2	84448.26	35.28	27.59	23.28	-27885.57	-15619.98	-43505.55
	Total	**362711.1**	**362711.1**	**362711.1**	**100.00**	**100.00**	**100.00**			

3.8 Land use Land Cover Change for the Years of 2000, 2010 and 2020

During the period from 2000 to 2010, a major change happened in the area of wasteland. Around 7.68% of wasteland has been converted to agricultural land and around 7.2% of forest land converted to both agriculture and urban area. Because of major decreases in a wasteland and forest land. And the urban area, agricultural area majorly increased. During the period between 2010 and 2020, the major changes happen between wasteland, barren land, and forest. By decreasing these three types of land around 7.1% of agricultural land and 8.03% of the urban area increased. Some major notable changes are happening during the period 2000 to 2020. Here wasteland, barren land and forest area and water bodies are decreased by 11.99%, 7.9%, 12.24%, and 0.14%_respectively, and agricultural land, the urban area increased by 18.46% and 13.82% respectively(Table 2).

4. CONCLUSION

The present study was conducted with an objective to analyze the land use land cover features and to detect the changes in LULC pattern of Noyyal basin over a period of 20 years from 2000 to 2020 by taking three time periods viz (2000, 2010 and 2020). Major portions of Coimbatore and a small portion of the Tiruppur district in Tamil Nadu were included in the study region. According to the study, wasteland, agricultural land, and built-up land have historically been the area's primary land uses. It was clear that the entire area covered by waste land had decreased over time and that the majority of it had been turned into built-up areas and agricultural land. The built-up area has increased by almost three times, which is the most noticeable alteration. Over the years, there has been a clear urbanisation. The research region also features a vast network of systematic tanks, including Kurichi Tank, ValanKulam, Perur Lake, Selvampathy Lake, Kumaraswamy Lake, Narasampathy Lake, Selva Chintamani Lake, and others. The majority of the tanks were nearly empty. This claim is supported by the study. It was clear that during the first half of the study period, water bodies made up a relatively small percentage of the entire geographic region, however they marginally rose during the second half.

This improvement can be attributed to the revitalization efforts made by various NGOs and Naturalists, such as Siruthuli (a Coimbatore-based NGO that works to revive the city's water sources), Environmentalist Foundation of India (a non-profit trust focused on wild life conservation and habitat restoration), etc. However, compared to 2010, the area of the water bodies has significantly decreased due to sedimentation in the year 2020.

Studies on land use and land cover change are important in light of population growth and settlement patterns. Periodic monitoring is crucial for identifying potential changes and implementing the necessary corrections. For instance, there is a critical need in the study region to revive more water bodies and restore natural forest cover. Planners can benefit from studies of this nature in this regard.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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