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Case Study

ANALYSIS OF LAND USE / LAND COVER AND CHANGE DETECTION USING REMOTE SENSING AND GIS: A CASE STUDY

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ABSTRACT

Among the major natural resources, land forms a vital non-renewable resource, the amount of which remains constant in spite of the tremendously increasing population. The ever increasing population is exerting a huge pressure on the available natural resources, the amount of which is depleting swiftly owing to the higher rate of exploitation in the forms of agricultural practices, urbanization and economic development. In wake of this many studies are being carried out globally to identify the types of land use and land cover and the changes happening in this field. An attempt is made here in this direction. The present study aims to identify the land use and land cover features of Vanathangarai water shed of River Noyyal. Also the change matrix of the LULC was done for three time periods spanning over 28 years. For the study, remote sensing data was used to derive the landscape features and it was analyzed and mapped using GIS techniques. LANDSAT TM & OLI imageries were used as data base. For the LULC classification, NRSC level 1 classification system was followed. The study has revealed a decline in area under forest and wasteland cover and an increase in area under built up activities.

Keywords: Land use, Land cover, Change Matrix, LANDSAT, NRSC

1. INTRODUCTION

Land is the major resource which houses other prominent resources like water, minerals, forest and so on. Any activity which alters or affects the land will in turn have repercussion on the other resources existing on it. This in turn has an alarming impact on the global climatic pattern and associated climatic and terrestrial hazards. The Land use/ land cover changes happening in our surroundings are to be viewed in this context and its study attains momentum in this changing world.

Land cover is the observed (bio) physical cover on the earth's surface. When considering land cover in a very pure and strict sense it should be confined to describe vegetation and man-made features. Consequently, areas where the surface consists of bare rock or bare soil are describing land itself rather than land cover. Land use is characterized by the arrangements, activities and inputs people undertake in a certain land cover type to produce, change or maintain it. Definition of land use in this way establishes a direct link between land cover and the actions of people in their environment [1].

Land cover, defined as the assemblage of biotic and a-biotic components of the earth surface is one of the most crucial properties of the earth system [2].

Although the terms "land cover" (LC) and "land use" (LU) are sometimes used interchangeably, they are actually different. Simply put, land cover is what covers the surface of the earth and land use describes how the land is used. Examples of land cover classes include: water, snow, grassland, deciduous forest and bare soil. Land use examples include: wildlife management area, agricultural land, urban, recreation area etc. Two land parcels may have similar land cover, but different land use. For instance, a golf course and an office building are both commercial land uses. The former would have a land cover of grass, while the latter would be considered built-up [3].

Change detection involves the ability to quantify temporal changes in land use and landcover using multitemporal data sets [4, 5]. During the past three decades, many change detection algorithms have been developed, and they vary widely in their sophistication and performance [6, 7]. The choice of a particular technique depends largely on the particulars of the study

area, the nature of the expected landcover change, and the temporal and spatial resolution of the data [7].

Land cover, a concern principally of the natural sciences, denotes the physical state of the land. It embraces, for example, the quantity and type of surface vegetation, water, and earth materials. Land-cover changes fall into two ideal types, conversion and modification. The former is a change from one class of land-cover to another: from grassland to cropland, for example. The latter is a change of condition within a land-cover category, such as the thinning of a forest or a change in its composition [8]. Recent development in remote sensing technology and Geographic Information Systems (GIS) allow us to use landscape ecology and spatial analysis approach to address the problem of deforestation and biodiversity conservation [9].

Currently, issues related to land-use and land-cover change (LUCC) have attracted interest among a wide variety of researchers, ranging from those who are modelling the spatial and temporal patterns of land conversion, to those who try to understand the causes and consequences of land-use changes [10-12]. Remote sensing and GIS based change detection studies have predominantly focused on providing the knowledge of how much, where, what type of land use and landcover change has occurred [13].

LULC information is a pre-requisite for any kind of planning activity. It is used in different levels of administration by different civic bodies. Also, from a very long time this study about LULC is a preferred topic in distinct academic and research levels. Conventionally the studies on LULC were carried out with data inputs from various economical/statistical or local administrative bodies. After the advancement in geospatial technology, the study has assumed greater significance and is more reliable and effortless.

2. STUDY AREA

The study area is Vannathangarai watershed of the Noyyal river basin, which drains into river Cauveri. It includes part of both Coimbatore and Tirupur districts of Tamilnadu. The Noyyal is a tributary of the riverCauveri and originates in the Velliangiri Hills. The river travels through the cities of Coimbatore and Tiruppur and meets the Cauveri in Karur district. The "Noyyal" is a sacred river in Tamil history. It was originally known as Kanchi Nadi, and only later came to be known as Noyyal, which means "one who is free of illness." The area of the Vanathangarai watershed accounts for 1512 square kilometers.

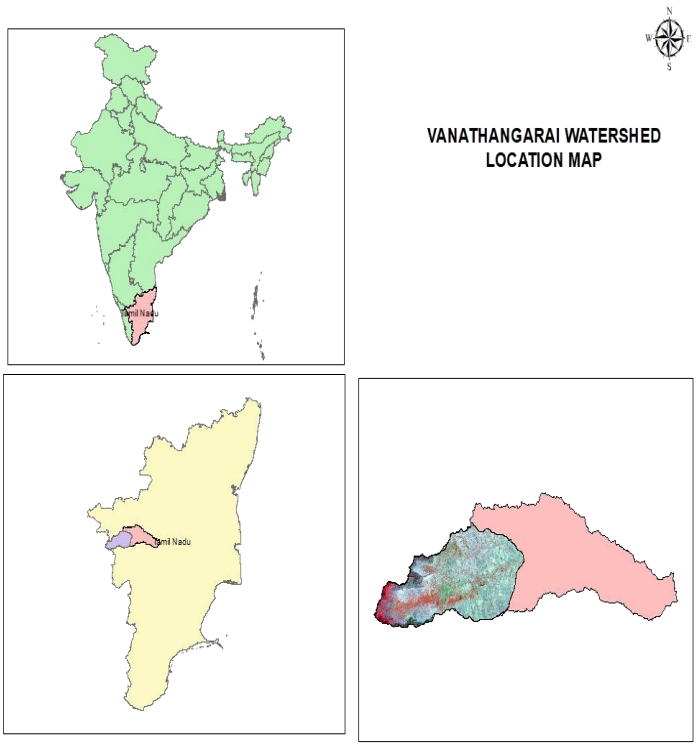

Fig. 1: Location Map of Vannathangarai water shed

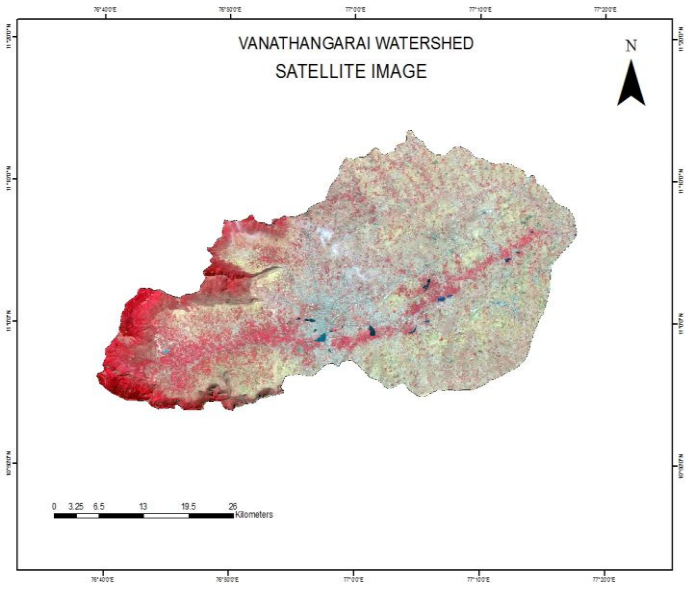

Fig. 2: Satellite Image of the study area

Coimbatore district occupies a major share of the region, while only marginal areas of Tirupur district are confined to this watershed. It is bounded by Palakkad district of Kerala to the west, Nilgiris district to the North, Tirupur to the north and east and parts of Coimbatore district to the south. This watershed is of paramount importance as the headwaters of the river Noyyal lies inside this. The western portion of the watershed embraces a small

portion of the leeward side of the Western Ghats above the Palakkad gap.

This is the most thickly and densely populated area of the whole Noyyal river basin. A major metropolitan centre in Tamil Nadu, Coimbatore, which is the second largest urban agglomeration in the state after the capital city lies inside the watershed. Also, many parts of Tirupur district, which is a major cotton growing hub as well as posses lots of cotton dyeing units and cotton textile mills, is included in this study area. The area is crisscrossed by several transport networks including national highways, railway stations and air port. Another notable feature is the presence of major tanks like, Perur lake, Selvampathy lake, Kumaraswamy lake, Narasampathy lake, Selva Chintamani lake, UkkadamPeriyakulam, ValanKulam, Kurichi tank etc. More vegetation is seen along the western region of the watershed while traversing to the other regions, settlements can be seen more.

Geomorphology: The area is charecterised by the presence of shallow weathered / buried pediplain, ridge type structural hills, shallow and moderately burried buried pediment, shallow flood plain etc. Almost the whole eastern half of the area is filled by shallow weathered / buried pediplain.

Geology: Quartz vein, granitoid gneiss, conglomerate sandstone, granite, ultra basic rocks, carbonatites are some of the major geological features seen in the region.

Soil: There are different varieties of soil seen in the study area. Red clayey, red gravel loam, calcareous gravel loam and gravels clay are the major soil types seen in the region.

3. OBJECTIVES

The present study aims at studying the land use / land cover features of the study area. The following are the main objectives:

1. To understand the land use and land cover features of the Vanathangarai watershed.
2. To identify the changes that has happened in the land use / land cover of the study area over three time periods.
3. To prepare change matrix for the LULC of the study area

4. MATERIAL & METHODS

The present study aims to make a temporal analysis of the dynamics of land use and land cover in the selected study area. For this, three time periods were identified viz. 1991, 2001 and 2019, spanning over a period of 28 years. Remotely sensed images of the study area for the three time periods were acquired. Images from LANDSAT 4,5 & 8 were used for the current study. The images were downloaded from United States Geological Survey (USGS) earth explorer (https:// earth explorer. usgs.gov). For 1991 LULC data, LANDSAT 4 TM imagery of 06 February 1991 was used. 2001 image was taken from LANDSAT 5 TM imagery of 14 February 2001. The current LULC details were extracted from LANDSAT 8 OLI of 15 March 2019. Image processing was done in ERDAS IMAGINE 2015 using supervised classification. The maps were prepared in ArcGIS 10.1. The LULC classes were typified based on NRSC (National Remote Sensing Center) level 1 classification.

5. RESULTS & DISCUSSION

The study is done by preparing LULC maps of the study area based on LANDSAT images. The LULC classes are derived based on NRSC Level 1 supervised classification. Accordingly 5 major types of LULC are identified- Agriculture, built up, forest land, water bodies and waste land. Crop land under all cropping seasons (kharif & rabi), fallow land and plantations come under the category of agriculture. Area under forest cover include evergreen, deciduous (moist & dry), scrub land, forest plantations, forest blanks etc. Wasteland comprises of water logged land, salt affected land, marshy / swampy land, gullied land, coastal and desertic sandy area, mining / industrial waste land, barren rocky/ stony waste etc. Under built up land, towns/ cities and villages are included. Water bodies constitute river / stream, canal, lakes/ reservoir/ tanks etc.

5.1.Land use/ land cover in 1991

Out of the total geographical area, wasteland accounts for 62.6% of the total area with 95077 hectares of area falling under this and it covers the whole of eastern side of the study area. The next main type of land use feature is agriculture covering 25595.5 hectares of land area which accounts for about 16.85% of the total area. Agricultural areas are seen more towards the central western portion which lies between the densely populated central portion and the forested western fringes. Forest area is seen along the western margin of the region and accounts for about 11.86% of the study area with an area coverage of 18019.7 hectares. Built up area is seen clustered at the central south portion of the area and accounts for about just 12468.1 hectares which is about 8.21% of the total area. The last land cover type identified here is water bodies which occur over a meager 731.45 hectares which is only 0.48% of the total area.

Table 1: Land use/ Land cover in 1991

Feature	Area in hectares	Percentage of land area
Agriculture	25595.5	16.85
Built Up	12468.1	8.21
Wasteland	95077.9	62.60
Forest	18019.7	11.86
Waterbodies	731.45	0.48

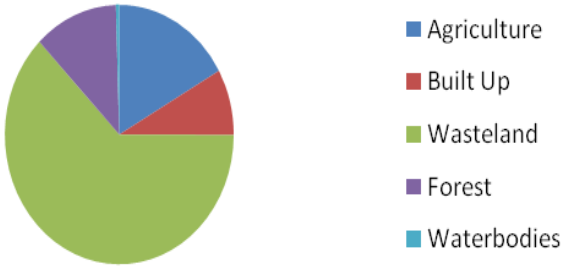

Fig. 3: Area under different Land use/ Land cover -1991

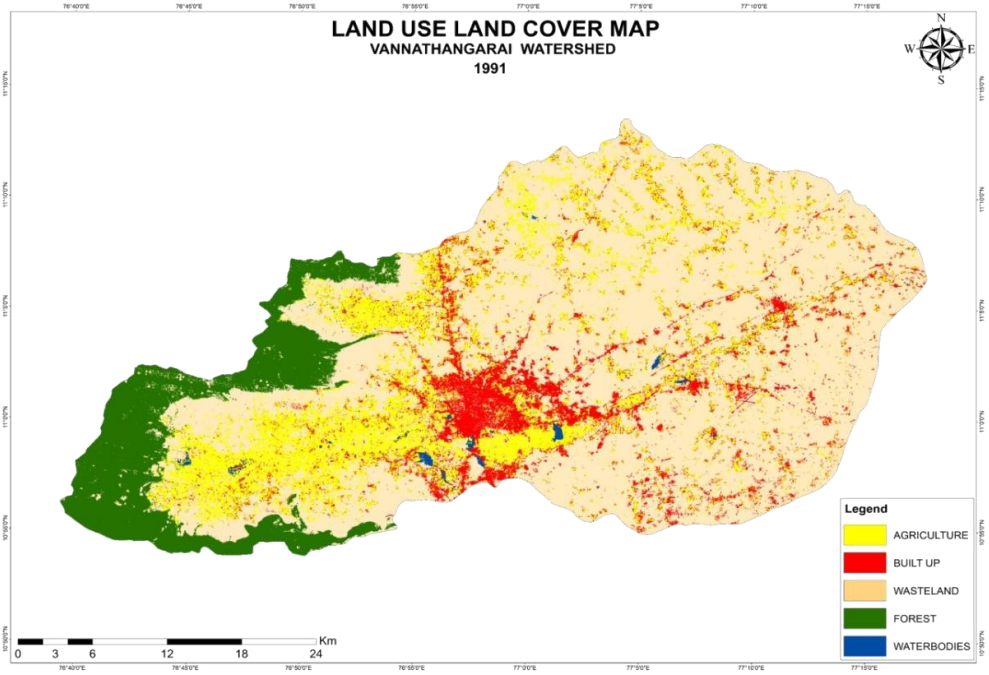

Fig. 4: Land use / land cover map of Vanathangarai watershed- 1991

5.2. Land use/ land cover in 2001

The analysis of LULC in the study area after a decade gives a slightly different picture. The two major areas where changes are evident are the increase in area under built up and the decline in area under waste land; all the other features remain without much change. As mentioned, the area under waste land has fallen to 76328.3 hectares which is only 50% of the study area coming under that. Area under built up activities has risen to 21621.7 hectares (14.23%). Land under agricultural activities is about 25690 hectares which is about 16.9 % of the total area. The area under forest cover almost remains the same with 11.41% (17424 hectares). There is a slight decline in the amount of area under water bodies. It accounts for about only 0.41% with an area of 636.87 hectares.

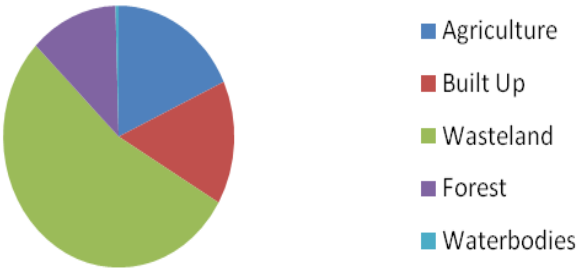

Fig. 5: Area under different Land use/ Land cover -2001

Table 2: Land use/ Land cover in 2001

Feature	Area in hectares	Percentage of land area
Agriculture	25690	16.91
Built Up	21621.7	14.23
Wasteland	76328.3	50.25
Forest	17424.5	11.47
Waterbodies	636.87	0.41

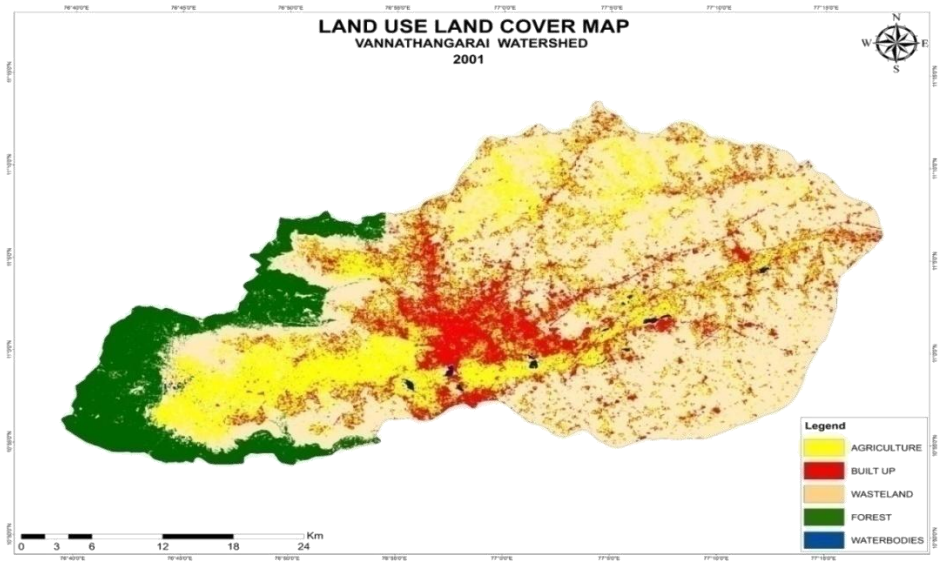

Fig. 6: Land use / land cover map of Vanathangarai watershed- 2001

5.3. Land use/ land cover in 2019

The trend of change in LULC pattern remains almost the same in 2019 also. The major changes are seen in two areas, built up area and waste land; while the area under built up has increased considerably, the area under waste land has reduced. There is a very slight decrease in the area under agriculture land, it accounts for about 25624 hectares which is about 16.86% of the area. Area under forest cover has gone down by about 2%. It covers 15134.9 hectares which is 9.9% of the total study area. An interesting feature to be noted here is the marginal increase in the area under water bodies, which in normal case is unusual. Area under water bodies accounts for 1.03% of the total area with an area of 1574 hectares. This increase may be attributed to the higher amount of rainfall recorded during that time. Also many NGOs like *Siruthuli*, *Environmentalist Foundation of India* have taken up the activities like cleaning up of water bodies. This has produced a visible positive result.

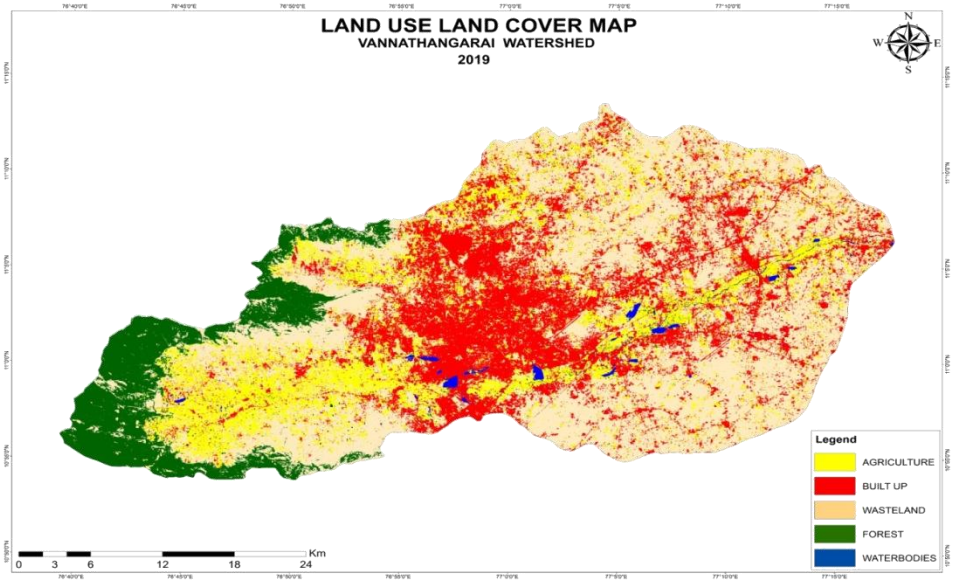

Fig. 7: Land use / land cover map of Vanathangarai watershed- 2019

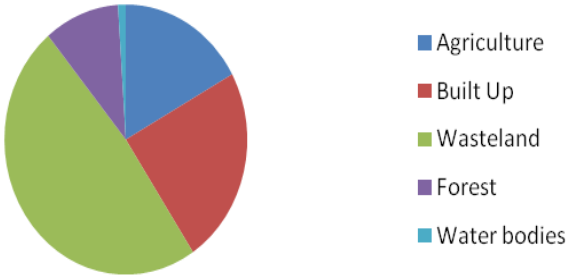

Fig. 8: Area under different Land use/ Land cover -2019

Table 3: Land use/ Land cover in 2019

Feature	Area in hectares	Percentage of land area
Agriculture	25624	16.86
Built Up	35626	23.45
Wasteland	72755.4	47.89
Forest	15134.9	9.96
Waterbodies	1574.05	1.03

5.4. Land Use / Land Cover Change Matrix

Land use / land cover change detection matrix was also prepared to understand the changes occurred in each category over the period of 28 years. Matrix was calculated by identifying three time periods which area 1991-2001, 2001-2019 and 1991-2019.

5.4.1. LULC Change Matrix 1991-2001

During the period from 1991 to 2001, the major change has happened in the area of waste land. Around 13944 hectares of waste land has been converted to agriculture land and 10825 hectares to built up land. 3195 hectares of agriculture land has been converted to built-up area and 4763 hectares into waste land. Another interesting feature here is that 985 hectares of forest land has been converted into waste land. As much as 328 hectares of water bodies were reclaimed to agricultural land.

Table 4: LULC Change Matrix 1991-2001

Class Names	Agriculture	Built Up	Wasteland	Forest	Waterbodies
Agriculture	NA	3195.77	4763.1	234.457	148.187
Wasteland	13944.1	10825	NA	1517.73	200.57
Forest	169.66	31.7223	985.098	NA	6.38
Waterbodies	328.72	84.2	99.5702	12.13	NA

Table 5: LULC Change Matrix 2001-2019

Class Names	Agriculture	Built Up	Wasteland	Forest	Waterbodies
Agriculture	NA	6860.37	11220.4	333.38	765.66
Wasteland	7166.1	14907.4	NA	737.402	287.271
Forest	406.757	69.34	3313.1	NA	15.46
Waterbodies	126.637	88.29	100.037	7.44	NA

Table 6: LULC Change Matrix 1991-2019

Class Names	Agriculture	Built Up	Wasteland	Forest	Waterbodies
Agriculture	NA	5469.37	8244.06	287.07	440.05
Wasteland	12332.9	21879.4	NA	922.92	693.26
Forest	287.11	72.02	2971.06	NA	9.55
Waterbodies	188.29	115.07	179.74	7.6	NA

5.4.2. LULC Change Matrix 2001-2019

The next time period considered for the study is an 18 year period from 2001 to 2019. During this time, major changes have taken place in agriculture; 6860 hectares being converted to built up and 11220 hectares being made as waste land. Around 7166 hectares of waste land got converted into agricultural land and 14907 hectares into built up land. Around 126 hectares, 88 hectares and 100 hectares of water bodies were converted into agriculture land, built up land and waste land respectively

5.4.3. LULC Change Matrix 1991-2019

There are some major notable changes visible during the period from 1991 to 2019. Around 5469 hectares of

agricultural land has got converted into built up land and 5469 hectares into waste land. The major change is seen in the case of wasteland where, 12332 hectares and 21879 hectares were converted into agricultural and built up area respectively. Among the forest covered area, 2971 hectares was changed into waste land. 188 hectares of water body got changed into agriculture land, 115 hectares into built up land and 179 hectares into wasteland.

6. 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 the Vanathangarai watershed of Noyyal basin over a period of 28 years from 1991 to 2019 by taking three time periods viz 1991, 2001 and 2019. The study area covered major parts of Coimbatore and few areas of Tiruppur district of Tamil Nadu. The study identified that the major land use feature of the area over the years are wasteland, agriculture land and built up land. It was evident that the total area under waste land has declined over the years and most of it was converted into agricultural land and built up areas. The most evident change noticed was the expansion of built up area which has multiplied almost three fold. The Urban growth is very evident over the years. Coimbatore city, which is the second largest urban agglomeration in Tamil Nadu, after Chennai lies at the centre of the study area.

Noyyal river is one of the major drainage feature which flows through the central part of the study area. It is an important tributary of River Cauvery. River Noyyal was the life line of the people 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.

The study area also has a wide network of systematic tanks like Perur lake, Selvampathy lake, Kumaraswamy lake, Narasampathy lake, Selva Chintamani lake, Ukkadam Periyakulam, ValanKulam, Kurichi tank etc. Most of the tanks were on the verge of dearth. The study justifies this point. It was very evident that water bodies occupied only a small portion of the total geographical area in the first half of the study period, while it has increased slightly in the later half. This positive change can be attributed to the revitalization strategies undertaken by certain NGOs and Naturalists like the Siruthuli (an NGO based in Coimbatore, which works to rejuvenate water sources in the city), Environmentalist Foundation of India(a non-profit trust aimed at wild life conservation and habitat restoration) etc.

Studies on Land Use/ Land Cover and its change are significant in the light of the expanding population and its settlements. It is highly essential to have a periodical monitoring to find out the probable changes happening and to take necessary rectification. For instance, there is an urgent need in the study area to restore natural forest cover and to bring more water bodies to life. This kind of study aids planners in such direction.

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