A DECADAL STUDY ON LAND USE AND LAND COVER CHANGE DETECTION ALONG THE COASTAL REGIONS OF CUDDALORE AND NAGAPATTINAM DISTRICTS OF TAMIL NADU, INDIA, USING REMOTE SENSING AND GIS

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ABSTRACT

Identification of Land Use and Land Cover (LULC) changes is an important for many planning and management activities. Remote sensing and GIS technology can be used to assess the Land use Land cover changes. In this paper, an attempt is made to identify the decadal LULC change in the coastal parts of Cuddalore and Nagapattinam. The data sets from Landsat ETM + and Landsat 8 OLI for the periods of 2000 and 2021 were used and the maximum likelihood supervised classifier (MLC) was applied to extract LULC maps. The LULC in the study area has undergone a serious and complicated change over the past two decades. Five major LULC classes were noticed and as per variation in refection, they are subdivided. The results show, that the wasteland and settlement have been increased by +53 km^2 and +149 km^2 while agricultural land and mudflat/saltpan increased by +154 km^2 and +47 km^2 , while forest land and plantation has decreased by -19 km^2 and -40km^2. The analysis and findings of the investigation highlight the importance of sustainable LULC management on the Cuddalore and Nagapattinam coastal regions during this period. Considerable LU/LC pattern can be seen in the study area because of the rapid urbanization and development. The socio-economic development affects the water resources, and ecosystems which are available in the study area. The results show that significant land use changes occurred in the Coastal regions of Cuddalore and Nagapattinam area from 2000 to 2021, which may be related to economic development and urban expansion between 2000 to 2021. The result reveals that the maximum changes were noticed in increase in Built-up-Land and in semi evergreen forest in the study area. Other changes also can be seen in the spatial distribution.

Keywords: *Land use and Land cover; Landsat ETM; Remote Sensing and GIS; Change Detection*

Introduction

The amendment of the Earth's surface through human and natural activity is referred to as land use and land cover change (LULCC). These modifications are the operating forces behind new alterations in ecosystems and environmental processes at the local, regional and global scales. LULC change is important for providing valuable information for future environmental management and planning decision making [4]. Land use/land cover changes have become the key to numerous approaches such as agriculture, environment, ecology, forestry, geology and hydrology [19].

The UNPD (2007) [17] has stated that the population of coastal areas has doubled in the last 40 years, and will double in the next 40 years. The reasons for rapid population growth and expansion of infrastructure accelerate the transformation of coastal natural land use and land cover features [8]. In recent decades, changes in coastal land use and land cover due to human activity have led to changes in the earth's life support system, leading to widespread concern [10, 6]. Waves, winds, tides, saline water, salinity, sea level rise, storms, cyclones and human intervention have led to significant changes in land use and land cover in coastal areas [12, 13, 18, 20].

On the Indian coast, the population was expanded from 11.42% to 14.20% between 1991 and 2014. This has a direct negative impact on land resources and leads to rapid land cover conversion through built-ups, settlements and other recreational uses [7,2].The Government of India has launched various land use and land cover change assessment projects across the country for monitoring and management of natural and environmental resources [5]. Similar effects of population growth and maritime activity have been observed in the coastal areas of Cuddalore and Nagapattinam coastal region. Over the modern decade, changes in land use and land cover in coastal areas have been adapted to the development of coastal landforms. Besides natural factors such as waves, storms, cyclones and erosion are slowly changing land use and land covers in coastal regions [15, 11, 9].

LULC change investigation provides basic information for sustainable coastal zone management, so it is essential to obtain reliable information to support accurate coastal resource management and planning at the national or regional level despite high population growth pressure [12, 16, 11, 1]. Landsat MSS, TM and ETM+ data are used worldwide for LULC change detection analysis [14]. Landsat images furnish better information about LULC changes than on-point data collected by on-site instrumentation [3].

Study Area

The study area confined to 10 selected coastal taluks of the districts such as Bhuvanagiri, Cuddalore, Mayiladuthurai, Nagapattinam and Karaikal district a part of Puducherry Union territory. Cuddalore, Kurinjipadi, Chidambaram, Sirkali, Tharangambadi, Karaikal, Nagapattinam, Kilvelur, and Vedaranyam taluks, as well as part of Karaikal, Puducherry Union territory, are depicted in Figure 1.

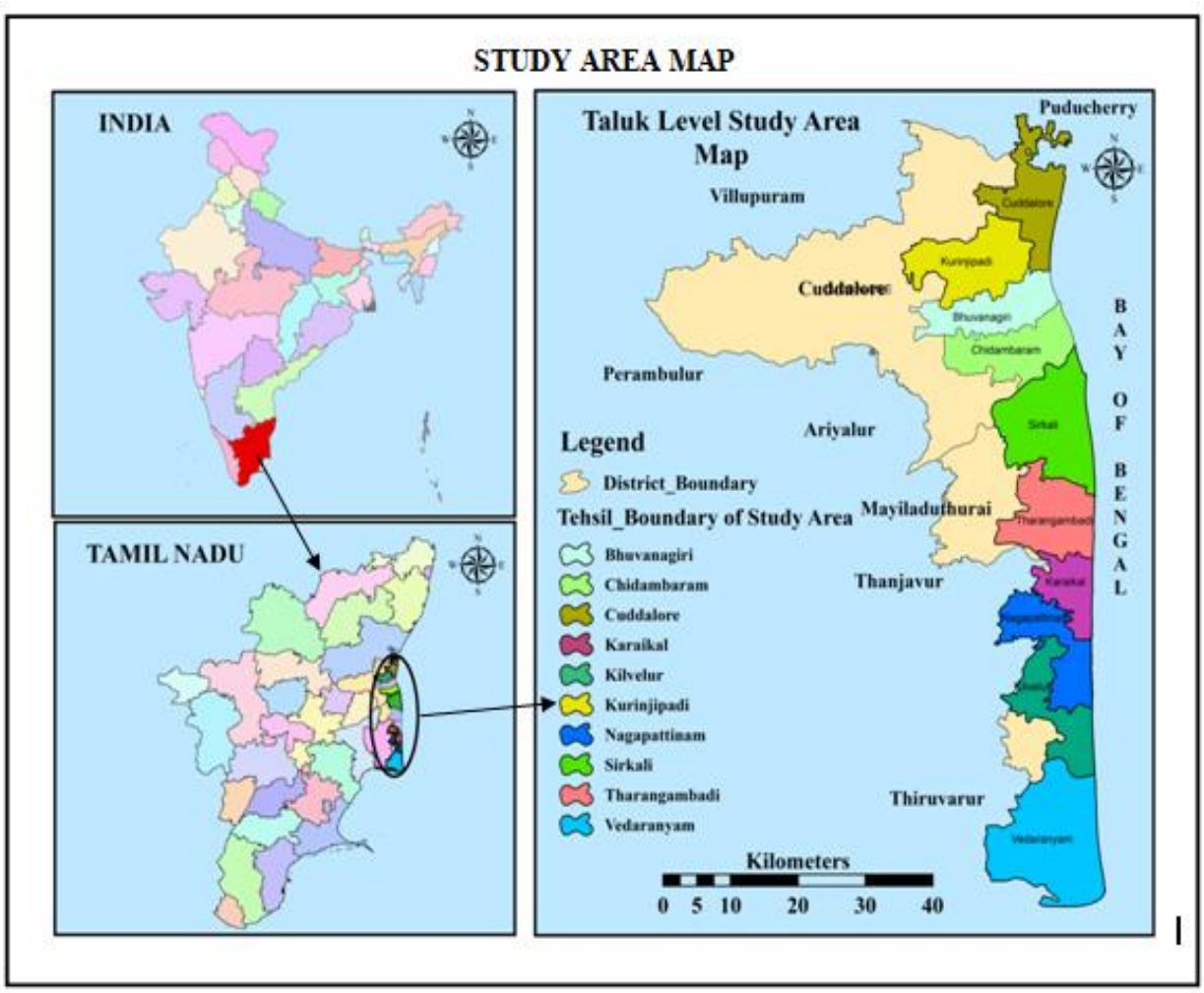


Figure.1. Represents the study area Map.

It comprises a total geo-graphical area of 3457 km^2. The study area extends in between 79^o 35`E to 79$^o$ 50`E and 10^o 16`N to 11$^o$ 54`N. It falls under the survey of India Toposheets no of 58 M/10, 13, 14, 15, 16, 58 N/11, 13 and 15 in the scale of 1:50,000. These district boundaries are delimited in the east by Bay of Bengal, in northern side Puducherry and Villupuram districts, in the west Perambalur, Ariyalur, Thanjavur and southern side is totally covered by the Bay of Bengal. The study area is lying along the eastern coastal region of Cuddalore, Mayiladuthurai and Nagapattianam coastal districts. These are low-lying coastal districts that are crisscrossed by extensive drainage networks and irrigation canals. They are located in the deltaic zone of the famous River Cauvery and have six major river basins, including the Ponnaiyar, Paravanar, Vellar, Coleroon, and Vennar river basins. It is

subjected to extreme weather conditions and floods on a regular basis during northeast monsoon season, particularly on the coastal plains.

Materials and Methodology

The Survey of India Toposheets numbers, 58M/10, 13, 14, 15,16, 58N/9, 11, 13, 14 and 15 with a representative fraction of 1:50,000 were used for preparing the study area map. The ArcGIS 10.8.1 and ERDAS Imagine 2015 image processing software were used for preparing, analyzing and quantifying the LULC features and change detection. The Multi-temporal Landsat-7 ETM+ and Landsat-8 OLI was downloaded from the USGS earth explorer website. The Landsat satellite image is a moderate resolution data (30 m). As the study area is under the domination of agriculture, and the maximum LULC variations are perfectly visible during the pre-monsoon and post-monsoon season; hence, the data from post monsoon season was taken into a discussion for identifying the LULC features. For detecting the 2000 LULC the data was accrued for the date of 24 February 2000 and the 2018 LULC features identification was done by referring to the data of 31st January 2021.

Table.1 Description of observed Landuse/ Landcover categories.

Major LULC Classes	Class description	LULC Classes
Agricultural land	Land used for cultivating crops.	Cropland
Fallow land	Fallow land refers to. Land not under cultivation. It is a fertile land, Cultivable land but not cultivated for a season to regain its fertility	
Forest (Mangrove Forest)	It is a scrub or tree that grows in coastal saline or brackish water, mostly found all over the tropical and subtropical areas along coastal area.	Forest area
Land without scrub	Lands associated with grassland and deserts without scrub.	Barren land
Land with scrub	It is a land covered with scrub, small trees and bushes.	
Mudflats/ Tidal flat	Mudflats also known as tidal flats are coastal wetlands that form when mud is deposited by tides or rivers, sea, lake side's and oceans.	
Plantations	Usually large group of plants and tress under cultivation and also natural vegetation.	Vegetation
Sandy area	A pebbly or sand shore, especially by the sea between high and low water marks, along the river or sea shore.	Barren land
Settlements	Land under houses, mines, roads, and other facilities associated with human active -ties.	Built up
Water bodies	Any significant accumulation of water on the surface of earth. It includes rivers, streams, water cannels, small water tanks, lakes or ocean.	Water accumulated area
Wetland/marshy/swampy	A wetland is a marshy/swampy land that is dominated by herbaceous rather than woody plant species. Marshes can often be identified at the edges of lakes and streams	Marshy /Swampy

The study depended on the use of computer-assisted interpretation of Landsat. The identification of LULC classes was done with the association of near-infrared, red and green bands (band combination of 4, 3 and 2) were used for preparing FCC image (False Color Composite). Based on the FCC image reflections all the features were extracted and the Maximum Likelihood Supervised Classification was utilized to produce an accurate LULC reflectance. The classification scheme utilizes fifteen LULC classes (cropland, fallow land, land with scrub, land without scrub, swampy land, forest, settlement/urbanization, water body, Sandy area, mudfalt and plantation, for mapping the

entire study area. Descriptions of all LULC features are presented in Table 1.

Result and Discussion

Land that serves for agricultural deeds is defined as agricultural lands. An agricultural land fulfills the basic need of mankind and other many commercial agricultural purposes. In the study area, the observed agricultural lands are of two types; crop lands and fallow lands. Again the crop-covered land can be irrigated and un-irrigated land. On a seasonal basis, a crop can be either kharif (June-September) or Rabi (October- March), or both kharif, rabi. The lands which are usually utilized for agricultural purposes but are currently left uncultivated are defined as fallow land, usually, for fertilization and crop rotation purposes these lands are allowed to rest as uncropped for one or more than one crop season. In 2000 the noticed cropland area was 33.93 % or 1173 km^2 of the entire LULC features and after 22 years the crop-covered area was increased to 1327 km^2 defining 38.39 % of the 2021 LULC classification. In 2000 the fallow land covered area was 1279 km^2 and in 2021 it reduces to 991 km^2 this difference denotes the reduction of -288 km^2 in the entire fallow covered area (Table 2).Wastelands are described as barren or degraded land. As a side effect, due to the natural hazards and the influence of urbanization, the waste land area was increased massively during the mentioned 22 years. In the study area four types of wastelands were identified; 1.Land with scrub 2. Land without scrub and 3. Wetland 4. Mudflat. The land without scrub refers to the lands that are covered with bushy small trees, the land without scrub refers to those lands usually found with higher topography and formed by degradation or erosion and the wetland describes those lands which are filled with muddy water. In 2000 the land with scrub was 57 km^2 (1.65%) and in 2021 it was 54 km^2 (1.56 %), the identified decreased by -3 km^2, in case of land without scrub covered area for 2000 it was 39 km^2 (1.13%) and after 22 years it increased to 136 km^2 (3.93 %) with the measured increase of +97 km^2, the area under influence of wetland was 20 km^2 in 2000 and in 2021 it was increased to +53 km^2 and the area under the influence of mudflat was 15 km^2 in 2000 and was increased to +47 km^2 in 2021.

The areas which are predominated by trees and plants and can produce timber or other forest production are defined as forest areas. In the study area, two types of forest covered are noticed; forest patches and mangrove forest. The forest that is located near shore and situated in the saline water infiltrating land is known as the mangrove forest. Mangrove forests act as a natural embankment to prevent the coast from marine hazards. In the study area, On the northeastern coastal side, the Pichavaram mangrove forest is seen near to eastern side of study area. And another subdivision forest is identified in patchy nature. In 2000 the mangrove covered area was 34 km^2, which was 0.98% of the entire study area and on the opposite in 2021 LULC it decreased to 15 km^2 which was 0.43 % of the study area, were decreased -19 km^2 in forest covered area, this decrease can be either by naturally or by human, it prevents the coast environment form coastal tides and waves.

The land use character that is mainly utilized for buildings, houses, transportation, factories, industries, recreations, etc., is defined as urbanization/settlement. In the study area, the settlements are of town and village types and clustered in nature. Moreover, they are scattered throughout the entire study area. In 2000 LULC distribution the settlement covered area was 265 km^2 covering 7.67% of the study area, and in 2021 LULC distribution it increased to 414 km^2 which demonstrates an increase of 11.98 km^2, this increase defines +149 km^2 changes. The 2 times increase in the settlement area defines the huge influence of civilization (Table 2). By the visual interpretation of the 2000 to 2021 LULCC distribution, it was noticed that the major influential settlements are Cuddalore, Kurinjipadi, Chidambaram, Sirkali, Kilvelur, Nagapattinam, Nagore, Karaikal, Tharangambadi, Parayar, Palaiyar, Thirunagam and Vedaranyam (Fig. 2).

Table .2. The comparative changes between the years 2000 and 2021.

Land Use & Land Cover	2000		2021		Area change in Sq.km
	Area in Sq.km	Area in %	Area in Sq.km	Area in %	
Agriculture land	1173	33.93	1327	38.39	+ 154
Fallow land	1279	37.00	991	28.67	- 288
Forest	34	0.98	15	0.43	-19
Land without Scrub	39	1.13	136	3.93	+97
Land with Scrub	57	1.65	54	1.56	- 3
Mud Flat	15	0.43	62	1.79	+ 47
Plantation	280	8.10	240	6.94	- 40
Sandy Area	81	2.34	75	2.17	- 6
Settlements	265	7.67	414	11.98	+ 149
Water Bodies	214	6.19	70	2.02	- 144
Wetland	20	0.58	73	2.11	+ 53
Total Area Sq.kms	3457	100.00	3457	100.00	

The water accumulated areas on the terrestrial surface are described as water bodies. The size of the water body can be varied from big to small and can be linear, circular, square, or in any shape. In the study area, the determined water bodies are in form of rivers, streams and lake types. In 2000 the water accumulated area was 214 km^2 and in 2021 it reduced to 70 km^2 refers to a -119 km^2 change. It is observed the flowing river beds are getting narrow from 2000 to 2021.

The other noticed LULC classes are vegetation and sandy area. The vegetation refers to the plants or trees near settlements. In 2004, the vegetation-covered area was 280 km^2 (8.10%) and after 22 years it decreased to 240 km^2 (6.94%), which indicates a decrease of -40 km^2. Between 2000 to 2021 the sandy area has been reduced to -6 km^2.

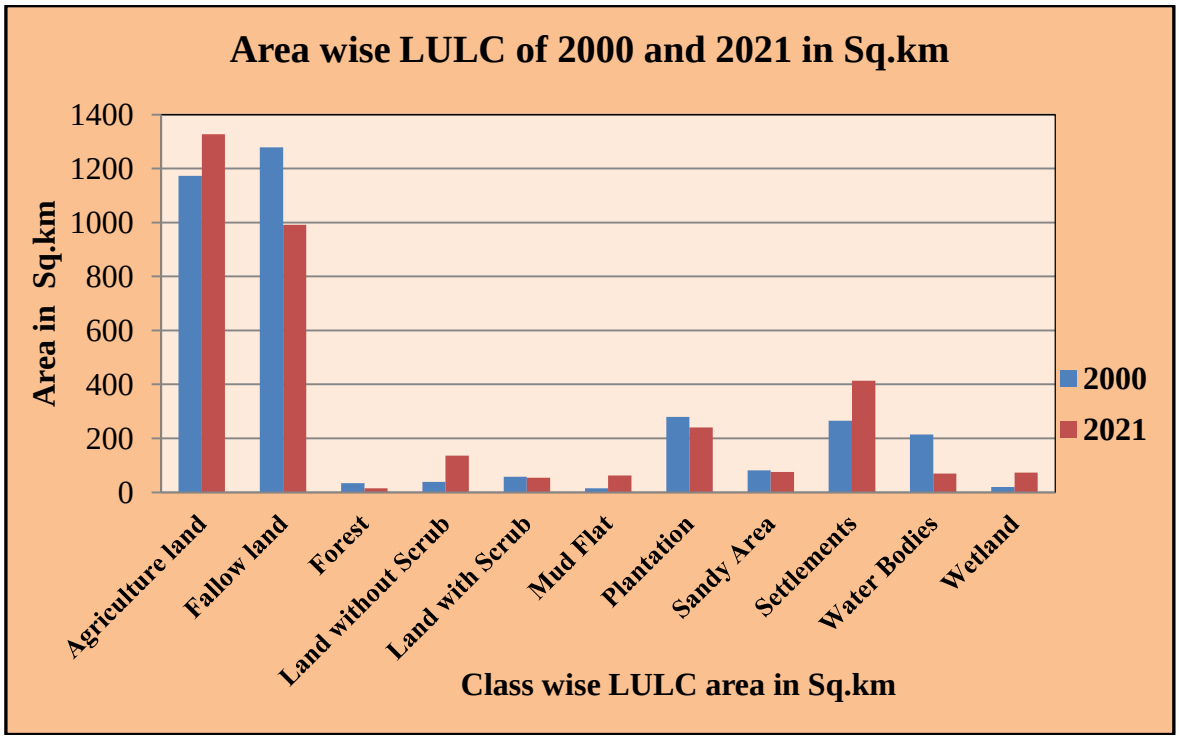


Figure .2. Chart shows the relative changes of LU/LC on 2000 and 2021.

Fig.3. Represents the LULC in 2000.

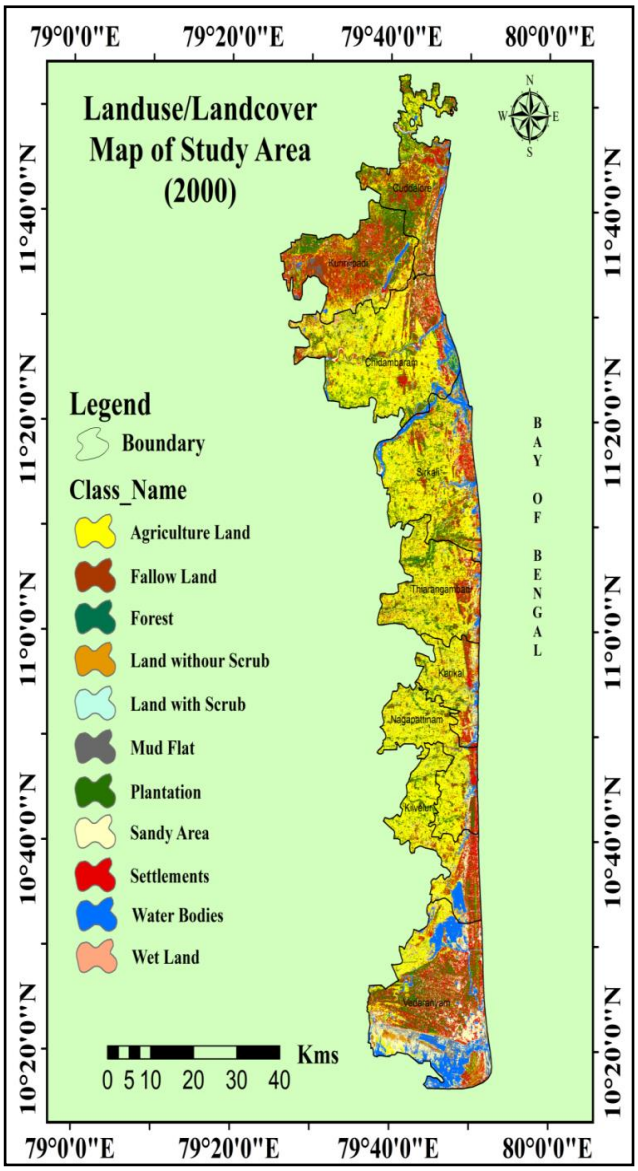
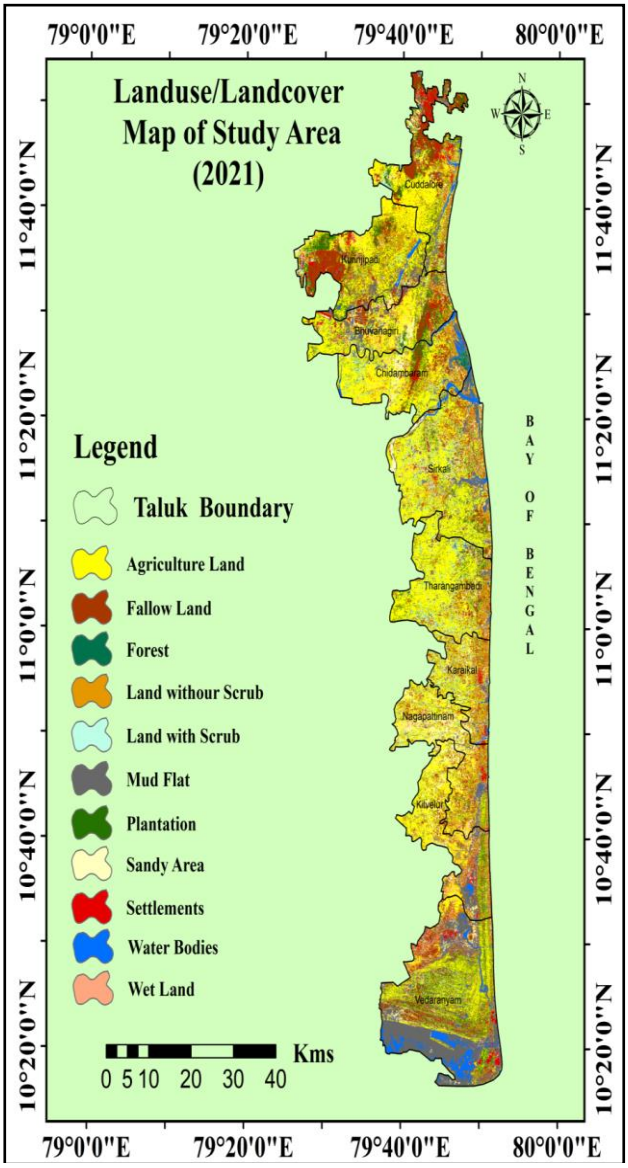


Fig.4. Represents the LULC in 2021.



Conclusion

The present investigation describes that the settlement covered area has increased by +149 km^2 during 2000 to 2021 years, and consequently, for the same reason the interest in doing primary production activities was reduced that effect can be observed by the calculated reduction of -288 km^2 in fallow land and -144 km^2 reduction in water bodies covered area, simultaneously an increase of +53 km^2 is noticed in the wasteland covered areas. The present study found that remote sensing combined with GIS can be effectively used for real-time and long-term monitoring of the environmental change identification and useful for emphasizing sustainable development planning. The baseline information generated in the study area depict that satellite remote sensing-based land cover mapping is very effective for coastal LULC monitoring as it is very dynamic.

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