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Land Use and Land Cover Change Detection in East Godavari District, India (2002-2020)

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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

Land Use Land Cover (LULC) dynamics must be monitored and mapped because changes in land cover reflect the state of the ecosystem and provide a clear picture of optimal natural resource utilization. The goal of this study was to use Remote Sensing and Geographical Information System techniques to classify and map LULC in the study area. This research is divided into two sections: (1) LULC classification and (2) Accuracy assessment. Between the years 2002 and 2020, satellite remote sensing data was acquired from the United States Geological Survey and analyzed using Arc GIS 10.1 software. The study region was divided into six major LULC types: agricultural land, built up area, barren land, forest and sediment using the likelihood classified approach and quantifying the changes throughout the time period indicated. According to the findings, Settlement area increased from 1.22 % in 2002 to 10.8 % in 2020, barren land increased from 7.58 % to 12.96 % in the same period, agricultural area decreased from 21.83 % in 2002 to 18.53 % in 2020, and forest cover decreased from 8.9 % to 2% in the same period, according to the findings. In the years 2002 and 2020, overall efficiency was 77.61 % and 73 %, respectively. In the years 2002 and 2020, the kappa coefficient was 0.67 and 0.66, respectively. Significant land cover change occurred throughout the research period as a result of increased settlement area and aquaculture land, and these changes in land cover led to forest and agricultural land degradation.

Keywords: land cover change; supervised classification; kappa efficient; change detection.

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1. INTRODUCTION

Land use refers to how land is used for agricultural, residential, or industrial purposes Riebsame *et al.* [1]. About three-quarters of the Earth's land surface has been altered by humans within the last millennium Luyssaert *et al.* [2] and Arneth *et al.* [3]. Land use/cover change detection is beneficial for a better understanding of landscape dynamics over time with sustainable management Basha *et al.* [4]. Land use/cover change is a large and growing process that is mainly driven by natural and anthropogenic processes, resulting in changes that have an impact on natural ecosystems Ruiz-Luna *et al.* [5] and Turner and Ruscher, [6]. Land use classification is important because it provides data that may be used as input for modelling, particularly modelling that interacts with the environment, such as models that deal with climate change and policy changes.

Land cover and land use changes in dry, semi-arid, and agriculturally productive land have been the subject of several studies. Rwanga and Ndambuki [7] did the classification of LULC and accuracy assessment test using Non parametric rule. The overall classification accuracy of the study was 81.7%, with a kappa coefficient (K) of 0.722. With MODIS and Landsat satellite data Spruce *et al.,* [8] created Land Use Land Cover maps for the Lower Mekong Basin (LMB) to improve hydrological modelling and basin planning. Unfortunately, effective mapping of certain LULC types in the LMB can necessitate more than one data set of remote sensing data per year, particularly for LULC classes with distinct foliar greenness phenology, such as agricultural and forest kinds. Although remotely sensed data is important in LULC change investigations, it cannot provide complete answers to topics such as why and how changes occur. Fisher, [9] Sohl and Sleeter [10]. Sudhakar and Alivelamma [11] used digital change detection techniques based on multi-temporal and multispectral remotely sensed data, which have shown a lot of promise as a way to understand landscape dynamics- detect, identify, map, and monitor differences in land use and land cover patterns over time, regardless of the causal factors. In the ERDAS Imagine Software, he used a supervised classification method with a maximum likelihood algorithm. Twisa *et al.* [12] investigated the upstream and downstream Wami River Basin's LULC patterns during a 16-year period. The Landsat series multitemporal satellite imagery was used to map LULC changes, which were separated into three stages (2000-2006, 2006-2011, and 2011-2016). The results of the change-detection analysis and the change matrix table from 2000 to 2016 show the magnitude of LULC changes in various LULC classes, with the majority of grassland, bushland, and woodland being intensively converted to cultivated land both upstream and downstream. The Geospatial Assessment of Land Use and Land Cover Patterns in the Black Volta Basin, Ghana was completed by Amproche *et al.* [13]. Satellite images were taken from the US Geological Survey's (USGS) Landsat archives and the Earth Observation database. Four separate Landsat scene pictures of 30 m resolution from the years 2000, 2015, and 2018 were used as the spatial dataset. ArcGIS 10.5, ENVI 5.3, MS Excel software, and Google Earth were used to examine the Landsat images. Using RS and GIS Ramanamurthy and Vijayasaradhi [14] investigate change detection in the LULC of the upstream Thandava reservoir. Toposheets of 65K5, 65K6, 65K9, and 65K10 (scale: 1:50000) were collected, and geo rectification and mosaicking were performed on all of them. For the years 1995, 2008, and 2020, supervised classification was applied by picking every pixel of the image. Formerly no such study related to changes in magnitude and dynamics of LULC was conducted in the East Godavari District. Little is known about the spatiotemporal extents of LULC change, and no information has been evaluated over time to improve land use planning in the district. Moreover, to understand the aspects of changes in the human environment across space and time, numerous studies are required Veldkamp A and Verburg PH, [15]. In order to address this, an integrated approach of RS and GIS data was used for monitoring the LULC change by Kasischke *et al.,* (2004) in the East Godavari District. The outcome of this study is expected to be highly useful to planners, resource managers, and policymakers for sustainable use of resources in the district.

2. MATERIALS AND METHODS

2.1 Study Area

The study area, East Godavari district is situated in Godavari River basin, Andhra Pradesh, India. It lies on the East coast of India with Bay of Bengal on one side and Eastern Ghats on the other side as boundaries and having a Coastal Plains in between with fertile alluvium soils. It is located between latitude 16°30'00" N and

18°00’00” N and longitude 81°30’00” E and 82°30’00” E. The total geographical area of the study area is 10,807 km^2 consisting of 3,23,2.44 km^2 forest area, 4194.33 km^2 net area sown, 830 km^2 under barren and uncultivated area, 2835.92 km^2 water bodies and 375.45 km^2 other areas like built-up areas etc CGWB [16]. The district is traversed by many water courses, like River Godavari, River Pampa, Yeleru, Tandava etc.

3. METHODOLOGY

3.1 Spatial Data Collection and Sources

The present study focuses on interpreting the changes in the land use through satellite imagery and demographic data. The quantitative method of change detection was used in this research. In the change detection method, each satellite image is classified. The resulting LULC maps obtained after the classification are then compared according to the pixel-by-pixel approach by using a change detection matrix. The methodology adopted in this study is as follows: (1) data collection, (2) pre-processing, (3) LULC classification, (4) selection of training data samples, (5) image classification, (6) accuracy assessment, and (7) change detection. Every step except the data collection step was performed using Arc Map 10.1. Fig. 1 depicts the flow chart that illustrates the methodology in the present study.

3.2 Data Pre-processing

This includes data operations which normally precedes further manipulation and analysis of the image data to extract specific information. The Landsat datas were processed in ArcGIS10.1 software. The operations like image rectification layer stacking and mosaicking were performed. study area had four data sets for respective years which covers the all parts of the study area. The operations like image rectification layer stacking and mosaicking were performed. All these four datasets were combined together by mosaicking. The required portion of the study area was mask out by the operation called extracted by mask in ArcGIS 10.1 software.

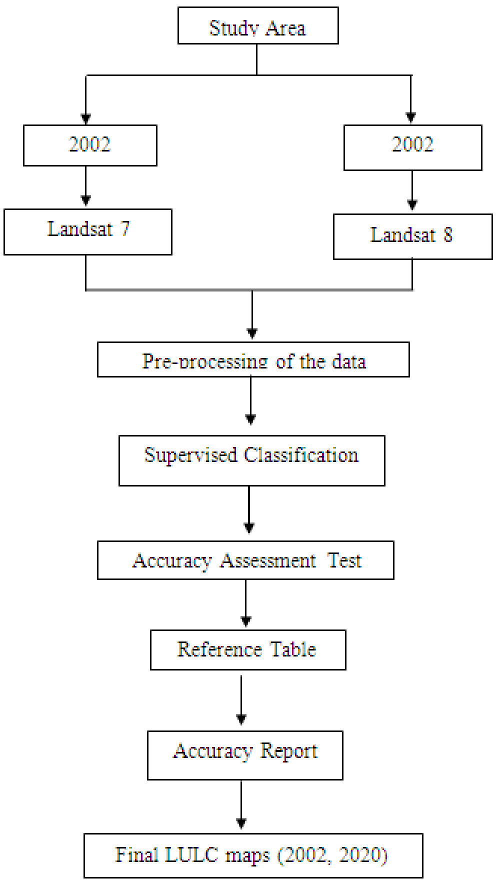


Fig. 1. Flowchart on methodology

3.3 Image Classification Process

Six unique types were used to divide the study area. Table 1 has a thorough description of the classes. Texture, tone, and colour were used to create each class [17]. In image categorization, these classes were allocated to pixels.

3.4 Selecting of Training Data Samples (Supervised Classification)

Data sets have been trained using different band combinations of the satellite images, field survey data, and Google Earth Maps. The satellite image of the study area and Landsat data were linked through (Ground control points) GCPs in Google earth. This progression empowered the interesting elements in the study area to be perceived. Different band combinations were utilized to decide the pixel group of a predetermined class. Band combinations are mentioned in the Table 2 for both Landsat 8 and Landsat 7 Data sets were prepared by the color of pixel. Preparing sites were made in the symbolism by drawing polygons, which were set in an AOI (Area of Interest) layer. To prepare each particular class, 20 polygons or more than that were drawn and placed in the signature editor. These polygons were combined and given a unique class name. Following that, the signature editor file was saved as a signature file (.sig format). In this work, two signature files were created to train the two data sets (2002 and 2020).

Table 1. Description of LULC classes

S.no.	Class	Description
1.	Built-up area	Low, medium and high-density road networks; residential, industrial, and commercial buildings; transportation; open-roof concrete structures; educational institutes; other human-made structures; and solid waste landfills are all examples of land covered by concrete.
2.	Forest	Land with a high percentage of forest vegetation.
3.	Agricultural land	Orchards and regularly tilled, planted croplands are examples of areas with a high density of grasses, herbs, and crops.
4.	Barren and/other lands	Areas with minimal vegetation that may alter or be converted to other uses in the future. Lands with exposed soil, sand or rocks, and never has more than 10% vegetated cover during any time of the year. Bare ground, bare exposed rocks, strip mines, quarries and gravel pits
5.	Water Body	Rivers, reservoirs, ponds, lakes, and streams, as well as aquaculture land are all covered by water.
6.	Sediment	Land without crops, land with barren rock, and sand sections along river/stream beaches all fall into this category.

Table 2. Band combination of landsat 8 and landsat 7

S.no	Composite Name	Band combination (RGB)	
		Landsat 8	Landsat 7
1.	Natural Color	7 6 4	3 2 1
2.	False Color (Urban)	5 4 3	-
3.	Color Infrared (Vegetation)	6 5 2	4 3 2
4.	Agriculture	5 6 2	-
5.	Healthy Vegetation	5 6 4	1 4 7
6.	Land/ Water	7 5 4	4 5 1
7.	Natural with ATM removal	7 5 4	-
8.	Shortage Infrared	6 5 4	-
9.	Vegetation Analysis	7 6 4	-

3.5 Image Classification

Through supervised classification, the different LULC of the East Godavari district were identified and mapped from Digital Landsat images. In this study, the supervised classification method Maximum Likelihood classifier (MLC) was applied. The primary goal of the image categorization process was to find pixel clusters. In the classification process, some LULC units were misclassified with different classes. For example, barren lands were misclassified to the farmland/settlements class. This happens due to the reason that some barren land's spectral properties or pixel color were almost similar to the harvested crop lands which creates the difficulties in separating them during image classification operation. To further develop arrangement exactness and lessen misclassifications, incline toward Google Earth. The last step on this classification was the maximum likelihood operation to be performed in the ArcGIS 10.1 software.

3.6 Accuracy Assessment Test

The accuracy assessment or validation of the LULC data is a key step in the processing. It determines the user's information value of the resultant data. All the same color pixels were organized into a particular class by supervised classification. To verify the accuracy of the classification by the software, the accuracy assessment is a key step. All the Landsat image classification accuracy were checked using error matrix rule. In this rule the kappa coefficient, overall accuracy, the producer's and user's accuracy were evaluated. The overall accuracy of the categorized image refers to how each pixel compares to the exact land cover conditions acquired from the ground truth point. The errors of omission, which are a measure of how accurately real-world land cover types are classified, are defined by the accuracy of the producers. The errors of commission are defined by the user's accuracy, which is the likelihood that a classified pixel would match the land cover type of its corresponding location. The kappa coefficient and error matrix have become common methods for evaluating image classification accuracy. Furthermore, error matrices have been employed in a variety of land categorization studies and were an important part of this study (Rwanga, *et al.,* 2017). This analysis was done with 67 verifying points which was also the Total Sample (TS) in the study area. These points were created as a shape file in study area. Google Earth was used as a reference source to verify the points. For this step the point shape file was converted in KML file.

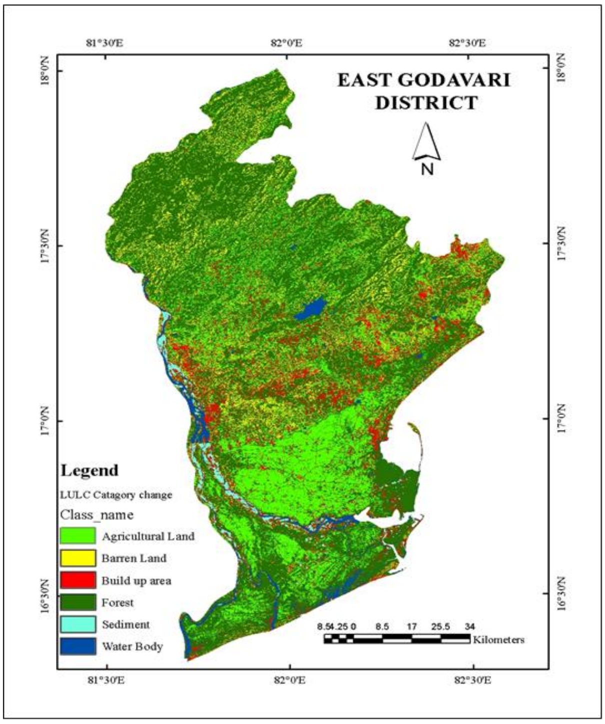
4. RESULTS AND DISCUSSION

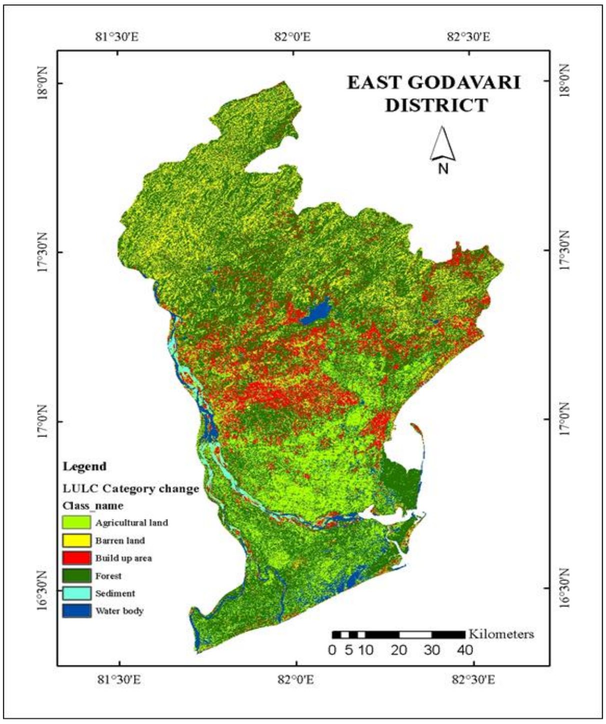
Supervised classification was carried out using ArcGIS 10.1 in the study area. The land use land cover categories were defined and the area under each class was calculated by adding area field. Later accuracy assessment process was done with already defined class values that are replaced by the given reference values and then generates the reports. The magnitude change for each class was calculated by subtracting latest year (2020) values from the previous year (2002) values. The percentage change is calculated as the magnitude change is divided by the base year (2002) and this value is multiplied by 100. A total of 6 numbers of classes are commonly defined in the supervised classification of 2002 and 2020 images using ArcGIS 10.1. The area under each LULC classes and its changes from 2002 to 2020 are presented (Table 3). Fig. 2 and Fig. 3 LULC classification of East Godavari District 2002 and 2020 respectively. The results obtained for water bodies, built-up area and barren land increased from 2.49 to 3.81%, 8.15 to 10.8% and 7.58 to 12.96% respectively (Table 3). Conversely, forest, agricultural lands and sediment areas decreases from 58.7 to 52.82%, 21.83% to 18.53% and 1.22 to 1.05% respectively (Table 3).

Table 3 shows that the area under water bodies increased from 268.67 km^2 in 2002 to 409.20 km^2 in 2020, representing a net gain of 140.3 km^2. This rise in area under water bodies was caused by an increase in aquaculture operations in the district's southeast side throughout time (reference). The area under built-up area increased from 876.823 km^2 in 2002 to 1162.921 km^2 in 2020, representing a net increase of 286.093 km^2. This increase due to the rapid increase in population, industries, and construction of buildings, roads etc., Mostly the built-up area increase is seen in central portion of the study area and around areas of Kakinada, Rajahmundry (reference). The area under forest decreased from 6309.459 km^2 in 2002 to 5677.78 km^2 in 2020, which represents a net decrease of 631.67 km^2. The decrease in forest area is attributed to the conversion of forest area into built-up areas, such as buildings, roads, and industrial places (reference). The area under agricultural land decreased from 2347.371 km^2 in

2002 to 1992.61 km^2 in 2020, which represent a net decrease of 354.76 km^2. During the study period, the amount of available agricultural land in the study area quickly reduced (2002-2020).

Table 3 shows that the area covered by barren land/other land increased from 815.224 km^2 in 2002 to 41.55 km^2 in 2020, representing a net gain of 578.04 km^2. Farmers have been abandoning farming and demonstrating interest in other industries or industrial labour, which has resulted in the growth of barren land/other land even though some barren land was converted into habitation and farmland. Also, the northern part of the district, which was majorly occupied by mountains, was identified as barren land in the absence of forest. In some portions of the district, the quarrying operations were also performed frequently, which is another reason for increasing barren land. The area under sediment slightly decreased from 131.39 km^2 in 2002 to 113.18 km^2 in 2020, which represent a net decrease of 18.219 km^2. With the observation of the classified data, some portion of the sediment area covered with vegetation in this study period [18].





Figs. 2 and 3. LULC classification of East Godavari District 2002 (Left) and 2020 (Right)

Table 3. Area statistics of LULC in 2002 and 2020

S. no.	Class Name	LULC, Area (km^2)				Area changed (km^2) (2002-2020)	% Change in LULC
		2002		2020			
		Area (km^2)	Area (%)	Area (km^2)	Area (%)		
1.	Water bodies	268.67	2.49%	409.20	3.81%	140.3	(+) 1.316%
2.	Built up area	876.823	8.15%	1162.92	10.8%	286.1	(+) 2.65%
3.	Forest	6309.459	58.67%	5677.78	52.82%	-631.68	(-) 5.85%
4.	Agricultural Land	2347.371	21.83%	1992.61	18.53%	-354.76	(-) 3.3%
5.	Barren Land	815.224	7.54%	1393.27	12.96%	578.04	(+) 5.42%
6.	Sediment	131.399	1.22%	113.18	1.05%	-18.22	(-) 0.17%

Table 4. Accuracy assessment test results of the year 2002

	Agricultural land	**Barren Land**	**Built up Area**	**Forest**	**Sediment**	**Water Body**	**Total User**
Agricultural Land	10	0	0	0	0	0	10
Barren Land	3	0	0	2	0	0	5
Built up Area	1	2	10	1	0	0	14
Forest	2	1	0	26	0	0	29
Sediment	0	1	0	0	2	0	3
Water Body	0	0	0	0	0	6	6
Total Producer	19	3	10	27	2	6	67

Table 5. Accuracy assessment test results of the year 2020

	Agricultural Land	**Barren Land**	**Built up Area**	**Forest**	**Sediment**	**Water Body**	**Total user**
Agricultural Land	15	0	0	1	0	0	16
Barren Land	0	1	0	4	0	0	5
Built up Area	6	2	11	0	1	0	20
Forest	0	1	2	7	0	0	10
Sediment	0	0	0	0	2	0	2
Water Body	0	0	0	0	0	11	11
Total Producer	23	4	11	12	3	11	64

Table 6. Overall efficiency and kappa coefficient of the years 2002 and 2020

LULC Classes	**2002**		**2020**	
	User's	**Producer's**	**User's**	**Producer's**
Agricultural Land	100	52.63	93.75	65
Barren Land	0	0	20	25
Built up area	71.48	100	55	100
Forest	82.75	88.89	70	58.33
Sediment	66.67	100	100	66.67
Water Body	100	100	100	100
Overall efficiency	**77.61**		**73**	
Kappa coefficient	**0.67**		**0.66**	

4.1 Accuracy Assessment test

Kappa statistics is a measurement between user's identified class data and Producer's identified data after the classification process is done. Kappa value is useful for accuracy check-in for each defined class. As per Cohen if this value between 0.20 to 1.00, he classified as 0.21-0.40 as fair, 0.41-0.60 as moderate, 0.61-0.80 as substantial, and 0.81-1.00 as almost perfect agreement [14]. A Kappa coefficient of 1 indicates complete agreement, whereas a value near zero indicates agreement that is no better than would be predicted by chance [7]. One of the most important final steps is accuracy assessment. The accuracy assessment result of LULC shows that for year 2002, overall accuracy was 77.81% with a kappa coefficient of 0.6. On the other hand, for the year 2020, overall accuracy was 73% with a kappa coefficient of 0.6. The accuracy assessment test results for the years 2002 and 2020 are shown in the Tables 4 and 5 respectively. The overall efficiency and Kappa Coefficient results are presented in the Table 6.

5. CONCLUSION

The image classification method had made a huge impact over the past years in classifying LULC. Therefore, based on the results of this study, it can be concluded as follows:

Most significant changes are observed in the barren land and built-up area category. Mostly built-up area is increased around the portions of Kakinada and Rajahmundry over the two decades due to increase in population. In view of LULC analysis of Landsat data for the year 2002 and 2020, it was observed that the LULC change patterns shifted fundamentally during the periods referenced above. The results showed that most of the forest and agricultural land converted into built-up area. The forest land was decreased from 58.67% in 2002 to 52.82% in 2020 because of increase in population to meet their demand for agricultural land was also decreased from 21.83% in 2002 to 18.53% in 2020 because of conversion of agricultural land to aqua culture land by farmers to increase their income. On the other hand, the built-up area was increased from 8.15% to 10.8%. The study had an overall classified accuracy of 77.61% for 2002 and 73% for 2020. The kappa coefficient is 0.67 for 2002 and 0.66 for 2020. The kappa coefficient is evaluated as generous and thus the classified image viewed as firm for additional research.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is no conflict of interest between the authors and producers of the products. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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