Creation of Land Resources Information System using Geoinformatics: a Case Study

R. Gayathri Devi, P.J. Chandrasekhara Rao, S.S. Asadi

Abstract:--- Development is a testimony for the growth of human species, which could only be attained by pioneering the ability for the effective usage of natural resources, of once country. Among the natural resources the land, whose use changes with time and space, stakes a major share. But unfortunately, in the prodigious constraint of agriculture need for humans only a less land is available for the urbanization. For nadir usage of land, a better understanding is necessary which could only attain through scientific approach, which would be provided by the Remote sensing and Geographic Information system(GIS). The present study confines to the change detection and Land resources available at Amaravati the capital city of an Indian state i.e., Andhra Pradesh from 2014 – 2018, which is been planned to build on the southern banks of the Krishna river in Guntur district, by using of Remote Sensing and GIS mapping. To eliminate or promote a process of land management, a postulated urbanization happened in the area within the specific time is known by performing change detection analysis. The LU/LC is done by using Combined classification technique and the Change detection Analysis, is done by using "Landsat 8 Images of 20 May 2014 and 31 May 2018". And this helped to study the growth of urbanization and for preparing various thematic maps i.e., Transportation Map, Slope Map, Soil Map etc., and data from various organizations and the Survey of India(SOI) toposheets were also used. Which obliging to get a brief on Land Resources and would help the government organizations in making proper land management policies for the environmentally friendly urbanization.

Index Terms: Remote Sensing& GIS, Change Detection Analysis, Land Resources, Thematic Maps

I. INTRODUCTION

The limitation of land available for urbanization in a highly populated country like India is a challenge, and when the conversion of agriculturally affirmed land to urbanization needs proper planning and data on land use/cover patterns and spatial distributions which can fit in the convergence of as minimal effect as possible on environmental and biodiversity aspect. To confront this issue a proper analysis and land management need to do by a scientific approach i.e., Land Use/ Land cover[2]. These are two different terminologies which could be interchangeably used[4], were the land cover constitutes about the physical characteristics of land i.e. vegetation, water, soil properties etc., on the other hand land use dealt with socio-economical aspects of land i.e. human habitation and usage of land existing in that region[5]. In a country like India were the urbanization is rapid due to the urban sprawl the accurate, reliable and comprehensive data is required for proper land management[1] and that to when the problem that is to confront of conversion of a huge base of rural and agricultural land for urbanization[8], then a proper planning which prioritize the minimal disturbance of bio-diversity and ecological balance is required, for that creation of a land resource data base is necessary. When it comes to the research on land use/cover in India has been done by many researches using the RS& GIS data gathering and are successful in creating the data base for proper land management.

To understand the dynamic change happening in the wide-spread area over a time period and the accelerating process behind it the approach of observing the earth from space i.e. Remote Sensing(RS) and Geographic Information System(GIS) which are providing effective tools in understanding the ecosystem and estimating socio-economic patterns of land[3], and the usage of change detection technique by LULC will accommodate in data gathering i.e. land resource information[7] Here, the land resource data is being created for a newly being urbanized city i.e., Amaravati as to aid the region to tackle issues of urbanization for ecofriendly environment by creating thematic maps of soil, transportation and slope, and also by identifying the rate of urbanization happening in the region in the time period of 2014-2018 by change detection method.

II. STUDY AREA

Amaravati which is situated in southern part of India, in between the 16.541˚ North latitude and 80.515˚ East longitude is a newly being developed to serve as a state capital of Andhra Pradesh. The city is been planned to be developed on the southren banks of the Krishna river with an area rounding to 233 Square Kilometers river front which includes all the geographical features and land cover in the district of Guntur by including 26 villages, and having borders with two major cities Guntur and Vijayawada. The city is being planned to have a landscaping of 51% for greenery and 10% for water bodies with the city coming under the Andhra Pradesh Capital Region and is safe from the natural hazard like cyclone as the nearest sea coast is

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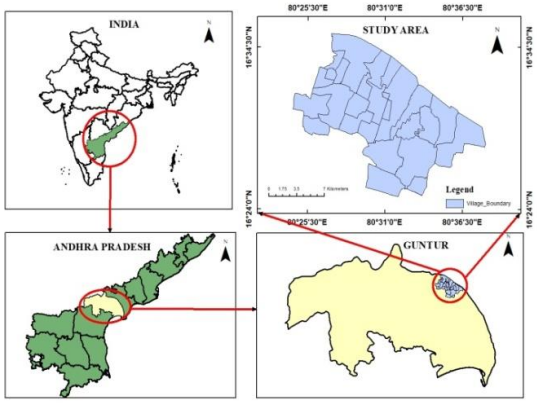


Figure 1: Study Area

III. OBJECTIVES

The main aim of this study is to scrutinize the condition of the land resources and to detect the changes or developments that had been taken place in the mentioned study area.

The objectives that are drawn from study to accomplish the aim are:

1. To prepare the digital thematic maps i.e., Base map, slope map, drainage map, Transportation map, Hydrogeomorphology map etc.., using the satellite data, collateral data and the field data available on GIS platform, so that the situation of the land resources can be easily recognized.
2. To create a land use land cover classification scheme for the satellite images of 2014 and 2018
3. To determine the rate of land use land cover change that had been occurred in the capital city.

IV. Methodology

A. Data collection:

The Landsat 8 TM+ satellite images (30m) of the years 2014 and 2018 and the ASTER GLOBAL DEM image which covers the study area are downloaded from USGS(United states geological survey) website. The sensors used in Landsat 8 are Operational Land Imager (Multispectral=30m, PAN =15m), and Thermal Infrared Sensor(100m). The Survey of India (SOI) toposheets (E44U6, E44U7, E44U10, E44U11) at 1:50,000 scale, collateral data and field data are provided by APCRDA (Andhra Pradesh Capital Region Development Authority)

B. Database preparation and analysis:

The extraction of the study area from the satellite images is done by sub-setting those images by considering the boundary of study area i.e., area of interest (AOI) to do that the images are been processed by using ERDAS IMAGINE 2014 and followed on to create false color composite (FCC) by using a tool called layer stack, and the images are enhanced by the convolution tool, as well as the image registration is also done for the 2014 and 2018 satellite images. There after the thematic maps i.e., the base map and transportation map are been developed by digitalizing the SOI toposheet using ARCMAP 10.2, by visual interpretation technique. The other thematic maps like slope map, streams map and drainage density map are been developed by downloading the DEM image from the USGS and versification by ARCMAP 10.2 using hydrology tool. From the field report and different organizations data Soil map, Geology map, Hydrogeomorphology map, Erosion map are been prepared in ARCMAP 10.2 and QGIS 3.2, this constitutes the spatial database. All these maps are prepared at a certain scale with colors and symbols to attribute entities so that they are simply identified.

C. Image classification:

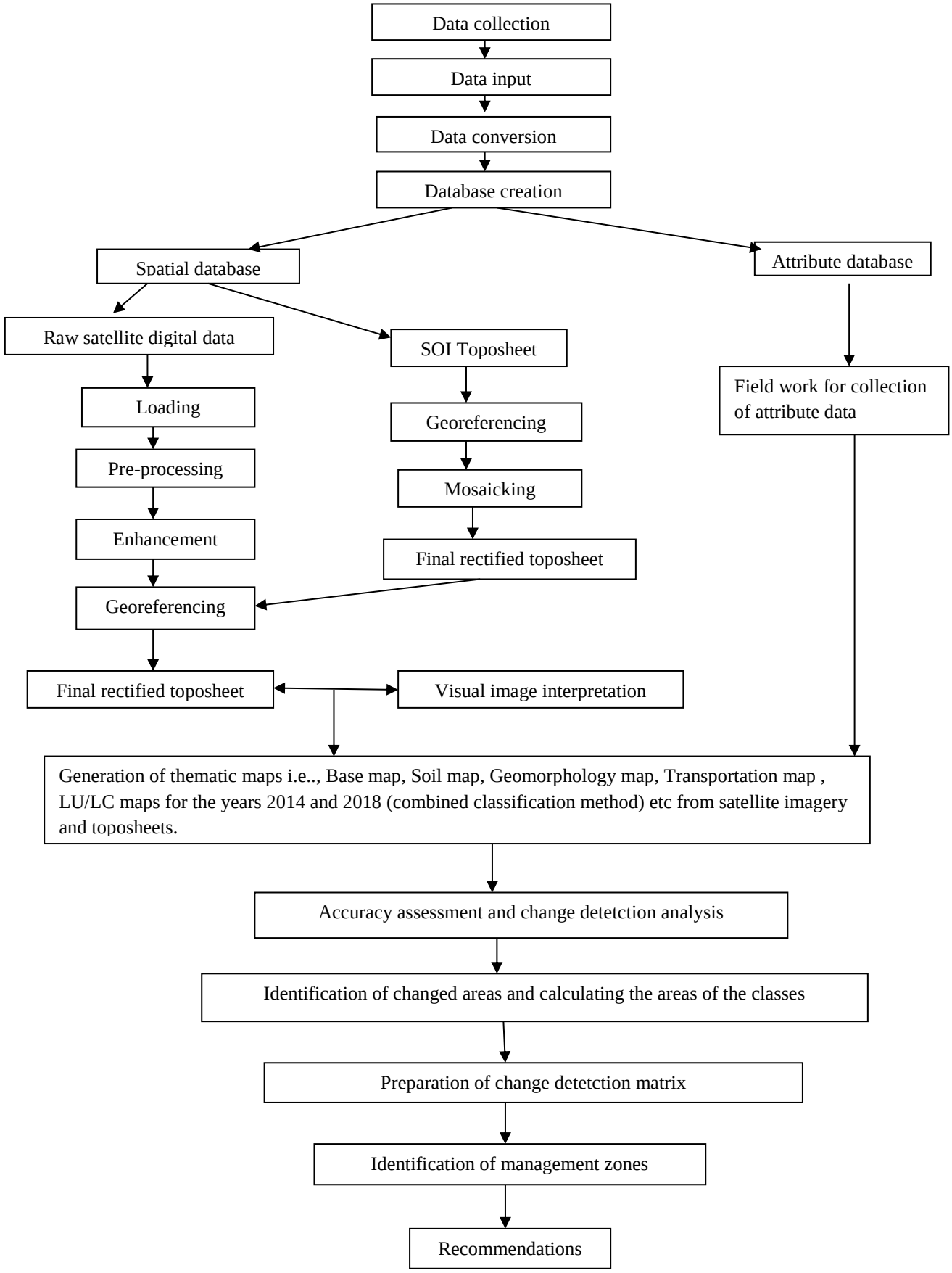
The classification method used for image classification in this study is combined classification method i.e.., it uses both unsupervised and supervised methods for Land use/Land cover classification[6]. In classification process the pixels are sorted into number of individual classes of data based on their data file values. Unsupervised classification is based on the software analysis of an image without user providing sample classes, it uses an ISODATA(Iteration Self-Organizing Data Analysis technique) algorithm for natural grouping of the spectral properties of pixels. In supervised classification the training sites should be specified by the user, in this method there are variety of algorithms like minimum distance, nearest neighbor, neutral likelihood, maximum likelihood etc. In this study we use Maximum likelihood decision rule because it calculates the probability of each pixel of each class and assigns to the class to which it is having higher probability.

D. Land use/Land cover:

Combined classification method is used for this study because some of the feature classes were confused during the classification as of their similar spectral signatures. So firstly, pixel break out (classifying image with many number of classes) using unsupervised classification method is done with 150 classes at gray scale. Then class identification in gray scale scale image is done and identified classes information is collected and saved to a word document so that they are used while recoding the image. Recode tool is used to change selected class numbers to other class numbers in ERDAS IMAGINE 2014 for pixel corrections of land use/Land cover classes. Then Maximum likelihood technique is used to reclassify the recoded image for accurate classification of the image.

E. Change detection analysis:

Change detetection analysis identifies, describes and quantifies variation between images of same place at different times[9]. Change detection encompasses a wide range of methods, in this study Matrix union tool in ERDAS IMAGINE 2014 is used to detect the changes between the two images i.e.., 2014 and 2018. The output image from matrix union is further analyzed in ARCMAP 10.2 for better understanding. The Matrix union tool enables to create an output image file that contains the class values of the input file overlap. In this context the census of natural resources – land, water, forest and other elements – conducted in a systematic manner to depict changes that had occurred over the period of 4 years.



Flowchart: Methodology

V. RESULTS

A. Village Map:

In the present study the 26 villages that are been confined to the Amaravati city area are been digitized with revenue boundaries entitled by using ARCMAP 10.2, and with the providing their representation in the village map with there geographical locations, which helps in easily traceable and identifiable land resources and features of those villages.

B. Base Map:

As known basically a base map depicts essential outline i.e. basic information, which could be used for plotting purposes or for presenting a specialized data of various kind. In as said the base map that is been conceived for this study render basic information like the water bodies, canals, railway tracks, settlements, roads etc., which are delineated from the toposheet.

C. Transport Network Map:

A transport network map which is used to employ the user with the knowledge of all the means of transport network available in that region, in a way sated so the transport network map of the study area evidently provides with the information that most of the study area is extensively connected by Metal, Un-Metal roads and Cart-tracks, and it happens to be a that there is a railway track which passes through the some of the villages in the study area.

D. Slope Map:

For preparing the Slope Map the DEM image is acquired from USGS website and analyzed in ARCGIS 10.2 using surface tool and finally slope classification map is prepared. Most of the area in the study area is moderately sloping and very less area is under very steep sloping**.**

E. Drainage Density Map:

The drainage density is the ratio of total length of all streams in drainage basin and total area of drainage basin. To develop the drainage map for the study area a slope map had been prepared first and then by using hydrology tool in ARC MAP 10.2 the drainage density and all the streams existing in the study area are mapped, also based on the stream ordering streams are further classified, and conclusive result is that the drainage pattern existing is dendritic.

F. Soil Map:

The soil map gives a clear picture and better understanding about the morphology of the soil strata available in the study area, to prepare the soil map the data that is collected from the filed is used and its observed that most of the soil is Moderately deep black clayey soils, clayey to gravelly, clayey moderately deep dark brown soil and loamy to clayey skeletal deep reddish brown soil.

G. Geology Map:

The dominant rock observed in the study area are Charnockite, khondalite and at the northern part of the study area were the water bodies are present are enclosed with alluvial soil. The geomorphic lineaments are observed in villages like Navvuluru, Penumaka, Undavalli, Tadepalli, Nekkallu, Ananthavaram, Borupalem.

H. Hydrogeomorphology Map:

The different geomorphological origins perceived in the study area are fluvial origin, structural origin, denudational origin. Almost 60% of the area is under fluvial origin and on the northern part of the capital city the land is associated with alluvial soil because of presence of water bodies in that area.

I. Erosion Map:

The sheet erosion is observed near the hill areas in the study area. The sheet erosion is formed due to the removal of soil uniformly in a thin layers by the forces of raindrops and overland flow. The other area is camouflaged with stabilized dunes.

J. Land use/Land cover(lu/lc) Map:

The Land use/Land cover classification maps are prepared for both the years 2014 and 2018 in order to know the status of land resources in both the years. The spatial distributional pattern of land use/land cover for the years 2014 and 2018 of study area are shown in Figure 2 and Figure 3. The different land use/land cover categories identified and mapped from the study area are Built up-Rural, Built up-Urban, Barren rocky, Agriculture-Crop land, Agriculture-Fallow, Agriculture-Plantation, Scrub forest, Scrub land, Water body-Pond, Water body-River. The level-2 classification is adopted for Land use/land cover classification of this study area. The classification is done from a satellite image so that every feature can be delineated evidently.

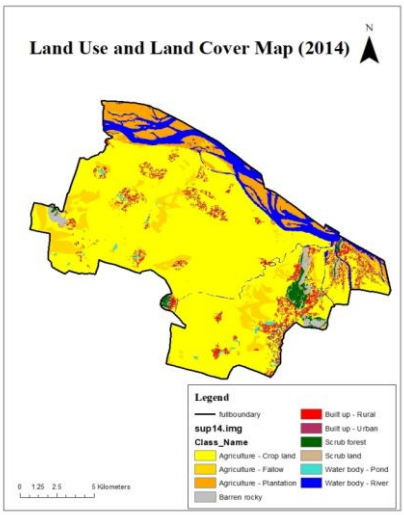


Figure 2: Land use/Land cover 2014

K. Land use/Land cover status:

The areas of each class for two years are clearly and diagrammatically illustrated in Figures 4 , 5 and Table I.

Table I: Area in Square Kilometers

Class Numbers	Classes	2014(SqKm)	2018(SqKm)
1	Water body – River	16.32	16.88
2	Water body – Pond	1.19	0.9
3	Built up – Urban	1.14	1.6
4	Built up – Rural	10.54	14.58
5	Scrub forest	3.33	2.55
6	Barren rocky	2.88	3.22
7	Scrub land	1.24	2.41
8	Agriculture – Fallow	17.47	22.43
9	Agriculture - Crop land	162.89	152.77
10	Agriculture – Plantation	16.87	16.57

Table II: change detection matrix

Class :No	classes	Water body - River	Water body - Pond	Built up - Rural	Built up Urban	Scrub forest	Barren rocky	Scrub land	Agriculture – Fallow	Agriculture - Crop land	Agriculture -Plantation	Total (2018)
1	Water body - River	14.44	0.04	0.00	0.04	0.01	0.00	0.00	0.05	0.27	2.03	16.88
2	Water body - Pond	0.03	0.58	0.00	0.05	0.00	0.00	0.00	0.01	0.22	0.00	0.90
3	Built up - Rural	0.00	0.02	0.51	0.07	0.00	0.00	0.00	0.01	0.98	0.00	1.60
4	Built up - Urban	0.12	0.11	0.12	3.20	0.11	0.05	0.02	0.57	10.17	0.07	14.55
5	Scrub forest	0.00	0.01	0.00	0.08	1.35	0.50	0.37	0.01	0.24	0.00	2.55
6	Barren rocky	0.00	0.01	0.00	0.08	1.15	1.23	0.47	0.01	0.27	0.00	3.22
7	Scrub land	0.00	0.01	0.00	0.19	0.50	0.90	0.36	0.11	0.33	0.00	2.41
8	Agriculture - Fallow	0.07	0.01	0.00	0.15	0.00	0.00	0.00	3.17	17.75	1.28	22.43
9	Agriculture - Crop land	0.35	0.36	0.50	6.38	0.19	0.19	0.02	12.67	131.26	0.83	152.77
10	Agriculture - Plantation	1.29	0.03	0.01	0.29	0.01	0.02	0.01	0.85	1.40	12.66	16.57
	Total(2014)	16.32	1.19	1.14	10.54	3.33	2.88	1.24	17.47	162.89	16.87	233.87

These data reveals that in 2014, about 70% (162.89 SqKm) of land was under Agriculture -Crop land, 7% (16.87 SqKm) under Agriculture – Plantation, 7% (17.47 SqKm) under Agriculture – Fallow, 1% (1.24 SqKm) under Scrub land, 1% (2.88 SqKm) under Barren rocky, 1% (3.33 SqKm) under Scrub forest, 5%(10.54 SqKm) under Built up – Rural, 0%(1.14 SqKm) under Built up – Urban, 1%(1.19 SqKm) under Water body – Pond and 7%(16.32 SqKm) under Water body – River. During 2018 the area under these land categories was found about 65% (152.77 SqKm) of land was under Agriculture -Crop land, 7% (16.57 SqKm) under Agriculture – Plantation, 10% (22.43 SqKm) under Agriculture – Fallow, 1% (2.41 SqKm) under Scrub land, 1% (3.22 SqKm) under Barren rocky, 1% (2.55 SqKm) under Scrub forest, 6%(14.58 SqKm) under Built up – Rural, 1%(1.6 SqKm) under Built up – Urban, 1%(0.9 SqKm) under Water body – Pond and 7%(16.88 SqKm) under Water body – River.

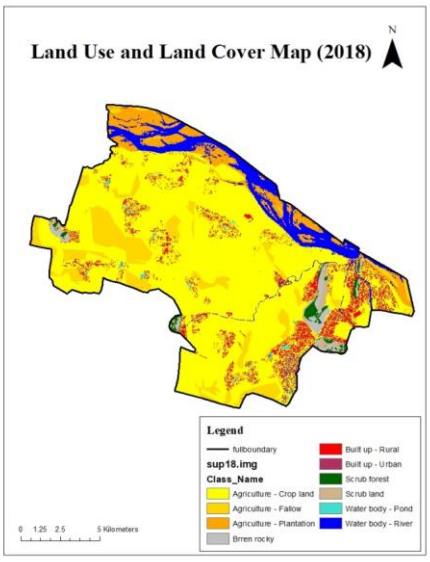


Figure 3: Land use/Land cover 2018

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L. Accuracy Assessment:

The land use/land cover map developed for the study are from the years 2014-2018is compared to the reference data to evaluate the accuracy of the LU/LC classification, and theaccuracy assessment of the land use/land cover classification results turns out to be 89.08% and 93.28% for the respective years of 2014 and 2018 with an overall kappa coefficients as 0.8762 and 0.9243 in the same order i.e. 2014 and 2018 respectiely.

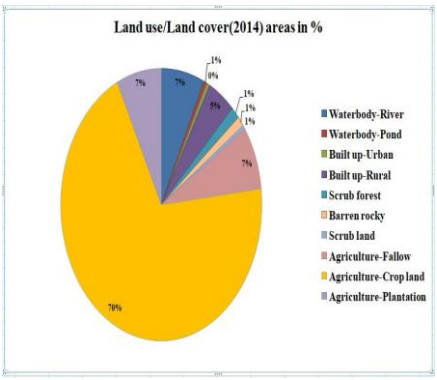

Figure 4: Pie graph representation of spatial distribution in 2014

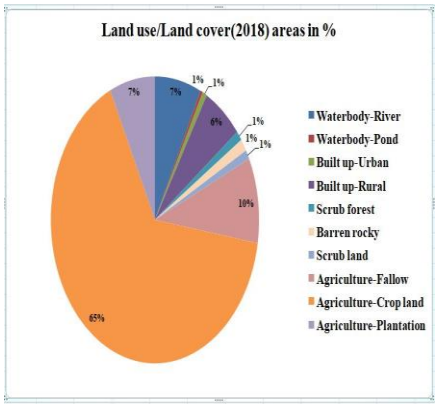

Figure 5: Pie graph representation of spatial distribution in 2018

M. Land use/Land cover change:

Data registered in Table II and Figure 6 portrays the changes that had occurred from the years 2014 to 2018 in land use/land cover pattern of Study Area. The changes show, the development taken place from the last four years in the area. From the last four years the water bodies i.e., River had decreased in area of 0.56 Square kilometers, and the Ponds had decreased in area of 0.29 Square Kilometers. When it comes to the built-up area the urban had increased to 0.46 Square Kilometers, were as the rural had confined to 4.04 Square Kilometers. In the same way the Scrub forest had decreased in area of 0.78 Square Kilometers and the Barren rocky had increased in area of 0.34 Square Kilometers. As the part of Scrub land comes into the picture that it had increased in area of 1.17 Square Kilometers. And in the case of agriculture the fallow had increased in area of 4.96 Square Kilometers, when the crop land had decreased in area of 10.12 Square kilometersand also the plantation had decreased in area of 0.3 Square Kilometers.

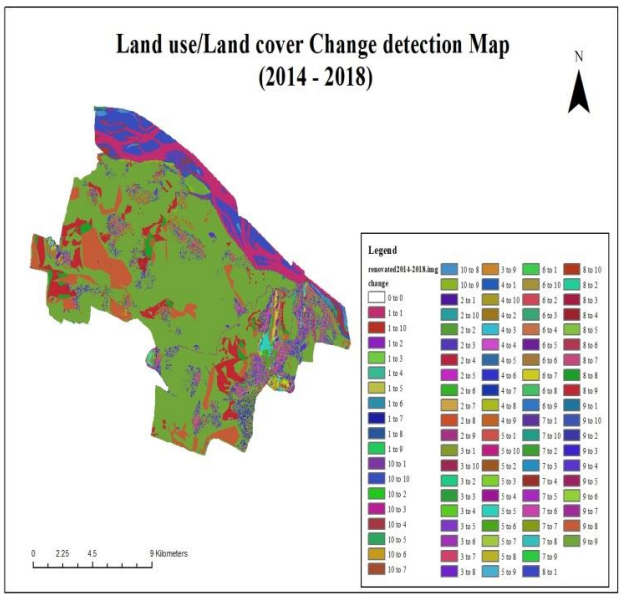

Figure 6: Lu/Lc Change detection Map (2014-2018)

VI.CONCLUSION AND RECOMMENDATIONS

The study conducted is one of the development blocks of Guntur district in Andhra Pradesh state (India) advocates that the remote sensing and GIS are very crucial technologies for temporal and quantification of spatial phenomena which is otherwise impossible through conventional mapping methods. With help of these technologies only the change detection analysis had been done in less time and at low cost. Sustainable land management technologies entail reliable and repetitive information on the existing status and utilization potential of natural resources. Satellite remote sensing data in conjunction with collateral data had proved that they are very effectual in meeting these requirements. In the present study it is clear that more than 20% of the area is effected by erosion. In future in the study area this may lead to sedimentation and other consequential problems to the near by water bodies. This can be controlled by construction of gully control bunds and extensive reforestation or by any management practices. The irrigation management, Catchment management, Drainage basin monitoring and management are the three vital activities for the development of a watershed area. To perform these three activities a planner or a developer need physical characteristic information of that particular area. So the present work, focused on the development of physical characteristic information for the study area.

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VII. AUTHORS PROFILE

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