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SPATIO-TEMPORAL DYNAMICS OF LAND COVER IN THE NEW CAPITAL REGION OF ANDHRA PRADESH, INDIA

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Abstract:The accurate and timely information on land use/land cover (LULC) and changes over time in the form of maps and statistical data is very vital for understanding, planning and management of sustainable urban development processes. With the advent of new capital development project taken up by the Government it has acquired tremendous potential for development in the industrial and infrastructural sectors. To mitigate and manage adverse environmental impacts of this future development, study of LULC dynamics will be immensely useful. In this paper the spatio-temporal changes in LULC of the capital region of newly formed Andhra Pradesh state, India have been estimated and presented for a period of 38years from 1977 to 2015. For this study Landsat satellite images of 1977and 2015 were procured and processed for development of LULC images. Supervised classification was performed using ERDAS imagine, an image processing software supplemented by ground truth data collected in the field using hand held Global Positioning System. The Land cover is classified in to seven classes: built-up, forest, agriculture, open area, barren land, water bodies and sand. The classification accuracy of the LULC image was found to be 93%. Finally LULC change analysis between1977-2015 has been conducted and presented in the form of tables, graphs and pie charts. The analysis reveals built-up area and open area has been increased by 3.99%and 22.06% respectively. Though there is an increase in forest area by 4.88%, agriculture area has been decreased by 15.37%. The overall reduction in greenery is at an alarming rate. This will have some serious impact on the ecology of this region. Hence proper environmental management practices must be adopted in the urban planning and development process for sustainable future.

Key words: Land use, Land cover, CRDA, Landsat images, Supervised classification, Change detection

1. Introduction

Land use land cover (LULC) is a fundamental variable that significantly impacts many parts of the human and physical environments. LULC change is also regarded as the single most important variable of global change affecting ecological systems. The impact of LULC changes on the environment is at least as large as that associated with climate change. It is also well established that LULC change has significant effects on basic processes like biogeochemical cycling and thereby on global warming, the gradual erosion of top soils and accordingly on sustainable land use, habitat fragmentation and destruction, most important variable, which impacts on biodiversity.[1, 2]

The LULC pattern of any region is the outcome of natural and socio-economic factors and their utilization by human being in time and space. [3] Land is now becoming a scarce resource due to immense agriculture and demographic pressure posed by the unprecedented growth in population. [4, 5] Vast surface of land is being converted into human settlements, infrastructure establishments, transportation systems and other anthropogenic constructions. The conversion of forests and other green lands into barren or open lands in the process of urbanization leads to several environmental issues which pose a severe threat to the sustainability of the region. [6, 7]

Hence, information on LULC and various possibilities for their optimal use is essential for the selection, planning and implementation of LULC schemes to meet the increasing demands for basic human needs and welfare. This information also assists in monitoring the dynamics of LULC resulting out of changing demands of increasing population. Modelling and mapping of LULC patterns have been reported since long back and are backbones of the urban planning and development activities. [8, 9]

Remote Sensing (RS) and Geographic information system (GIS) are now providing new tools and new methods for advanced ecosystem management.[10, 11] The collection of remotely sensed satellite data facilitates the synoptic analysis of earth's system function, patterning, and change at local, regional and global scales over time. The acquired satellite images contain spectral reflectance information of the earth's surface in the form of pixels. These satellite images cover the entire earth's surface continuously. Hence through satellite images, it is not only possible to study the LULC, but also we can study the change in LULC over a period of time. [12, 13] These change detection studies are found to be immensely useful in developing the models for future land use land cover studies. [14, 15] One of the greatest application of such studies is estimation of land surface temperature and urban heat island assessment which were widely documented. [16, 17] In this paper, change detection and analysis was carried out for a period of 38 years from 1977 to 2015 in the new capital region of Andhra Pradesh, India. For this purpose multispectral and multi-temporal satellite images from Landsat satellite were used. Supervised classification technique was performed to classify the satellite image. Ground truth data was obtained by visiting the site with hand held Global Positioning System (GPS). The changes in the LULC of the study area are presented and analysed.

The aim of this present study is to produce a LULC map of the study area at different epochs in order to detect the changes that have taken place over a given period. The following are the objectives of the present work.

- To create an LULC classification scheme.
- To determine the nature, magnitude and trend of LULC change during the study period.

2. Study area and Data

2.1 Study area selected:

With the bifurcation of Andhra Pradesh in to two states, Telangana and Andhra Pradesh, the new state of Andhra Pradesh has got tremendous potential for development in infrastructure, industrial and commercial sectors. The Andhra Pradesh Capital Region Development Authority (APCRDA) was notified on December 30th, 2014 by the Government of Andhra Pradesh, which replaced the existing Vijayawada-Guntur-Tenali-Mangalagiri Urban Development Authority (VGTMUDA). The extent of the region is spread across 7,068 km² in 58 mandals, of which 29 are in Krishna district and 29 in Guntur district. The capital region covers 18 mandals fully and 11 mandals partially in Guntur district. In Krishna district, it covers 15 mandals fully and 14 mandals partially under the jurisdiction of APCRDA. Within this new capital region, several infrastructural projects were already proposed. One outer ring road project and one inner ring road project, capital city development project, airport development projects are some examples. All these projects will definitely consume a lot of land and there will be a significant change in the land use and land cover. In order to estimate the future implications of the developmental activities on the LULC, first we need to understand the current trend in the LULC change. Hence in the present work, LULC change in the past 38 years has been estimated from the study area. The location of the study area is shown in the Figure.1.

2.2 Data collected:

To carry out the present work first, CRDA master plan proposed was collected from the authorities. Total 20 topomaps were collected from Survey of India with the following numbers: 65 D/1 to 65 D/16, 65 H/1 to 65 H/4. The mosaic of these topomaps after clipping the study area is shown in the Figure.2. Landsat Satellite images for the two dates viz., 1977 and 2015 were selected and downloaded from the official website of USGS: http://earthexplorer.usgs.gov/. The details of satellite imagery collected were presented in the Table.1. For supplementing the image classification process with ground truth data, field visits were conducted in the entire study area, and about 100 locations were identified, and latitude and longitude were noted using hand held GPS. Some of the field data collected were shown in the Table.2 as a sample.

Table.1 Details of satellite images collected

Date	Time of Pass (GMT)	Satellite	Sensor	Reference System	Path/ Row (Scene centre)	Bands	Resolution Multi-spectral
1977-01-09	4:07:17	Landsat-1	MSS	WRS-I	153/49	4	60
2015-05-23	4:56:46	Landsat-8	OLI/TIRS	WRS-II	142/49	11	30

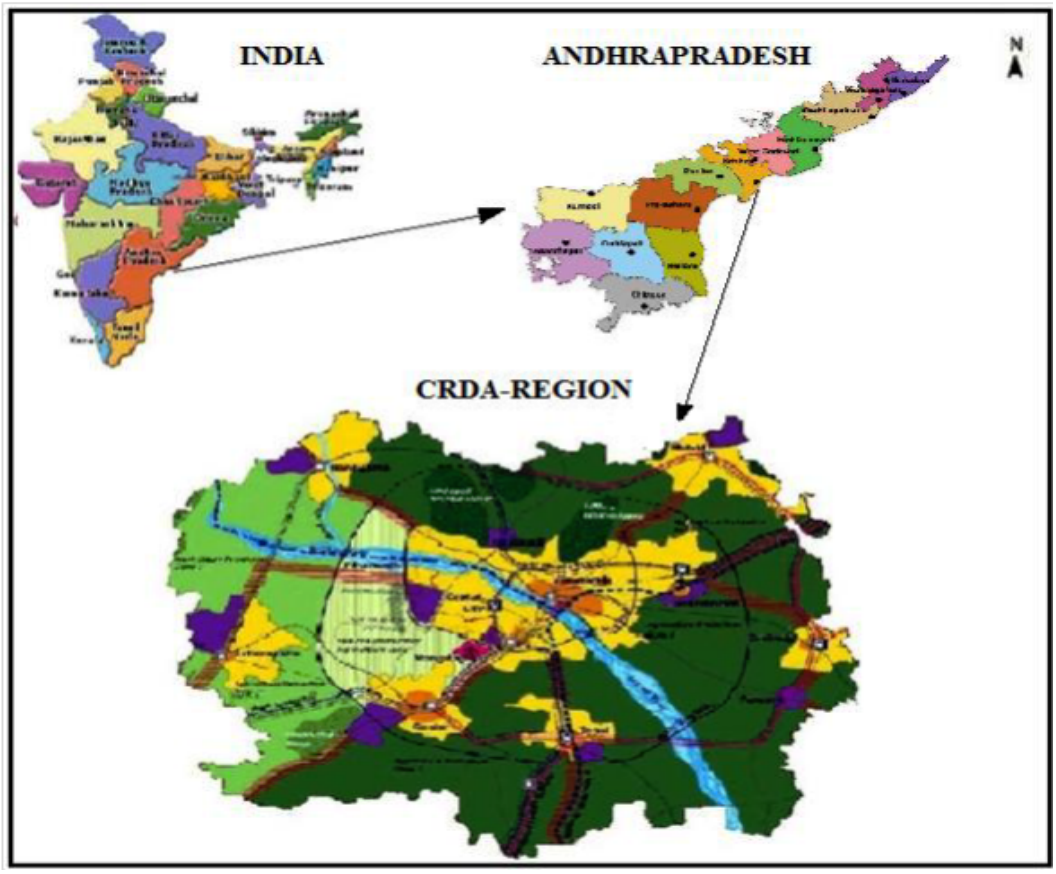


Figure.1 Location of the study area: CRDA

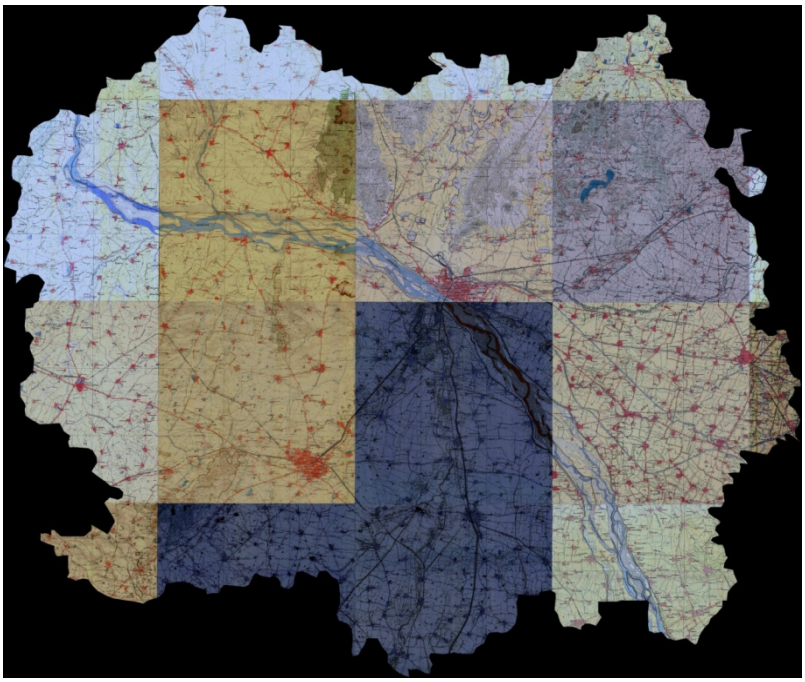
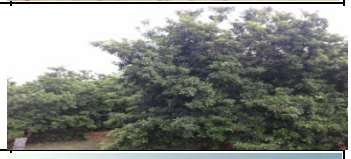


Figure.2 Study area extracted from mosaic topomaps

Table.2 Ground truth data collected by field visit in the study area (12 points were shown here as a sample)

POINT ID	CLASS ID	LATITUDE	LONGITUDE	PLACE	PHOTO
1	AL	16 12 56.21 N	80 46 17.38 E	Vellabadu	
2	AL	16 33 35.77 N	80 41 46.32 E	Nunna	
3	OD	16 37 02.94 N	80 25 14.69E	Kothapeta	
4	BR	16 39 42.42 N	80 45 53.18E	Agiripalli	
5	BR	16 33 36.76 N	80 49 34.91 E	Atkuru	
6	FD	16 13 13.53 N	80 00 56.17 E	Kaza	
7	WB	16 20 56.73 N	80 43 48.74 E	Krishna river	
8	AL	16 03 52.33N	80 32 19.49 E	Kasukarru	
9	BR	16 28 00.58 N	80 35 33.39 E	Yerrabale-m	
10	OD	16 23 52.37 N	80 32 55.99 E	Chinnakka-ni	
11	AL	16 24 43.55 N	80 36 38.55 E	Pedavadla-pudi	
12	AL	16 05 04.37 N	80 46 40.59 E	Vemavaram	

WB- Water Bodies/Wet Lands, AL- Agricultural Land/Light Vegetation, FD- Forests/Dense Tree Clad Area, OD- Open Area/Dry Fields, BR- Barren Land/Rocky Area

3. Methodology

The main objective of the present work is to develop LULC images for the years 1977 and 2015 and to carry out the change detection analysis. For this purpose, the satellite images were down loaded. For the year 1977, three scenes with path and row numbers 152-49,153-48,153-49 were taken where as for the year 2015, four scenes with path and row numbers 143-48,143-49,142-48,142-49 were taken.

The images are processed in ERDAS by Mosaicing, Stacking, and Histogram Equalization. After the processing of imagery, the imagery the required study area is extracted by sub-setting. Now the prepared images were subjected to classification process using supervised classification technique. In this supervised classification process, the computer is assisted by field-based knowledge in identifying the different classes of the land cover. Hence, different training sites will be selected for known classes of land cover and class names will be assigned, so that the computer is trained for classification. For assigning the class names field knowledge is required.

For classifying the image of 2015, direct field data collected was used where as for classifying the image of 1977, topographic-maps and other Government published data was used. The image is classified based on maximum likelihood algorithm, and it is classified into seven classes. The seven classes of land use types identified are water bodies, sand, built-up, forests, agricultural land, open area and barren land. Classification accuracy assessment is also performed. After classification of two images, i.e. 1977 and 2015 the areas of land use of six classes are calculated, and change detection between 1977 and 2015 is performed. Finally with the results are presented in the form of table and pie charts. The detailed description about the methodology adopted is presented below in the Figure 3. The base map of thestudy area developed from topomaps and Google earth images was shown in Figure.4.

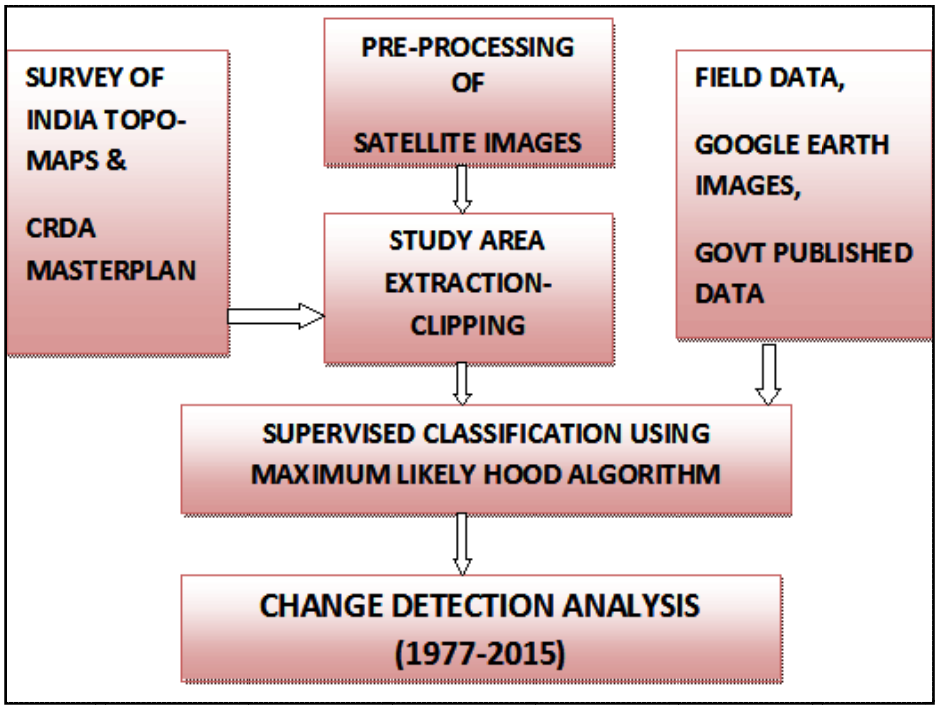


Figure.3 Methodology adopted in the present work

4. Results and Discussion

The LULC images for the years 1977 and 2015 obtained from supervised classification were shown in the Figure.5 and Figure.6 respectively. The areas of LULC classes over the years 1977 and 2015 and the corresponding changes were shown in the Table. 4. The distribution of LULC areas throughout the year 1977 and 2015 was shown in pie charts given in the Figures 7 and 8. From the LULC image of 1977, it was understood that 42% of the area is covered with agricultural and light vegetation land and 25% of the area is observed as open are and dry fields. Another huge share, 22% of the area is covered with barren land and rocky area. Built-up area, including rural and urban accounts for about 1% of the total area and forests occupied 5% of the area and from the LULC image of 2015, it was understood that 26% of the area is covered with agricultural and light vegetation land and 48% of the area is observed as open are and dry fields. Another huge share, 8% of the area is covered with barren land and rocky area. Built-up area, including rural and urban accounts for about 5% of the total area and forests occupied 10% of the area.

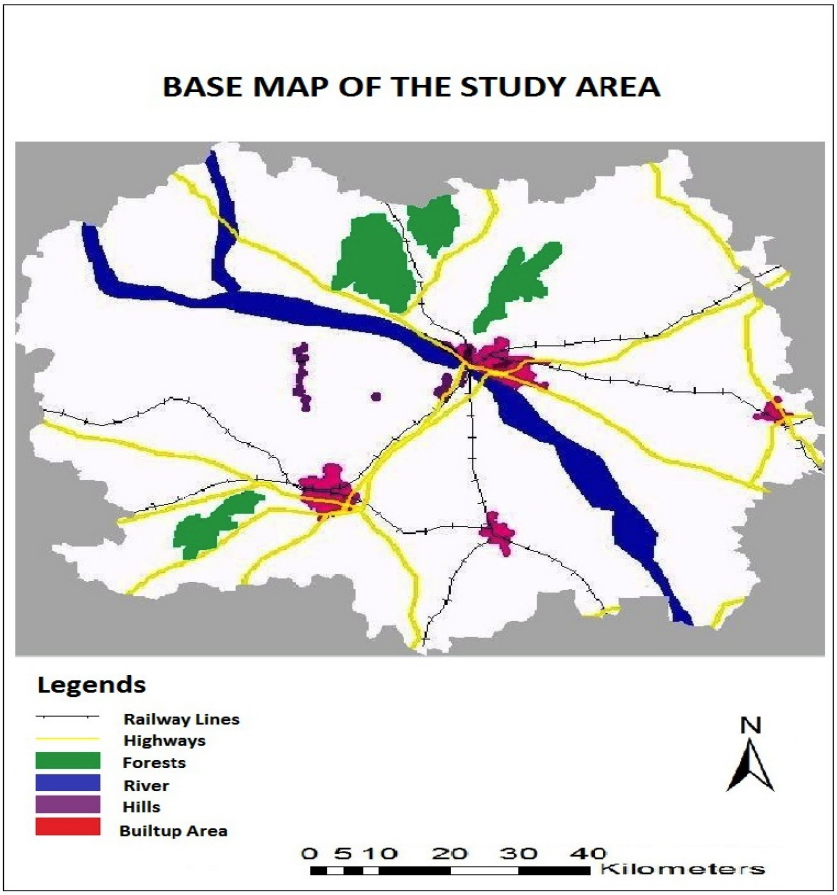


Figure.4 Base map of the study area prepared from topomaps

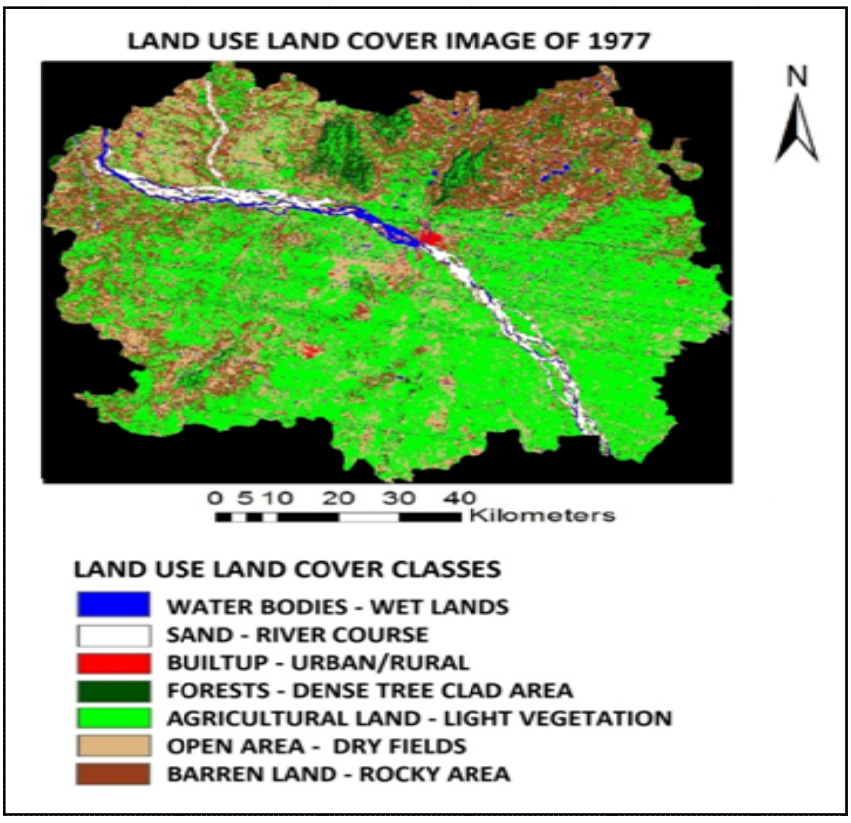


Figure.5 LULC image developed for the year 1977

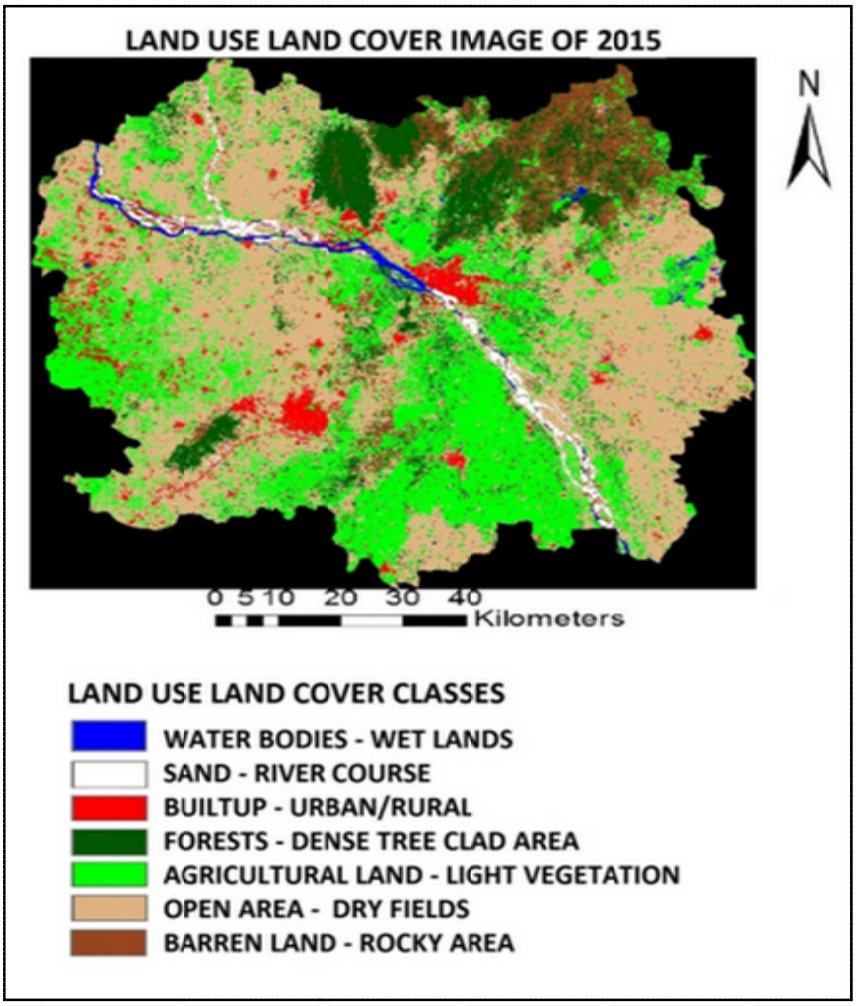


Figure.6 LULC image developed for the year 2015

Classification accuracy assessment report was presented in the Table.3.below. The overall classification accuracy obtained is 93% and the corresponding Kappa statistic is 0.9102.

Table 3. Classification Accuracy assessment Report

LAND COVER CLASS	**Year -2015**	
	PRODUCER'S ACCURACY	**USER'S ACCURACY**
WATER BODIES - WET LANDS	100.00%	100.00%
SAND - RIVER COURSE	53.33%	100.00%
BUILT UP - RURAL & URBAN	100.00%	92.31%
FOREST - DENSE TREE CLAD AREA	100.00%	91.43%
AGRICULTURE LAND - LIGHT VEGETATION	100.00%	89.29%
OPEN AREA - DRY FIELDS	100.00%	100.00%
BARREN LAND - ROCKY AREA	100.00%	100.00%
OVERALL CLASSIFICATION ACCURACY	93.00%	
KAPPA STATISTIC	0.9102	

Table 4. Change detection in areas of different LULC classes

LAND USE TYPE	AREA IN HECTARES		CHANGE IN AREA	% CHANGE
	1977	2015	1977-2015	
WATER BODIES - WET LANDS	13738.8	8281.08	-5457.72	-0.76
SAND - RIVER COURSE	18135.4	14008	-4127.4	-0.58
BUILT UP - RURAL & URBAN	7164.08	35750.3	28586.22	3.99
FOREST - DENSE TREE CLAD AREA	38309.3	73216.9	34907.6	4.88
AGRICULTURE LAND - LIGHT VEGETATION	297152.41	187164	-109988.41	-15.37
OPEN AREA - DRY FIELDS	180861.9	338747	157885.1	22.06
BARREN LAND - ROCKY AREA	160322	58516.61	-101805.39	-14.22
TOTAL	715683.89	715683.89	0	0

Change Detection Analysis

The land use land cover images developed for the years 1977 and 2015 were compared and change detection analysis was carried out. From the land use land cover image of the year 1977, it is understood that out of the total area 42% was occupied with agricultural fields, 22% were covered with barren land, and 25% were left as open land. During the study period, there had been a lot of changes observed in the classes of land use land cover. Water bodies and wetlands have been decreased by 0.76% of the original, sand & river course decreases by 0.58%. Built-up area (rural/urban) has been increased by 3.99%. This corresponds with the expansion within the city. Forest area which includes dense tree clad area found to be increased by 4.88%. However agricultural area and light vegetative area have been drastically decreased by 15.37%, which shall be taken as environmentally damaging factor. Area of open land and dry fields got increased by 22.06%, this is because of conversion of agricultural areas into real estate plots. Existing barren area has been decreased by 14.22%. This analysis shows that there is a decrease in agricultural and light vegetative area and increase in open area and built-up area. The outcome of this research can be used by the city planners for better urban environmental management.

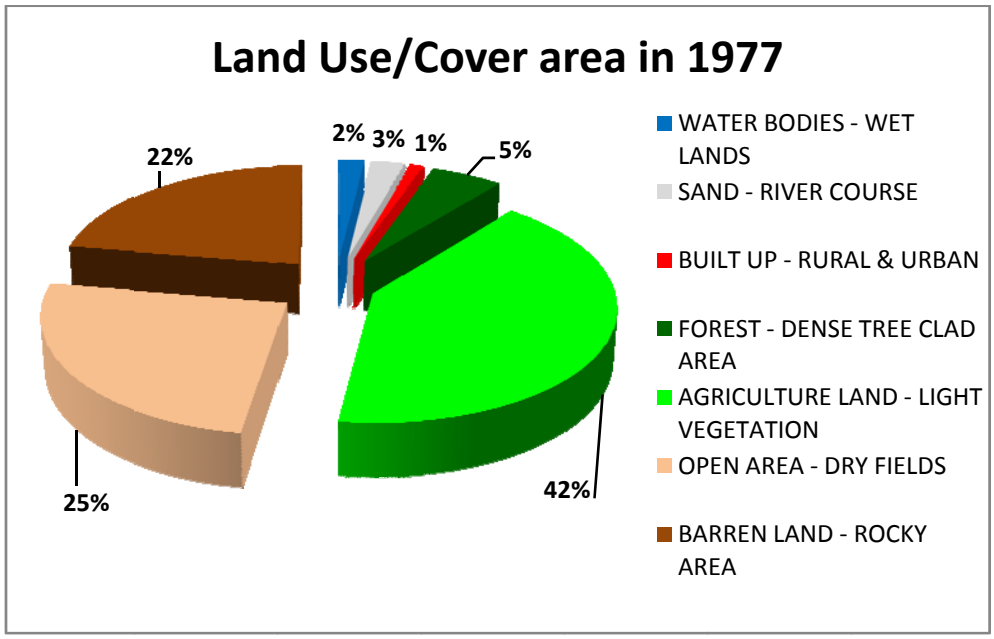


Figure.7 LULC distribution for the year 1977

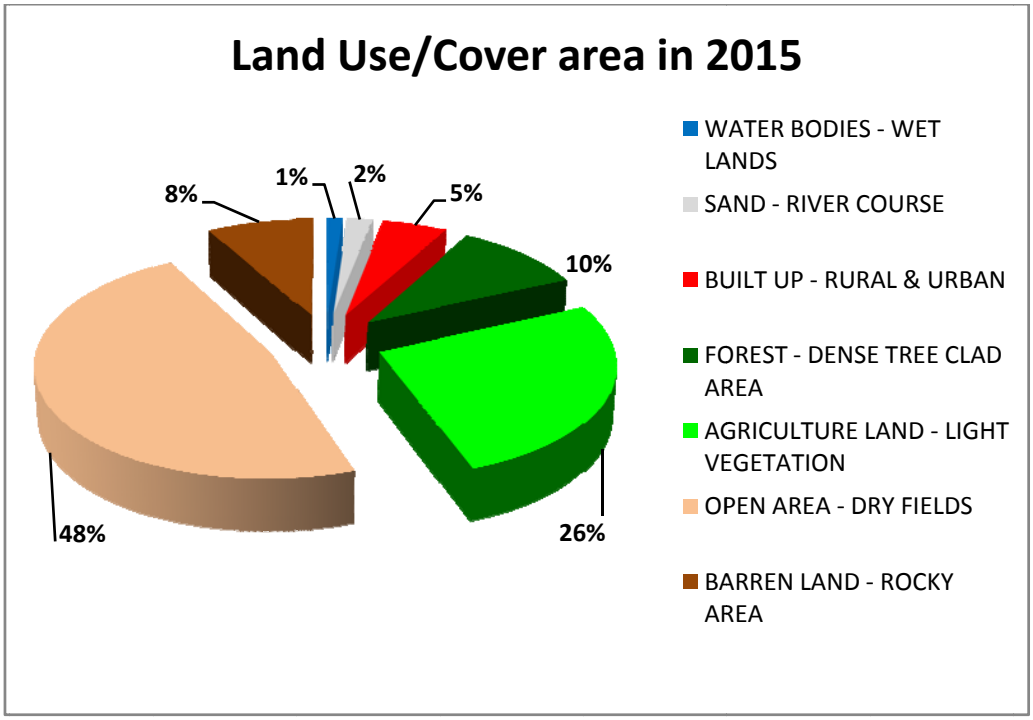


Figure.8 LULC distribution for the year 2015

5. Conclusions

In this paper the spatio-temporal changes in LULC for a period of 38years from 1977 to 2015, of the capital region of newly formed Andhra Pradesh state, India has been evaluated. For this study Landsat satellite images of 1977and 2015 were procured, and LULC images were developed using the supervised classification algorithm in ERDAS imagine. Ground truth data was collected in the field using hand held Global Positioning System. Land cover is classified into seven classes: built-up, forest, agriculture, open area, barren land, water bodies and sand. The classification accuracy of the LULC image was found to be 93% with Kappa statistic as 0.91. The change analysis between1977-2015 reveals the built-up areas, and open area has been increased by 3.99%and 22.06% respectively. The agriculture area has been decreased by 15.37%. The overall reduction in greenery is at an alarming rate. This also shows that large agricultural area has been converted in to open area for further construction. Hence proper environmental impact mitigation practices must be adopted in the urban planning and development process for sustainability of the region.

Acknowledgement

The USGS official web site for distribution of satellite imagery “Earthexplorer” is duly acknowledged for making the requisite remote-sensing satellite data available for the study.

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