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PREDICTION OF FUTURE LAND USE LAND COVER CHANGES OF VIJAYAWADA CITY USING REMOTE SENSING AND GIS

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ABSTRACT-- ***Cities are experiencing rapid urban expansion which deteriorates the quality of life of city dwellers and ecological sustainability of the region. Prediction of future urban expansion is very useful for urban planning and environmental management of rapidly growing cities. Use of Geo-informatics is immensely helpful in accomplishing this task with lot of saving in time and energy. In this work Vijayawada, a rapidly growing city is considered as a case study, and urban expansion has been studied over a period of 26 years to predict future urban expansion in the year 2040. Landsat satellite images of 1988, 2008and 2014 are used for this study. A total area of 85515.75 hectares was taken as study area which is identified as area with potential for expansion. After processing the imagery, land use land cover images are developed in ERDAS Imagine. The output images are used to predict the future land use land cover image using Land Change Modeller of IDRISI Selva. The results shows that built up of Vijayawada city has been increased from 1671.84 hectares in 1988 to 25992.27 hectares in 2014 and finally to 44611.2 hectares in 2040. The percentage increase in built up area from 2008 to 2014 is 28.43% and that from 1988 to 2040 is 50.21%. An accuracy of more than 80% was obtained in all stages. The output images and analysis are also presented for understanding the extent of urban growth.***

KEY WORDS: Urban expansion, Land use land cover, Landsat imagery, Classification, Remote sensing, Land Change Modeler, ERDAS, IDRISI

1. INTRODUCTION

Land use and land cover change is most important anthropogenic driver of environmental change on all spatial and temporal scales. These changes encompass the greatest environmental concerns of human populations today, including climate change, biodiversity loss and the pollution of water, soils and air. Monitoring and mediating the negative consequences of LULC while sustaining the production of essential resources has therefore become a major priority of researchers and policymakers around the world. It has become the central point of research in the field of management of natural resources. The land use land cover pattern of a region is an outcome of natural and socioeconomic factors and their utilization by man in time and space. Land use is the human use of land and land cover refers to physical and biological cover on the surface of land. Knowledge of land cover and land use change is important for many planning and management activities. Satellite remote sensing, in conjunction with geographic information systems (GIS), has been widely applied and been recognized as a powerful and effective tool in detecting land use and land cover change. Satellite remote sensing provides cost-effective multi-spectral and multi-temporal data, and turns them into information valuable for understanding and monitoring land development patterns and processes and for building land use and land cover data sets over a period of time. GIS technology provides a flexible environment for storing, analyzing, and displaying digital data necessary for change detection and database development. 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 land cover change has occurred.[1]

Prediction of future land use land cover image is a latest research which will be very much useful to the urban planning and natural resources management. Land-Use and Cover Change modeling is growing rapidly in scientific field. There are many modeling tools in use but the performance of different modeling tools is difficult to compare because LULC change models can be fundamentally different in a variety of ways. Among many land use land cover modeling tools and techniques, the commonly used models are the Cellular Automata (CA) Markov, Markov chain, GEOMOD, etc.[2]

In this context, it is much needed to estimate the land use changes over the time and predict the future scenario of Vijayawada city of Andhra Pradesh which is rapidly growing. For this study, analysis is performed by a remote sensing based Land Change Modeler (LCM) method.

Based on past trend (from 1988-2014) of land use changes, the future land use prediction map of Vijayawada city and in its surrounding for the year 2040 have been generated. The result shows that some of the land use land cover classes will change significantly which may pose severe environmental threats to the urban environment. This kind of analytical study can be remarkable in sustainable development of cities. [3,4]

2. STUDY AREA AND DATA COLLECTION

2.1 STUDY AREA

Vijayawada is a historical city situated at the geographical centre of Andhra Pradesh state in India on the banks of Krishna River with latitude 160311 N and longitude 800 391 E. The climate is tropical, with hot summers and moderate winters. The peak temperature reaches 47 °C in May-June, while the winter temperature is 20-270 C. The average humidity is 78% and the average annual rainfall is 103 cm. Vijayawada gets its rainfall from both the southwest monsoon and north-east monsoon. The topography of Vijayawada is flat, with a few small to medium sized hills. It is also a major railway junction connecting all states in the country. The Vijayawada now has become the capital of the new state called Andhra Pradesh. The population growth has been rapidly registering almost three fold increase in 3 decades ending 2001 with a population account of 8.45lakhs The overall gross density as of 2001 was 13600 per sq km. Vijayawada has a lot of scope for development and urban growth.[5].

The city's population is expected to increase to 16.5 lakh by 2021.With ever increasing population and Unprecedented growth of urban area the city's landscape is undergoing unwanted changes. For present study a rectangular area which includes surrounding area of Vijayawada city has been selected. The geographical location study area of Vijayawada is shown in Figure. 1. For collection of field data nearly 100 points were selected over the entire study area from the satellite image. The corresponding coordinates were placed on Google Earth image and using GPS and compass the points were located on the ground during the field visit. Some points were shown on Google earth in the Figure. 2 below.

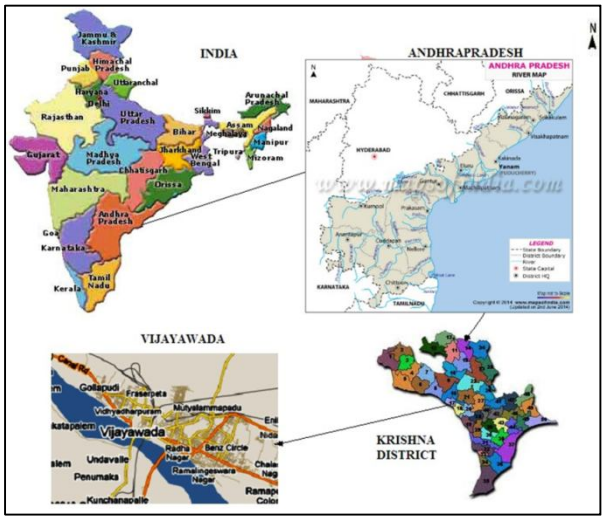


Figure.1 Location of the study area

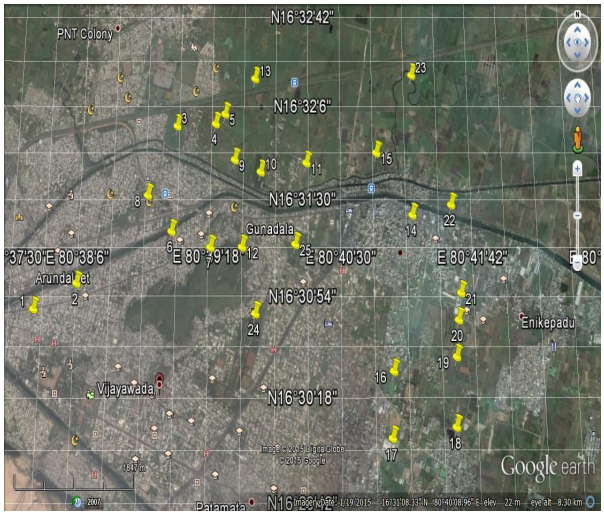


Figure.2 Sampling points on Google Earth

2.2 DATA COLLECTION

Toposheets : For the present study Toposheets of 1:50,000 scale for the corresponding region with No 65D/6, 65D/7, 65D/8, 65D/9, 65D/10, 65D/11, 65D/14, 65D/15 are collected from Survey of India.

Landsat satellite images

Landsat satellite images are down loaded from USGS earth explorer website. Landsat 4-5 (MSS-TM) image for Path 142 and Row 49 WGS 84, Zone 44 Date: 20-11-1988 is collected. It has sensors called Multispectral Scanner (MSS) and Thematic Mapper (TM). Landsat 7 (ETM+ SLC) image for Path 142 and row 49 WGS 84, Zone 44, Date: 31-10-2001 is collected. It has sensors called Enhanced Thematic Mapper Plus (ETM+) and Scan Line Corrector. Landsat 8 (OLI-TIRS) image for Path 142 and Row 49 WGS 84, Zone 44, Date: 17-03-2014 is collected. It has sensors called Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS). The details of the Landsat satellite images selected for the present work are given in the Table.1 below.

Table.1 Landsat satellite imagery downloaded

S.NO	DATE OF IMAGE	SATLLITE/ SENSOR	REFERENCE SYSTEM/PATH/ROW
1	20-11-1988	Landsat 4-5 (MSS-TM)	WRS-II/142/49
2	23-08-2008	Landsat 7(ETM+ SLC)	WRS-II/142/49
3	17-03-2014	Landsat 8 (OLI-TIRS)	WRS-II/142/49

Field Survey Data

Field survey has been conducted to assist the classification of the satellite images in to different land use land cover types. For this nearly 100 points were selected in the satellite image of the entire study area which are unidentified land use land cover types or ambiguous about classification. These points were again placed on Google Earth map to exactly locate on the ground. Using GPS & Compass the pre identified points on Google earth map were located on the ground and observations are made on land use and land cover. The land cover type of the area was noted and photographs were taken for reference.This data is very useful to identify different features observed in satellite images for classification and also for the accuracy assessment of classification. All other ancillary data like population data, information regarding the Vijayawada city are obtained from Municipal authorities.

3. METHODOLOGY

The present study involves processing of the satellite images for making them ready for use. Cutting the selected area from the whole scene called sub-setting. Classification of the images using supervised classification with maximum likelihood algorithm to produce land use land cover images. All the above steps are carried out using image processing software called ERDAS Imagine. In the development of land use land cover images, using supervised classification technique, field data photographs are studied and used for accurate signature development. Six land use land cover classes were considered viz., Built-up, Open land, Light Vegetation, Dense Vegetation, Water and Sand. River course is shown separately as a single class since it includes some water, sand and grass. The produced land use land cover images are analysed and change detection was carried out. The output land use land cover images are used to predict the future land use land cover image by Land Change Modeler of IDRISI Selva software. A Road network map is developed from Toposheets and Google earth map in ARC GIS, and fed to the Land Change Modeler. Digital Elevation map from ASTER Data was downloaded from USGS Earth explorer and fed to the Land Change Modeler. By running the Land Change Modeler, after giving successive inputs the predicted land use land cover image was obtained. Using Landsat images of 1988 and 2008,land use land cover image of 2014 was predicted first and compared with actual land use land cover image developed using Landsat image of 2014. A good accuracy was obtained in the validation. Now using 1988 and 2014 images land use land cover image of 2040 was predicted. The change detection analysis was carried and presented. The methodology adopted in this work is shown in the Figure. 3 below.

1. RESULTS AND DISCUSSION

The output images of land use land cover and analysis was presented in this section. The land use land cover images developed for the years 1988, 2008 and 2014 along with the future predicted land use land cover image of the year 2040 are presented in the following Figure.4 Table.2 shows the statistical change analysis of land use land cover between the years 1988 &2008. Table.3 shows the statistical analysis of land use land cover between the years 1988 &2014. Table.4 shows the statistical analysis of land use land cover between the years 1988 &2040. An overall change in land use land cover in all the four years is shown in Figure.5. From change analysis of land use land cover between 1988 and 2008 it was observed that there is an increase in built up area by 5.35% and decrease in light vegetation by 28.86% and decrease in dense vegetation by 8.96%. Open land was found to increase by 30.38%.

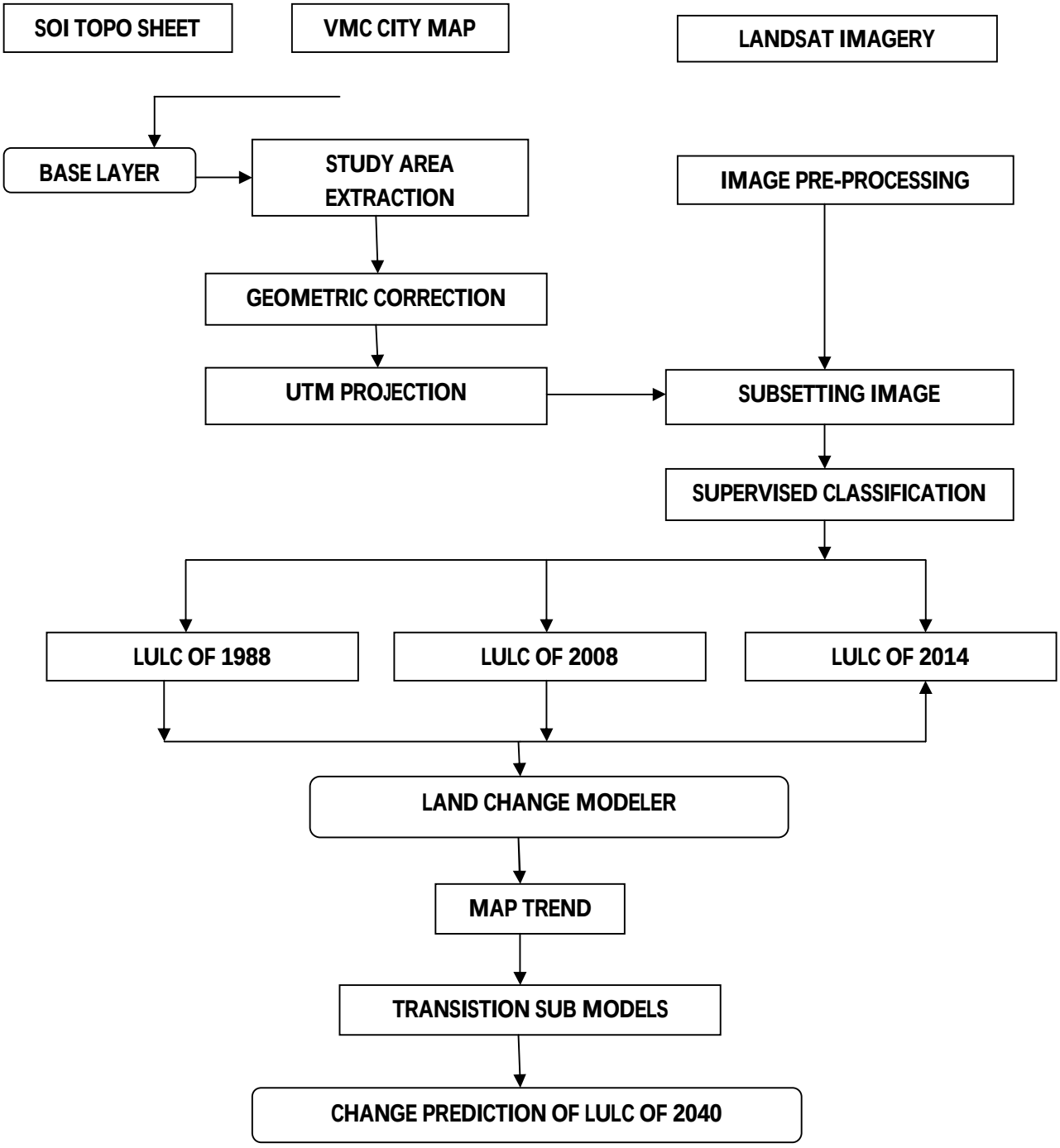
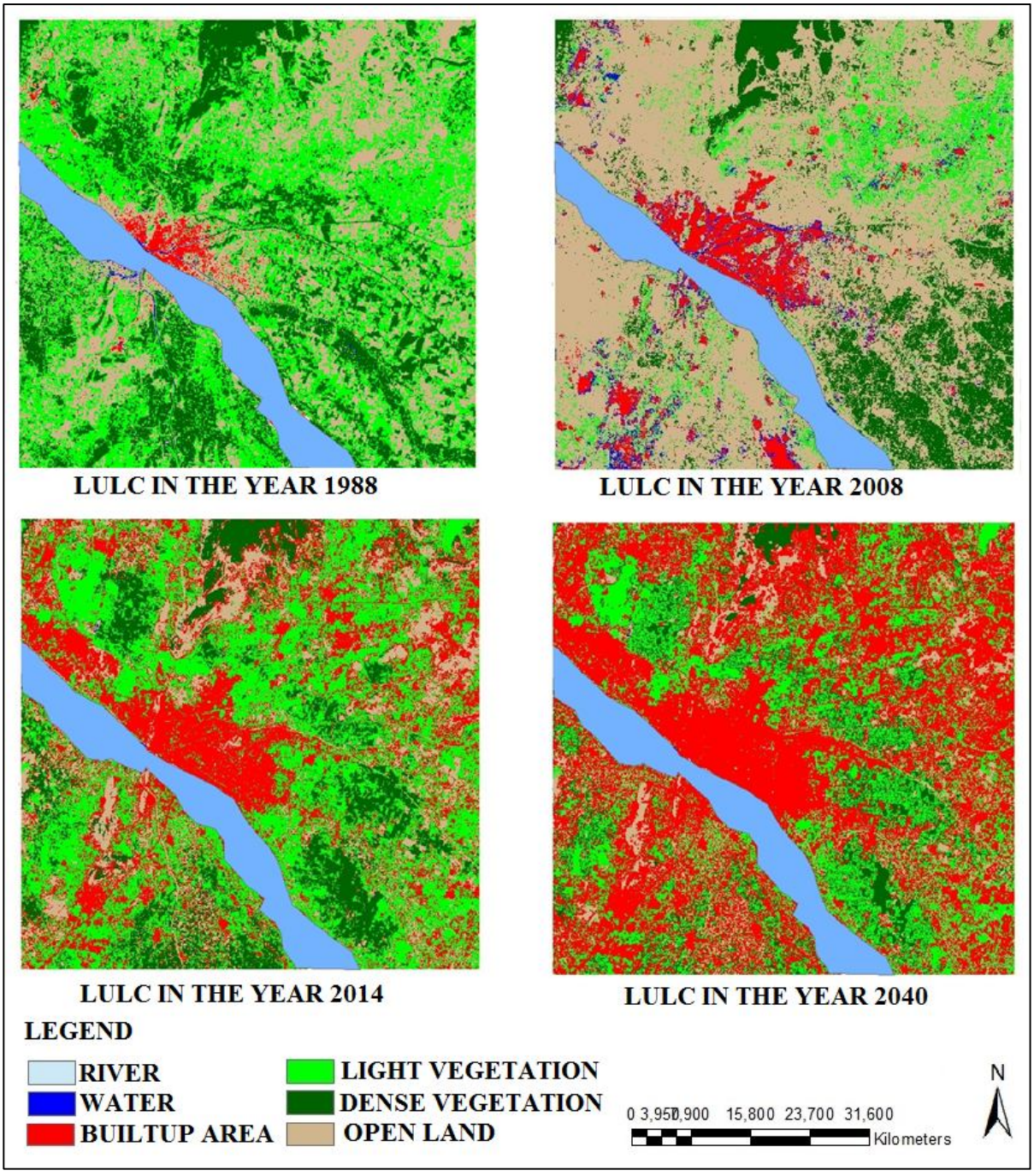


Figure.3 Flow chart showing the Methodology

Figure.4 Land use land cover(LULC) images obtained for different years



Significant change between 1988 and 2008 is that light vegetation and dense vegetation areas are got converted in to open or barren lands. From change analysis of land use land cover between 1988 and 2014 it was observed that there is an increase in built up area by 28.43 % and decrease in light vegetation by 0.87% and decrease in dense vegetation by 11.67%. Open land was found to decrease by 14.31%. Here the main change is that open land got converted to built up area. Finally from the change analysis of land use land cover between 1988 and 2040 it was observed that there is an increase in built up area by 50.21 % and decrease in light vegetation by 12.78% and decrease in dense vegetation by 17.42%. Open land was found to decrease by 18.42%.

The significant change occurred in land use land cover between 1988 and 2040 is that conversion of light vegetation, dense vegetation and open land in to built up area. This is mainly due to housing and infrastructure development that are already taken place and going to take place because of the development of new capital of the Andhra Pradesh state in and around Vijayawada. These changes will definitely have adverse impacts on the urban environment and proper planning and environmental management plans are necessary to mitigate these effects.

Table.2. Change analysis of land use land cover between the years 1988 &2008

LAND USE TYPE	Area in 1988(Hectares)	Area in 2008(Hectares)	Change in 1988-2008	Change %
WATER	2130.21	5013.99	2883.78	3.372221
SAND	1456.38	353.25	-1103.13	-1.28997
BUILT UP	1671.84	6254.73	4582.89	5.359118
DENSE VEGETATION	21614.04	13950.27	-7663.77	-8.96182
LIGHT VEGETATION	33333.03	8650.53	-24682.5	-28.8631
OPEN LAND	25310.25	51292.98	25982.73	30.38356
TOTAL	85515.75	85515.75	0	0

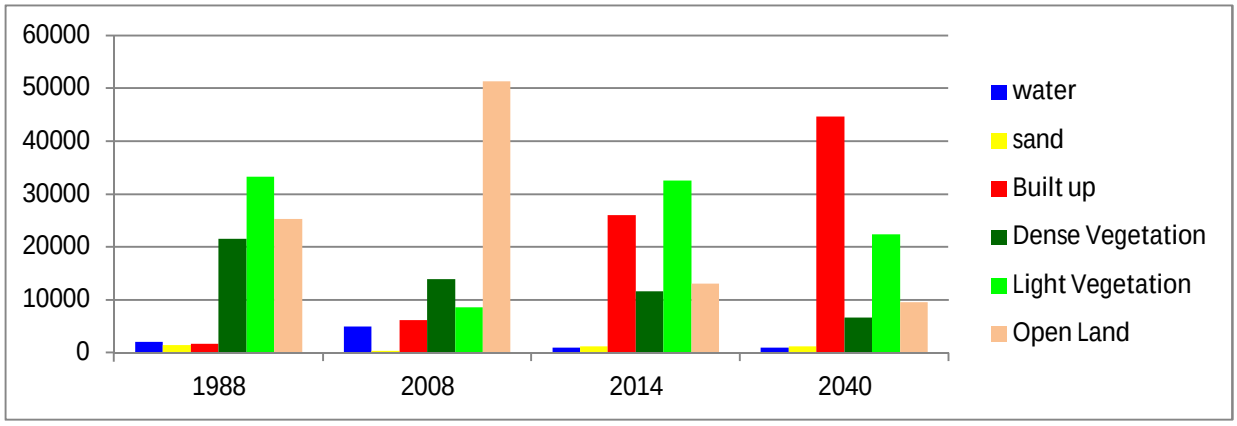
Table.3. Change analysis of land use land cover between the years 1988 &2014

LAND USE TYPE	Area in 1988(Hectares)	Area in 2014(Hectares)	Change in 1988-2014	Change %
WATER	2130.21	1017.09	-1113.12	-1.30165
SAND	1456.38	1221.21	-235.17	-0.275
BUILT UP	1671.84	25992.27	24320.43	28.43971
DENSE VEGETATION	21614.04	11628.54	-9985.5	-11.6768
LIGHT VEGETATION	33333.03	32586.3	-746.73	-0.87321
OPEN LAND	25310.25	13070.34	-12239.9	-14.313
TOTAL	85515.75	85515.75	0	0

Table.4. Change analysis of land use land cover between the years 1988 &2040

LAND USE TYPE	Area in 1988(Hectares)	Area in 2040(Hectares)	Change in 1988-2040	Change %
WATER	2130.21	1017.09	-1113.12	-1.30165
SAND	1456.38	1221.21	-235.17	-0.275
BUILT UP	1671.84	44611.2	42939.36	50.21222
DENSE VEGETATION	21614.04	6714.63	-14899.4	-17.423
LIGHT VEGETATION	33333.03	22400.55	-10932.5	-12.7842
OPEN LAND	25310.25	9551.07	-15759.2	-18.4284
TOTAL	85515.75	85515.75	0	0

Figure.5 Land use land cover(LULC) changes in different years from 1988 to 2040(y-axis area in hectares)



2. CONCLUSION

In this work urban expansion of a rapidly growing city Vijayawada has been studied over a period of 26 years in the past(from 1988 to 2014) to predict the future urban expansion in the year 2040. Landsat satellite images of 1988, 2008and 2014 are used for this study. A total area of 85515.75 hectares was taken as study area. Land use land cover images are developed in ERDAS Imagine and the future land use land cover image was predicted using Land Change Modeller of IDRISI Selva. The results shows that built up of Vijayawada city has been increased from 1671.84 hectares in 1988 to 25992.27 hectares in 2014 and finally to 44611.2 hectares in 2040. The percentage increase in built up area from 2008 to 2014 is 28.43% and that from 1988 to 2040 is 50.21%. An accuracy of more than 80% was obtained in all stages. This rapid and massive conversion of vegetative and open land in to built up area may have serious environmental impacts unless proper environmental management plans were implemented for the urban area.

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