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APPLICATION OF LAND CHANGE MODELER FOR PREDICTION OF FUTURE LAND USE LAND COVER A CASE STUDY OF VIJAYAWADA CITY

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ABSTRACT

Land use dynamics play vital role in the ecological sustainability of any region. Land use land cover (LULC) images developed from satellite images are widely used for carrying out research on spatial and temporal changes of land use of any area. Prediction of future LULC image will be helpful for proper planning of urban environmental management. The main objective of this paper is to predict and analyse the present and future growth of Vijayawada city of Andhra Pradesh, India, using Landsat satellite images of 1973, 2001and 2014. A total area of 85515.75 hectares was taken as study area which has potential for expansion. After processing the imagery, LULC images are developed and used to predict the future LULC images of 2030 and 2040 using Land Change Modeller (LCM) of TerrSet software. Land cover change was predicted by a neural network and Markov chain-Cellular Automata based built-in module of TerrSet called LCM. Dynamic road network prepared from toposheets of Survey of India and elevation map developed from SRTM image are used as ancillary data to run the software and get the output. An accuracy of more than 80% was obtained in all stages. The outputs images were analysed and presented.

Keywords: Land use land cover, Landsat imagery, Classification, Land Change Modeler, TerrSet.

I. INTRODUCTION

Changes in land use and land cover (LULC)are the most important anthropogenic drivers 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.[1] Satellite remote sensing, in conjunction with geographic information systems (GIS), has been widely applied and has 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.[2] 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 recently. 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.[3] Land Change Modeler of TerrSet software was found to be very effective which incorporate CA-Moakov chain based neural network to predict future LULC.

In this work Vijayawada, the capital city of Andhra Pradesh which is rapidly growing is considered as a case study. Based on past trend (from 1973-2014) 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. [4,5]

II. STUDY AREA AND DATA COLLECCTION

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. Vijayawada now has become the capital of the new state called Andhra Pradesh. There is lot of scope for urban development because of the new state capital construction and there will be severe changes in the landscape of the area. 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.

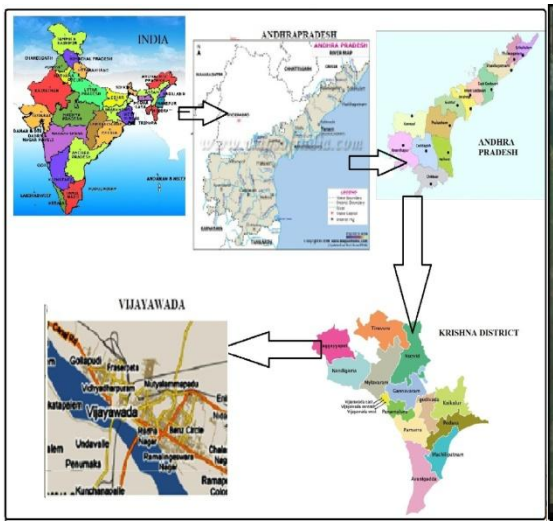

Figure.1 Location of the study area

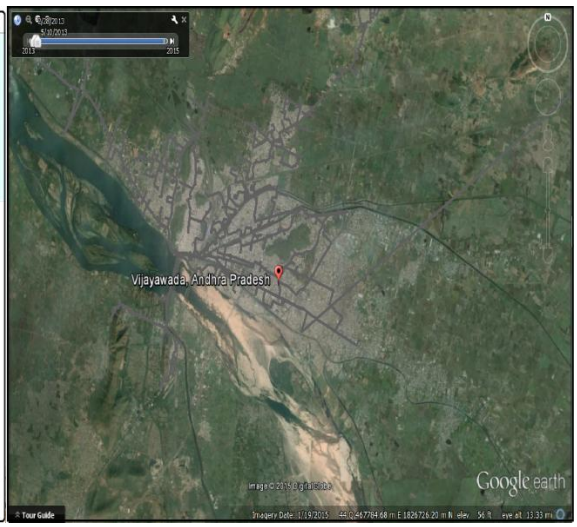

Figure.2 Google Earth image of study area

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. The study area obtained by mosaic of the toposheets is shown in the Figure.3. The elevation map of the study area cut from the SRTM image, down loaded from Earthexplorer is shown in Figure.4.

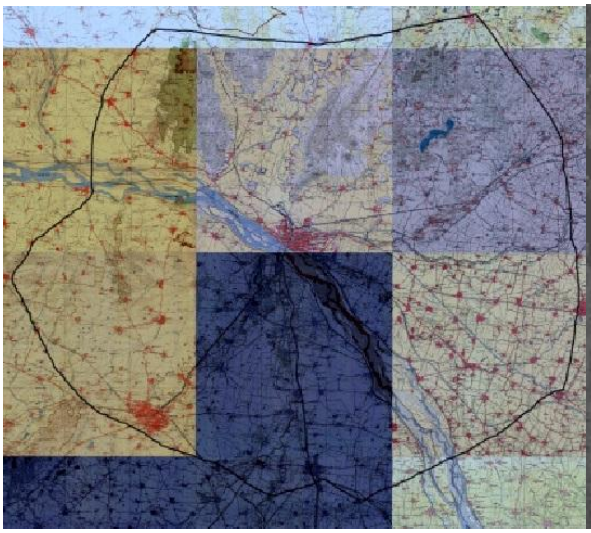

Figure.3 Study area in mosaic Toposheets

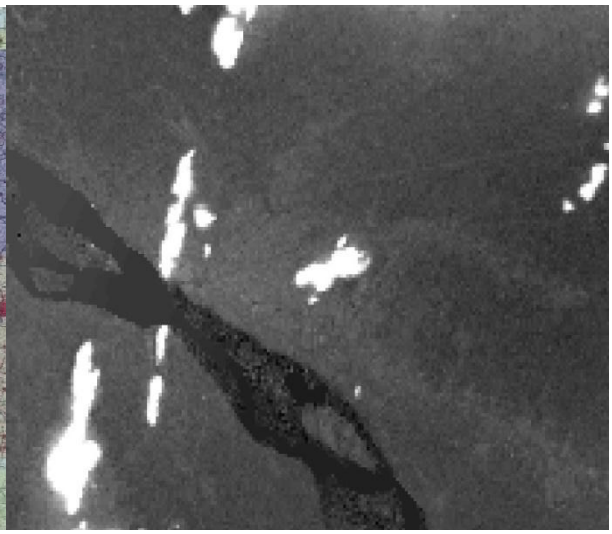

Figure.4 SRTM data of study area

Landsat satellite images: Landsat satellite images are down loaded from USGS earth explorer website. The details of the Landsat satellite images selected for the present work are given in the Table.1 below.

TABLE.1 Details of Landsat satellite imagery downloaded

S.NO	DATE OF IMAGE	SATLLITE/ SENSOR	REFERENCE SYSTEM/PATH/ROW
1	26-02-1973	Landsat 1(RBV-MSS)	WRS-II/153/49
2	31-10-2001	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. 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.

III. METHODOLOGY

The present study involves processing of the Landsat satellite images, development of LULC images and application of Land change modeller. After pre-processing the satellite images, supervised classification with maximum likelihood algorithm is used to produce LULC images using ERDAS imagine. Six land use land cover classes were considered viz., Built-up, Open land, Light Vegetation, Dense Vegetation, Water and Sand.

Field data photographs are studied and used for accurate signature development. 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 LULC images are used to predict the future LULC image by Land Change Modeler of TerrSet. 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 SRTM 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 LULC image was obtained. Using Landsat images of 1973 and 2001, LULC image of 2014 was predicted first and compared with actual LULC image developed using Landsat image of 2014. A good accuracy was obtained in the validation. Now using 2001 and 2014 images, LULC image of 2030 &2040 were predicted. The change detection analysis was carried and presented. The methodology adopted in this work is shown in the Figure.5 below. Different stages of LCM running were shown using screen shots from Figure.6 to Figure.10

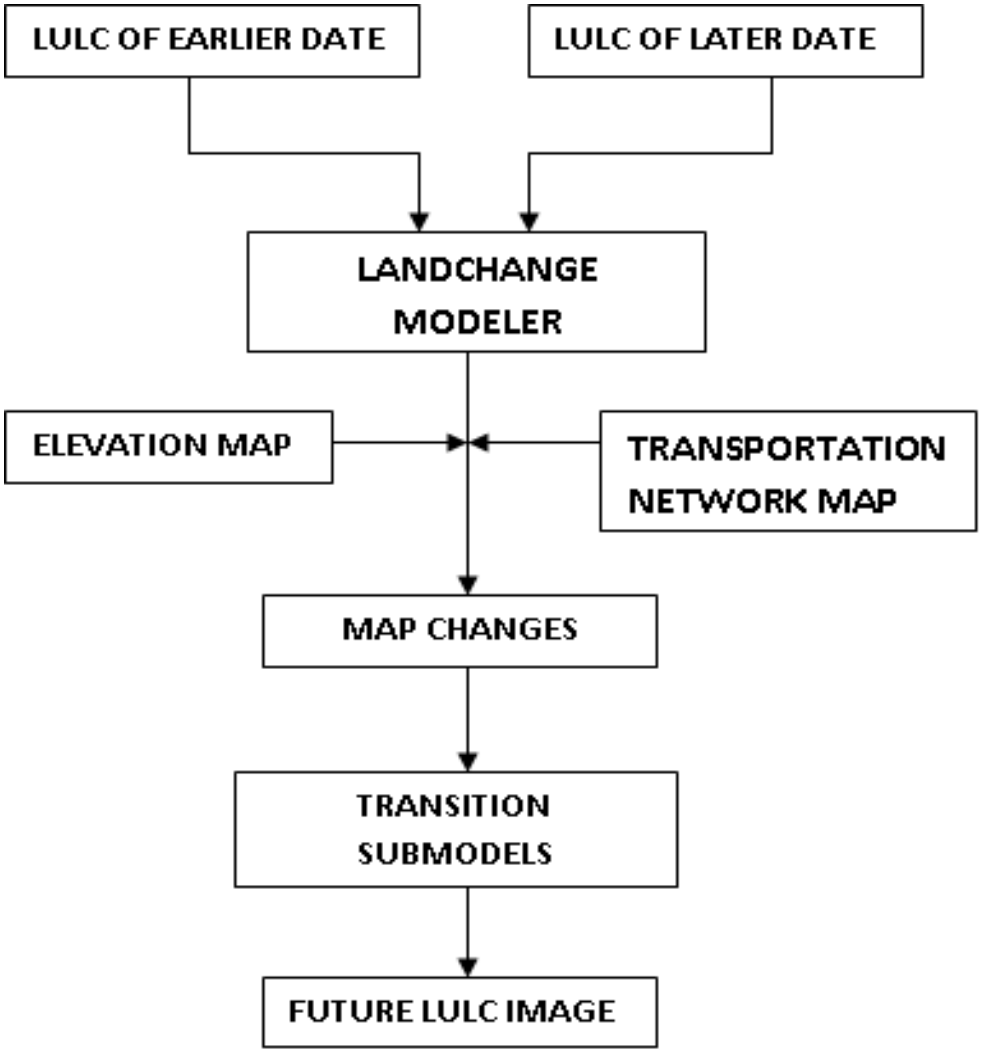

Figure.5 Flow Chart Showing the Methodology

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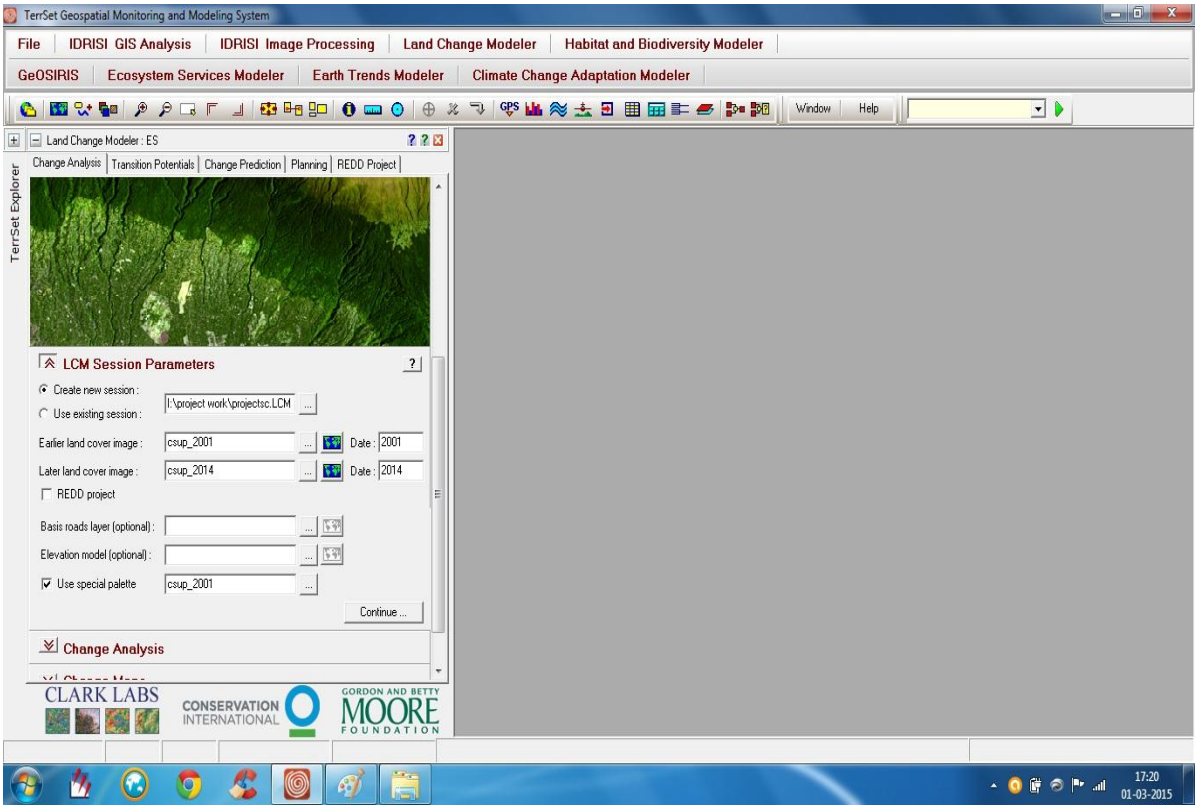

Figure.6 Creating new LCM project and give earlier and later land cover images as inputs.

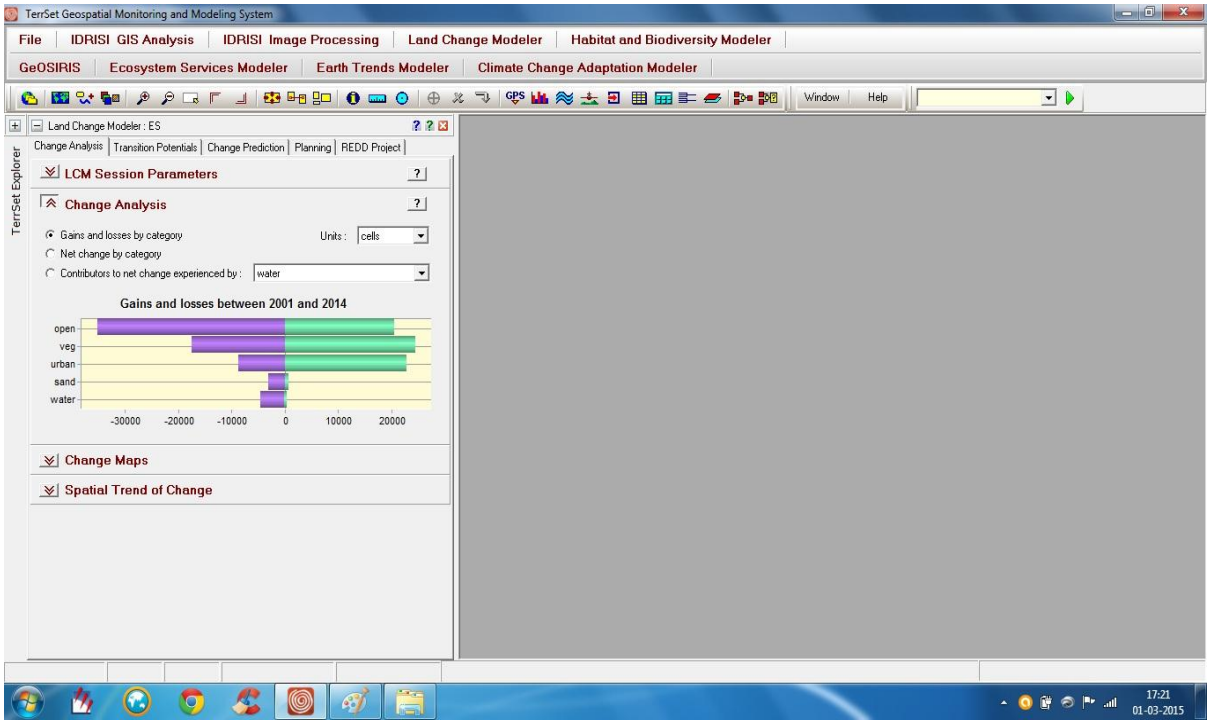

Figure.7 Gains and Losses of Earlier and Later Land Cover Images

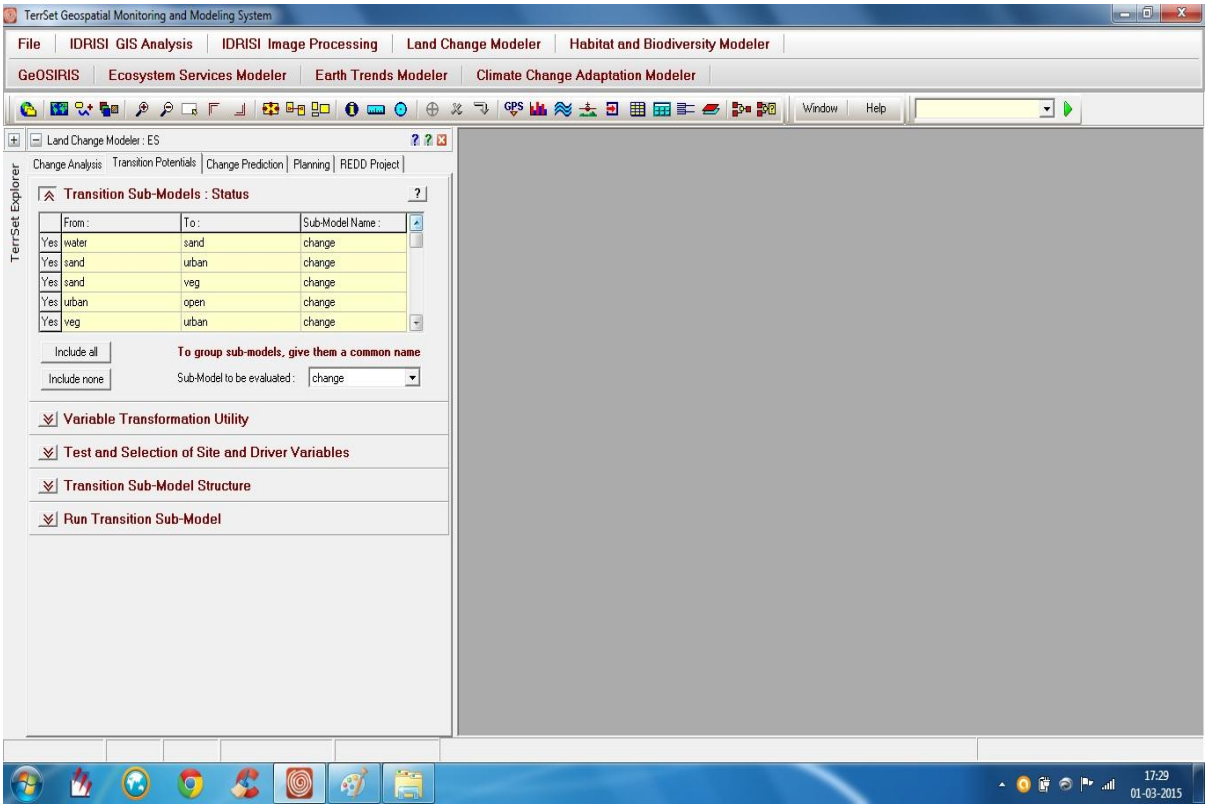

Figure.8 Transition sub-model status table, shows the transition between different sub models.

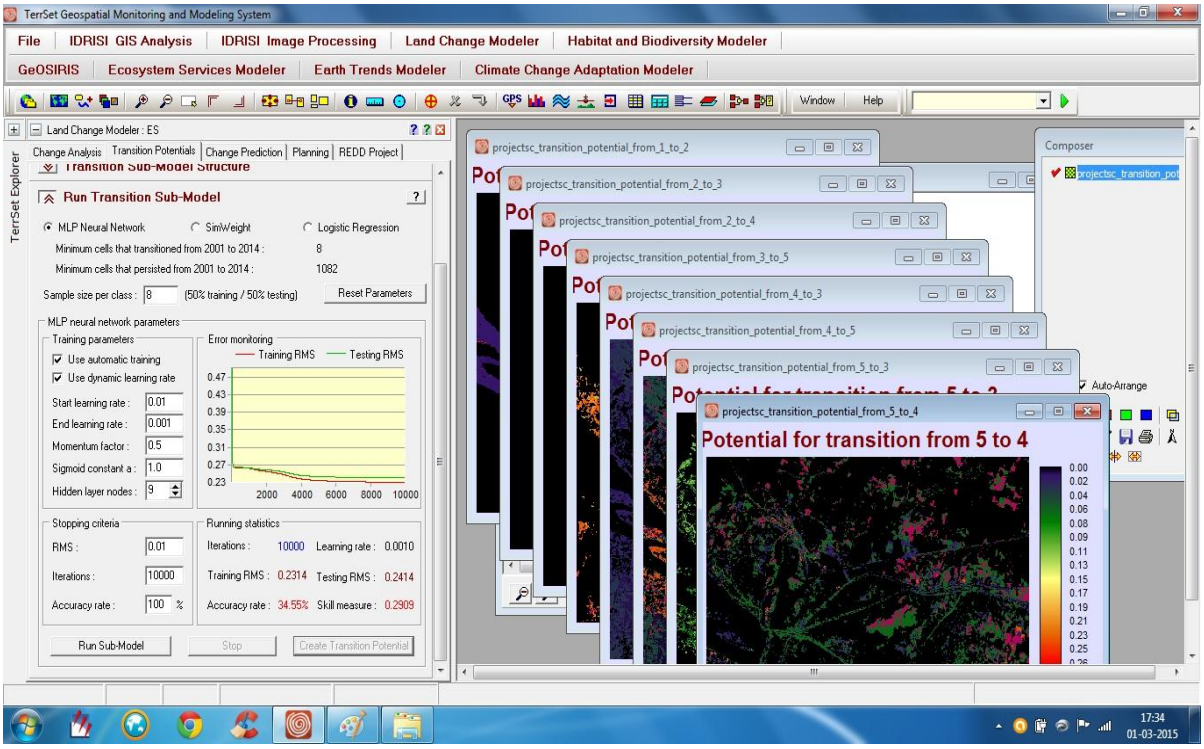

Figure.9 Obtained transition potential maps

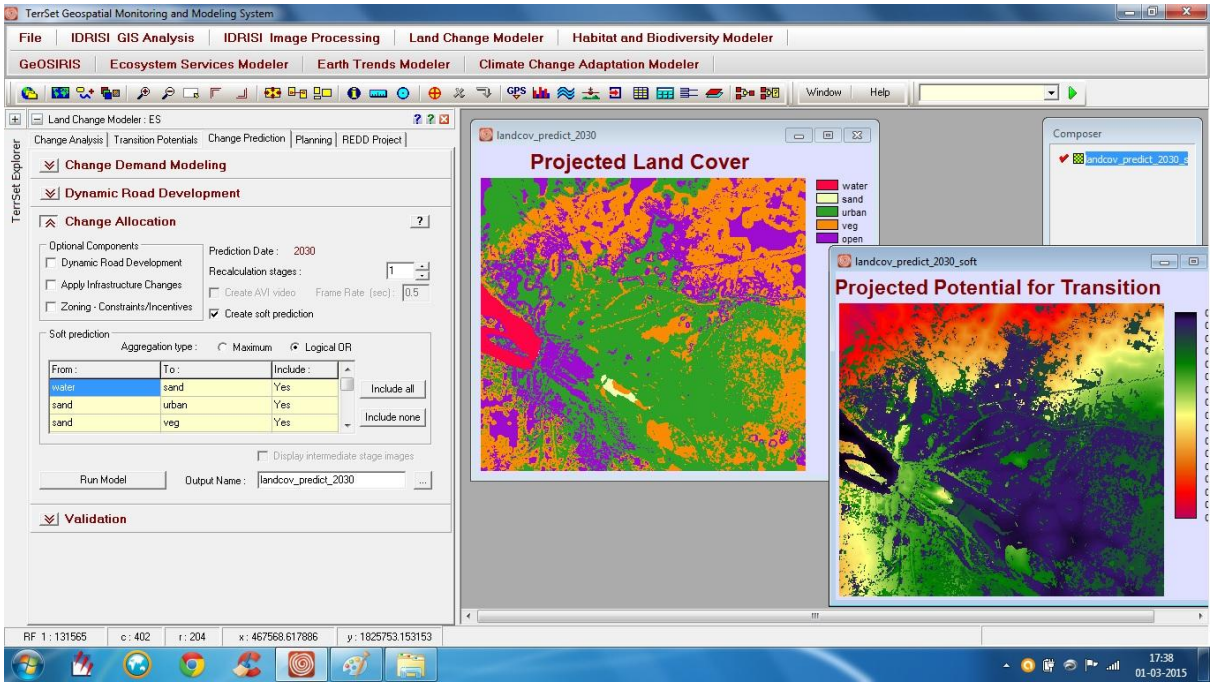

Figure.10 Final output of predicted land cover image.

IV. RESULTS AND DISCUSSION

The output images of LULC and analysis was presented in this section. The LULC images developed from Landsat satellite images for the years 1973, 2001 and 2014 using ERDAS imagine are shown in the following Figure.12. The classification accuracy calculated using the field data was found to be nearly 80%.The future predicted land cover image of the year 2030 & 2040 obtained from the Land change modeller are presented in the following Figure.12. These LULC images of different dates are thoroughly analysed and change detection was carried out. The percentage decrease or increase in each class of land cover are estimated and presented. Table.2 shows the statistical change analysis of land use land cover between the years 1973 &2001. Table.3 shows the statistical analysis of land use land cover between the years 1973 &2014. Table.4&5 shows the statistical analysis of LULC between the years 1973 &2030 and 1973 &2040 respectively. An overall change in land use land cover in all the four years is shown in Figure.12.

Finally from the change analysis of land use land cover between 1973 and 2040 it was observed that there is an increase in built up area by 44.15 % . Open land was found to decrease by 58.68%.The significant change occurred in land use land cover between 1973 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.

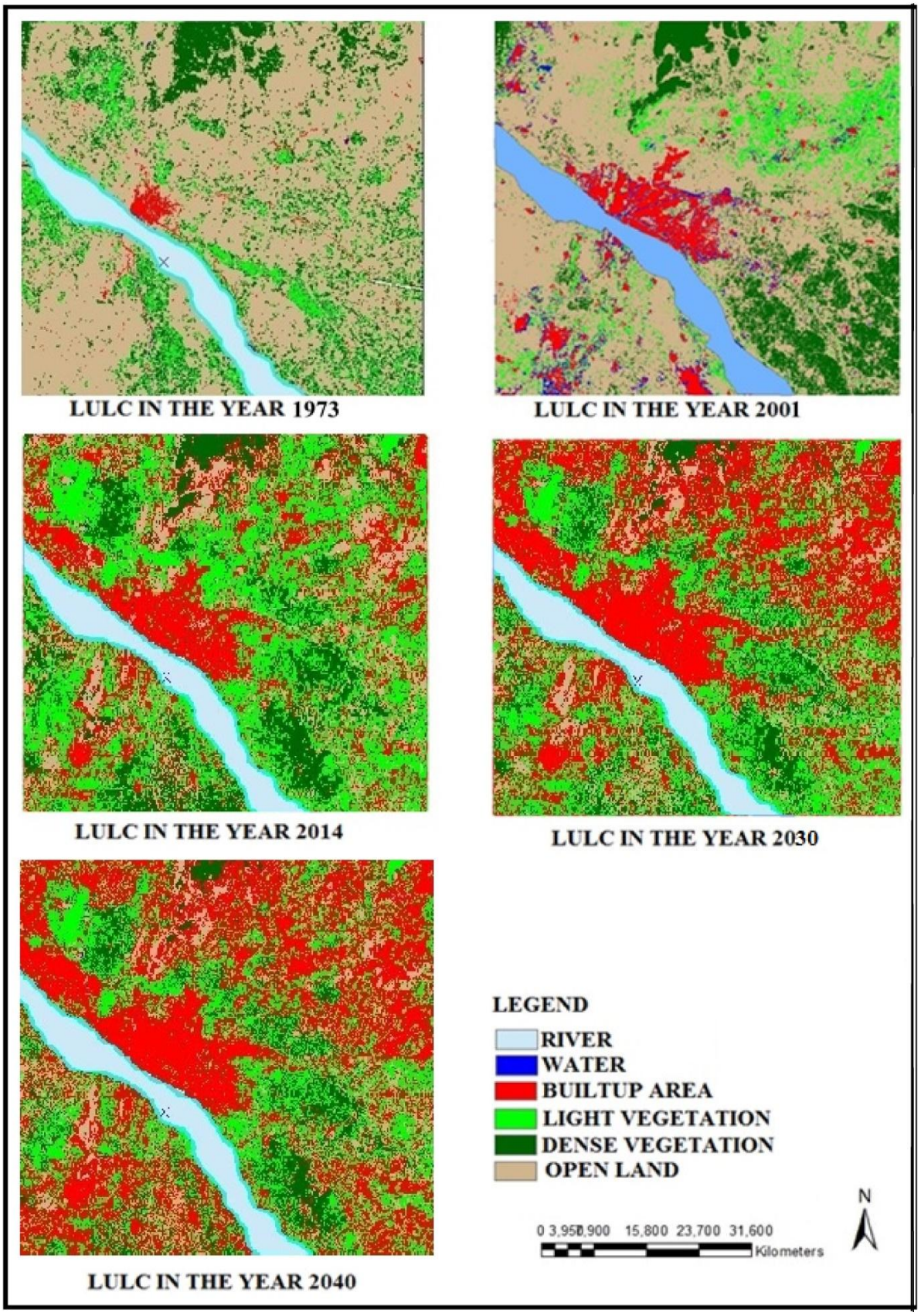

Figure.11 LULC images obtained for different years

TABLE.2. Change analysis of LULC between the years 1973 &2001

LAND USE TYPE	Area in 1973(Hectares)	Area in 2001(Hectares)	Change in 1973-2001	Change %
WATER	1572.19	9606.6	8034.41	9.39524
SAND	1623.52	1474.65	-148.87	-0.17408
BUILT UP	3873.56	11534.31	7660.75	8.958291
DENSE VEGETATION	2706.38	15763.32	13056.94	15.26846
LIGHT VEGETATION	15561.15	36638.1	21076.95	24.64686
OPEN LAND	60178.95	10498.77	-49680.18	-58.0948
TOTAL	85515.75	85515.75	0	0

TABLE.3. Change Analysis of LULC Between the Years 1973 &2014

LAND USE TYPE	Area in 1973(Hectares)	Area in 2014(Hectares)	Change in 1973-2014	Change %
WATER	1572.19	1017.09	-555.1	-0.64912
SAND	1623.52	1221.21	-402.31	-0.47045
BUILT UP	3873.56	25992.27	22118.71	25.86507
DENSE VEGETATION	2706.38	11628.54	8922.16	10.43335
LIGHT VEGETATION	15561.15	32586.3	17025.15	19.90879
OPEN LAND	60178.95	13070.34	-47108.61	-55.0876
TOTAL	85515.75	85515.75	0	0

TABLE.4. Change analysis of LULC between the years 1973 &2030

LAND USE TYPE	Area in 1973(Hectares)	Area in 2030(Hectares)	Change in 1973-2030	Change %
WATER	1572.19	1017.09	-555.1	-0.64912
SAND	1623.52	1221.21	-402.31	-0.47045
BUILT UP	3873.56	37976.22	34102.66	39.87881
DENSE VEGETATION	2706.38	8539.29	5832.91	6.82086
LIGHT VEGETATION	15561.15	26148.96	10587.81	12.38112
OPEN LAND	60178.95	10612.98	-49565.97	-57.9612
TOTAL	85515.75	85515.75	0	0

TABLE.5. Change analysis of LULC between the years 1973 &2040

LAND USE TYPE	Area in 1973(Hectares)	Area in 2040(Hectares)	Change in 1973-2040	Change %
WATER	1572.19	1017.09	-555.1	-0.64912
SAND	1623.52	1221.21	-402.31	-0.47045
BUILT UP	3873.56	41669.19	37795.63	44.19727
DENSE VEGETATION	2706.38	7543.35	4836.97	5.656233
LIGHT VEGETATION	15561.15	24069.15	8508	9.949044
OPEN LAND	60178.95	9995.76	-50183.19	-58.683
TOTAL	85515.75	85515.75	0	0

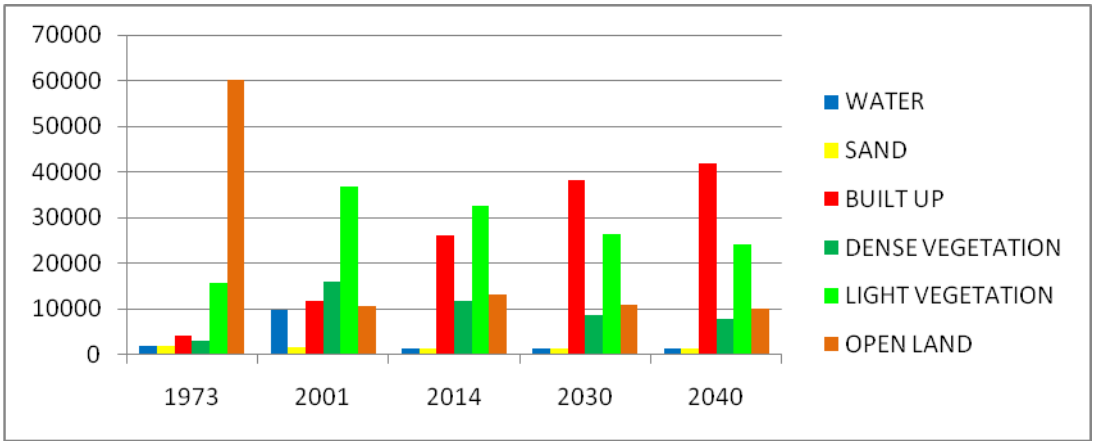

Figure.12 LULC changes in different years from 1973 to 2040(y-axis area in hectares)

V. CONCLUSION

In this work prediction of future urban expansion Vijayawada has been studied over a period of 26 years in the past(from 1973 to 2014) to predict the future urban expansion in the year 2030 &2040. Landsat satellite images of 1973, 2001and 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 TerrSet. Dynamic road network map and elevation maps are also supplied to the Land Change Modeler for prediction of future LULC image. The overall model efficiency in predicting the future LULC images was found to be nearly 80%. From the change detection analysis it is observed that there is an increase in built up area by 44.15 % and open land was found to decrease by 58.68%. 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. This kind of prediction of future LULC image can be helpful for planning proper urban environmental management.

VI. ACKNOWLEDGMENT

We express our sincere thanks to the United States Geological Survey (USGS) for supplying Landsat imagery for the study area of the present work. We thank the Survey of India for supply of Toposheets. We thank Municipal Corporation of Vijayawada for providing the master plan of Vijayawada city.

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