PREDICTION OF URBAN GROWTH IN CHAMARAJANAGARA REGION USING GEOSPATIAL TECHNIQUES

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Absract: The Prediction of future LULC will be significant for proper planning of urban environmental management. The present paper is there for an attempt to predict urban growth of 2031and analyze the present growth of Chamarajanagar region (town and its surrounding villages) in Karnataka, India, using Landsat satellite images of 1991, 2001, 2011 and 2019. The surrounding villages of Chamarajanagar town has considered for the analysis, to understand the direction of urban growth and development. Satellite images and geospatial tools were used to calculate and analyze the spatio-temporal urban land use and land cover changes during the study period. The satellite images were subjected to supervised classification of Land use Land cover using Erdas imagine platform. The future Land use Land cover using Land change Model was performed with Markov Chain Modeler of IDRISI SELVA. The final results shows that the Built up area of Chamgrajnagar region has been increased from 631.68 hectares in 1991 to 711.06 hectares in 2001 and 853.35 hectares in 2011 & 898.70 hectares in 2019, Finally to 1084.91 hectares in 2021.

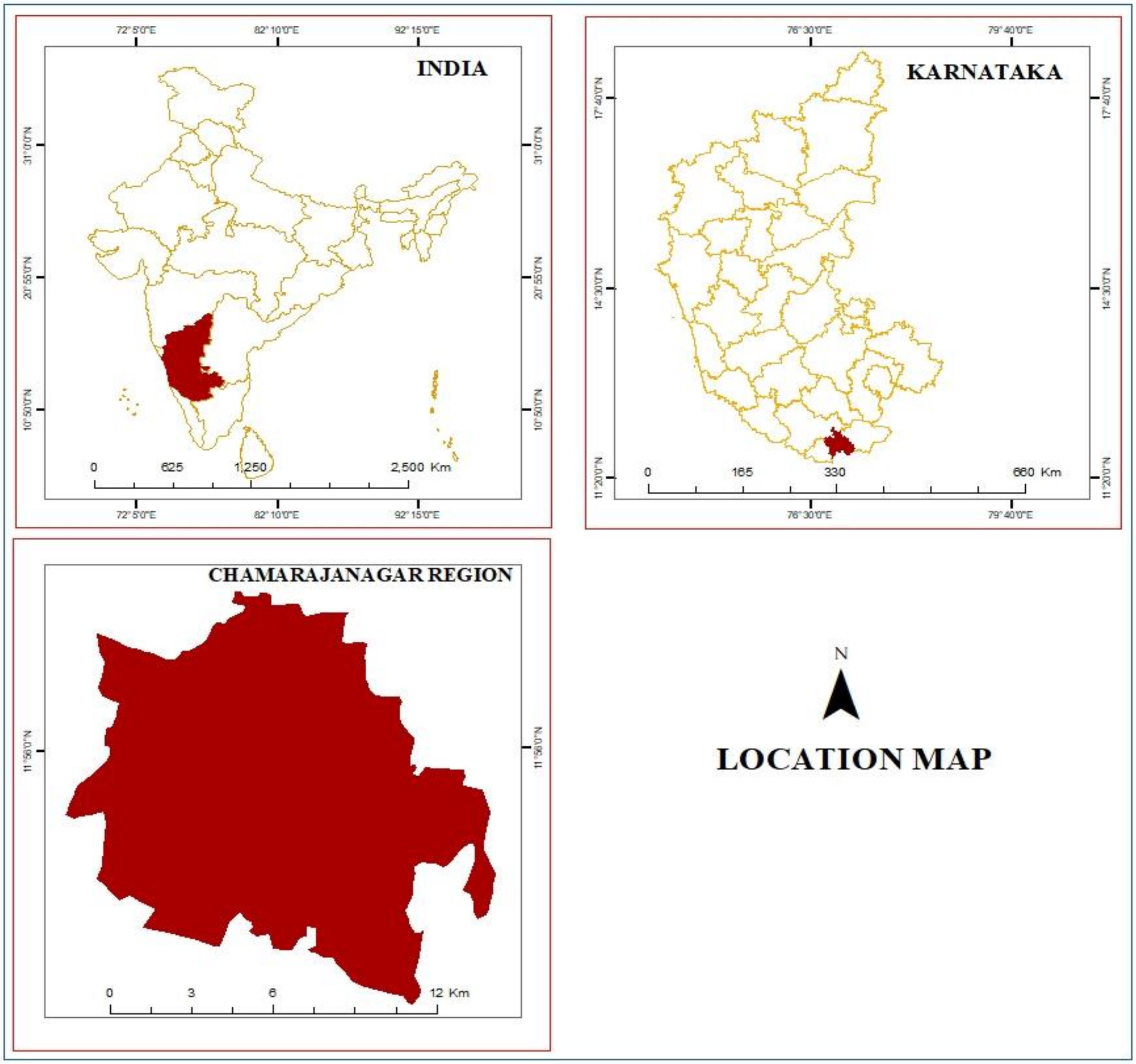
***IndexTerms* – Urban Land use, Land change Model, IDRISI SELVA**

I. INTRODUCTION

Urbanisation is an unavoidable process due to economic development and rapid population growth. Accurate and recent land use Land cover changes are required to understand and assess the environmental consequences of such changes. The urbanization is a major threat of many world regions which includes noticeable spreading of a town/city with poor planning. The unplanned urbanization will create problems like pollution, traffic, deforestation, and congestion of places. The Land use land cover maps can develop from satellite data, which are widely used for carrying out research on spatial and temporal changes of land use of any area. This paper attempts to highlight the Land use Land cover classification in Chamarajanagar region derived from remotely sensed data. The future prediction of land use land cover change will be very essential to the urban planners. The main purpose of this study is to monitor the land use land cover changes from 1991 to 2019 and to predict the future scenario of 2031 land use land cover changes. The most common and appropriate LULC model applied in this study (Markov chain model).

II. STUDY AREA

The study area is located in the southern part of Deccan Plateau and in the south of Karnataka state. It was carved out of the original larger Mysore District in the year 1998. Chamarajanagar was earlier known as Sri Arikottara. Chamaraja Wodeyar, the Wodeyar king of Mysore was born here and hence this place was renamed after him. Chamarajanagar town is located in central part of the Chamarajanagar taluk of Chamarajanagar District of Karnataka and lies between 11° 53´ 03.94´´ N to 11° 56´ 29.49´´ N latitude and 76° 55´ 20.25´´ E to 76° 56´ 29.49´´ E longitude. It is bounded by Mysore, Mandya and Ramanagara of Karnataka in the north, Kannur district of kerala on the south, east and Nilgiris and Coimbatore districts of Tamil Nadu on the Southeast.



III. METHODOLOGY

The present study involves the processing of Landsat images, development of LULC images and Land Change Modeller (LCM) Applications. After pre-processing the images, supervised classification with maximum likelihood algorithm is used to produce the LULC images using ERDAS imagine software. Five LULC classes were considered viz., Built-up, Agriculture land, Vegetation, Water bodies, Wasteland. Change detection was carried out by using produced LULC images. The output LULC images are used to predict the future LULC by Land Change Modeler. A road network map is developed from Toposheet and Google earth using Arc Gis 10.5, and fed to the Land Change Modeler (LCM). Digital Elevation Model from SRTM data was downloaded from USGS Earth explorer and fed to the Land Change Modeler (LCM). After successive inputs to the LCM model, the predicted LULC image was obtained. The change detection analysis was carried and presented. The methodology adopted in this work is shown in figure 1 below.

3.1 Source of data

- Landsat imageries of 1991, 2001, 2011 and 2019 (30 mts resolution).
- The images were subjected to the supervised classification.
- The classification results used as the input for the analysis of Land Change Modeler (LCM) model.
- Elevation, Slope, distance to the road, distance to the city was used as inputs for modeling to futuristic prediction of land use change.

3.2 Analysis:

- Satellite images have been spatially and radiometrically corrected. The error rectified images would improve the accuracy of result.
- Supervised classification: Land use and land cover analysis.(built-up area, vegetation, wasteland and water bodies)
- Accuracy assessment of classified data
- The change detection has been carried out and generated various thematic maps of different time period.
- Land use change model using Land Change Modeler.

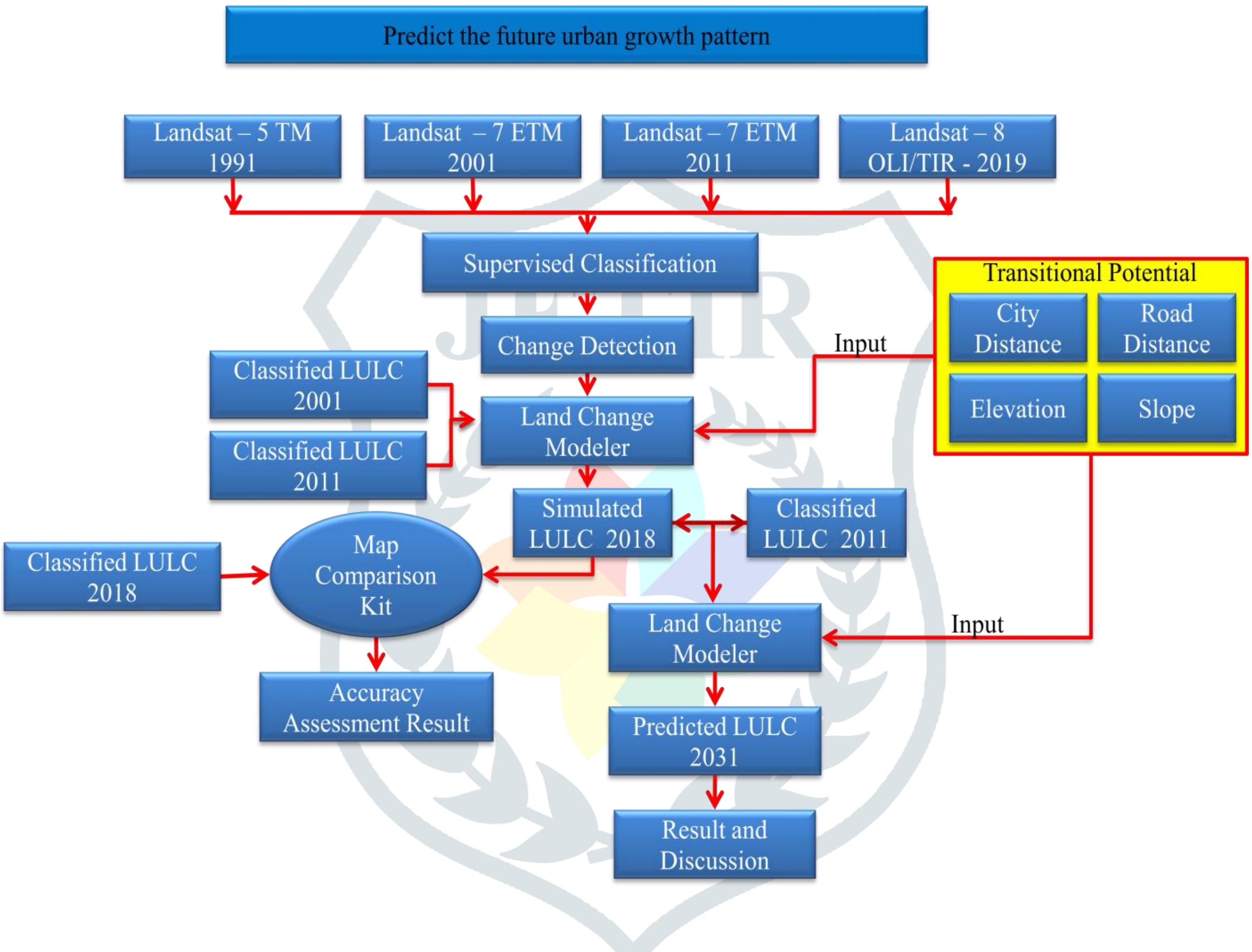


Figure 1: Methodology Flowchart

IV. LAND USE AND LAND COVER OF CHAMARAJANAGAR REGION

Landsat images of 1991, 2001, 2011 and 2019 have been corrected geometrically and radio-metrically to generate the LULC map in the study area. The geometric and radiometric correction has been carried out through ERDAS imagine software. The figure 2 shows Landsat images used in the present study in four different time periods.

1. Landsat 5 TM (14th January 1991)
2. Landsat 7 ETM (3rd March 2001)
3. Landsat 7 ETM (11th February 2011)
4. Landsat 8 OLI/TIR (10th January 2019)

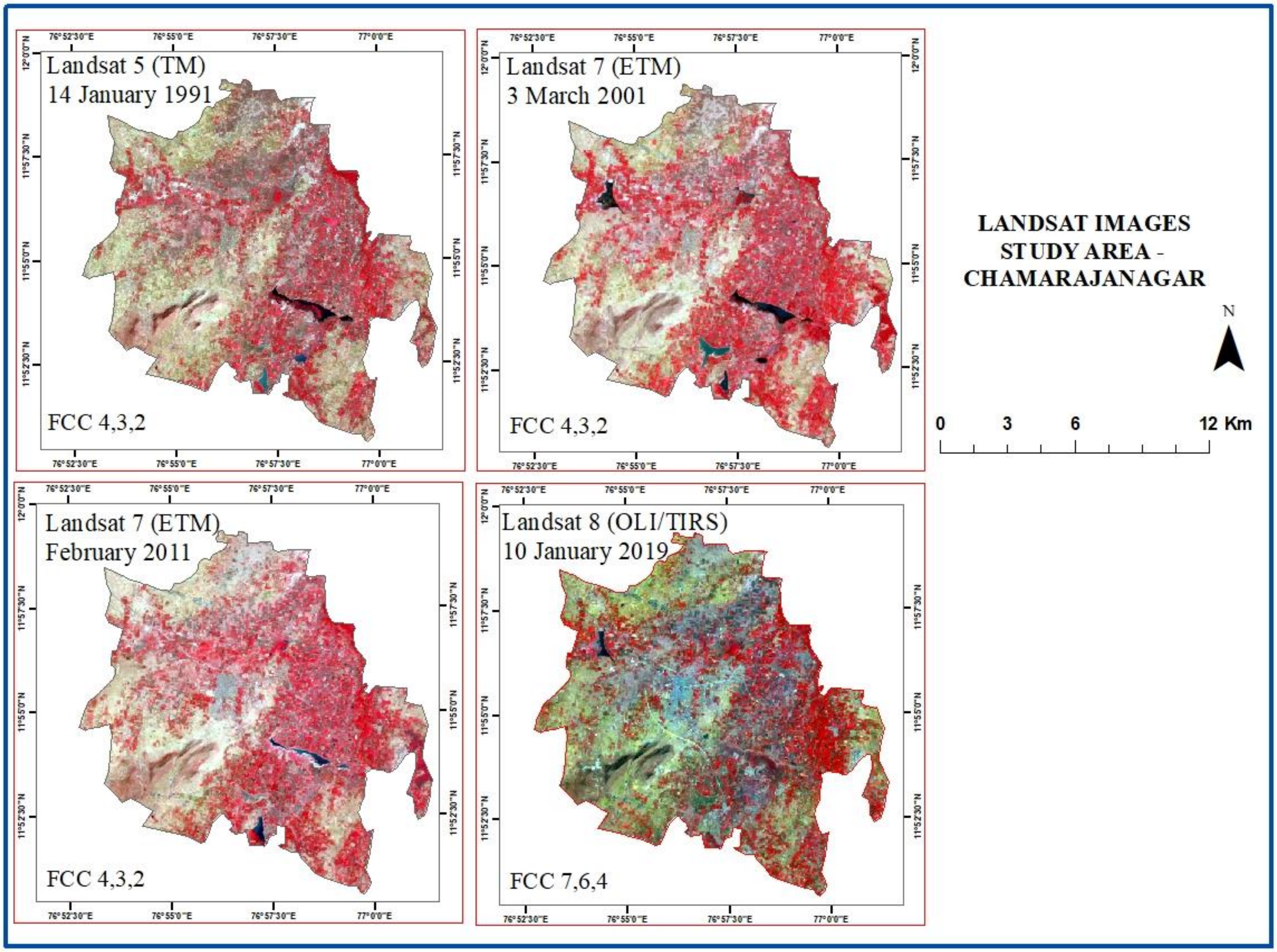


Figure 2. Landsat imageries

V. ASSESSMENT OF CLASSIFICATION ACCURACY

After ground truth/verification, Accuracy assessment was carried out. It is the most important aspect to assess the reliability of classified map. No image classification is said to be complete unless its accuracy has been assessed. To determine the accuracy of classification, a sample of pixels is selected in the classified image and their class identity is compared with the ground reference data. In present study the classification error matrix is used, which is very common means of expressing classification accuracy. The second technique used for accuracy assessment is KAPPA analysis. KAPPA analysis is a multivariate technique which calculates the producer's accuracy and user's overall accuracy, as well as KAPPA accuracy level.

The Confusion Matrix represents the actual and classified results in a table format. In this table the classified LULC is in rows and the ground verified samples are in columns. When the matrix has been framed successfully, the accuracy classification results can be seen in diagonal values in the matrix. Other than the diagonal values in the table there are wrongly classified samples and the errors placed in rows are commission errors, while the columns display the omission errors. The user and producer accuracy can be obtained by dividing the number of correctly classified samples by the total number of samples in the error matrix, and resulting in the column which illustrates the producer accuracy while the user accuracy is demonstrated in the row of error matrix.

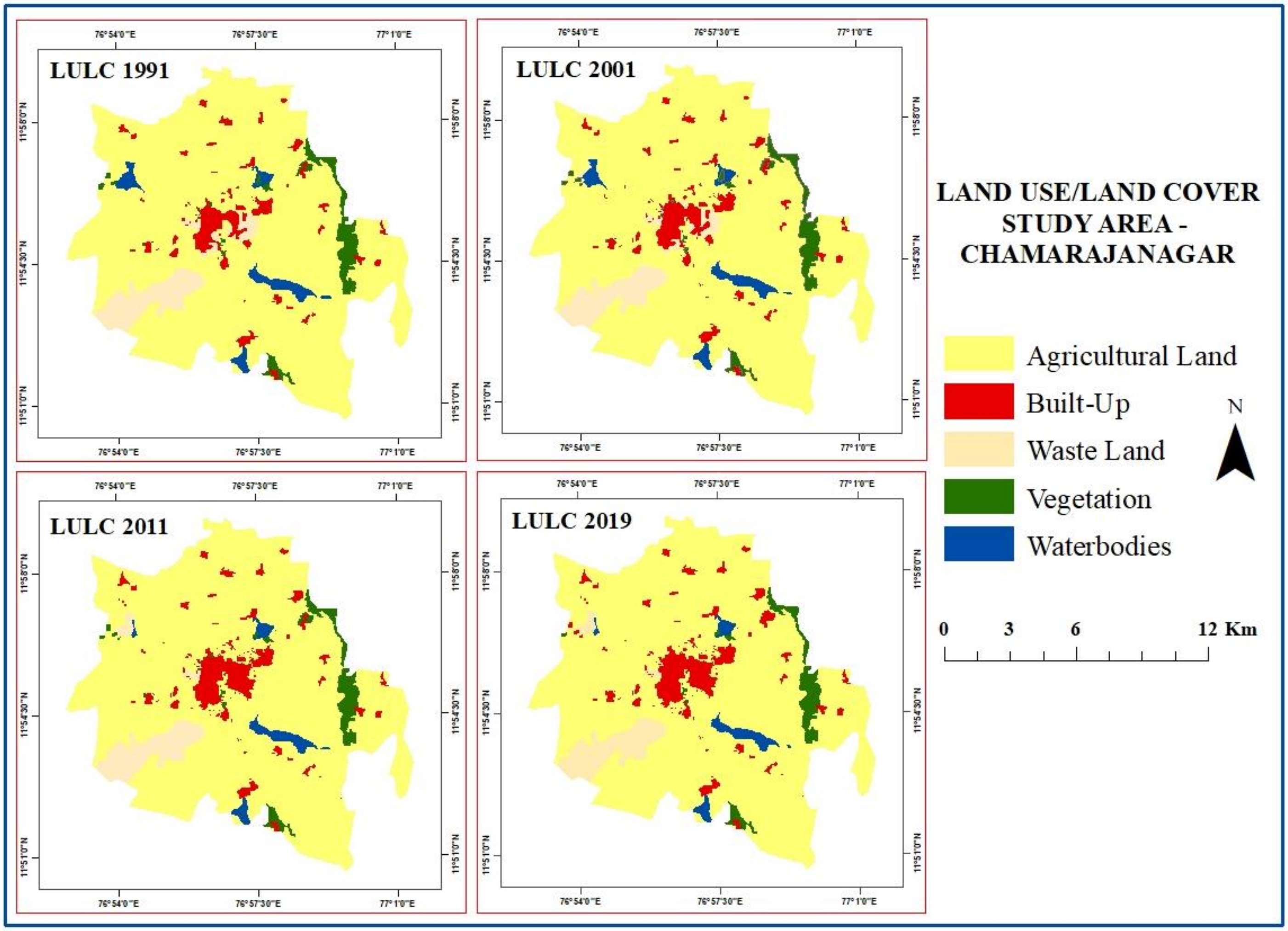


Figure 3: Land use/Land cover map

The error matrices and Cohen's Kappa are commonly used for Accuracy Assessment. These are very useful when building models that predict discrete classes or classifying imageries. More over it helps to provide a sense of how accurate or useful the model is. Kappa mainly used as a measure of agreement between model predictions and reality (Congalton 1991) or to determine if the values contained in an error matrix represent a result significantly better than random (Jensen 1996). The Cohen's Kappa can be used to calculate the agreement between two individual variables that measures the same land use. The result of Kappa is lesser than 0 or equal to 1. With the values near to 1 represents the perfect agreement, while those near to 0 represents the worst agreement. The table1 shows the error matrix table that is prepared to measure the classification accuracy.

Table. 1 Accuracy Assessment of LULC

S. No.	Classified LULC	Agricultural Land	Buit-Up	Vegetation	Water bodies	Waste Land	Total	User Accuracy
1	Agricultural Land	39	0	1	0	0	40	97.50
2	Buit-Up	0	19	0	0	1	20	95.00
3	Vegetation	1	0	11	0	0	12	91.67
4	Water bodies	0	0	0	11	0	11	100.00

5	Waste Land	0	1	0	0	14	15	93.33
Total		40	20	12	11	15	98	
Producer Accuracy		97.50	95.00	91.67	100.00	93.33		
Overall Accuracy = 95.91								
Kapa Result = 0.944								

5.1. Assessment of Classification Accuracy

The overall 98 samples have taken from the classified image randomly. In which 40 samples belong to Agricultural Land, 20 belongs to Built-Up, 12 for Vegetation, 11 for Water bodies, 15 are related to Waste Land. The results in table 1 highlights that among the selected 40 samples for the Agricultural Land, 39 were accurately classified and 1 were wrongly classified on Vegetation. There for the user accuracy of the Agricultural Land is 97.50%. The total number of sample selected in built-up area was 20, in that 19 were exactly classified and 1 wrongly placed on the wasteland, which gives the accuracy rate 95.00% for the built-up in the classification accuracy. From the total 12 samples of Vegetation, only one was wrongly placed on the Agricultural land, which provided the user with an accuracy of 91.67%. 11 samples were collected in Water bodies and all 11 were accurately classified, which gives the accuracy rate of 100%. The selected 15 samples for the Waste land, placed correctly on 14 sample areas along with one sample on the Agricultural Land and one is on Vegetation, the classification accuracy of this class is 93.33%,

The results in Table 1 shows that the overall accuracy of 95.91 for the January 2019 image. Therefore the result generated from the error matrix depicts that the classified outcome of the land use and land cover is highly suitable for the scientific research. The Kappa marks the value of 0.944 which is equal to 94%. The result shows in Kappa also support the higher accuracy of classified result with the error matrix. The detailed report on the user accuracy, producer accuracy, overall accuracy and Kappa values are shows in Table 1

VI. LULC ANALYSIS OF CHAMARAJANAGAR REGION

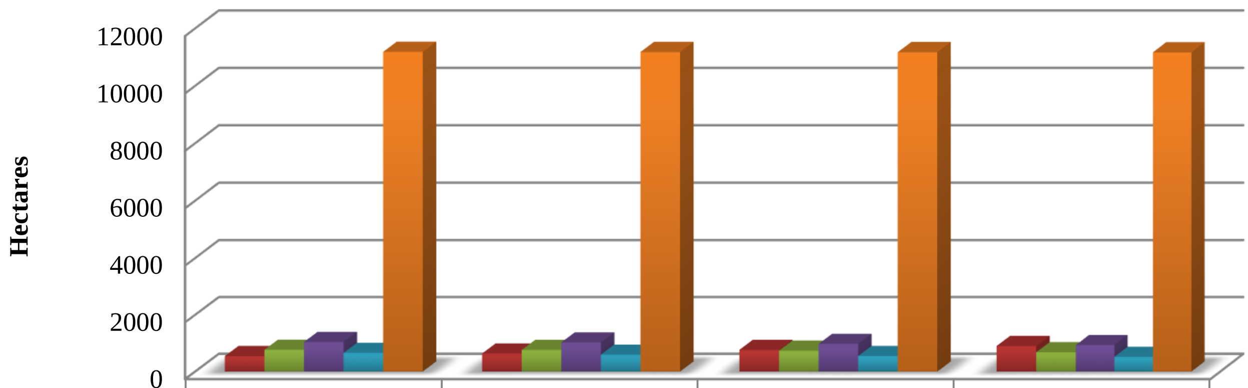
The table 2 represented the areal extent of land use/Land cover classes in the study area with major changes in all categories. There is a considerable increase in built-up areas were noticed. Decrease in Agricultural area, Vegetation, Waste Land and Water body is observed over last 4 decades.

Table. 2 Temporal Changes in Land Use Land Cover: Study area - Chamarajanagar

S.No	LULC Classes	Area in Hectares				Changes in Hectares			
		1991	2001	2011	2019	1991 - 2001	2001 - 2011	2011 - 2019	1991 - 2019
1	Built-Up	631.68	711.06	853.35	898.70	79.39	142.28	45.35	267.02
2	Vegetation	450.63	429.72	414.93	410.10	-20.91	-14.79	-4.83	-40.53
3	Wasteland	782.20	777.62	721.16	699.45	-4.58	-56.46	-21.71	-82.75
4	Water Bodies	324.16	315.52	276.90	267.59	-8.64	-38.62	-9.31	-56.57
5	Agricultural Land	12509.96	12464.71	12432.30	12418.81	-45.26	-32.41	-13.49	-91.16

In the 1991 the built-up area was 631.68 hectares, Vegetation was 450.63 hectares, Wasteland was 782.20 hectares, Water bodies were 324.16 hectares and Agricultural Land was 12509.96 hectares. During the year 2001 the built-up area was 711.06 hectares, Vegetation was 429.72 hectares, Wasteland was 777.62 hectares, Water bodies were 315.52 hectares and Agricultural Land was 12464.71 hectares. The classified result shows in 2011, the built-up were 853.35 hectares, Vegetation was 414.93 hectares, Wasteland 721.16 hectares, Water bodies were 276.90 hectares and Agricultural Land was 12432.30 hectares. When considering 2019 the built-up area was 898.70 hectares, Vegetation was 410.10 hectares, Wasteland was 699.45 hectares, Water bodies were 267.59 hectares and Agricultural Land was 12418.81 hectares.

figure 4. land use/land cover 1991 - 2019 : study area chamarajanagar



	1991	2001	2011	2019
Built-Up	543	632.76	762.15	899.02
Vegetation	764.42	760.42	733.43	678.63
Wasteland	1040.45	1024.56	972.61	930.68
Water Bodies	656.6	592.36	546.11	514.12
Agricultural Land	11179.1	11173.47	11169.27	11161.12

Figure 4 shows the temporal changes of the LULC results confirm that except in built-up area, there is a negative change in rest of the land use. The increase in built-up is steadily compensated by the reduce the area of Vegetation, Wasteland, Water bodies and Agricultural land.

Built-up land: Built-up area has been increased in all the selected periods. In 1991 to 2001 period the built-up area was 79.39 hectares. Between the years of 2001 to 2011 it has been increased to 142.28 hectares. From the years 2011 to 2019 the built-up area has been increased to 45.35 hectares than the previous decade. In overall study period of 1991 to 2019 it has elevated to 267.02 hectares, which clearly indicates the positive growth in built-up area.

Vegetation: The changes in vegetation for the selected time period was negative growth rate, as 20.91 hectares decreased from 1991 to 2001, 14.79 hectares were declined in the period of 2001 to 2011 and 4.83 hectares reduced between years of 2011 to 2019. The overall changes of vegetation during the entire study period were – 40.53 hectares. The outcome of the above table 2 clearly shows that there is a decreasing rate of vegetation in the study area.

Wasteland: Similar to the case of vegetation, the wasteland also decreased. During the year of 1991 to 2001, it was -4.58 hectares; in 2001 to 2011 it increased to -56.46 hectares and in 2011 to 2019, it has changed the rate of -21.71 hectares. The overall changes during the study period were -82.75 hectares.

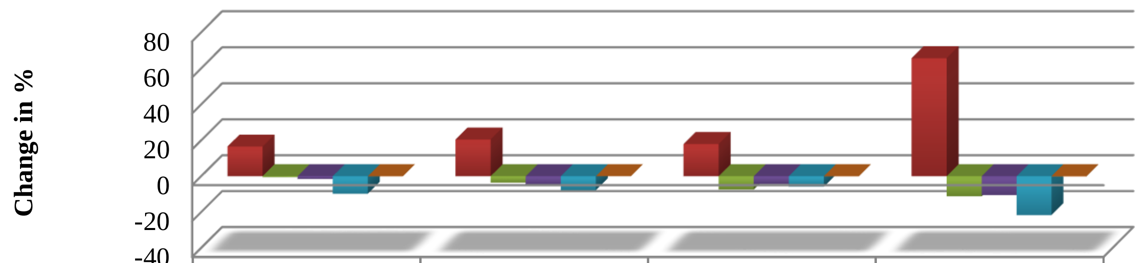
Water bodies: The changes of water bodies in the study area illustrate the negative trend following that of the Vegetation and Wasteland. During the period of 1991 to 2001 it was -8.64 hectares. In 2001 – 2011 it has been decreased again to -38.62 hectares and in 2011 - 2019 it has changed the rate of -9.31 hectares. The overall changes of water bodies for the study period were -56.57 hectares.

Agricultural Land: The temporal changes of Agricultural Land for the selected time period shows negative growth rate, as -45.26 hectares between the years of 1991 to 2001, -32.41 hectares were declined in the period of 2001 -2011 and -13.49 hectares reduced between years of 2011 to 2019. The overall changes of Agricultural Land during the entire study period were -91.16 hectares. The outcome of the above table clearly shows that there is a decreasing rate of Agricultural land in the study area and it is compensated by increasing trend in the built-up area.

Table. 3 Temporal Changes in Land Use Land Cover: Study area - Chamarajanagar

LULC Classes	Area (%)				Changes (%)			
	1991	2001	2011	2019	1991 to 2001	2001 to 2011	2011 to 2019	1991 to 2019
Built-Up	4.30	4.84	5.81	6.12	12.57	20.01	5.31	42.27
Vegetation	3.07	2.92	2.82	2.79	-4.64	-3.44	-1.17	-8.99
Wasteland	5.32	5.29	4.91	4.76	-0.59	-7.26	-3.01	-10.58
Water Bodies	2.21	2.15	1.88	1.82	-2.67	-12.24	-3.36	-17.45
Agricultural Land	85.11	84.80	84.58	84.51	-0.36	-0.26	-0.11	-0.73

figure 5. land use land cover changes in percentage: study area chamarajanagar



	1991 to 2001	2001 to 2011	2011 to 2018	1991 to 2019
Built-Up	16.53	20.44	17.96	65.57
Vegetation	-0.52	-3.54	-7.47	-11.22
Wasteland	-1.52	-5.06	-4.31	-10.54
Water Bodies	-9.78	-7.8	-5.85	-21.7
Agricultural Land	-0.05	-0.03	-0.072	-0.16

6.1 Land use Land cover changes in percentage

The percentage of the LULC class has been calculated to identify the changes that have taken place in the study area during the period of 1991-2001, 2001-2011, and 2011-2019. The built-up area has a positive change in its growth which was 12.57% in 1991-2001, 20.01% in 2001 – 2011 and 5.31% for 2011 – 2019. The overall growth rate of 1991-2019 was reached 42.27%. Whereas negative change is noticed in Vegetation that is -4.64% for the period of 1991-2001, and further decrease of -3.44% and -1.17% in its area during the years of 2001- 2011 and 2011-2019 respectively. The overall vegetation changes has taken place in its area was -8.99% for the period of 1991 – 2019. A negative change is witnessed in Wasteland which has been certainly converted into built-up area shares a similar trend. The wasteland has been changed -0.59% in 1991-2001, -7.26% in 2001 -2011 and further it has been changed to -3.01% in 2011 – 2019. In general wasteland lost 10% of its area in the study area (-10.58%) for the period of 1991 -2019. Similarly negative growth has been noticed in Water bodies and agricultural Land. For the period of 1991-2019, the area of the water bodies were recorded a negative growth of -17.45%. Agricultural Land has a very minimum negative trend has been observed (-0.73%) during the period of 1991 – 2019.

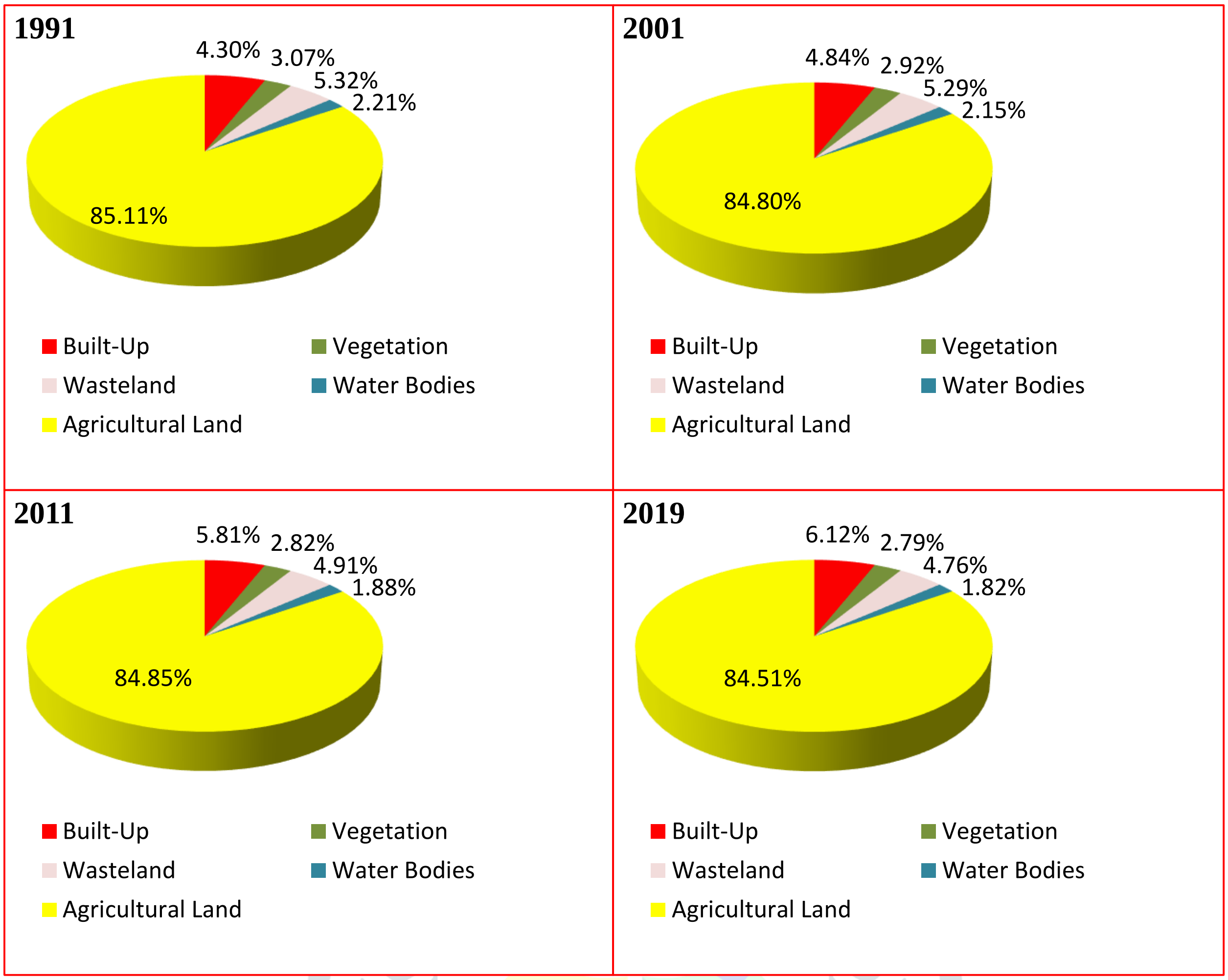


figure 6: spatial expansion of land usr land cover

6.2 Spatial Expansion:

The spatial expansion of each LULC class in the study area is graphically represented in Figure 6. The built-up area has a positive growth, which was 4.30% in 1991 and has increased to 6.12% in 2019. Wasteland and Vegetation cover has decreased from 5.32% to 4.76% and 3.07% to 2.79% respectively between the years of 1991 to 2019. Similar way Water bodies and Agricultural Land was decrease from 2.21% to 1.82 and 85.11% to 84.51 respectively from 1991 to 2019.

6.3. Spatio- temporal changes of LULC in Chamarajanagar region

The spatio-temporal changes of LULC information of Chamarajanagar region clearly indicate that the built-up area has a positive change in its growth. In the study area Chamarajanagar the overall growth rate during the study period was 42.27%. Whereas negative changes are identified in rest of the LULC classes (Vegetation, Wasteland, Water bodies and Agricultural land). The Agricultural land has a very minimum negative trend has been observed in the study area. In chamarajanagar it was -0.73% between the period of 1991 to 2019.

Finally from the change analysis of LULC between 1991 and 2019 it was observed that there is a increasing trend in built-up area, where as other classified classes has a decreasing trend. The significant change occurred in LULC between 1991 and 2019 is that conversion of Wasteland and Vegetative land 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 Chamarajanagar towns. The classified images clearly provide all the information to understand the Land Use and Land Cover of Chamarajanagar region.

VII. LAND USE AND LAND COVER PREDICTION

The prediction of future land use and land cover will be very much useful to the urban planning and natural resource management. LULC modeling is mounting rapidly scientific field. There are many modeling tools are using recent days, but the performance of different modeling tools area difficult to compare because LULC change models can be basically deferent in a variety of ways.

Among much land use land cover models and techniques, the commonly used models are Markov chain, Cellular Automata (CA), GEOMOD, etc. In this study, it is more required to estimate the land use changes over the time period and predict the future scenario of the study area Chamarajanagar. For this study the analysis is performed by a remote sensing based Land Change Modeler (LCM) method. The main aim of this study is simulating future urban expansion of the study area, from 1991 to 2031.

The IDRISI Selva is a module of LCM, which operates on the Markov chain. The LCM module has been used by LULC researchers, especially (Ahmed et al., 2013; K.S. Kumar et al., 2015; Mishra et al., 2014; Olajuyigbe et al., 2014), who have confirmed the acceptable accuracy of prediction using LCM.

7.1 Data required to the Markov Model

1. Classified Land Use Land Cover data in raster format
2. Distance to the nearest road
3. Distance to the nearest urban centers
4. Elevation
5. Slope

The distance to the nearest road, distance to the nearest urban centers, slope and elevation of the surface stand up the major impact on the changes in LULC in the study area. So these are the main input were used as the major driving forces in the LCM model for future prediction. While doing prediction of the changes from one LULC class to another, the threshold value of 100 hectares considered to assess the main change as well as strengthen the prediction results. The input data required for the Land Change Modeler is showed in Figure 7.

In the present study, the classified LULC imageries of 2001 and 2011 have been used to forecast the year of 2018. The result obtained from LCM model has been compared with those attained by the researcher that is shaped by supervised classification. The accuracy of the predicted image with the image classified by the researcher has been compared using the Map Comparison Kit software, which showed 87.98% of accuracy between the classified image and the predicted LULC images of Chamarajanagar region. Therefore 2001 and 2011 LULC classified results have been estimable to predict 2031 LULC of the study area.

VIII. MARKOV MODEL RESULTS

The result of the LCM model shows the future prediction of the land use. The predicted 2021 LULC results attained through the analysis gives the clear information that there is positive growth in built-up area, where as there is a negative trend in other land use classes in the study area. The table 4 provides the result of the study area. It clearly shows that there is an increase of 186.21 hectares of built-up land along with the shrinkage of 8.29 hectares of vegetation, 97.34 hectares of wasteland, and 16.53 hectares of water bodies and 64.06 hectares of agricultural land for the predicted year of 2031.

The result clearly depicts that the built-up area has a positive change in its growth. The percentage increase in built-up area of the study area, the growth rate is 20.72 %. The Agricultural land has a very minimum negative trend has been observed in the study area, it is -0.52% in chamarajanagar region.

Table 4. Predicted Land Use Land Cover 2031

S.No	LULC Classes	Area in Hectares		Changes (Hect.)	Change (%)
		2019	2031		
1	Built-Up	898.70	1084.91	186.21	20.72
2	Vegetation	410.10	401.81	-8.29	-2.02
3	Wasteland	699.45	602.11	-97.34	-13.92
4	Water bodies	267.59	251.06	-16.53	-6.18
5	Agricultural Land	12418.81	12354.75	-64.06	-0.52

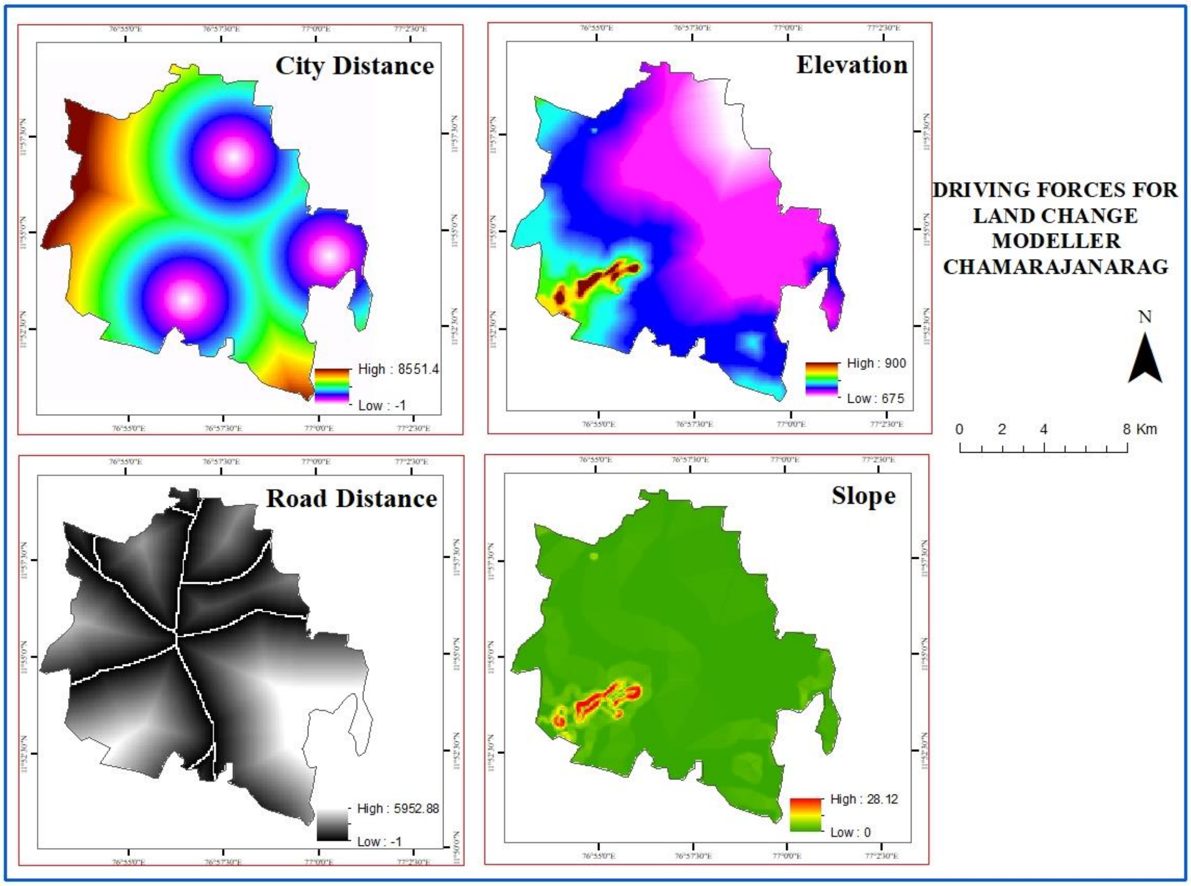


Figure 7. Spatial Parameters for LCM model

8.1 Accuracy Assessment of Prediction

To understand the accuracy level of 2031 prediction, 2019 years prediction was carried out using 2001 and 2011 classified images. The result obtained from LCM model (2019 predicted image) has been compared with those attained by the researcher that is shaped by supervised classification. The accuracy of the predicted image with the image classified by the researcher has been compared using the Map Comparison Kit software, which showed 91.8% of accuracy between the classified image and the predicted LULC images of Chamarajanagar region. Therefore 2011 and 2018 LULC classified results have been estimable to predict 2031 LULC of the study area.

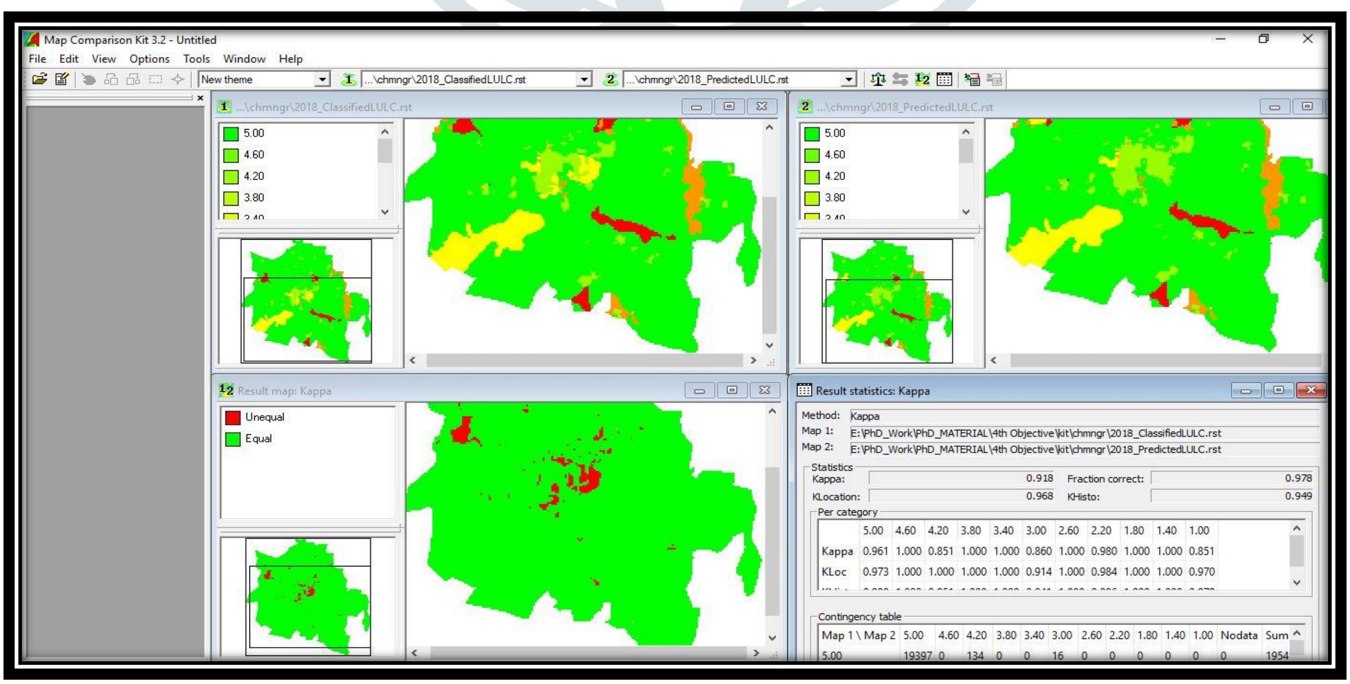


Figure 8. Comparison of classified and predicted LULC map

The Map Comparison Kit has been developed for the analysis and comparison of raster maps. The software developed by Research Institute for Knowledge systems and this software package is available to the public at the beginning of 2004, via the RIVM website. A raster comparison module of this model contained three comparison method has been programmed: (i) cell by cell, (ii) Hierarchial fuzzy pattern matching and (iii) the fuzzy set algorithm. After the confirmation of accuracy is in acceptable level, the prediction of 2031 is performed.

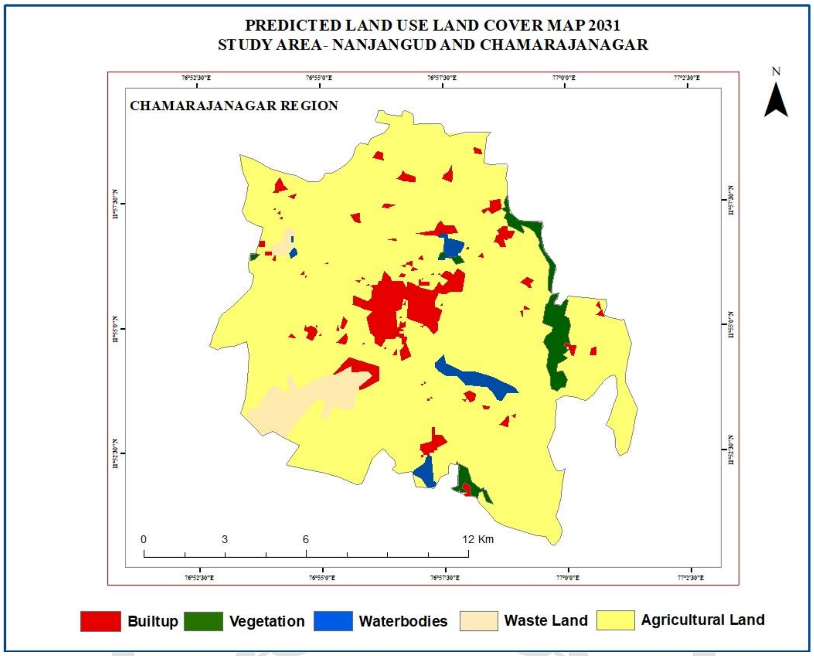


Figure 9 Predicted LULC map of 2031

CONCLUSION

Integration of temporal satellite data with Geographic Information System is helpful to visualise the urban growth. The incorporation of driving force in the modeling exercise provided a sensible picture of the urban growth. The LCM model output validated with the actual data (2019) showed reliability and good accuracy. The validations of LCM with driving forces are further used to simulate the land uses by 2031.The land use scenario illustrates a drastic increase in built-up area of the study area with the decline of wasteland and other category. The trajectory growth is a pointer to the town planners to prerequisite basic amenities apart from the protection of essential natural resources. Land use modeling with the integration of driving force into Markov and with GIS technology has supported in successful simulation of spatial changes and reliable forecast. This will helps the decision makers to plan sustainable town with the provision of basic amenities. The study helps the local land use planners and administrators with approaching to the dynamically evolving land use system for preserve the ecological entities and other forms of land uses.

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