International Journal of Civil Engineering and Technology (IJCIET)
Volume 16, Issue 2, March-April 2025, pp. 51-64, Article ID: IJCIET_16_02_003
Available online at https://iaeme.com/Home/issue/IJCIET?Volume=16&Issue=2
ISSN Print: 0976-6308 and ISSN Online: 0976-6316
Impact Factor (2025): 21.69 (Based on Google Scholar citation)
Journal ID: 6971-8185; DOI: https://doi.org/10.34218/IJCIET_16_02_003

ASSESSMENT OF CHANGE DETECTION AND FORECASTING OF LAND USE LAND COVER IN HEMAVATHI CATCHMENT, KARNATAKA, INDIA

Ashwini B
Research Scholar, Department of Civil Engineering, UVCE, Bangalore University, Jnanabharathi, Bengaluru 560056, India.

Shivakumar J Nyamathi
Professor, Department of Civil Engineering, UVCE, Bangalore University Jnanabharathi, Bengaluru 560056, India.

ABSTRACT

Land use and land cover assessment, combined with change detection establishes a dynamic component of environmental monitoring and supervision. It includes study of distribution and dynamics of various land use and land cover types within a region throughout the time. In this study, the area is categorized into five classes namely forest, cultivated land, uncultivated land, built-up land and water bodies. The assessment is carried out for the years 1990, 2001, 2013 and 2023 using Landsat satellite image by performing supervised classification. The accuracy assessment with reference to ground truth observations of google earth is investigated. The overall accuracy for year 1990 is 94.20%, for year 2001 is 90.00%, for year 2013 is 92.80 % and for year 2023 is 91.04%, the value of kappa coefficient for year 1990 is 0.93, for year 2001 is 0.88, for year 2013 is 0.91 and for year 2023 is 0.89. Land use land cover is predicted for *year 2030 and 2035. In the forthcoming scenario, the converted region is distributed to uncultivated land and built-up land classes. Subsequently, decision-makers are advised to take necessary measures to preserve agricultural land from changes, ensuring the sustainability of land.*

Keywords: Land Use Land Cover (LULC), LANDSAT, accuracy assessment, forecasting.

Cite this Article: Ashwini B, Shivakumar J Nyamathi. (2025). Assessment of Change Detection and Forecasting of Land use Land Cover in Hemavathi Catchment, Karnataka, India. *International Journal of Civil Engineering and Technology (IJCIET),* 16(2), 51-64.

https://iaeme.com/MasterAdmin/Journal_uploads/IJCIET/VOLUME_16_ISSUE_2/IJCIET_16_02_003.pdf

1. INTRODUCTION

Land use and land cover (LULC) analysis is a general term used to describe Earth surface, whether it is natural or manmade. Land use refers to the natural processes that arise on the Earth's surface, enclosing residential, commercial, industrial, cultivated, and recreational accomplishments. Alternatively, land cover portrays natural cover over the terrestrial surface, including forests, grasslands and water bodies. This analytical approach provides critical visions into the Earth's surface transformations, enabling informed decision-making progressions in urban planning, natural resource management, agriculture, forestry. Satellite imagery, aerial photographs, and other geospatial datasets act as important sources of data for accompanying such investigates. Land use and land cover analysis, combined with change recognition methodologies deals with significant insights into the changes of landscapes and environments which show a fundamental role in identifying and assessing modifications in land use and land cover over time.

The primary objective of this investigation is to recognize the changes occurring on land over a period and to know the alterations in future through forecasting. To fulfil the purpose of the objective Landsat satellite image is considered downloaded from https://earthexplorer.usgs.gov/ for the years 1990, 2011, 2013 and 2023 and change detection is studied. To check the accuracy of the analysis, accuracy assessment carried out by utilizing google earth, the result shows good overall accuracy and kappa coefficient. Further to know the future scenario it is projected for year 2030 and 2035. This study approaches gives a basis for evidence-based decision-making, fostering ecological progress and environmental management.

2. STUDY AREA

For the present study Hemavati Catchment up to M H Halli gauging station located in Hassan district having North Latitude of 12°49’08” and East Longitude of 76°08’00” (GOI CWC report 2012) is considered. The river takes birth in the Western Ghats at an altitude of about 1,219 meters nearby Ballalarayanadurga in the Chikmagluru district of Karnataka state, it flows through Hassan district where it is united by its chief tributary Yagachi River which lastly joins river Cauvery near Krishnarajasagara.

From the observed investigation of rainfall data from 1990-2022, the highest rainfall received is 7887.70 mm and the lowest rainfall recorded is 296.20 mm. The study region is outlined using ArcGIS, the catchment area has 3014 Sqkm and perimeter of 536 km as displayed in the figure 1. The catchment supports for agriculture in the surrounding area and the river is useful for drinking and other purposes.

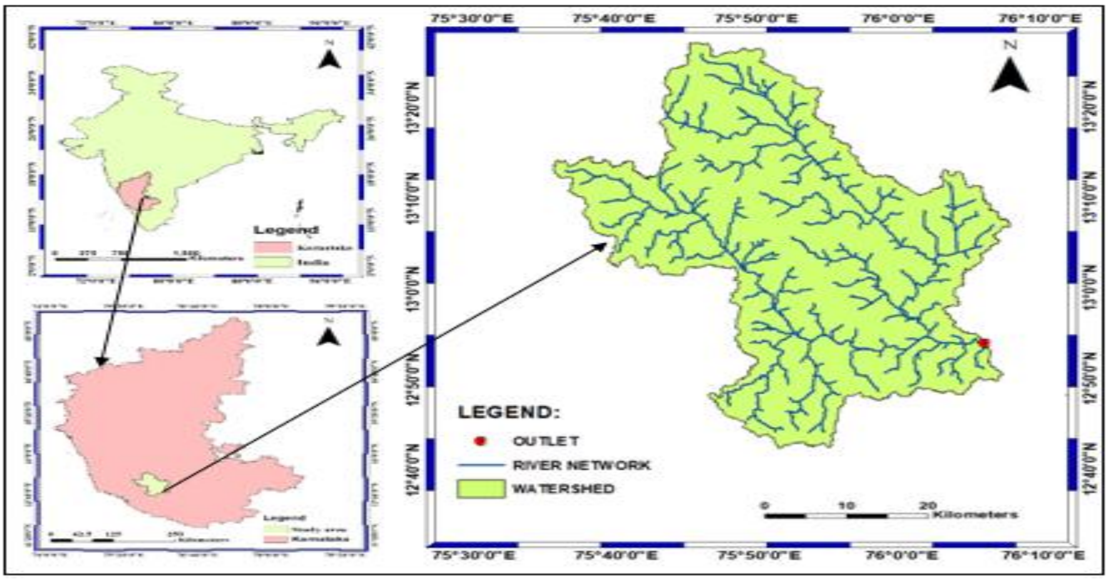

Figure 1. Location Map of Study Area

3. METHODOLOGY AND DATA ACQUISITION

The work flow process involved in doing LULC classification and forecasting is as specified in figure 2.

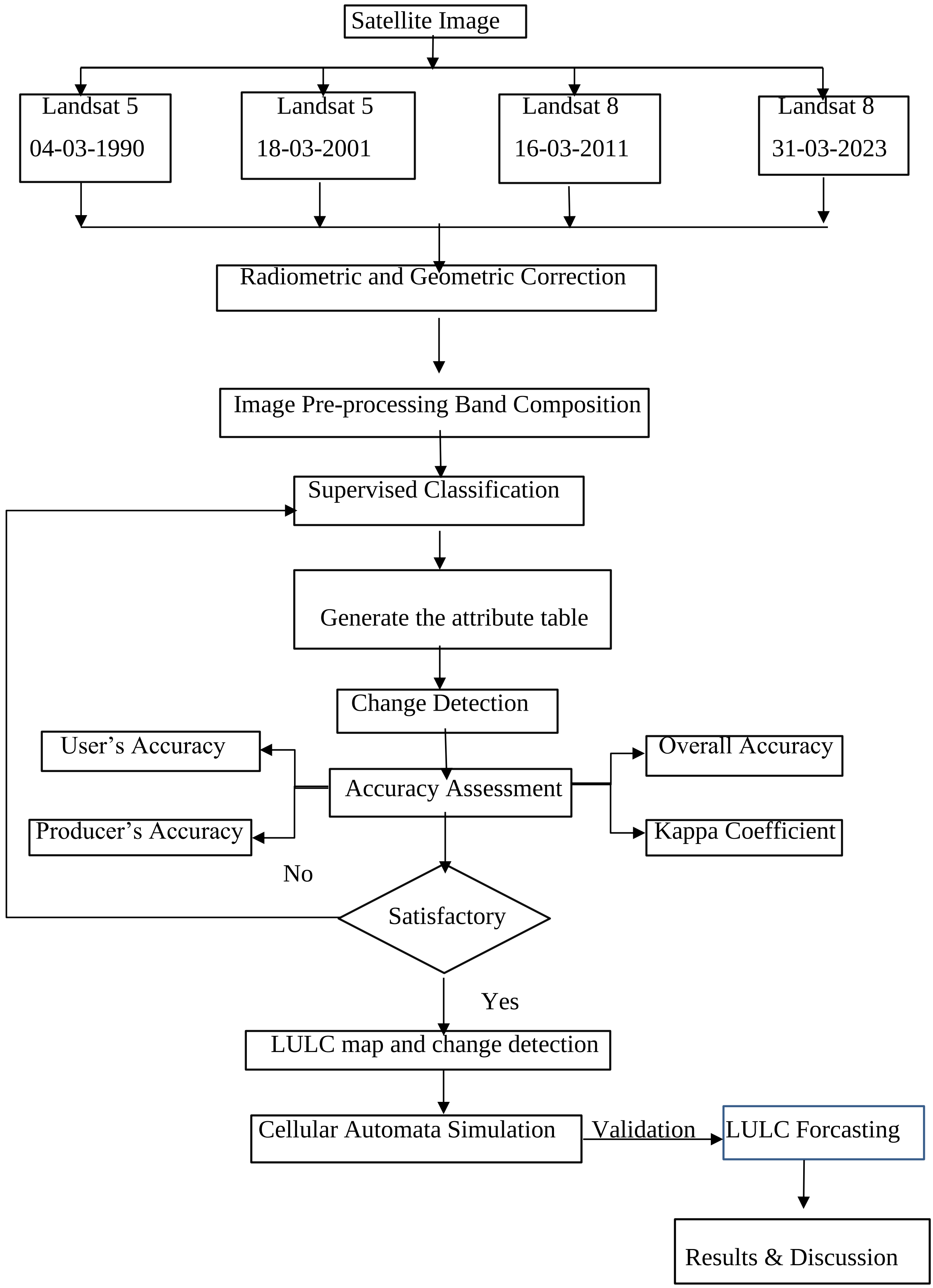

Figure 2. Work Flow Process for Forecasting LULC

For the current work satellite images of Landsat 5 TM dated 04.03.1990 and 18.03.2001 and Landsat 8 OLI_TIRS dated 16.12.2013 and 31.03.2023 Path/Row 145/051 having zero Land cloud cover with spatial resolution of 30m x 30m were used.

The land use and land cover information were extracted from these satellite images by geometrically registering them to the Universal Transverse Mercator (UTM 43N) coordinate system. A critical stage in satellite image processing is radiometric correction, which involves converting digital numbers to radiant reflectance values. While working with estimations from multiple remote sensing platforms, this correction becomes vital. To prevent errors during satellite image processing, radiometric corrections were applied to each band, prior to performing layer stacking. Atmospheric correction was verified using the following formula.

The formula used for TOA reflectance with a correction for the sun angle is,

$$\rho\lambda = \frac{\rho\lambda'}{Sin(\theta_{(SE)})} \text{ -------------- } (1)$$

Where:

$\rho\lambda$= TOA planetary reflectance.

$\rho\lambda'$ = TOA planetary reflectance without correction for solar angle.

θ_{SE} = Local sun elevation angle.

Accuracy assessment is accomplished by using of Google Earth Pro as ground truth data and calculated user's accuracy, producer's accuracy, overall accuracy and kappa co-efficient. The range of kappa co-efficient obtained have indicated almost perfect and the formulae used to find user accuracy, producer accuracy, overall accuracy and kappa coefficient is as revealed in the below.

$$\text{User Accuracy} = \frac{Number\ of\ correctly\ classfied\ pixels\ in\ each\ catogary}{Total\ Number\ of\ classified\ pixels\ in\ that\ catogary}\ x\ 100 \text{ ---- } (2)$$

$$\text{Producer Accuracy} = \frac{Number\ of correctly\ classified\ pixels\ in\ eah\ catogory}{Total\ Number\ of\ Reference\ pixels\ in\ tha\ catogary}\ x100 \text{ ----- } (3)$$

$$\text{Overall Accuracy} = \frac{Total\ number\ of\ correctly\ classified\ pixels}{Total\ number\ of\ reference\ pixels}\ x\ 100 \text{ ------------ } (4)$$

$$\text{Kappa Coefficient} = \frac{(TS\ x\ TCS\ ) - \sum(Column\ total\ x\ row\ total)}{TS^2 - \sum Column\ total\ x\ row\ total)} \text{ ---------------- } (5)$$

Where,

TCS is total number of correctly classified sample.

TS is total sample, for this assessment total sample of 500 is considered.

4. RESULTS AND DISCUSSIONS

For the investigation, five classes were considered they are forest, cultivated land, uncultivated land, built upland and waterbodies. The result of the map after converting to vector for year 1990, 2001, 2013 and 2023 are as displayed in figure 3, figure 4, figure 5, and figure 6 respectively and distribution of area in terms of percentage is as displayed in the table 1 for various classes as mentioned earlier.

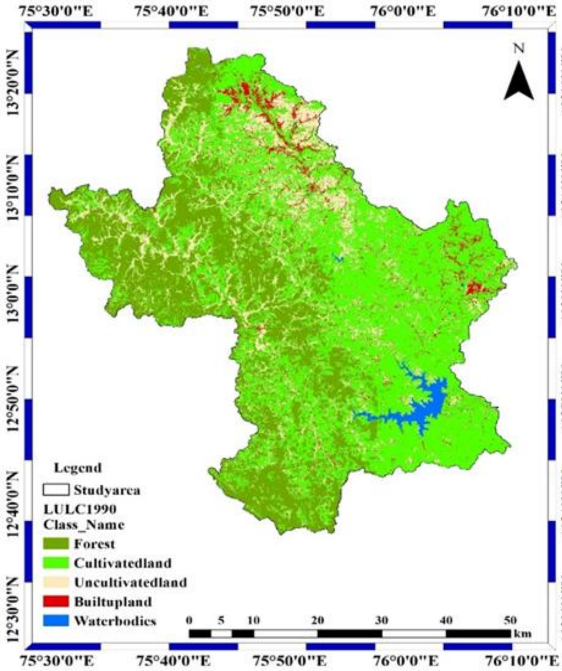

Figure 3. LULC Map of 1990

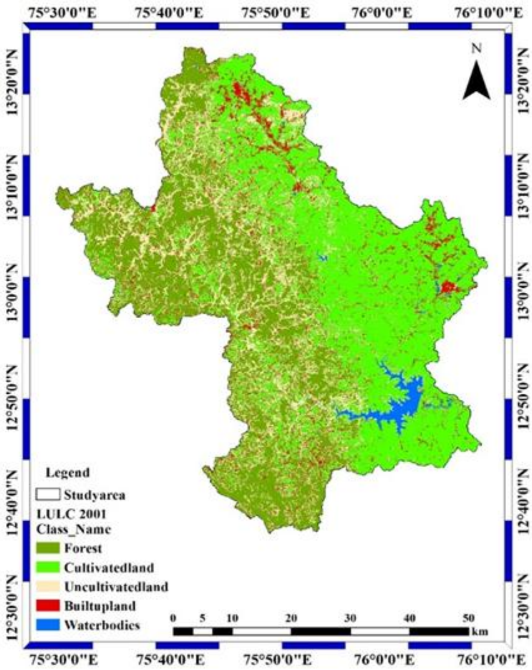

Figure 4. LULC Map of 2001

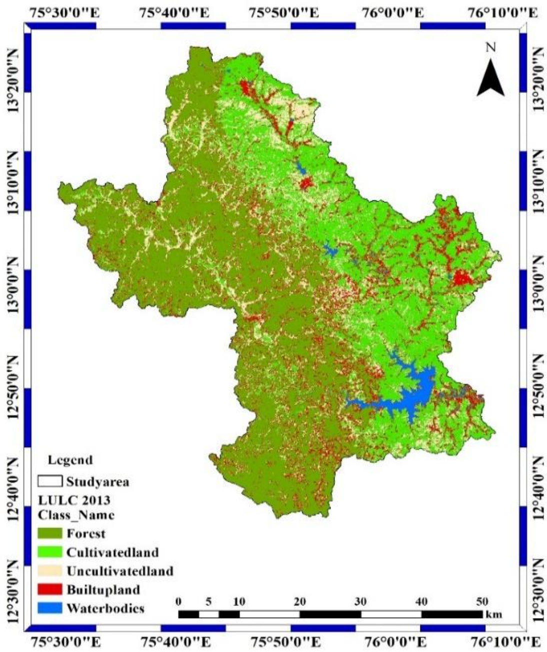

Figure 5. LULC Map of 2013

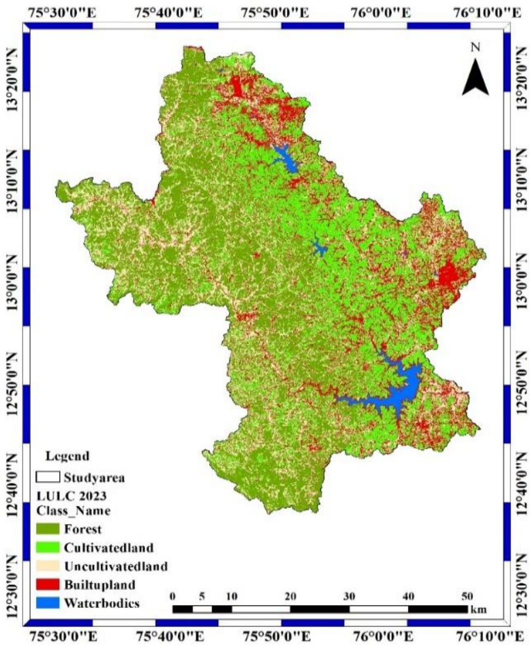

Figure 6. LULC Map of 2023

Table 1: Details of distribution of area in percentage from 1990-2023

SL No	Class Name	1990	2001	2013	2023
1	Forest	29.509	28.316	27.985	27.885
2	Cultivated land	51.463	45.213	41.577	28.914
3	Uncultivated land	13.701	17.312	16.52	23.403
4	Built upland	3.975	7.519	12.102	17.814
5	Waterbodies	1.352	1.64	1.816	1.984

Table 2: Details of user accuracy, producer accuracy, overall accuracy and kappa coefficient (1990-2023)

CLASSES	1990		2001		2013		2023	
	Producer Accuracy (%)	User Accuracy (%)	Producer Accuracy (%)	User Accuracy (%)	Producer Accuracy (%)	User Accuracy (%)	Producer Accuracy (%)	User Accuracy (%)
Forest	97.00	97.98	88.00	97.78	98.00	95.15	90.00	96.77
Cultivated land	96.00	88.07	93.00	84.55	97.00	80.83	95.00	83.04
Uncultivated land	97.00	93.27	91.00	87.50	85.00	95.51	92.00	89.32
Built-up land	85.00	97.70	83.00	90.22	85.00	97.70	85.00	92.22
Water bodies	96.00	95.05	95.00	91.35	99.00	98.02	95.00	93.14
Overall Accuracy	94.20%		90.00%		92.80%		91.04%	
Kappa Coefficient	0.93		0.88		0.91		0.89	

From the above table, the overall accuracy for year 1990 is 94.20%, for year 2001 is 90.00%, for year 2013 is 92.80 % and for year 2023 is 91.04%. Further the value of kappa coefficient for year 1990 is 0.93, for year 2001 is 0.88, for year 2013 is 0.91 and for year 2023 is 0.89 which shows the investigation carried out is almost perfect agreement.

Table 3: Change Detection area in percentage from 1990 to 2023

Classes	Forest	Cultivated land	Uncultivated land	Built-up land	Waterbodies
Forest	26.648	0.692	3.810	0.637	0.008
Cultivated land	0.845	23.873	13.321	10.514	0.265
Uncultivated land	0.392	4.214	5.216	3.914	0.083
Built-up Land	0.000	0.135	1.054	2.634	0.004
Waterbodies	0.000	0.000	0.002	0.115	1.624
Total area (%)	27.885	28.914	23.403	17.814	1.984

When it is compared area changes from 1990 to 2023, Forest has undergone changes into different classes, 26.648% of area is remained as forest, 0.692% of area is converted into cultivated land, 3.810% of area is converted as uncultivated area, 0.637% of area is converted into built-up land and 0.008 % of area is converted as waterbodies.

Cultivated land changed to different classes, 0.845 % of area is converted into forest, changes in cultivated land is 23.873%, 13.321 % of area as uncultivated land, 10.514 % of area as built-up land, 0.265 % of area as water bodies.

Uncultivated land changed to forest by 0.392 % of area, 4.214 % changed to cultivated land, uncultivated land is remained by 5.216 %, this is also changed to built-up land by 3.914 %, and to water bodies by 0.083 %.

Further Built-up land has not undergone any changes to forest, but converted into cultivated land by 0.135 %, uncultivated land by 1.054 %, built-up land remained by 2.634 % and water bodies by 0.004 %.

Also, no changes are occurred from waterbodies to forest and cultivated land, but however waterbodies have changed to uncultivated land by 0.002 %, built-up land by 0.115 % and increase in waterbodies has observed from the analysis due to which the catchment area has received more rainfall during the years, Therefore, the waterbodies area is 1.624 %. The details are tabulated in table 3.

5. LULC FORECASTING

Forecasting of LULC involves various techniques and data sources to forecast how land will be utilized for varied classes. Forecast of LULC guides socio-economic guidelines by knowing areas for development, investment opportunities etc., and it is essential to balance environmental sustainability in the present region. In this study the "MOLUSCE" plugin of QGIS (known as Land Change Modeler) tool is utilized to predict LULC based on historical maps.

Firstly, LULC maps of 2011 and 2013 were added and tested for geometry and area changes, then by the method of Artificial Neural Network (Multi-layer perception), neural network was trained then performed cellular automata simulation and map was simulated for year 2023 and then it is validated by the historical map of 2023 for this result the percentage of correctness was found to be 95.53 with overall kappa coefficient of 0.94, histogram kappa coefficient of 0.94 and location kappa coefficient of 0.99. The validated graph with respect to the historical map which is generated from the software is as presented in figure7. After the validation, LULC maps for year 2030 and 2035 were generated as presented in figure 8 and figure 9 respectively.

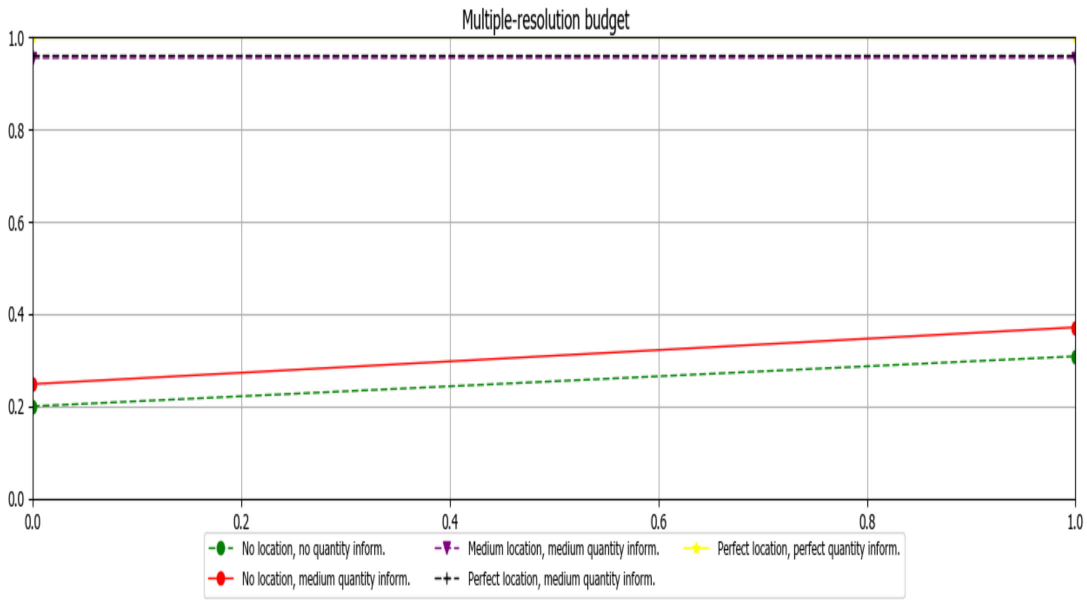

Figure 7. Validation of Model with respect to historical map

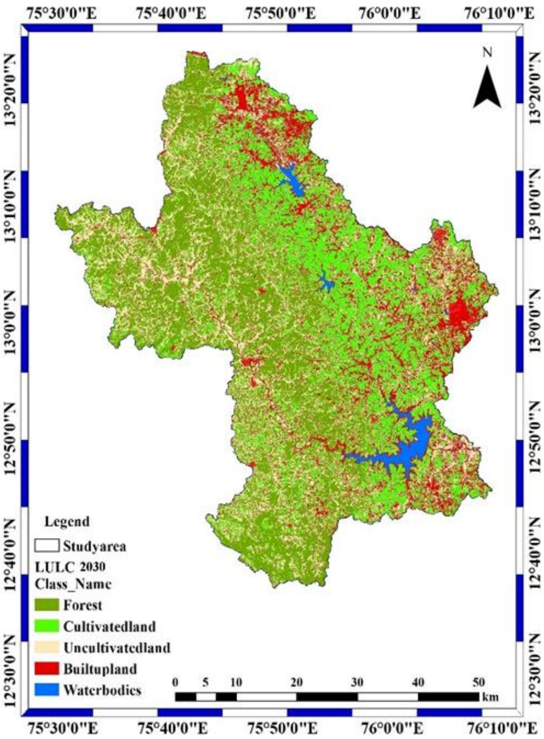

Figure 8. Forecasted LULC Map for 2030

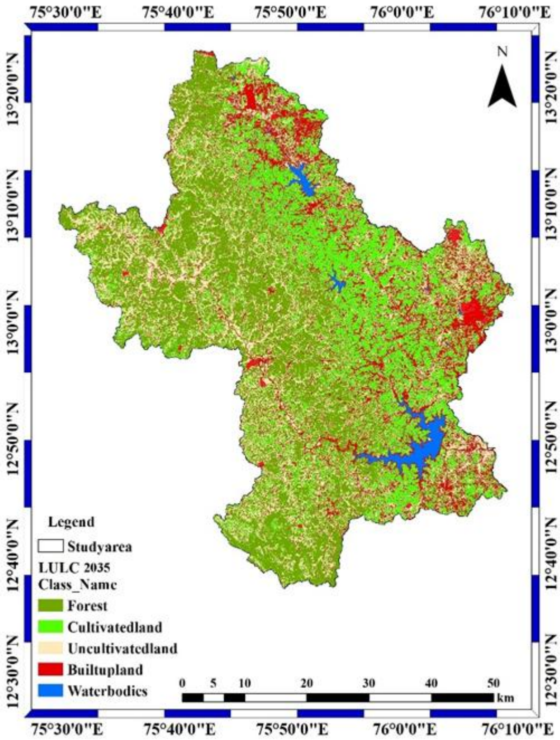

Figure 9. Forecasted LULC Map for 2035

Table 4: LULC area prediction for year 2030 and 2035

SL No	Classes	2030	2035
		Area (%)	Area (%)
1	Forest	27.885	27.885
2	Cultivated land	28.051	27.411
3	Uncultivated land	22.766	21.516
4	Built-up land	19.314	21.204
5	Waterbodies	1.984	1.984

Table 4 presents the forecasting of future LULC area changes in percentage for year 2030 and 2035. LULC area changes after forecasting for year 2030 for classes forest, cultivated land, uncultivated land, built-up land and waterbodies will be 27.885%, 28.051%, 22.766%, 19.314%, and 1.984% and predicted areas for year 2035 will be 27.885%, 27.411%, 21.516%, 21.204% and 1.984% respectively. Also, from the above table it is observed that, no changes have occurred in forest area and waterbodies area.

6. CONCLUSION

GIS and remote sensing are vital tools for effective LULC analysis and prediction, providing the data, analysis capabilities, and visualization needed to understand and manage land resources sustainably. QGIS especially MOLUSCE plugin is used to notice and evaluate the LULC change and to forecast future using cellular automata-Markov chain based simulation. The results specify the proficiency of open source GIS to run spatial analysis for land use changes study region.

From the analysis, changes from 1990 to 2023, decrease areas of forest and cultivated land has observed by 1.624 % and 22.549% respectively and also areas are increased for uncultivated land, built-up land and water bodies by 9.702%, 7.839% and 0.632% respectively. The changes in cultivated land and uncultivated land is quite natural which depends on the rainfall received during the period of cropping season and it also depends on cropping pattern and availability of water for irrigation.

Forecasted results for year 2030, shows that there are no changes in forest and waterbodies area, Cultivated and uncultivated area are decreased by 0.863% and 0.637%, but built-up area got increased by 1.500% by considering the reference year 2023.

Continuingly, when it forecasted for year 2035, the cultivated land and uncultivated land gets further decreases by 1.503% and 1.887% respectively, by considering the reference year 2023, built up area gets increases by 3.39% due to human activities, but the areas which belongs to forest and waterbodies remain unchanged.

The outcome of LULC change forecast, which was carried out using satellite images suggests that Built-up area will keep on expanding particularly by converting cultivated and uncultivated land to a greater extent. QGIS provided plugins, which played a great role in studies of this type of investigation and it is extremely useful for organizer to resolve the issue, which emerge because of environmental modification and human activities.

REFERENCES

[1] Abijith, D., & Saravanan, S. (2022). Assessment of Land use and Land Cover Change Detection and Prediction Using Remote Sensing and CA Markov in the Northern Coastal Districts of Tamil Nadu, India. Environmental Science and Pollution Research, 29(57), 86055–86067. https://doi.org/10.1007/s11356-021-15782-6.

[2] Aldiansyah, S., & Saputra, R. A. (2023). Comparison of Machine Learning Algorithms for Land Use and Land Cover Analysis Using Google Earth Engine (Case Study: Wanggu Watershed). International Journal of Remote Sensing and Earth Sciences (IJRESES), 19(2), 197. https://doi.org/10.30536/j.ijreses.2022.v19.a3803.

[3] Aneesha Satya, B., Shashi, M., & Deva, P. (2020). Future Land Use Land Cover Scenario Simulation Using Open Source GIS For the City of Warangal, Telangana, India. Applied Geomatics, 12(3), 281–290. https://doi.org/10.1007/s12518-020-00298-4.

[4] Bera, S., & Das Chatterjee, N. (2019). Mapping and Monitoring of Land Use Dynamics with their Change Hotspot In North 24-Parganas District, India: A Geospatial- and Statistical-Based Approach. Modeling Earth Systems and Environment, 5(4), 1529–1551. https://doi.org/10.1007/s40808-019-00601-2.

[5] Bhagyanagar, R., Kawal, B. M., Dwarakish, G. S., & Surathkal, S. (2012). Land use/land cover Change and Urban Expansion During 1983–2008 in the Coastal Area of Dakshina Kannada District, South India. Journal of Applied Remote Sensing, 6(1), 063576–1. https://doi.org/10.1117/1.jrs.6.063576.

[6] Chughtai, A. H., Abbasi, H., & Karas, I. R. (2021). A Review on Change Detection Method and Accuracy Assessment for Land use and cover. Remote Sensing Applications: Society and Environment, 22(February), 100482. https://doi.org/10.1016/j.rsase.2021.100482.

[7] Dubertret, F., Tourneau, F. M. Le, Villarreal, M. L., & Norman, L. M. (2022). Monitoring Annual Land Use/Land Cover Change in the Tucson Metropolitan Area with Google Earth Engine (1986–2020). Remote Sensing, 14(9). https://doi.org/10.3390/rs14092127.

[8] Garg, V., Aggarwal, S. P., Gupta, P. K., Nikam, B. R., Thakur, P. K., Srivastav, S. K., & Senthil Kumar, A. (2017). Assessment of Land Use Land Cover Change Impact on Hydrological Regime of a Basin. Environmental Earth Sciences, 76(18). https://doi.org/10.1007/s12665-017-6976-z.

[9] Hosseini, S. A. R., Gholami, H., & Esmaeilpoor, Y. (2019). Assessment of Land Use And Land Cover Change Detection by Using Remote Sensing and GIS Techniques in the Coastal Deserts, South of Iran. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives*, *42*(4/W18), 489–492. https://doi.org/10.5194/isprs-archives-XLII-4-W18-489-2019.

[10] Jalayer, S., Sharifi, A., Abbasi-Moghadam, D., Tariq, A., & Qin, S. (2022). Modeling and Predicting Land Use Land Cover Spatiotemporal Changes: A Case Study in Chalus Watershed, Iran. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, *15*, 5496–5513. https://doi.org/10.1109/JSTARS.2022.3189528.

[11] Kumar, M. P., Lakshmi, K. N., Prasad, T. L., Raju, N. J., & Hmanna, B. L. (2019). Land Use and Land Cover Analysis using Remote Sensing and GIS: A Case Study in and Around Bramhamgarimatam, Kadapa District, Andhra Pradesh, India. *International Journal of Geoinformatics and Geological Science*, *6*(1), 16–20. https://doi.org/10.14445/23939206/ijggs-v6i1p104.

[12] Mallupattu, P. K., & Sreenivasula Reddy, J. R. (2013). Analysis of Land use/Land cover Changes using Remote Sensing Data and GIS at an Urban Area, Tirupati, India. *The Scientific World Journal*, *2013*. https://doi.org/10.1155/2013/268623.

[13] Manjunatha, M. ., & Basavarajappa, H. (2020). Land Mapping and Its Change Detection Analysis in Chitradurga Taluk of Karnataka State, India using Geospatial Technology. *Academicia: An International Multidisciplinary Research Journal*, *10*(10), 360. https://doi.org/10.5958/2249-7137.2020.01148.9.

[14] Megahed, Y., Cabral, P., Silva, J., & Caetano, M. (2015). Land Cover Mapping Analysis and Urban Growth Modelling using Remote Sensing Techniques in Greater Cairo region-Egypt. *ISPRS International Journal of Geo-Information*, *4*(3), 1750–1769. https://doi.org/10.3390/ijgi4031750.

[15] Nalina, P., Meenambal, T., & Sathyanarayan Sridhar, R. (2014). Land Use Land Cover Dynamics of Nilgiris District, India Inferred From Satellite Imageries. *American Journal of Applied Sciences*, *11*(3), 455–461. https://doi.org/10.3844/ajassp.2014.455.461.

[16] Rahnama, M. R. (2021). Forecasting Land-Use Changes in Mashhad Metropolitan Area Using Cellular Automata and Markov Chain Model For 2016-2030. *Sustainable Cities and Society*, *64*(November 2019), 102548. https://doi.org/10.1016/j.scs.2020.102548.

Citation: Ashwini B, Shivakumar J Nyamathi. (2025). Assessment of Change Detection and Forecasting of Land use Land Cover in Hemavathi Catchment, Karnataka, India. International Journal of Civil Engineering and Technology (IJCIET), 16(2), 51-64.

Abstract Link: https://iaeme.com/Home/article_id/IJCIET_16_02_003

Article Link:
https://iaeme.com/MasterAdmin/Journal_uploads/IJCIET/VOLUME_16_ISSUE_2/IJCIET_16_02_003.pdf

✉ **editor@iaeme.com**