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Research Paper

Projecting Urban Footprint of the Kolkata Metropolitan Area through Machine Learning Algorithms and Stochastic Modelling Techniques

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ABSTRACT
Remote sensing and GIS play a crucial role in urban monitoring, thereby providing information on the land use and land cover pattern of urban scenes. Rapid urban growth is consuming other land use and land cover classes at an alarming rate. One of the serious consequences of it is the alteration of ecological balance. This study tries to simulate the future urban scenario through SVM a machine learning algorithms and Markov chain a stochastic modeling process. The alteration of the land use and the land cover pattern is continuing in the future also, therefore various planning policies and urban growth boundaries should be incorporated for mitigating the effect of the rapid urban footprint.
Keywords: *Remote Sensing and GIS; Urban Expansion; SVM; Markov Chain; Urban Growth Boundary*

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I. INTRODUCTION

Monitoring urban expansion and giving information on urban land use and land cover patterns are both important functions that are significantly aided using remote sensing and geographic information systems (GIS). This pattern of land use and land cover has been changed because of the fast growth of metropolitan areas, which may be efficiently investigated using a variety of machine learning methods and modeling strategies. Here Support Vector Machine and Markov Chain, a stochastic process were effectively utilized to derive the LULC map and built-up map from 2011-2031

II. OBJECTIVES

1. To study the urban growth of the Kolkata metropolitan area from 2011-2021
2. To derive land use and land cover classification (LULC) of the area using SVM
3. To explore the transition from all other classes to the built-up area
4. To derive a polynomial spatial trend map
5. To project LULC and built up the transition of 2031
6. To derive built-up maps from 2011-2031.

III. METHODOLOGIES

1. Downloading of LANDSAT satellite imageries
2. Derivation of land use and land cover classes of 2011 and 2021 through support vector machine (SVM) classifier.
3. Deriving built-up transition maps and polynomial urban trend surface
4. Transition potential maps of 2031 were derived through the SVM algorithm based on driving variables
5. Simulated map of 2031 based on Markov Chain techniques which is a stochastic process.

STUDY AREA

Kolkata metropolitan area which is the largest urban agglomeration of eastern India (Fig .1). The region is composed both of urban and rural components. the urban area is mostly urban centers while the urban area is surrounded by rural areas. River Hooghly runs through the metropolitan area exerting considerable influence on the area.

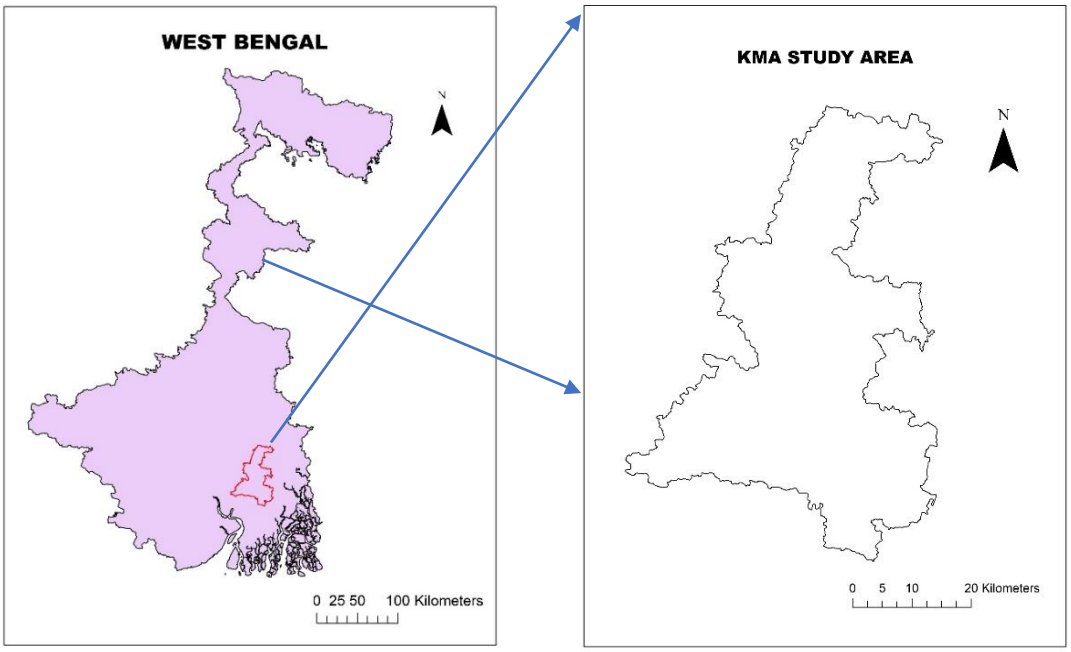

Fig 1. Location map of the study area

IV. RESULTS AND ANALYSIS

LULC classification

LANDSAT satellite imageries Collection 2 Level 2 is radiometrically and atmospherically corrected (Micijevic et al. 2021). So, no pre-processing is necessary. After downloading the imageries, vector training samples were carefully chosen and fed into Support Vector Machine classifiers for deriving a LULC map of the study area. Sun et al. 2015 utilized SVM techniques for conducting image classification. Two LULC images from 2011 and 2021 (Fig. 2) were derived which were further assessed through an error matrix (Obodai et al. 2019).

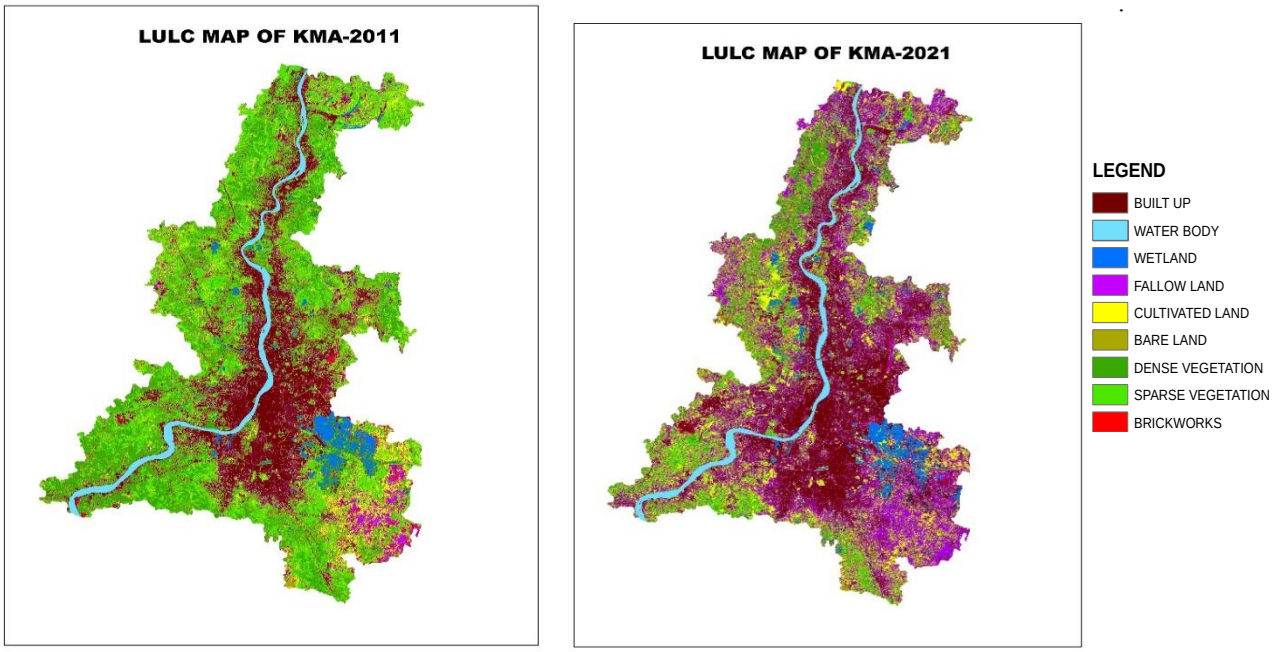

Fig 2. LULC map of KMA 2011-2021

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Built-Up Transition Map

Zhu and Woodcock 2014, studied change detection using Landsat data in their study. The built-up transition map of the Kolkata Metropolitan Area (KMA) was created via the use of change detection methods. This map illustrates the transition scenario from all other regions to built-up, hence suggesting a considerable rise in built-up at the expense of other LULC classes. Change detection is an effective tool for capturing the transition scenario from one class to another. In their study, Kundu et al. 2020 documented change detection in the Kolkata context.

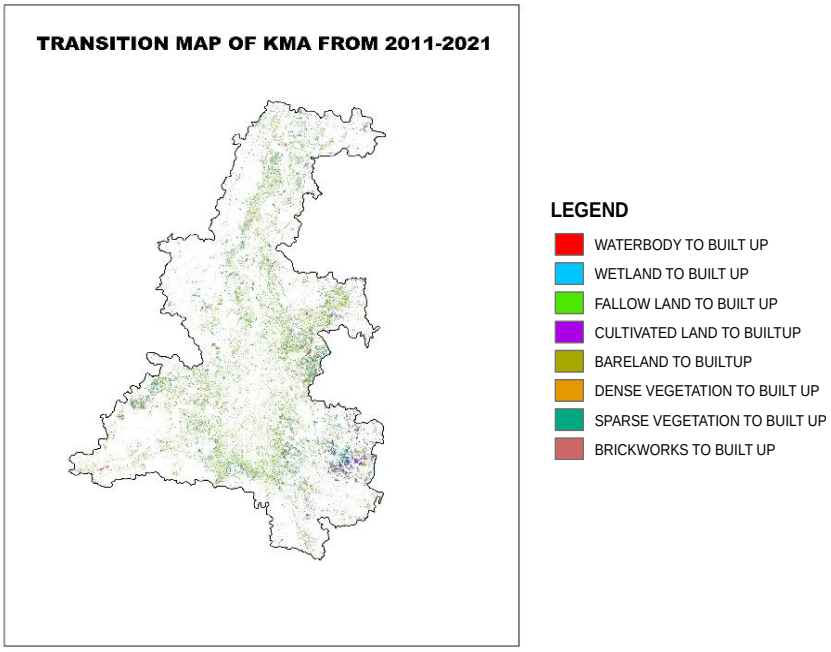

Fig 3. Transition map showing the transition of all other classes to built up

Polynomial Spatial Trend Map of KMA

The polynomial spatial trend map of KMA indicates the trend surface of built-up concentration. The red area indicates the highest built-up, concentration thereby decreasing from the core towards the peripheries (Fig 4.)

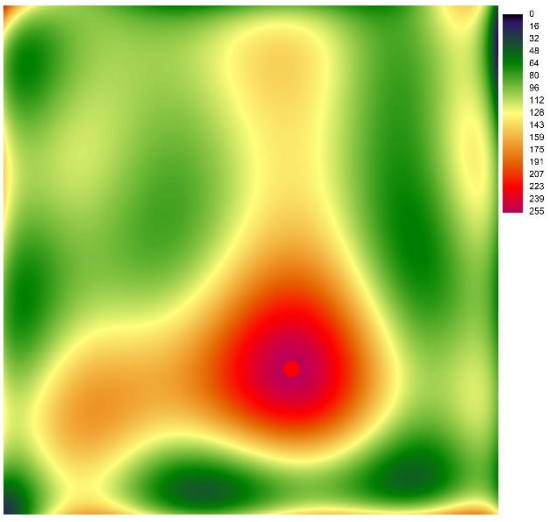

Fig 4. Polynomial Spatial Trend Map of KMA

Built up and Projected built up map of KMA

The LULC map was used to construct the built-up maps for 2011 and 2021, and the transition potential modeling via SVM approaches based on driving factors was used to derive the projection potentiality of 2031. Both of these processes were carried out in order to determine the projection potentiality. In addition, projection potentiality was employed as the basis for using the Markov chain approach to anticipate the simulated LULC and built-up map for the year 2031 (Fig 5.) Okwuashi & Ndehedehe 2021, well-documented urban modeling through coupling Markov Chain -Cellular Automata modeling techniques.

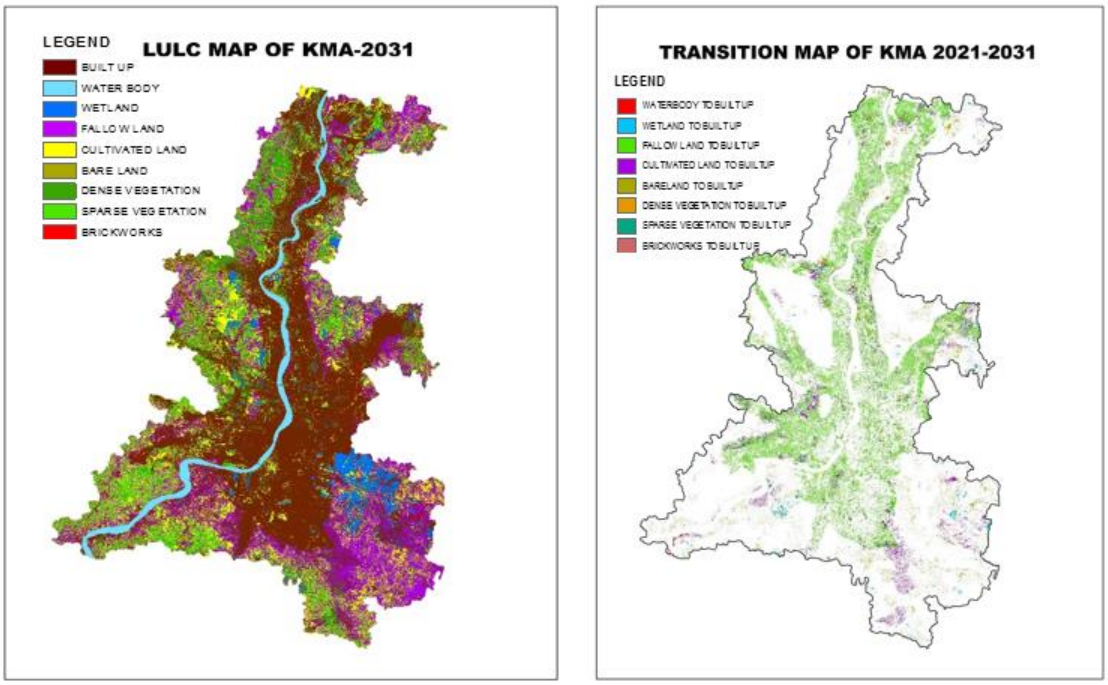

Fig 5. Projected map of KMA 2031 and transition map of KMA from 2021-2031

Built up maps from 2011-2031

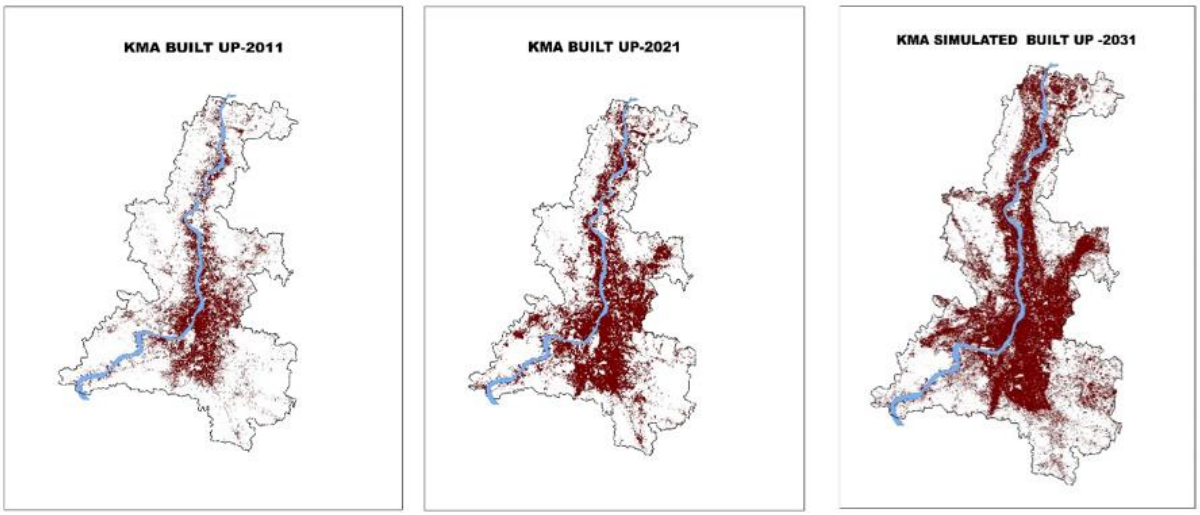

Fig 6. Built Up Maps of KMA From 2011-2031

The built-up maps of 2011,2021,2031 were derived through reclass procedures. It can be easily visualized from the map (Fig 6.), how built-up expansion is taking place and it is occurring both as a concentrated as well as fragmented urban patches.

V. CONCLUSION

In this study, a support vector machine approach is used against a geographical and temporal backdrop in order to investigate the many forms of land use and land cover that occurred between 2011 and 2031. By generating a map of the Kolkata metropolitan area (KMA) from 2011 to 2021 and a simulated map of 2031 using the Markov process, one may see one possible outcome of how urbanization is affecting the LULC pattern. As a result of human interference in the form of urbanization, the findings of this study demonstrate the critical need of enhancing the management of urban sustainability.

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