Urban growth modelling using SLEUTH: A case study of Vijayawada city, India

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Keywords:Cellular Automata, Modeling, Monte Carlo, SLEUTH, Urban

Abstract

The knowledge of Land Use Land Cover (LULC) of an area is essential not only to know the current status but also to plan for future challenges on the environmental processes in order to ensure sustainability of the available resources (James et al. 1976).The Land Use- Cover Changes (LUCC) has both positive as well as negative impacts on the physical, chemical and biological processes of the earth surface. Though LUCC has beneficial effects on the human community in terms of economic and social growth, it has adverse impacts on the regional and global scale affecting climatic conditions, in addition to vegetation and hydrological conditions at local scale. A significant change observed in LUCC is rapid urbanization. Urbanization is a process of metamorphism of the rural or sub-urban area into a modern and developed urban area. This is further promoted by the continuous immigration of people to a well-developed urban center that satisfies their economic needs. Over time as the urban center reaches a saturation point where no further development can be accommodated, the necessity for encroachment of undeveloped areas in and around the urban centers takes place resulting in the extension of the built up area. As an example to above cited context, the current study aimed at modelling the future urban growth of Vijayawada, an ever growing city of Andhra Pradesh state, India using the Cellular Automata (CA) based SLEUTH (Slope, Land use, Exclusion, Urban extent, Transportation, Hill shade) model developed by Keith Clarke in 1998. CA are simple mathematical magnifications of physical system in which space and time is discrete, and physical quantities take on reproduction of finite set of discrete values (Wolfram 1983). CA follows highly localized neighborhoods where changes takes place purely as a function of what happens in the immediate vicinity of any particular cell. The CA approach achieves a greater level of spatial details and a better virtual reality to match the outcomes with the generalized theories of structural evolution (Monjure 2015). Silva and Clarke (2002) recommend SLEUTH as a universally applicable model to study the evolution of cities; increasing the spatial resolution and specifications on the input data makes the model adapt easily to the local conditions; brute force functionality helps in achieving finer calibration of the model. SLEUTH is a modified CA urban growth model that effectively predicts the growth of a city under different types and controlling factors viz., spontaneous growth, new spreading center, edge growth and road influenced growth controlled by dispersion, breed, spread, road gravity coefficients, and slope of the terrain respectively. The model consists of two sub-models: Urban Growth model (UGM) and Deltatron Land Use / Land Cover model (DLM).The UGM effectively models the growth of the city while the DLM highlights the non-urban land use transitions in the growth. Working of the model can be summarized into three phases as testing phase, calibration phase and prediction phase (Clarke et al. 1997). Testing phase checks for the accuracy of the input data requirements; calibration phase involves training and improving the model to achieve best fit; and the final prediction phase. As the name of the model indicates, slope of the terrain, hill shade representing the morphology of the study area, historical land use maps, historical urban extent maps, exclusion layer indicating areas restricted for urbanization, and road network map satisfy the input data requirements to the model. LULC maps derived from Landsat series of satellite imageries from 1990, 2000, 2010 and 2018 were used to test and calibrate the model. The model was tested and predictions were done for different scenarios of growth rates and types. A comparison between the modeled urbanized pixels for the year 2018 with the manually classified output of the same year proved the reliability of the model at final calibration (Fig. 1(a), (b)). Model output on predicting the urban growth indicate that the available open spaces within the existing city extent gets further converted to

built-up, and more growth along the fringes of the existing city. Also, emergence of new urban centers merged with the existing city areas for predictions till 2040 and extended into the dense vegetation on the north resulting in further reduction of green cover around the city. The stability of the model to predict the future extent of the city till 2100 was also analyzed. It was inferred that the model is more reliable for predicting urban growth of Vijayawada till 2030 and is acceptable with further finer calibrations for predictions only till 2040. Model validation and prediction ensures that SLEUTH is a reliable model to forecast growth of a city. The work is being carried out on different growth rate scenarios and controlling coefficients for the emergent years and on different study areas.

a b

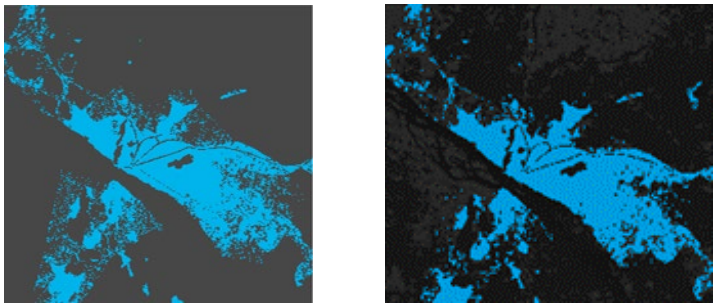

Fig. 1. (a) Actual Urban extent map in 2018; (b) Predicted Urban extent map in 2018

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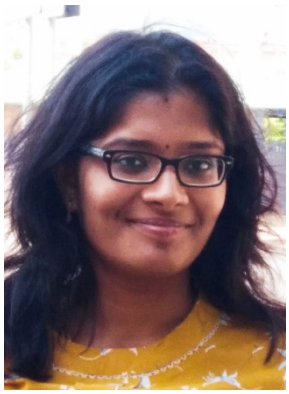
Author/sBiography



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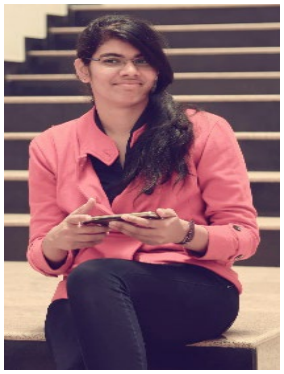

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