

Prediction and Simulation of Land Use and Land Cover Changes Using Open Source QGIS. A Case Study of Purwokerto, Central Java, Indonesia

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Abstract Population size multiplies along with the increasing need for residential space. As often occurs in developing cities like Purwokerto, population growth is associated with land use/land cover (LULC) change to accommodate housing demand both in the present and future. Therefore, this study was intended to map LULC changes in three different years: 2008, 2013, and 2018, and predict the change in 2023. For LULC data extraction, a pixel-based digital classification with a maximum likelihood algorithm was applied to Landsat images. In addition, the LULC change prediction was modeled with Modules for Land Use Change Simulations (MOLUSCE) from the QGIS plugins. It used two algorithms: artificial neural network (ANN) with a multilayer perceptron (MLP) and cellular automata (CA). The LULC classifications for 2008, 2013, and 2018 were 88%, 86%, and 88% accurate, while the prediction was 75.26% accurate, with a kappa of 0.634. Predictions and simulations indicate fluctuations in LULC change in the City of Purwokerto periodically, especially for built-up land, showing growth that continues to increase significantly.

1. Introduction

Land use and land cover change (LULC) change is one of the indicators for urbanization process. The influence of human activities on landscape is the main driving factor for the LULC change process in an urban area (Liu et al., 2020). LULC change is related to environmental change and ecological shift, the expansion of built-up land will encourage the loss of green space, loss of agricultural land, and affect the local urban climate to increase the regional economy (Muhammad et al., 2022).

The simulation model helps to know the transition of changes in the past to the present, to find out the transition patterns and generate predictions in the future from the detected transition patterns. Several simulation models of change and spatial distribution that are successful in predicting the direction of change in LULC are Markov-chain, cellular automata, cellular automata-artificial neural network, and artificial neural network-Markov chain (Kaswanto et al., 2021; Muhammad et al., 2022). MOLUSCE is able to perform LULC change prediction can be modeled with the artificial neural network (ANN), specifically multilayer perceptron (ANN-MLP), and cellular automata algorithms.

Purwokerto is developing through the trade and service sector. The development was triggered by the regional identity as the best educational area and its history as a trade transit center between the eastern and western parts of Java. A study by Munggiarti and Buchori (2018) found that the existence of a public campus at the Universitas Jendral Sudirman in Purwokerto also increased the change in LULC by 81.2% in a radius of 1 Km. The spatial structure of Purwokerto gives rise to a corridor area along the road that expands the function of urban land. Through the Regional Medium-Term Development Plan, every five-year period a development policy is established to achieve long-term development. In this study, detection

of changes in LULC was carried out according to the RPJMD period, namely 2008 to 2013 and 2013 to 2018 to determine the transition process.

The spatial-temporal approach produces geographical patterns and temporal patterns caused by several driving factors. Pattern identification requires time series data containing information on the spatial distribution of landscape changes. Remote sensing data capturing landscape changes in particular pixels because each pixel captures responses to geographical features of the electromagnetic spectrum (Jensen, 2015). Remote sensing satellites have captured the earth's surface for decades and produce huge data sets that are real time and time series. Integrating remote sensing with GIS is applied in this study using open source QGIS. The application of MOLUSCE still needs to be explored, so it helps to develop the proper use of the open-source MOLUSCE method widely.

Modeling in MOLUSCE uses two sets of data: LULC and driving factors its change. These factors include the distance from the city center, distance from the river, distance from the main road, slope, and elevation. The selection of driving factors is considered from the spatial structure of the Purwokerto city area and the influence of terrain conditions which are mountainous landscapes. Mapping of LULC changes in the city of Purwokerto can be used as a recommendation in the city development as the proposed new autonomous region. For this reason, the study aimed to map the LULC condition in 2008, 2013, and 2018 and predict LULC changes that would potentially occur in 2023 in PNAR Purwokerto.

2. Methods

Study Area

The research location is proposed new autonomous region (PNAR) Purwokerto (Figure 1), part of the regional expansion plan of the Banyumas Regency (Radar Banyumas,