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Surabaya land cover prediction based on Landsat Satellite using the Multi-layer Perceptron Method

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Abstract
Infrastructure development has occurred very rapidly in Surabaya in the last few decades. There is pressure on the need for land use in line with the increase in population. This study aims to analyze changes in land cover with inter-decade analysis and predict land cover in 2021-2030 in Surabaya using the Multi-Layer Perceptron method. The data used in this research is Landsat satellite which is considered good in representing the actual land cover. A decrease in the amount of vegetation occurs every decade in Surabaya, while the number of buildings is increasing and the bodies of water are relatively the same. The Multi-Layer Perceptron method has a good level of accuracy in predicting land cover in the city of Surabaya. In 2021-2030 it is predicted that Surabaya will still experience an increase in the number of buildings and a decrease in the amount of vegetation.

1. Introduction

Population growth has become an issue that cannot be avoided anymore. The need for housing is the main priority for the community. The pressure of increasing population and infrastructure development has caused urban areas to become hot spots in climate change due to the increase in the frequency and intensity of heat [1]. Changes in land cover greatly impact the local circulation that occurs in urban areas. The replacement of vegetation with buildings causes a significant increase in surface temperature [2]. Any change in infrastructure results in a change in the heat-receiving material or material on the surface. Road and building materials usually have a higher thermal capacity than vegetation. So that if there is a significant change in land cover it will cause adverse effects in urban areas in the form of an Urban Heat Island (UHI) [3].

At this time the use of satellite imagery has been widely used as an alternative to observing the types of land cover on the earth's surface [4]. The use of satellite imagery has the advantage of making good spatial observations and is more effective in making observations in large areas. In addition, satellite imagery has long historical objectivity and data in observing the earth's surface. The Landsat satellite, which is the first earth surface observation satellite, has a spatial resolution of 30 meters which is considered good in describing the shape of the earth's surface. The working principle of the Landsat satellite itself uses electromagnetic waves to make observations. In principle, every object has special characteristics in reflecting electromagnetic waves so that the satellite can identify each object with a different classification. Each band has a different wavelength so each object will receive a different treatment. Prediction of land cover changes is vital in preparing distribution patterns of settlements and green open land as a climate change mitigation measure. There are several techniques for predicting land cover change using Landsat satellite imagery, such as Markov Chain (MC), Cellular Automata (CA), regression analysis, and Multi-Layer Perceptron (MLP). Several supporting parameters can be used to predict land cover such as elevation, slope, distance from the main road, rivers, and so on [5].
The city of Surabaya is the capital of the province of East Java which has a very rapid development. Several previous studies have shown that metropolitan cities in the world are significantly affected by UHI due to changes in land cover in urban areas [6]. The existence of research on UHI is very important for the process of urban and environmental planning and its relation to microclimate interactions and

human activities. This study aims to analyze land use changes in Surabaya and make predictions about its future land cover. The results of this study can provide a better understanding of changes in land cover in the city of Surabaya which can be used as a master plan for urban planning in the future.

2. Methodology

The research was conducted in the city of Surabaya which is the capital of the province of East Java and a city that has developed very rapidly in the last few decades. This study uses Landsat 5, 7, and 8 Path 118 Row 65 imagery data from 1991-2020 from the United States Geological Survey (USGS) which can be downloaded via the website http://earthexplorer.usgs.gov/. The analysis is carried out on a decadal or tenth-year basis. The analysis was carried out by taking the median values in 1991-2000 (decade 1), 2001-2010 (decade 2), and 2011-2020 (decade 3). The first stage in the research process is the collection of Landsat satellite imagery data. The Landsat satellite imagery is processed and resampled to a resolution of 30 m[7]. Before being processed, Landsat satellite imagery data is filtered with a total cloud cover of <10% so that there are not many disturbances in the form of clouds that affect the results of observations of Landsat satellite imagery. Radiometric correction is then carried out to remove the effects of atmospheric interference and produce a better image [8]. The final step in the pre-processing step is cloud masking. or the process of removing clouds in the study area (Figure 1).

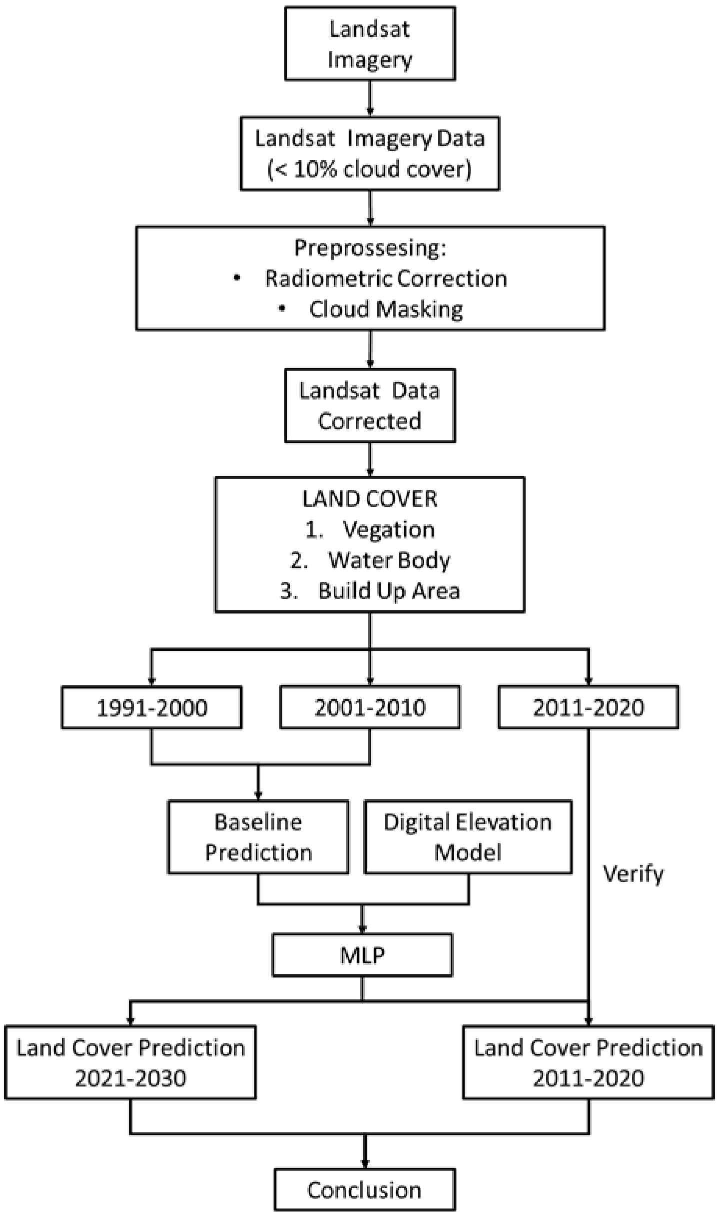

Figure 1. Research flowchart

The land cover analysis is divided into 3 types of land cover, namely vegetation, buildings, and water bodies. The three types of land cover were chosen because they have a special reflectivity value for each type. The determination of land cover classification is based on the Classification and Regression Tree (CART) method. Each monochromatic channel from the Landsat satellite is used as training and test data. CART is a classification method that uses historical data to decide class determinations. In principle, CART divides into smaller groups with increasing similarity in the dependent variable within each group and meanwhile with increasing differences in the size of the dependents between the newly formed groups. The CART algorithm will find the best separation between classes so that it can determine the class division [9].

The Shuttle Radar Topography Mission (SRTM) data is radar observation data to obtain high-resolution topography of the earth's surface. Digital Elevation Model (DEM) data from SRTM in this study is used as an independent variable in carrying out the MLP process. MLP is a layered neural network in which information flows one way from the input layer to the output layer, bypassing the hidden layers. The performance of MLP model depends not only on the selection of variables, the number of hidden layers, nodes, and training data, but also on training parameters such as learning rate, momentum controlling weight change, and number of iterations. [10]. In modeling land cover change, the analysis of the complex relationships between land transitions and the large number of variables that act as drivers requires advanced empirical techniques to find nonlinear functions that describe these complex relationships[11]. In this study, the MLP process was processed using the MOLUSCE plugin in the QGIS application. Land cover in decades 1 and 2 is used as the baseline for land cover prediction, while land cover in decade 3 is used as a verifier of prediction results. After obtaining good accuracy values, then predictions are made for the next decade.

3. Results and discussions

3.1 Land Cover Classification.

Land cover classification is divided into 3 types: buildings, vegetation, and water bodies. The accuracy rate of the 100 land cover sample points that have been tested in Surabaya is 96%. This accuracy value is considered to represent the actual land cover of Surabaya. Based on the results of the land cover sample test, the Landsat satellite is considered to be able to detect building areas and water bodies properly. In contrast to the type of vegetation, there were still detection errors in 2 building samples and 2 water body samples. The development of urbanization in Surabaya occurred very quickly in the 1991-2020 period. Land cover changes occurred significantly, from vegetation to building areas (Figure 2). The development of Surabaya is centered on the central region and will develop more dominantly in a west-east direction until 2020. In addition, the distribution of water bodies in Surabaya is dominated by ponds on the east, north, and west sides.

In decade 1, the percentage of vegetation area dominates 48.11% of the area of Surabaya, then in decade 2, the building area is more dominant with a total of 30.84% and in decade 3 more than half of the area of Surabaya is a type of building land cover (57 .01%) (Figure 3). It was detected that the vegetation area was decreasing every decade, with a decrease in the area of 38,072 km^2 between decades 2 and 1 and 20,047 km^2 between decades 3 and 2, then a significant increase in a built-up area of 66,098 km2 between decades 2 and 1 and an increase in a building area of 31,131 km^2 between decades 3 and 2. In contrast to land cover types of vegetation and buildings, water bodies experienced a smaller decrease in area, namely 5.138 km^2 between decades 2 and 1 and 11.085 km^2 between decades 3 and 2. Changes in land cover in Surabaya occurred very rapidly. fast. The most significant development occurred in 2001-2010 with changes in vegetation to buildings covering an area of 76.29 km^2. Several areas have changed from buildings to vegetation with an area of 10.62 km^2 in decade 1 to decade 2 and 13.86 km^2 in decade 2 to decade 3.

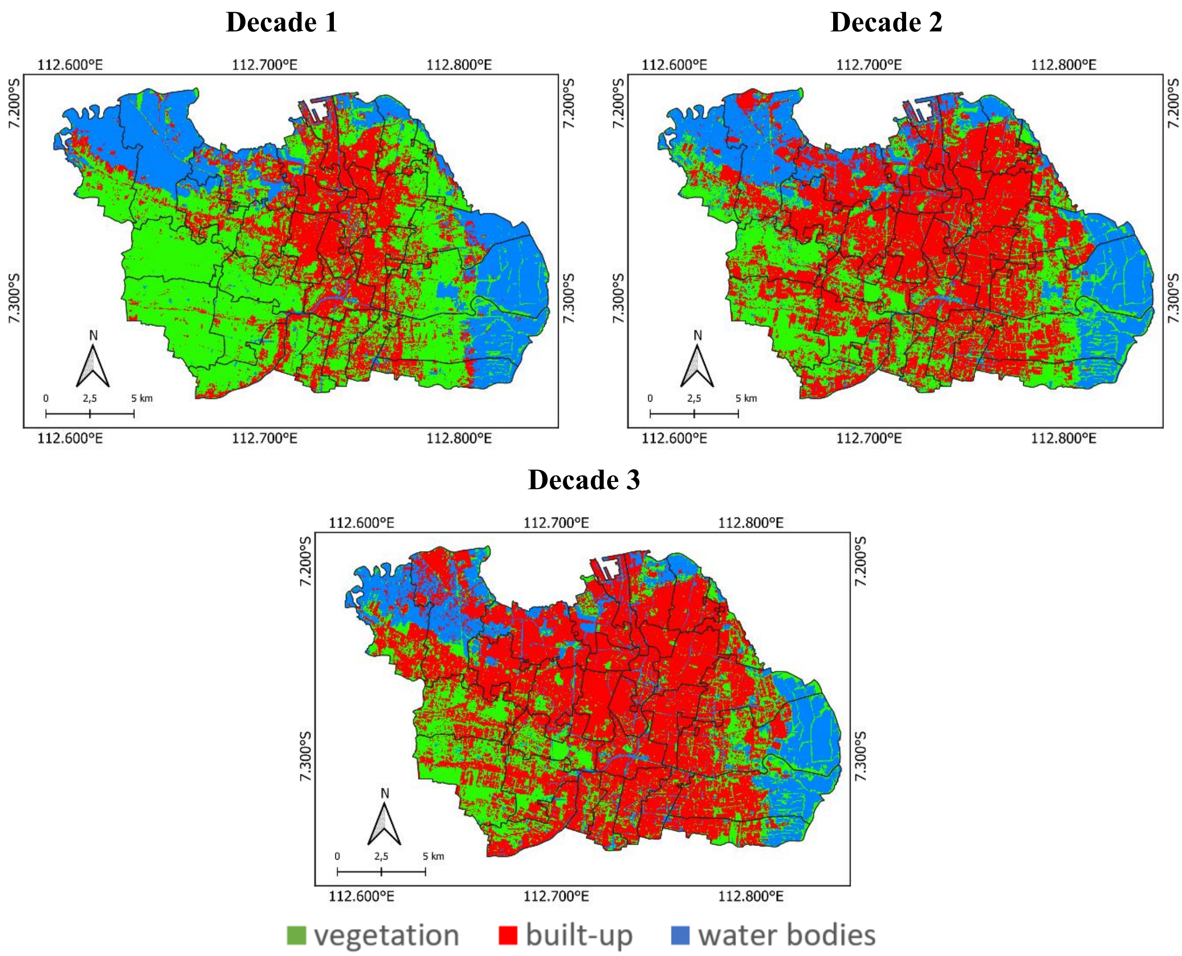

Figure 2. Classification of Surabaya land cover

The change of buildings to vegetation detected by the Landsat satellite is a sign of greening in Surabaya, such as planting trees on roadsides, building city parks, or reforesting housing. Some buildings may have implemented the concept of green building by planting plants on the roofs of buildings to reduce solar radiation reaching the surface of the building. It was observed that there was a change in the water area into a small number of buildings in the western and eastern Surabaya areas. The amount of vegetation and water bodies in eastern Surabaya has a constant trend because it is a protected area that cannot be converted. Changes in vegetation to become the most dominant buildings occurred in the western and northern parts of Surabaya. The development of Surabaya during the study period tended to be in a west-east direction where there was still a lot of undeveloped land in the area.

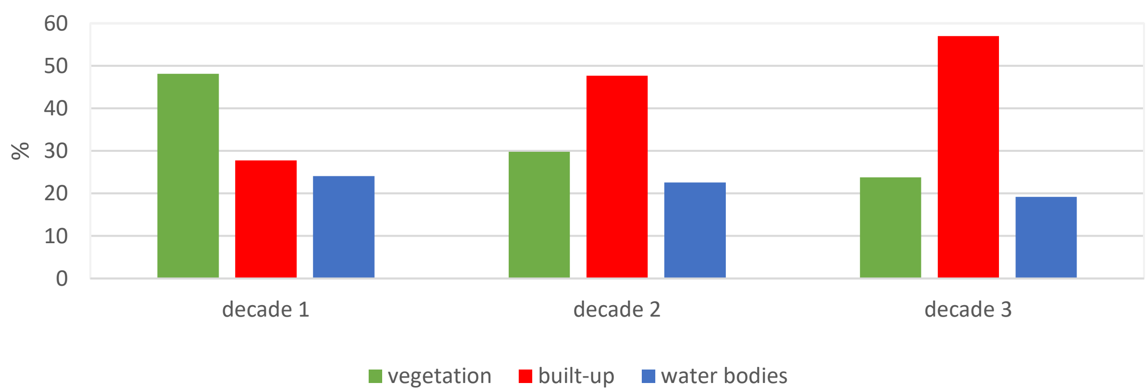

Figure 3. Percentage of Surabaya land cover

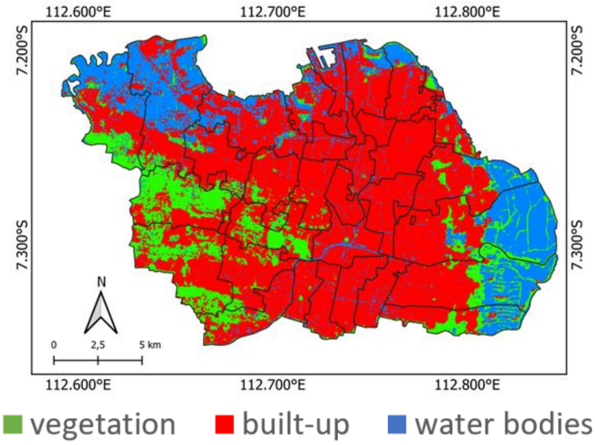

Figure 4. Land cover prediction of Surabaya in 2021-2030

3.2 Surabaya Land Cover Prediction.

The accuracy of land cover prediction for decade 3 when compared to Landsat observations is 73.46%. This result is considered quite good in describing land cover in Surabaya. The area of vegetation land cover in decade 4 is predicted to decrease to 50.879839 km^2, while the area of buildings and water bodies has increased to 215.06348 km^2 and 66.818118 km^2 respectively (Figure 4). The increase in the area of water bodies was not significant from decade 3, inversely proportional to the significant increase in building area, which was 13.36%. The tendency of land cover to change from vegetation to buildings in the western and eastern parts of Surabaya. Industrial estates, transport systems, urban expansion, and current increased migration will increase environmental degradation, urban heat islands, thermal variations, green deficiencies, and ecological imbalances [12], [13].

The most significant change in land cover was from vegetation to buildings, amounting to 38.95032186 km^2. This can happen because of the construction of urban infrastructure or the addition of community residences. In contrast to changes in vegetation land cover to water bodies have insignificant value [14]. Even though there was a change in land cover from buildings to vegetation, this was not comparable to changes in land cover from vegetation to buildings (Table 1). During the research period, the building area has an increasing tendency every decade, and the vegetation area has a decreasing tendency, while water bodies have an area that does not vary much between decades. Increasing pressure on land use can exacerbate current environmental conditions, necessitating a sustainable approach to land use and land management [15]. Significant land cover changes can cause an energy imbalance in urban environments, causing severe environmental problems, such as thermal conditions that are hazardous to residents [16].

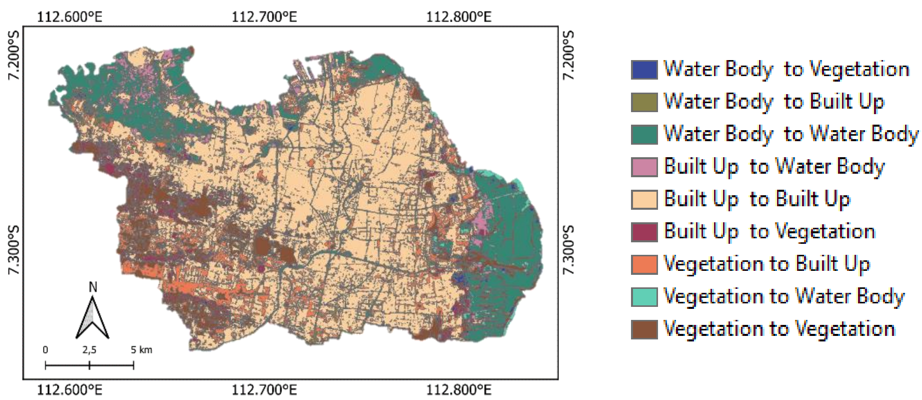

Figure 5. Changes in land cover from decade 3 to decade 4

Table 1. Area of land cover change in Surabaya

Land cover	**Area (km^2)**
Vegetation to Vegetation	32,1750108
Vegetation to Built-up	38,95032186
Vegetation to Water Body	7,069449726
Built up to Vegetation	13,48221469
Built up to Built-up	163,0860634
Built up to Water Body	14,4539718
Water Body to Vegetation	5,126996671
Water Body to Built-up	12,99889024
Water Body to Water Body	45,19096696

4. Conclusion

The building area has the highest value compared to other land covers in each decade. This is supported because there is a significant increase in building area every decade in the city of Surabaya. The most significant change is the land cover from vegetation to buildings, while changes to water bodies are not too significant. Surabaya City land cover prediction using the MLP method shows a good accuracy value. In 2021-2030 the building area of the City of Surabaya is predicted to continue to increase and is inversely proportional to the decreasing vegetation.

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