Analysis of Cellular Automata-Binary Logistic Regression for Prediction of Settlement Land In Madiun City, East Java

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Abstract. The development and growth of a region have implications for population growth and density. Land use changes can lead to spatial control difficulties resulting in mismatches in urban land use, especially in Madiun City. The purpose of this study is to predict the development of land use in Madiun City in 2030. The analysis of land development predictions uses the Cellular Automata-Binary Logistic Regression method with the variables used in this study including, distance from public facilities, distance from local roads, and distance from collector roads. In 2030 the area of the arsenal will reach 2199.35 Ha, this shows that there is an increase in the area of reserve land, namely, 121.76 Ha. The total non-residential land area in 2030 will be 1191.97 Ha, this land area has decreased from 2020 to 120.43 Ha. Based on the results of the prediction of changes from non-weapon land to weapons through the CA-Regression Logistics model, it can be seen that in 2030 it is predicted that a lot of weapons land will develop in the center of Madiun City.

Keywords: Land use change, Cellular Automata-Binary Logistics Regression, Settlement land prediction

1 Introduction

The development and growth of a region have implications for population growth and density. the increase in population leads to an increase in land use for the agricultural sector [1]. Changes in land use are increasing due to the increasing rate of economic growth so in the future land use changes in urban areas will continue to occur in urban land [2]. Land use changes can lead to spatial control difficulties resulting in mismatches in urban land use. Agricultural land in urban areas is increasingly narrow resulting in land conversion which will affect the economic, social, and environmental aspects of certain communities. As a result, the amount of land for preservation zones significantly decreases because of the continuous increase of land change for agricultural activities [3].

The highest population growth rate for seven years from 2010 - 2017 was in Taman District with an amount of 0.74%, then followed by Kartoharjo District with a total of 0.49% and Manguharjo District -with 0.23%, thus it can know that Taman sub-district will increasingly need more residential land, while the availability of land in urban centers is

becoming increasingly limited [4]. Population growth in Madiun Regency is affected by the high birth rate [5]. The existence of development of this facility may be needed when an increase in the number of people who need housing as a consequence of meeting basic needs due to population growth. So agricultural and plantation areas are the main targets in meeting the needs for housing for residents who will live and work in the area.

This study uses the CA method and the logistic regression method to predict agricultural land because the CA method and the logistic regression method are dynamic models that integrate the dimensions of space and time. The use of CA for land use change can be divided into three based on determinism and stochasticity aspects in the modeling. The estimated area of change and the transition algorithm are determined using the stochastic method [6]. Cellular Automata (CA) which in the end this modeling will produce a spatial prediction model based on a predetermined time.

The use of logistic regression for land change can be approached by quantitative analysis [7]. Logistic regression is a model to analyze the relationship between variables [8]. From the explanation above, the purpose of this paper is to describe the CA-logistics regression transition rule that is applied to determine the prediction of residential land in 2030. The variables used in this study include the distance from public facilities, distance from local roads, and distance from collector roads.

2 Method

This research method is divided into research locations, data, and settlement prediction analysis.

2.1 Research Site

Madiun City is one of the cities in East Java Province which is 164 Km eleven west of Surabaya or 111 km east of Surakarta. The area of Madiun City is 33.92 km2 with a population of 176,099 thousand in 2017. In Madiun City, there are 3 Districts namely Manguharjo District, Taman District, and, Kartoharjo District. Population growth in the City of Madiun increases every year, indicating that the 3 cities of Madiun will experience city widening due to limited areas in the City of Madiun.
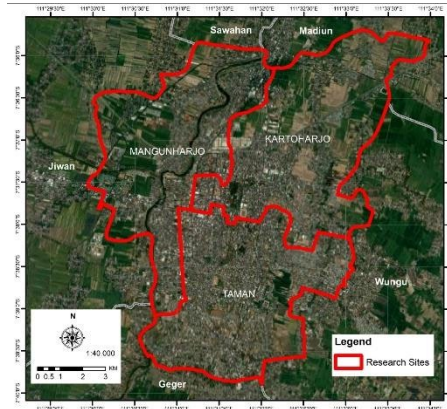
Fig. 1. Research site

2.2 Image Dataset

The initial interpretation in distinguishing settlement and non-settlement classes uses Landsat 7 imagery for 2010 and Landsat 8 for 2020. The image classification used in distinguishing settlement and non-settlement classes uses a supervised maximum likelihood classification, that is, an algorithm that is statistically homogeneous objects always displays a histogram that is normally distributed [9], [11].

2.3 Prediction Mapping

The predictor variables of land change in this study were identified through exploratory analysis based on initial assumptions [10]. The combination of literature study, local knowledge of the area studied, and logic based on experience (empirical) are used as the basis for selecting several variables from a large number of variables that may be used. The variables used in this study include the distance from public facilities, the distance from local roads, and the distance from collector roads. The results obtained from the distance analysis are a map of the distance to each object. The distance map in this study was obtained from the results of spatial analysis using ArcGIS 10.3 software distances to objects (roads, buildings, and so on) are determined using the Euclidean distance method and the results are stored as spatial data in raster format. This research utilizes the Mollusca Plugin in the Qgis software. The method used in predicting land change from non-settlement to settlement is Cellular Automata Logistic Regression.

Binary logistic regression works with response variables (independent) that are dichotomous/binary and all data types are nominal, ordinal, and interval as predictor variables in this study, the response variables used are changes and no changes in land use within a certain period of time. The variables used are non-residential land and settlements. Changes are denoted by the number 1 and no change is denoted by the number 0.

3 Result and Discussion
3.1 Land use change in 2010 and 2020

Based on the results of the classification that has been carried out, changes in land use in Madiun City are visible, especially in settlement and non-settlement land. In addition, the development of settlement land areas has seen an increase in several points. If you look at the land use map, residential land tends to be dense in the downtown area. On the 2010 land use map, Manguharjo and Kartoharjo Subdistricts do not appear to be densely populated, but in 2020 several points in the two subdistricts have experienced settlement developments. In addition, in the southern part of Taman District, in 2010 there were also not yet dense settlements but in 2020 there have been settlement developments. Land change maps for 2010 and 2020 can be seen in Fig.1.
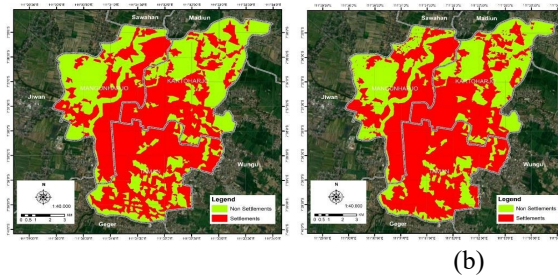

(a)   (b)

Fig. 2. (a) land use change in 2010; (b) land use change in 2020

The results of the study show that settlements have changed between 2010 and 2020. Land use change statistics show the dynamics of existing land use. From 2010 to 2020, the dominant land use in Madiun City is residential land. The trend of non-residential land use is always decreasing, in other words, there has been a lot of conversion from non-residential land to residential land. Classification of non-residential land in this study includes agricultural land. The area of land use can be seen in the table below.

Table 1. Land Use Area

Classification of Land Use	Area (Ha)	
	2010	2020
Non-Settlement	1465,39622	1312,406
Settlement	1925,65235	2077,596

The total area of land change in Madiun City between 2010 and 2020 is 304,933 hectares. In the period 2010 -2020, the total area of non-residential land in Madiun City has decreased by 152,989 hectares. Furthermore, settlement land increased by 151,943 hectares. Land change that occurs according to the category of land use used is one-way. The one-way change in question is from non-residential land to residential land. Changes in the opposite direction (settlement land to non-settlement) are generally not possible.

3.2 Analysis of Factors of Land Use Change

This research determines the factors that influence land change, especially non-residential land to settlements. These factors include distance to public facilities, distance to collector

roads, and distance to local roads. These three factors are considered to influence changes in land use from non-settlements to settlements. Changes in land use in Karawang Regency are indicated by an increase in built-up land, especially residential land, accompanied by a decrease in agricultural land.
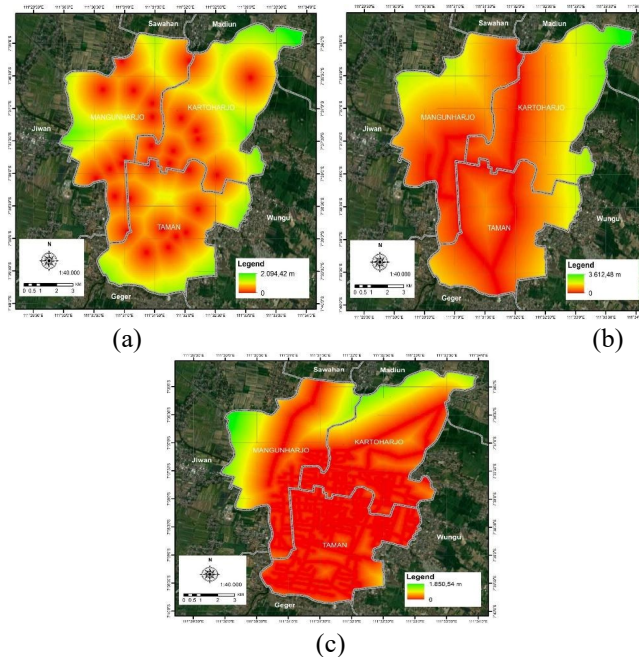
Fig. 3. (a) Distance to public facilities; (b) distance from collector roads; and (c) distance from local roads

Distance to public facilities is done by Euclidean distance analysis, the values obtained from this analysis are 0 for the minimum value and 2094.42 m for the maximum value. Based on the map of the distance to public facilities, the most dominant public facilities are in the downtown area compared to the suburbs. So that settlements are denser in the downtown area. The distance to the collector road is 0 for the minimum value and 3612.48 for the maximum value. The existence of a collector road is very helpful for community activities in the City of Madiun. The importance of collector roads to drive economic development in Madiun City and rural areas. The third factor, namely, the distance to the local road is 0 for the minimum value and 1850.54 m for the maximum value. Local roads greatly influence activities that require accessibility in the form of roads that also influence the development of the economic area and the surrounding settlements. Local roads in the City of Madiun are very helpful in supporting the role of development, especially in the economic sector which is carried out through a regional development approach in order to achieve a balanced and equitable development in the City of Madiun.

3.3 Prediction of Land Use Change

Land use maps for 2010 and 2020 are used as initial input in the simulation and act as initial land use conditions. This research utilizes the Mollusca Plugin in the Qgis software. The method used in predicting land change from non-settlement to setllement is Cellular Automata Logistic Regression. The prediction results of residential land in 2010, 2020, and 2030 using the CA-Logistics Regression method show an increase from non-settlement land to settlements in Madiun City. Settlement development prediction diagram can be seen in Figure 4.

Fig. 4. Settlement development prediction diagram

Based on the results of the analysis, in 2030 the area of residential land will reach 2199.35 Ha. This indicates that there is an increase in the area of residential land, which is 121.76 Ha. The total area of non-residential land in 2030 is 1191.97 Ha, the land area has decreased from 2020 to 120.43 Ha. The increase in residential land is caused by the growth of development in Madiun City. Madiun City is one of the industrial areas in East Java Province and is a transit city between provinces, namely, East Java and Central Java Provinces. Based on the prediction results of changes in non-settlement land to residential land through the CA-Logistics regression model, it is seen that in 2030 it is predicted that residential land will develop a lot in the center of Madiun City, especially in Taman District. The prediction map of settlement land can be seen below
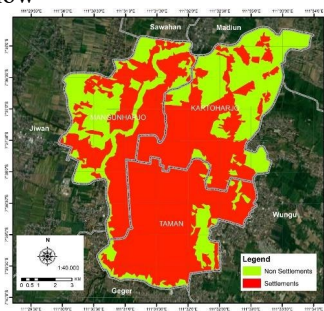

Fig. 5. The prediction map of settlement land

4 Conclusion

The total area of land change in Madiun City between 2010 and 2020 is 304,933 hectares. In the period 2010 -2020, the total area of non-settlement land in Madiun City has decreased by 152,989 hectares. Furthermore, settlement land increased by 151,943 hectares. the factors that influence the change include distance to public facilities, distance to collector roads, and distance to local roads. These three factors are considered to influence changes in land use from non-settlements to settlements. Based on the results of the prediction of the change of non-settlement land to settlement land through the CA-Logistic regression model, it can be seen that in 2030 it is predicted that residential land will develop a lot in the center of Madiun City.

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