Land change modeler for predicting land cover change in Banjarmasin City, South Borneo (2014 - 2022)

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Abstract. Land change is a phenomenon that often occurs in urban areas in the province. Banjarmasin city is one of several provinces that have experienced rapid land changes. Various government efforts such as buying rice fields from local residents have been sought by the local government to protect agricultural land. One of the spatial analyses that can be done to examine the phenomenon of land change is the modeling of geographic information systems and remote sensing. The method that can be used is IDRISI's Land Change Modeler. This modeling is based on 2014 and 2018 land cover data and several additional parameters such as road data, DEM and Euclidean distance to the road. Based on the modeling results from 2014-2018, Banjarmasin city developed changes in land from built up land of less than 800 hectares. Most land changes occur in the middle of the city. Based on the Markov Chain method by looking at land changes in the previous year, non-built land by 40% became built up land. Based on the predictive model of land cover change using the Marchov-Chain method, the development of built-up land in the Banjarmasin city is centered in the middle of the city and towards the north because there has been development of road access and housing development.

1. Introduction

Spatial planning is an effort to balance the use of natural resources and the environment. The result of this balance is the achievement of environmental function sustainability [1] Preservation of environmental functions can be guaranteed by spatial utilization activities that pay attention to the carrying capacity of the environment. Referring to Law Number 26 of 2007 [2], the carrying capacity of the environment is one of the principles in urban spatial planning. The carrying capacity of the environment is closely related to land cover and population factors that inhabit it. Land cover is a combination of the existence of a constant interaction, balance, and dynamism between the activities of the population on the land and the limitations in their environment [3, 4]. Interactions that then occur between the dimensions of space and time and the activities of the population lead to changes in land cover [4]. Changes in land use are also influenced by population and climate change that shape patterns of land use [5]. The complexity between physical, biological, social, political, and economic factors is the cause of the process of changing land cover when it occurs at the same time and space dimension [6]. The effects of land cover change also influence local ecological conditions such as water pollution, air pollution and local climate change [6-9] and even the effect on biodiversity [10]. Changes in land cover in the Banjarmasin area have been very pronounced and are increasing in recent years. The development of changes in land cover around Banjarmasin city is also much influenced by increased development in the center of Banjarmasin City. The transfer of the administrative capital to Banjarbaru City in the period of 2012 was the starting point for changes in land cover trends in Banjarmasin City. Other conditions that influence changes in land cover are many fast food outlets and shopping centers. The appearance of these outlets was marked by a growth rate of 12% only for food franchises in 2015 [11]. Increased growth is predicted to increase along with the stability of people's purchasing power. The provincial level of growth in the first quarter of 2018 grew by 5.01%, an increase compared to the previous quarter which was only 4.46% [12]. Factors that also influence the growth and quite noticeable

increase is the number of residents who inhabit Banjarmasin city. The availability of jobs that also continues to increase is reflected in the 2015 from Central Bureau of Statistics data with the highest number of Banjarmasin City labour force compared to other cities or regencies with a total of 311,951 people.

The factors previously explained have the effect of a high rate of change in land cover in Banjarmasin City. The rate of change is feared to have an impact on the ecological conditions in Banjarmasin City. The study of the process of changing land cover itself requires three levels of approach [13]; 1) direct measurement of location, spatial pattern and temporal characteristics of land cover changes; 2) case studies and field investigations to get the dynamics of changes in land cover on a local scale; 3) identification of broad-scale factors that drive changes in land cover and enable projections of future trends in land cover changes. Based on this, it is necessary to know the types and trends for projecting land cover changes by spatial modelling using remote sensing data.

2. Method

This research was conducted in Banjarmasin City, South Kalimantan Province. The location was chosen because Banjarmasin city is one of the cities experiencing rapid growth supported by good education infrastructure such as State Universities such as Lambung Mangkurat University. Ibnu Sina, 2018 states that it is undeniable that not a few agricultural lands that were so extensive have now turned into urban development, especially settlements. Research locations can be seen at Figure 1.
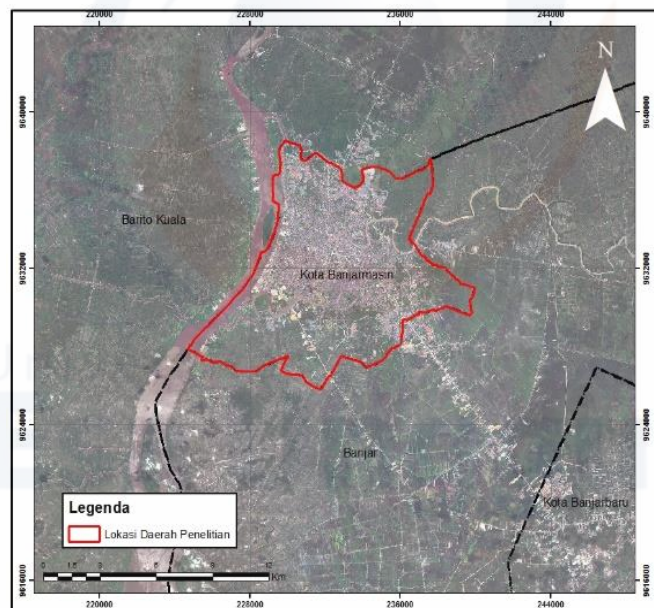
Figure 1. Research Location

In this research, the remote sensing image used for land cover interpretation and classification process is Landsat 8 OLI imagery. OLI Landsat 8 imagery used is September 2014 and October 2018. The classification method used is maximum likelihood, where samples are taken from high-resolution imagery from Google Earth. This study used a land cover classification from Anderson for Level I [14]. In total there are 5 land selection classes that can be found in this study according to Anderson's approval (Table 1)

Table 1. Anderson Land Cover Classification Scheme

Land cover types	Description
Built-up	Residental, commercial and services, industrial, socio-economic, infrastructure and urban and other urban
Bare Soil	Exposed soils, landfill sites and area of active excavation
Vegetation	Deciduous forest, mixed forest lands, palms and other
Water Bodies	River, permanent open water, lakes, ponds and reserirs

Source : [14]

3. Land Cover Classification

Land cover interpretation in Banjarmasin city is obtained through multi temporal digital interpretation. The process of interpreting digital images using OLI multispectral Landsat 8 images uses a hybrid method that is combining visual interpretation using object delineation and digital analysis (supervised) for object identification [15]. According [16] the use of intermediate resolution images such as Landsat 8 OLI for interpretation of land cover using hybrid interpretations can improve the accuracy of classification results.
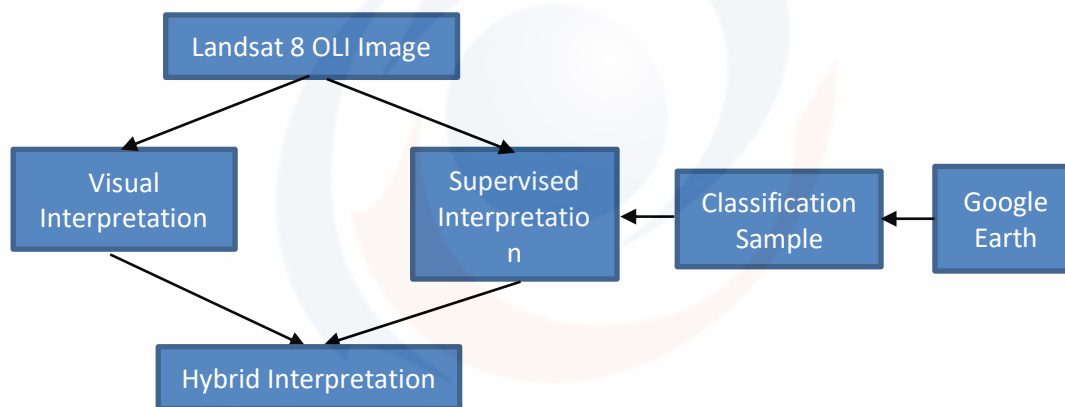

Figure 2. Hybrid Interpretation Chart

The classification and accuracy samples are used for land cover digital analysis were obtained from higher resolution images. Using Google Earth data by equating historical imagery between input image. For land cover classes taken can be seen in table 1.

4. Land Change Modeler

Land change modeler is a function of spatial modeling to predict land cover changes. This method uses the Markov Chain algorithm to determine how much land cover change occurs from 2014 and 2018. The procedure will be a determining factor in predicting land cover at the specified time. The probability value generated from the comparison of 2014 and 2018 land cover will be a matrix.

Table 2. Matrix Probability of Land Cover Changing

	Water body	Build up	Vegetation	Bare Land	Cloud
Water body	0.9370	0.0506	0.0000	0.0124	0.0000
Build up	0.0051	0.8808	0.0164	0.0973	0.0005
Vegetation	0.0000	0.0459	0.7697	0.1841	0.0003
Bare Land	0.0060	0.2714	0.1139	0.6077	0.0010

Cloud	0.0469	0.1738	0.2893	0.4738	0.0161

To get the Potential Transition, it is necessary to determine the land cover class that needs to be evaluated because it has the possibility of a change. The land cover class that needs to be evaluated because there is a change in the form of increase is built up area. External parameters that influence land changes in addition to the land cover itself are roads and topographic conditions of the area. Road distribution is used to determine dynamic variable prediction and SRTM DEM data used to determine Dynamic Road Development and regional topography. The methodology flow chart can be seen in Figure 3.
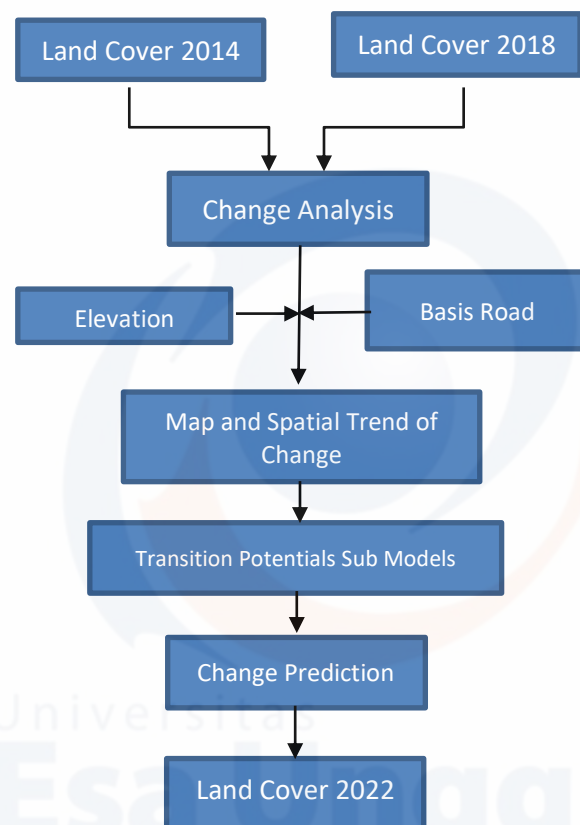

Figure 3. Flow Chart Land Change

5. Result and Discussion

Hybrid Interpretation result from land cover of Banjarmasin city at 2014 and 2018 can be seen in figure 5. Supervised interpretation using ENVI with the Maximum Likelihood algorithm and for visual interpretation using ArcMap. Accuracy of land cover interpretation reached 86% for 2014 and 89% for 2018. The apparent change occurred in the land density built in the center of Banjarmasin City for 4 years experiencing an increase in addition to that the development of land was built spreading to the north, south and southeast of the city Banjarmasin. Changes also look patterned especially along the big road. In accordance with the theory of urban development, namely urban sprawl by Northam in [17], namely ribbon / linear / axial development where the physical development of cities follows the pattern of road networks and shows unequal propagation in each part of the city.

For the elevation of the Banjarmasin city itself is relatively flat, an increase in elevation goes northeast. The elevation in Banjarmasin city is between 0-22 mdpal as shown in figure 5.

(a)   (b)
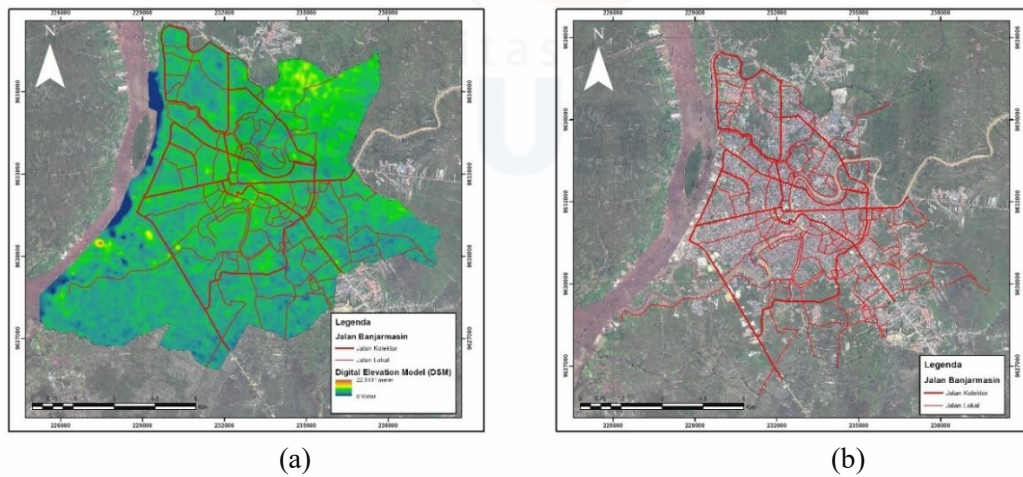
Figure 4. Land Cover Change Parameter (a) Elevation, (b) Road

Classes and road access in the central city of Banjarmasin have been well facilitated. Class and road access for the southwest and northeastern parts of Banjarmasin are still not much even for local road classes. The development of the road is more towards the southeast (Handil Bakti area) and northwest which is towards the City of Banjarbaru (figure 5). This was influenced because the Handil Bakti area in the last few years had been a lot of land clearing for public housing. Developments for the northwest region are influenced by the transfer of central government from Banjarmasin city to the Banjarbaru city which occurred during the period 2012 - 2014. This transfer is in accordance with the RPJMD 2016 - 2021 proclaimed by the governor through South Kalimantan PERDA No. 7 of 2016 [18].

(a)   *(b)*
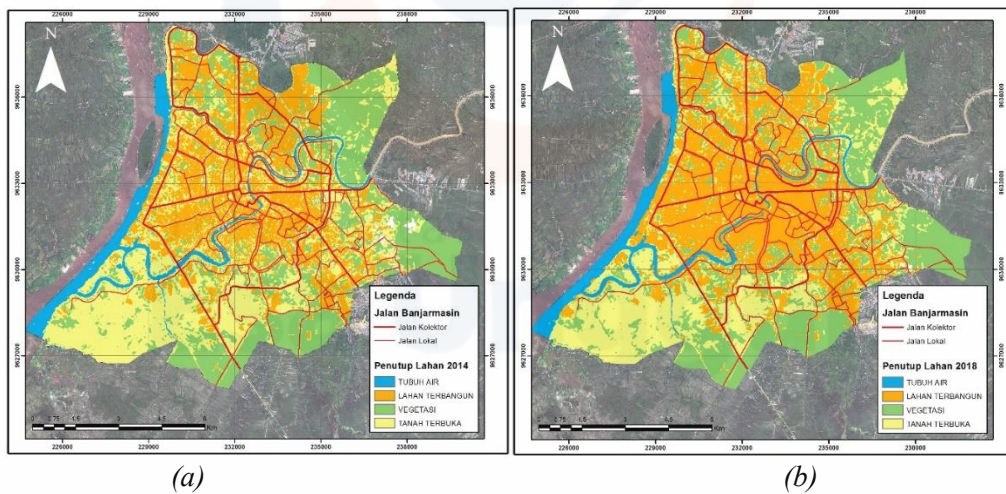
Figure 5. Land Cover Classification Result (a) 2014, (b) 2018

(a)   (b)

(c)   (d)
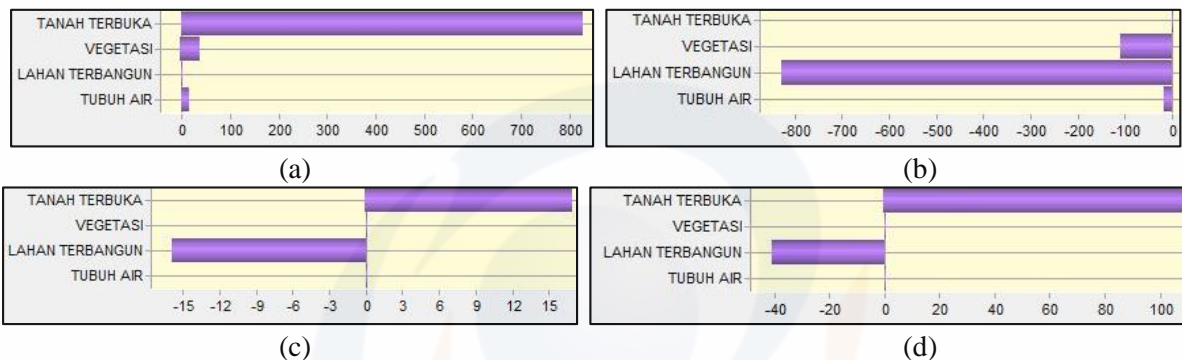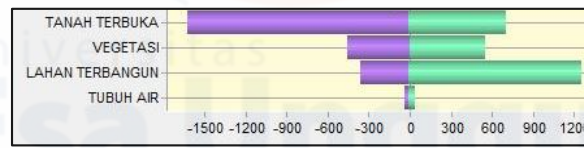
(e)

Figure 6. Gain and Losses Land cover Class (a) Build up, (b) Bare Land, (c) Water (d) Vegetation

Land Change analysis result for each land cover class at 2014 and 2018 can be see in figure 6. The biggest increase change occurs is build up area. Bare land has the greatest conversion to be built up area ± 800 Ha while for vegetation less than 20 Ha. Intepretation result for bare land classes can be transformed into vegetation land and the opposite because it is very possible that the area is rice fields or cultivation field where rice fields and cultivation field are planted seasonally so that when the image recording time may not be planted, planted or post-harvest so that the object same but remote sensing image becomes a different object. Bare land class are also possible change because the growth of vegetation is getting higher and dense every year. Some sample points show locations such as parks or residential yards besides other observation points in rice fields.

*(a)*   *(b)*
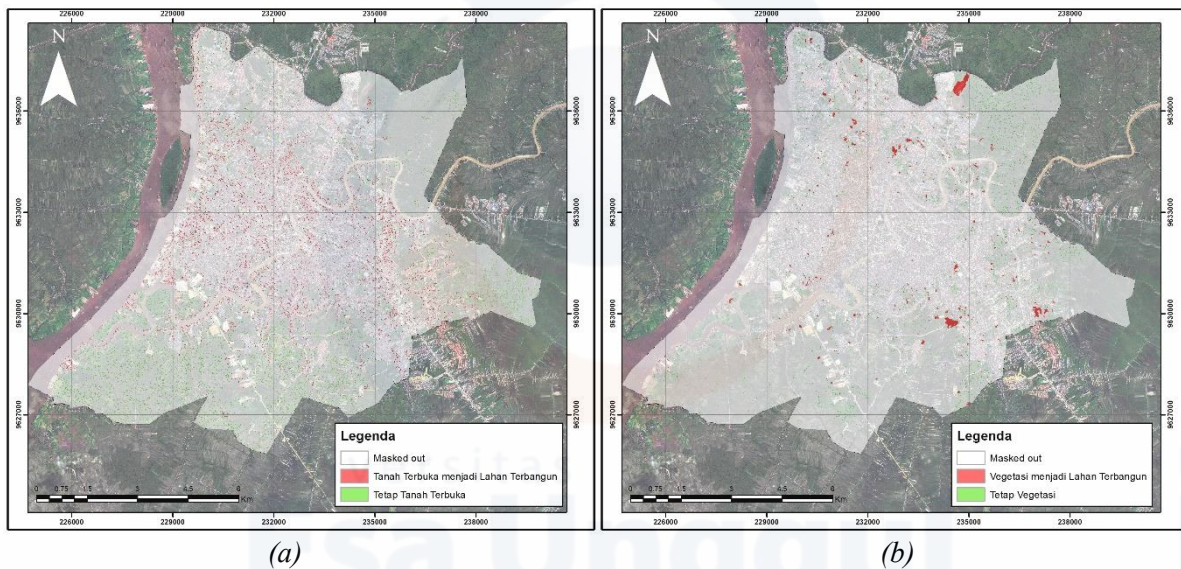
Figure 7. Distribution Land Cover Change (a) Bareland-Build up, (b) Vegetation-Build up

Land cover change for bare land into built up area spread evenly in the middle part of Banjarmasin city. This shows that the density in downtown Banjarmasin increases with time while the change in vegetation into built up area is spread over several locations with large areas where formerly swamp rice fields and shrubs change functions into settlements and industries (Figure 6). Bare land changes are dominant in the centre of city while for vegetation changes spread on the outside of the city. It can be seen in Figure 7 that the distribution location of land cover that is transformed into build up area from bare land, vegetation and water body are in the center of the city and northwest side while the change from bare land to vegetation is on the outside side of Banjarmasin city. Land cover changes from vegetation to bare land it can be from land clearing activity or wetlands landchange. Location in the city center and the northern part of Banjarmasin city. Based on the spatial trend using polynomial order 9, it can be seen clearly that the pattern of changes that occur from bare land into built-up area and vegetation into built-up area. (Figure 8 and Figure 9)
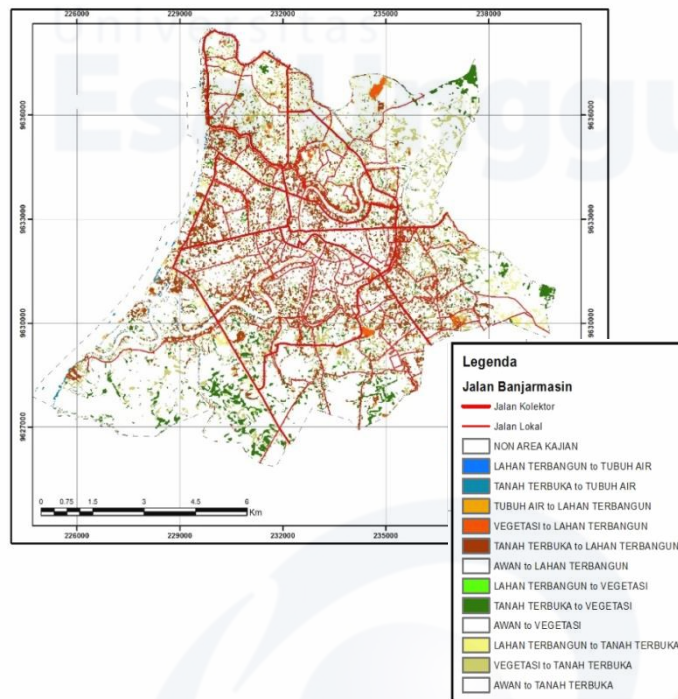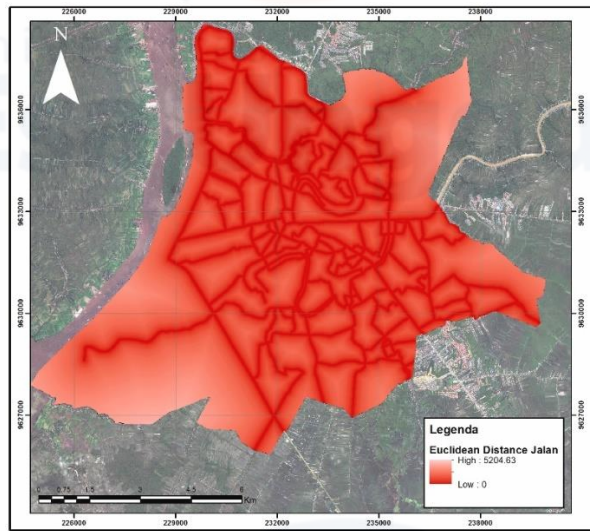
Figure 8. Land Cover Change Distribution
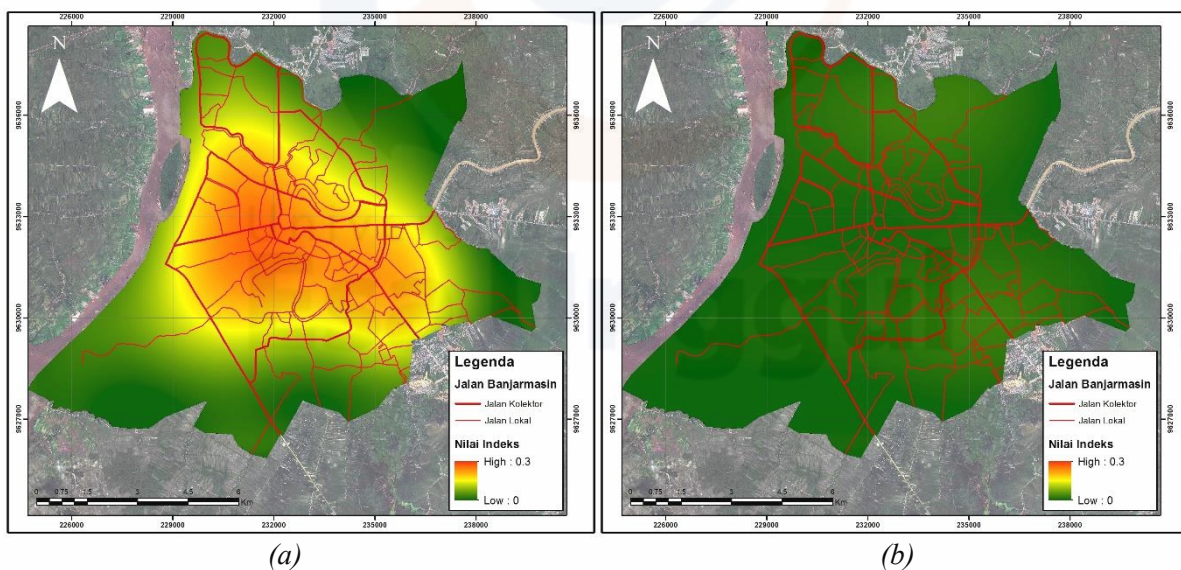
Figure 9. Spatial Trend Change (a) Bareland-Build up, (b) Vegetation-Build up

Based on the results of the spatial trend change, it can be seen that the greatest change in index value occurs in the land constructed against other land coverings. The next step is to analyze probability transition potential from bare land and vegetation to built-up area. (Figure 10). The results show that the development of bare land into built-up area based on road development data and distance to the road (figure 11) in Banjarmasin City has a high probability of heading south along with road connectivity. According to [19] the closer the distance of land to the road, the greater the chance for land use change.

Figure 10. Spatial Trend Change (a) Bareland-Build up, (b) Vegetation-Build up

For the probability value of vegetation change into built-up land is not too influenced by the road, but more close to the built-up area around it. The presence of build-up area around it gives a higher probability value for land changes.

(a)   *(b)*
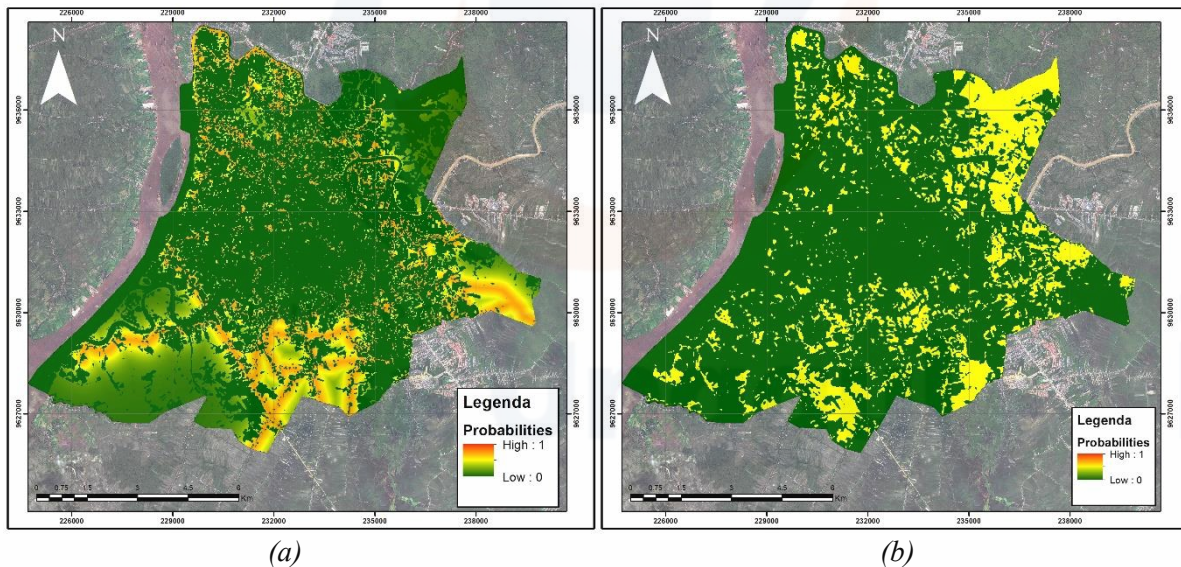
Figure 11. Transiton Potensial (a) Bareland-Build up, (b) Vegetation-Build up

Based on the parameters generated through LCM analysis, the prediction of land cover change for the year 2022 is obtained. The prediction for 2022 based on the changes that occurred in 2014-2018 and the parameters that could affect land change occur both the pull factor and the driving factor. The results of the predicted land cover can be seen in Figure 10.
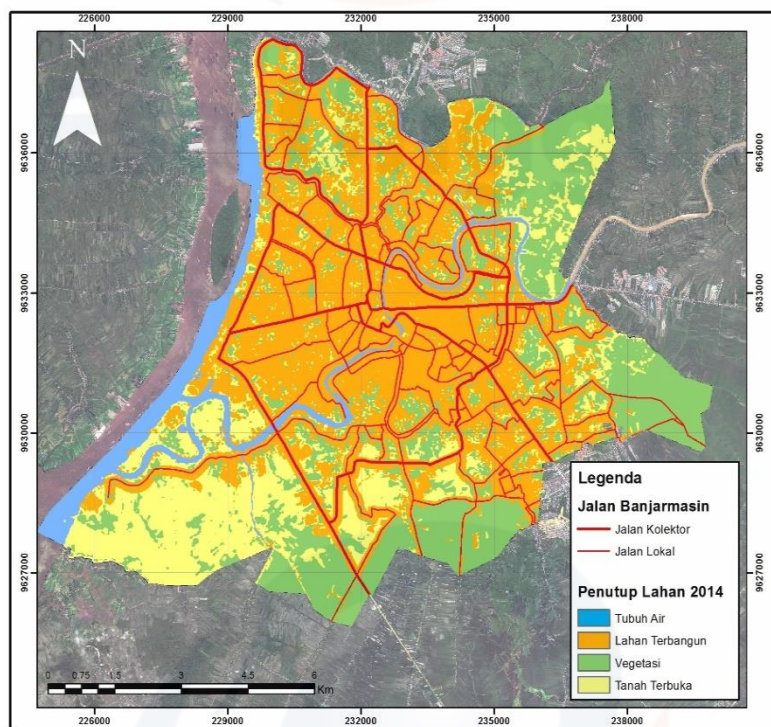
Figure 12. Land Cover Prediction 2022 Banjarmasin City

Based on the results of the Land Change Modeler to predict Banjarmasin City land cover in 2022, the condition of Banjarmasin city in 2022 will be more crowded for areas in the city center and spread to the north as residential areas. It is expected that the results of this study can be a development outlook of Banjarmasin city in the future so that it can be utilized in determining the development of Banjarmasin city in the future

6. Conclusion

Land Change Modeler can be used to see land changes that occur in the Banjarmasin city in 2014-2018. Based on land changes that occurred in 2014-2018, predictions of land cover that occurred in 2022 can be analyzed based on road development parameters, road distance and the topography of the Banjarmasin city. The development of the city of Banjamasin in 2022 was increasingly crowded in the center of the city and developed to the north especially as residential land

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Attachment :

Vegetasi menjadi lahan terbangun

Tanah terbuka menjadi lahan terbangun