Identification of Driving Factors Causing Land Cover change In Bandung Region Using Binary Logistic Regression Based on Geospatial Data

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Abstract. Land is a fundamental factor in production activity and is closely related to economic growth that supports the needs of human life. In many cases, human activities related to land use are often uncontrollable and have negative impacts on the environment, both locally and globally. In an effort to understand the phenomenon of land cover changes, land cover change modeling can be used. One model that can be used to identify factors causing land cover change is the Binary Logistic Regression (BLR). Based on this ability, this model can simulate the prediction of land cover changes that occur in a region by considering the parameters that represent the characteristics of the studied area, in this case physical and social economic conditions. In this study, Bandung Region is selected as the study area. Bandung Region has a fairly high economic activity which will have direct impact on many things, including land use changes, and eventually lead to land cover changes. The results show that physical condition represent by elevation, curvature, and road have more influence to cause land cover changes in Bandung Region. However social economic condition represent by population and central business district has low impact.

Keywords: *Binary Logistic Regression, Characteristics of Bandung, Geospatial Data, Land Cover Prediction.*

1. Introduction

In terms of land changes, there are the terms of land use and land cover. Land use is an overview of the activities performed by humans on the land. While land cover is a variety of biophysical materials contained on the land, such as buildings, vegetation, roads, and so forth (Ellis, 2007; Jensen, 2000; Kaiser, E. J. Et al, 1995; Koomen et al, 2007; Lambin et al, 1999; Turner et al, 1995; United States Global Change Research Programme, 2009). Land cover changes in an area within a certain time can be studied as a phenomenon or event which only consists of two categories, namely changed or unchanged. While the factors that affect the land cover/use changes are generally a combination of the continuous and categorical parameters (Xie et al, 2005). Both properties associated with the phenomenon of land cover change can be modeled using Binary Logistic Regression (BLR).

RLB is a probability method of the land cover changes in one spatial unit (pixels), which is determined by the interaction of land cover with the driving factors of the changes. The

relationship between the probability of land cover with the driving factors is based on statistical analysis of land cover data and factors involved, resulting a specific formula which is used in the model. The advantage of this RLB method is able to predict land cover changes in an area by considering the driving factors of land cover changes (Hilbe, 2009). Figure 1 below is an illustration of interaction between environment and land cover change.

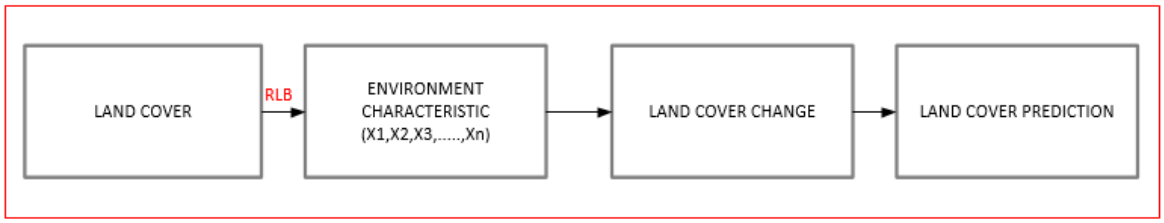


Figure 1. Interaction Between Environment and Land Cover Change

In the context of land cover changes, the factors that cause the changes are very important to know. The negative impact of land cover changes can be controlled, if it is known what factors cause these changes. One of the negative impacts imposed is climate change both locally and globally (Joshi et al., 2002; Koomen et al., 2008). Deforestation in the development of agricultural land or for the use of built up area is one example of land cover changes. These changes can have an impact on the reduction of biodiversity, soil degradation, and other material resources necessary for humans (Lambin et al., 2003).

Based on the background, it is necessary to identify the driving factors of land cover changes prior to prediction. Therefore, this study aims to identify the driving factors of land cover changes in an area, especially in Bandung Region, so it can be used to predict the land cover changes in the future. This area has population growth rate which always increases annually and also Bandung City is Capital of West Java Province. This condition has potential influence that causes land cover change on Bandung Region.

Figure 2. Bandung Region as Study Area

2. Data and Methods

The data used are land cover data for the period of 2001, 2006, and 2011 obtained from the Geospatial Information Agency (BIG) in a raster form with a spatial resolution 30x30 m^2. Data for 2001 and 2006 are used to predict land cover data in 2011, and land cover data in 2011 are used as a reference to validate the model. Land cover data in 2001, 2006, and 2011 are the data that have been classified into six land cover classes namely: forests, paddy fields, built up area, shrubs, plantations, and fields/moor.

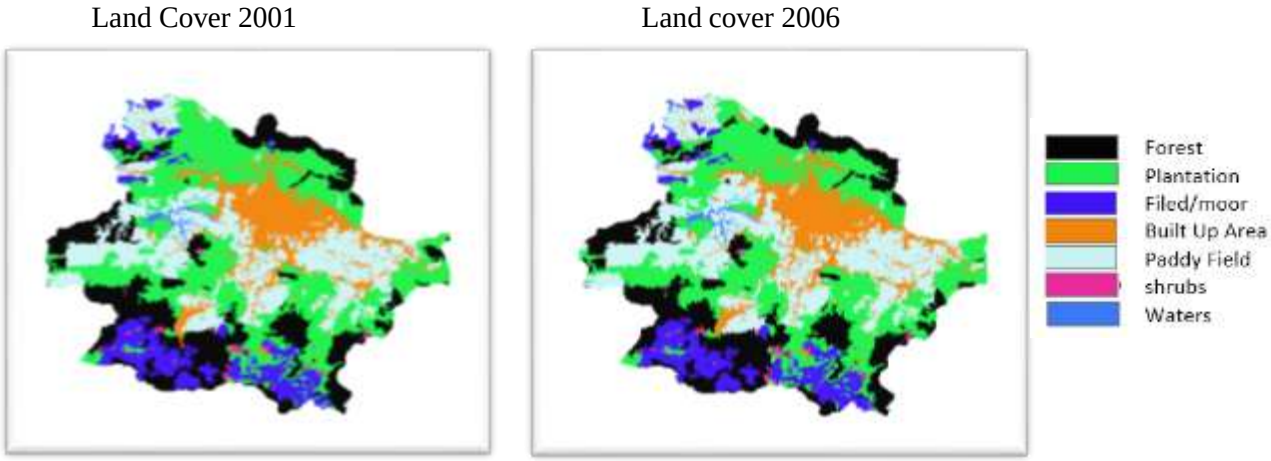


Figure 3. Land Cover Data Periods 2001 and 2006.

The research methodology is a scientific aspect (epistemology) in the study of land cover change prediction models in Bandung Region. In an effort to solve the problems of research and achieve the desired objectives, the stage being taken is to perform the modeling process using RLB with the data of land in 2001 and 2006 to obtain the information of changed and unchanged land classes in 2011. And also identify the driving factors of land cover changes in Bandung Region. The approach for solving problems in this activity can be described simply as the flow chart below (Figure 4).

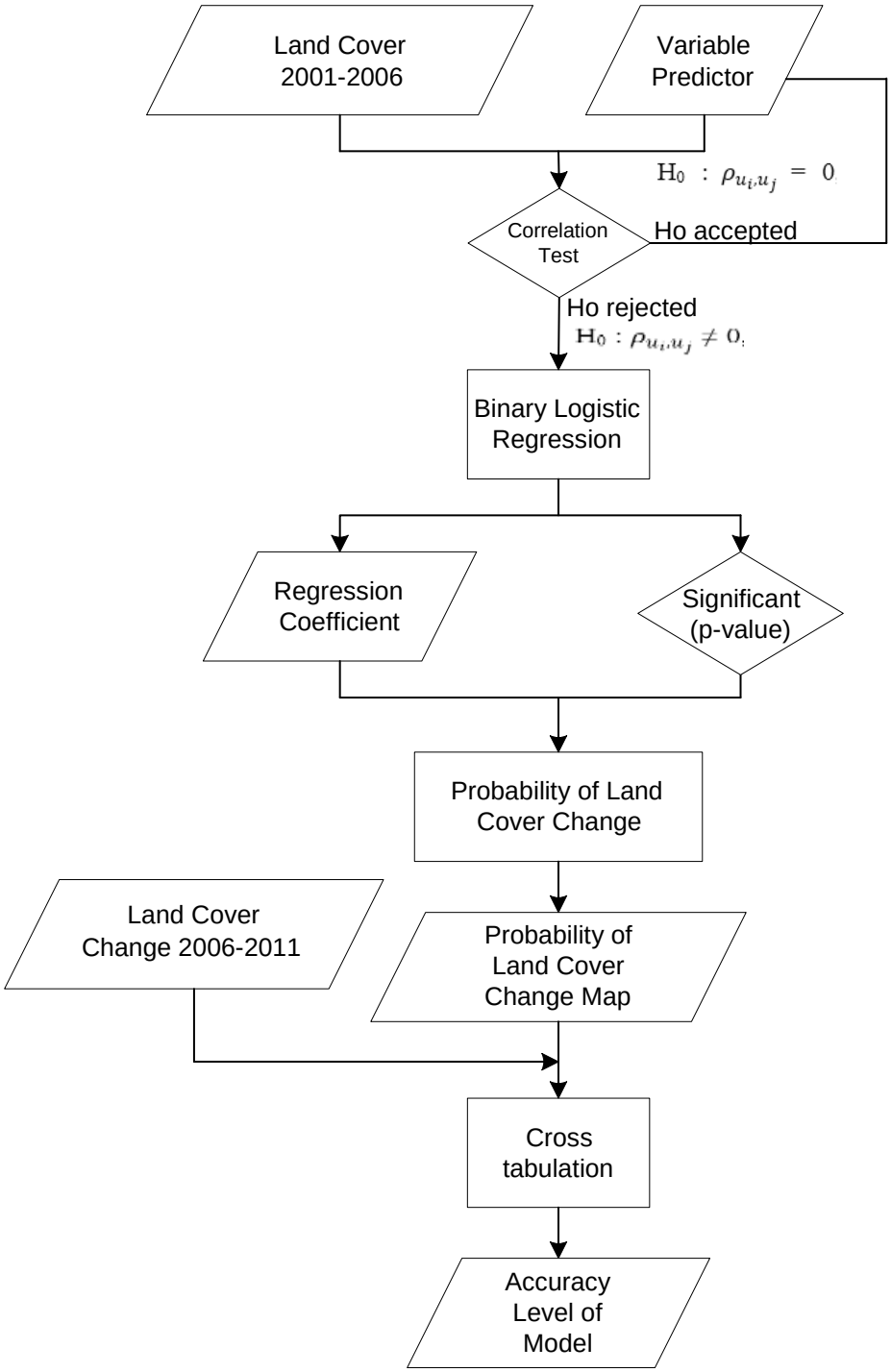


Figure 4. Scenario Model for the Research.

The results of probability calculations using the RLB have a range of values between 0 and 1. In general, the relationship between the predictor variable and the probability of occurrence is not linear, resulting S-shaped sigmoid curve. Where x-axis is the independent variable and y-axis is the probability of occurrence (Figure 5).

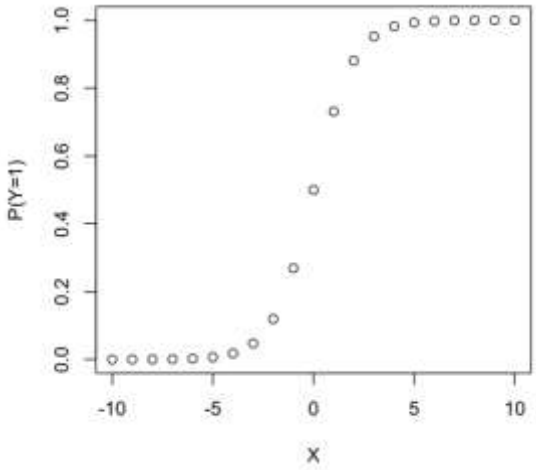


Figure 5. Sigmoid (logistic) Function.
(https://web.stanford.edu/class/psych252/tutorials/Tutorial_LogisticRegression.html)

RLB method is Bernoulli distribution where the distribution of the response variable has only two categories, changed and unchanged. RLB in the statistics is used to predict the probability of occurrence of an event to match the data on the logit function of logistic curve, where the logistic function (z) is on the horizontal axis and f (z) is on the vertical axis. RLB produces odds ratio which is the ratio between the probability of occurance with the probability of not occurrence. Odd Ratio equation can be written as follows:

$$Odd\ Ratio = \frac{\pi_i}{1-\pi_i}$$

Where:

π_i : Probability of occurence *i (*land cover changes)

$1 - \pi_i$: Probability of not occurrence *i*

3. Results and Discussion

As described in the previous discussion, RLB model can predict land cover in the future where the factors that cause land cover changes can be known. The reliability of RLB model is greatly influenced by the selection of driving variables of land cover changes in accordance with the characteristics of the area. In the RLB equation, all the predictors function as independent variables, while data on land cover changes in 2006-2011 serve as the response variable. Table 1 contains information on the value of each variable tested in RLB method of regression coefficient (β) and the value of significance (p-value) of each variable tested in the RLB method.

Table 1. RLB method of regression coefficient (β) and the value of significance (p-value) of each variable tested in the RLB method

Land cover / Driving Factors	Forest		Field/Moor		Plantations		Built Up Area		Shrubs		Paddy Field	
	B	p-value	B	p-value	B	p-value	B	p-value	B	p-value	B	p-value
Slope	-2,74E-03	0,00E+00	3,67E-04	0,00E+00	1,00E-03	0,00E+00	-1,23E-03	0,00E+00	-3,97E-05	6,50E-02	-1,92E-03	0,00E+00
Curvature	2,05E-02	8,55E-04	-1,42E-03	3,39E-02	-4,83E-03	2,68E-05	8,74E-03	1,31E-04	4,17E-03	2,84E-01	9,17E-03	6,81E-31
Elevation	-2,74E-03	0,00E+00	3,67E-04	0,00E+00	1,00E-03	0,00E+00	-1,23E-03	0,00E+00	-3,97E-05	6,50E-02	-1,92E-03	0,00E+00
Population	-4,44E+00	0,00E+00	-2,58E-02	0,00E+00	-8,36E-03	0,00E+00	6,98E-02	0,00E+00	1,06E-02	0,00E+00	-2,29E-02	0,00E+00
Distance To Road	-1,48E-01	1,05E-05	1,92E-05	3,67E-96	2,54E-04	0,00E+00	-1,00E-04	1,68E-208	-1,77E-04	1,37E-31	-1,49E-04	0,00E+00
Distance To Cimahi	-1,64E-04	8,72E-73	-7,94E-05	0,00E+00	2,90E-06	2,70E-01	-1,29E-04	1,75E-175	-2,55E-05	7,22E-05	-2,79E-04	0,00E+00
Distance To Soreang	-3,04E-05	1,91E-55	-7,96E-06	4,96E-152	1,54E-04	0,00E+00	-1,45E-05	5,28E-56	1,06E-04	0,00E+00	-3,74E-05	0,00E+00
Distance To Bandung	6,93E-05	2,16E-101	2,87E-05	0,00E+00	2,30E-05	3,88E-126	3,81E-05	2,07E-136	-1,80E-05	1,33E-13	8,33E-05	0,00E+00
Distance To Ngamprah	1,86E-04	2,93E-245	6,23E-05	0,00E+00	-1,27E-04	0,00E+00	1,13E-04	0,00E+00	-7,88E-05	7,60E-105	2,72E-04	0,00E+00

Table 1 interprets the influence of the driving factors of land cover changes on each land cover classes. Each driving factor has diverse influences for each class of land, which is characterized by positive or negative impacts. The whole predictor variables which are not proven to be correlated to land cover changes in Bandung Region are not included in the calculation of regression. Based on those result, all of the predictor variables proven give the impact that cause land cover change in Bandung Area with level of confident 95 % except for distance to Cimahi (plantation class) and curvature (shrubs class) has level of confident 70%.

Regression analysis is an analysis of the relationships between deterministic variables. Based on the deterministic nature, it can certainly determine the relationship between variables (causality), in this case the predictor variables to changes in land cover classes. For the predictor variable with interval or ratio scale, the interpretation of βi coefficient on a logistic regression model is that every increase c unit in the predictor variable will cause the risk of Y = 1, is exp (c.βi) times larger.

Odd ratio of all variables almost has the same value, between 0,97-1,007. These results indicate all driving variables have relatively the same influence (force) or none is dominant factor that causes changes in Bandung Region. However, land cover changes caused by such factors can have a diverse impact, both encouraging and discouraging the change. Such changes can have a positive or negative impact on the condition of land in Bandung Region. The changed of vegetation in to built up area is one of the negative impact of land conversion, although it is not investigated further the impact that occurs.

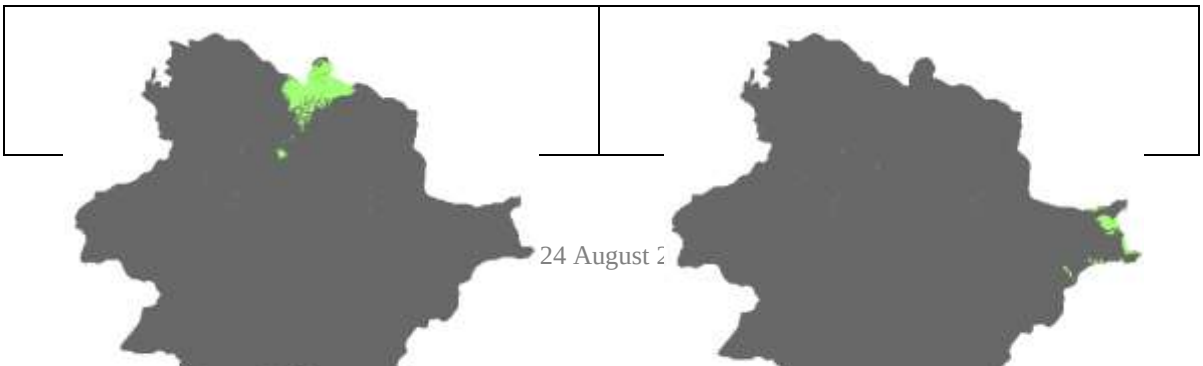
The results of regression analysis also show that the population density is one of the factor that influential to encourage land use changes for built up area and shrubs in Bandung Region. The population insistence will increase the probability of shrubs class changes into another cover classes. Class of forest, field, plantations, and paddy field are able to keep themselves from population pressure. Table 2 below shows that each class of land has a uniform driving variable of the changes. The regression coefficient (β) is then classified into two categories based on positive sign (red area/predictor variables that are encouraging land cover changes) and negative sign (grey area/predictor variables that are not encouraging land change).

Table 2. Driving Factors that Caused Land Cover Change in Bandung Region

Land cover / Driving Factors	Forest	Field/Moor	Plantations	Built Up Area	Shrubs	Paddy Field
Slope				■		■
Curvature	■			■	■	■
Elevation		■	■			
Population				■	■	
Distance To Road		■	■			
Distance To Cimahi			■			
Distance To Soreang			■		■	
Distance To Bandung	■	■	■	■		■
Distance To Ngamprah	■	■		■		■

■ Factor cause land cover change
Factor did not caused Land cover change

One step that could be selected related to control of land cover changes is to reduce the population growth rate, and also do not add new CBD in Bandung Region can be further consideration. Although the influence of driving factors between land cover change can be observed individually, but to know for certain whether the land classes change or not, it can be seen from the unity of the regression equation (influence), both positive and negative of each of the driving factors. After the classification process is done for each class of land cover, the probability map of land change which previously only provides information in the form of an interval value of 0 to 1, at this stage will obtain the map of land cover change prediction in Bandung Region by category changed and unchanged. Figure 6 shows a map of land cover change prediction in Bandung Region 2011 as a results of modeling using the partial RLB method.



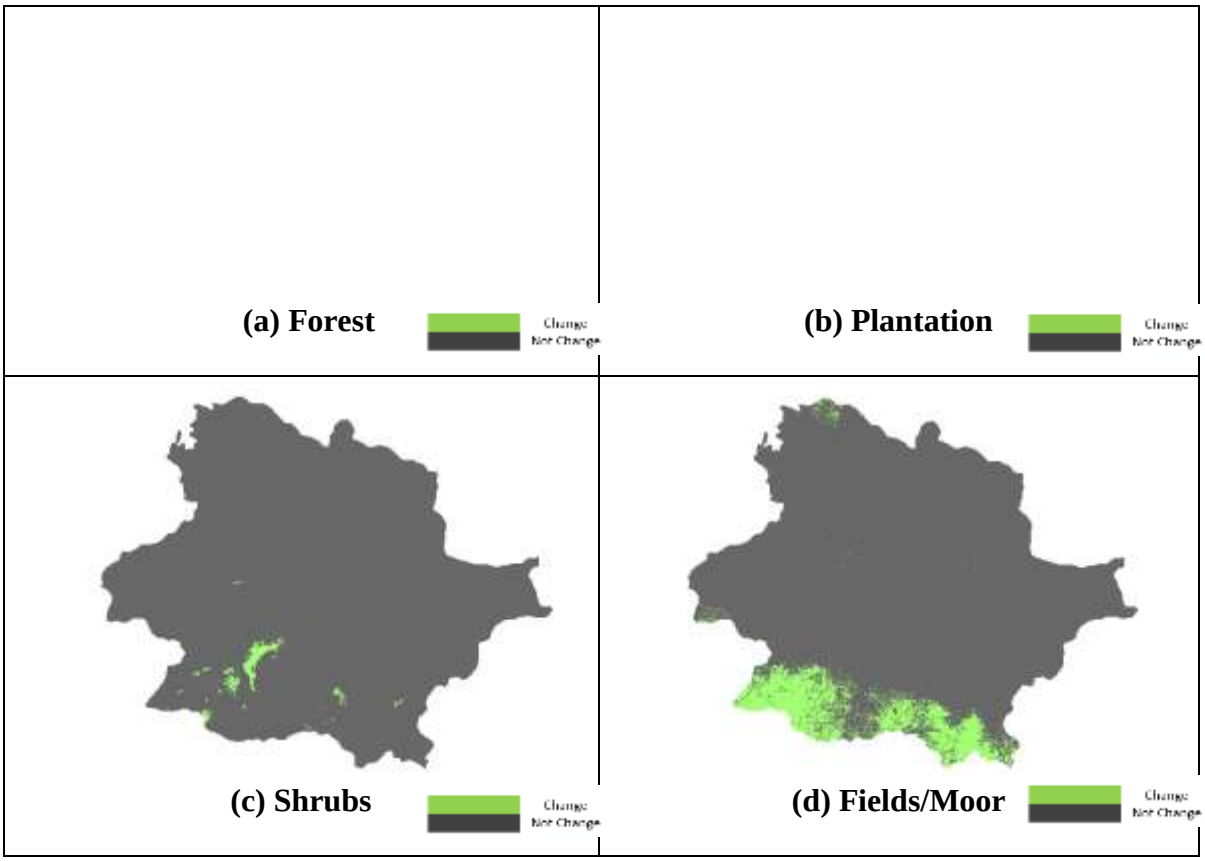


Figure 6. A Map of Land Cover Change in 2006-2011 in Bandung Region Using RLB.

4. Conclusion

Based on the discussion that has been done, this research obtains a land cover prediction model based on the driving factors in Bandung Region. RLB model shows that each land cover classes influenced by the driving factors that are not homogeneous. Thus the driving factors in land cover changes must be identified individually, not as a whole study area. Overall, the drivers of both physical and socioeconomic aspects tend to have an equally influence as a factor that causes land cover changes in the Bandung Region.

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