Spatial Analysis of Driving Factors on Land Cover Change’s Clusters in West Java Province

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Abstract. The study of land cover change as a phenomenon is necessary to do in order to understand global environmental change. With a cluster, the pattern and concentration of land cover change can be indicated, so that decisions can be made on target. The understanding of land cover change can be improved by identifying the factors affecting it. Land cover change depends on the physical and socio-economic characteristics of a region. Thus, the driving factor of land cover change in each region is different. This research is conducted to identify the driving factors on West Java Province's land cover change based on it is land cover change clusters. The relation between each factor and land cover change can be evaluated using the binary logistic regression, which is a data analysis method used to find a relationship between a binary response variable (y) and predictor variable(s) (x). In this case, the land cover change, as a dichotomous phenomenon, acts as the response variable, while the driving factors act as the predictor variables. The result of this study indicates that in general, the distance to the nearest central business district, as a factor, is the dominant driving factor of land cover change on West Java Province.

1. Introduction
The diverse nature of the topography and high socio-economic activities will affect changes in land cover. Regions will have different physical and socio-economic characteristics, meaning that every region has a different impact caused by land cover change. The impacts caused by the phenomenon of land cover change can be both positive and negative. Thus, information is needed to provide a strong foundation in maximizing the positive impact of land cover change. This study aims to provide information concerning the driving factors of land cover change. The results obtained are expected to be able to support the availability of information related to the factors that affect changes, with the hope that the information can help interested parties in making policy formulations and decision making.

In this study, the driving factors on land cover change clusters on West Java Province is determined using the Binary Logistic Regression (BLR) method through spatial analysis process using GIS. The analysis using the BLR method itself includes significance (p-value), β coefficient, and odds ratio. The BLR modelling is done for each cluster used (18 in number). The five factors used in this study includes two physical factors and three socio-economic factors, including height, slope, distance to the nearest central business district (CBD), distance to the nearest main road, and population.
2. Methods

2.1. Area of study
The study area conducted in land cover change clusters of West Java Province (Figure 1), with a total area of approximately 1,700 km². West Java Province itself has a geographical condition situated between 104° 48' 00" until 108° 48' 00" East longitude and 5° 50' 00" until 7° 50' 00" South latitude. Based on the available facts and data, West Java has a high economy activity that will have an impact on changes in land cover. Considering a good availability of data and information of this region, West Java Province is considered as an excellent research area.

![Figure 1. Area of study (marked in red)](image)

2.2. Datasets used
The data used in this study primarily consists of six primary data, namely:
- SRTM (Shuttle Radar Topographic Mission) Digital Elevation Model with a resolution of 90 meters derived from USGS,
- Thematic map of 2005 and 2010 land cover derived from Geospatial Information Agency (BIG),
- Administrative boundary map derived from Geospatial Information Agency (BIG),
- Road network map derived from Geospatial Information Agency (BIG),
- Social population data of 2005 and 2010 derived from the Central Statistical Agency (BPS), and
- Land cover change cluster map of West Java Province

2.3. Land cover change
Land cover change is a phenomenon of shifting on type of land cover to another, followed by the increase and decrease of the type of use over time, or changing the function of land at different times (Wahyunto et al., 2001). The process of land cover changes can also be in the form of conversion. The conversion process happens if land use is converted to other types of use, while the modification process occurs if there is a change in the intensity of use (Briassoulis, 2000).
Nowadays, land cover change is mostly caused by human activities in the use of such residential and production purpose (Lambin, 2004). Group or individual may use the land-based on various considerations, both from the physical aspects, such as topography and geomorphology, and socio-economic aspects (Briassoulis, 2000).

2.4. The binary logistic regression method
Binary Logistic Regression (BLR) is a regression model where response variables are binary (dichotomous or categorical). BLR formulated to predict and explain a dichotomous phenomenon (dependent variable) with the use of all data types as the independent variables (Hair, 2010). The purpose of BLR is to determine the effect of the independent variables on the dependent variable (land cover change) with a probability of occurrence of 0 (unchanged) and 1 (changed). BLR equation can be written as follows:

$$\text{Logit}(p_i) = \alpha + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n$$

Where:
- $p_i$: The probability of occurrence of the event $i$ (e.g. changes in land cover)
- $\alpha$: Constant of the regression equation
- $\beta_1 \ldots \beta_n$: Coefficient of the predictor variable (1, 2, ..., n)
- $X_1 \ldots X_n$: Variables of the predictor (1, 2, ..., n)

2.4.1. Significance. A binary logistic regression model has a significance value (p-value) for each predictor variable, which is a value used to prove whether a predictor variable has a significant effect on the response variable. A statistical test is conducted with the hypothesis of $H_0$ and $H_1$. In this case, $H_0$ means that a predictor variable has no significant effect on the response variable, where $H_1$ means that a predictor variable has a significant effect on the response variable. If the value of $p > 0.05$, then $H_0$ is accepted. Conversely, if the value of $p < 0.05$, then $H_0$ is rejected and $H_1$ is accepted. A variable that has a value of $p > 0.05$ can be ignored.

2.4.2. Odds ratio. A binary logistic regression model has a value called odds ratio, which is a ratio between the probability of something occurring and the probability of it is not occurring (Hair, 2010). The value of the odds ratio is used to determine the amount of effect of each predictor variable on the response variable. Odds ratio equation can be written as follows:

$$\text{Odds Ratio} = \frac{\pi_i}{1 - \pi_i}$$

Where:
- $\pi_i$: The probability of occurrence of the event $i$ (e.g. changes in land cover)
- $1 - \pi_i$: The probability of not occurrence of the event $i$

3. Results and discussion
In the BLR method, land cover change corresponds to the response variable ($y$), while five factors used corresponds to predictor variables ($x$) with height as $x_1$, distance to the nearest CBD as $x_2$, distance to the nearest main road as $x_3$, the population as $x_4$, and slope as $x_5$. Eighteen clusters of land cover change on West Java Province is used. The relationship between each factor and the land cover change are modelled for each cluster, resulting in a total of 18 models.

3.1. Result of significance value
The result of significance (p-value) can be seen on the table 1 below:
| Cluster | x1   | x2   | x3   | x4   | x5   |
|---------|------|------|------|------|------|
| 1       | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| 2       | 0.000000 | 0.000000 | 0.012766 | 0.000000 | 0.000000 |
| 3       | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| 4       | 0.000000 | 0.000839 | 0.000000 | 0.130805 | 0.158146 |
| 5       | 0.007718 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| 6       | 0.000000 | 0.000417 | 0.000000 | 0.000000 | 0.000000 |
| 7       | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| 8       | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| 9       | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| 10      | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| 11      | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| 12      | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| 13      | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| 14      | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| 15      | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| 16      | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| 17      | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| 18      | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |

Based on the results in Table 1, some factors on specific clusters do not have a significant effect on the related clusters (marked in yellow), showed by the significance value p > 0.05. Slope as a factor is the one with the most insignificant effect on clusters, with a total of 8 clusters. Height has an insignificant effect on 1 cluster, distance to the nearest CBD has an insignificant effect on 3 clusters, distance to the nearest main road has an insignificant effect on 6 clusters, and population has an insignificant effect on 2 clusters. Those data that has no significant effect can be ignored in the subsequent part of the process. The clusters that have insignificant factors is remodelled using only significant factors.

3.2. Result of BLR
Modelling using the BLR method produces an equation for each cluster observed. In the equation, there are constant values ($\alpha$) and coefficient values ($\beta$) for each factor affecting the clusters. The resulting model of BLR in the form of table can be seen in Table 2 below:

| Cluster | Intercept ($\alpha$) | x1 | x2 | x3 | x4 | x5 | x6 |
|---------|----------------------|----|----|----|----|----|----|
| 1       | 2.994602             | -0.001345 | 0.000026 | 0.000076 | -0.022349 | -0.048864 |
| 2       | 2.575101             | -0.000774 | 0.000025 | -0.000017 | -0.033277 | -0.073485 |
| 3       | 2.034051             | 0.001169 | 0.000062 | -0.000991 | -0.012018 | -0.057110 |
| 4       | 8.716462             | -0.048324 | -0.000115 | -0.000158 | - | - |
| 5       | -21.93217            | 0.004781 | 0.001068 | -0.001494 | 4.371217 | -0.050470 |
| 6       | -7.930110            | 0.009715 | 0.000165 | - | - | 0.032013 |
| 7       | 4.921200             | -0.002261 | -0.000065 | 0.000035 | -0.008579 | -0.030242 |
| 8       | -25.532591           | 0.020486 | 0.000474 | - | 5.179954 | - |
| 9       | -2.053212            | 0.023919 | - | - | -0.010188 | 0.112477 |
Based on the result in table 2, the regression coefficient (β) can be either positive or negative. A positive value on clusters indicates that the related predictor variable (factors of land change cover) is the driving factor for the change of land cover in those clusters. The distance to the nearest CBD encourages changes in land cover in more clusters compared to other factors, namely as many as 11 clusters. The height factor encourages land cover change in 8 clusters, distance to the main road in 4 clusters, population in 3 clusters, and slope in 4 clusters.

### 3.3. Result of the odds ratio

The value of odds ratio indicates that for every increase of 1 unit of a factor on a particular cluster, the probability of a change in land cover on that cluster will multiply as much as the odds ratio value. The result of the odds ratio can be seen in table 3 below:

#### Table 3. Result of the odds ratio

| Cluster | Odds ratio | x1 | x2 | x3 | x4 | x5 |
|---------|------------|----|----|----|----|----|
| 1       | 0.998656   | 1.000026 | 1.000076 | 0.977899 | 0.952311 |
| 2       | 0.999226   | 1.000025 | 0.999983 | 0.967271 | 0.929150 |
| 3       | 1.001170   | 1.000062 | 0.999909 | 0.988054 | 0.944490 |
| 4       | 0.952825   | 0.999885 | 0.999842 | -       | -       |
| 5       | 1.004792   | 1.001069 | 0.998507 | 79.139877 | 0.950783 |
| 6       | 1.009763   | 1.000165 | -       | -       | 1.032531 |
| 7       | 0.997343   | 0.999935 | 1.000035 | 0.991458 | 0.970211 |
| 8       | 1.020697   | 1.000474 | -       | 177.674670 | -       |
| 9       | 1.024207   | -       | -       | 0.989864 | 1.119047 |
| 10      | 0.997000   | 0.999895 | 1.000256 | 0.956813 | 1.042689 |
| 11      | 0.989724   | 0.999907 | -       | 0.978861 | -       |
| 12      | 1.002800   | 1.001305 | 0.999086 | 0.966293 | 1.029815 |
| 13      | 1.005148   | 1.000056 | 0.999723 | 0.980998 | -       |
| 14      | 0.997876   | -       | -       | 56.949335 | -       |
| 15      | 0.951891   | 1.000192 | 0.999702 | 0.934583 | -       |
| 16      | -          | -       | -       | 0.968149 | -       |
| 17      | 0.993172   | 1.000177 | 0.999804 | 0.963000 | 0.963757 |
| 18      | 2.107726   | 1.000373 | 1.000302 | 0.942515 | -       |
Based on the result in table 3, the value of odds ratio ranges from 0.929150 (slope factor in cluster 2) to 177.674670 (population factor in cluster 8). Odds ratio value for driving factors range from 1.000025 (distance to the nearest CBD factor in cluster 2) to 177.674670 (population factor in cluster 8). The population as a driving factor has high values of odds ratio compared to other driving factors.

4. Conclusions
Based on the results of the study, the driving factors of land cover change on West Java Province is heterogeneous. In general, the dominant driving factor of land cover change on West Java Province based on it is land cover change clusters is the distance to the nearest central business district (CBD).

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