

Multiscale Spatial Assessment of Determinant Factors of Land Use Change: Study at Urban Area of Yogyakarta

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Abstract. Studies of land use change have been undertaken by different researchers using various methods. Among those methods, modelling is widely utilized. Modelling land use change required several components remarked as model variables. Those represent any conditions or factors which considered relevant or have some degree of correlation to the changes of land use. Variables which have significant correlation to land use change are referred as determinant factors or driving forces. Those factors as well as changes of land use are distributed across space and therefore referred as spatial determinant factors. The main objective of the research was to examine land use change and its determinant factors. Area and location of land use change were analysed based on three different years of land use maps, which are 1993, 2000 and 2007. Spatial and temporal analysis were performed which emphasize to the influence of scale to both of analysis's. Urban area of Yogyakarta was selected as study area. Study area covered three different districts (kabupaten), involving 20 sub districts and totally consists of 74 villages. Result of this study shows that during 14 years periods (1993 to 2007), there were about 1,460 hectares of land use change had been taken place. Dominant type of land use change is agricultural to residential. The uses of different spatial and temporal scale in analysis were able to reveal different factors related to land use change. In general, factors influencing the quantities of land use change in the study area were population growth and the availability of land. The use of data with different spatial resolution can reveal the presence of various factors associated with the location of the change. Locations of land use change were influenced or determined by accessibility factors.

Keywords: multiscale spatial assessment, land use, Yogyakarta

1. Introduction

Studies on land use change have been conducted by the researcher along with the growing awareness to the importance of the phenomena. At the beginning of 1980s, land use and land cover change became a concern because of it has relation with global climate change by the carbon cycle [1, 5, 6, 7]. Changes in land use are also seen as a fundamental factor for the operation of the environmental and socio-economic systems, from local to global scale [2].

Land use change can be assessed using different methods. Among those methods, spatial modeling is widely utilized. Model is simplification of real-world phenomena [8, 11, 12]. Through a model or



modeling, a complex phenomenon is represented using simplest manner i.e. a number of components referred to as modeling variables.

Variables used in the land use change model are representation of factors related to the phenomenon. These factors often referred to as determinant factors of land use change. Land use change is considered as a complex spatial phenomenon as a result of the interaction of various determinant factors. The physical condition of land, socio-economic, demographic and policy are factors that are generally supposed to be related to changes in land use [6]. These factors interact in the manner and intensity of which varies according to time and space. Study of the determinant factors therefore is necessary as a basis of modeling the spatial dynamics of land use.

Land use change is a spatial phenomenon as well as its determinant factors. Changes in land use occupy a certain location and occur in a certain period as well. Study of spatial phenomena requires appropriate methods that are known as spatial analysis. Spatial analysis, on the other hand, has a critical issue related to the use of different scale in analysis. The same phenomenon which is analyzed at different scales, very likely leads to a different conclusion. The problem is known as MAUP, which is an abbreviation of the modifiable area unit problem [4].

The objective of this study is to examine changes in land use and the factors associated with it. The most influential factor is referred to as determinant of change. The study was conducted through a spatial analysis by taking into account the effect of scale in the process of analysis. Urban area of Yogyakarta was selected as study area. Land use change in the study area were considered intensive, particularly from agriculture to other type of land use [9, 10].

2. Study Area

The study was conducted at the Urban area of Yogyakarta (Figure 1). This area covered whole area of Yogyakarta City and some parts of Sleman as well as Bantul Districts (kabupaten). Yogyakarta City consist of 16 sub districts (kecamatan). Parts of Sleman Districts used in the study, involved 3 sub districts namely Gamping, Mlati and Depok. Depok is quite well known for rapid development as well as for being the location of Universitas Gadjah Mada, one of the famous universities in Indonesia. Bantul Districts also involved 3 sub districts namely Kasihan, Sewon and Banguntapan. The entire study area, therefore involving 20 sub districts and totally consists of 74 villages (desa).

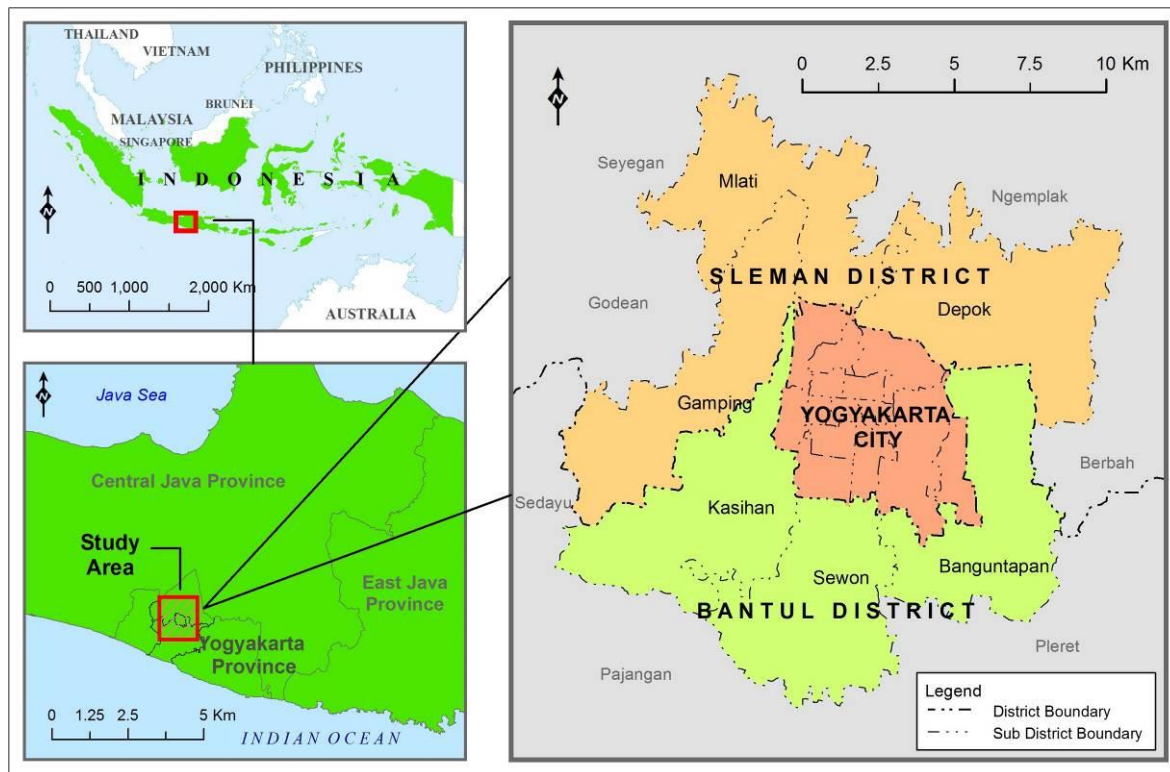


Figure 1. Study area

3. Methods

Determinant factors of land use changes in the study were assessed by means of mapping and spatial analysis. Mapping was conducted to identify spatial distributions of land use changes as well as presumably factors related to the land use changes. Spatial and statistical analyses were used to assess significant factors related to area and location of land use change.

3.1. Data

Data used in this study include 1: 25.000 multi temporal land use maps, 1: 25.000 Indonesian topographic maps (RBI), demographic and socio-economic data. Multi temporal land use maps consisted of 1993, 2000 and 2007 maps respectively. Those maps originally derived from 1: 25.000 Indonesian topographic maps and updated periodically based on interpretation of remote sensing imagery.

Time series of demographic and socio-economic data, from year 1993 up to 2007, were obtained from secondary sources. Books namely Sleman District in Figures, Bantul District in Figures and Yogyakarta City in Figures were used as main source. Those books were published by Central Bureau of Statistics (Badan Pusat Statistik).

3.2. Mapping of Land Use Change as Dependent Variable

Land use change maps were obtained by overlaying land use maps of 1993, 2000 and 2007. Those maps show the spatial distribution of land use change over the period of 1993 – 2000 and 2000-2007 (Figure 2). Land use changes were simplified in to two categories namely change and persistence. The location where the change occurs is referred to as change, while the location where the change does not occur is referred to as persistence.

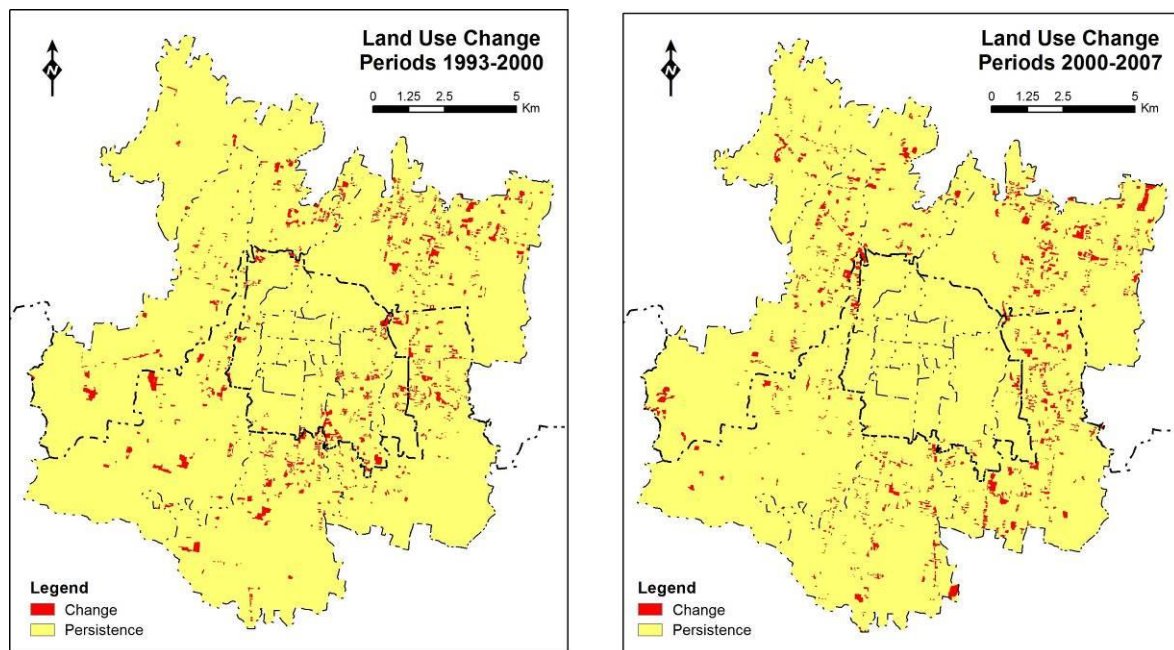


Figure 2. Spatial distribution of land use change 1993-2000 and 2000-2007

Quantities as well as spatial distribution of land use changes were vary across time periods. In the 1993-2000 periods, total area of land use change was 704.9 ha. Those changes were taken place in the city as well as in urban fringe area. In the urban fringe area, land use change mostly distributed in the northern and eastern part of study area. In the 2000-2007 periods, total area of land use change was 769.4 ha and mostly taken place in urban fringe area. Detail information about quantities and spatial distribution of land use change in the study area are shown in Table 1.

Table 1. Area of land use change by administrative division

District	Sub district	Area of Land Use Change (Ha)	
		1993-2000	2000-2007
Bantul	Banguntapan	99,67	177,21
	Kasihan	83,39	60,31
	Sewon	108,08	109,88
Sleman	Depok	168,27	195,17
	Gamping	51,52	117,16
	Mlati	66,78	88,21
Yogyakarta	Gondokusuman	3,93	
	Kotagede	10,28	9,75
	Mantrijeron	3,43	0,81
	Mergangsan	8,05	
	Tegalrejo	14,56	2,58
	Umbulharjo	79,57	8,3
	Wirobrajan	7,33	
Total		704,86	769,38

3.3. Mapping of Predetermining Factors as Independent Variable

Any conditions or factors presumably related to land use change are referred to as predetermining factors. Identification of those factors was conducted based on literature and local knowledge about study area.

3.3.1. Presumably Variable Related to Area of Land Use Change. Factors presumably related to the quantity or area of land use change consisted of 6 (six) variables. Each variable was given a name and a specific code for purpose of analysis. Table 1 shows the presumably variables related to area of land use change. Those variables were used in analysis to assess determinant factors of area or quantity of land use change.

Table 2. Presumably variables related to area of land use change

No	Variable Name	Variable Code	Description
1	Tegal	Var_A1	Area and proportion of dry field
2	Kebun	Var_A2	Area and proportion of mix garden
3	Sawah	Var_A3	Area and proportion of rice field
4	Pdd	Var_A4	Number of population
5	Tum_Pdd	Var_A5	Rate of population growth
6	Kpdt	Var_A6	Population density

The first three variables were used to represent availability of land, which is land available for conversion. Previous analysis indicates that dominant type of land use change in the study area was conversion from agricultural land to settlement. Therefore, availability of agriculture land supposedly determines the quantity of land use change. The last three variables were used to represent demand for land. Quantity of land use change, particularly conversion from agricultural land to settlement, supposedly determines by increasing demand for residential use.

3.3.2. Presumably Variable Related to Location of Land Use Change. Factors presumably related to the location of land use change consisted of 7 (seven) variables. Each variable was given a name and a specific code for analysis. The first six variables (Var_L1 to Var_L6) were representing the accessibility of land. Accessibility can be expressed in terms of money, time, preference, effort or any concept of cost (Braumoh and Onishi, 2007). In this study, accessibility was measured in terms of distance to targets (government office, university, existing settlement and roads). The seventh variable (slope) represents topographic condition. Table 2 shows the presumably variables related to location of land use change.

Table 3. Presumably variables related to location of land use change

No	Variable Name	Variable Code	Description
1	Jr_Kntr	Var_L1	Distance to government office
2	Jr_kmps	Var_L2	Distance to university
3	Jr_Bang	Var_L3	Distance to existing settlement
4	Jr_JalAll	Var_L4	Distance to roads
5	Jr_JalLok	Var_L5	Distance to access roads (local roads)
6	Jr_JalUt	Var_L6	Distance to main roads
7	Slope	Var_L7	Slope

Accessibility variables were obtained through spatial analysis called distance analysis. This analysis used pixel, with a certain size, as a unit of measurement. Topographic variable (slope), derived from

DEM (Digital Elevation Model). All maps of presumably factors related to location of land use change are shown in Figure 3.

3.4. Statistical Analysis Techniques

Assessments of determinant factor were conducted using two statistical techniques namely regression and logistic regression analysis. Regression analysis was used to assess the determinant of area or quantities, while logistic regression analysis was used to assess the determinant of location.

3.4.1. Multiple Regressions. Area or quantities of land use change serve as dependent variable or response variable. Presumably factors serve as independent variable or predictor variable. Multiple regressions linking the dependent variable with several independent variables through an equation as shown in equation [1].

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2, \beta_k X_k \quad [1]$$

The above equation linking the value of Y that is area of land use change with variables X_1, X_2 up to X_k . The value of α is a constant regression while β_1, β_2 and β_k are regression coefficient for the predictor variables.

3.4.2. Logistic Regression. Location of land use change serves as dependent variable or response variable. Presumably factors serve as independent variable or predictor variable. Logistic regression analysis is basically the same as ordinary regression analysis. The difference lies in the value of the response or dependent variable. Instead of using the real value, logistic regression using logit function as the response variable. Using binary notation, the response variable values can be written with the number 1 and number 0. Number 1 represents the location where changes occur while the number 0 represents the location where the change does not occur. Logistic regression can be written in the form equation as shown in equation [2]

$$\text{Logit}(p_i) = \alpha + \beta_1 X_1 + \beta_2 X_2, \beta_k X_k \quad [2]$$

where,

- p_i : the probability of occurrence (change or no change)
- α : regression constants
- β_1 : coefficients of predictor variables 1
- $X_{..k}$: predictor variable (1, 2, ... k)

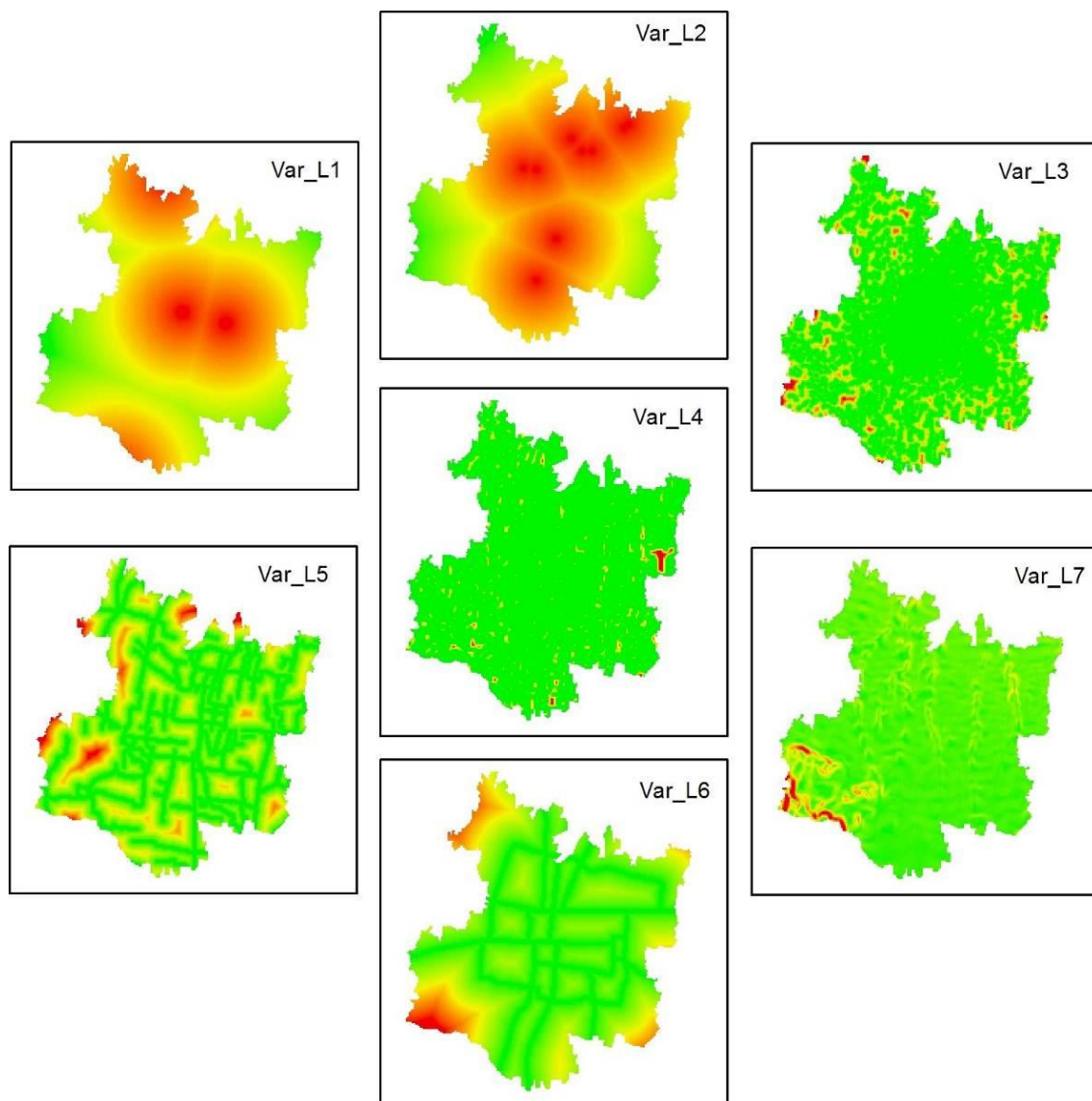


Figure 3. Maps of presumably variables related to location of land use change

3.5. The Multi Scale Analysis

Analysis of determinant factor using regression and logistic regression, as previously described, were performed on a different spatial and temporal scale. This was done to demonstrate what so called “multi scale effect” of performing spatial analysis. Multi scales in the context of spatial analysis were shown by using what is referred to as spatial extent and grain or resolution. Determinant factors of area or quantities of land use change were analysed using different spatial extent. Determinant factors of location of land use change were analysed using different grain or resolution. Figure 4 illustrates different spatial extent in the analysis of determinant factors related to area of land use change. Figure 5 illustrates different spatial resolution or spatial grain used in the analysis of determinant factors related to location of land use change.

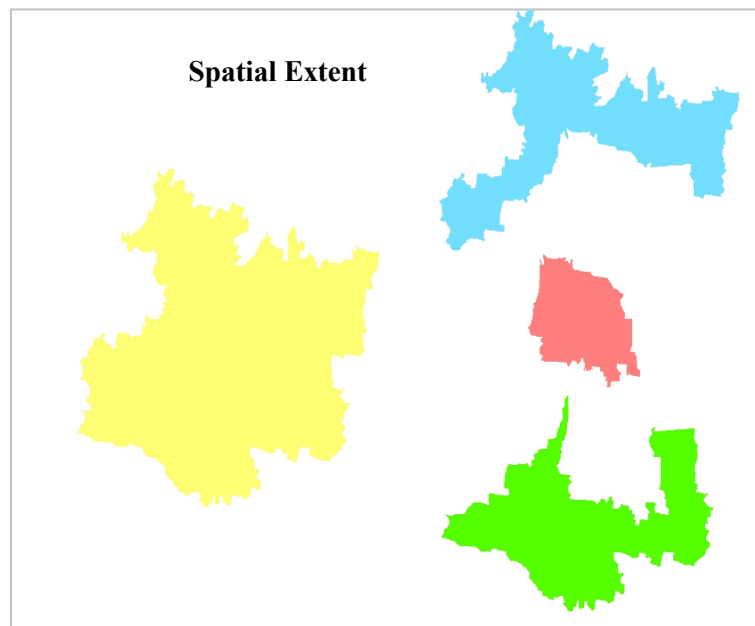


Figure 4. Three different spatial extent used in multi scale analysis

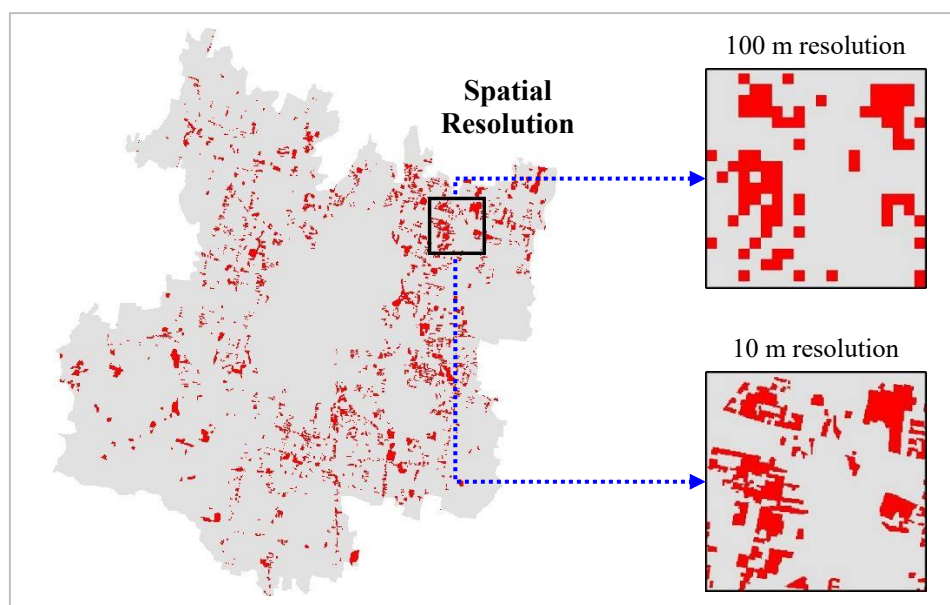






Figure 5. Two different spatial resolution used in multi scale analysis

4. Result and Discussion

4.1. Determinant Factors Related to Area of Land Use Change

Statistical analyses show that area or quantity of land use change has significant correlation with several variables. As analyses performed using different spatial and temporal scales, different results were obtained. Table 4 show variables which have significant correlation to area of land use change. Those variables area referred as determinant factors of area of land use change. It should be noted that population growth variable (Var_A5), marked as significant variable in different scale of analyses.

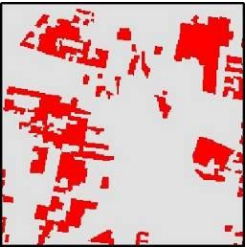
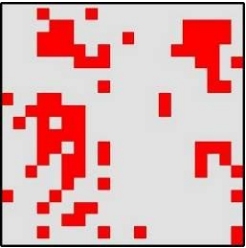
Table 4. Significant variables related to area of land use change

Analysis Extent (Spatial Scale)	Periods of Analysis (Temporal Scale)					
	1993 – 2000		2000 – 2007		1993 – 2007	
	Variable	β	Variable	β	Variable	β
 Whole Area	Constant	-9.677	Constant	-28.884	Constant	-50.198
	Var_A1	.268	Var_A3	.100	Var_A3	.002
	Var_A2	-.098	Var_A4	.001	Var_A4	.129
	Var_A3	.031	Var_A5	8.195	Var_A5	18.806
	Var_A4	.001				
	Var_A5	3.595				
	R	.880	R	.800	R	.831
	R ²	.774	R ²	.640	R ²	.631
 Bantul	Constant	-8.166	Constant	-18.668	Constant	-27.795
	Var_A4	.002	Var_A3	.088	Var_A4	.003
			Var_A5	11.972	Var_A5	15.310
	R	.747	R	.830	R	.755
	R ²	.559	R ²	.689	R ²	.601
 Sleman	Constant	13.504	Constant	-1.120	Constant	38.777
	Var_A1	.436	Var_A1	.489	Var_A1	1.057
	Var_A2	-.197	Var_A2	-.302	Var_A2	-.495
			Var_A3	.106		
	R	.921	R	.912	R	.919
	R ²	.849	R ²	.832	R ²	.844
 Yogyakarta	Constant	-.139	Constant	.712	Constant	-.627
	Var_A1	-.269	Var_A1	.470	Var_A3	.653
	Var_A3	.376				
	R	.925	R	.837	R	.902
	R ²	.855	R ²	.700	R ²	.813

4.2. Determinant Factors Related to Area of Land Use Change

Statistical analyses show that location of land use change has significant correlation with several variables. Analyses were performed using two different spatial resolutions which are 100 meters and 10 meters. Spatial resolution reflects detail of data used in analysis. Some time, spatial data which has some level of detail is not available. For example, rather than using Ikonos or QuickBird imagery we use Landsat imagery as a source data for mapping and analysis the location of land use change. The use of less detail spatial data will affect the result of analysis. Table 4 show significant variables related to location of land use change.

Table 5. Significant variables related to location of land use change

Resolution (Spatial Scale)	Periods of Analysis (Temporal Scale)					
	1993 – 2000		2000 – 2007		1993 – 2007	
	Variable	Exp (B)	Variable	Exp (B)	Variable	Exp (B)
10 m 	Constant	3.277	Constant	.844	Constant	6.701
	Var_L1	1.000	Var_L2	1.000	Var_L1	1.000
	Var_L2	1.000	Var_L3	1.000	Var_L2	1.000
	Var_L3	0.997	Var_L4	0.989	Var_L4	0.987
	Var_L4	0.988	Var_L5	0.999	Var_L5	0.999
	Var_L5	0.999	Var_L6	0.999	Var_L6	0.999
	Var_L6	0.999	Var_L7	0.917	Var_L7	0.952
	Cox & Snell R ²	0.112	Cox & Snell R ²	0.077	Cox & Snell R ²	0.200
	Nagelkerke R ²	0.223	Nagelkerke R ²	0.142	Nagelkerke R ²	0.294
100 m 	Constant	2.008	Constant	0.534	Constant	1.732
	Var_L1	1.000	Var_L1	1.000	Var_L2	1.000
	Var_L2	1.000	Var_L2	1.000	Var_L4	0.996
	Var_L4	0.995	Var_L4	0.997	Var_L5	0.999
	Var_L5	0.999	Var_L5	0.999	Var_L6	0.999
	Var_L6	0.999	Var_L6	0.999		
	Var_L7	1.139				
	Cox & Snell R ²	0.115	Cox & Snell R ²	0.073	Cox & Snell R ²	0.133
	Nagelkerke R ²	0.226	Nagelkerke R ²	0.136	Nagelkerke R ²	0.205

5. Conclusions

Scale is a concept related to the use of specific dimensions to measure or assesses the phenomenon. Scale becomes an important aspect in conducting analysis particularly spatial analysis. This study clearly demonstrates the effect of spatial and temporal scale in the analysis of the determinant factors of land use change. The use of different analysis extents was able to reveal the different factors related to quantities of land use change. The use of data with different spatial resolution can reveal the presence of various factors associated with the location of land use change.

During the period of 14 years between 1993 and 2007 there were 1,460 ha of land use change occurred in the study area. Dominant type of land use change was agricultural land converted to residential use. Land use change in the study area has significant correlation with a number of factors. Number of factors as well as degree of correlation varies spatially and temporally. In general, factors influencing the quantities of land use change in the study area were population growth and the availability of land. Availability of land in this study refers to the presence of agriculture land. These two factors have significant influence in urban fringe areas, while in Yogyakarta City the only significant factor is availability of land. Locations of land use change were influenced or determined by accessibility factors. Accessibility of land in this study was indicate by it distance to roads and other facilities. The probability of land use change will take place in certain location, increase as distance to roads and other

facilities decrease. Analysis of data with higher spatial resolution revealed that location of land use change has also significant correlation with topographic condition.

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