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MODELING LAND USE CHANGE USING GIS AND LOGIT MODEL

Ita CAROLITA
Ernan RUSTIADI
Sunsun SAEFULHAKIM
Alinda M ZAIN

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Department of Economics & Development Studies
Padjadjaran University

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By
Ita CAROLITA,
(Remote Sensing Application Center, LAPAN, Jakarta)
Jl. LAPAN 70, Pekayon. Jakarta Timur, Indonesia.
Email: ita_carolita@yahoo.com

Ernan RUSTIADI
Lab of Land Resources Development Planning, Fac. Of Agriculture,
Bogor Agricultural University
Jl. Meranti, Darmaga Campus IPB. Bogor, Indonesia
Email: ernan@hdp-ina.net

Sunsun SAEFULHAKIM
(Bogor Agricultural University, Bogor)
Lab of Land Resources Development Planning, Fac. Of Agriculture,
Bogor Agricultural University
Jl. Meranti, Darmaga Campus IPB. Bogor, Indonesia

Alinda M ZAIN
Lab. Of Landscape Architecture, Fac. Of Agriculture
Bogor Agricultural University
Jl. Meranti, Darmaga Campus IPB. Bogor, Indonesia
Email : alindafm@ipb.ac.id

ABSTRACT

Rapid urbanization in Jabotabek has caused serious environmental problem, including land use conversion. Therefore, it's necessary to determine the land use change pattern in Jabotabek by using GIS and Remote Sensing techniques. The advantage of remote sensing data are repetitive, real time and in digital format allowing for quantitative approach. Te objectives of this research is was to study temporal change and spatial distribution of land cover, by comparing the data from Landsat of Jabotabek in 1992 and 2001.

This research was carried out in 3 stages: remote sensing data processing, GIS analysis and modeling. Analysis using logit model showed that the factors which influenced land use change to urban are: distance from CBD, slope and altitude of area.

Key words *: LUCC, GIS, Remote Sensing, Logit Model*

Introduction

By the end of the 20^{th} century, the urban population in Indonesia was increasing rapidly particularly in the largest urban agglomeration, the Jakarta Metropolitan Region also known as Jabotabek (Jakarta, Bogor, Tangerang, Bekasi). In 1990, more than 70% of the Jabotabek population resided in urban areas (Central Board of Statistics, 1990). The population growth here, in the center of economic growth and national development since the beginning of the 20^{th} century, has led to the expansion of urbanization in Jakarta and adjacent areas.

In the capital cities of Indonesia, Jakarta, urbanization has pushed the peripheral zones much beyond their earlier limits and has spilled over into the rural villages or towns surrounding the city. The growth of these capital has been rapid over the past several decades, causing rapid rural-to-urban regions, housing storages, and expansion of squatter settlements. Several studies have indicated that rapid urbanization caused rapid land use/cover change and serious environmental problems (Zain, 2002).

Concerns for land use and land cover study are increasing due to multiplying urban and rural populations, which are leading to enlargement of agricultural areas at the expense of forest areas, and encroachment of urbanization and industrial activities on agricultural land (Spaargaren, 1999). Urbanization, the conversion of other types of land uses associated with growth of population and economy, in the main type of land use and land cover change in human history (Weng, 2001).

Rapid urbanization and industrialization in Jabotabek has caused serious environmental problem, including land use conversion. Therefore, it's necessary to determine the land use effectively and efficiently, since research be able conducted without the need of extensive observation through the whole area.

During the last 25 years, remotely sensed data have been used extensively to monitor environmental change, to map land cover, and to monitor urban expansion (Kawamura et al, 1998; Jim, 2000). The advantage of remote sensing are repetitive, real time, and in digital format allowing for quantitative approach.

Baker (1989) classified landscape/land use models into three categories. The first category includes all kinds of landscape indices, which describe the structures of a landscape/land use. The second kind of model is the distributional model, which analyze the distributional landscape/land use changes. The third category of landscape/land use model is the spatial model which focuses on the spatial-explicit patterns of landscape/land use. Distributional models such as Markov models and regression models can be used pixel by pixel to simulate spatial pattern of a landscape (Turner, 1987). Regression model can be modified into probit or logit models to analyze factors contributing to landscape/land use changes, and to predict the probabilities of landscape/ land use change at different spatial locations. Therefore, in this study logit models were subsequently used to examine factors responsible for those changes, and to predict probabilities of landscape changes spatially.

II. MATERIALS AND METHODS

2.1. Study Area and Materials

The study area, Jabotabek (Jakarta, Bogor, Tangerang, Bekasi) covering an area of about 6,752 km2, is the largest urban agglomeration in Indonesia. Jabotabek area is situated along the northern coast and mountainous western part of Java. The altitude varies from 0 to 3,000 m. Three types of landform exist the northern lowlands of the coastal plain along Jakarta Bay, the central plateau, and the southern uplands and mountainous area.

For this study, we used 2 Landsat TM images data for two points of time (1992 and 2001) were sourced from Indonesia National Institute of Aeronautics and Space (LAPAN). Topographic maps were sourced from the National Coordination Agency for Surveys and Mapping (BAKOSURTANAL). Socio-economics data was sourced from Statistical Bureau (BPS), and soil type maps were sourced form CSAR Bogor.

This study was carried out in 3 stages. First, remote sensing data processing to generate land use changes map. Second, identifying the driving forces and other related factors of land cover change, then integration these data using GIS technique. Finally developed model that could explain the dominant factor of land use change.

2.2.1. Remote Sensing Data Processing

In practice, land use changes detection by using remotely sensed data was obtained from the analysis of multi-temporal data as visualized in Figure 1. Nevertheless, spatial and spectral properties have been considered. During each data capture, environmental conditions should be similar as much as possible to minimize the difference in the reflectance caused by moisture variation or sun angle differences. The remote sensing data processing for land use and land cover changes can be classified into three main processes. There are processing, land covers classification and multi-date land cover comparisons and analysis.

Pre-Processing

The raw remote sensing data may contain flaws or deficiencies. Therefore, it is necessary to remove data errors and unwanted or distraction elements of the image. Teir correction is termed radiometric pre processing, which contain destripping, stretching and haze removal. The fitting of a remotely sensed image to the scale and projections of a map, geometric correction was done by Landsat ETM automatically. Image to image rectifications where registering uncorrected image (Landsat TM) to a geometric corrected image with same map projection and spatial resolution. Then, by re-sampling process with cell size of 30 m x 30 m, we obtain the same spatial properties. Finally, cropping is done to fit with district area of Jabotabek.

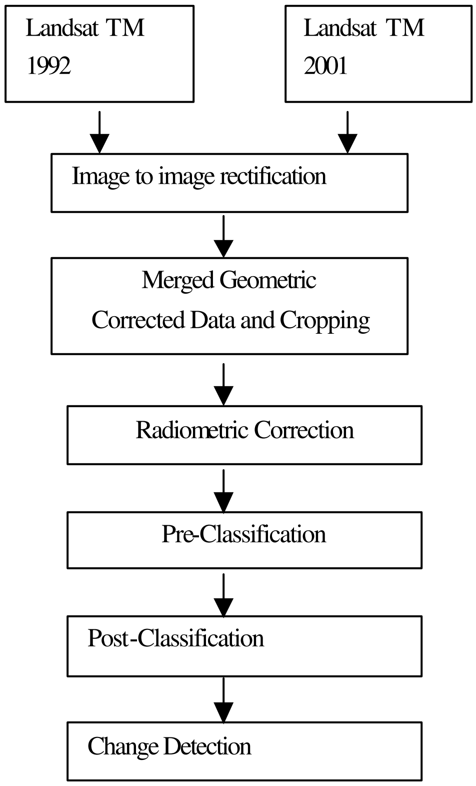


Figure 1. Conceptual Land Use Changes Detection Using Remote Sensing Data

Land Cover classification

Supervised classification was applying to classify the remote sensing data by using maximum likelihoods method. Ground truth and verification were also conducted to ensure the accuracy of the remote sensing classification. The classes of land cover for this classification are: built up, water, agriculture, paddy field and forest

Multi-date land cover comparison and analysis

Multi-date comparison was carried out to obtain coincidence matrix and statistic. Analysis land cover change was performed within sub-district.

2.2.2. Geographic Information System

Technically GIS can be used to combine both spatial and statistical data. Spatial data should be related to info-text in which spatially data would be able to expound a particular area.

There are 6 data which will be integrated in GIS, those are : land cover classification map (generated from Landsat data), slope map and altitude map (generated from topographic map), "*desa*" (sub district) boundary map (generated from land use map that produced by Bakosurtanal) , population density (from BPS) and the distance from business/activities center of JABOTABEK to center of "*desa*".

Slope and altitude map

Slope map, which was generated from topographic map is classified into 6 classes, so the distribution of certain slope can be determined on the map. Altitude map -also generated from topographic map- was classified into 10 classes.

Socio-economics

Socio economic data utilized in this study was compiled by Government Statistics Agencies (BPS), which officially published to be utilized by interested individual or parties. Data were taken from two points of time, 1992 and 2000. Compared to the data produced by remote sensing colleagues, which is use two points of time (1992 and 2001), this is a little bit difference. But the differences can be tolerated since changes in the variables in the two times period more or less the same, or there were no drastic changes during the period.

2.2.3. Logit Model

The process of land use change is determined by universal driving force, such as urbanization, population growth, industrialization and so on. This process also depend on local characteristics such as inherent socio-economic, natural condition and behavioral characteristic of the people. Land use change models, which are sensitive to local characteristics are needed for evaluation scenario and to develop effective policy recommendation.

The purpose of this study is to develop a set probabilistic models for predicting land use changes spatially. Multinomial models were used to examine the factors contributing to land use changes. This methodology was proposed by Kitamura *et al*, (1997), which could predict changes of major land uses by means of relatively simple procedures. A multinomial logit model was applied for estimating the land use ratio function. The equation were specified as follows:

$$P_{i/r} = \frac{\exp(\beta_{0r} + \sum_{j=1}^{R} \beta_{jr} X_j)}{1 + \sum_{r=1}^{R-1} \exp(\beta_{0r} + \sum_{j=1}^{q} \beta_{jr} X_j)}$$

Where p=1,2,…n

X1 = distance to CBD

X2 = population density

X3 …X8 = slope (in 6 classes)

X9… X18= altitude (in 10 classes)

X19…X21=type of previous land use

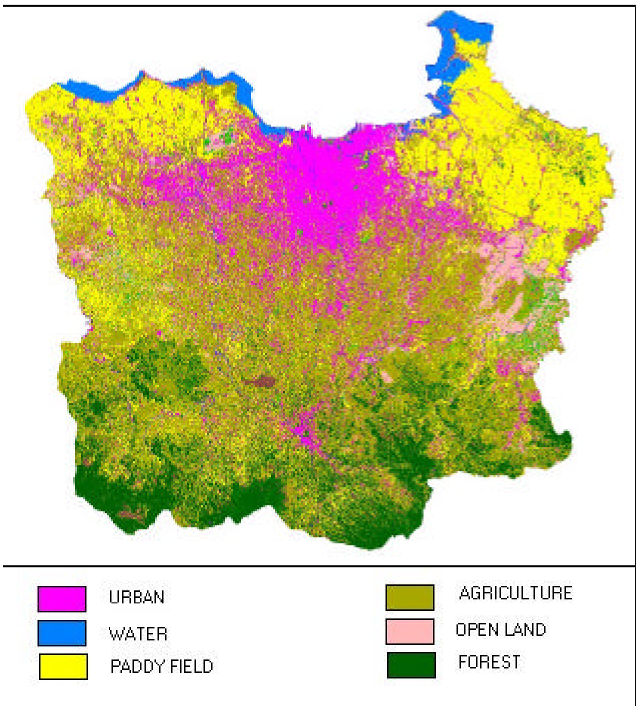
III. RESULT AND DISCUSSION

3.1. Land Use Change 1992-2001

Analysis of classification by using Landsat showed that built up areas are increasing rapidly between 1992 and 2001 (figure 2). Built-up areas increasing from 12% total areas of Jabotabek in 1992 into 24 % in 2001. In the other hand, agriculture land which is cover around 37% of total areas in 1992 decreasing into 31% in 2001 as well as decreasing of rice fields areas from 31% to 30.5 at the same period of analysis. Land Use map and Land Use changes map that generated from Landsat imagery showed that the changing pattern of land use is dominantly by encroachment of agricultural land to urban uses (Figure 2 and Figure 3).

Analysis by using logit model showed that the physics factors which influenced land use change to urban is slope and altitude of area. The model that the flat land and low land play and important role in land use change to urban. But for land use change to agriculture, the influence of slope and altitude of area are not significant.

For social economics factors, we also found that the distance (from CBD) influences the changing pattern for urban and influences enough the changing pattern for paddy field. For paddy field land uses, the probability of changing pattern is higher at the place which far from city center. In the other hand, for urban land uses probability of changing pattern is higher at the place, which closed to city center. We found that housing developments dominated in these areas especially when property business became booming since the beginning of 1990"s. The low prices and high access to the center of trade in these areas became the determining factors for conversion.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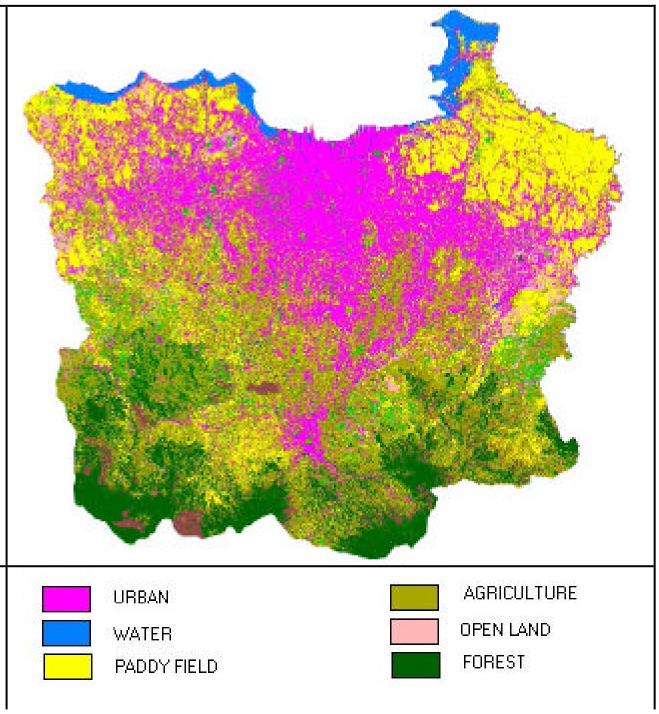
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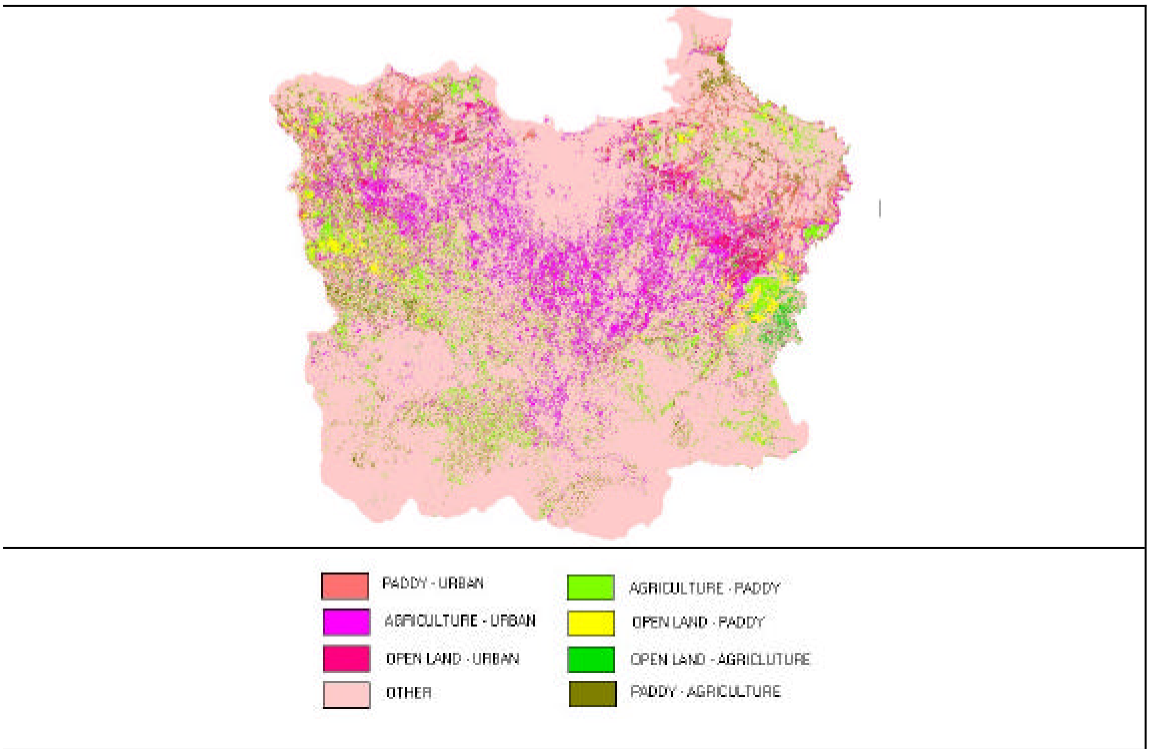
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PADDY - AGRICULTURE

IV. CONCLUSION

The result of this study showed that topographic effects (slope and altitude) appeared to be more influential in affecting urban land use change than agriculture land use change. Factor that had most significant effects is distance from CBD.

Jabotabek Region is considered to be the largest urban concentration in Indonesia. The growth of the city has always been integrated with that of its surrounding areas (Botabek Region). The agglomeration process and urban expansion of Jabotabek Regions seem to continue even for several years but has passed the fastest growing period. It means that land use conversion in the region, especially from this country's prime agricultural land to urban activities will still excise.

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