THE LAND USE PATTERN CHANGES OF JABOTABEK REGION AND ITS MAJOR CAUSES

Ita CAROLITA
Center of Remote Sensing Application, LAPAN,
Jl. LAPAN 70, Pekayon, Jakarta Timur Indonesia
Email: ita_carolita@hotmail.com

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

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

Bambang H. TRISASONGKO
Lab. of Remote Sensing, Fac. of Agriculture, Bogor Agricultural University,
Jl. Meranti, Darmaga Campus, IPB. Bogor, Indonesia; Email: bht@bogor.indo.net.id

ABSTRACT

Rapid urbanization and industrialization 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. Our main objective was to study temporal change and spatial distribution of land cover, by comparing the data from landsat of Jabotabek in 1992 and 2001.

We carried out the study in 3 stages by using GIS and remote sensing techniques. Landsat imagery showed that the changing pattern of land use is dominantly by encroachment of agricultural land to urban uses. Analysis by using logit model showed that the dominant factor, which influenced land use change to urban, paddy and agriculture is slope, following by distance and population growth in Jabotabek areas.

Keywords: *LUCC, GIS, Remote Sensing, Logit Model*

I. INTRODUCTION

1.1. Background

According to the United Nations, only 30% of the world's population lived in cities in 1950. This proportion increased to nearly 50% in 2000, and is projected to reach 60% in 2025 (Sukopp, 1998). The escalation of urbanization is dramatic in the developing world, where the number of urban dwellers has increased more than fourfold since 1950. This phenomenon is also evident in countries of Southeast Asia, which are the most populous among tropical countries.

By the end of the 20th 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, Tanggerang, Bekasi). In 1990, more than 75% of the Jabotabek population resided in urban areas (Central Board for Statistics, 1990). The population growth here, in the center of economic growth and national development since the beginning of the 20th 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 cities. The growth of these capital cities has been rapid over the past several decades, causing rapid rural-to-urban conversion of large areas surrounding the cities, uncontrolled development of the urban regions, housing shortages, and expansion of squatter settlements. Several studies have indicated that rapid urbanization causes rapid land use/cover change and serious environmental problems (Zain, 2002). Murakami *et al.* (2000), for example, reported a rapidly diminishing amount of green open space inside and around the cities of metropolitan Manila.

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, is 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 change pattern in Jabotabek by using GIS and Remote Sensing. The existence of GIS and Remote Sensing technologies makes it possible for research on urban 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 data are repetitive, real time, and in digital format allowing for quantitative approach. However, satellite based land cover or agricultural land use classifications requires more ground data observations to reach the level of acceptable quality.

1.2. Objectives

Our main objective was to study temporal change and spatial distribution of land cover within Jabotabek. We carried out the study in 3 stages by using GIS and remote sensing techniques. First, we analyzed land cover change from remote sensing data. Second, we identified the driving forces and other related factors of land cover change. Third, we developed a model, which could explain the dominant factor of land use change.

II. METHODS

2.1. Study Area and Materials

Jabotabek comprises 7 areas within 3 provinces. The first province is Jakarta (Daerah Khusus Ibukota). The second is West Java Province, consisting of the municipalities of Bogor and Bekasi, and the districts of Bogor and Bekasi. The third is Banten Province, which before 2001 used to be a region of West Java Province, and comprises the municipality of Tanggerang and district of Tanggerang. This metropolitan region, covering an area of about 6,752 km^2, is the largest urban agglomeration in

Indonesia. The study 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 areas.

Landsat TM image data for 1992 and ETM image data for 2001 were sourced from LAPAN. Topographic map sheets maps for 1990 (scale 1:25,000), used for geometric correction of the images was obtained from the National Coordination Agency for Surveys and Mapping (Bakosurtanal), Jakarta, Indonesia. Socio-economics data was sourced from Statistical beauru (BPS), Indonesia.

2.2. Data Processing and Analysis

2.2.1. Remote Sensing

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 to be 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 comparison and analysis.

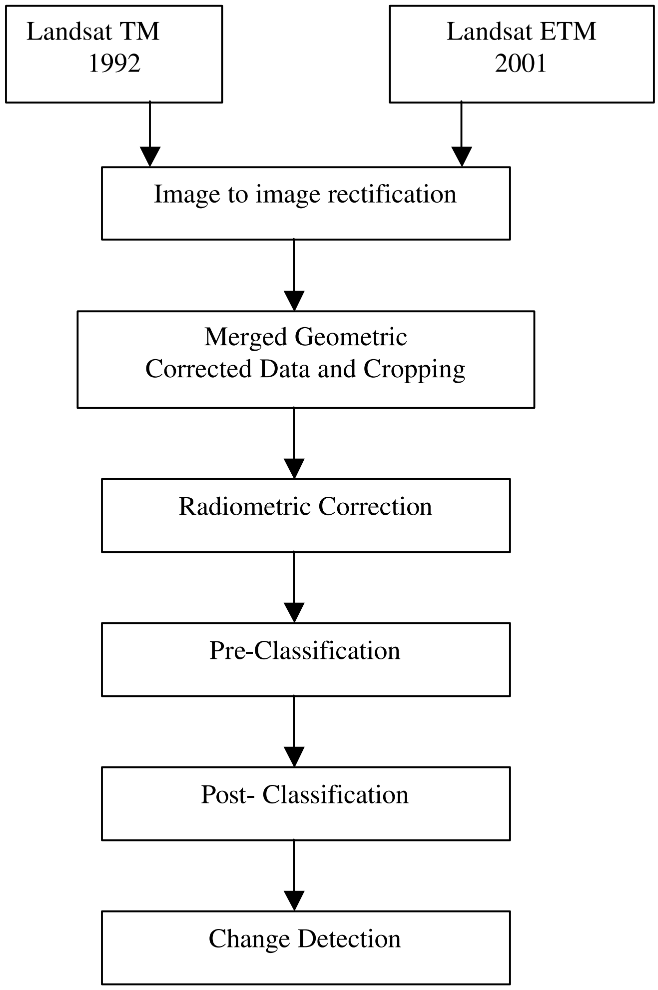

Figure 1. Conceptual Land Use Changes Detection Using Remote Sensing Data

Pre-Processing

The raw remote sensing data may contain flaws or deficiencies. Therefore, it is necessary to remove data errors and unwanted or distracting elements of the image. Their correction is termed radiometric pre processing, which contain destriping, 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 resampling 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.

Land Cover classification

Supervised classification was applying to classify the remote sensing data by using maximum likelihood 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 statistics. Analysis land cover change was performed within sub-district.

Socio-Economics

Socio-economic data utilized in this study was compiled by Government Statistics Agencies (*BPS*), which officially published to be utilized by interest ted 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.

2.2.2. 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 5 data which will be integrated in GIS, those are: land cover classification map (generated from Landsat data), Slope map (generated from topographic map), district boundary map (generated from land use map that produced by Bakosurtanal), population growth (BPS) and the distance from center of Jakarta (MONAS) to center of sub-district.

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. The process for administrative boundary is carried out to sub-district level.

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 (Fig. 3). Built –up areas increasing from 12 % of 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 field areas from 31 % to 30.5 % at the same period of analysis. Landsat imagery showed that the changing pattern of land use is dominantly by encroachment of agricultural land to urban uses (Fig. 4 and Fig. 5).

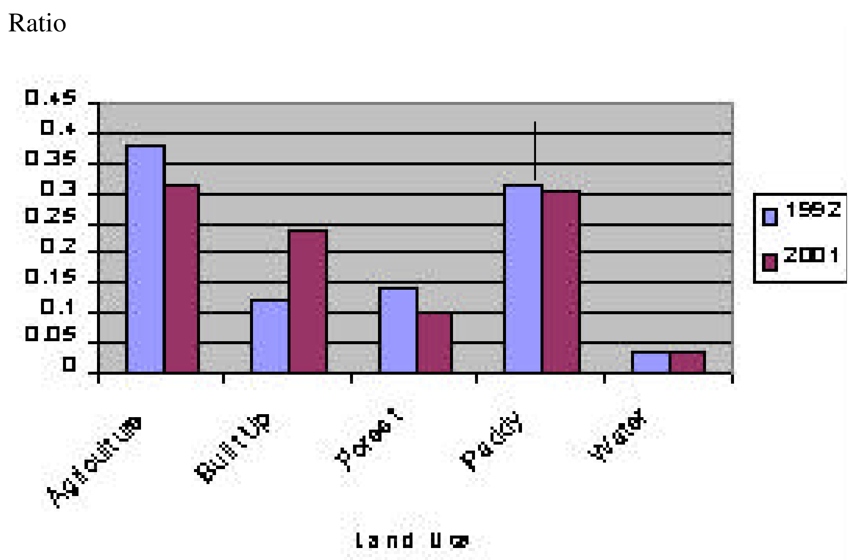

Fig. 3 Land use change in Jabotabek (1992-2001)

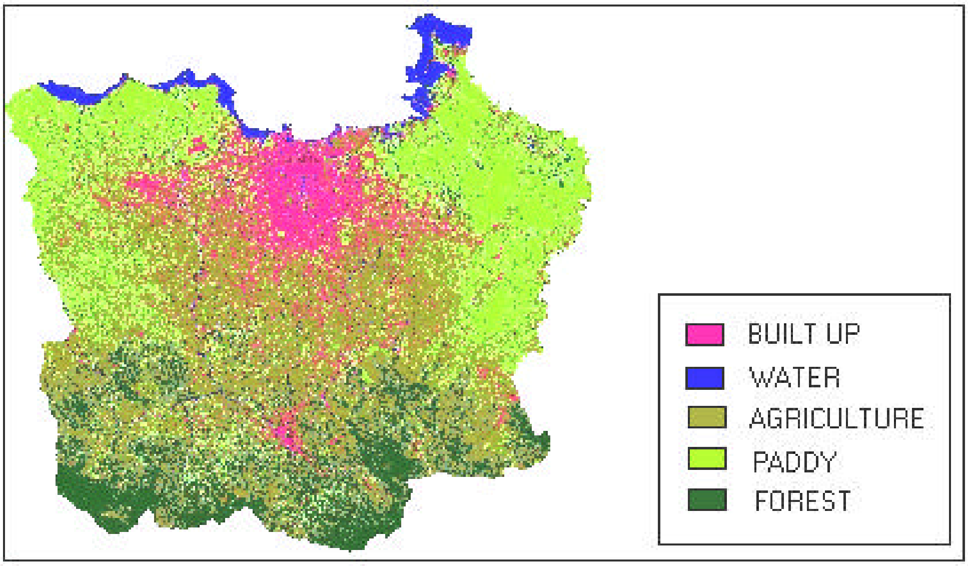

Figure 4. Land use of Jabotabek from Landsat imagery in 1992

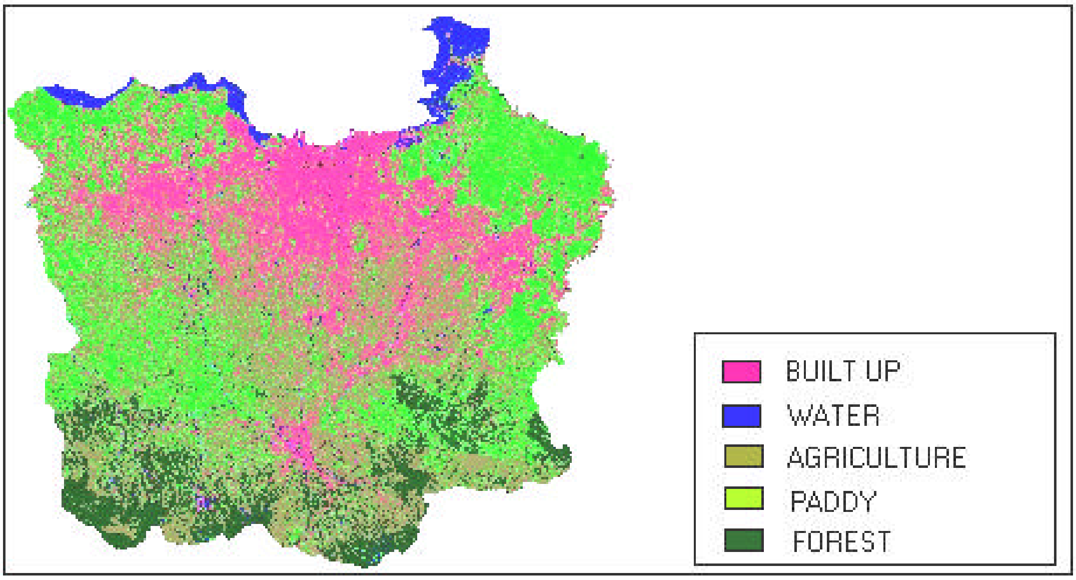

Figure 5. Land use of Jabotabek from Landsat imagery in 2001

3.2 Land use change and 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 depends on local characteristics such as inherent socio-economic, natural condition and behavioral characteristics of the people. Land use change models, which are sensitive to local characteristics are needed for evaluation scenario and to develop effective policy recommendation.

A methodology for modeling land use was proposed by Kitamura *et al*, (1997), which could predict changes of major land uses by means of relatively simple procedures. We applied modeling to predict the driving forces of land use change in Jabotabek. 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, …, 10

X1 = distance to CBD

X2 = proportion of agricultural land use of each sub-district (kecamatan)

X3 = proportion of forest use of each sub-district

X4 = proportion of paddy land of each sub-district

X5 = population growth from 1992 to 2000

X6 = acreage area with slope more than 45%

X7 = acreage area with slope between 0 to 3%

X8 = acreage area with slope between 15 to 30%

X9 = acreage area with slope between 3 to 8%

X10 = acreage area with slope between 30 to 45%

Analysis by using logit model showed that the dominant factor, which influenced land use change to agriculture is slope. The model proved that the flat land (0-3% and 3-8%) play an important role in land use change to agricultural land and paddy field. Encroachment of forest area to agricultural land also become determinant factors on land use change in these areas. As well as the case of agricultural and paddy field areas, we found also by using logit model that slope play a dominant factor for changing pattern to urban uses.

For social economic factors, we also found that the distance (from CBD) influences enough the changing pattern for paddy field and urban land uses. 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 the 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.

By using logit model, we still found that other factors are not significantly influence land use change within Jabotabek areas. It seems that Jakarta and botabek areas showed different characteristics of land use change. The area in suburbs of Jakarta rapidly change caused by encroahment of agriculturl land to urban uses, while in Jakarta, urban areas still exist and no change to greenery anymore. It means that land use change in suburbs more dynamic than in urban areas itself. In addition, application of logit model is better doing on smaller area such as at `desa level` in the future, in attempt to obtain more correctly result.

IV. CONCLUSION

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.

Land use conversion problem has been the concern of national planners but there is no significant actions have been done. Therefore, there is great need for decision-makers to understand the trend, magnitude, and characteristics of land use cover changes in the region in their attempt to cop the problems.

Refferences

Central Board for Statistics (1990): Statistics of Indonesia 1990. Jakarta, Indonesia.

Final Report Dynamic Model For Monitoring Land Use/Land Cover Changes in Upper Citarum Watershed. 1997. Project Research Under IGBP-LUCC Activities (Indonesian Case Study).

Hamonangan, Bintang. Analisis Neraca Penggunaan Lahan dan Pola Perubahannya serta Implikasinya Terhadap Penataan Ruang dan Pengembangan Wilayah. Jurusan Tanah, Fakultas Pertanian, Institut Pertanian Bogor. Bogor, 2000

Jim, C.Y. (2000): The urban forestry program in heavily built-up milieu of Hong-Kong. *Cities* 17 (4), 271–283.

Kawamura, M., Sanath J., Yuji T., and Akira S. (1998): Comparison of urbanization of four Asian cities using satellite data. *Journal of Environmental Systems and Engineering* 608/VII (9), 97–105.

Murakami, A., Takeuchi, K., Tsunekawa, A., and Moriwake, N. (2000): The changing pattern of urban population density and landscape structure in Metro Manila. *City Planning Review* 35, 625–630.

Rustiadi, Ernan. Land Use Change in The Suburb Area (The case study in Nagahama City, Shiga Prefecture, Japan and Jabotabek area of Indonesia). A thesis for Degree of Master of Agriculture. Division of Tropical Agriculture, Kyoto University. 1996.

Spaargaren, O and V. Van Englen. (1999) Land Resources Information Systems- A Source on Information and Basic Tool for Modelling and Monitoring Land-use and Land-cover hanges. In: Otsubo, K. (Eds.). *Proceedings of 1999 NIES Workshop on Information Bases and Modeling for Land-use and Land-cover Change Studies in East Asia.* Center for Global Environment Research. Tokyo, pp 65-72.

Sukopp, H. (1998): Urban Ecology- Scientific and Practical Aspect. In: J. Breute *et al.* (Eds.). *Urban Ecology*. Springer, Berlin, pp 3-16.

Weng, Q. (2001): A remote sensing-GIS evaluation of urban expansion and its impact on surface temperature in the Zhujiang Delta-China. *International Journal of Remote Sensing* 22 (10), 1999-2014.

Zain, A.M. 2002. Distribution, Structure and Function of Urban Green Space in Southeast Asian Mega-cities with Special Reference to Jakarta Metropolitan Region (Jabotabek). Department of Agricultural and Environmental Biology, Graduate School of Agricultural and Life Sciences. Doctor Dissertation of The University of Tokyo.